



# **Exploring Methods to Assess the Economic Value of Dairy Cattle Reproductive Programs**

**2011 ASAS/ADSA Midwest Meeting**

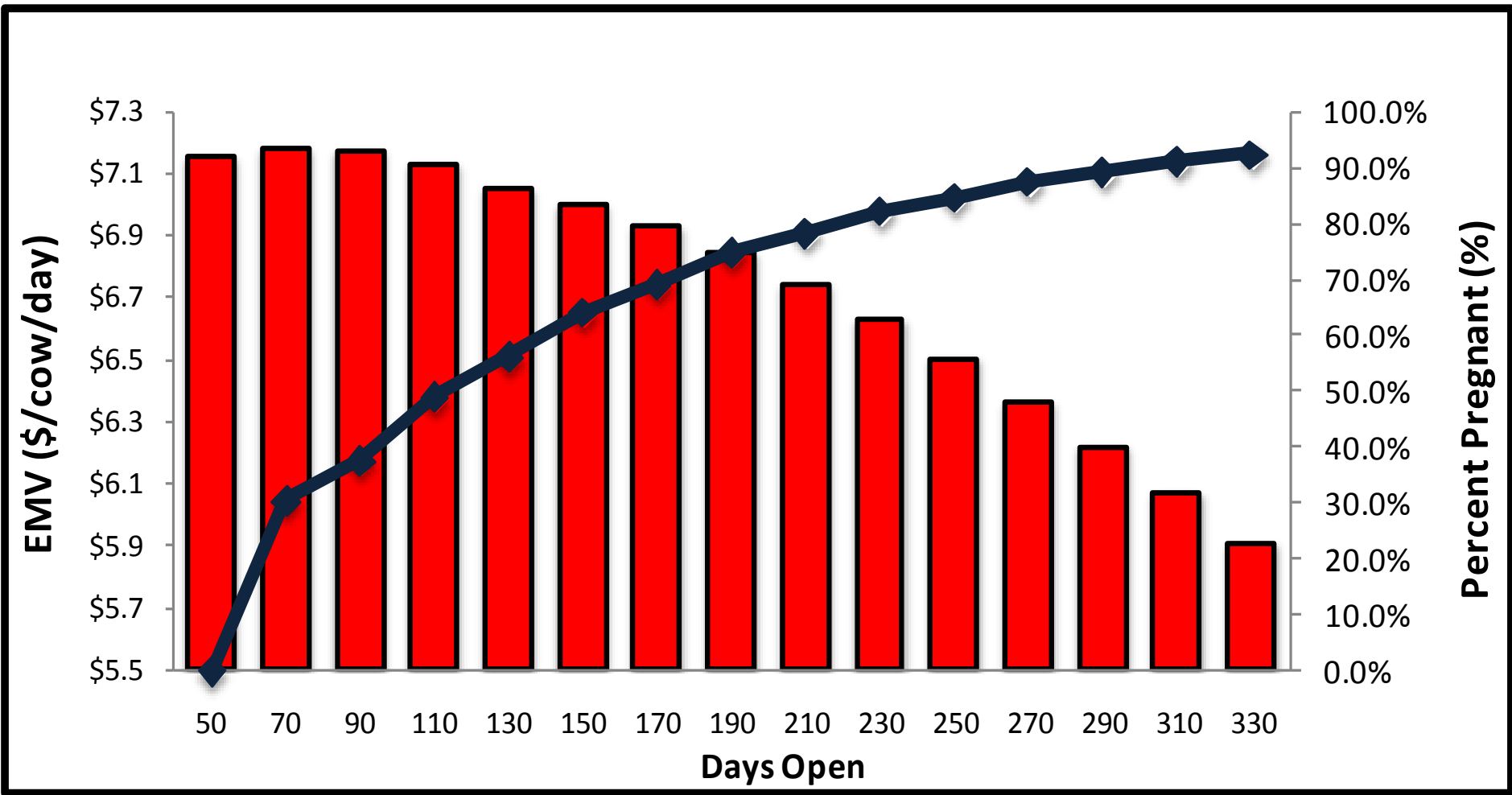
**Victor E. Cabrera**

# **Dairy cattle reproductive performance associated with profitability**

**Louca and Legates, 1968**  
**Britt, 1985**  
**Lima et al., 2010**



# Expected monetary value (EMV) and reproductive survival curve



# **Economic assessment of economic value is difficult and complex**

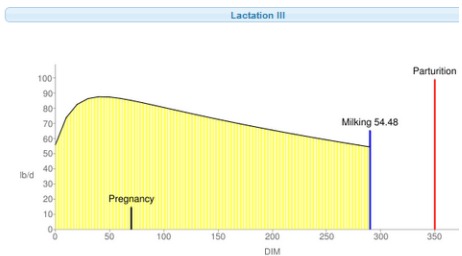
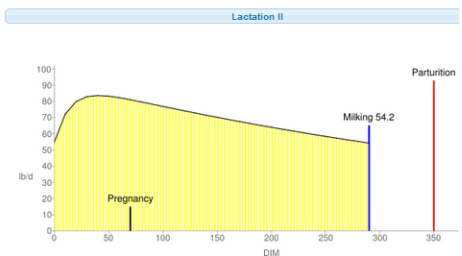
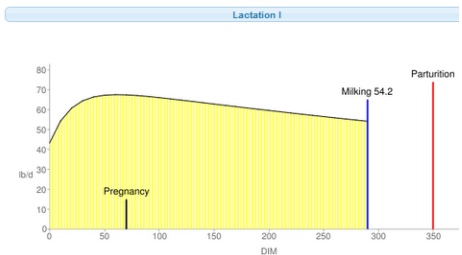
**Fricke et al., 2008**  
**Cabrera and Giordano, 2010**

Dairy Management UW-Extension  
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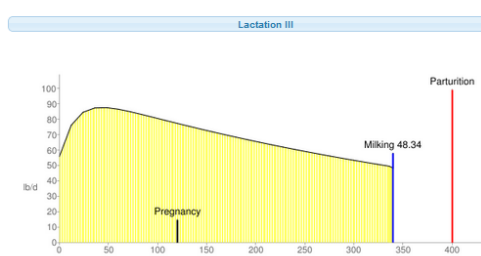
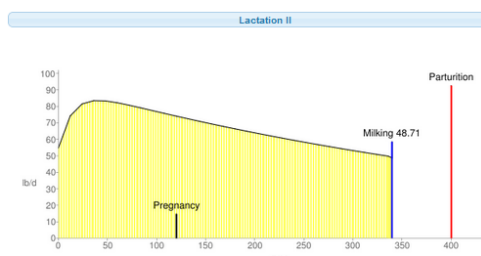
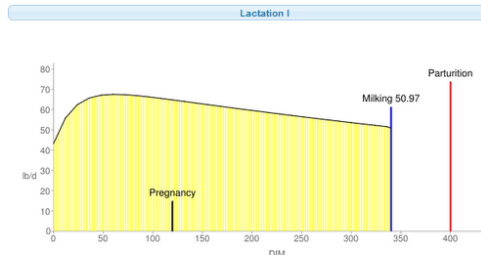
# Milk production and productivity depends on reproductive performance

