Principles of Dairy Herd Management
Economic Evaluation

V.E. Cabrera

University of Wisconsin-Madison Dairy Science

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Outline

120 minutes

Principles of dairy herd management
Economic decision-making

Applications
Practical usage

Understanding basic methodologies
Economic models, simulation, optimization

Demonstration
Existing applications

Dairy farm economic management

Principles of dairy farm management

Making and implementing decisions
Maximum (production) profit

Decisions at different levels
Different planning horizons
Cow, farm,region

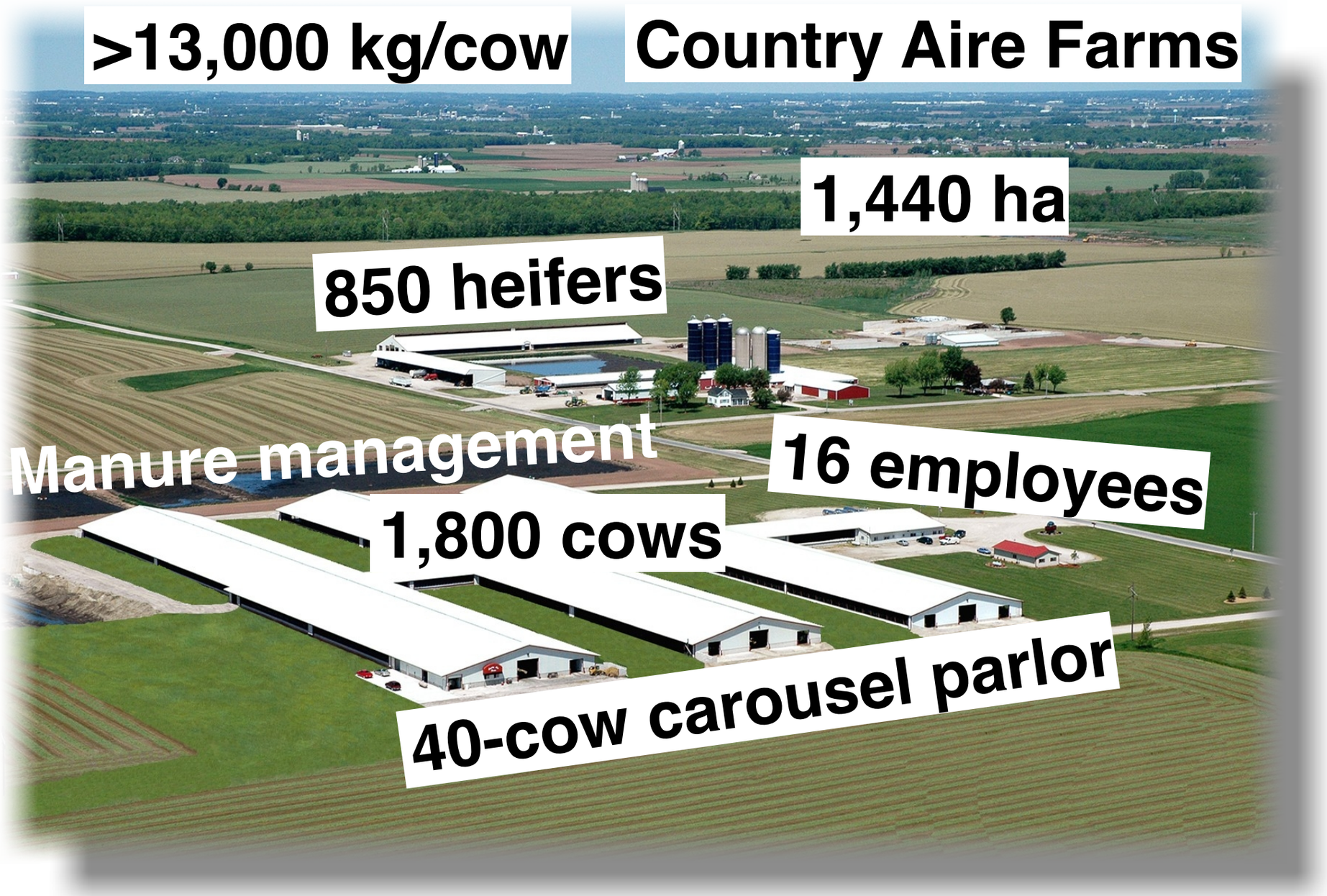
Relies on agricultural economics
Subject to multiple restrictions

Integrates various disciplines
Biology, physiology, economics, crops, ...

Dairy farm economic management

Principles of dairy farm management

Farm is unit of concern

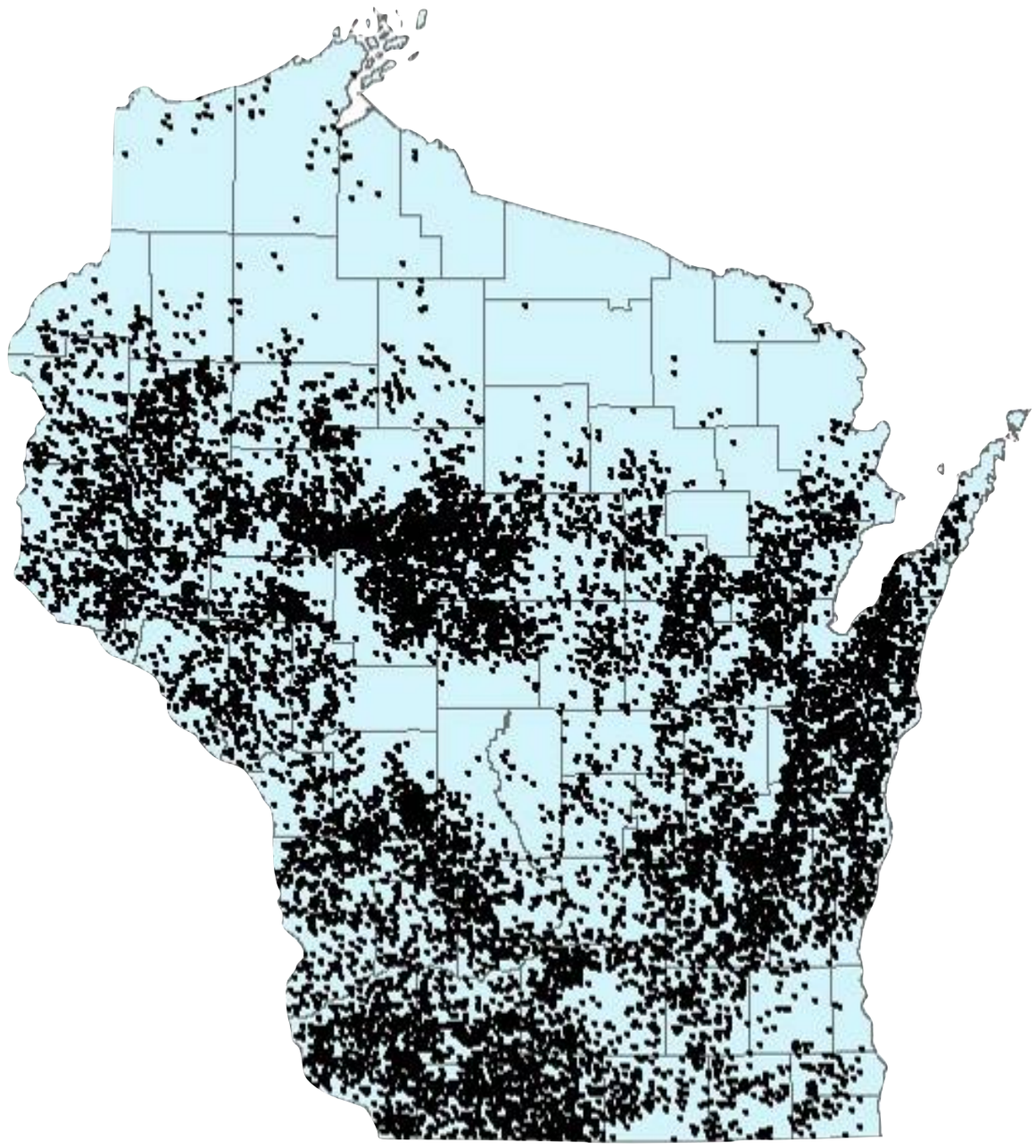


Dairy farm economic management

Principles of dairy farm management

Wisconsin

11,000 dairy farms

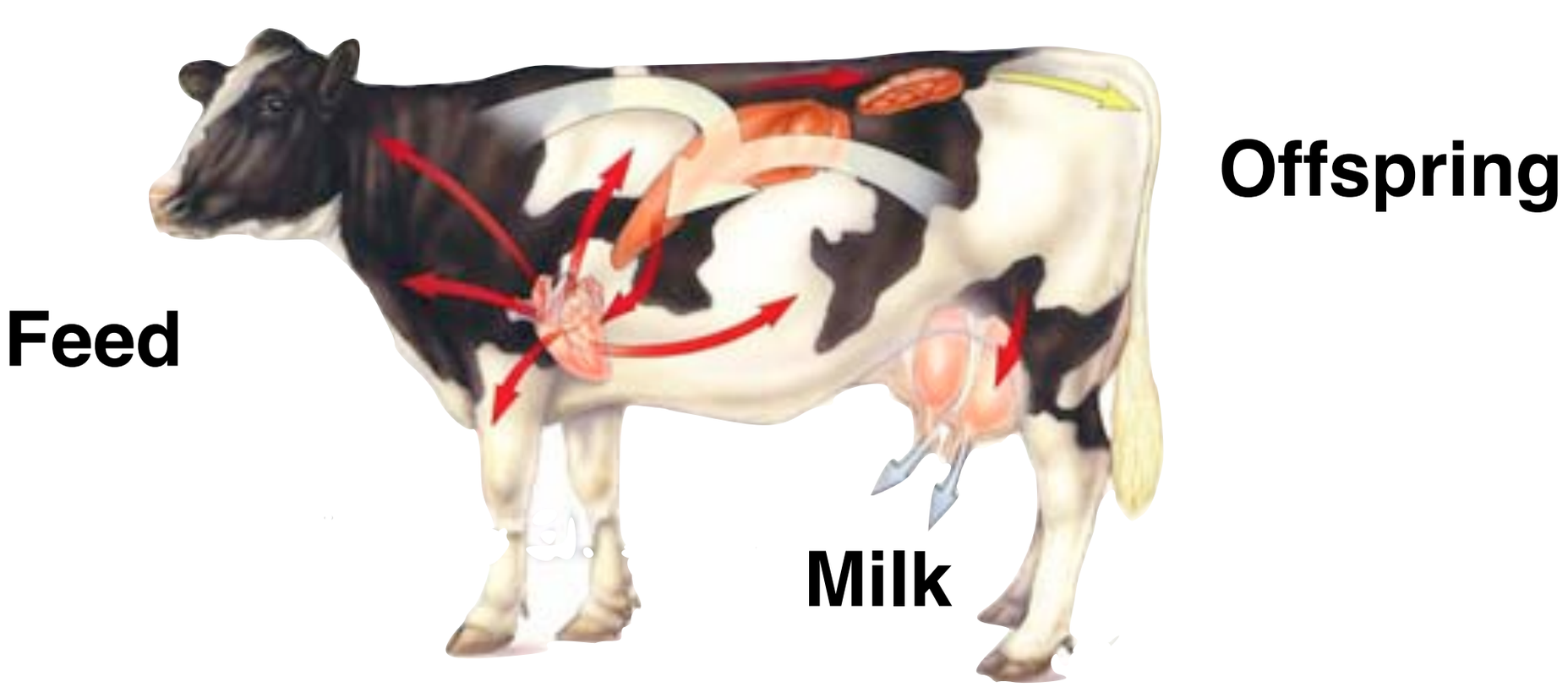


Dairy farm economic management

Principles of dairy farm management

Dairy cow

A complex system

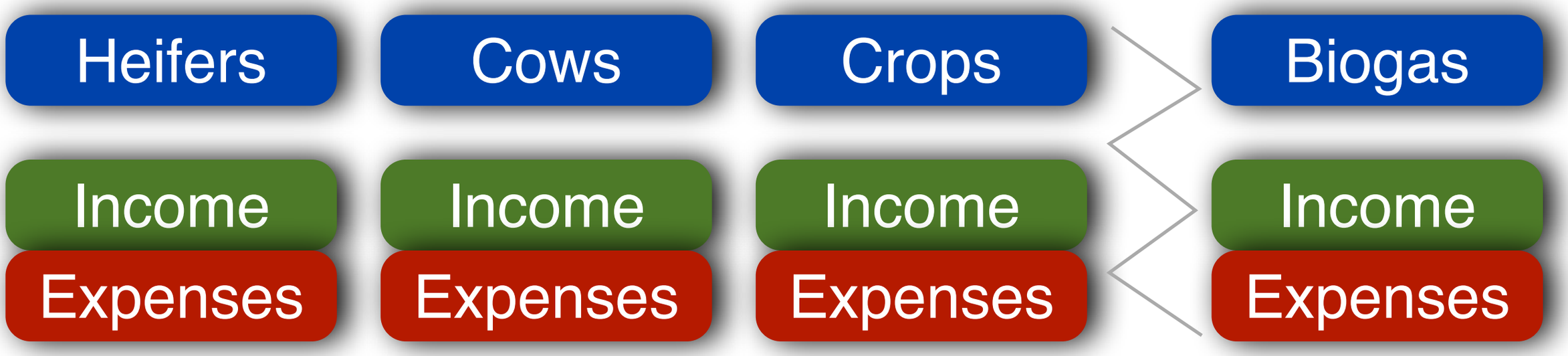


The dairy management cycle

Planning and analyzing outcomes

Enterprise budgets

Enterprises inside a dairy farm



Total gross margin

Total fixed costs

Net profit of a dairy farm

Partial budgeting

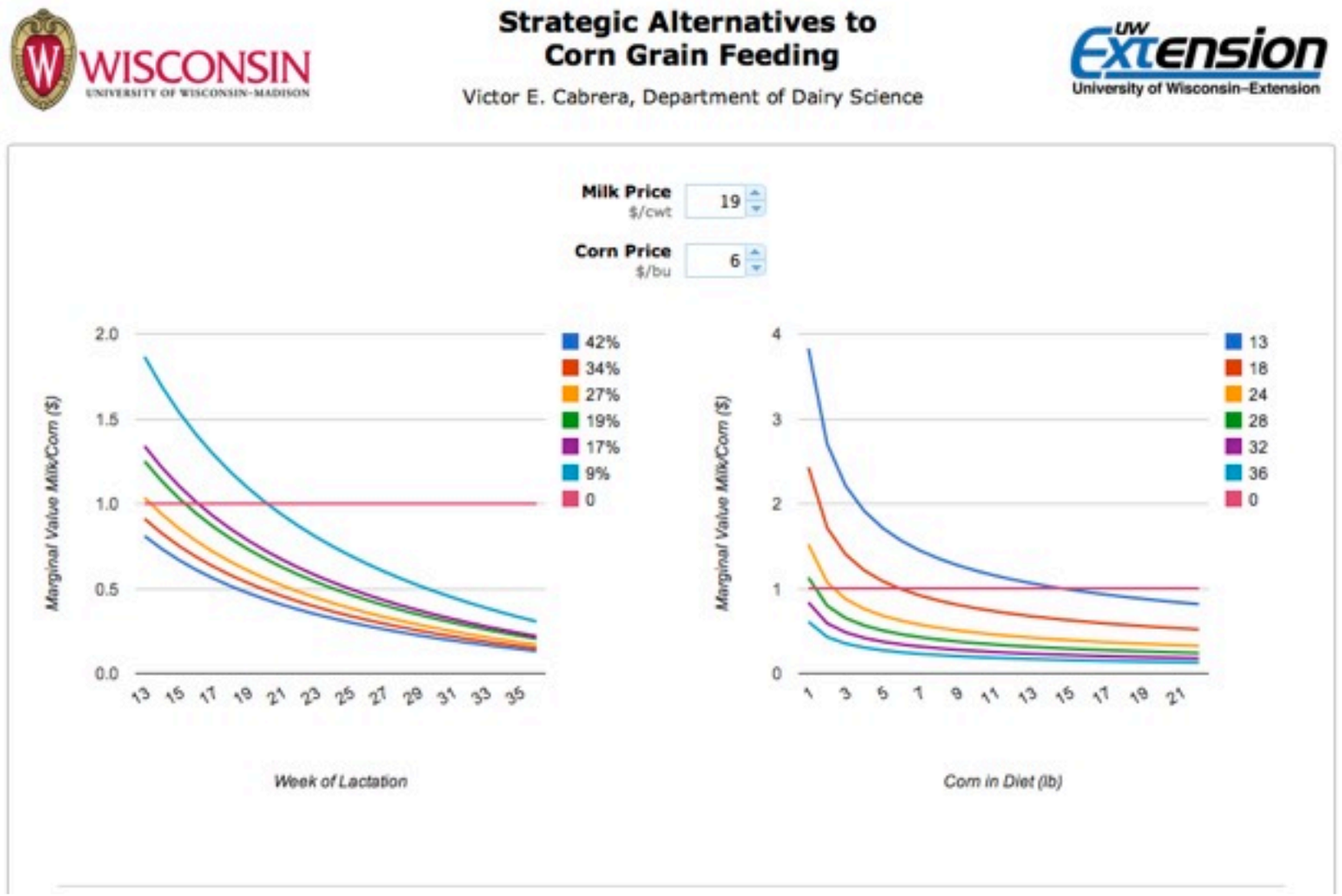
Effective when looking at one component

+ Additional Returns

+ Reduced Costs

− Returns Foregone

− Additional Costs



Cost-Benefit analysis

Useful for possible new investments

Costs & Benefits

Discount rate (β)

$$PV = FV \div (1 + \beta/100)^n$$

Decision Criterion

- NPV — Net present value
- C/B — Cost-benefit
- IRR — Internal rate of return

Cost-Benefit analysis

An example

Year	Strategy A		Strategy B	
	Costs	Benefits	Costs	Benefits
1	20	0	2	1
2	10	8	2	3
3	7	14	4	6
4	0	23	6	14

β	5%

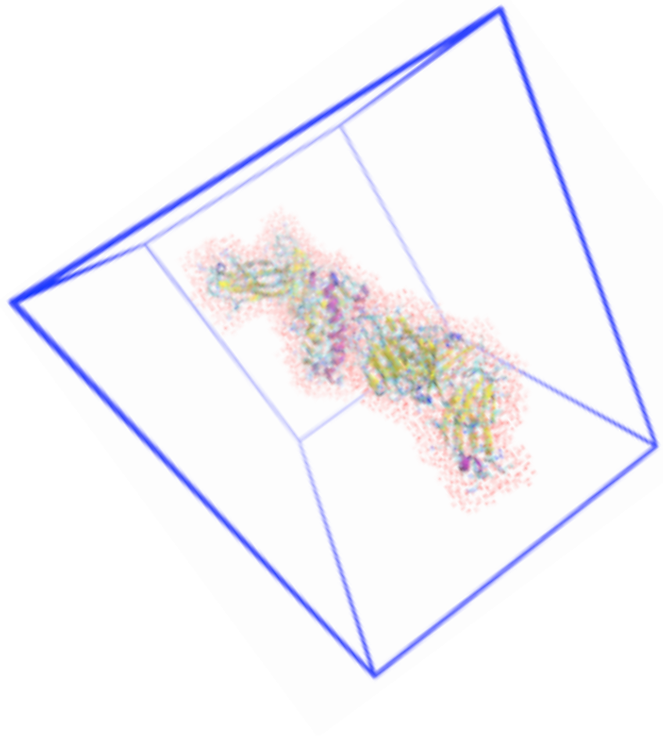
Present value

PV	

NPV	
C/B	
IRR	

Decision analysis

Include uncertainties



Mathematical techniques
Maximum (production) profit

Process diagrams
Maximum (production) profit

Payoff matrices
Maximum (production) profit

Decision trees
Maximum (production) profit

Mathematical techniques

Specific algorithms

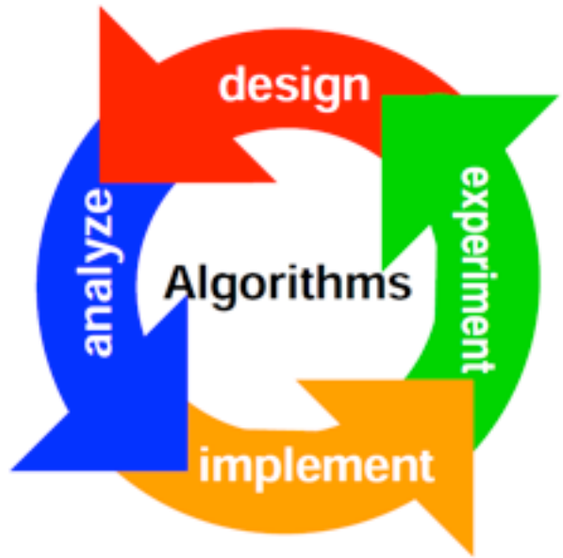
$A_i = f(A_i, S_1 \ldots S_j, P_1 \ldots P_j, V_{i1} \ldots V_{ij})$

