Data Science Applications for Dairy Farming

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The Modern Dairy Challenge: Navigating a Sea of Complexity

Today's dairy operations are highly dynamic and deeply integrated systems. Success depends on navigating a constant flow of variables.

Dynamic External Factors: Fluctuating market prices, shifting climate patterns, and evolving environmental policies create a landscape of uncertainty.

Integrated Internal Systems: Decisions in one area—like feed—have cascading effects on herd health, reproduction, and overall profitability.

The critical question is no longer about collecting data, but how to transform it into clear, profitable decisions.

Cabrera, 2012: IntechOpen


How do you turn complex variables into your most profitable decisions?

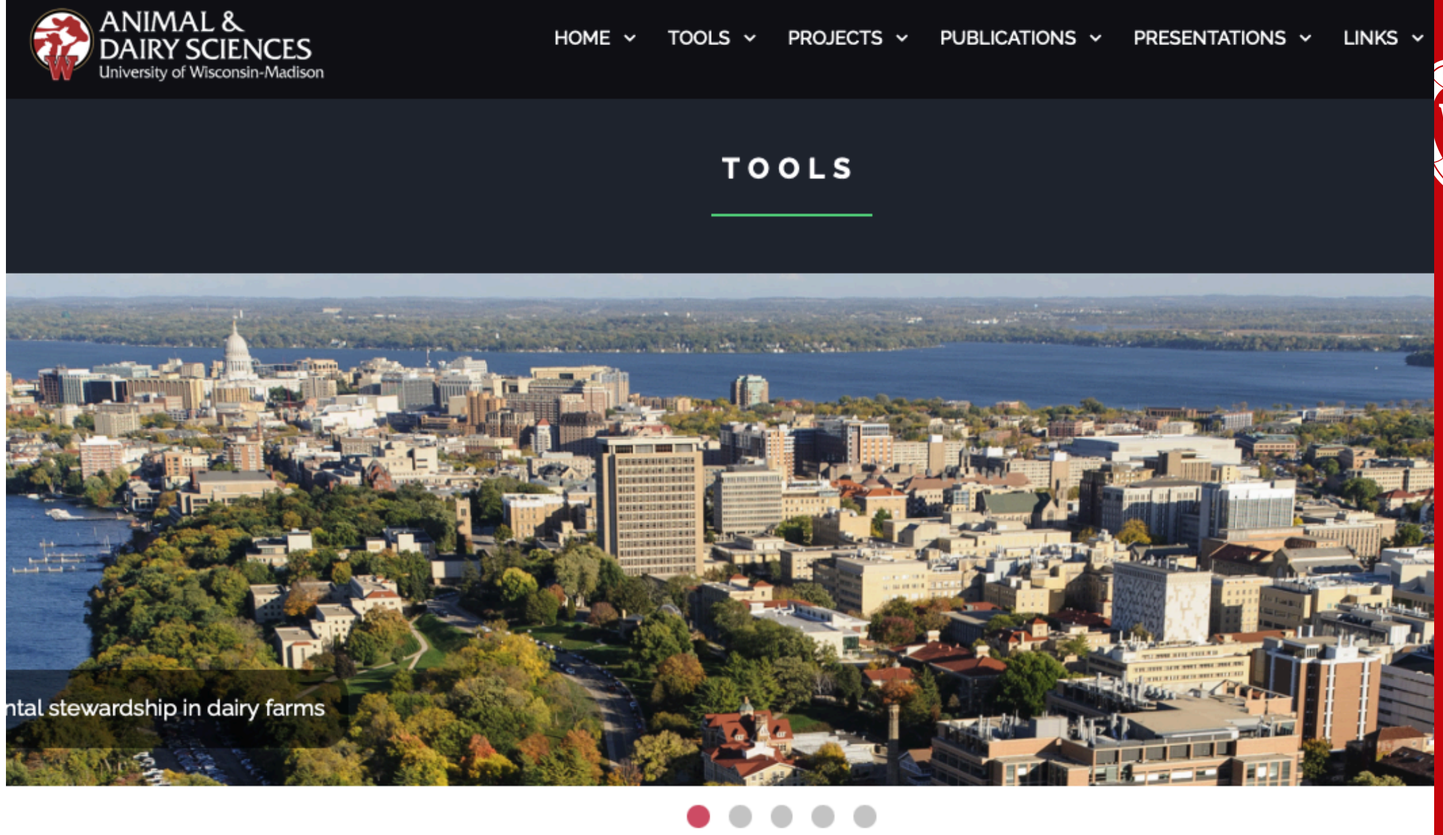
Outline

DST

- **Background and Introduction**
- **Introduce DairyMGT.info**
  - DairyMGT.info
  - >40 DSS
  - > Management
- **Some critical DSS for dairy farm management**
- **Addressing the replacement problem**

DariyMGT.info

Largest collection of DST



A Complete Toolkit for the Modern Farm

The DairyMGT.info platform is organized into 10 key management areas, providing specialized tools to optimize every facet of your operation.

Feeding & Nutrition

Heifers

Reproduction

Genomics

Production

Replacement

Health

Financial

Price Risk

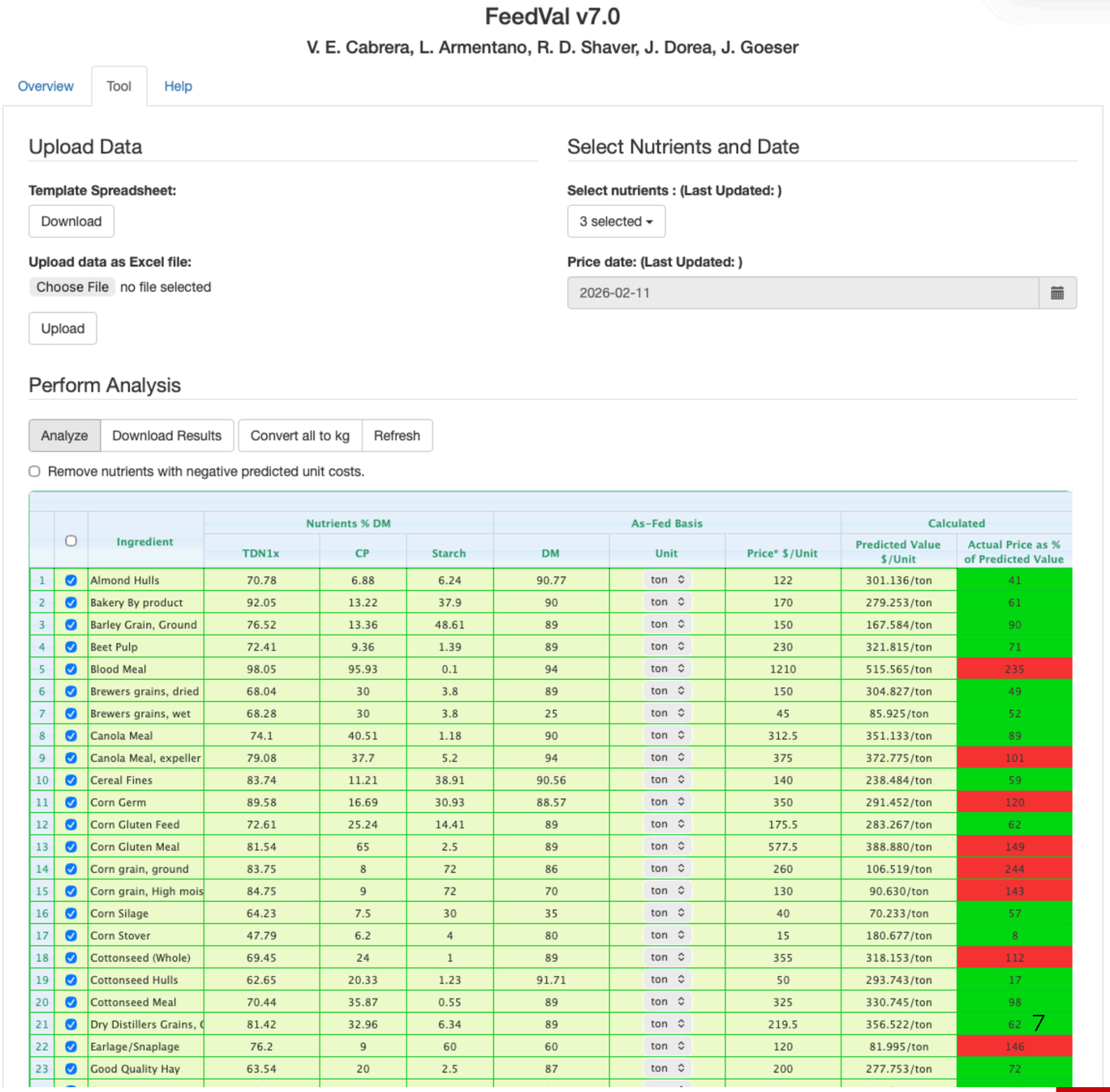
Environment

In the following slides, we'll explore high-impact tools from several of these critical areas.