## 60 d Pregnant



**20,502 lb/cow/yr**

## 120 d Pregnant

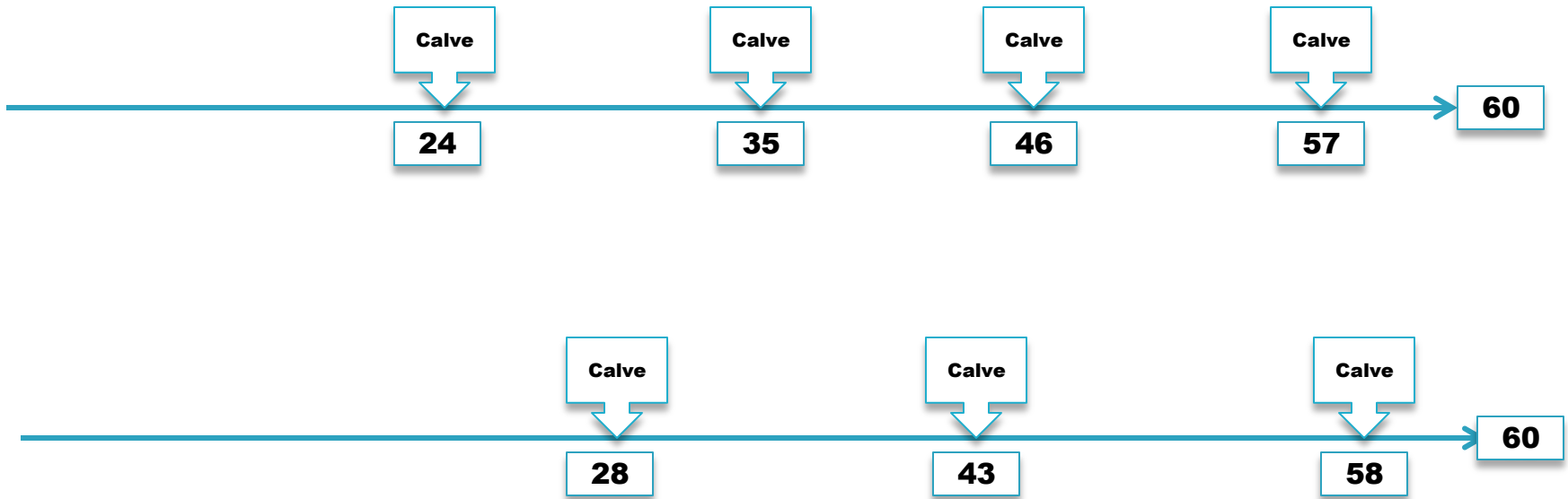


**\$20,306 lb/cow/yr**

**Eg., 60 d less =  
↑200 lb/cow/yr**



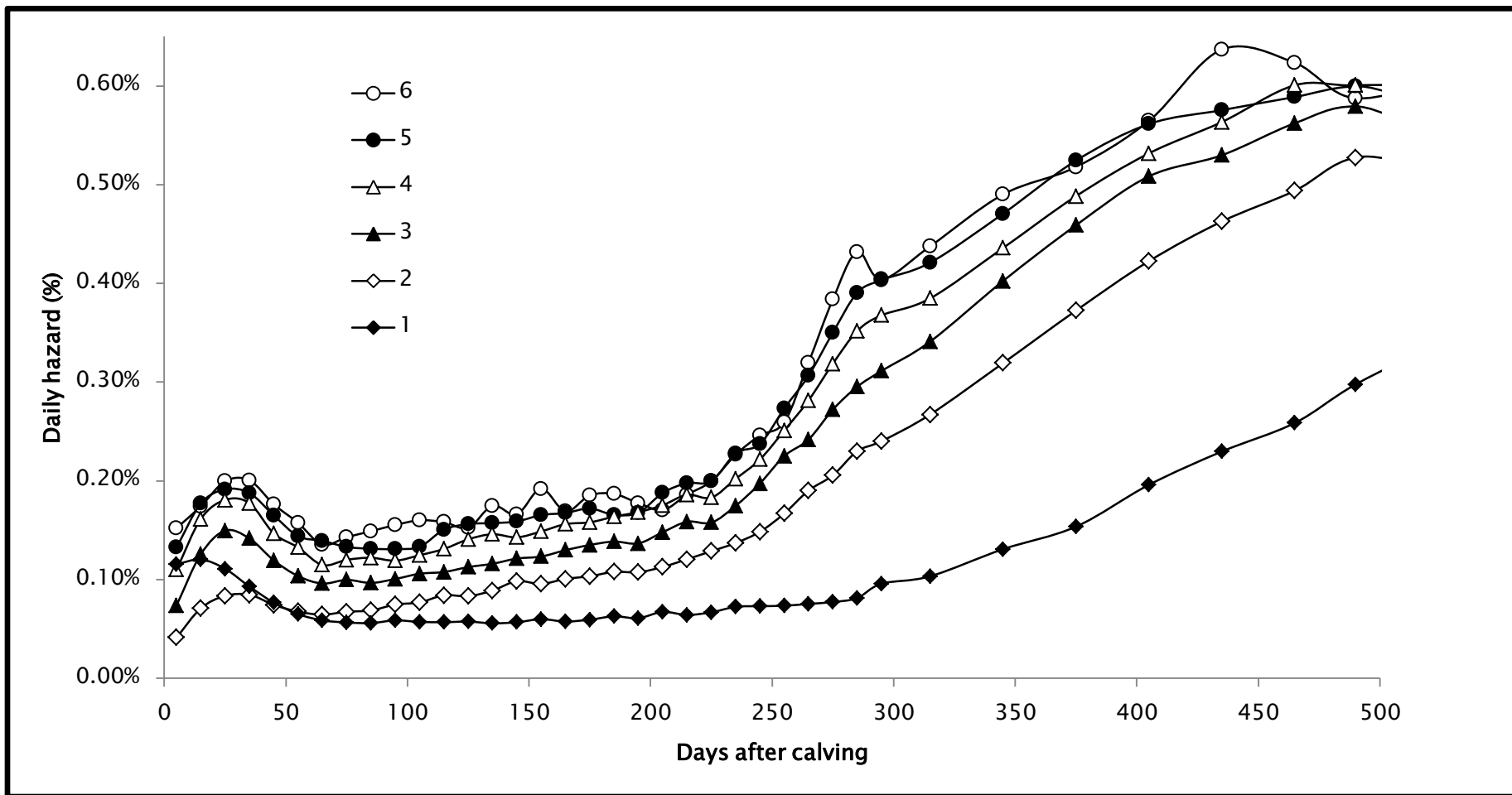
# Number of offspring depends on reproductive performance