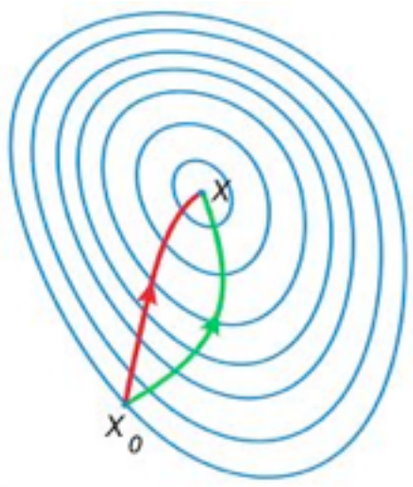
A_i=Decision option A_i(action)

S_j=State of nature

P_j=Probability of occurrence S_j

V_{ij}=Value option $_i$ for state $_j$





Max EMV (A_i) = Max $\sum_j(P_jV_{ij})$

EMV=Expected monetary value

Maximum of weighted average of all probabilities of occurrence and their respective values

Mathematical techniques

An example

Reproductive programs

Programs		Outcomes	Probabilities	Values
A_1	Current		0.16, 0.84	$631, $409
A_2	Alternative		0.25, 0.75	

EMV (A_1)=	0.16 x $631 + 0.84 x $409	**$444.5**
EMV (A_2)=	0.25 x $631 + 0.75 x $409	**$464.5**

Conclusion

Alternative program brings **$20/cow** extra net return

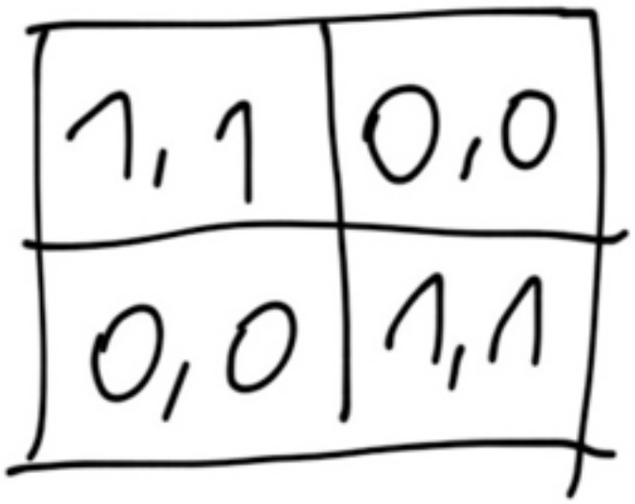
Giordano et al. (2011)

Payoff matrices

Tabular data representation

Decision actions

Multiple results



Probabilistic outcomes

Uncertain possibilities

State of nature	Value of outcome	Probability
S_j	A_{ij}	P_j

Payoff matrices

An example

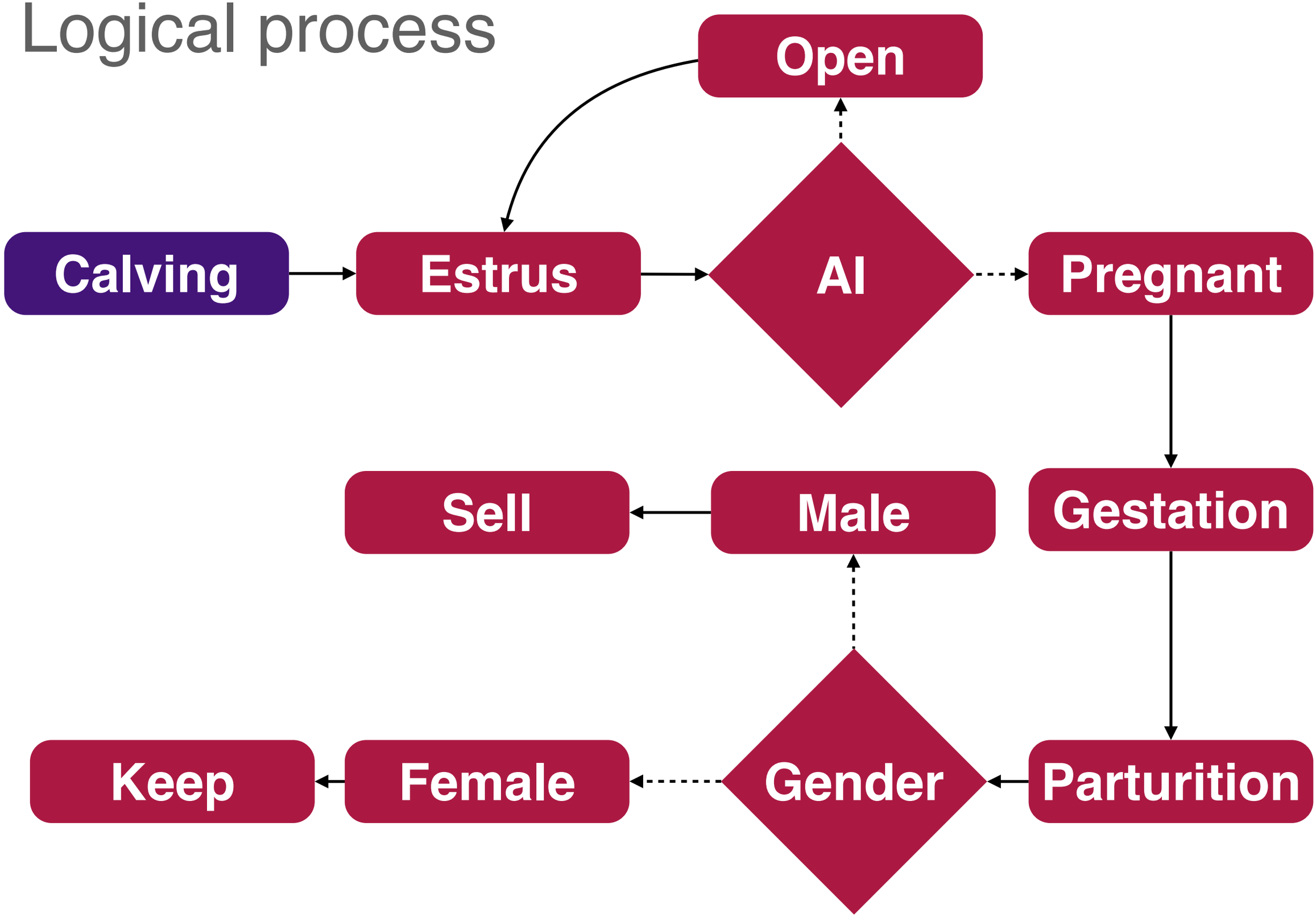
			Milk price ($/cwt)				
			14	15	17	19	20
		P_j	0.1	0.1	0.1	0.4	0.3
Corn price ($/bu)	6.1	0.1	741	1081	1421	1761	2101
	6.8	0.1	661	1001	1341	1681	2021
	7.6	0.2	581	921	1261	1601	1941
	8.3	0.3	501	841	1181	1521	1861
	9.1	0.3	421	761	1101	1441	1781

Conclusion

Return to labor =
$**1,451**/cow per year

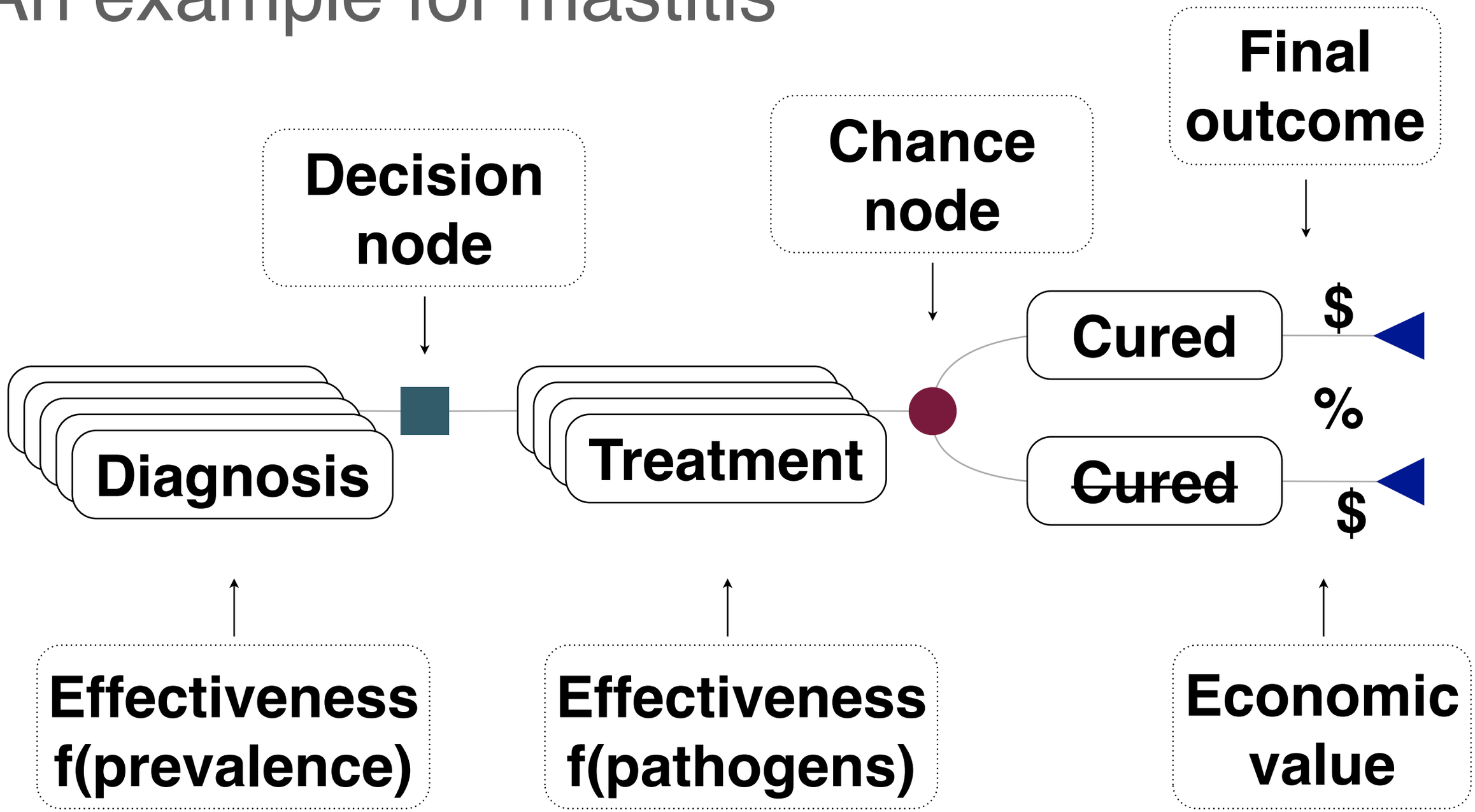
Process diagrams

Logical process



Decision trees

An example for mastitis



Pinzón-Sánchez et al. (2011)

Simulation of dairy farm systems

Whole or part of the system

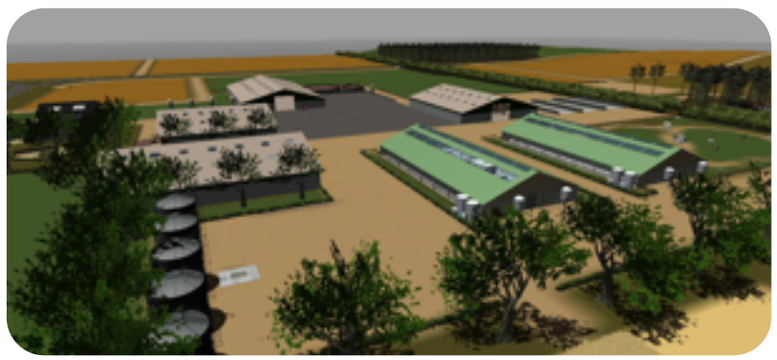
Essential for informed **decision-making**

Detect need or lack of **science-based knowledge**

Useful to describe **interrelated system parts**

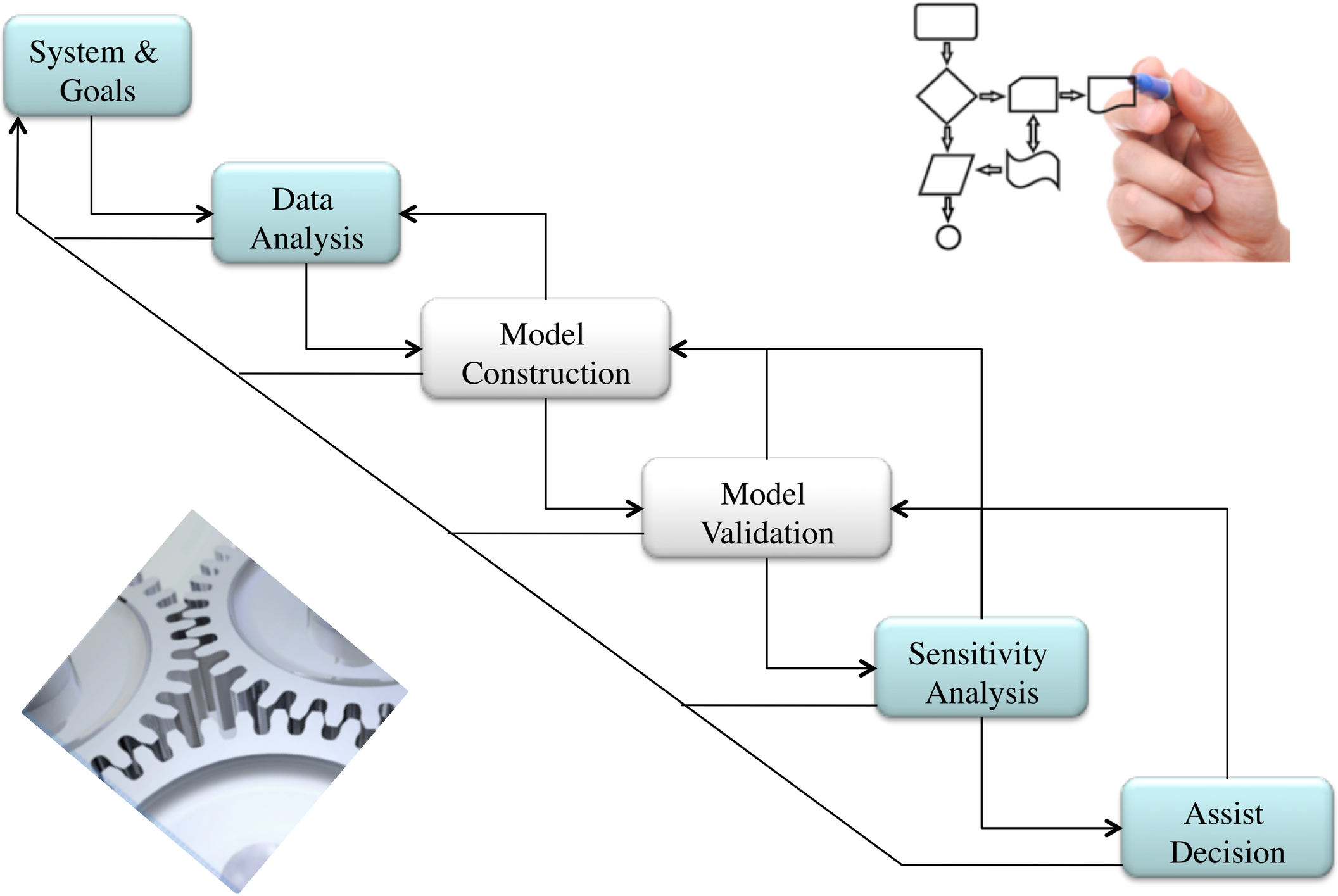
Assist management **control of dairy farm systems**

Basis for assessing & assimilating **available information**



Simulation of dairy farm systems

The process



Simulation techniques

Dairy farm systems

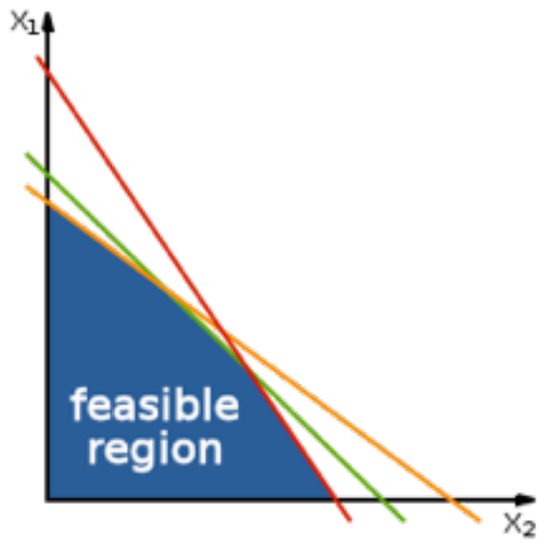
	Static	Dynamic	Deterministic	Probabilistic	Random	Simulation	Optimization
Gross margin	☑		☑			☑	
Partial budgeting	☑		☑			☑	
Cost-benefit		☑	☑				
Linear programming	☑		☑				☑
Dynamic programming		☑		☑			☑
Markov-chain		☑		☑		☑	
Monte-Carlo		☑			☑	☑	

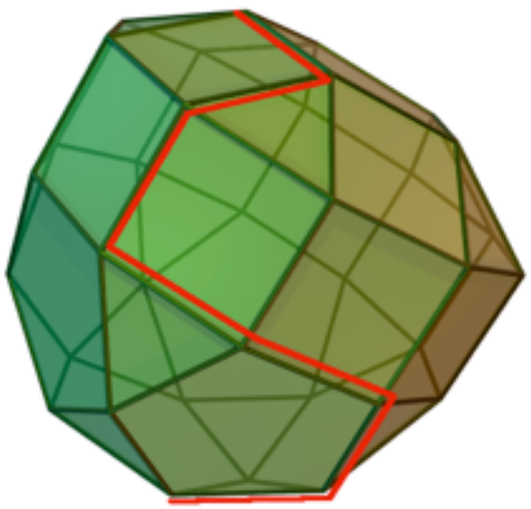
Linear programming

Optimize objective function

Principles

- Function to optimize
- Limited resources
- Several ways to use





Elements

- Objective function
- Constraints
- Solving algorithm
- Feasible solution

Linear programming

An example

Problem

- Maximize IOFSC = *Max*(Milk Value - Feed Cost)
- Limited resources = Corn, SBM, RUP, RDP

		Upper limit	
	$/T	kg/cow/d	%
Milk	396	-	-
Corn	228	7.7	-
SBM	363	11.0	-
RUP	-	-	6.5
RDP	-	-	12.0

Linear programming

An example

Milk Value

Milk production x Milk price

Feed Cost

Feed used x Feed prices

Milk production

f (RUP, RDP)

Linear programming

An application = IOFSC

3	Set Source of Energy Supplements and Prices	Price ($/bu)	Current Diet (lb)	Upper Limit (lb)	Optimal (lb)
3.1	27-Corn-CGG	6	16	17	16.66
3.2	8-Barley-BGR	4.8		0	0.00
3.3	116-Wheat-WGR	7.4		0	0.00

4	Set the Source of Protein, Byproduct Supplements and Prices	Price ($/ton)	Current Diet (lb)	Upper Limit (lb)	Optimal (lb)
4.1	106-Soybean Meal-SBM	330.00	5	6	5.17
4.2	25-Corn Gluten Meal-CGM	550.00		0	0.00
4.3	24-Corn Gluten Feed-CGF	160.00		0	0.00
4.4	23-Corn Distiller Grains-CDG	140.00		5	5.00
4.5	109-Soybean Whole Roasted- HSB	318.00		0	0.00
4.6	104-Soybean Meal Expellers-SBMx	402.00		0	0.00
4.7	14-Blood Meal Ring Dried-BMRD	900.00		0	0.00
4.8	Urea	635.00		0	0.00

5	Set the Upper Limits for RUP and RDP, and Milk Price				Upper Limit	Amount in Diet
5.1	RUP	Rumen Undegradable Protein		% of Diet DM	6.50%	6.16%
5.2	RDP	Rumen Degradable Protein		% of Diet DM	12.00%	12.00%
5.3	CP	Crude Protein		% of Diet DM	18.50%	18.17%
5.4	Milk Price		$/cwt 18			

6	Perform Optimization, Maximize IOFSC		Current	Optimal
6.1	Click the button to maximize the Income Over Feed Supplement Cost (IOFSC)	→ Maximize IOFSC		
6.2	Expected Milk Producion (E-MP)	lb/cow/day	81.00	82.46
6.3	Maximum Income Over Feed Supplement Cost (IOFSC)	$/cow/day	11.69	11.86