FeedVal

Actual value of dairy feed ingredients

According to nutrient composition and market prices

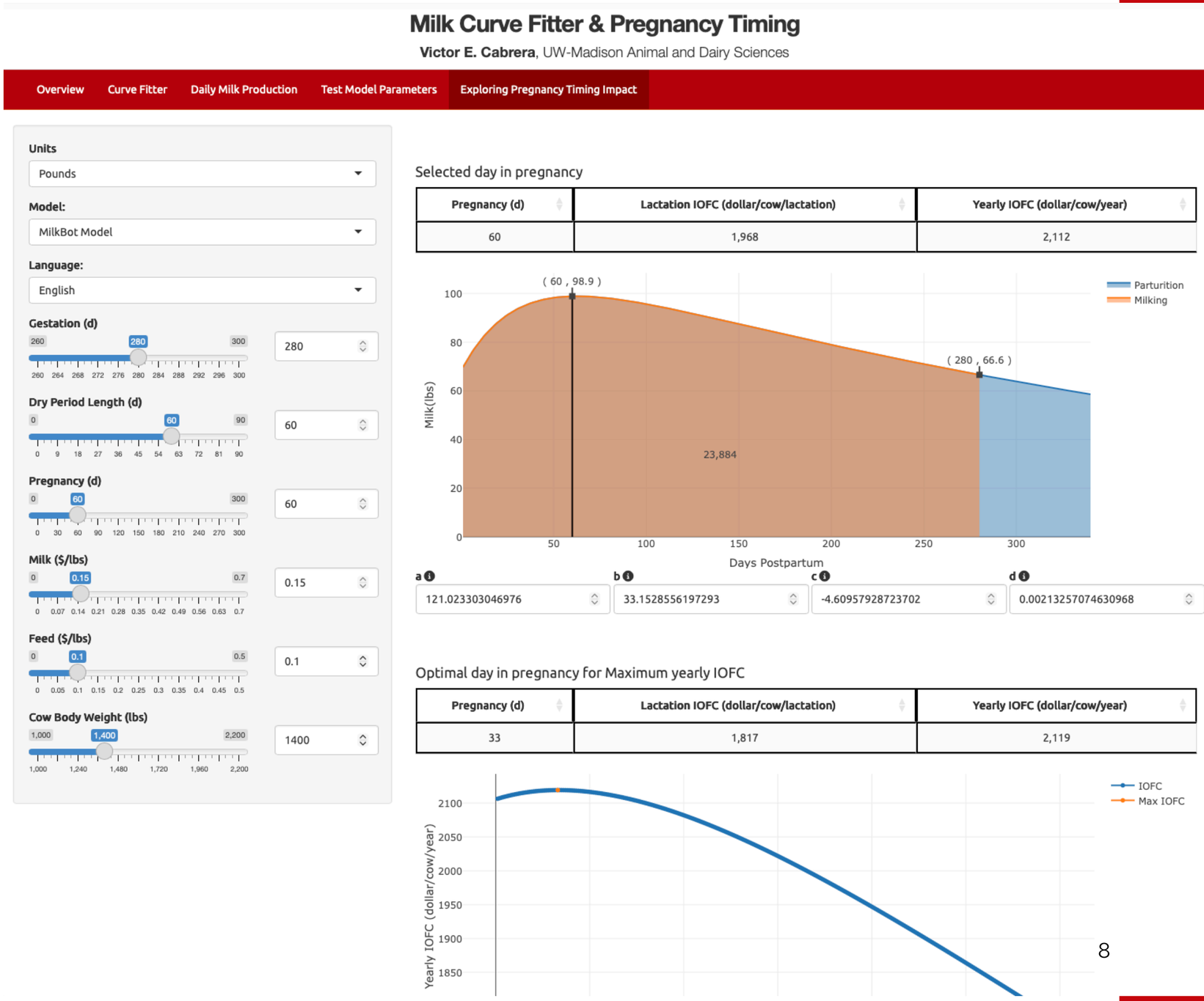


		Ingredient	Nutrients % DM			As-Fed Basis			Calculated	
			TDN1x	CP	Starch	DM	Unit	Price* $/Unit	Predicted Value $/Unit	Actual Price as % of Predicted Value
1	☑	Almond Hulls	70.78	6.88	6.24	90.77	ton	122	301.136/ton	41
2	☑	Bakery By product	92.05	13.22	37.9	90	ton	170	279.253/ton	61
3	☑	Barley Grain, Ground	76.52	13.36	48.61	89	ton	150	167.584/ton	90
4	☑	Beet Pulp	72.41	9.36	1.39	89	ton	230	321.815/ton	71
5	☑	Blood Meal	98.05	95.93	0.1	94	ton	1210	515.565/ton	235
6	☑	Brewers grains, dried	68.04	30	3.8	89	ton	150	304.827/ton	49
7	☑	Brewers grains, wet	68.28	30	3.8	25	ton	45	85.925/ton	52
8	☑	Canola Meal	74.1	40.51	1.18	90	ton	312.5	351.133/ton	89
9	☑	Canola Meal, expeller	79.08	37.7	5.2	94	ton	375	372.775/ton	101
10	☑	Cereal Fines	83.74	11.21	38.91	90.56	ton	140	238.484/ton	59
11	☑	Corn Germ	89.58	16.69	30.93	88.57	ton	350	291.452/ton	120
12	☑	Corn Gluten Feed	72.61	25.24	14.41	89	ton	175.5	283.267/ton	62
13	☑	Corn Gluten Meal	81.54	65	2.5	89	ton	577.5	388.880/ton	149
14	☑	Corn grain, ground	83.75	8	72	86	ton	260	106.519/ton	244
15	☑	Corn grain, High mois	84.75	9	72	70	ton	130	90.630/ton	143
16	☑	Corn Silage	64.23	7.5	30	35	ton	40	70.233/ton	57
17	☑	Corn Stover	47.79	6.2	4	80	ton	15	180.677/ton	8
18	☑	Cottonseed (Whole)	69.45	24	1	89	ton	355	318.153/ton	112
19	☑	Cottonseed Hulls	62.65	20.33	1.23	91.71	ton	50	293.743/ton	17
20	☑	Cottonseed Meal	70.44	35.87	0.55	89	ton	325	330.745/ton	98
21	☑	Dry Distillers Grains, (	81.42	32.96	6.34	89	ton	219.5	356.522/ton	62
22	☑	Earlage/Snaplage	76.2	9	60	60	ton	120	81.995/ton	146
23	☑	Good Quality Hay	63.54	20	2.5	87	ton	200	277.753/ton	72

Milk Curve Fitter

& Pregnancy Timing

Milk production projection and its impact on pregnancy timing

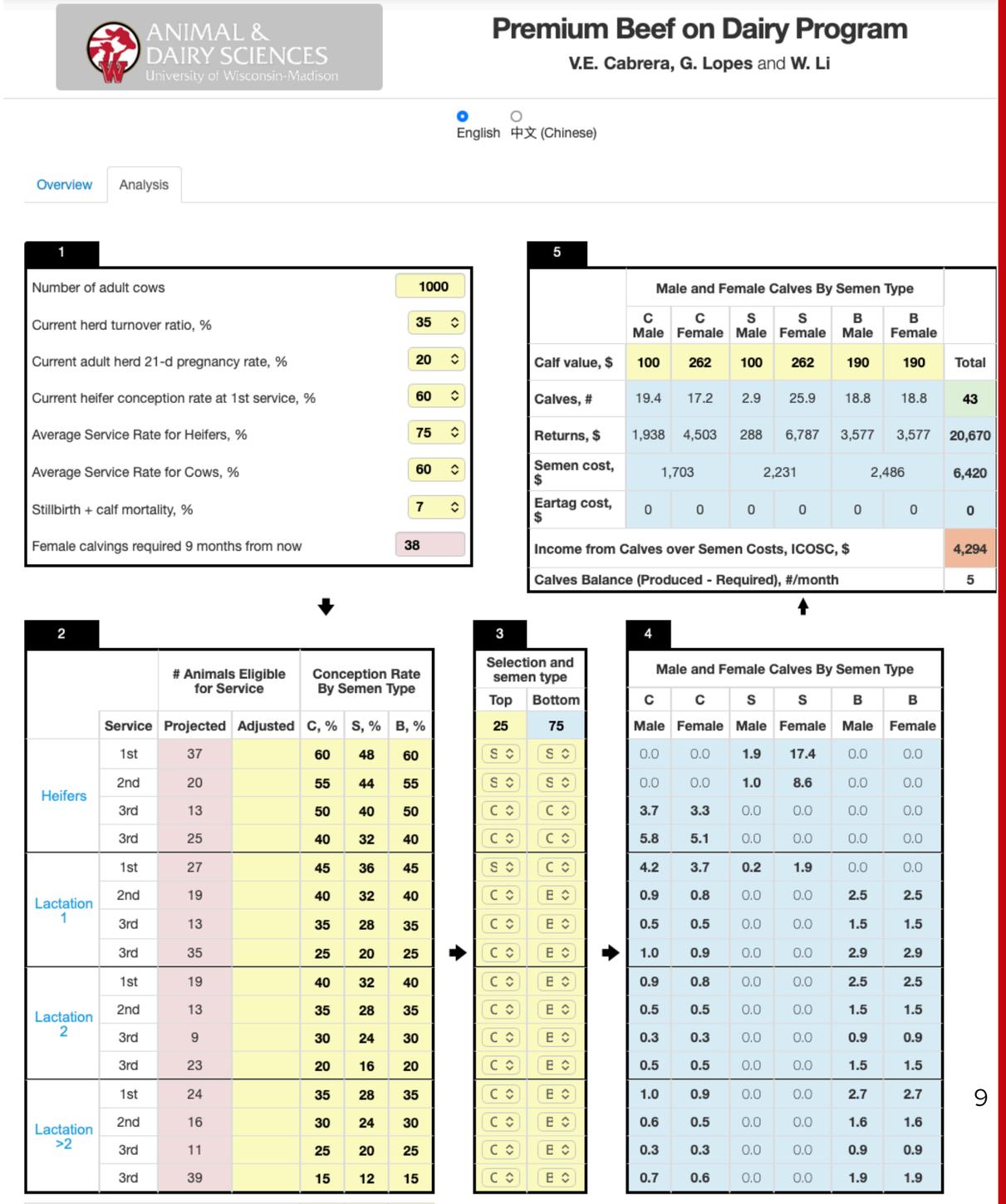


Beef x Dairy

Value of beef & sexed

Use of conventional, sexed, and beef semen on dairy

Cabrera, 2022: JDS Communications 3:147



ANIMAL & DAIRY SCIENCES
University of Wisconsin-Madison

Premium Beef on Dairy Program

V.E. Cabrera, G. Lopes and W. Li

English 中文 (Chinese)

Overview | Analysis

1

Number of adult cows	1000
Current herd turnover ratio, %	35
Current adult herd 21-d pregnancy rate, %	20
Current heifer conception rate at 1st service, %	60
Average Service Rate for Heifers, %	75
Average Service Rate for Cows, %	60
Stillbirth + calf mortality, %	7
Female calvings required 9 months from now	38

5

	Male and Female Calves By Semen Type						
	C Male	C Female	S Male	S Female	B Male	B Female	
Calf value, $	100	262	100	262	190	190	Total
Calves, #	19.4	17.2	2.9	25.9	18.8	18.8	43
Returns, $	1,938	4,503	288	6,787	3,577	3,577	20,670
Semen cost, $	1,703		2,231		2,486		6,420
Eartag cost, $	0	0	0	0	0	0	0
Income from Calves over Semen Costs, ICOSC, $							4,294
Calves Balance (Produced - Required), #/month							5

2

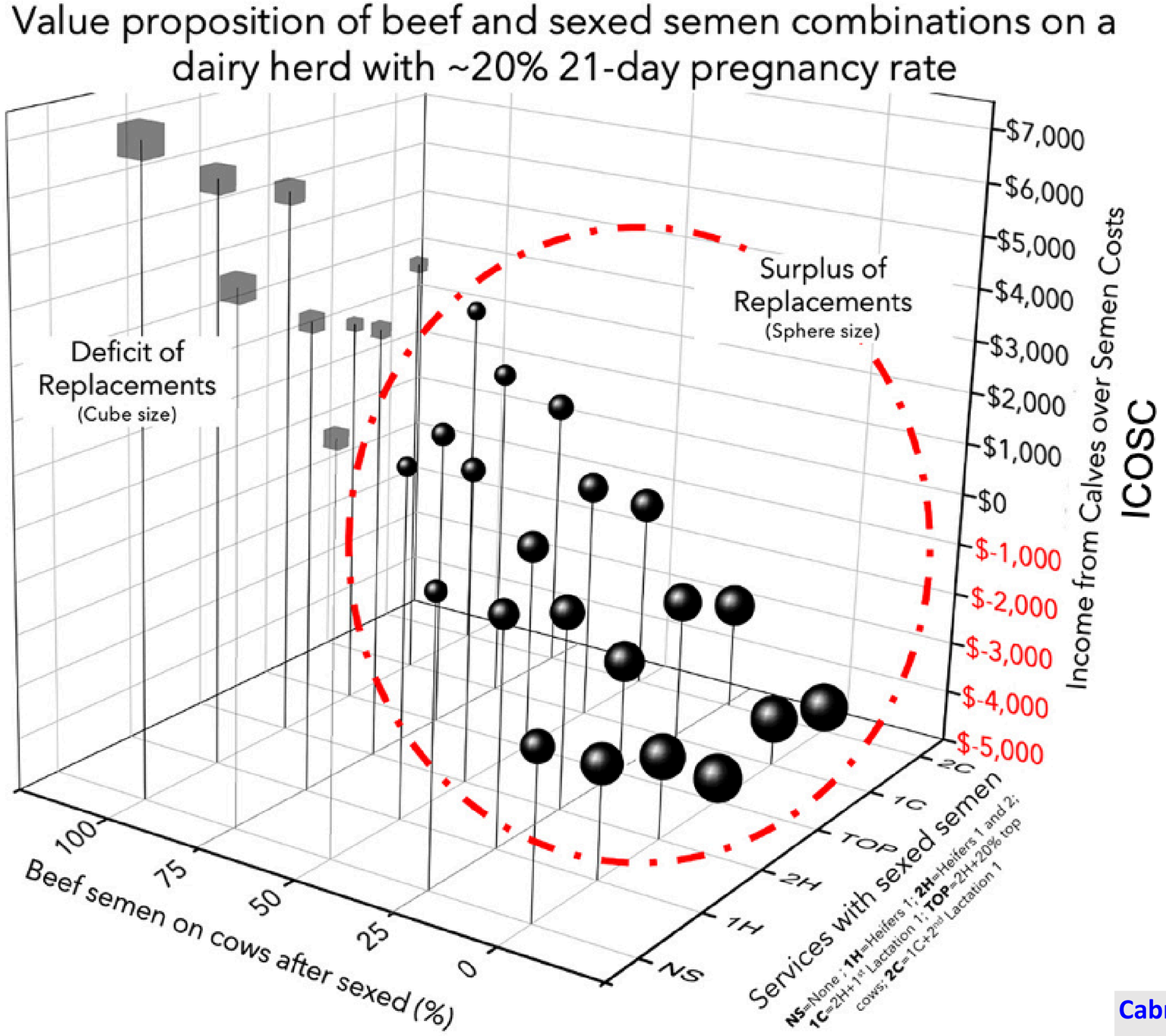
	Service	# Animals Eligible for Service: Projected	Adjusted	Conception Rate By Semen Type: C, %	S, %	B, %
Heifers	1st	37		60	48	60
	2nd	20		55	44	55
	3rd	13		50	40	50
	3rd	25		40	32	40
Lactation 1	1st	27		45	36	45
	2nd	19		40	32	40
	3rd	13		35	28	35
	3rd	35		25	20	25
Lactation 2	1st	19		40	32	40
	2nd	13		35	28	35
	3rd	9		30	24	30
	3rd	23		20	16	20
Lactation >2	1st	24		35	28	35
	2nd	16		30	24	30
	3rd	11		25	20	25
	3rd	39		15	12	15

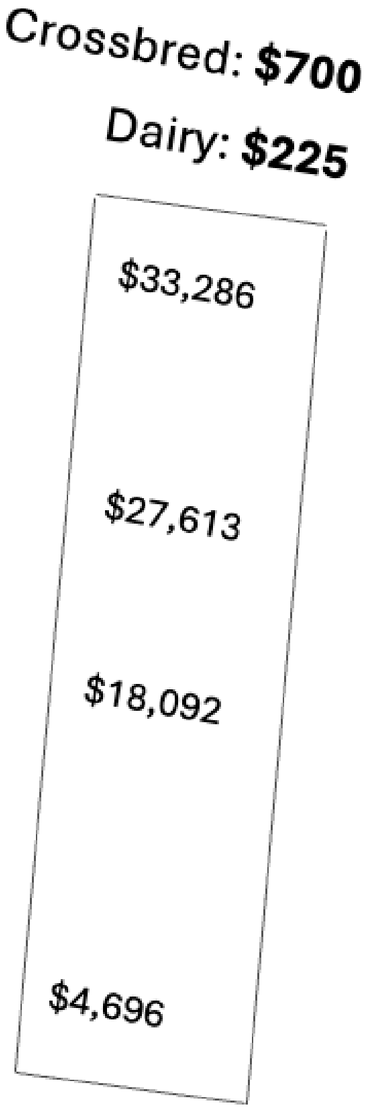
3

Selection and semen type: Top	Bottom
25	75
S	S
S	S
C	C
C	C
S	C
C	B
C	B
C	B
C	B
C	B
C	B
C	B
C	B
C	B
C	B
C	B
C	B
C	B
C	B