**Eg., better  
repro =  
1 more  
calving**



# Involuntary culling and mortality depends on reproductive performance

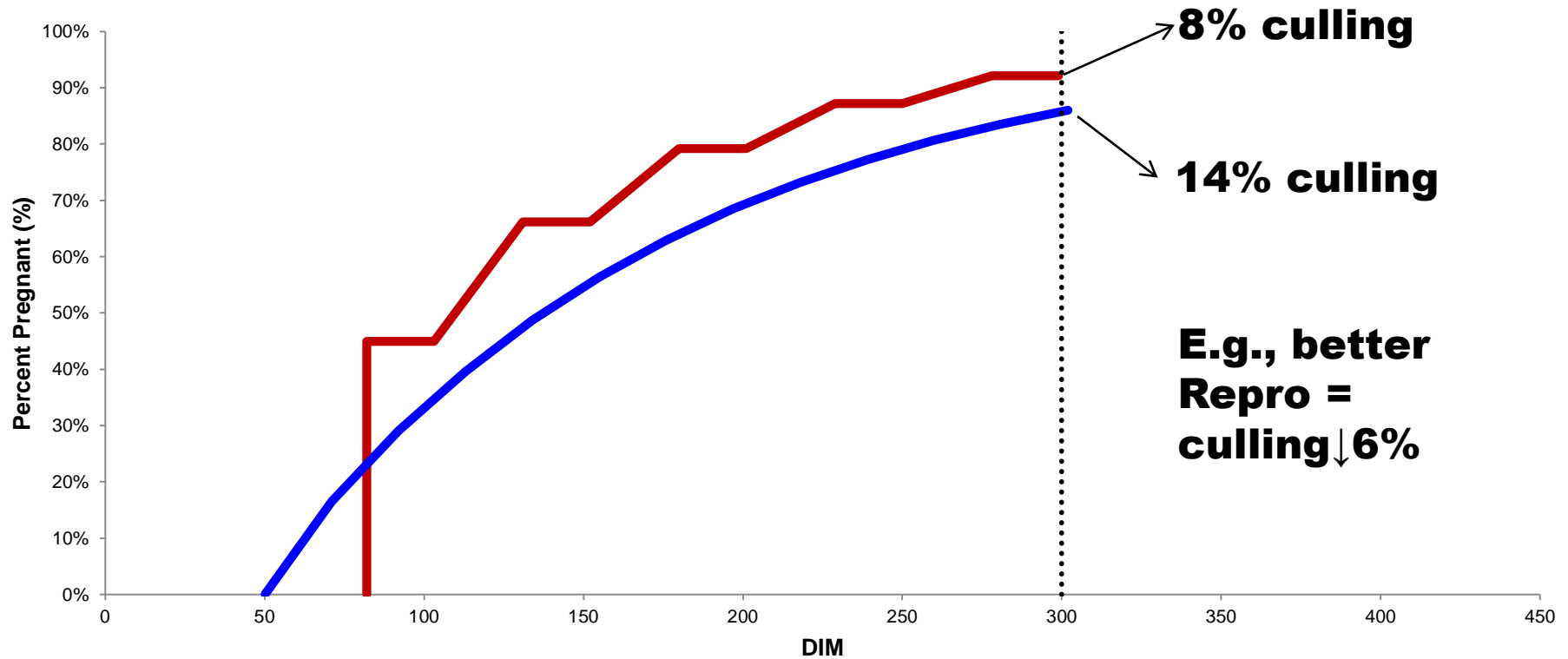


**E.g., 2<sup>nd</sup> parity 60 d after  
340 d = ↑21% cull risk**

**De Vries et al., 2010**

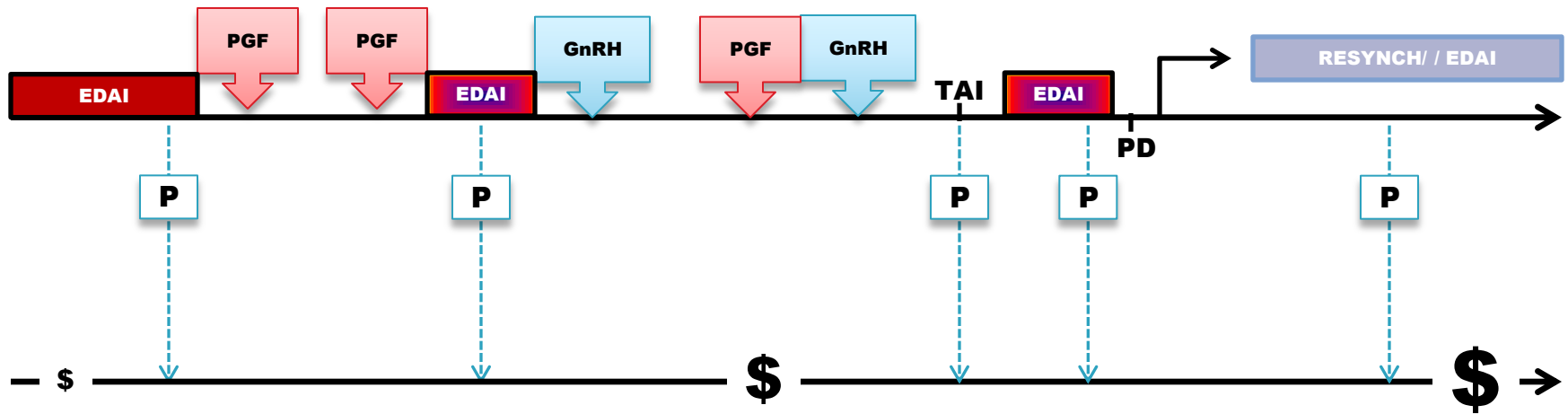


# Voluntary culling (reproductive failure) depends on reproductive performance





# Reproductive program costs depends on reproductive performance



**There is a NEED for a suite of  
methodological options**



# Adjusted Partial Cash Flows (APCF)



# UW-DairyRepro\$: A reproductive economic analysis tool



**UW-Dairy Repro\$**  
Victor E. Cabrera & Julio O. Giordano  
Department of Dairy Science



Farm Name **Farm A** Location **Wisconsin**

1. Productive Parameters		
Lactating Cows (#)		1,688
Rolling Herd Average (RHA) (lb/cow/y)	30000	
Involuntary Culling Rate (%/y)		29.4%
Mortality Rate (%/y)		6.9%
Stillbirth Rate (%)		9.0%

2. Lactation Curves			
	Lact. 1	Lact. 2	Lact. > 2
Cow Number	778	469	441
Body Weight (lb/cow)	1,350	1,400	1,450
Test	Define Lactation Curves Below		
1	15	61	86
2	45	81	107
3	75	90	110
4	105	94	107
5	135	93	100
6	165	90	92
7	195	91	84
8	225	87	77
9	255	85	74
10	285	83	65
11	315	78	62
12	345	72	53
13	375	68	52
14	405	63	59
15	435	51	51
16	465	51	43
17	495	51	35
18	525	47	30
19	555	44	25

3. Economic Parameters		Check if total breeding costs are known
Milk Price (\$/cwt)	16.97	
Cost Feed Lactating (DM) (\$/lb)	0.10	
Dry Period Fixed Cost (\$/d)	2.20	
Female Calf Value (\$/calf)	108	
Male Calf value (\$/calf)	40	
Heifer Replacement Value (\$/heifer)	1,288	
Salvage Value (\$/cow)	624	
Labor Cost for Injection (\$/hr)	15.00	
Heat Detection Cost (\$/hr)	15.00	
Artificial Insemination Cost (\$/cow)	10.00	
Interest Rate (%/y)	6.5%	

4. Pregnancy Diagnosis Cost		Current	Alternative	100% HD
Palpation (\$/hr)		105		105
Ultrasound (\$/hr)			135	
Blood Test (\$/cow)				

5.a. Reproductive Program		Start day	Alternative	Start day
1 <sup>st</sup> Service Postpartum	Double-Ovsynch	Fri	Double-Ovsynch	Fri
2 <sup>nd</sup> and Subsequent Services	Ovsynch	Mon	Double-Ovsynch	Fri
Resynch before preg check	YES		YES	

5.b. Reproductive Program Parameters			
	Current	Alternative	100% HD
Voluntary Waiting Period (d)	82	82	50
Estrus Cycle Duration (d)		21	
Maximum DIM for Breeding		300	
DIM to 1 <sup>st</sup> TAI (d)	82	82	
Interbreeding Interval (d)	42	49	
Heat Bred Before 1 <sup>st</sup> TAI (%)	0%	0%	50%
CR Heat Bred Before 1 <sup>st</sup> TAI (%)	0%	0%	33%
Heat Bred After 1 <sup>st</sup> TAI (%)	0%	0%	50%
CR Heat Bred After 1 <sup>st</sup> TAI (%)	0%	0%	30%
CR 1 <sup>st</sup> Service TAI (%)	45%	45%	
CR 2 <sup>nd</sup> + Services TAI (%)	30%	39%	
Projected Calving Interval (mo)		14.1	
Days Open (d)		70	



**UW-Dairy Repro\$**  
Victor E. Cabrera & Julio O. Giordano  
Department of Dairy Science



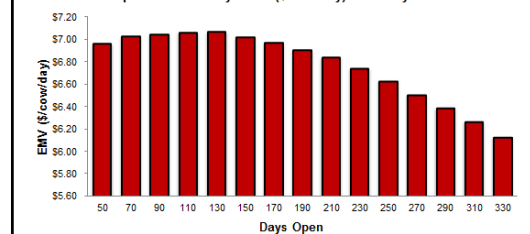
## 1. Productive and Economic Parameters Summary

Cows in Parity All (#)	1688
Rolling Herd Average (RHA) (lb/cow/y)	30000
Milk Price (\$/cwt)	16.97
Average Value New Born (\$)	71
Heifer Replacement Value (\$)	1,288
Salvage Value (\$)	624

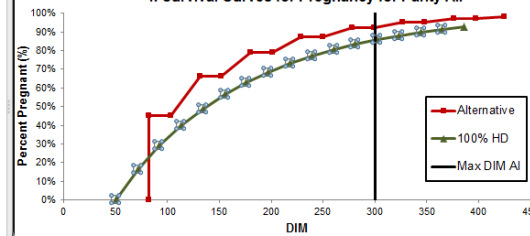
## 2. Reproductive Programs Summary

	Current	Alternative	Baseline
1 <sup>st</sup> Service Postpartum	Double-Ovsynch	Double-Ovsynch	Heat Breeding
2 <sup>nd</sup> and Following Services	Ovsynch	Double-Ovsynch	Heat Breeding
Voluntary Waiting Period	82d	82d	50d
Maximum DIM for Breeding		300d	
DIM 1st TAI	82d	82d	
Interbreeding Interval	42d	49d	21d
Heat Bred Before 1 <sup>st</sup> TAI	0%	0%	50%
CR Heat Bred Before 1 <sup>st</sup> TAI	0%	0%	33%
Heat Bred After 1 <sup>st</sup> TAI	0%	0%	50%
CR Heat Bred After 1 <sup>st</sup> TAI	0%	0%	30%
CR 1 <sup>st</sup> Service TAI	45%	45%	
CR 2 <sup>nd</sup> + Services TAI	30%	39%	
21d-Pregnancy Rate	22%	25%	15%
21d-Service Rate	61%	61%	50%
Average CR all breedings	38%	42%	32%
Days Open (d)	131	130	142
Projected Calving Interval (mo)	14.0	14.0	14.7
Cost 1st Service Breeding	\$29.17	\$29.23	
Cost Resynch Breedings	\$21.00	\$29.23	
Cost Heat Breedings	\$13.04	\$13.55	\$13.06
Pregnancy Diagnosis Method	Palpation	Ultrasound	Palpation
Pregnancy Diagnosis Cost	3.00	3.55	3.06