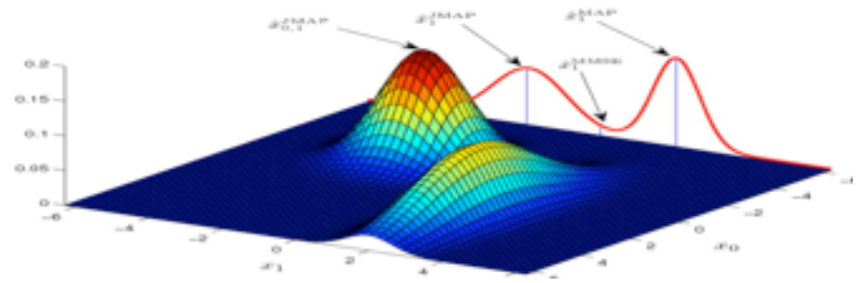
Cabrera et al. (2009)

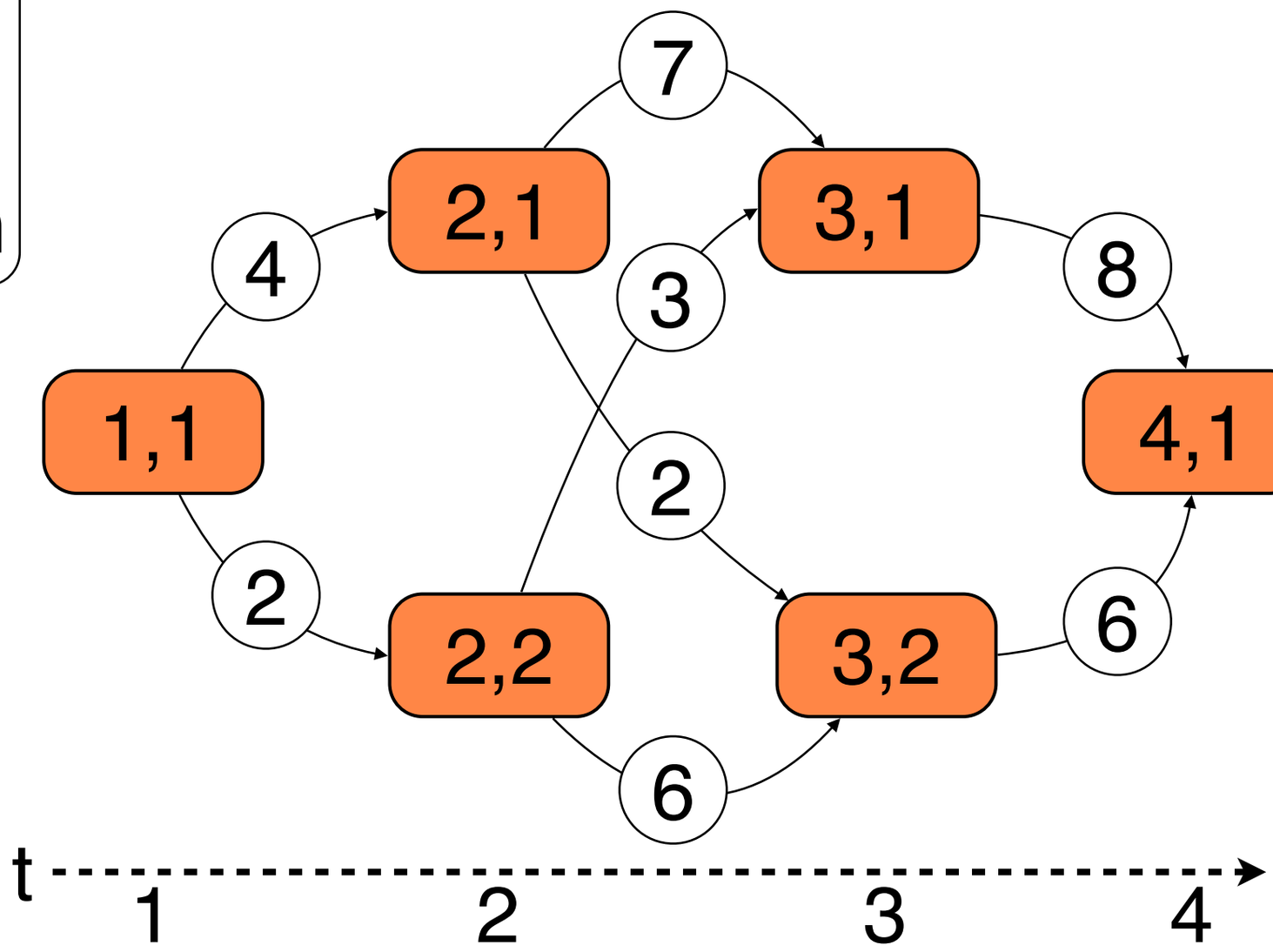
Dynamic programming

Sequential optimization

Principles

- Optimal policy
- Stage = time
- State = cow
- Objective function





Kalantari and Cabrera (2012)

Markov chains

Sequential simulation

Principles

- Stage = time
- State = cow
- Transition probabilities
- Steady state

Month in Milk	Month in Pregnancy									
	0	1	2	3	4	5	6	7	8	9
	Lactation 1									
1	3.54									
2	3.39									
3	2.70	0.59								
4	2.17	0.48	0.59							
5	1.77	0.38	0.47	0.57						
6	1.45	0.31	0.38	0.46	0.55					
7	1.20	0.26	0.31	0.37	0.44	0.54				
8	0.99	0.21	0.25	0.30	0.35	0.43	0.53			
9	0.82	0.17	0.21	0.24	0.29	0.35	0.43	0.53		
10	0.67	0.14	0.17	0.20	0.24	0.28	0.34	0.42	0.52	
11	0.55	0.12	0.14	0.17	0.20	0.23	0.28	0.34	0.42	0.52
12	0.01		0.12	0.14	0.16	0.19	0.23	0.28	0.34	0.41
13	0.01			0.11	0.13	0.16	0.19	0.23	0.27	0.33
14	0.01				0.11	0.13	0.16	0.19	0.22	0.27
15	0.00					0.11	0.13	0.15	0.19	0.22
16	0.00						0.11	0.13	0.15	0.18
17	0.00							0.10	0.13	0.15
18	0.00								0.10	0.12
19	0.00									0.10

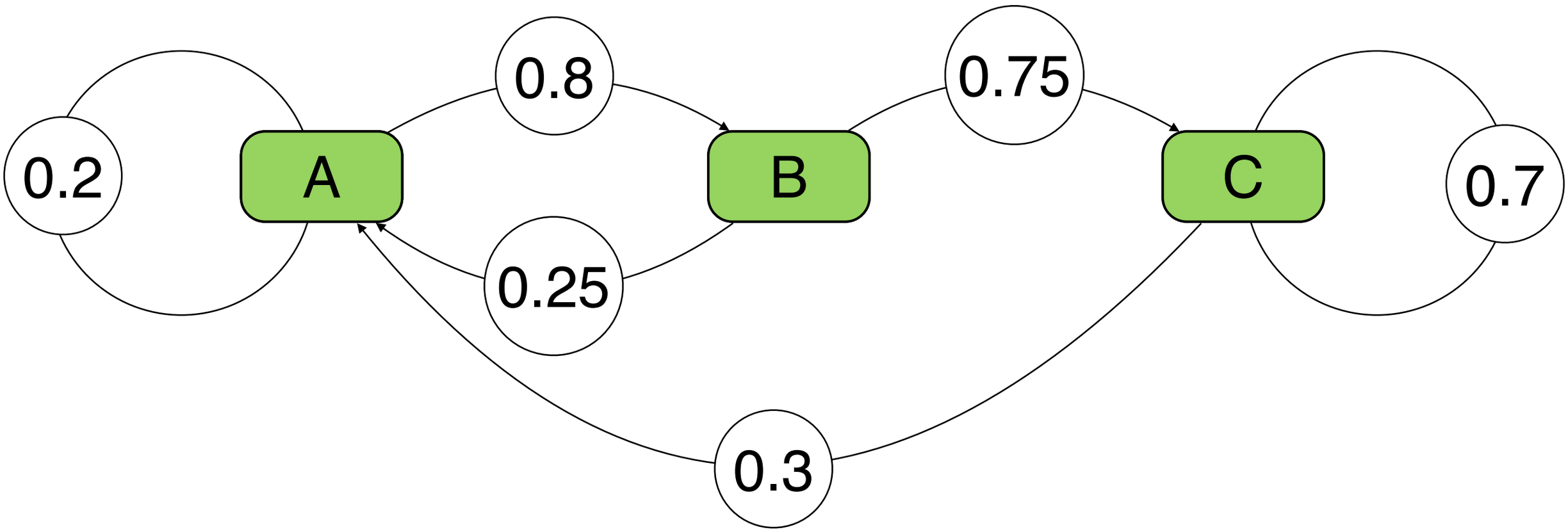
	Lactation 9									
1	0.02									
2	0.02									
3	0.01	0.00								
4	0.01	0.00	0.00							
5	0.01	0.00	0.00	0.00						
6	0.01	0.00	0.00	0.00	0.00					
7	0.01	0.00	0.00	0.00	0.00	0.00				
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00			0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00				0.00	0.00	0.00	0.00	0.00	0.00
16	0.00					0.00	0.00	0.00	0.00	0.00
17	0.00						0.00	0.00	0.00	0.00
18	0.00							0.00	0.00	0.00
19	0.00								0.00	0.00
20	0.00									0.00

States

- Parity
- Days in milk
- Pregnancy
- Production levels
- Disease
- ...

Markov chains

An example



B — State of nature. E.g., Diseased cow

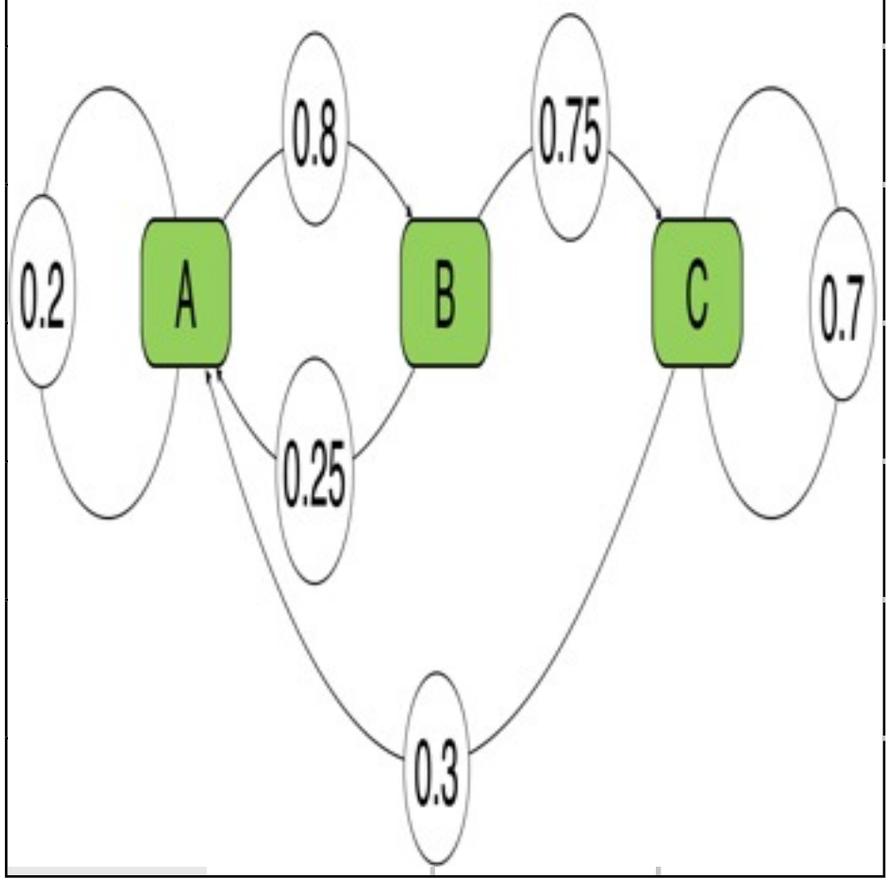
0.8 — Transition probability

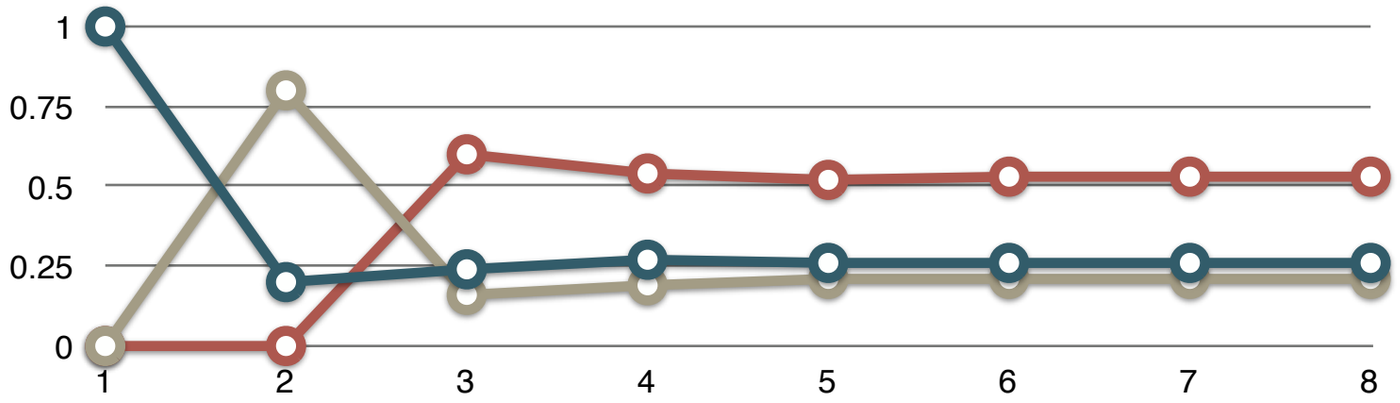
Markov chains

An example

	A	B	C
A	0.20	0.25	0.30
B	0.80	0.00	0.00
C	0.00	0.75	0.70
Total	1.00	1.00	1.00

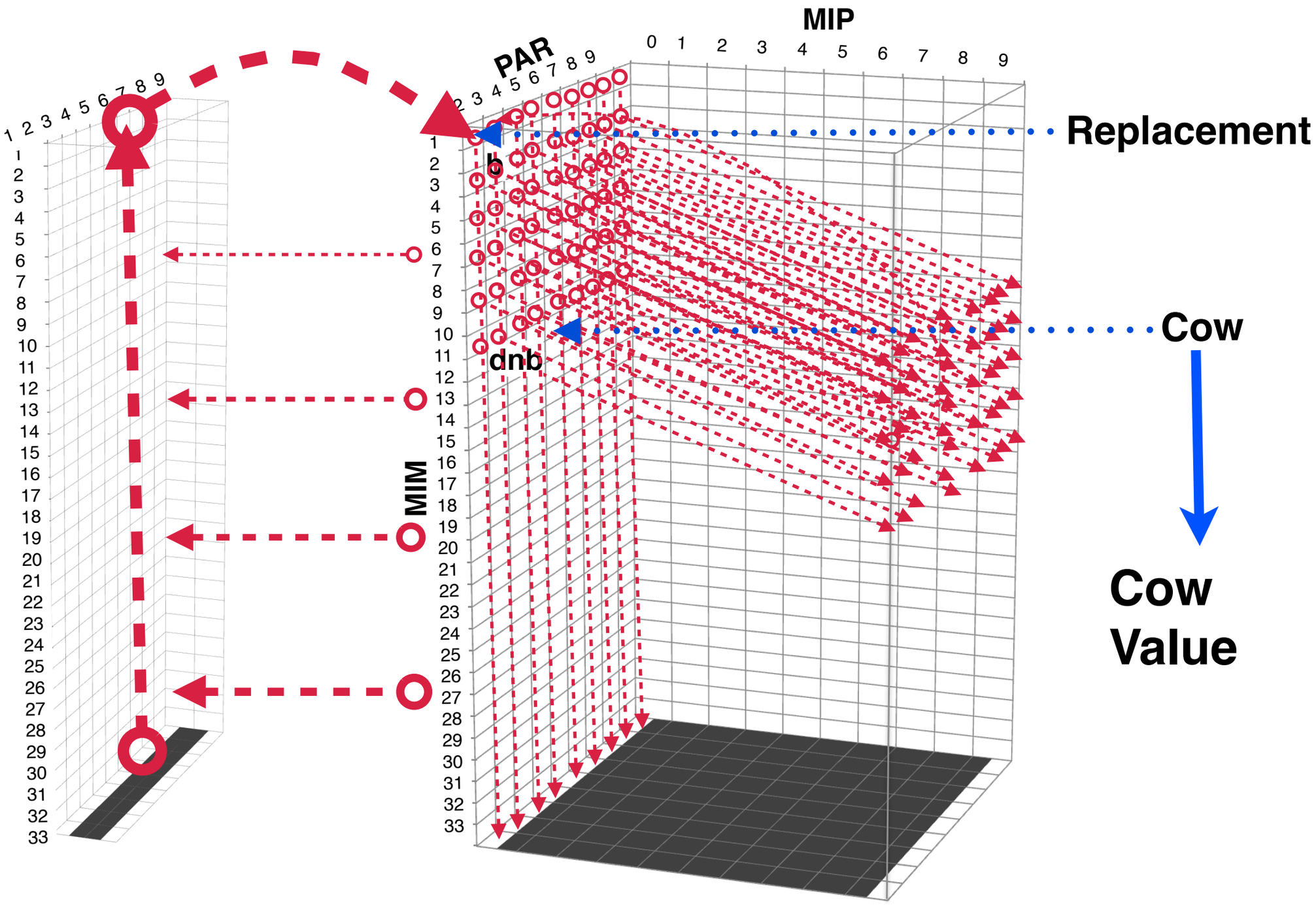
t	A	B	C
1	1.00	0.00	0.00





Markov chains

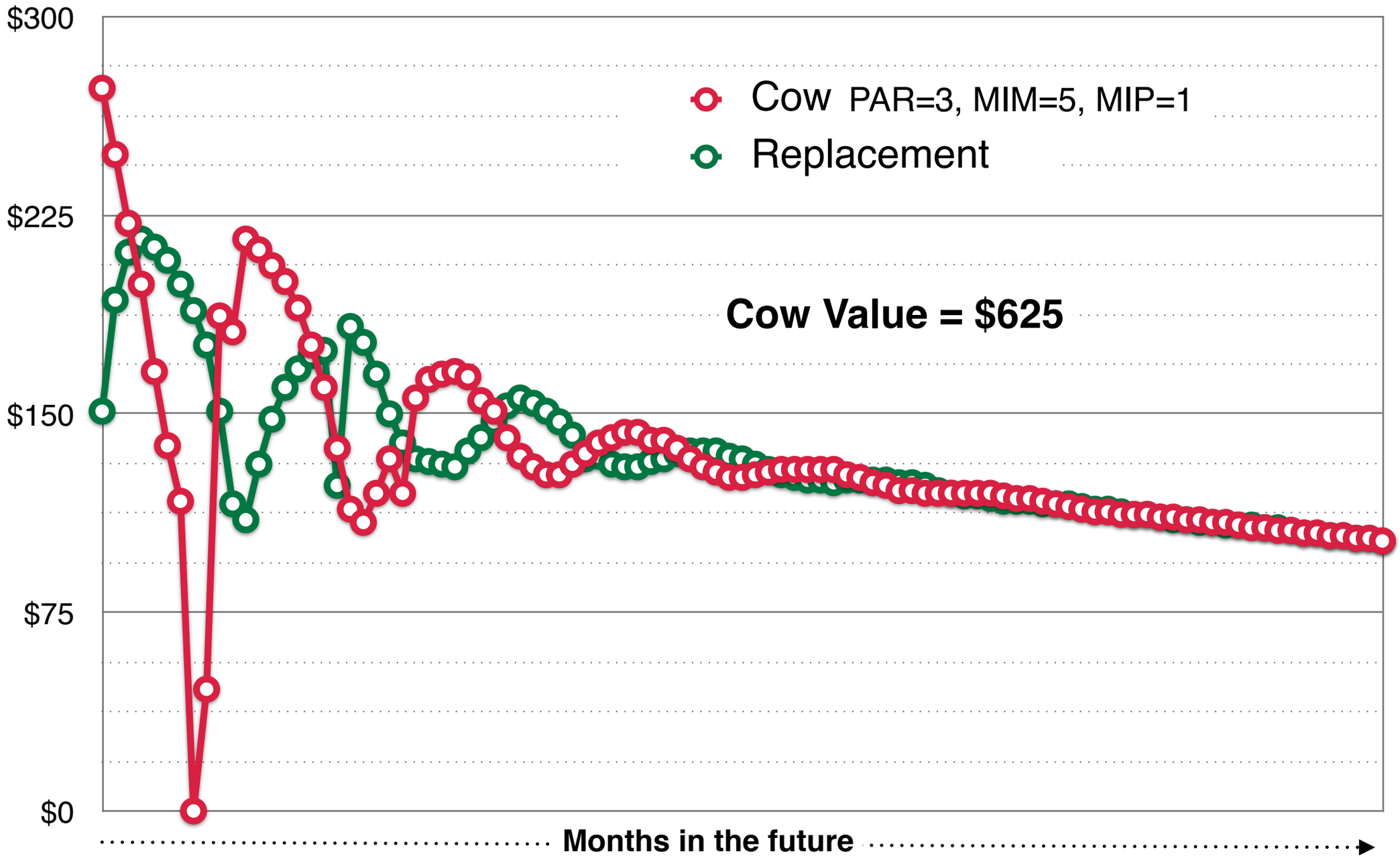
An application



Cabrera (2012)