4

Male and Female Calves By Semen Type: C Male	C Female	S Male	S Female	B Male	B Female
0.0	0.0	1.9	17.4	0.0	0.0
0.0	0.0	1.0	8.6	0.0	0.0
3.7	3.3	0.0	0.0	0.0	0.0
5.8	5.1	0.0	0.0	0.0	0.0
4.2	3.7	0.2	1.9	0.0	0.0
0.9	0.8	0.0	0.0	2.5	2.5
0.5	0.5	0.0	0.0	1.5	1.5
1.0	0.9	0.0	0.0	2.9	2.9
0.9	0.8	0.0	0.0	2.5	2.5
0.5	0.5	0.0	0.0	1.5	1.5
0.3	0.3	0.0	0.0	0.9	0.9
0.5	0.5	0.0	0.0	1.5	1.5
1.0	0.9	0.0	0.0	2.7	2.7
0.6	0.5	0.0	0.0	1.6	1.6
0.3	0.3	0.0	0.0	0.9	0.9
0.7	0.6	0.0	0.0	1.9	1.9

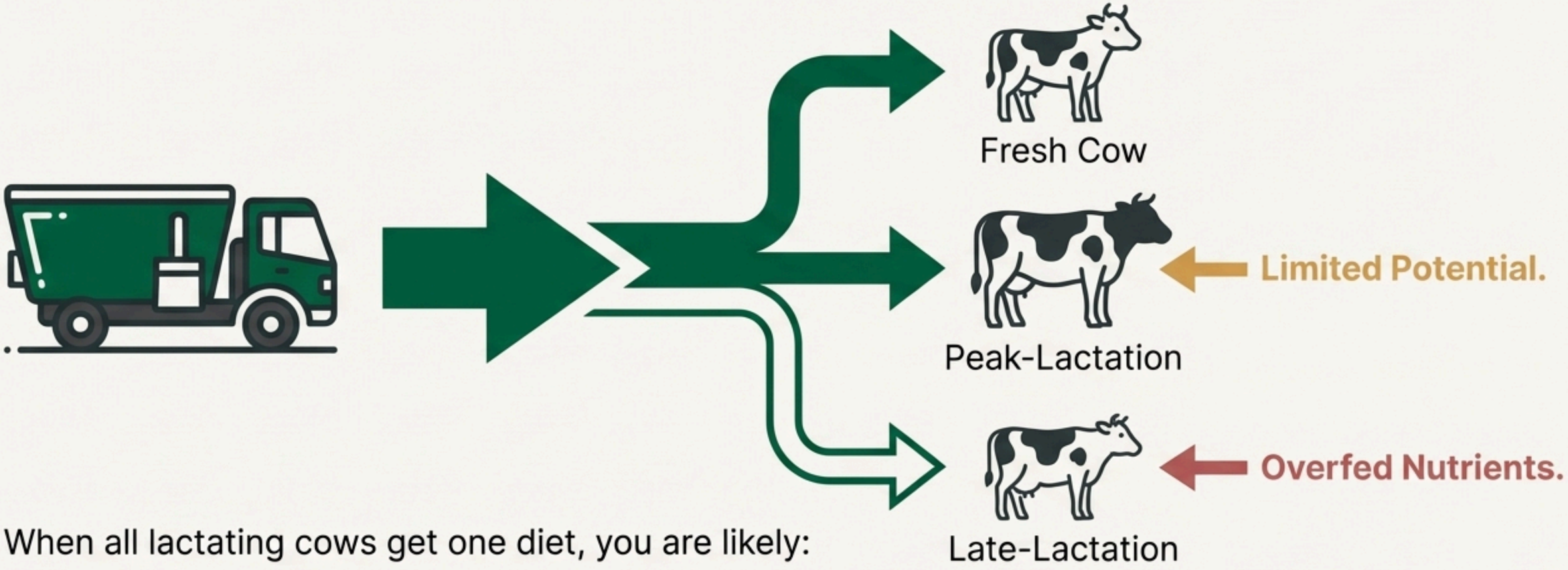




Cabrera, 2022: JDS Communications 3:147

The Herd's Nutritional Engine

The One-Size-Fits-All TMR Problem.

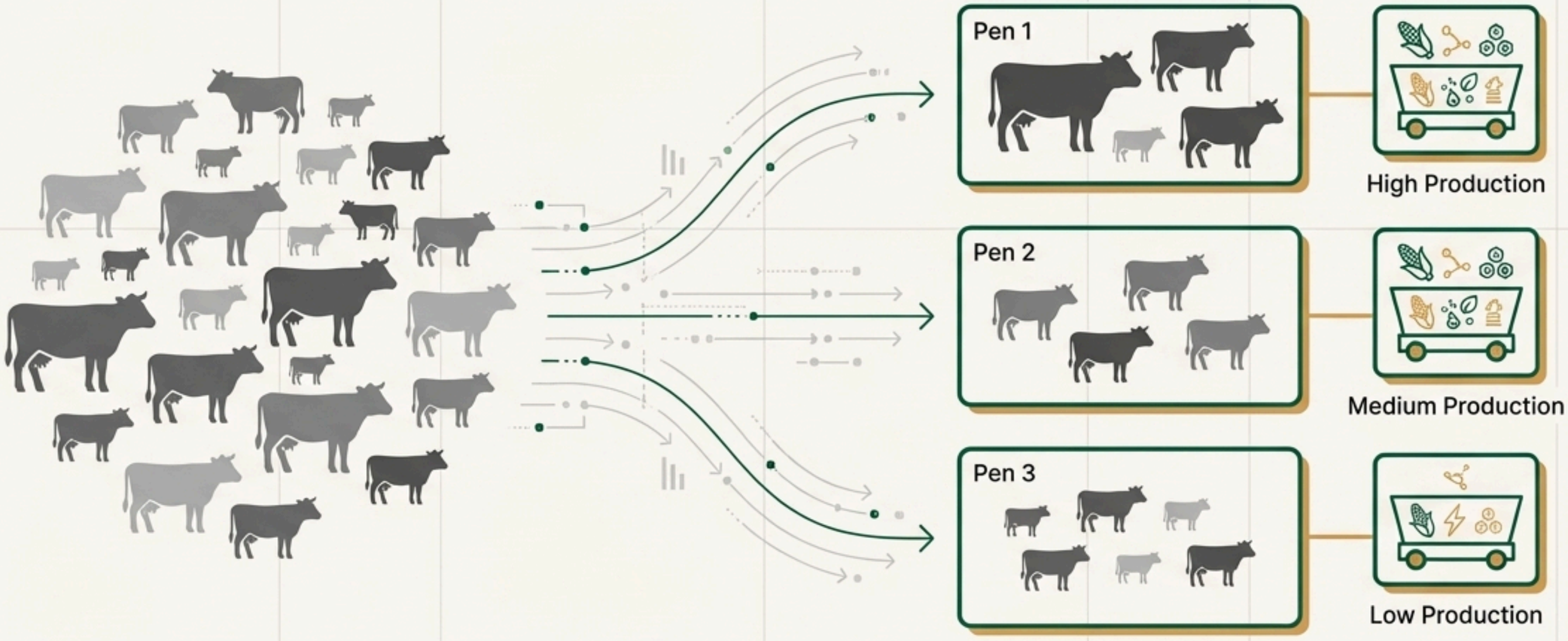


When all lactating cows get one diet, you are likely:

* Wasting expensive protein on late-lactation cows.
* Limiting the potential of high-producing cows.

The Solution: The Nutritional Grouping Tool

Simulating your herd to find the optimal number of groups and the economic return.



Based on a dynamic stochastic Monte Carlo simulation modeling daily energy & protein requirements, BW, and BCS for every cow.

Grouping

Strategies for feeding

Evaluation of nutritional grouping strategies

Kalantari et al., 2016: JDS 99:1672
Wu et al., 2019: JDS 102:4682
Barrientos et al., 2020: JDS 103:3774

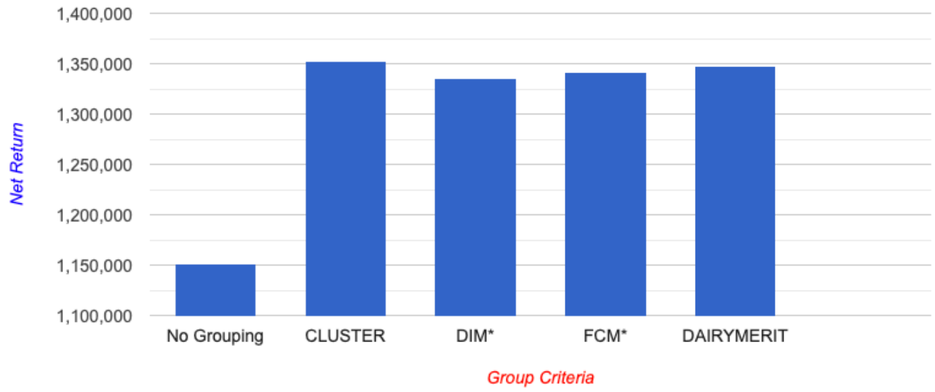
Grouping Strategies for Feeding Lactating Dairy Cattle

V.E. Cabrera, UW-Madison Animal and Dairy Sciences

Overview | Upload Farm Details | Group Cows | Reap Benefits

Sample Farm: Total Cows = 470

Figure: Yearly Net Return ($/herd/yr) for different Group Criteria



FCM* - Fat Corrected Milk; DIM* - Days In Milk

Table: Group Criteria, Diets, Income Over Feed Cost(IOFC) and Total Herd Net Return

Group Criteria	Group Number	Number of Cows	NEL* (Mcal/lb)	CP * (%)	IOFC ($/cow/d)	Cost of Management ($/cow/d)	Cost Milk Depression ($/cow/d)	Savings on Additives ($/cow/d)	Total ($/herd/yr)
NO GROUPING (No Optimization)	1	470	0.82	18.00	6.71				
	Mean		0.82	18.00	6.71	-0.0000	-0.0000	0.0000	1,151,483
CLUSTER	1	120	0.73	16.53	10.27				
	2	200	0.68	15.04	8.39				
	3	150	0.64	13.60	5.30				
	Mean		0.68	14.96	7.88	-0.0000	-0.0000	0.0000	1,352,338
DIM	1	120	0.73	16.51	9.06				
	2	150	0.69	15.46	8.66				
	3	200	0.67	14.71	6.36				
	Mean		0.69	15.41	7.79	-0.0000	-0.0000	0.0000	1,335,639

The Next Level: Your Reproductive Strategy

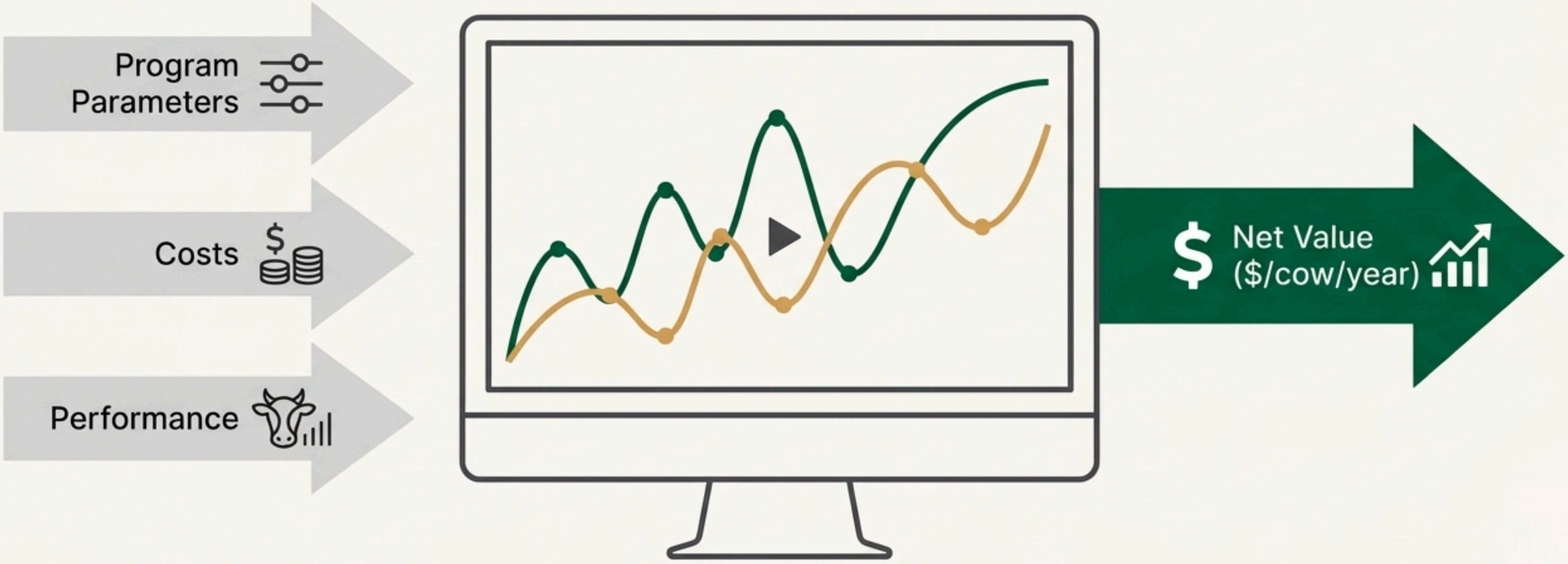
Which program delivers the highest net return?