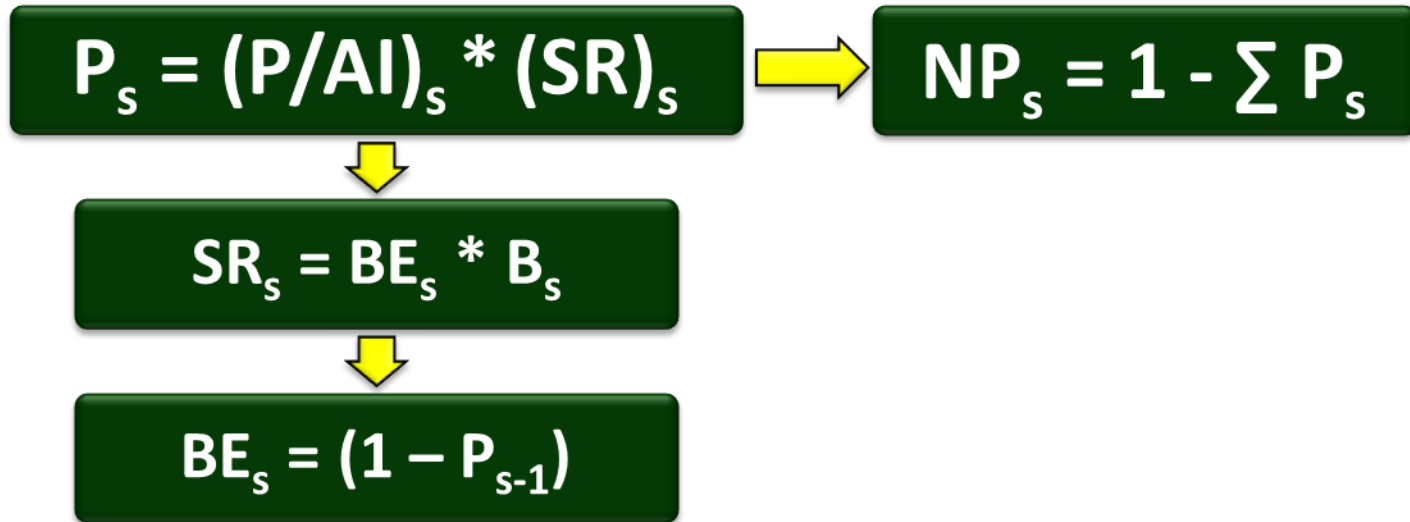
## 3. Expected Monetary Value (\$/cow/day) for Parity All



## 4. Survival Curves for Pregnancy for Parity All



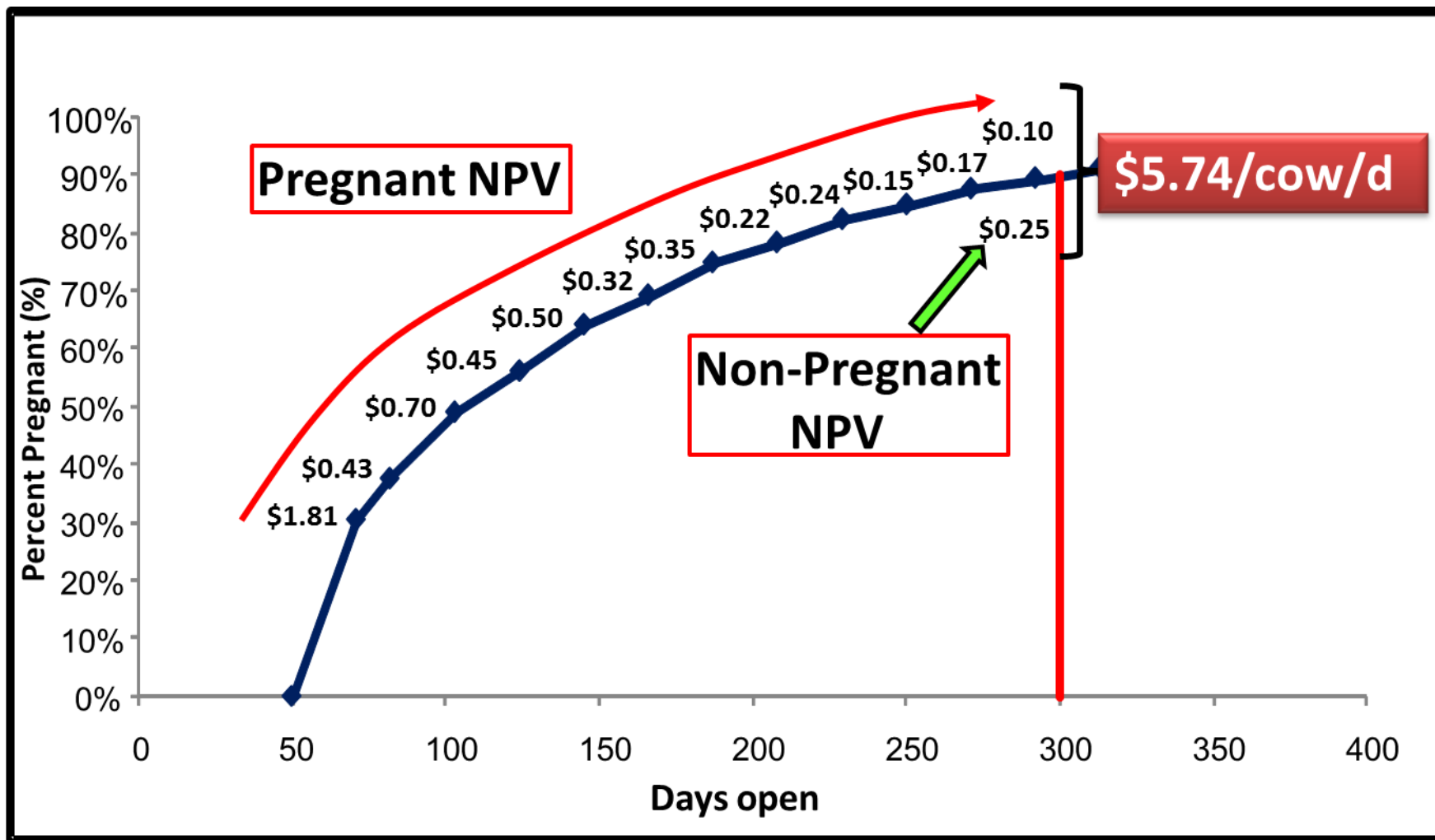
# UW-DairyRepro\$: Reproductive performance



	Days Open	Pregnant	Non-Pregnant	Available	AI	Pregnant Period	Open Period
VWP	50	0.00%	100.00%	100.00%	0.00%		
Heat Bred	71	30.40%	69.60%	100.00%	80.00%	30.40%	49.60%
1 <sup>st</sup> TAI	82	37.60%	62.40%	20.00%	20.00%	7.20%	12.80%
Heat Bred	103	48.96%	51.04%	62.40%	40.56%	11.36%	29.20%
2 <sup>nd</sup> TAI	124	56.16%	43.84%	21.84%	21.84%	7.21%	14.63%



# UW-DairyRepro\$: Economic performance



$$NPV = \sum DEMV (P) + DEMV (NP)$$

**DEMV = f(milk, feed, new born, culling, mortality, breeding)**



# UW-DairyRepro\$: Case study

		<b>Program A</b>	<b>Program B</b>	<b>Program C</b>
<b>First service postpartum</b>		<b>Double-Ovsynch</b>		<b>Estrus Detection</b>
<b>Second and subsequent services</b>		<b>Resynch-D32</b>	<b>Double-Ovsynch</b>	<b>Estrus Detection</b>
<b>Voluntary waiting period (VWP)</b>	<b>(d)</b>	<b>82</b>	<b>82</b>	<b>50</b>
<b>Interbreeding interval (IBI)</b>	<b>(d)</b>	<b>42</b>	<b>49</b>	<b>21</b>
<b>CR<sup>2</sup> 1<sup>st</sup> service postpartum</b>	<b>(%)</b>	<b>45</b>	<b>45</b>	<b>33</b>
<b>CR 2<sup>nd</sup> and later AI services</b>	<b>(%)</b>	<b>30</b>	<b>38</b>	<b>30</b>

