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

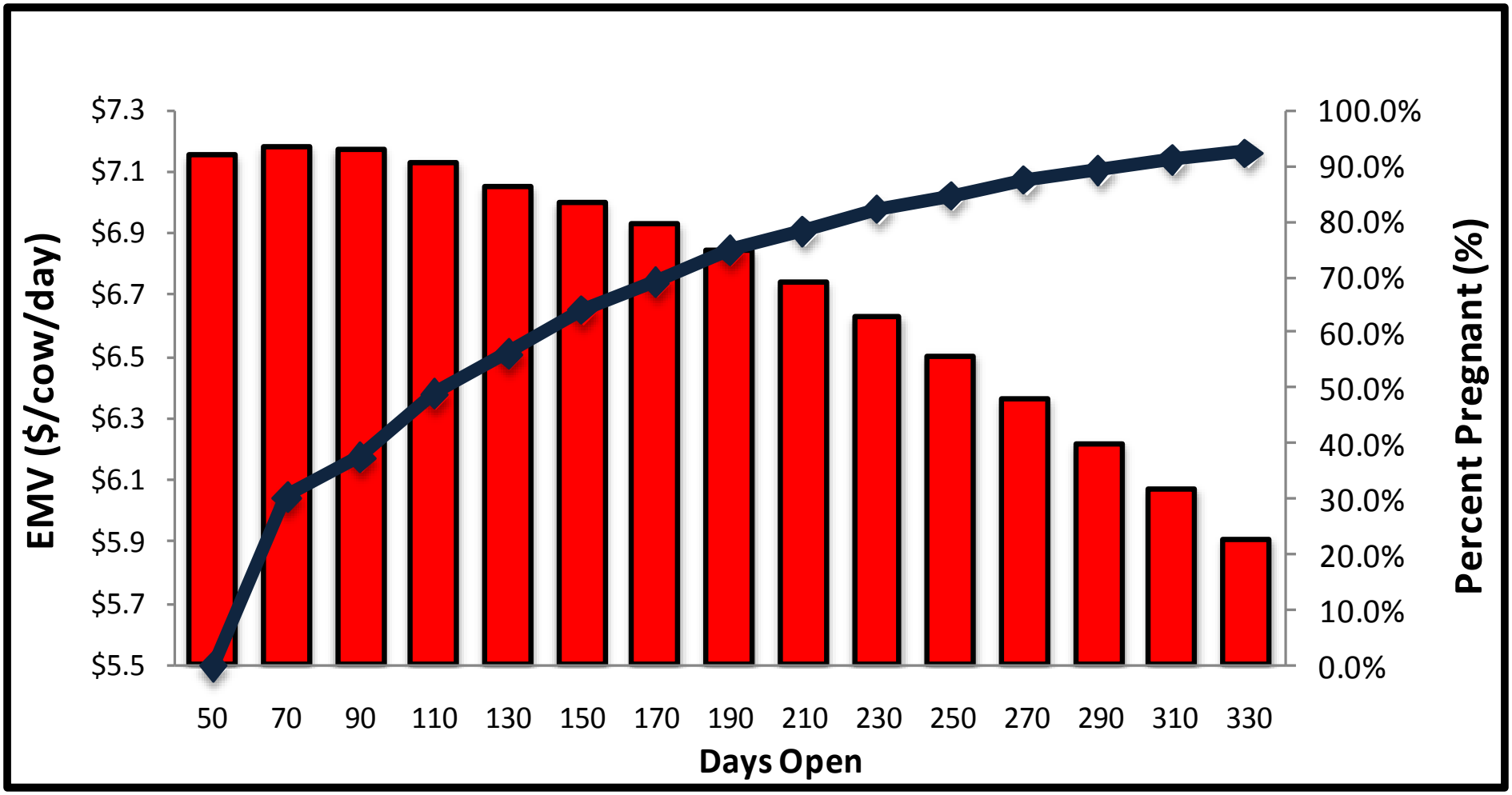
2011 ASAS/ADSA Midwest Meeting

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

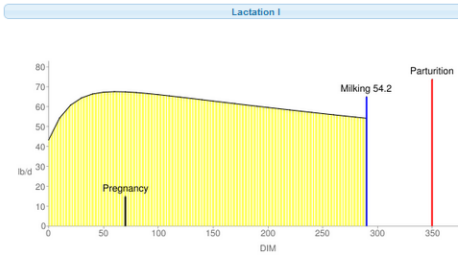


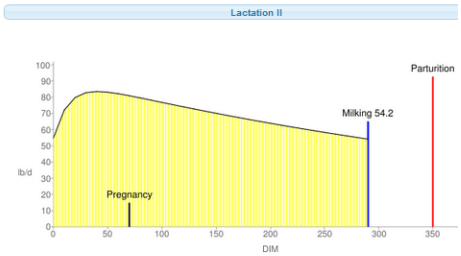
Economic assessment of economic value is difficult and complex