It’s a trade-off between:

- Hormone & Labor Costs
- Insemination Risk
- Conception Rates

The Solution: UW-Cornell Dairy Repro$

A daily herd simulation to compare the economic outcomes of reproductive programs head-to-head.



Wisconsin-Cornell Dairy Repro$

Reproductive Economic Assessment

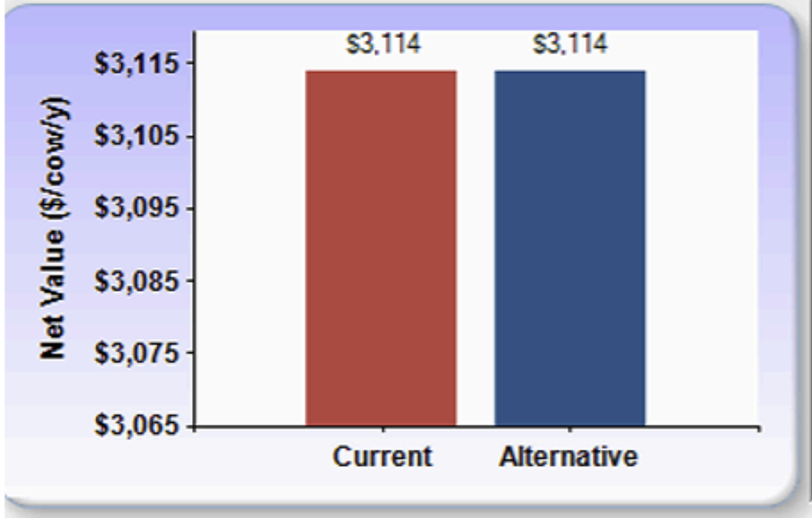
Economic analysis of specific reproductive programs

Giordano et al., 2012: JDS 95:5442

Wisconsin-Cornell DairyRepro$ (UWCURepro$) 1.4

erd Description | Reproduction | Results | About & Help

Economic Results



Profit made by switching to the Alternative program

$/herd/year: $

$/cow/year: $.0

Reproductive Programs Summary

Item	Current	Alternative
First AI postpartum	Presynch-Ovsynch-14	Presynch-Ovsynch-14
Second and sub. AI	Ovsynch	Ovsynch
VWP (d)	50	50
Maximum DIM for Breeding	300	300
Do-not-Breed Minimum Milk (lb/d)	50	50
DIM first injection for first AI sync program (d)	36	36
Interbreeding interval for TAI services (d)	42	42
Heat bred before first TAI service (%)	60	60
CR heat bred before first TAI service (%)	25	25
CR first TAI service (%)	30	30
Heat bred after first TAI service (%)	60	60
CR heat bred after first TAI service (%)	25	25

Reproductive Programs

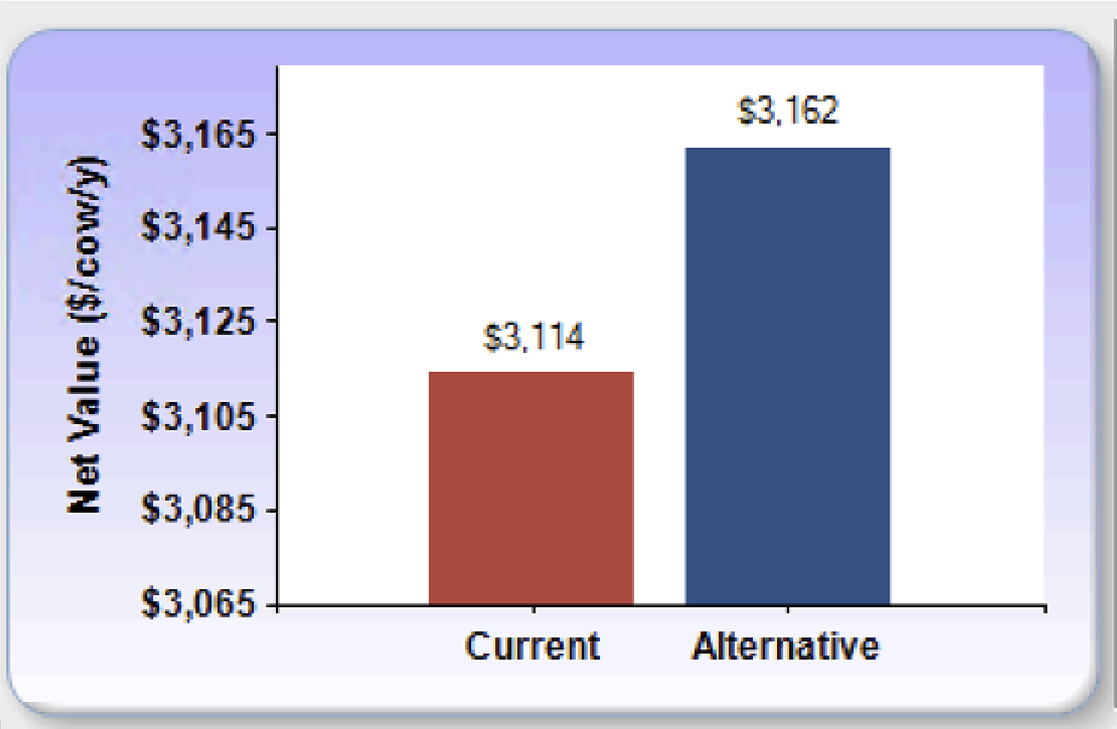
	Current	Alternative
First AI postpartum	Presynch-Ovsynch-14	Presynch-Ovsynch-14
Second and sub. AI	Ovsynch	Ovsynch
Resynch before preg check	YES	YES

Programs Description

	Current	Alternative
VWP (d)	50	50
Estrous Cycle Duration (d)	22	22
Maximum DIM for Breeding	300	300
Do-not-Breed Minimum Milk (lb/d)	50	50
DIM first injection for first AI sync program (d)	36	36
Weekday first injection	Tuesday	Tuesday
Interbreeding interval for TAI services (d)	42	42
Heat bred before first TAI service (%)	60	60
CR heat bred before first TAI service (%)	25	25
CR first TAI service (%)	30	30
Heat bred after first TAI service (%)	60	60
CR heat bred after first TAI service (%)	25	25
CR second and subsequent TAI services (%)	28	28
Pregnancy Loss (%)	24.4	24.4

Double-Ov. vs. Presynch Ov.

Although DO requires +investment, it could be a better alternative

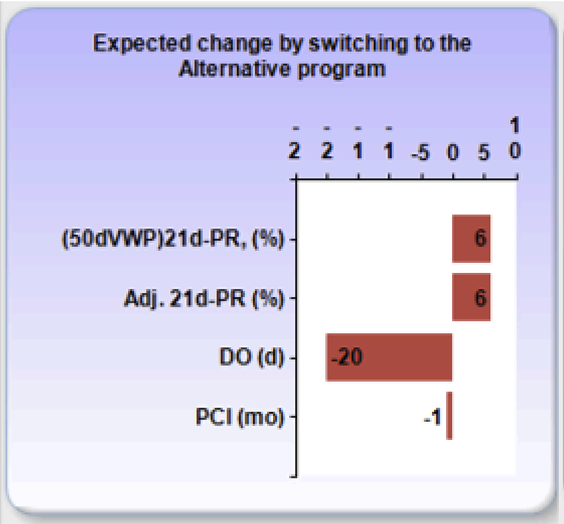


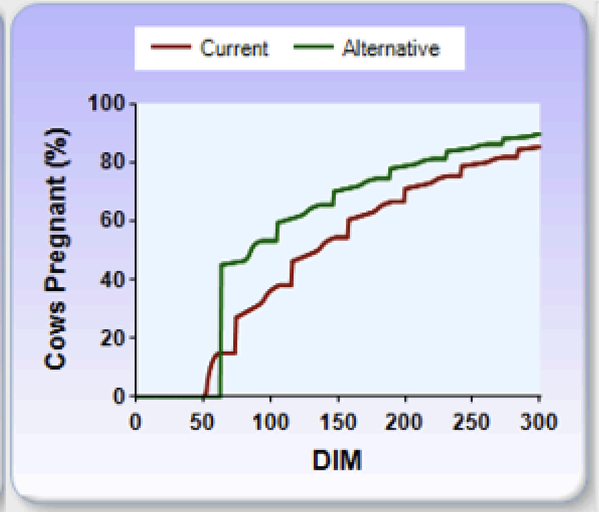
Profit made by switching to the Alternative program

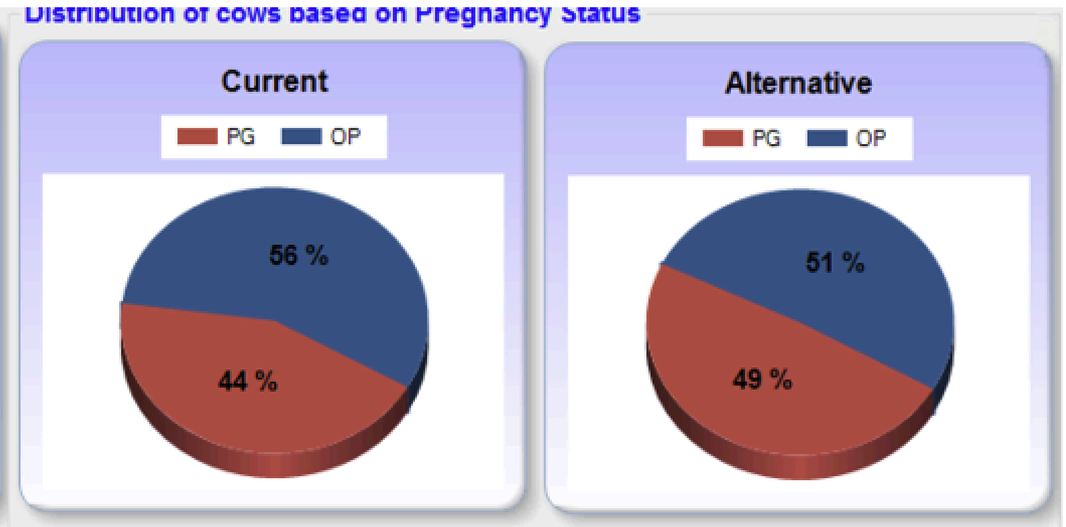
$/herd/year	$4,770
$/cow/year	$47.7

Contribution to Net Value

Item	Current	Alternative	Diff
Total Net Value ($/cow/y)	3,114.4	3,162.1	47.7
IOFC ($/cow/y)	3,272.4	3,308.9	36.5
Replacement Cost ($/cow/y)	-160.5	-151.9	8.6
Reproductive Cost ($/cow/y)	-35.2	-39.0	-3.8
Calf Value ($/cow/y)	37.7	44.1	6.4