**Giordano et al., Unpublished**



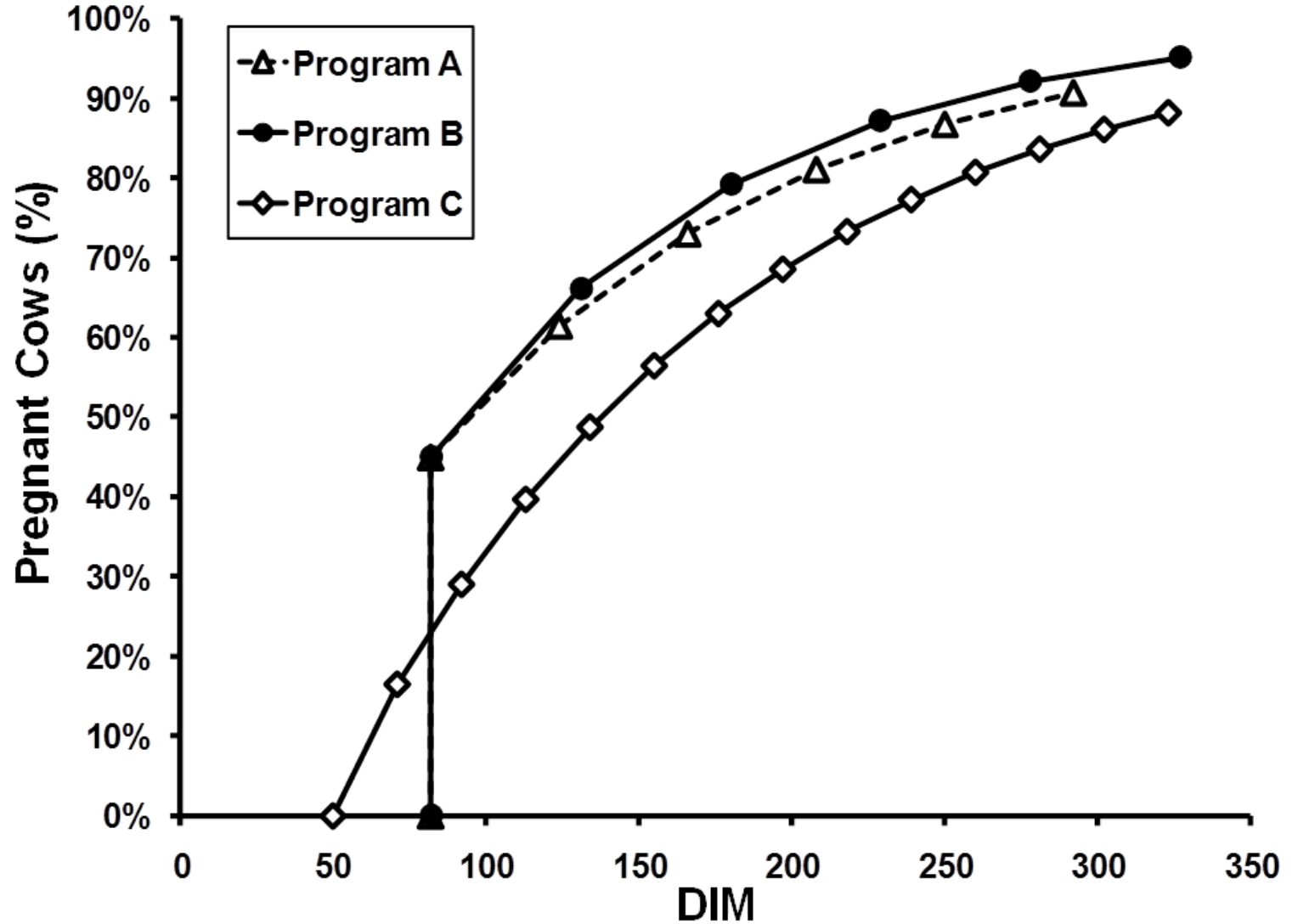
# UW-DairyRepro\$: Results

		Program A	Program B	Program C
<b>First service postpartum</b>		<b>Double-Ovsynch</b>		<b>Estrus Detection</b>
<b>Second and subsequent service</b>		<b>Resynch- D32</b>	<b>Double- Ovsynch</b>	<b>Estrus Detection</b>
<b>Reproductive parameters</b>				
<b>21d - Pregnancy rate</b>	(%)	<b>22</b>	<b>25</b>	<b>15</b>
<b>21d - Service rate</b>	(%)	<b>62</b>	<b>60</b>	<b>50</b>
<b>Average CR all AI services</b>	(%)	<b>38</b>	<b>42</b>	<b>32</b>
<b>Average days open</b>	(d)	<b>131</b>	<b>137</b>	<b>151</b>
<b>Projected calving interval</b>	(mo)	<b>14.1</b>	<b>14.0</b>	<b>14.9</b>





# UW-DairyRepro\$: Results



**Giordano et al., Unpublished**

Dairy Management UW-Extension  
University of Wisconsin-Madison

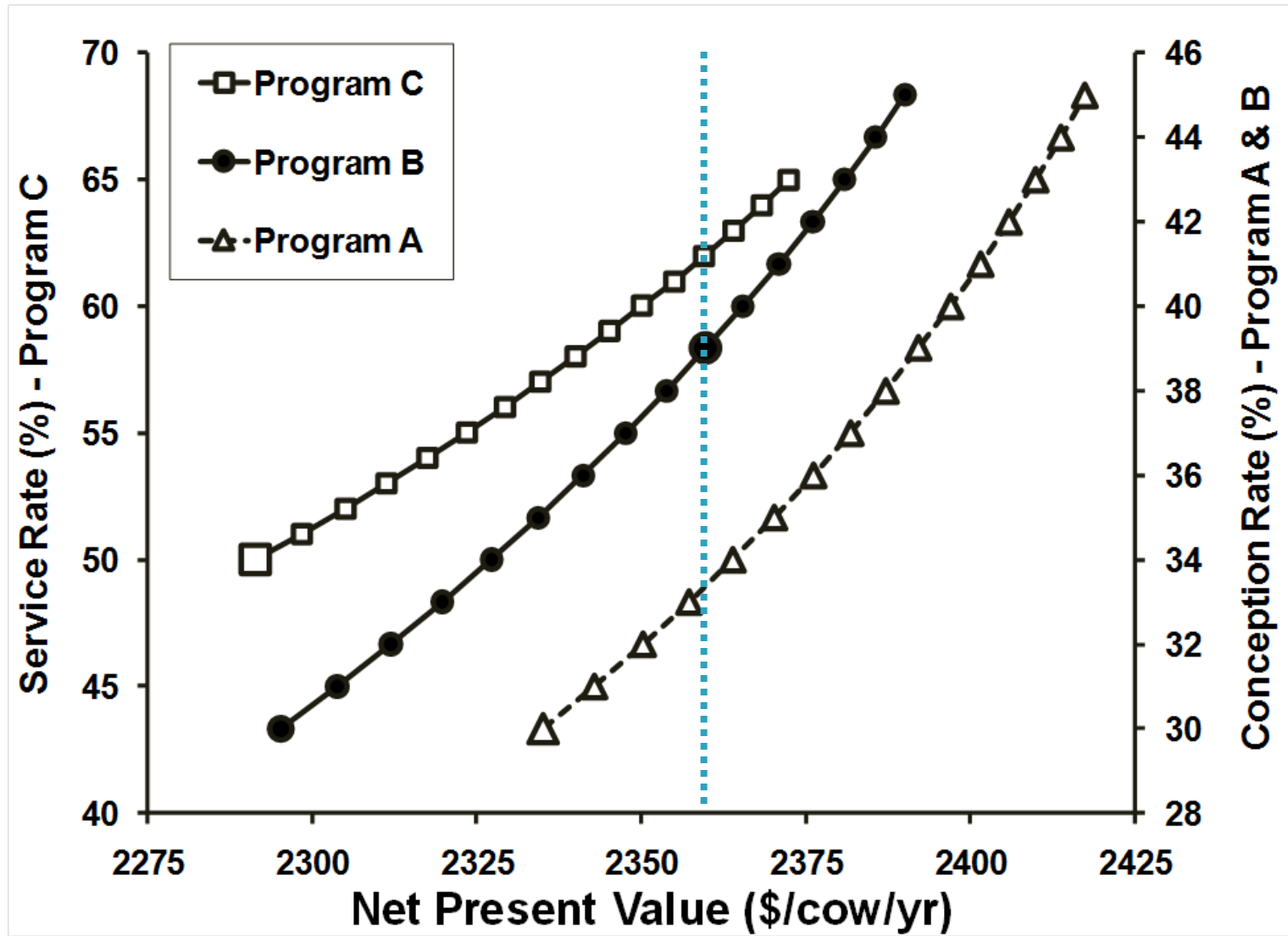


# UW-DairyRepro\$: Results (\$/cow/yr)

	Program A	Program B	Program C
First service postpartum	Double-Ovsynch		Estrus Detection
Second and subsequent service	Resynch-d32	Double-Ovsynch	Estrus Detection
Milk Income over feed cost	<b>2622.69</b>	<b><u>2633.44</u></b>	<b>2560.99</b>
Milk value	4235.41	4262.43	4141.67
Feed Cost Milking Period	1487.93	1500.72	1464.23
Feed Cost Dry Period	124.78	128.27	116.45
Culling and mortality cost	<b>-287.77</b>	<b><u>-274.43</u></b>	<b>-283.76</b>
Involuntary Culling Pregnant	-241.90	-250.97	-234.10
Involuntary Culling Non-pregnant	-13.53	-7.25	-15.34
Reproductive culling	-32.33	-16.21	-34.32
Reproductive program cost	<b>-54.36</b>	<b>-58.19</b>	<b><u>-36.67</u></b>
First service AI service cost <sup>1</sup>	29.17	29.23	13.06
Second and subsequent AI service cost <sup>1</sup>	21.0	29.23	13.06
Income from newborn	<b>54.56</b>	<b><u>56.09</u></b>	<b>50.92</b>
Value of reproductive program (NPV)	<b>2335.13</b>	<b><u>2356.91</u></b>	<b>2291.48</b>
Value over 100% ED program	<b>-43.65</b>	<b>-65.43</b>	