Markov chains

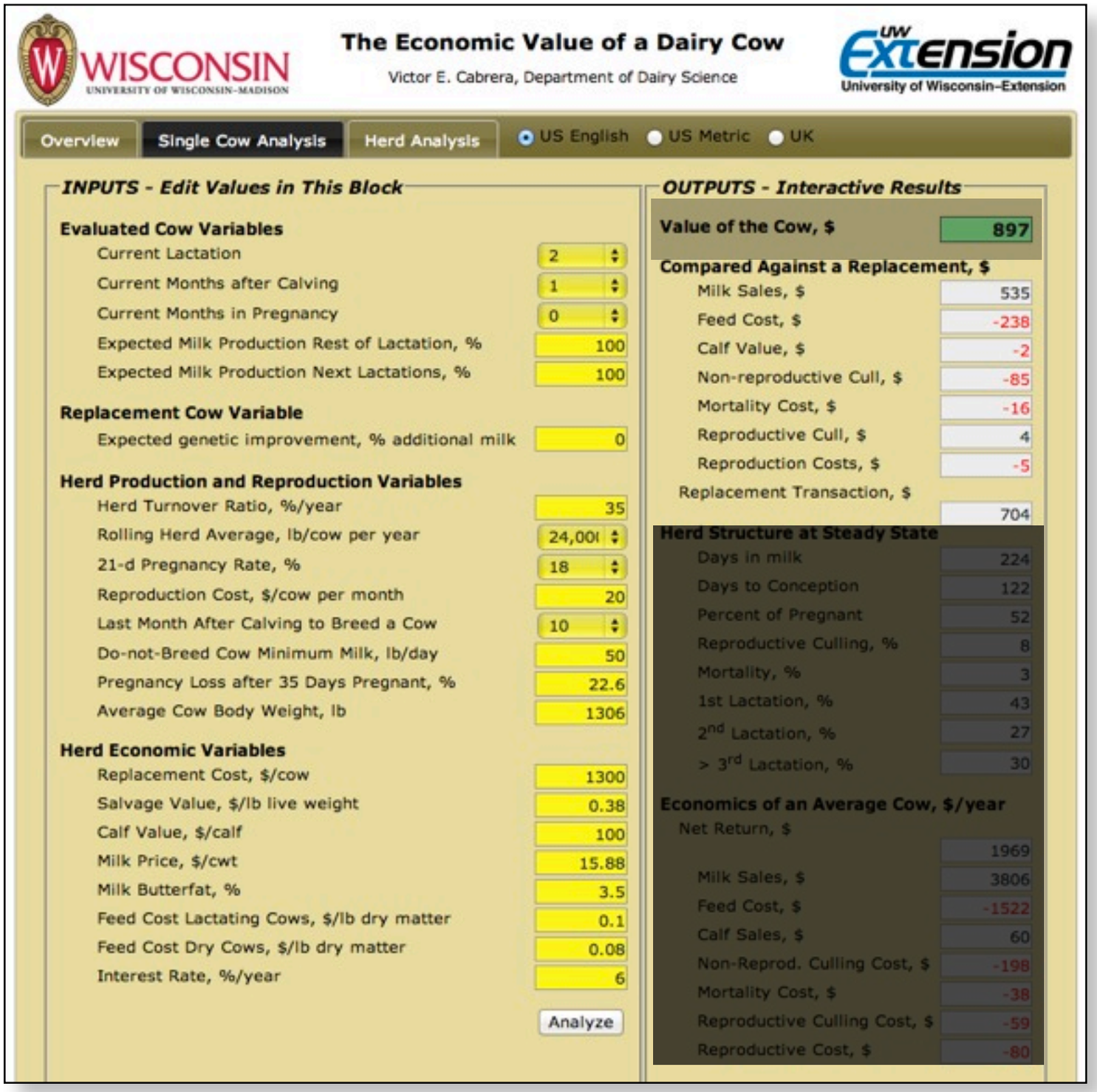
An application



Cabrera (2012)

Markov chains

An application



$897

Economic value of a non-pregnant cow in second lactation one month after calving

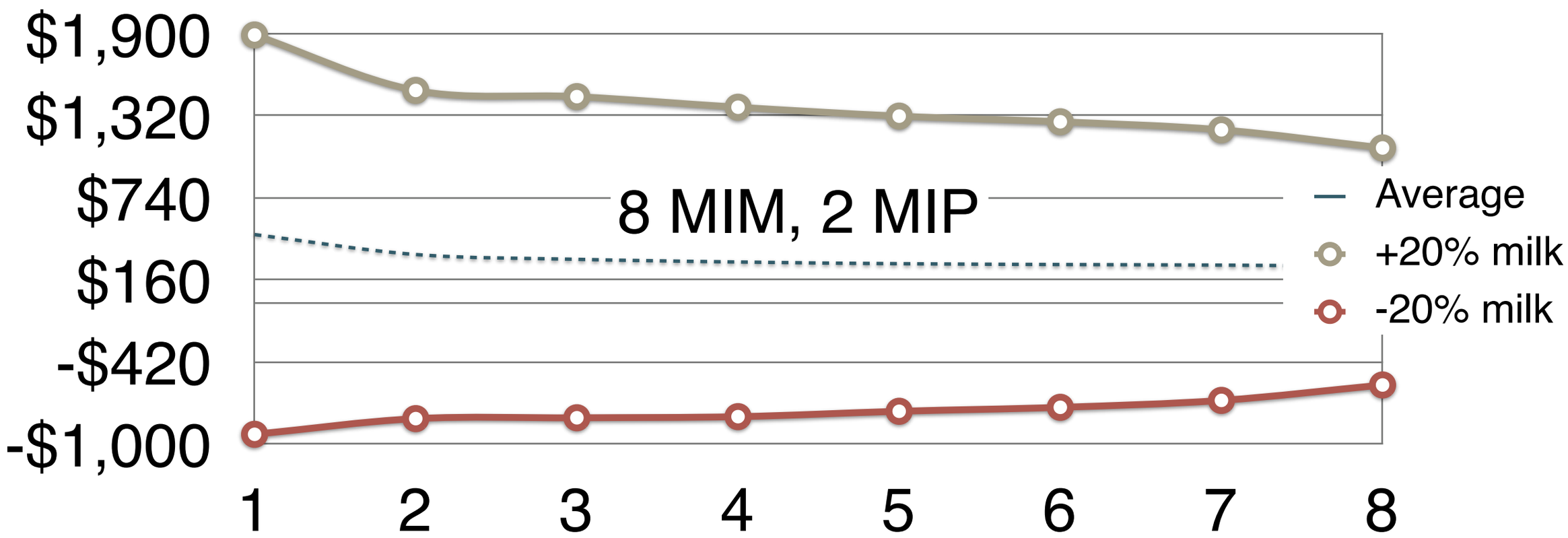
Cabrera (2012)

Economic value of a dairy cow

Practical decision-making

Cull or not cull

Positive cow value indicates cow brings more value than replacement

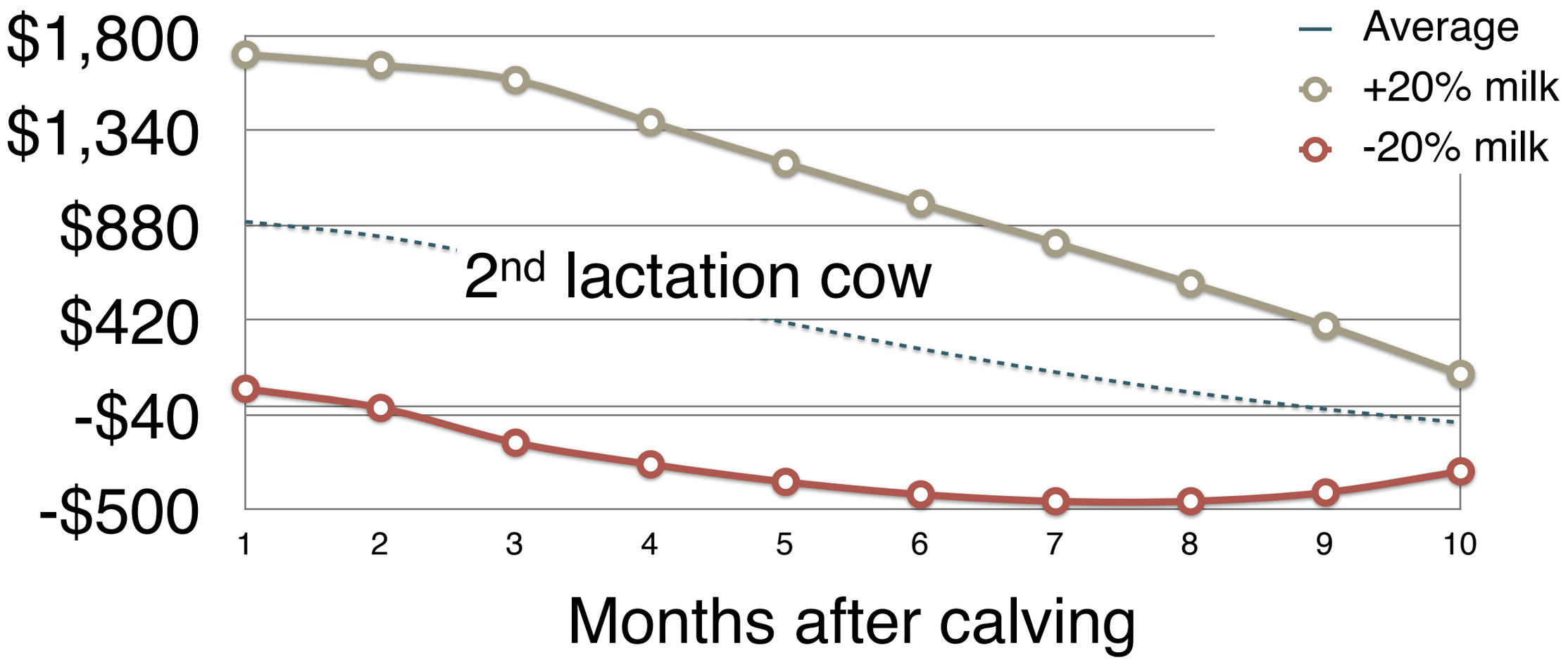


Economic value of a dairy cow

Practical decision-making

Breed or not breed

Better chance for higher value cows

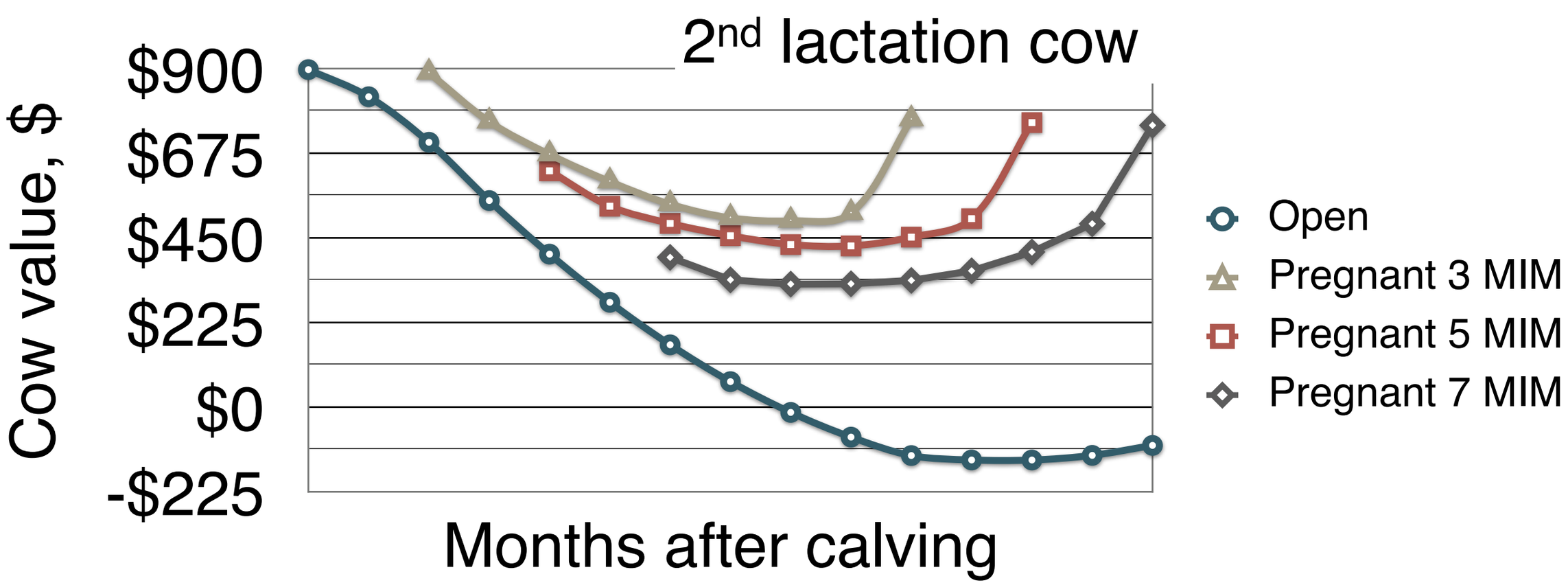


Economic value of a dairy cow

Practical decision-making

Treat or not treat

More investment allowed
in higher value cows

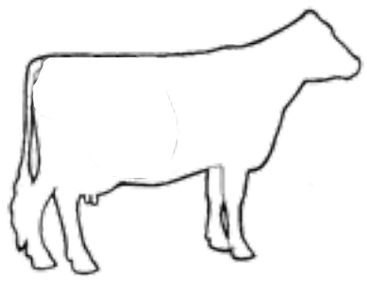


Economic value of a dairy cow

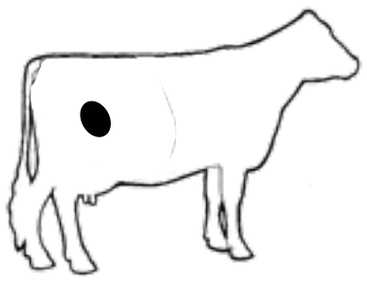
Practical decision-making

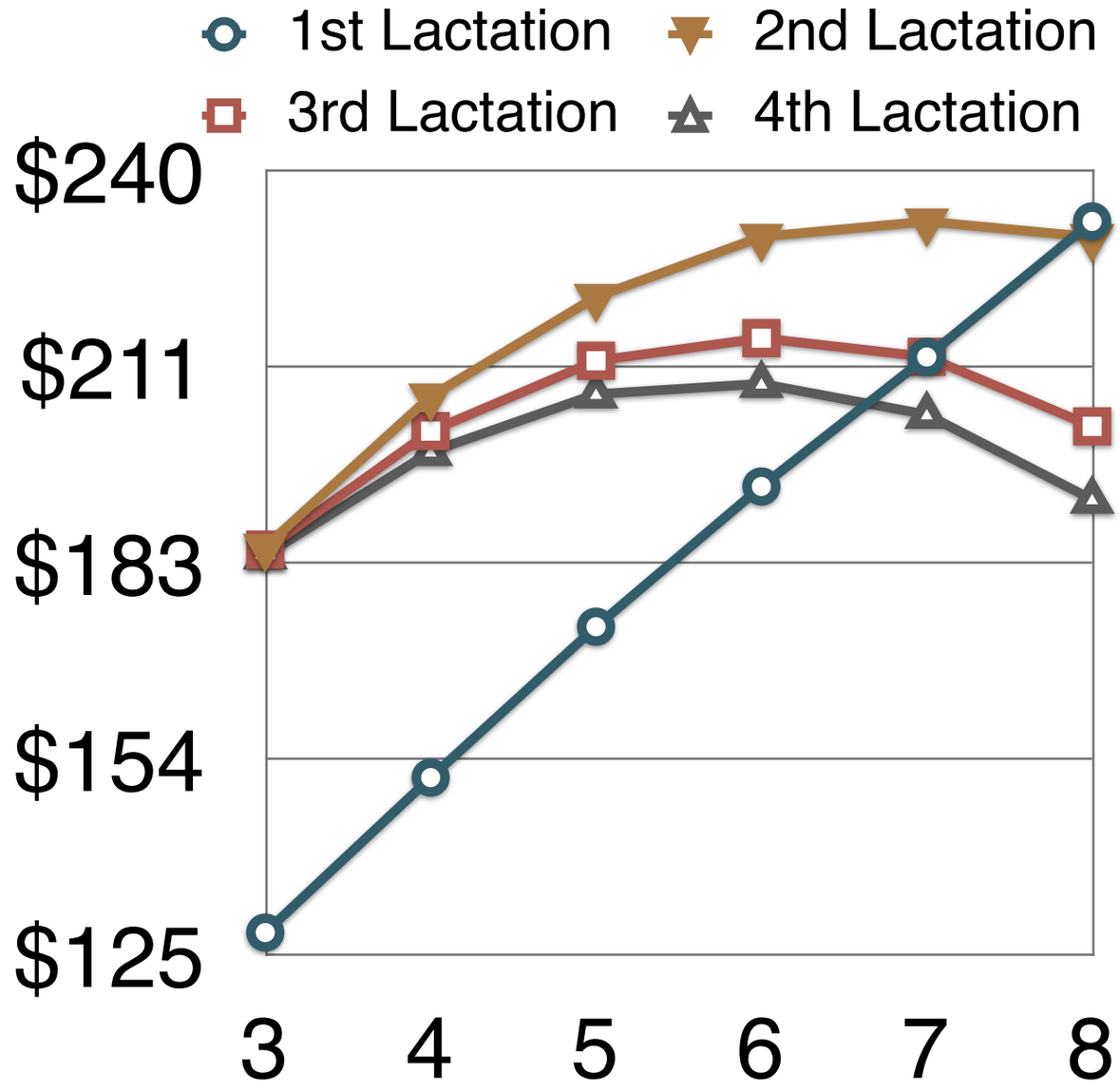
Calculate the value of a pregnancy

Difference between pregnant and non-pregnant



vs.