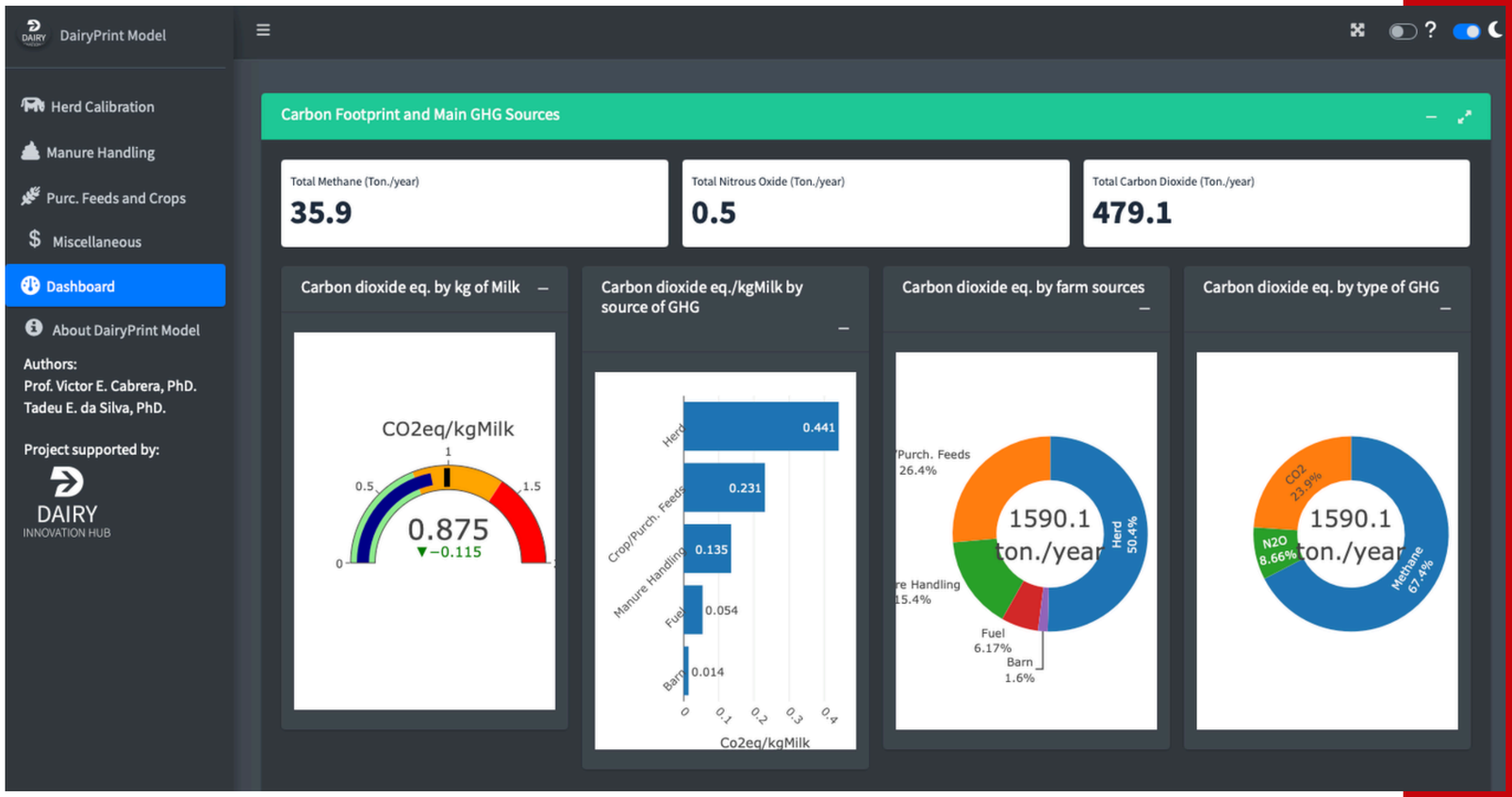




DairyPrint

Environmental assessment

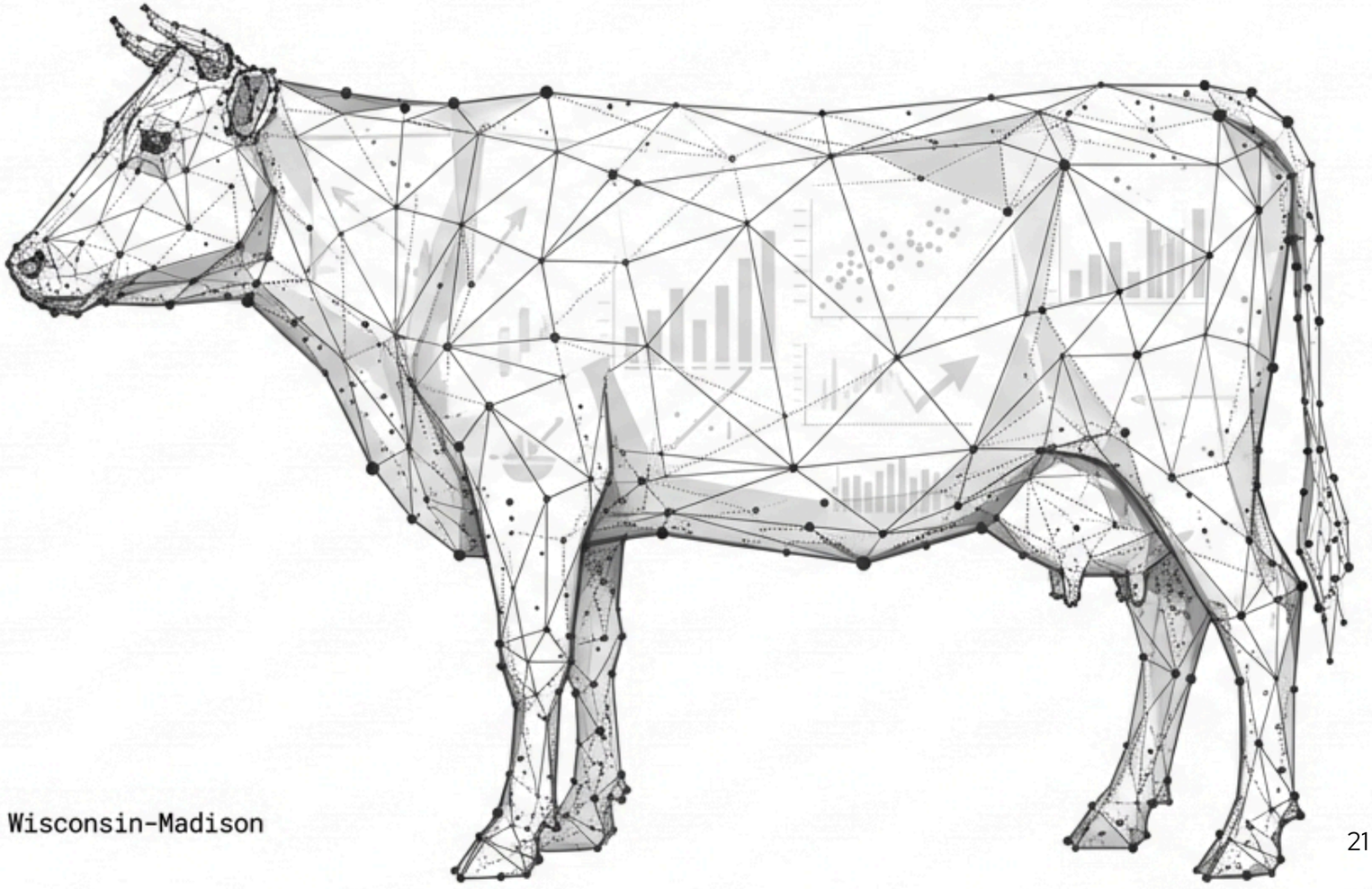
Whole dairy farm simulation model



Da Silva & Cabrera, 2024 JDS

The Economic Value of a Dairy Cow

A Markov Chain Approach to the Replacement Problem



Research by V. E. Cabrera (2012) | University of Wisconsin-Madison
Source: J. Dairy Sci. 95:4683–4698

The Incumbent (Current Cow)

Mature Animal in Production

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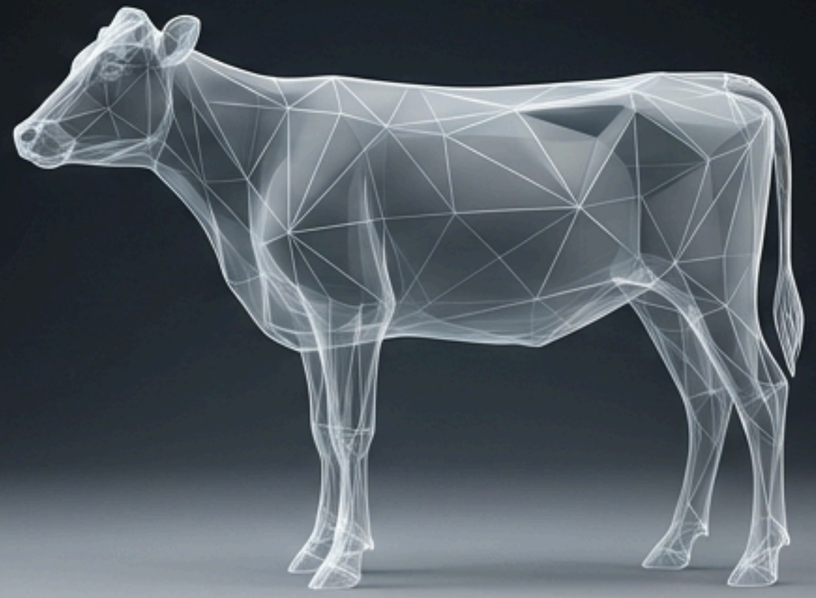
The Challenger (Replacement Heifer)



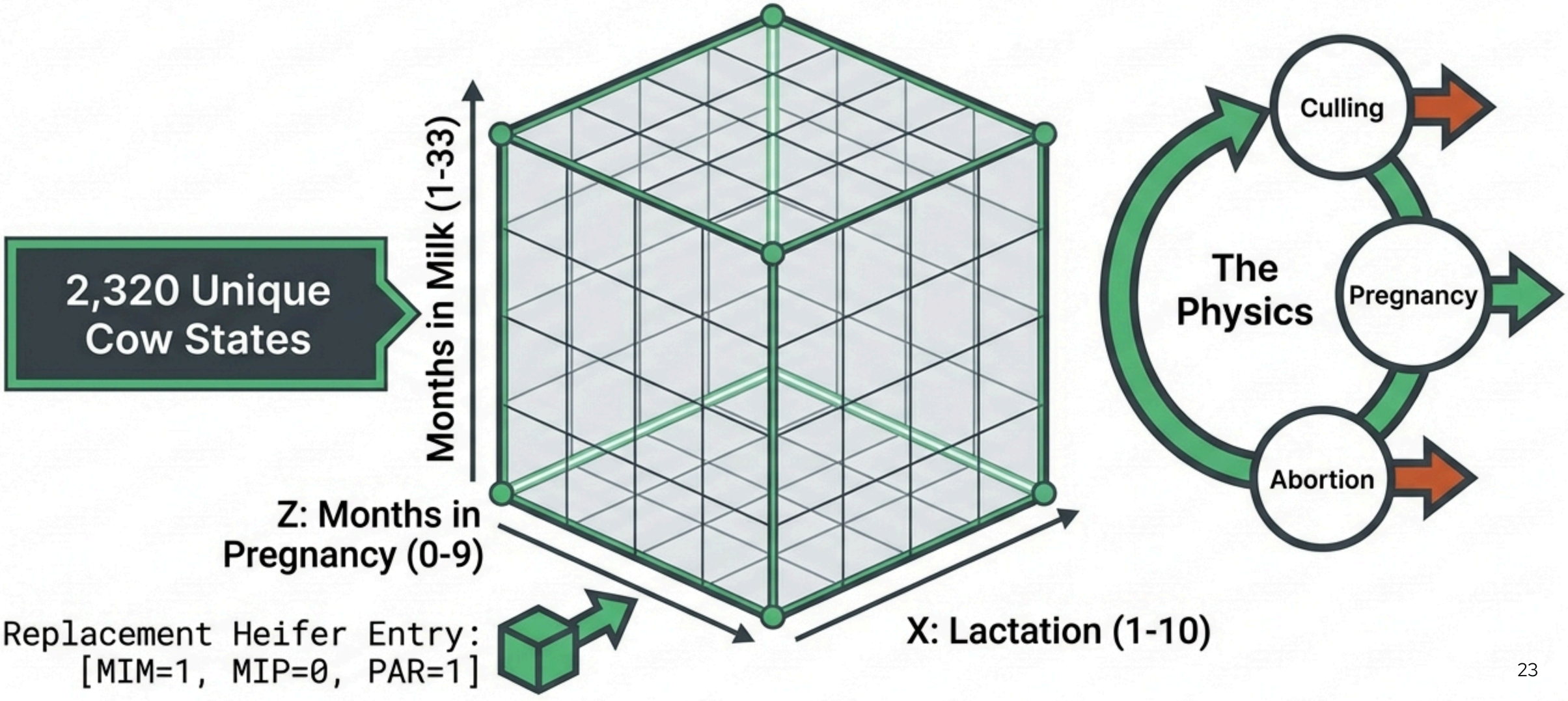
Young Animal Entering Herd

The Core Dilemma: What is the value of a specific animal at this specific moment?

Keep: Future Net Return (Cow) > Future Net Return (Replacement)

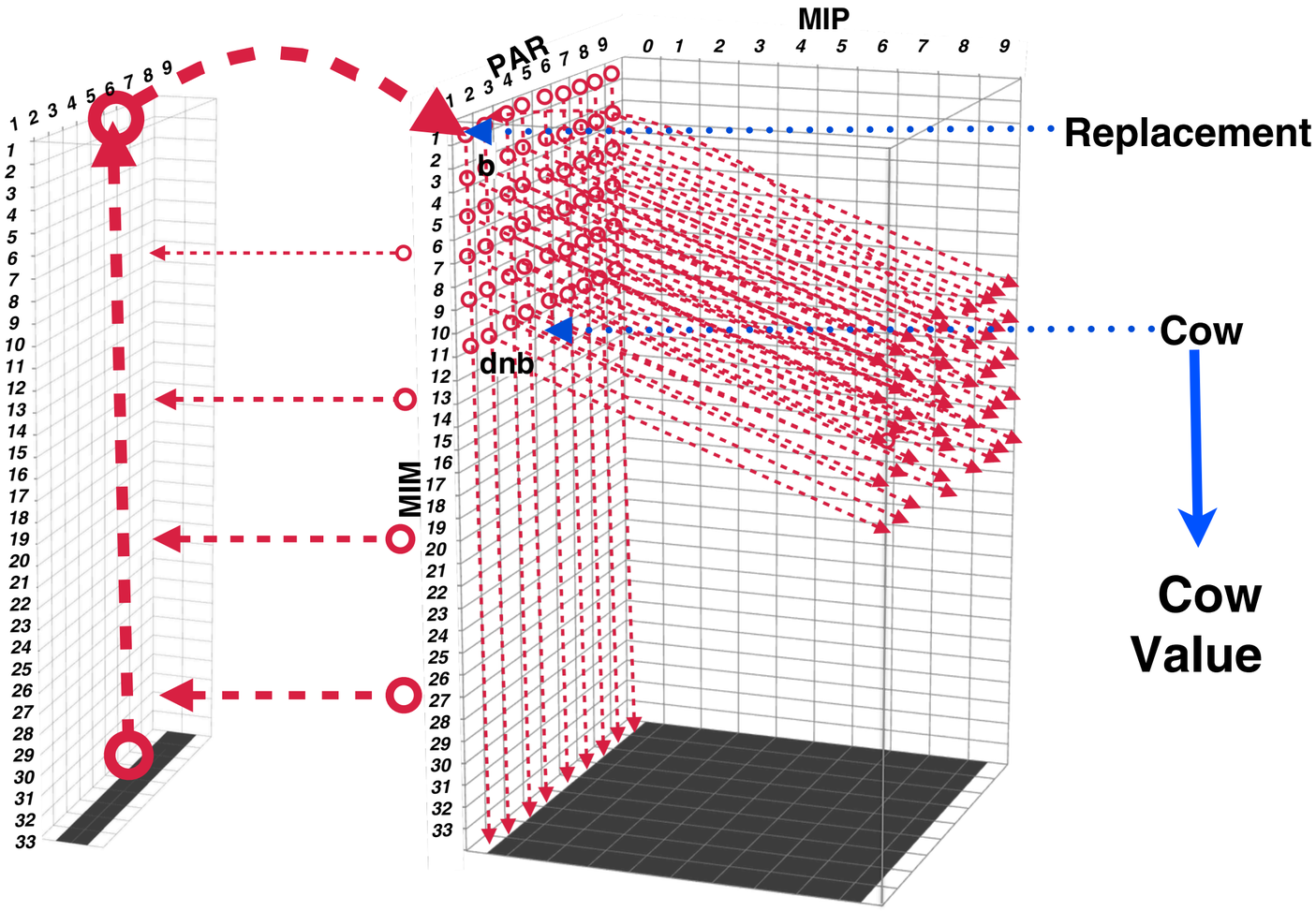
Replace: Future Net Return (Cow) < Future Net Return (Replacement)

The Model Engine: A Probabilistic Matrix



How to calculate the cow value?