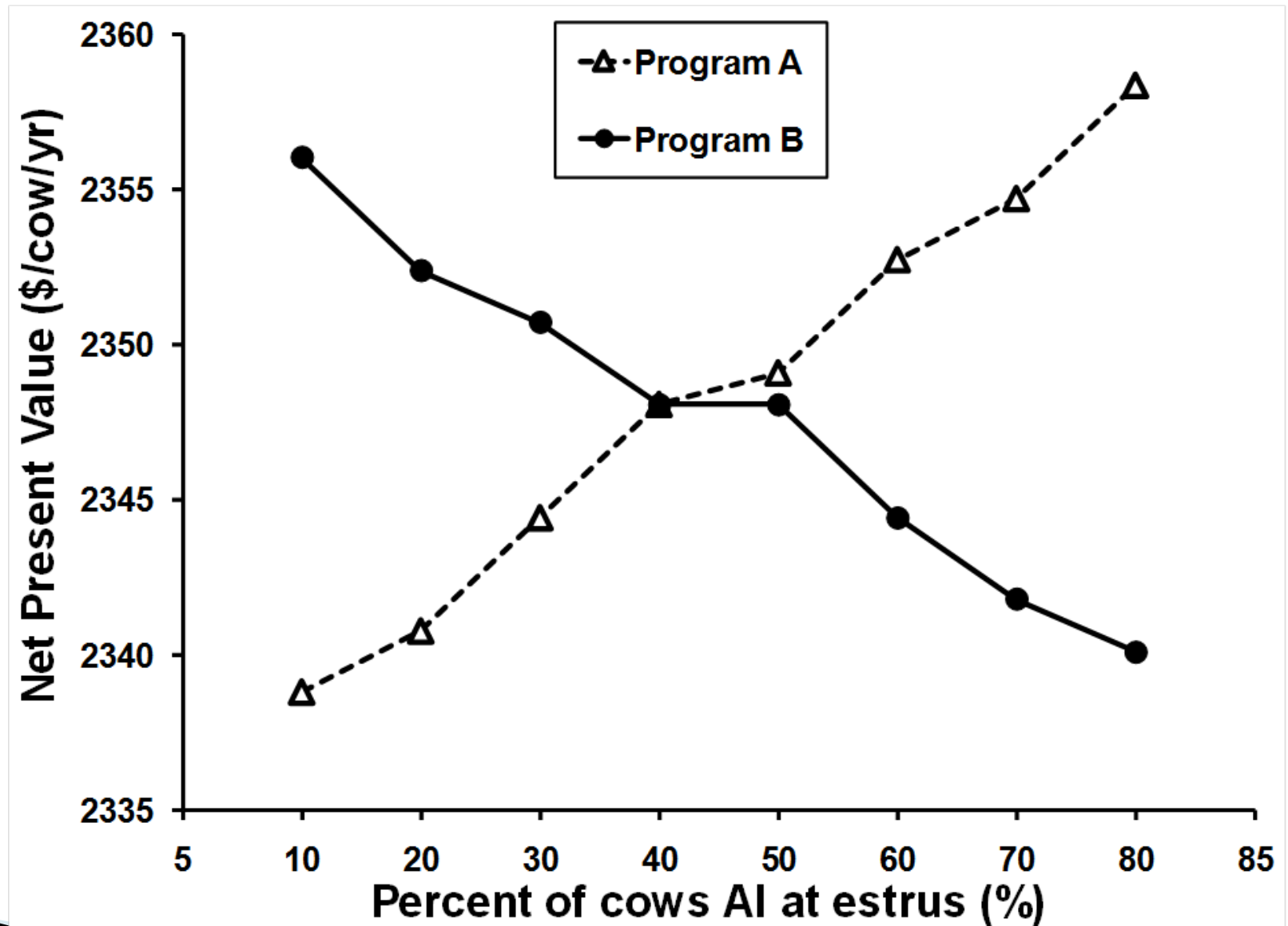
# UW-DairyRepro\$: Results



Giordano et al., Unpublished



# UW-DairyRepro\$: Results



**Giordano et al., Unpublished**



# Adjusted Partial Cash Flows (APCF)

## Strengths

- **Detailed definition repro programs**
- **Highly user-friendly application**
- **Farm-specific analysis**

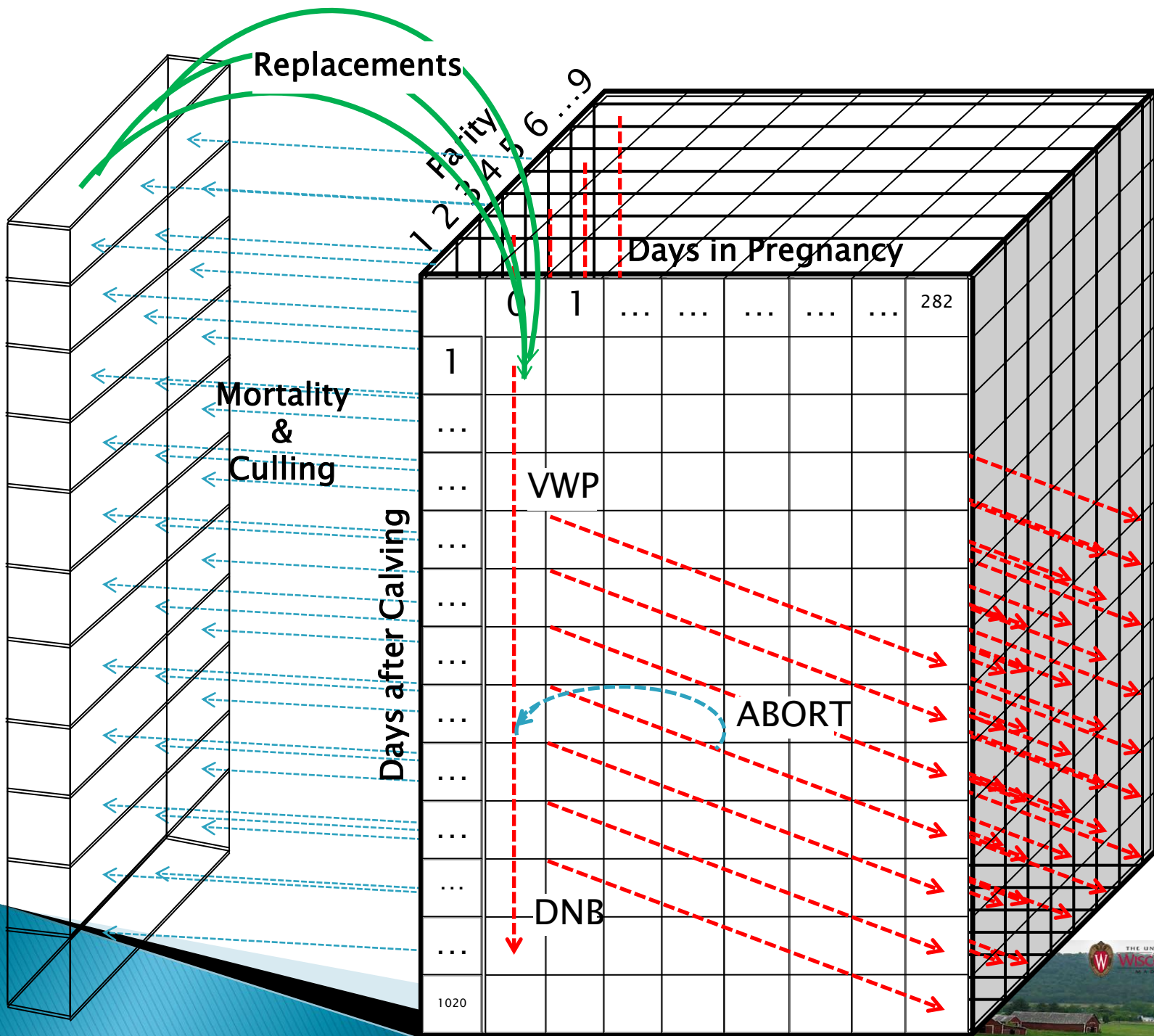
## Limitations

- **No iterations among lactations**
- **No abortions**
- **All AI during fixed 21-d estrous cycles**



# Daily Markov Chains (DMC)





# Daily Markov Chains: Case study

	Program 1	Program 2	Program 3
Type of program	100 % HD	100 % TAI	HD + TAI
1 <sup>st</sup> Service Program	Estrous Detection	Presynch-Ovsynch	Presynch-Ovsynch
2 <sup>nd</sup> Service Program	Estrous Detection	D32 Resynch	D32 Resynch
Voluntary Waiting Period (HD) (d)	<b>50</b>		<b>50</b>
Voluntary Waiting Period (TAI) (d)		<b>72</b>	<b>72</b>
Interbreeding Interval (d)	<b>21</b>	<b>42</b>	<b>42</b>
Maximum DIM for breeding (d)	<b>330</b>		
Milk production to remain in herd (kg)	<b>27.24</b>		

**Cabrera and Giordano, 2010**





# Daily Markov Chains: Case study

	Program 1	Program 2	Program 3
Type of program	100 % HD	100 % TAI	HD + TAI
1 <sup>st</sup> Service Program	Estrous Detection	Presynch-Ovsynch	Presynch-Ovsynch
2 <sup>nd</sup> Service Program	Estrous Detection	D32 Resynch	D32 Resynch
Bred at estrus before 1 <sup>st</sup> TAI (%)			<b>60</b>
CR Bred at estrus before 1 <sup>st</sup> TAI (%)			<b>28</b>
Bred at Estrus after 1 <sup>st</sup> TAI (%)			<b>60</b>
CR Bred at estrus after 1 <sup>st</sup> TAI (%)			<b>28</b>