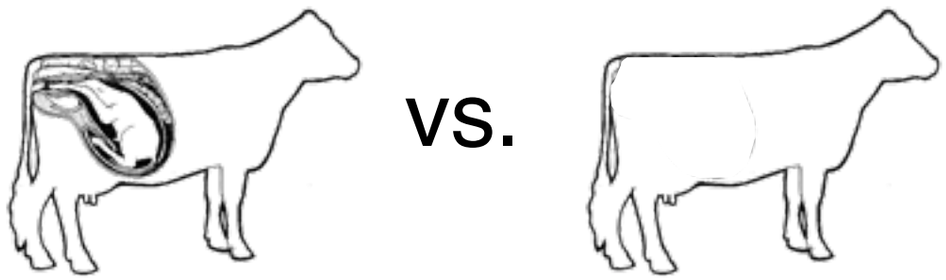


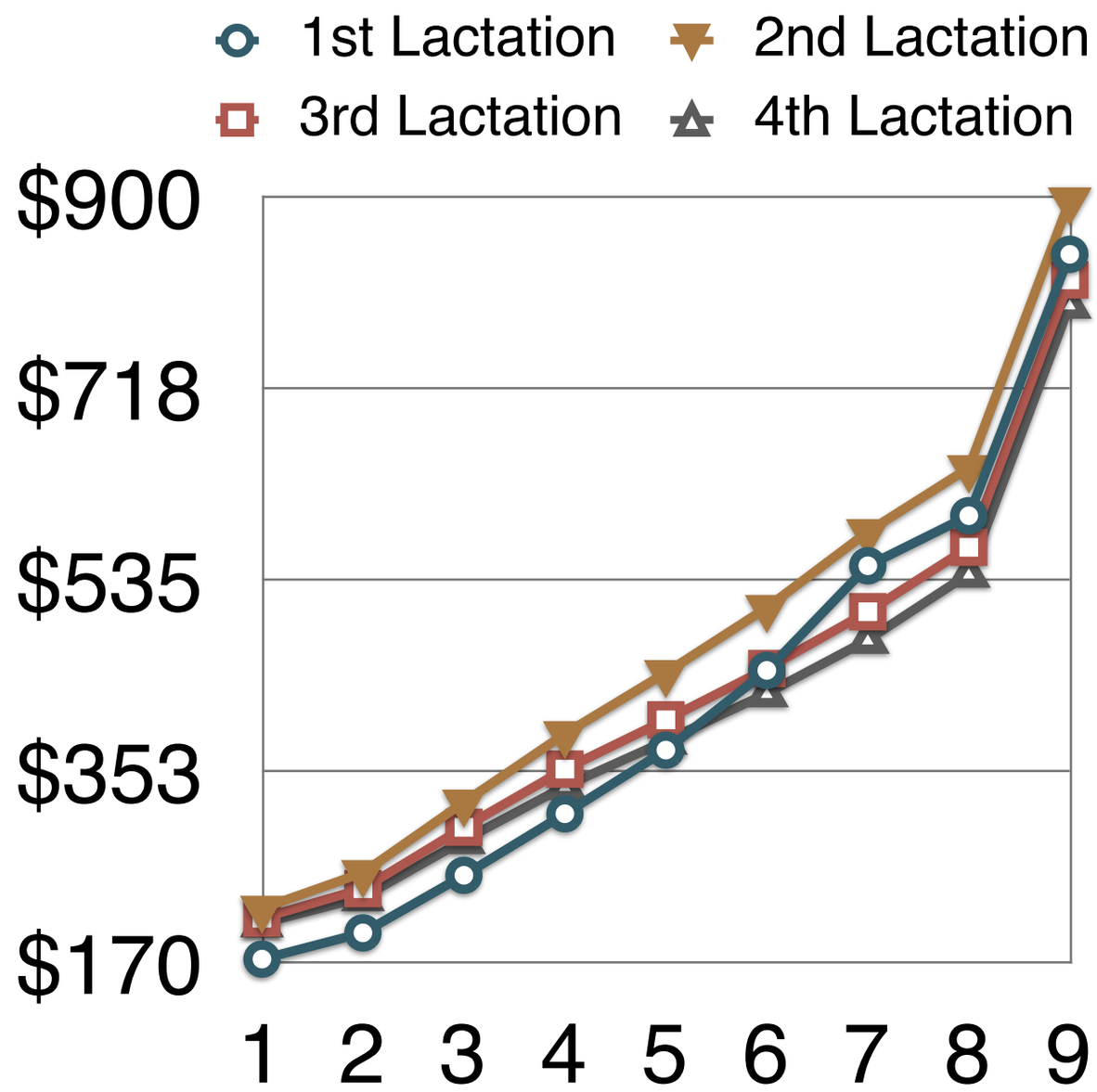
Economic value of a dairy cow

Practical decision-making

Calculate the cost of a pregnancy loss

Difference between non-pregnant and pregnant



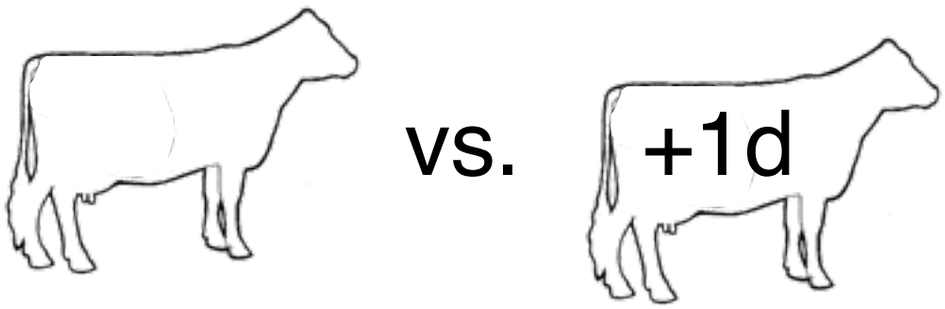


Economic value of a dairy cow

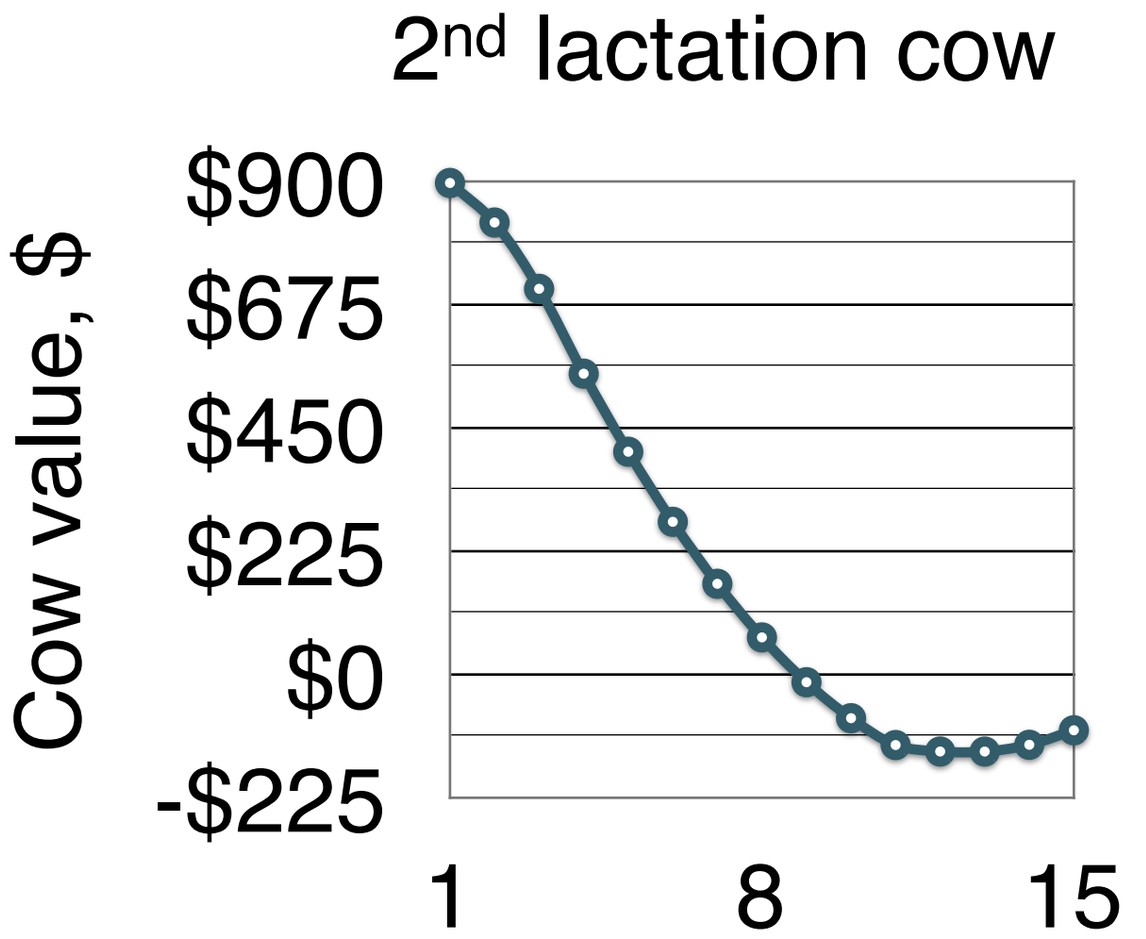
Practical decision-making

Calculate the cost of a day open

Difference between value of non-pregnant cow in 2 successive days

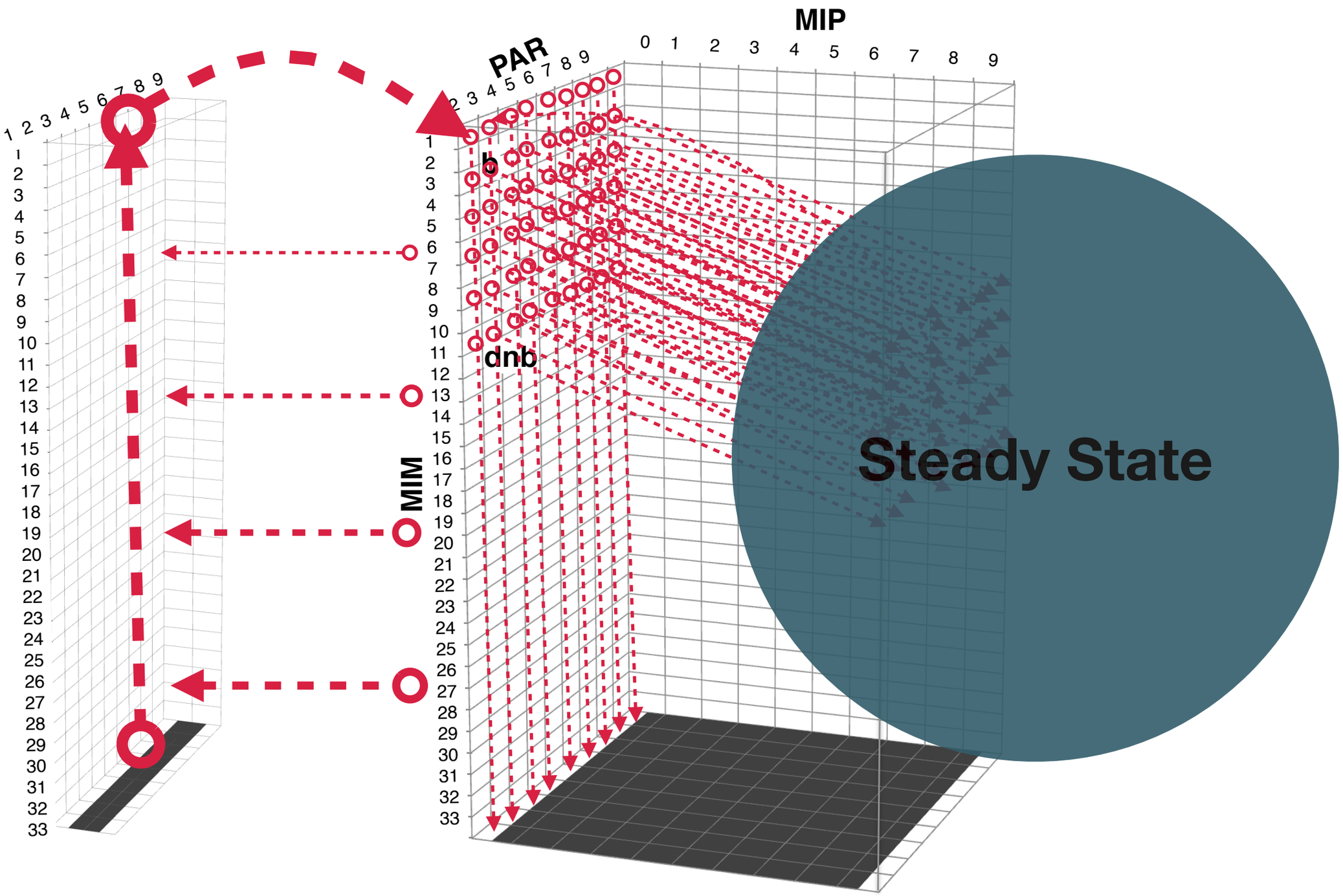


E.g., $5.16 (month 2-3) and $4.26 (month 5-6)



Markov chains

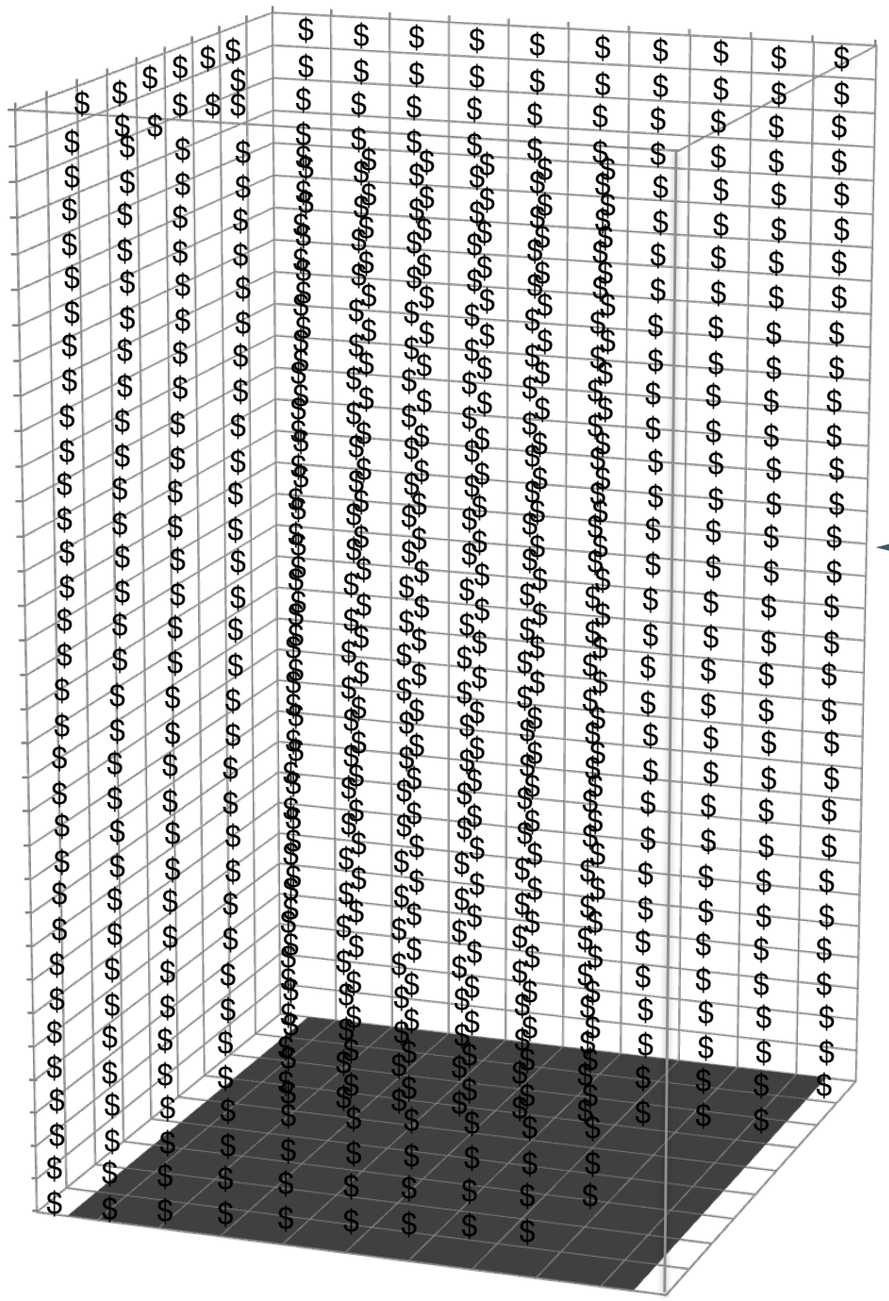
Another application: Herd value



Cabrera (2012)

Markov chains

Another application: Herd value

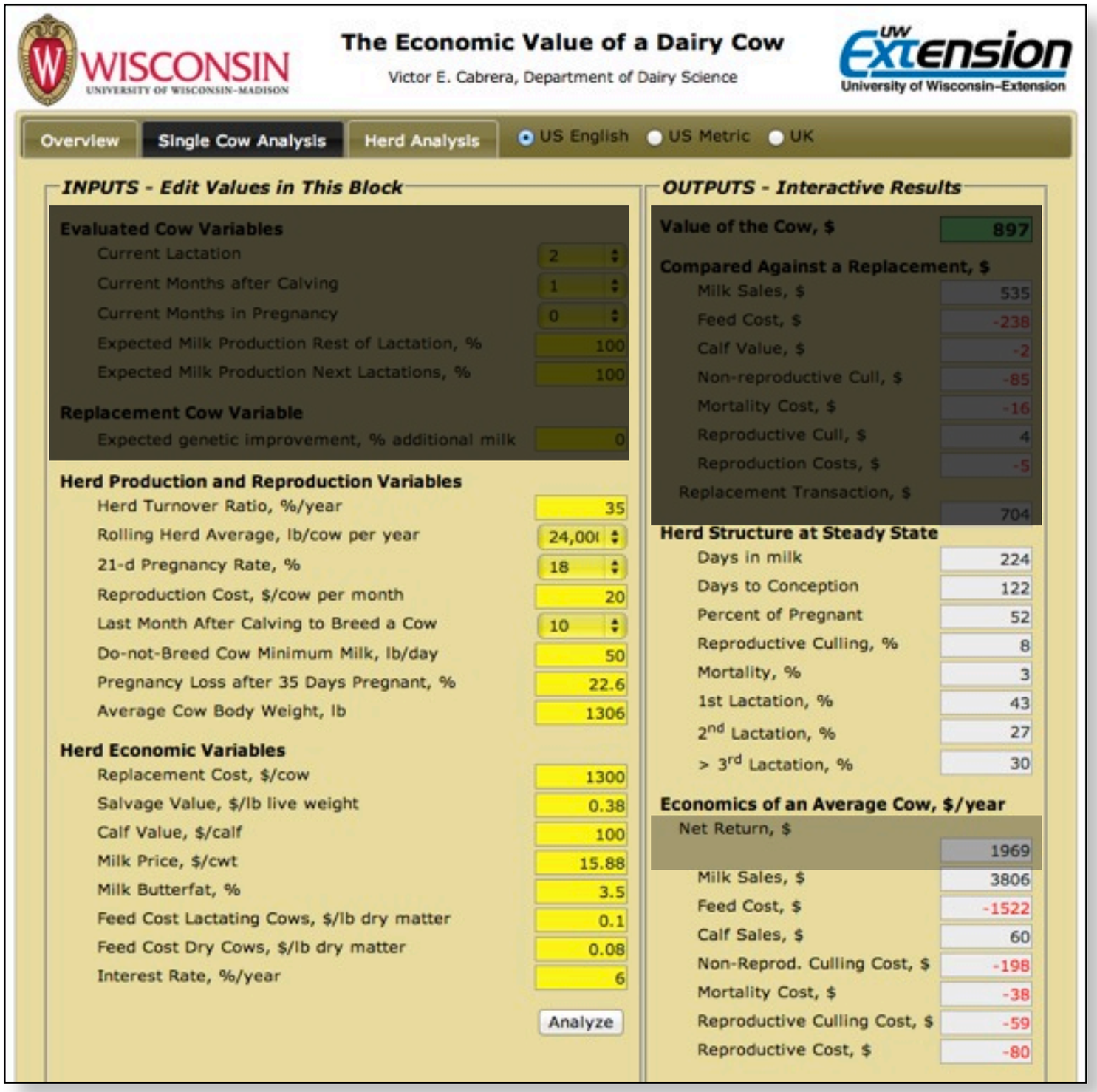


Herd net return ($)
Aggregation of individual cow's net return

Cabrera (2012)

Markov chains

Herd value calculation



$1,969/cow per year

Average net return of a cow in the herd according to herd production, reproduction, and economic variables