Markov chains to simulate herd dynamics



Cabrera, 2012

Defining Cow Value

$$\text{Cow Value} = (NPV_{cow} - NPV_{replacement}) + \underbrace{\text{Transaction Costs}}$$

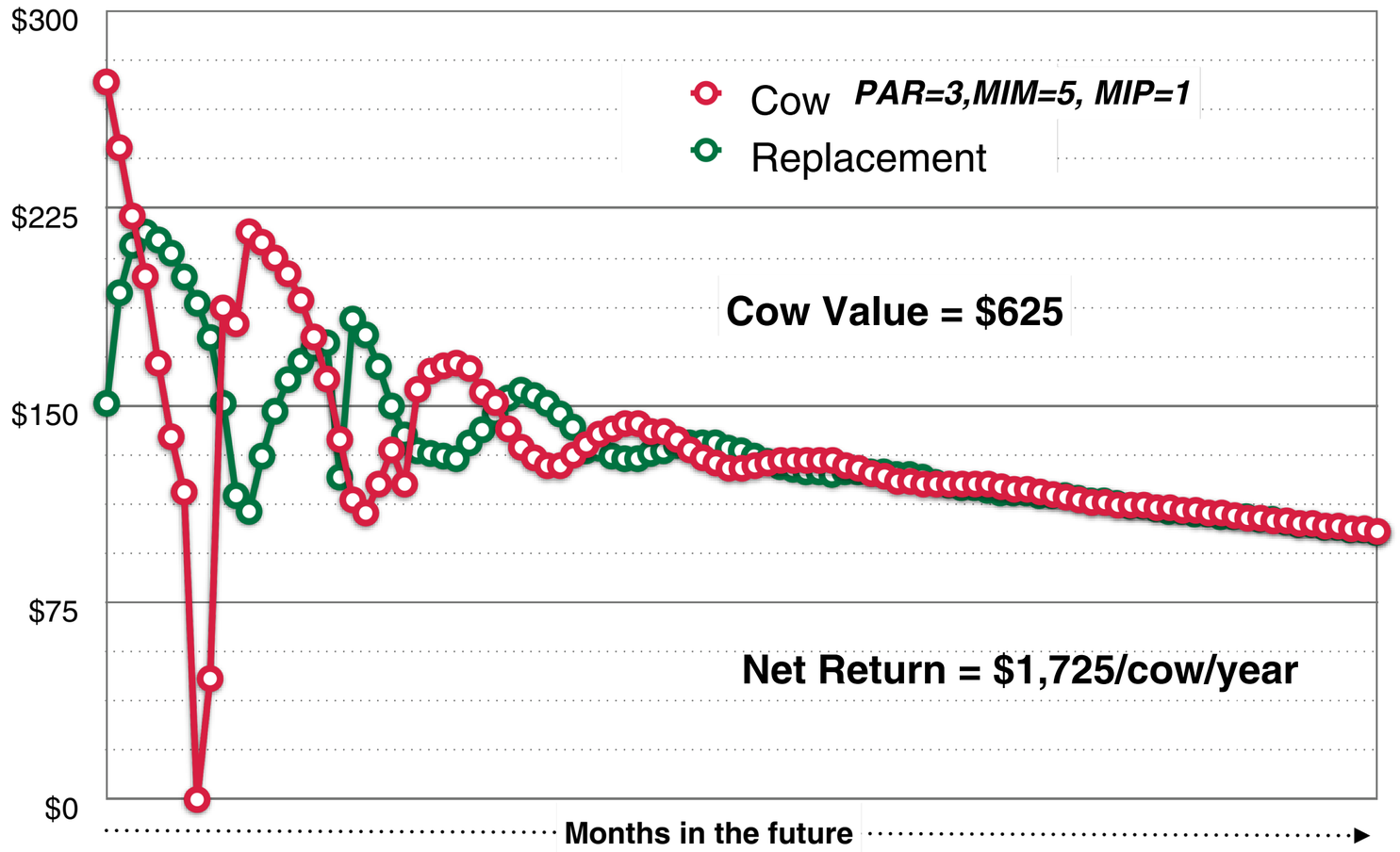
Transaction Costs = (Replacement Cost - Cow Salvage Value - Calf Value)

Interpretation:

- Positive Value (+) = Economic Asset (KEEP)
- Negative Value (-) = Economic Liability (REPLACE)

Economic net return

Expected future net returns



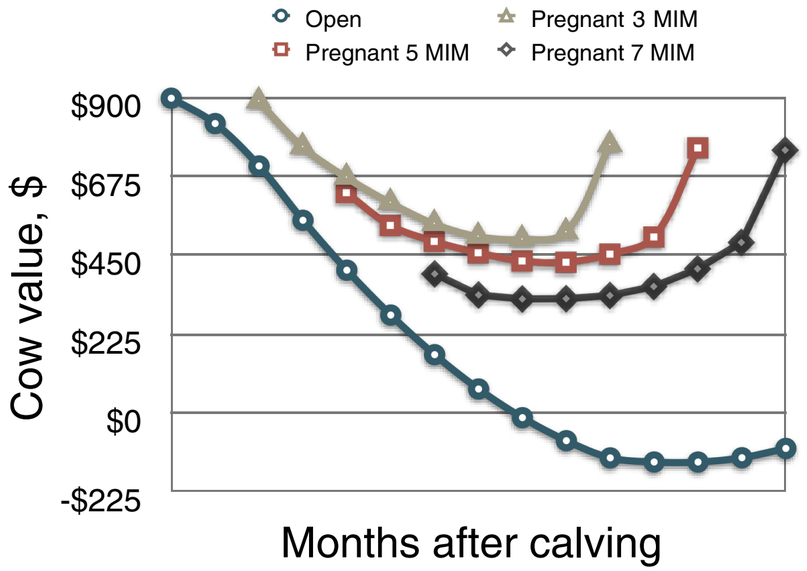
Model illustration

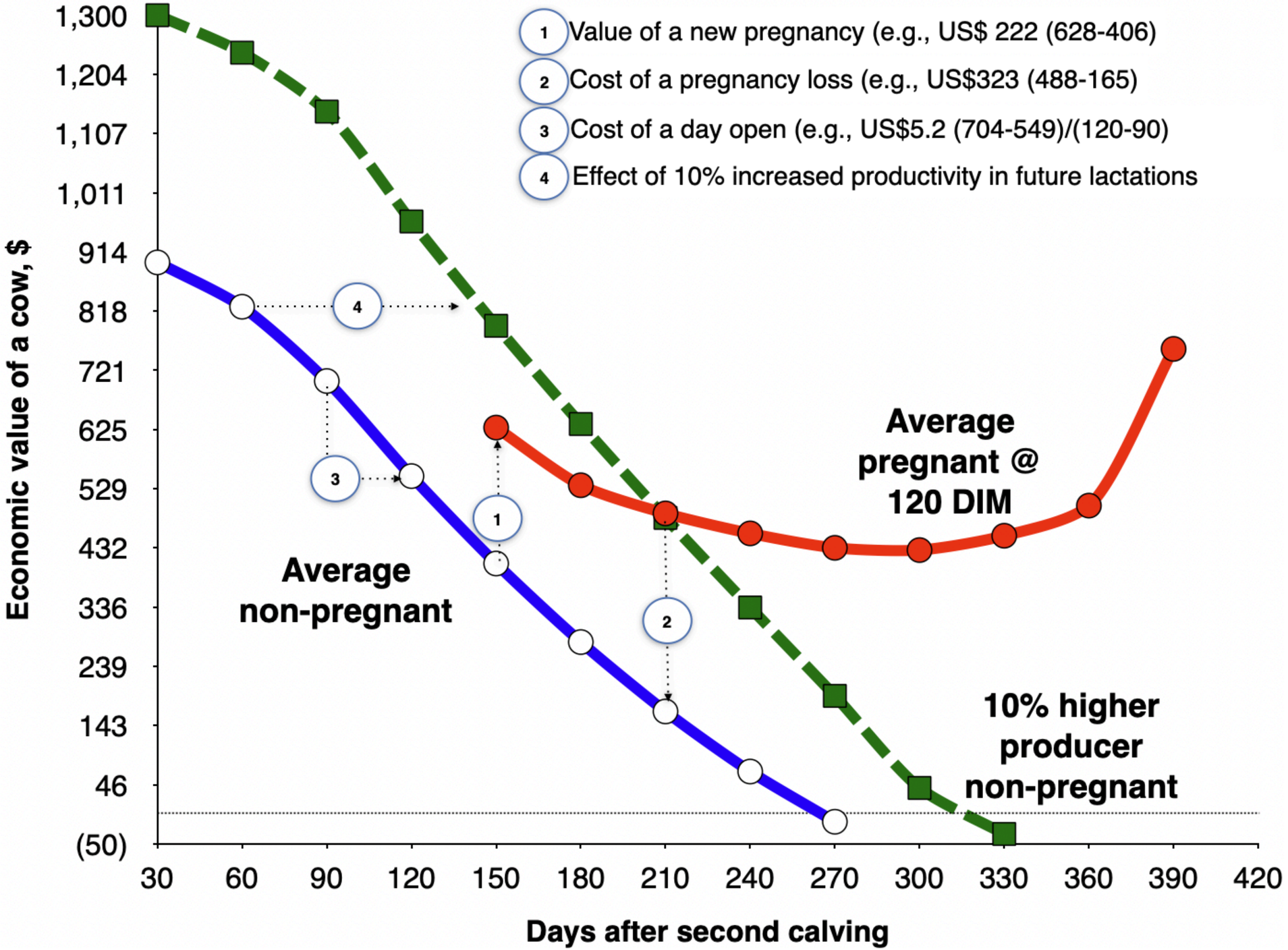
Average cow and replacement

Open cow value
- Decreases
- Becomes negative

Pregnant cow value
- Higher than open
- U-shaped
- Similar value at calving

Overall cow value
- Increases to 3rd or 4 lactation




1 Value of a new pregnancy (e.g., US$ 222 (628-406)
2 Cost of a pregnancy loss (e.g., US$323 (488-165)
3 Cost of a day open (e.g., US$5.2 (704-549)/(120-90)
4 Effect of 10% increased productivity in future lactations
Economic value of a cow, $
1,300
1,204
1,107
1,011
914
818
721
625
529
432
336
239
143
46
(50)
30
60
90
120
150
180
210
240
270
300
330
360
390
420
Days after second calving
Average pregnant @ 120 DIM
Average non-pregnant
10% higher producer non-pregnant

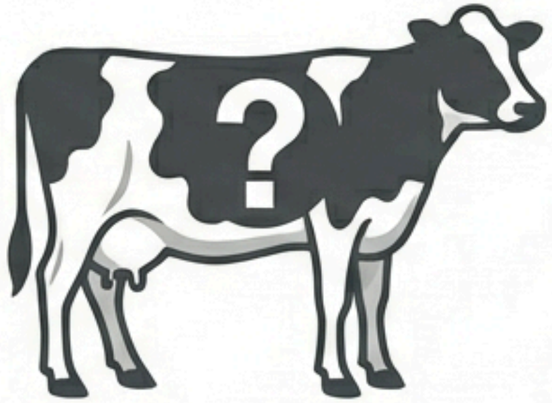
Practical Use Cases.

The Cull List

Cow ID	$ Value
103	-$350
107	-$120
109	-$210
110	-$210
111	$150

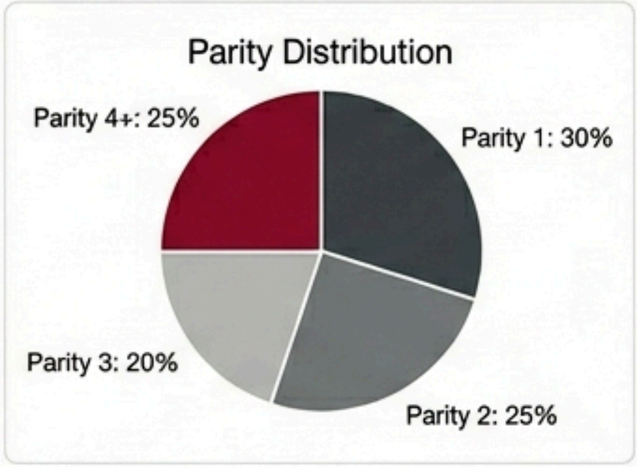
Action: Replace.