**Cabrera and Giordano, 2010**



# Daily Markov Chains: Case study

	Program 1	Program 2	Program 3
Type of program	100 % HD	100 % TAI	HD + TAI
1 <sup>st</sup> Service Program	Estrous Detection	Presynch-Ovsynch	Presynch-Ovsynch
2 <sup>nd</sup> Service Program	Estrous Detection	D32 Resynch	D32 Resynch
CR 1 <sup>st</sup> Service TAI (%)		<b>42</b>	<b>32</b>
CR 2 <sup>nd</sup> + Service TAI (%)		<b>30</b>	<b>28</b>
HD rate 1 <sup>st</sup> AI (%)	<b>50</b>		
CR 1 <sup>st</sup> AI (%)	<b>30</b>		
HD rate $\geq$ 2 <sup>nd</sup> AI (%)	<b>50</b>		
CR $\geq$ 2 <sup>nd</sup> AI (%)	<b>28</b>		

**Cabrera and Giordano, 2010**

# Daily Markov Chains: Results

Type of program	Program 1 100 % HD	Program 2 100 % TAI	Program 3 HD + TAI
1 <sup>st</sup> parity cows (%)	42.20	33.94	38.60
2 <sup>nd</sup> parity cows (%)	25.84	24.73	25.44
3 <sup>rd</sup> parity cows (%)	15.49	17.14	16.28
4 <sup>th</sup> parity cows (%)	8.63	11.14	9.74
5 <sup>th</sup> parity cows (%)	4.61	6.96	5.60
6 <sup>th</sup> parity cows (%)	2.17	3.78	2.82
7 <sup>th</sup> parity cows (%)	0.74	1.51	1.04
8 <sup>th</sup> parity cows (%)	0.25	0.60	0.38
9 <sup>th</sup> parity cows (%)	0.09	0.24	0.14

**Cabrera and Giordano, 2010**



# Daily Markov Chains: Results

	Program 1 100 % HD	Program 2 100 % TAI	Program 3 HD + TAI
50 d VWP 21-d PR (%)	<b>12</b>	<b>17</b>	<b>15</b>
72 d VWP 21-d PR (%)	---	<b>21</b>	---
Herd pregnant cows <sup>1</sup> (%)	<b>44.65</b>	<b>52.12</b>	<b>48.24</b>
Days open <sup>2</sup> (d)	<b>147</b>	<b>130</b>	<b>134</b>
Average DIM <sup>3</sup> (d)	<b>187</b>	<b>178</b>	<b>182</b>
Lactating population (%)	<b>90</b>	<b>88</b>	<b>89</b>

<sup>1</sup>Animals that were  $\geq 35$  d in gestation

<sup>2</sup>Average number of days in milk at which cows became pregnant

<sup>3</sup>Average number of days in milk of all herd

**Cabrera and Giordano, 2010**



# Daily Markov Chains: Results

Program 1	Program 2	Program 3
100 % HD	100 % TAI	HD + TAI

-----\$/cow/yr-----

Value of reproductive program	2,546.63	<u>2,584.29</u>	2,571.19
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Value over 100% HD	---	37.66	24.56
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Income from newborn	187.59	<u>217.34</u>	202.04
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Culling and mortality cost	-191.57	<u>-171.76</u>	-183.26
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Reproductive program cost	<u>-46.47</u>	-66.56	-50.07
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Milk income over feed cost	2,597.08	<u>2,605.26</u>	2,602.48
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# Daily Markov Chains (DMC)

## Strengths

- **Highly detailed herd/repro simulation**
- **Iterations among lactations**
- **Solid framework to study repro**

## Limitations

- **Large dimensions, data intense**
- **Imposed repro and culling policies**
- **Not a user-friendly application**



# Monthly Markov Chains (MMC)

Dairy Reproductive Economic Analysis



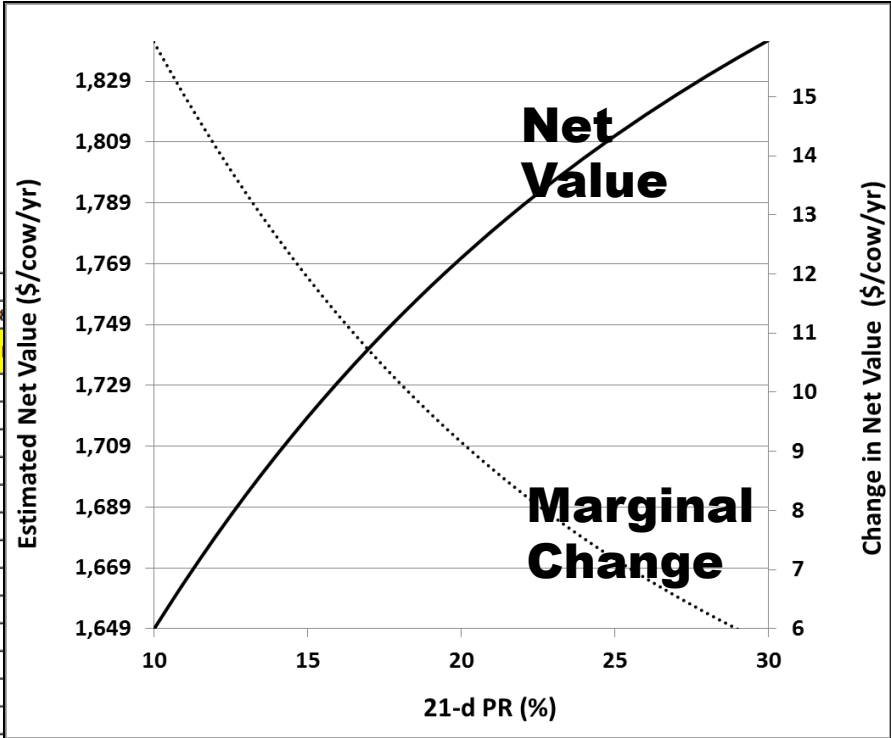
V.E. Cabrera

Overview Upload Repro Abort Cull Milk Economics Run Model Results Analyze

Total Number of Cows	100
Iterations Performed	709
Reached Steady State	YES

	Total Revenues & Costs				
	IOFC	Cull	Repro	Calves	Net Return
\$/herd/month	15795.47	-1405.18	-1021.92	1028.3	14396.67
\$/herd/day	526.52	-46.84	-34.06	34.28	479.89
\$/cow/year	1921.78	-170.96	-124.33	125.11	1751.6

Month in Milk	Month in Pregnancy										Cull Cows	IOFC	Cull	Revenues	Costs	Net
	0	1	2	3	4	5	6	7	8	9						
	Lactation 1															
1	3.35										0.14	453.19	-66.23			
2	3.21										0.09	594.15	-43.03			
3	2.56	0.56									0.05	616.65	-26.48			
4	2.06	0.45	0.56								0.05	603.35	-22.81			
5	1.67	0.36	0.45	0.54							0.04	577.58	-19.77			
6	1.37	0.30	0.36	0.43	0.52						0.04	548.93	-18.17			
7	1.13	0.24	0.29	0.35	0.42	0.51					0.04	515.73	-17.44			
8	0.94	0.20	0.24	0.28	0.34	0.41	0.50				0.03	480.32	-16.79			
9	0.77	0.16	0.20	0.23	0.27	0.33	0.41	0.50			0.03	444.20	-16.82			
10	0.64	0.14	0.16	0.19	0.22	0.27	0.33	0.40	0.49		0.04	305.35	-17.70			
11	0.52	0.11	0.13	0.16	0.18	0.22	0.26	0.32	0.40	0.49	0.04	196.86	-19.31			
12	0.43	0.09	0.11	0.13	0.15	0.18	0.22	0.26	0.32	0.39	0.04	152.38	-17.76			
13	0.42		0.09	0.11	0.13	0.15	0.18	0.21	0.26	0.31	0.04	117.16	-17.53			
14	0.41			0.09	0.10	0.12	0.15	0.18	0.21	0.26	0.04	88.57	-18.74	0.00	51.22	
15	0.38				0.08	0.10	0.12	0.15	0.18	0.21	0.04	65.09	-19.10	0.00	42.02	
16	0.35					0.08	0.10	0.12	0.14	0.17	0.04	46.03	-18.82	0.00	34.63	
17	0.32						0.08	0.10	0.12	0.14	0.04	31.13	-18.83	0.00	28.57	
18	0.29							0.08	0.10	0.12	0.04	19.51	-18.95	0.00	23.54	
19	0.25								0.08	0.10	0.26	10.50	-17.49	0.00	19.33	
20	0.00									0.08	0.00	-6.62	-0.53	0.00	15.78	
21											0.00	0.00	0.00	0.00	0.00	
22											0.00	0.00	0.00	0.00	0.00	
23											0.00	0.00	0.00	0.00	0.00	
24											0.00	0.00	0.00	0.00	0.00	
25											0.00	0.00	0.00	0.00	0.00	