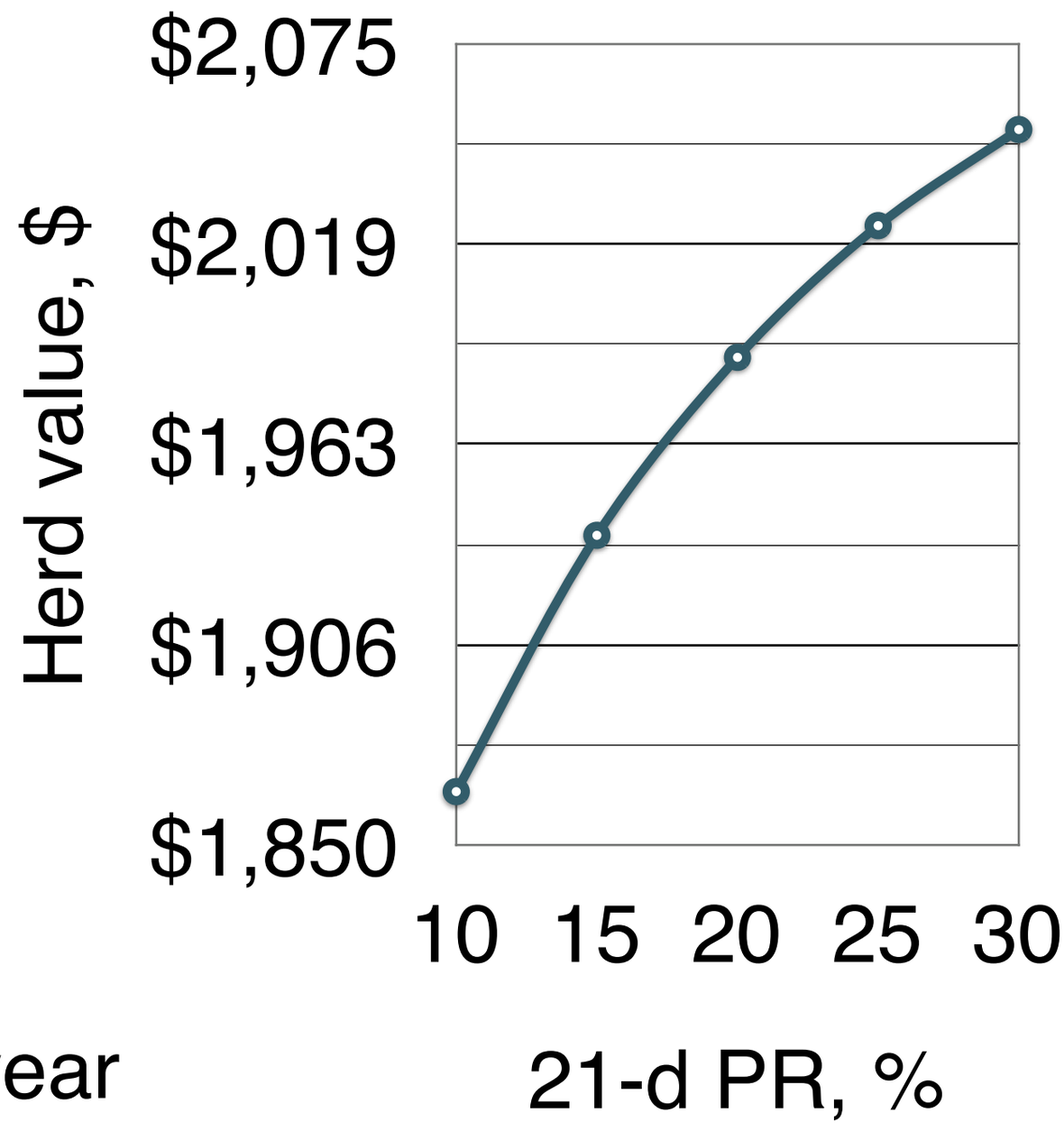
Cabrera (2012)

Herd value

Practical decision-making

Calculate the value of improved reproductive performance

Herd value difference of reproductive efficiency



E.g., value of improving 21-d pregnancy rate from 15 to 20% is **$50**/cow per year

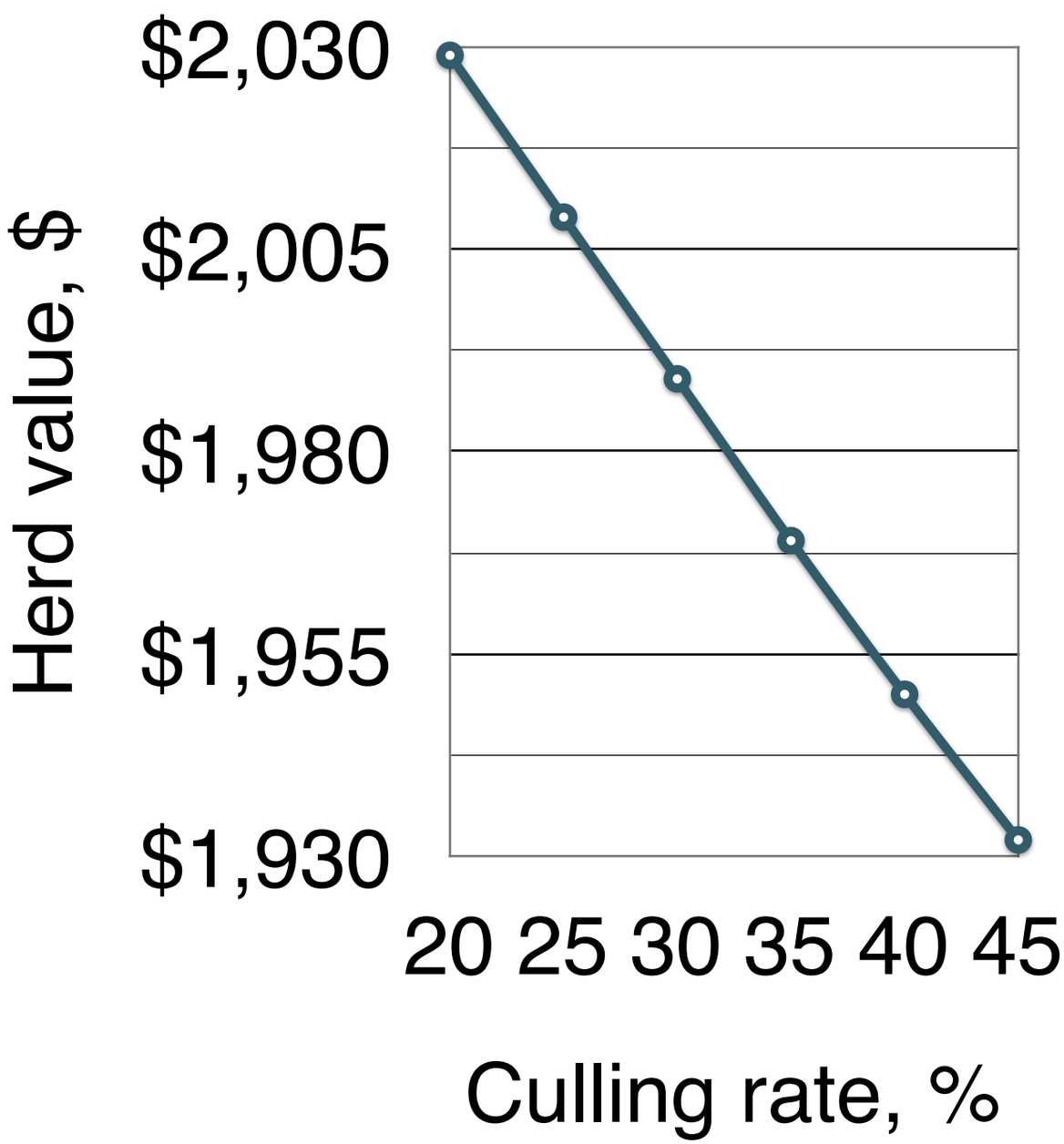
Herd value

Practical decision-making

Calculate the value of decreased culling rate

Herd value difference of changed culling rate

E.g., value of decreasing culling rate from 40 to 35% is **$19**/cow per year

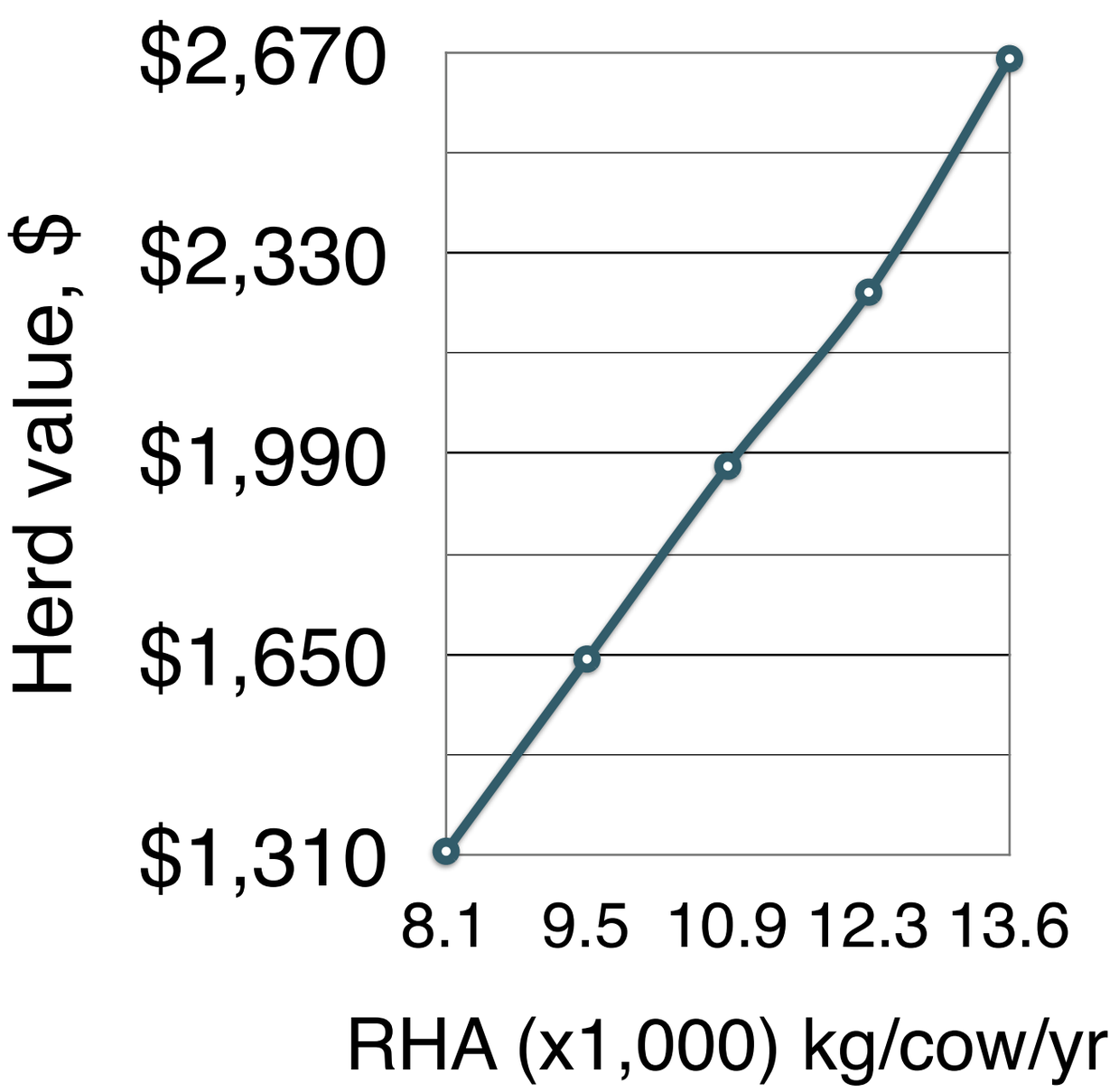


Herd value

Practical decision-making

Calculate the value of increased productivity

Herd value difference of changed rolling herd average (cow average production in a year)



E.g., value of improving RHA from 10.9 to 12.3 kg/cow per yr
is **$295**/cow per year

Dairy feed cost evaluator

Benchmarking income over feed cost

Income over feed cost
Milk value - feed cost
(very simple concept)

Important to benchmark
Against historical data
Against peers

http://extension.psu.edu/animals/dairy

Dynamic procedure
Permanent cycle of data collection, analysis, and decision making

Enables informed decisions
purchase feeds, price risk management, ration adjustment, etc.

Dairy feed cost evaluator

How to benchmark IOFC

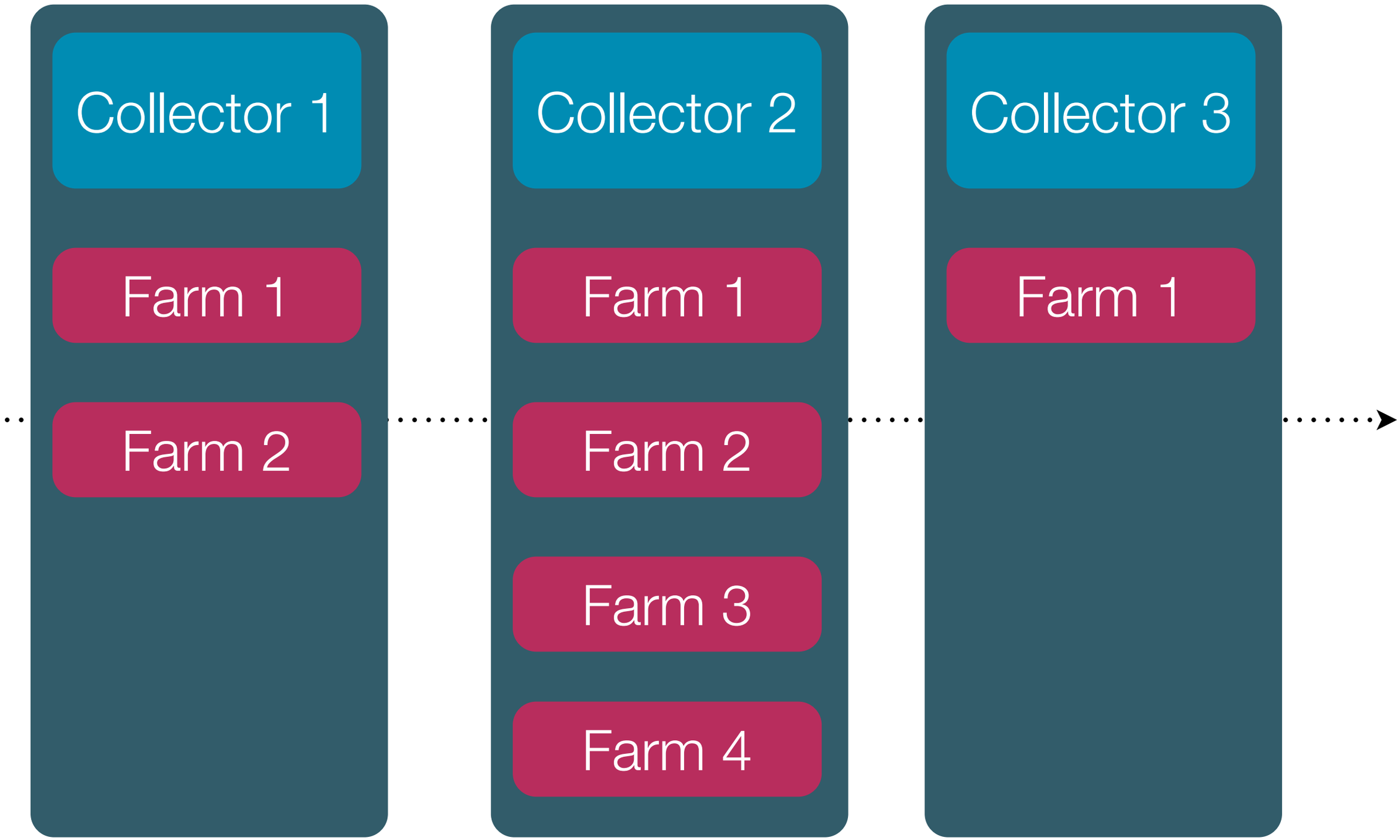
Collect farm data

Analyze farm data

Compare farm data

Dairy feed cost evaluator

Data collection scheme

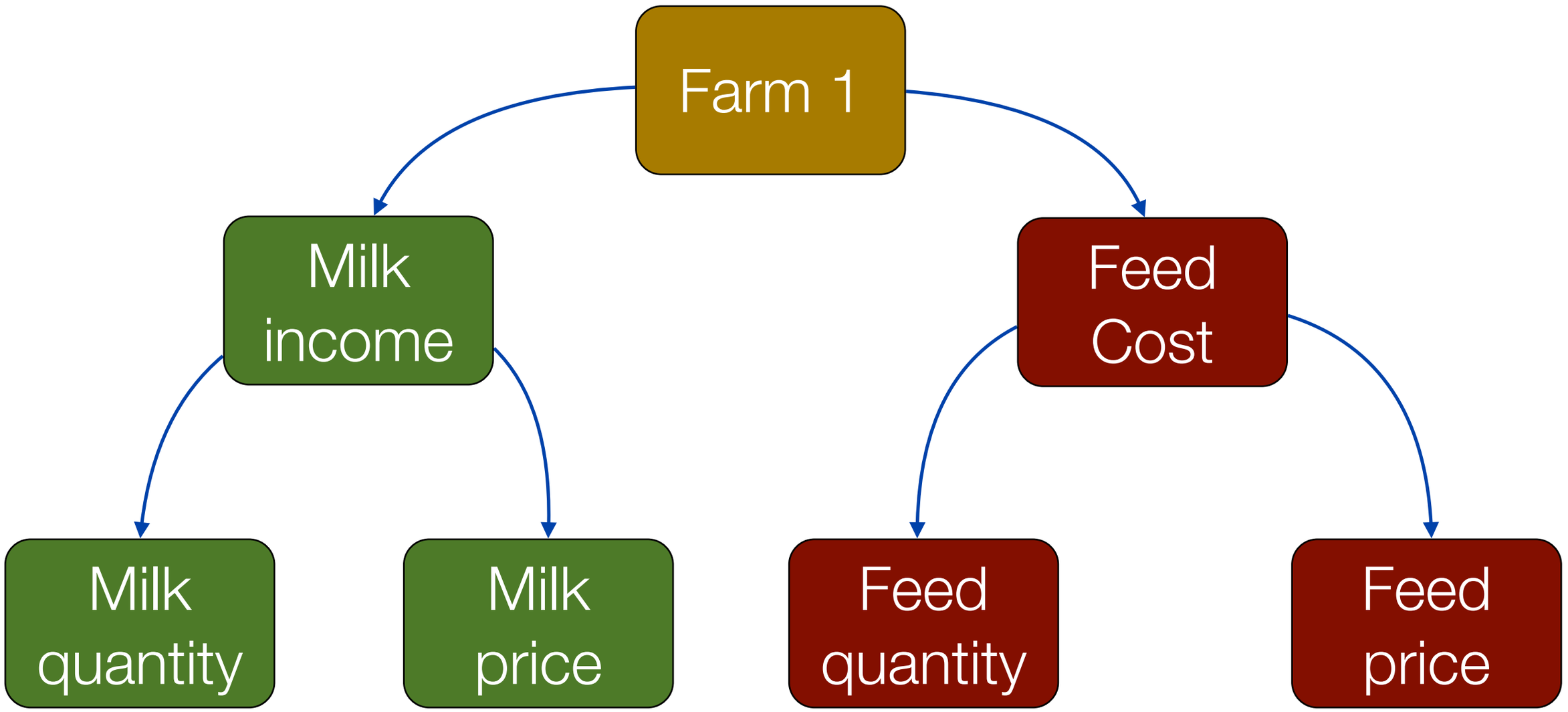


Dairy feed cost evaluator

Data collection scheme

Dairy feed cost evaluator

Data collection scheme



Dairy feed cost evaluator

Data collection scheme

Forage	%DM	Price As Fed $/ton	Price DM $/ton
Corn Silage 1			
Hay Forage 1			
Mx. Silage-MxSi			
Hay Forage			
Silage Mature>46% NDF-Si50			
Silage Mid-mature 40-46% NDF-Si43			
Silage Inmature<40% NDF-Si40			
wheat straw			
aggregate			

Dairy feed cost evaluator

Data collection scheme

Farm Name

Finalise

Month

February 2013

Ration Group Information	Name	Number	Milking
Ration Group 1	Ration 1	0	☐
Ration Group 2	Ration 2	0	☐
Ration Group 3	Ration 3	0	☐
Ration Group 4	Ration 4	0	☐
Ration Group 5	Ration 5	0	☐
Ration Group 6	Ration 6	0	☐
Ration Group 7	Ration 7	0	☐
Ration Group 8	Ration 8	0	☐
Ration Group 9	Ration 9	0	☐

Dairy feed cost evaluator

Data collection scheme

Total DMI

Total DMI (lb/cow/d)

	Ration 1	Ration 2	Ration 3	Ration 4	Ration 5	Ration 6	Ration 7	Ration 8	Ration 9
Total DMI	0	0	0	0	0	0	0	0	
Actual DMI									

Forage

Ration Group (lb/cow/d) DM

	P	Ration 1	Ration 2	Ration 3	Ration 4	Ration 5	Ration 6	Ration 7	Ration 8	Ration 9
Corn Silage-Cosi										
Hay Forage										
Mx. Silage-MxSi										
Hay Forage										
Silage Mature>46% NDF-Si										
Silage Mid-mature 40-46%										
Silage Inmature<40% NDF-										
wheat straw										