Repro Decisions



Action: Breed at Month 10?

Herd Demographics



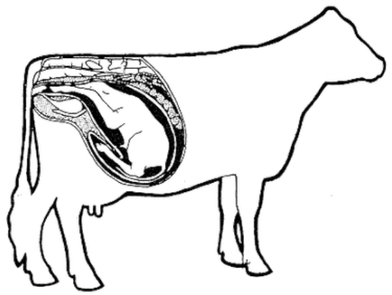
Action: Simulate Policy Impact.

The value of a new pregnancy

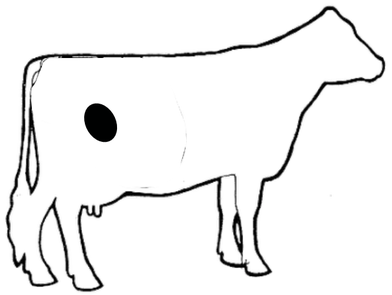
How much more when a cow becomes pregnant?

Difference in cow value:

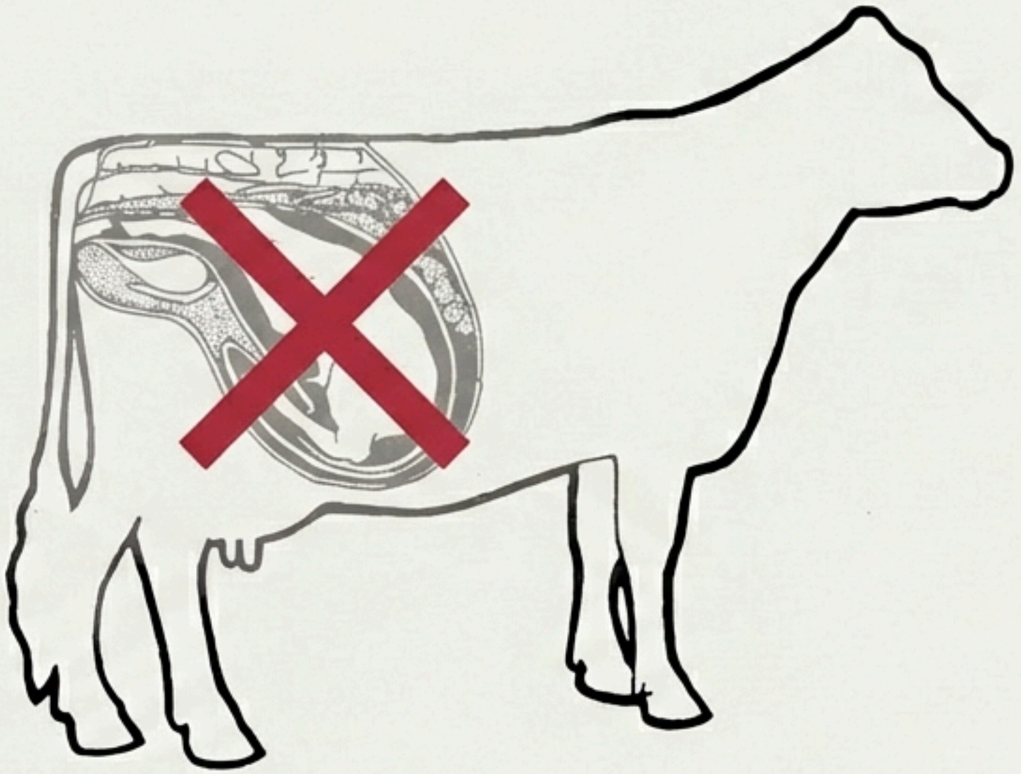
- Cow becoming pregnant
- Cow remaining non-pregnant

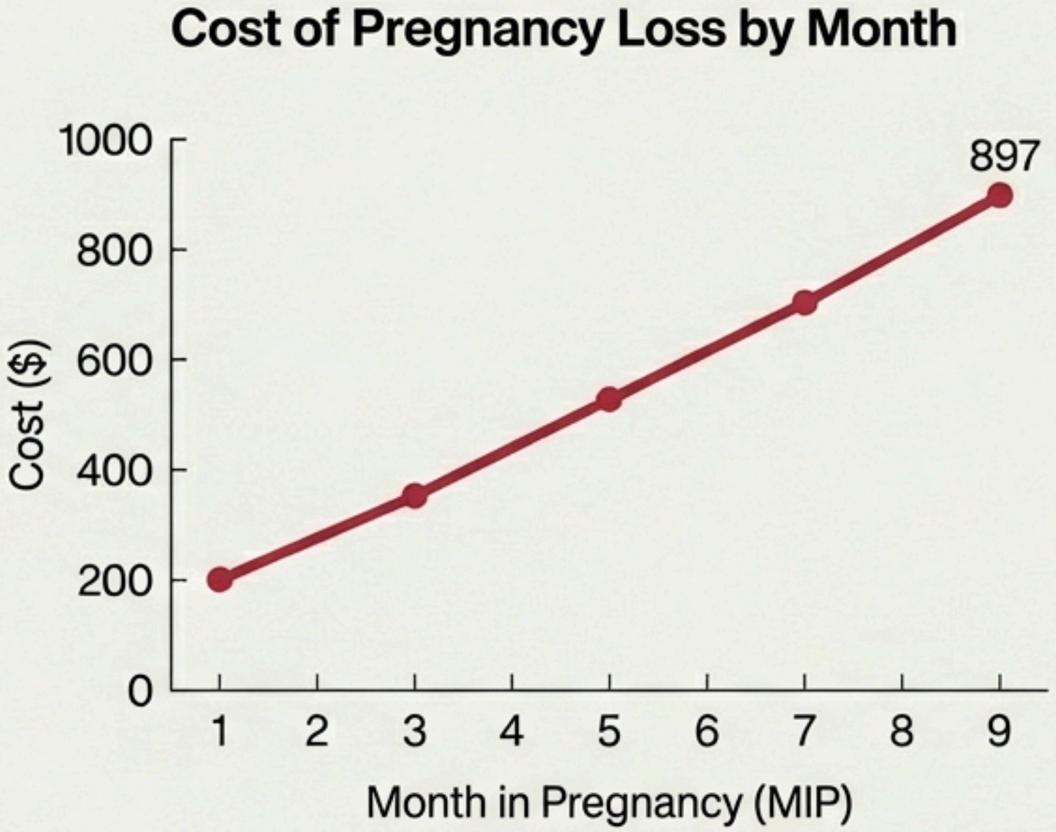


Vs.



Derivative Value 2: The Cost of Pregnancy Loss.





Late losses are most costly due to lost expected milk surge and wasted reproductive investment.

Value of a Cow

Economic Projection

Estimates the long-term net return of a cow and compares it with a potential replacement

Cabrera, 2012: JDS 95:4683

The Economic Value of a Dairy Cow

V.E. Cabrera, UW-Madison Animal and Dairy Sciences

Language: (•) English ( ) Spanish ( ) Czech ( ) Italian ( ) Slovak ( ) Dutch ( ) Chinese ( ) German ( ) Portuguese

Units: (•) US ( ) Metric

Currency: (•) Dollar ( ) British Pound ( ) CZK ( ) Euro ( ) COP ( ) Yuan ( ) Brazilian Real

Overview | Single Cow Analysis | Herd Analysis

INPUTS - Edit Values in This Block

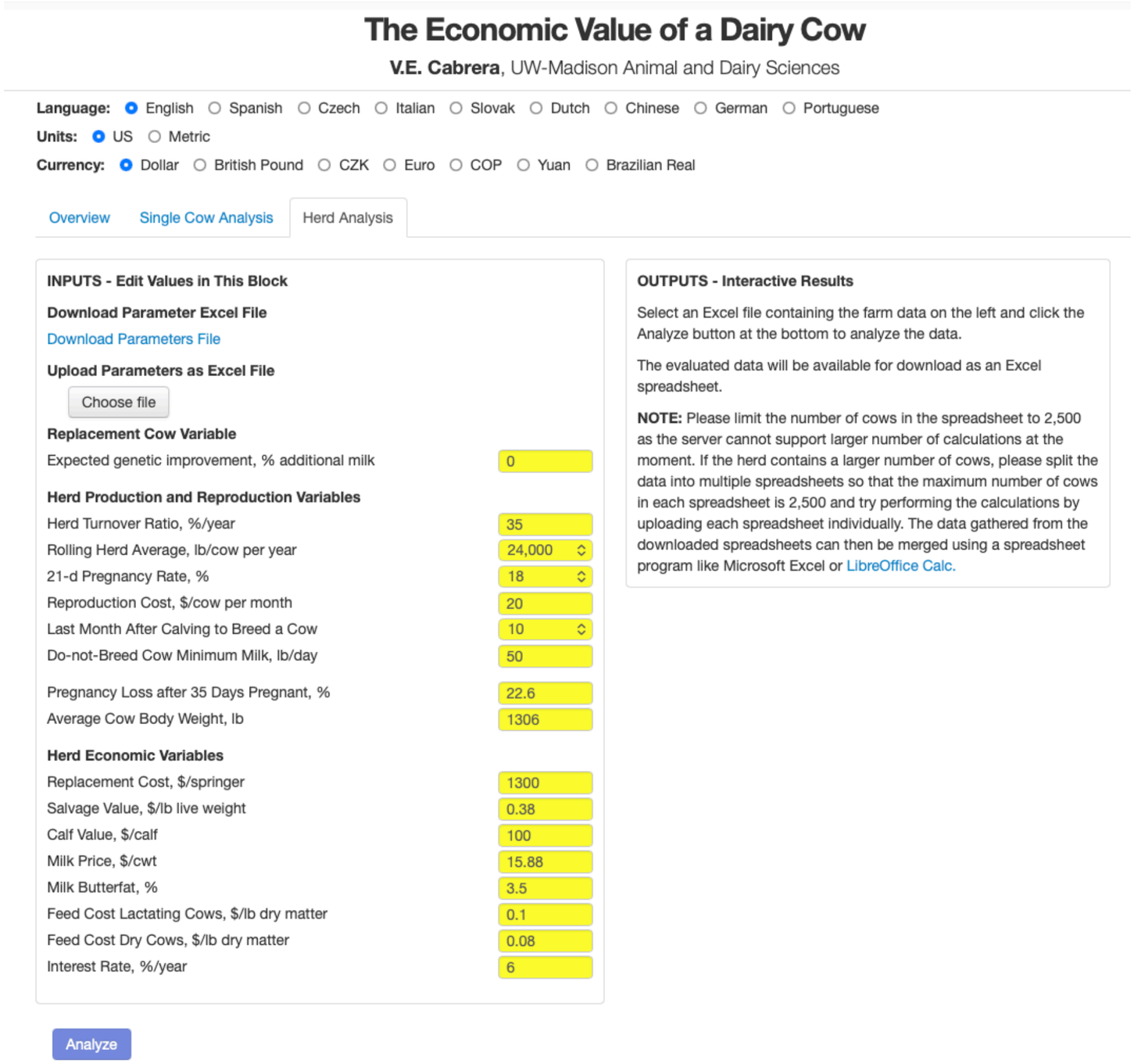
Evaluated Cow Variables	
Current Lactation	3
Current Months after Calving	5
Current Months in Pregnancy	1
Expected Milk Production Rest of Lactation, %	100
Expected Milk Production Next Lactations, %	100
Replacement Cow Variable	
Expected genetic improvement, % additional milk	0
Herd Production and Reproduction Variables	
Herd Turnover Ratio, %/year	35
Rolling Herd Average, lb/cow per year	24,000
21-d Pregnancy Rate, %	18
Reproduction Cost, $/cow per month	20
Last Month After Calving to Breed a Cow	10
Do-not-Breed Cow Minimum Milk, lb/day	50
Pregnancy Loss after 35 Days Pregnant, %	22.6
Average Cow Body Weight, lb	1306
Herd Economic Variables	
Replacement Cost, $/Springer	1300
Salvage Value, $/lb live weight	0.38
Calf Value, $/calf	100
Milk Price, $/cwt	15.88
Milk Butterfat, %	3.5
Feed Cost Lactating Cows, $/lb dry matter	0.1
Feed Cost Dry Cows, $/lb dry matter	0.08
Interest Rate, %/year	6
Evaluated Heifer Variables	
Calf and Heifer Culling Rate, %	7
Current Heifer Conception Rate 1st Service, %	60
Average Service Rate for Heifer, %	75
Average Cost of Rearing a Heifer from born to 24 months, $	2.77