<http://dairymgt.info/markov/>

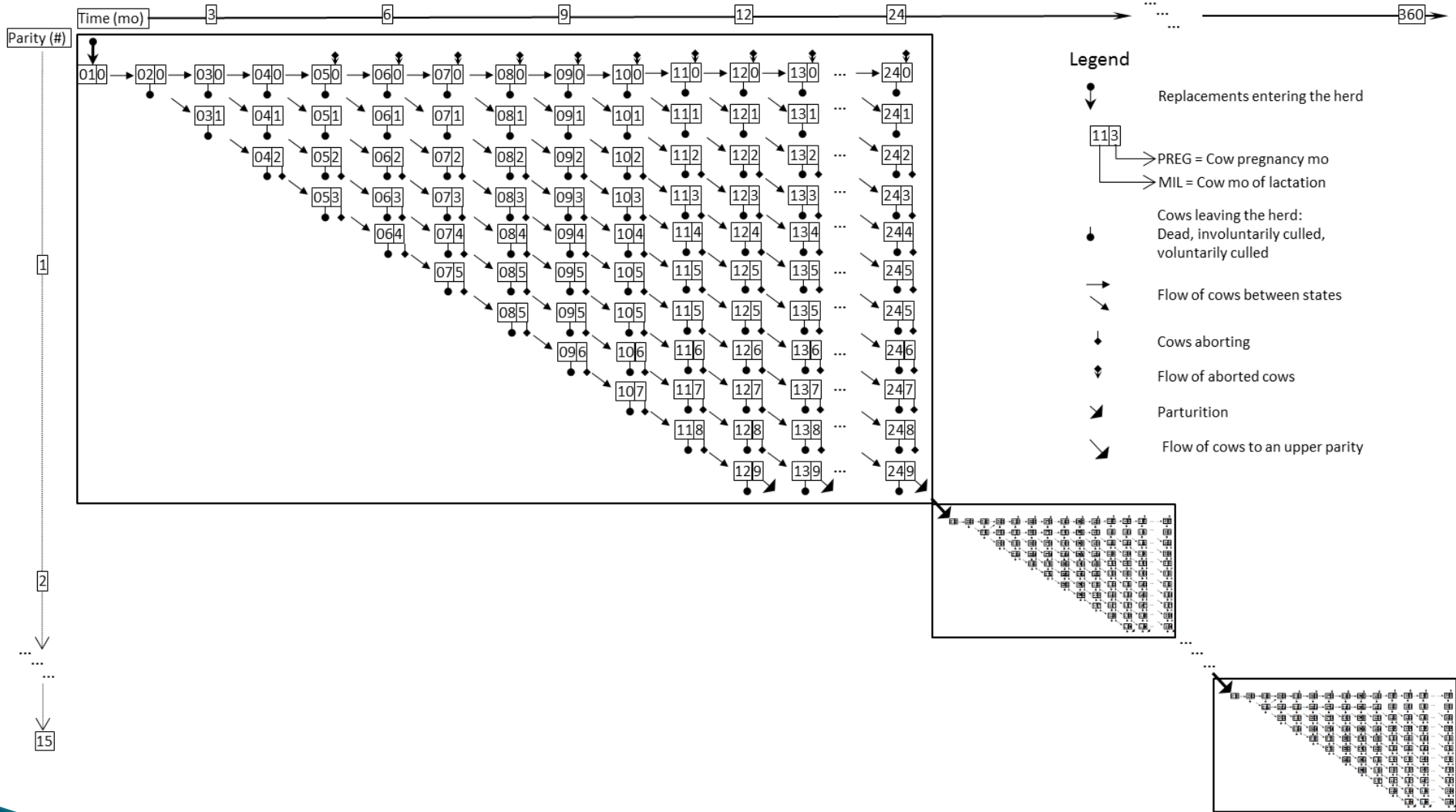


# Dynamic Programming (DP)





# DP in a Linear Program Framework



Cabrera, 2010

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# DP in a Linear Program Framework

$$\text{Optimum economic solution} = \max \sum_{i=1}^{792} \sum_{k=1}^2 y_{ik} NR_{ik}$$

$$y_{ik} \geq 0 \text{ for } i \text{ and } k \quad \sum_{i=1}^{792} \sum_{k=1}^2 y_{ik} = 1 \quad \sum_{k=1}^2 y_{ik} - \sum_{i=1}^{792} \sum_{k=1}^2 y_{ik} P_{ijk} = 0$$

$i$  = cow state

$k$  = decision to keep (1) or replace (2)

$y_{ik}$  = steady state proportion of state  $i$  when decision  $k$  is made

$NR_{ik}$  = net revenue for state  $i$  when decision  $k$  is made



# Dynamic Programming: Case Study

	Reproductive Program (1 <sup>st</sup> TAI 2 <sup>nd</sup> +TAI)	VWP 1 <sup>st</sup> TAI (d)	Interbreeding Interval (d)	Method of PD <sup>2</sup>	CR <sup>3</sup>		Cost <sup>4</sup>	
					(%)	(%)	(\$)	(\$)
					1 <sup>st</sup> TAI	2 <sup>nd</sup> +TAI	1 <sup>st</sup> TAI	2 <sup>nd</sup> TAI
1	Presynch-Ovsynch 12 Ovsynch	75	42	Ultrasound	42	30	36.18	28.87
2	Presynch-Ovsynch 12 Ovsynch	75	49	Palpation	42	28	34.80	27.48
3	Presynch-Ovsynch 14 Ovsynch	75	42	Ultrasound	37	30	34.95	28.34
4	Ovsynch Ovsynch	65	49	Palpation	33	28	27.17	27.17
5	Ovsynch Ovsynch	65	42	Ultrasound	33	30	28.56	28.56
6	Double-Ovsynch Ovsynch	80	42	Ultrasound	47	30	39.02	27.63
7	Double-Ovsynch Ovsynch	80	49	Palpation	47	28	37.70	26.32
8	Double-Ovsynch Double-Ovsynch	80	49	Ultrasound	47	38	39.90	39.90
9	G-6-G G-6-G	80	49	Ultrasound	45	35	35.50	35.50
10	G-6-G Ovsynch	80	42	Ultrasound	45	30	35.50	27.63



# Dynamic Programming: Results

	Reproductive Program (1 <sup>st</sup> TAI 2 <sup>nd</sup> +TAI)	Maximum Net Return		1 <sup>st</sup> Parity		2 <sup>nd</sup> Parity		≥3 <sup>rd</sup> Parity	
		(\$/cow/yr)	Rank	DIM to last Service (d)	Number of Services (#)	DIM to last Service (d)	Number of Services (#)	DIM to last Service (d)	Number of Services (#)
1	Presynch-Ovsynch 12 Ovsynch	1613.55	4	369	8	285	6	243	5
2	Presynch-Ovsynch 12 Ovsynch	1604.04	9	369	7	271	5	271	5
3	Presynch-Ovsynch 14 Ovsynch	1606.35	8	369	8	285	6	285	6
4	Ovsynch Ovsynch	1598.46	10	359	7	310	6	261	5
5	Ovsynch Ovsynch	1610.06	7	359	8	275	6	275	6
6	Double-Ovsynch Ovsynch	1619.30	1	332	7	290	6	248	5
7	Double-Ovsynch Ovsynch	1610.49	6	374	7	276	5	276	5
8	Double-Ovsynch Double-Ovsynch	1614.58	3	325	6	276	5	276	5
9	G-6-G G-6-G	1613.52	5	325	6	276	5	276	5
10	G-6-G Ovsynch	1618.55	2	332	7	290	6	248	5

**Cabrera et al., Unpublished**

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# Dynamic Programming (DP)

## Strengths

- **Decision-making inside repro programs**
- **Iterations among lactations**
- **Solid framework to optimize**

## Limitations

- **Difficult to include all repro details**
- **Not a user-friendly application**
- **Interpretation might need simulation**



# Let's RECAP

- **Repro** → **Profit (\$)**
- **\$ f(Repro)** → **Complex & difficult**
- **Need** → **Suite of methods**
  - **APCF**
  - **DMC**
  - **DP**



# Let's RECAP

	<b>APCF</b>	<b>DMC</b>	<b>DP</b>
<b>Detail for Repro Programs</b>	<b>+++</b>	<b>+++++</b>	<b>+</b>
<b>User—friendliness/farm specific</b>	<b>+++++</b>	<b>+++</b>	<b>+</b>
<b>Iterations among lactations</b>		<b>+++++</b>	<b>+++++</b>
<b>Solid framework</b>	<b>?</b>	<b>+++++</b>	<b>+++++</b>
<b>Decision-making/optimization</b>	<b>?</b>	<b>+++</b>	<b>+++++</b>



**Thanks**