Dairy feed cost evaluator

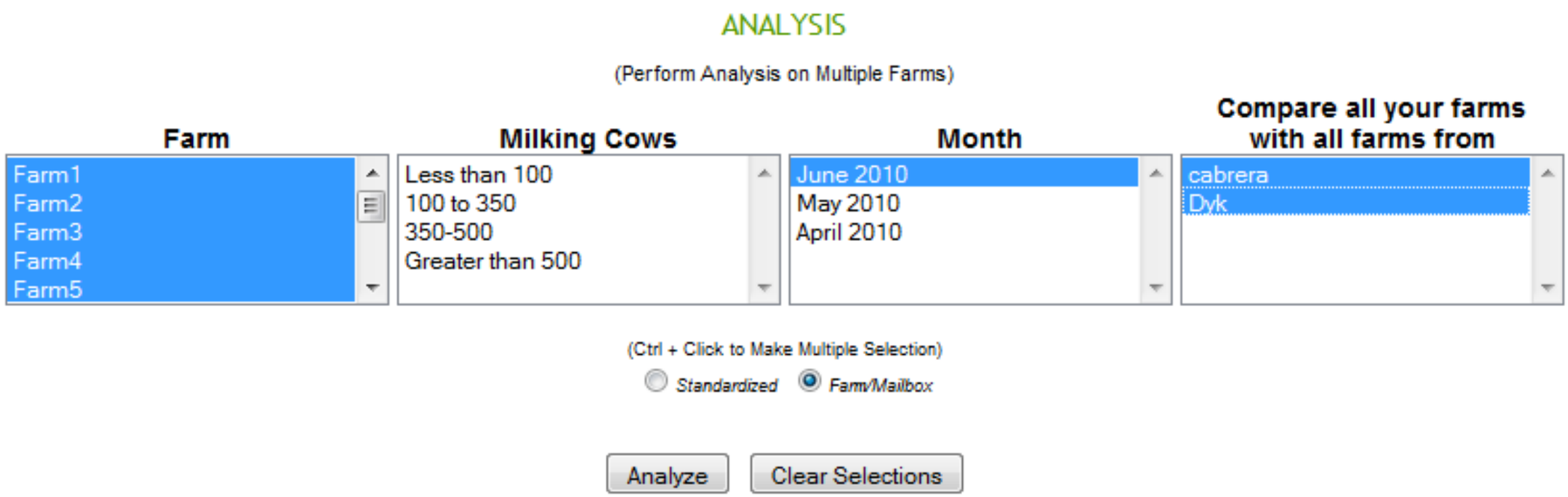
Data summary

	Ration 1			Dry
	Purchased		Home-Grown	
	DMI	Cost	DMI	Cost
Forage	0	0	0	0
Energy/Protein Supplem	0	0	0	0
Min-Vit & Additive Supp	0	0	-	
Total Feed	0	0	0	
DMI (lb/cow/d)	0			
Feed Costs ($/cow/d)	0			
Number of Cows (#)	0			

Summary	Milking	Dry
DMI (lb/cow/day)		
MILK/DMI	0	
FCM/DMI	0	
ECM/DMI	0	
INCOME OVER FEED COSTS (IOFC) ($/cow/day)	0	
Income over Feed Costs per CWT(IOFC/cwt) ($/cwt)	0	
Feed Costs per DMI ($/cwt)	0	

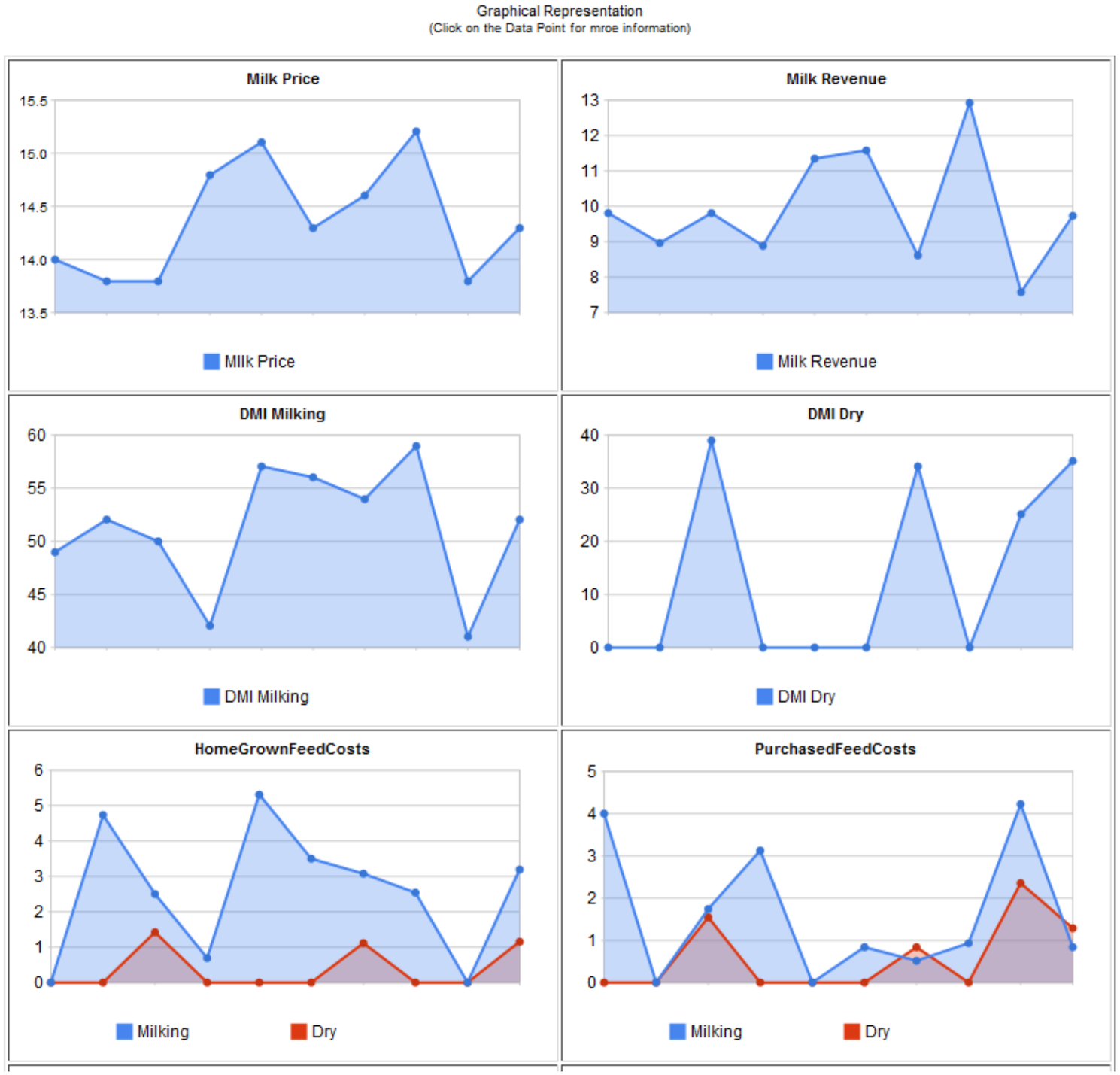
Dairy feed cost evaluator

Data analyses



Dairy feed cost evaluator

Data analyses



Dairy feed cost evaluator

Data analyses

Dairy feed cost evaluator

Case study

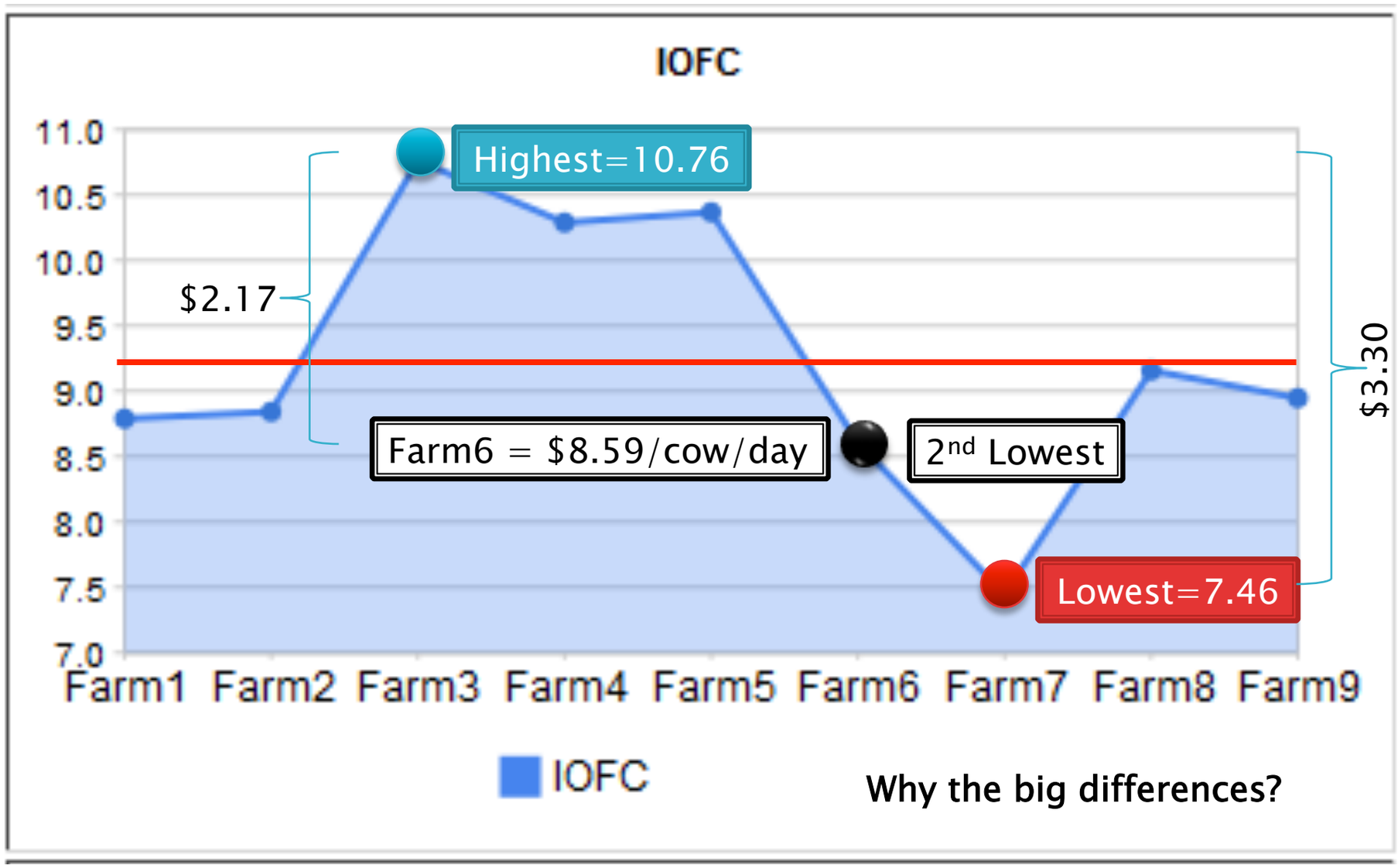
9 Wisconsin dairy farms
Around 12,000 cows

Fond Du Lac
Central East part of the State

Collector
Paul Dyk (former Extension agent)