OUTPUTS - Interactive Results

Value of the Cow, $	**627**
Compared Against a Replacement, $	
Milk Sales, $	147
Feed Cost, $	-157
Calf Value, $	26
Non-reproductive Cull, $	-126
Mortality Cost, $	-24
Reproductive Cull, $	12
Reproduction Costs, $	45
Replacement Transaction, $	704
Herd Structure at Steady State	
Days in milk	224
Days to Conception	122
Percent of Pregnant	52
Reproductive Culling, %	8
Mortality, %	3
1st Lactation, %	43
2nd Lactation, %	27
>= 3rd Lactation, %	30
Youngstock Population, % of adult cows	85.67
Average Age at First Calving, days	707.47
Number of Springers Required, % of adult cows	39.66
Number of Springers Produced, % of adult cows	41.89
Number of Female Calves Produced, % of adult cows	47.66
Economics of an Average Cow, $/year	
Net Return, $	1969
Milk Sales, $	3806
Feed Cost for Adult Cows, $	-1522
Calf Sales, $	60
Non-Reprod. Culling Cost, $	-198
Mortality Cost, $	-38
Reproductive Culling Cost, $	-59
Reproductive Cost, $	-80
Total Rearing Cost from Born to Calving, $/heifer	1689

Value of each Cow

Herd Analysis



The economic value of a cow

Calculates the net return of a cow in the long-run: Cow Value

Calculates the net return of an average cow: $/cow/yr

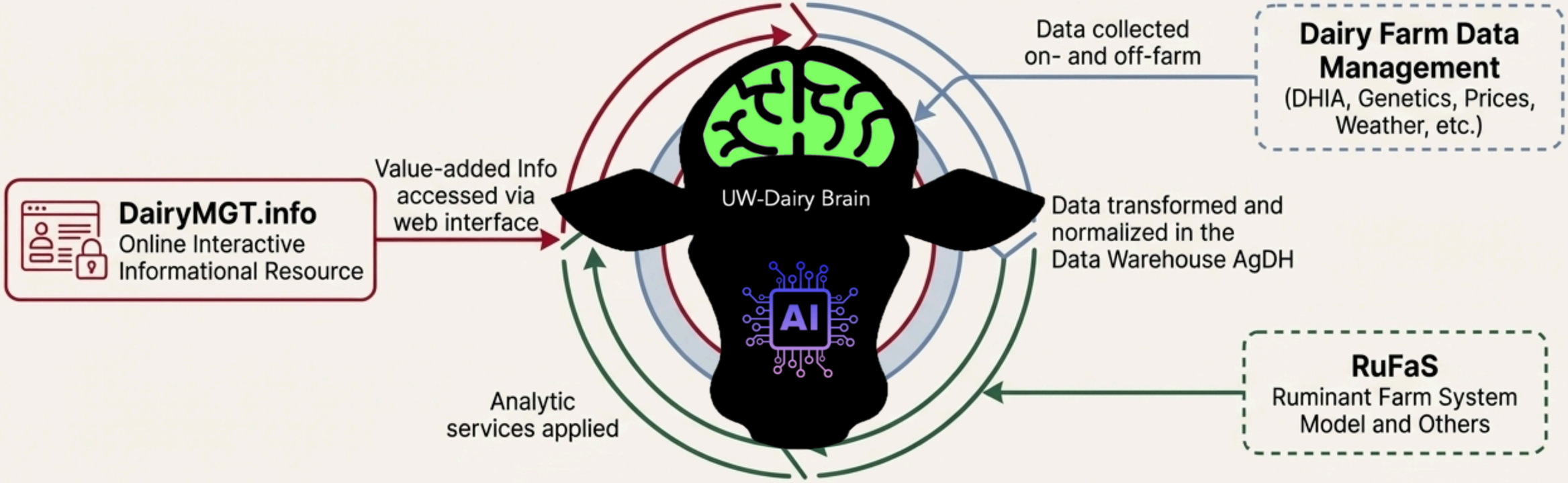
INPUTS - Edit Values in This Block	
Evaluated Cow Variables	
Current Lactation	3
Current Months after Calving	5
Expected Milk Production Rest of Lactation, %	100
Expected Milk Production Next Lactations, %	100
Expected genetic improvement, % additional milk	0
Herd Production and Reproduction Variables	
Herd Turnover Ratio, %/year	35
Rolling Herd Average, kg/cow per year	10890
21-d Pregnancy Rate, %	18
Reproduction Cost, €/cow per month	18.20
Last Month After Calving to Breed a Cow	10
Do-not-Breed Cow Minimum Milk, kg/day	22.68
Pregnancy Loss after 35 Days Pregnant, %	22.6
Average Cow Body Weight, kg	592.39
Salvage Value, €/kg live weight	0.76
Milk Butterfat, %	3.5
Feed Cost Lactating Cows, €/kg dry matter	0.20
Feed Cost Dry Cows, €/kg dry matter	0.16
Interest Rate, %/year	6

OUTPUTS - Interactive Results	
Value of the Cow, €	571
Compared Against a Replacement, €	
Milk Sales, €	134
Calf Value, €	24
Non-reproductive Cull, €	-115
Reproduction Costs, €	-22
Replacement Transaction, €	11
Herd Structure at Steady State	41
Days in milk	641
Days to Conception	224
Percent of Pregnant	122
Reproductive Culling, %	52
Mortality, %	8
1st Lactation, %	3
2nd Lactation, %	43
Net Return, €	27
Milk Sales, €	1807
Calf Sales, €	3478
Non-Reprod. Culling Cost, €	-1385
Mortality Cost, €	55
Reproductive Culling Cost, €	-180
Reproductive Cost, €	-35
	-54
	-73

Cabrera 2012 (JDS 95:4683-4698)

The Future is Integrated: The UW-Dairy Brain Project

The next leap in dairy management is moving from standalone tools to a fully integrated, continuously learning ecosystem.

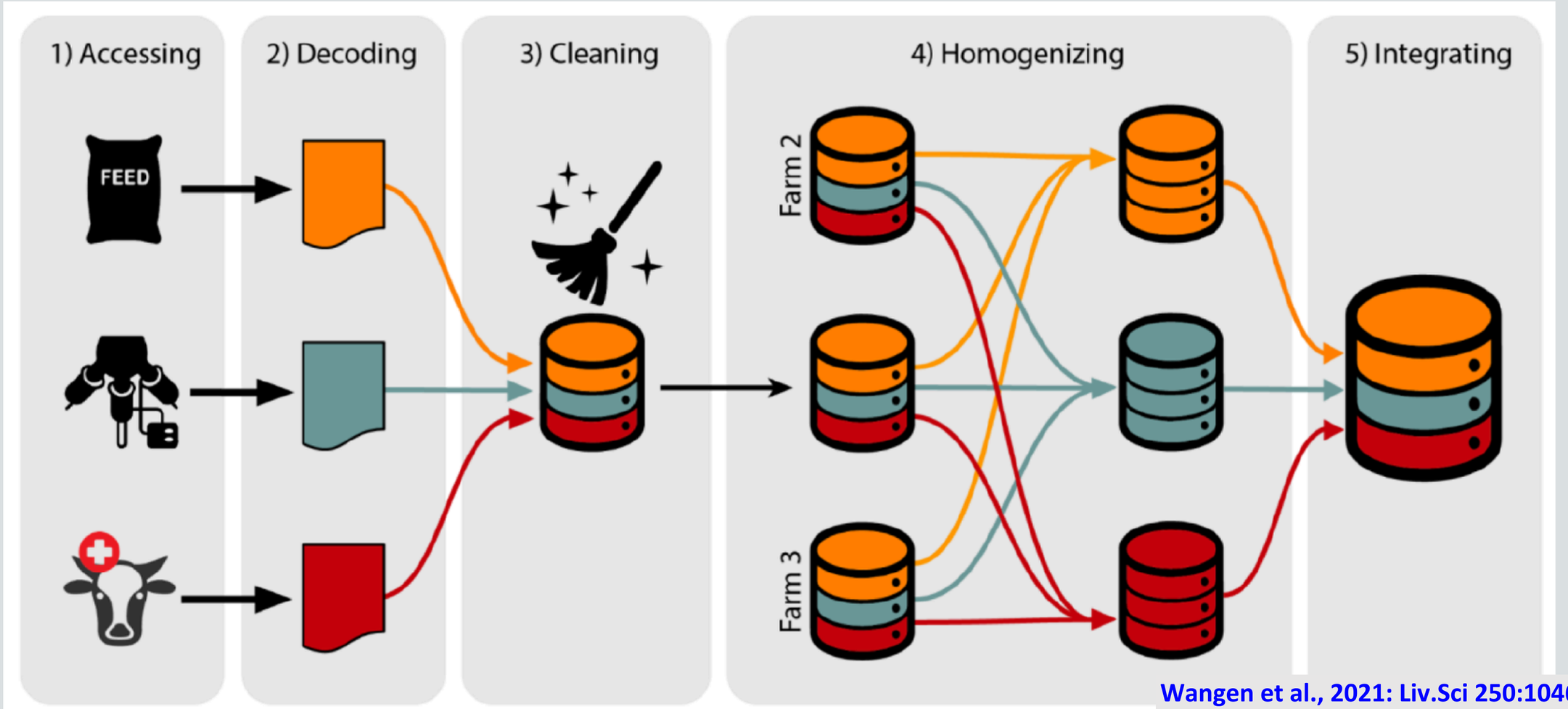


- **Collecting & Harmonizing Data**: Automatically pulling data from all on-farm and off-farm sources into a central, secure data hub.
- **Applying Advanced Analytics:** Using AI and machine learning to uncover deep insights and predictive patterns.
- **Delivering Value-Added Info:** Powering a new generation of real-time tools that provide alerts, forecasts, and prescriptive advice directly through the DairyMGT.info interface.

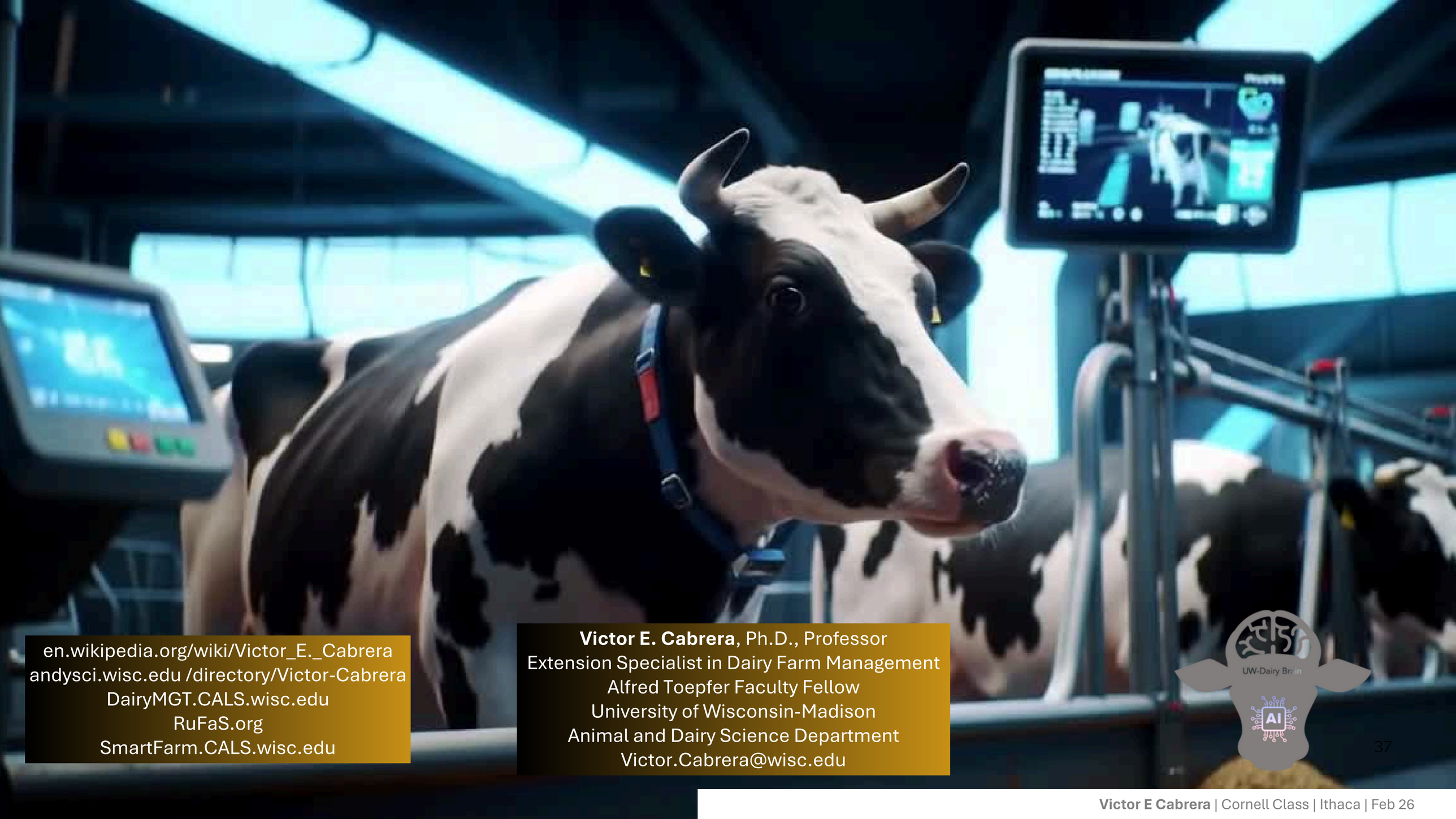
This is the vision: a virtual brain for your dairy farm.

Cabrera et al., 2020: JDS 103:3856

Data integration



Wangen et al., 2021: Liv.Sci 250:104602



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