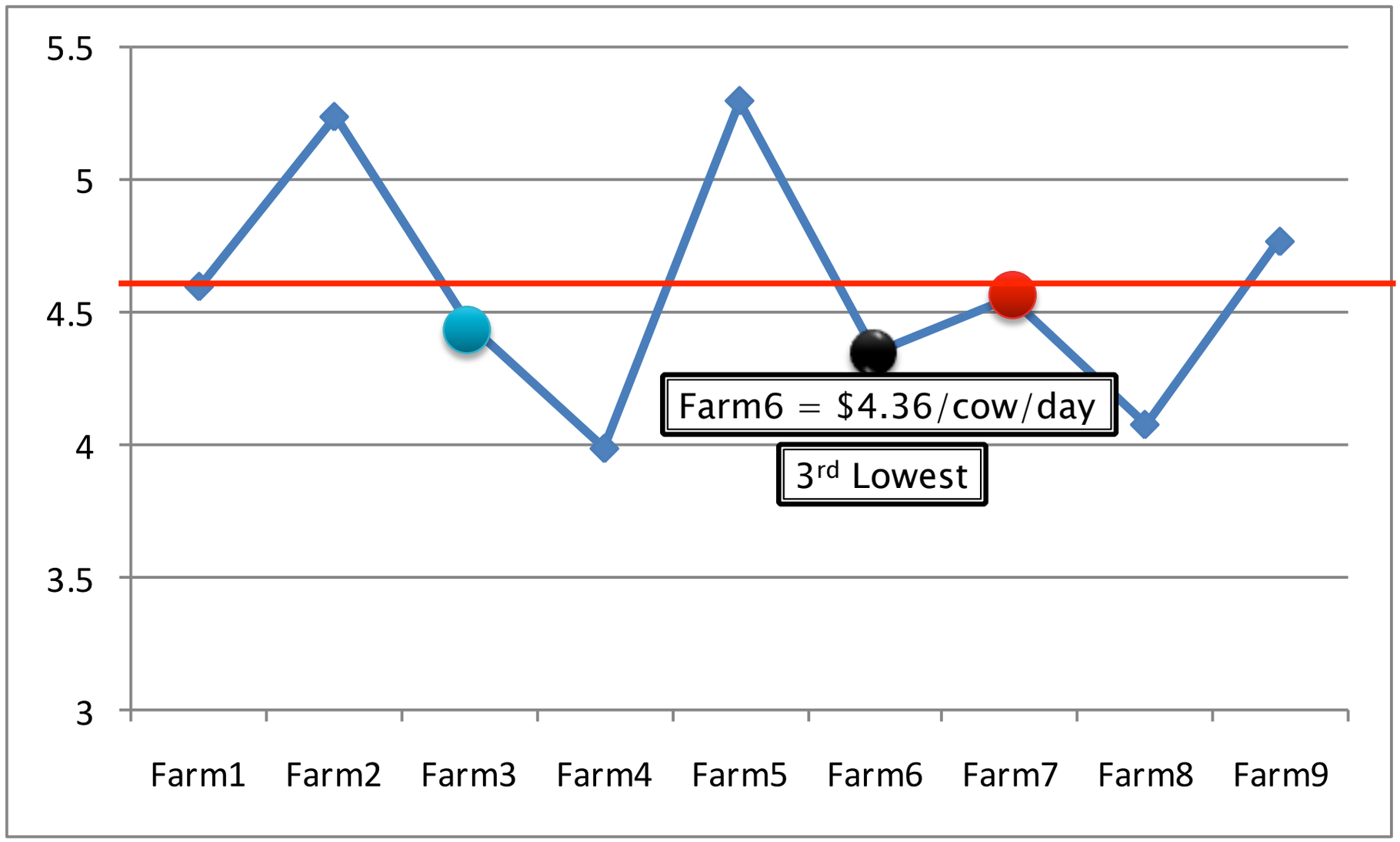
Dairy feed cost evaluator

Wisconsin case study



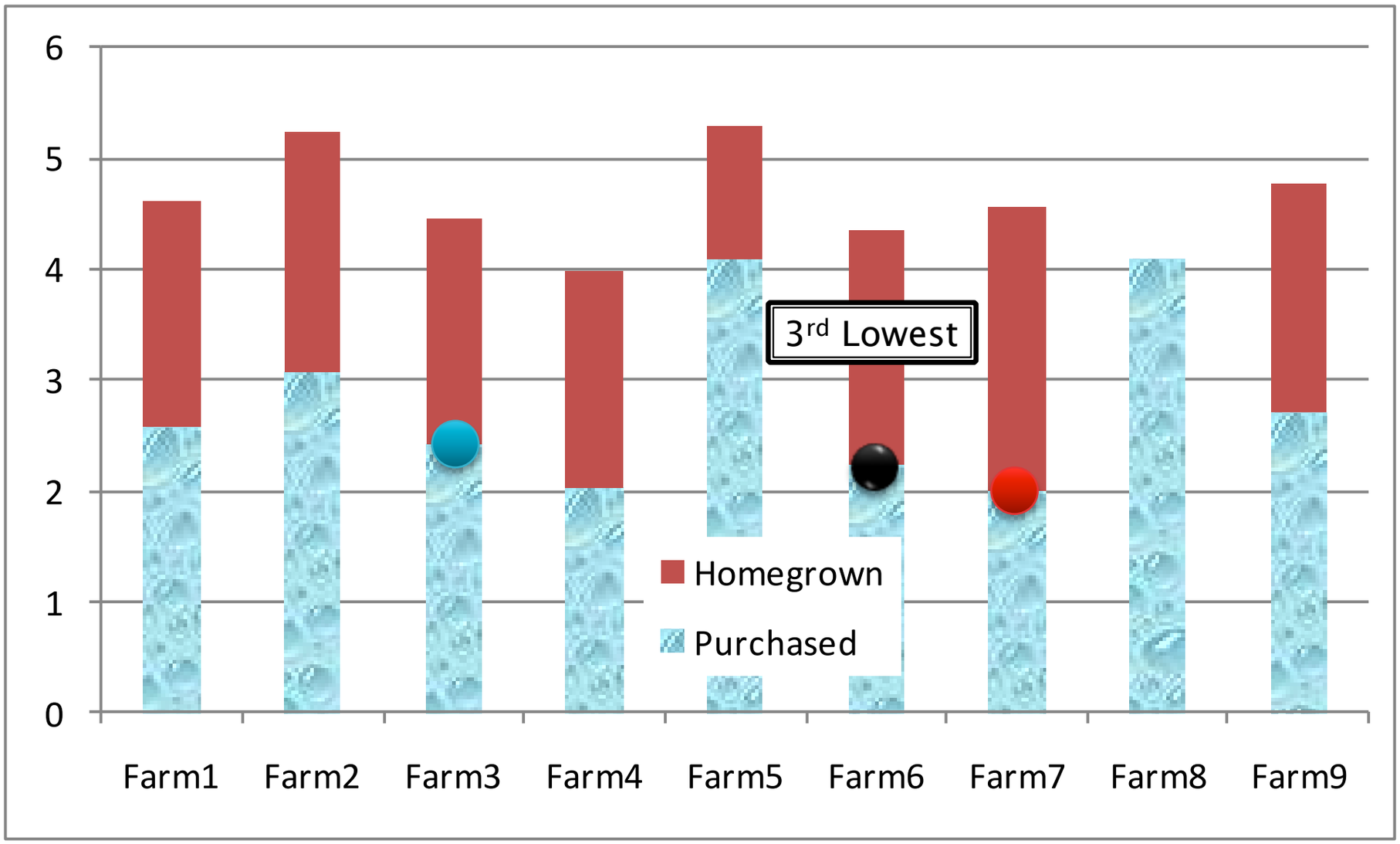
Dairy feed cost evaluator

Wisconsin case study: Feed costs



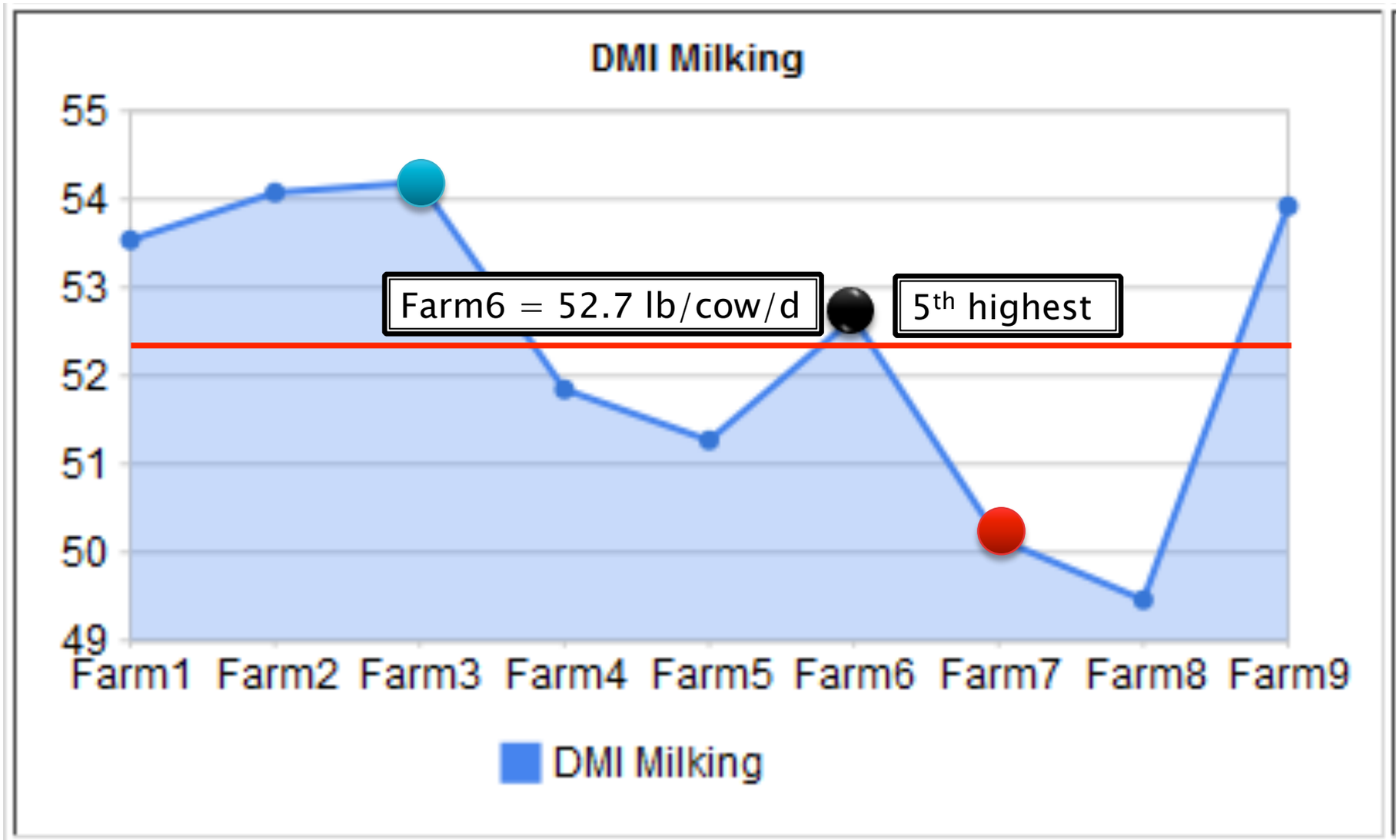
Dairy feed cost evaluator

Wisconsin case study: Feed costs



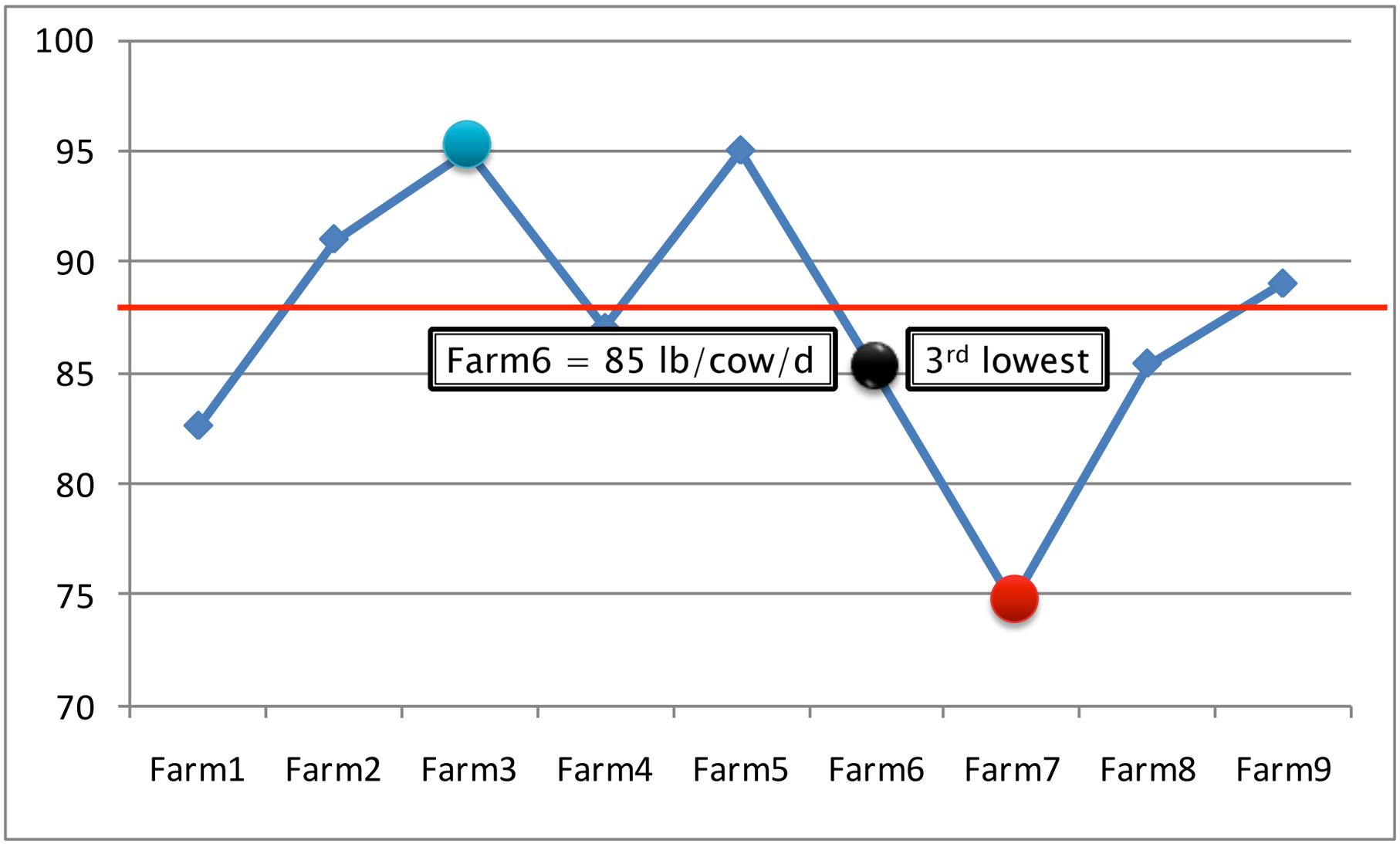
Dairy feed cost evaluator

Wisconsin case study: Dry matter intake



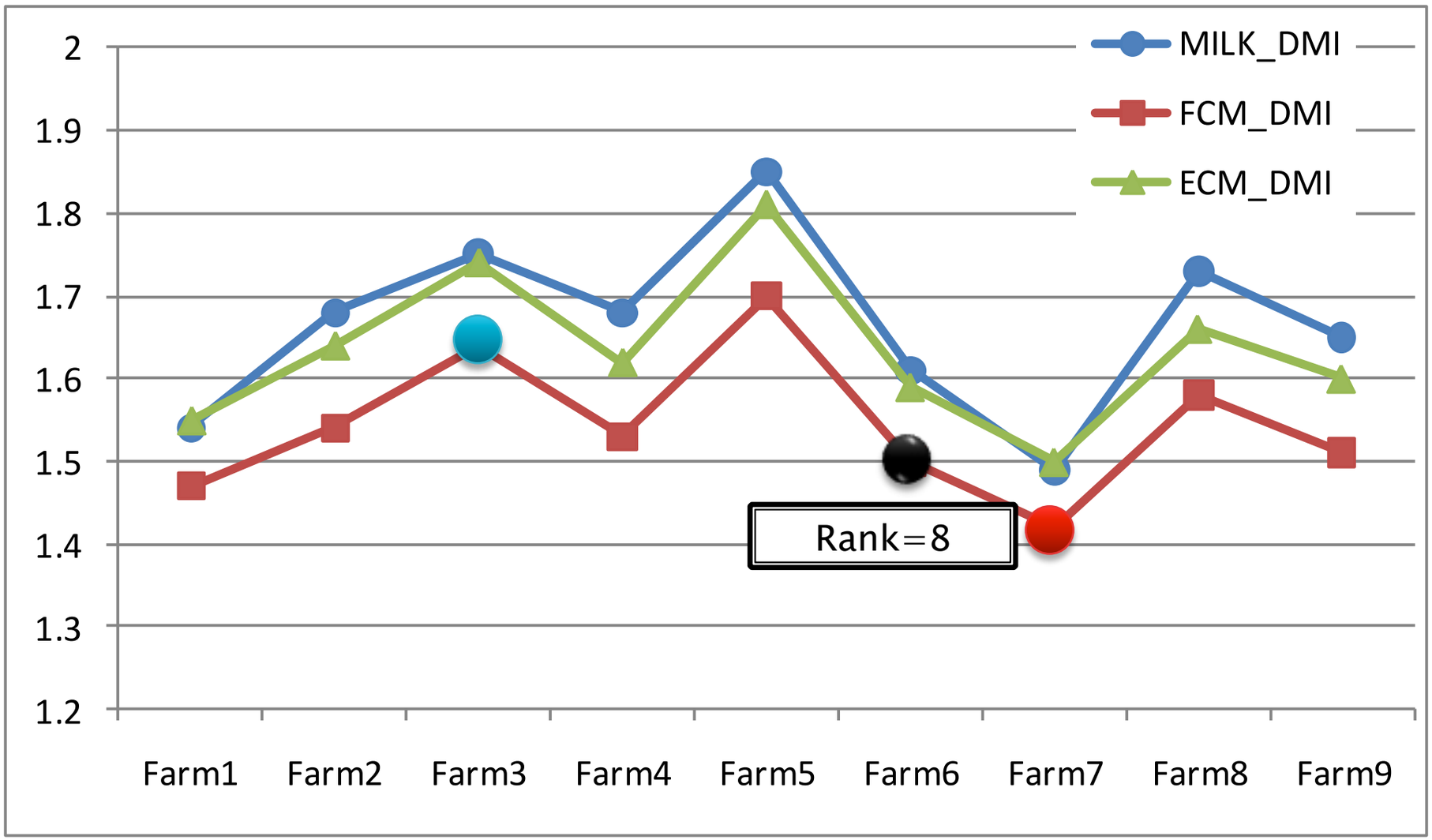
Dairy feed cost evaluator

Wisconsin case study: Milk (lb/cow per d)



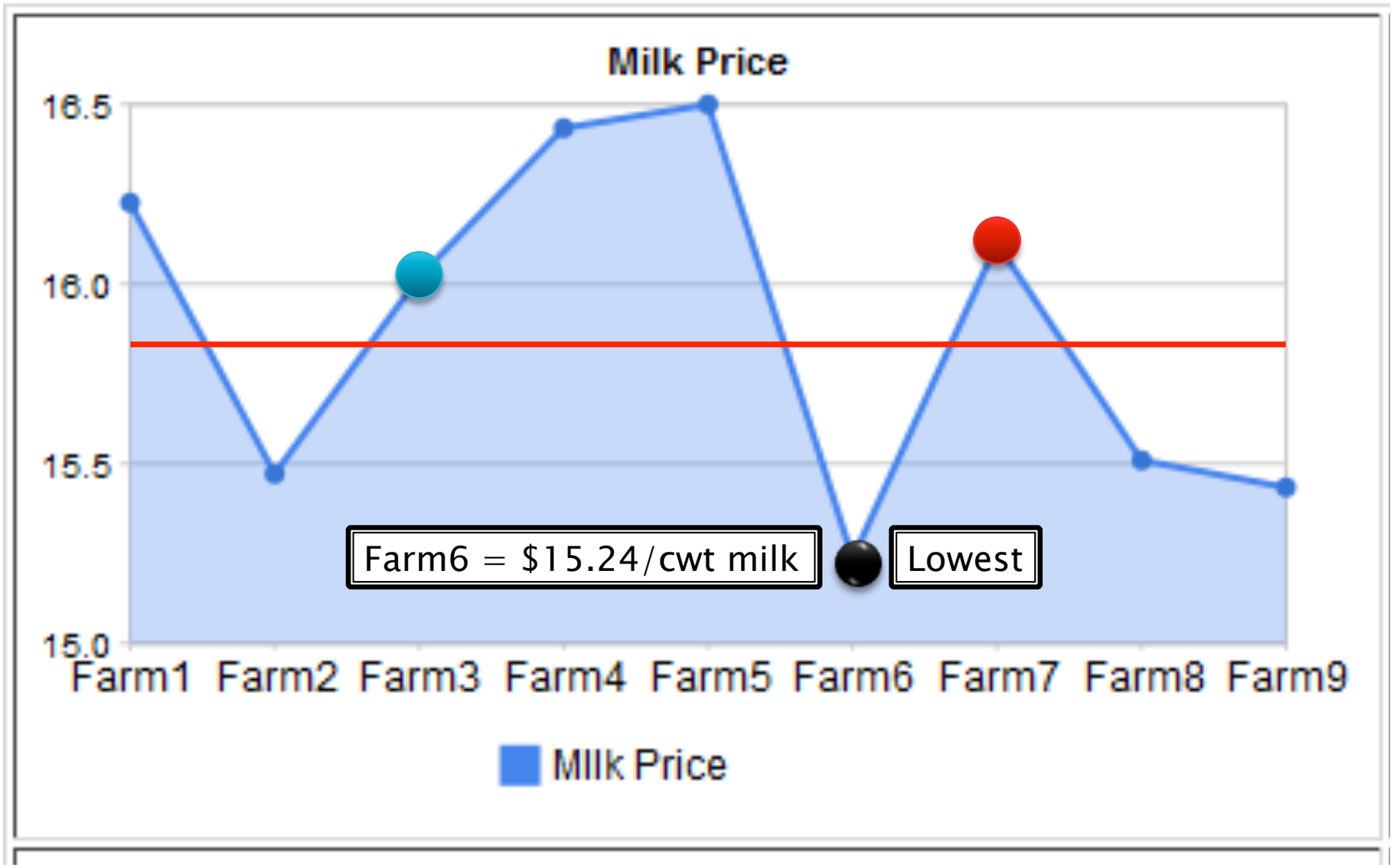
Dairy feed cost evaluator

Wisconsin case study: Feed efficiency



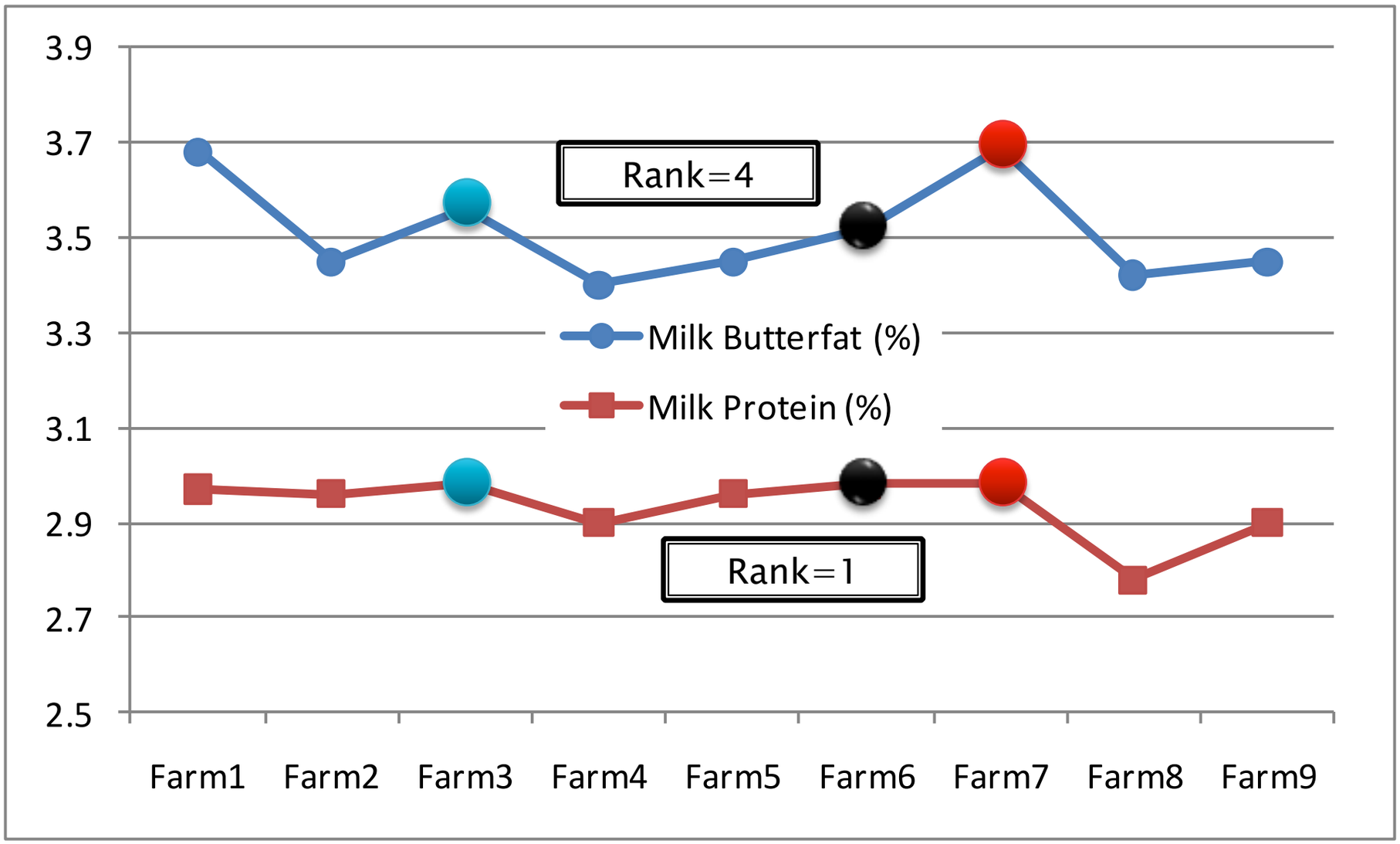
Dairy feed cost evaluator

Wisconsin case study: Milk price



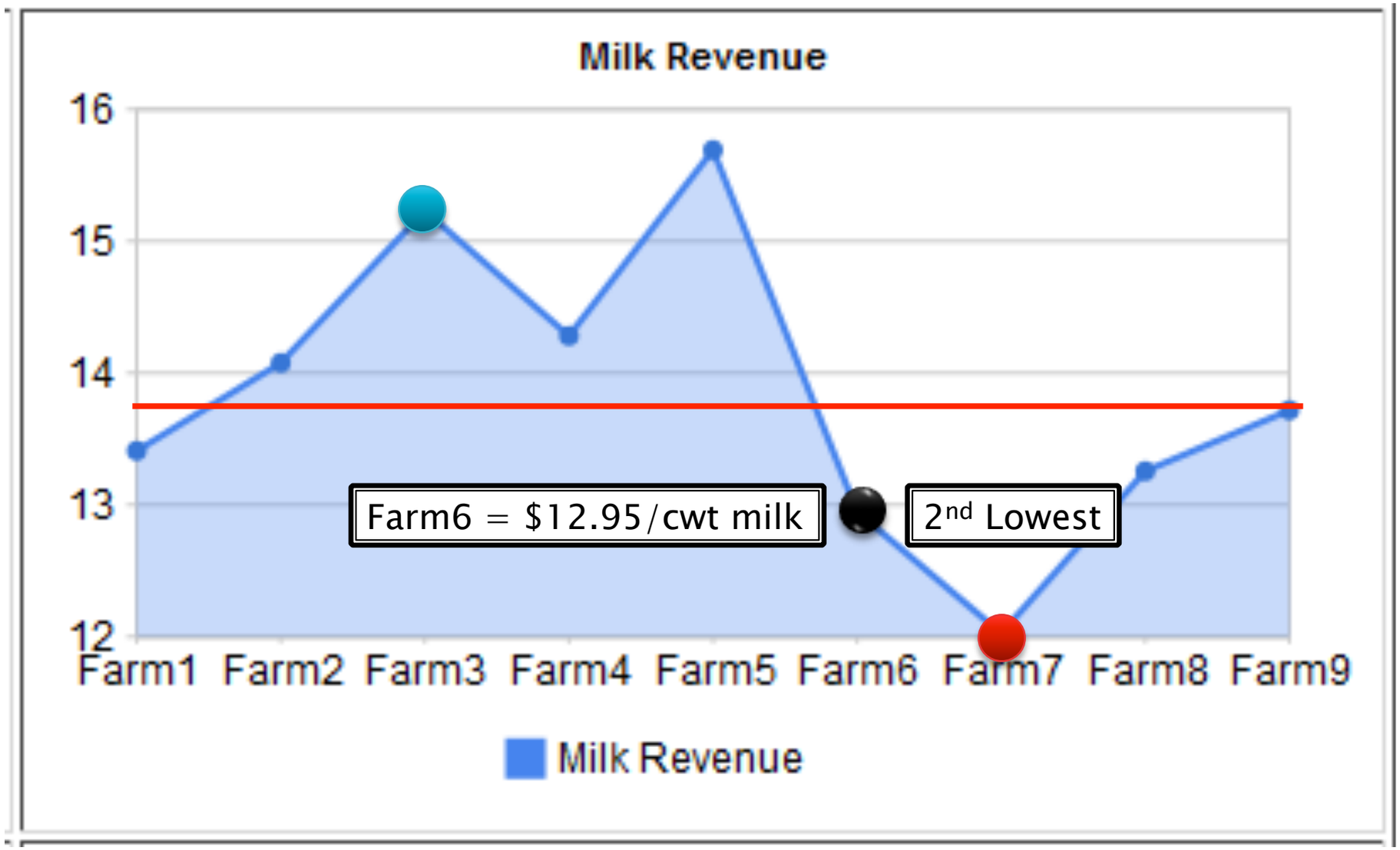
Dairy feed cost evaluator

Wisconsin case study: Milk components



Dairy feed cost evaluator

Wisconsin case study: Milk revenue



Dairy feed cost evaluator

Farm6 improvement plan

Look for better milk price
Good milk components,
but lowest price received:
Opportunity to negotiate

Improve feed efficiency
Look for enhanced
production at DMI level
Maintain production at
lower DMI level
Check feed quality
permanently

Reduce feed costs
Homegrown and
purchased
Forages and concentrates

Thanks