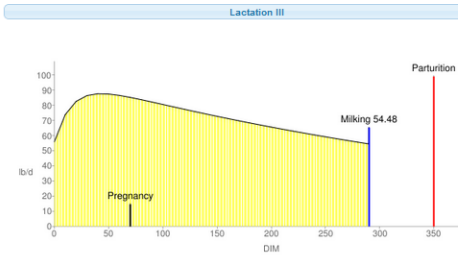
Fricke et al., 2008
Cabrera and Giordano, 2010

Milk production and productivity depends on reproductive performance

60 d Pregnant

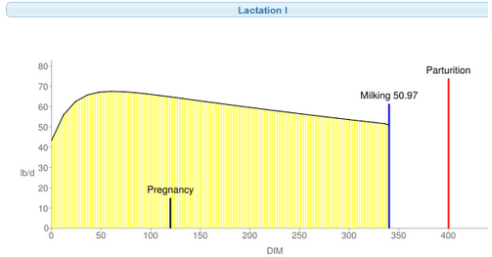


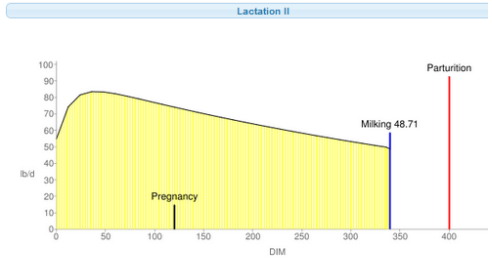


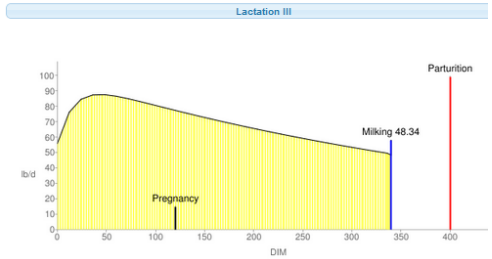


20,502 lb/cow/yr

120 d Pregnant





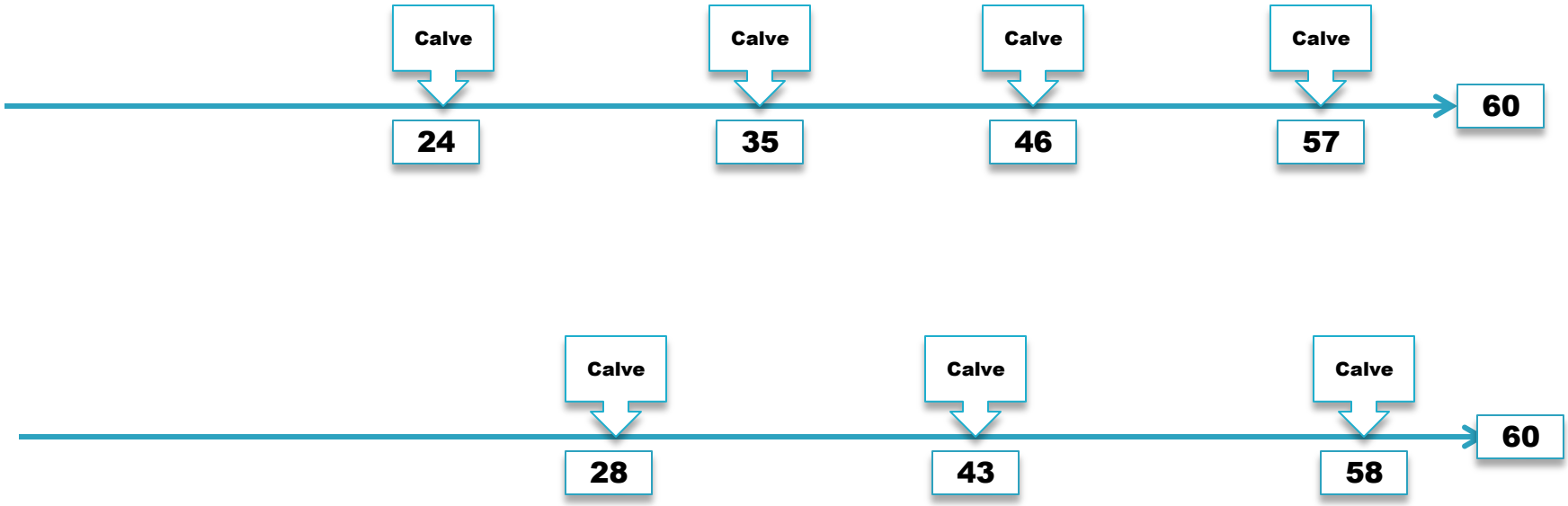


$20,306 lb/cow/yr

Eg., 60 d less = ↑200 lb/cow/yr

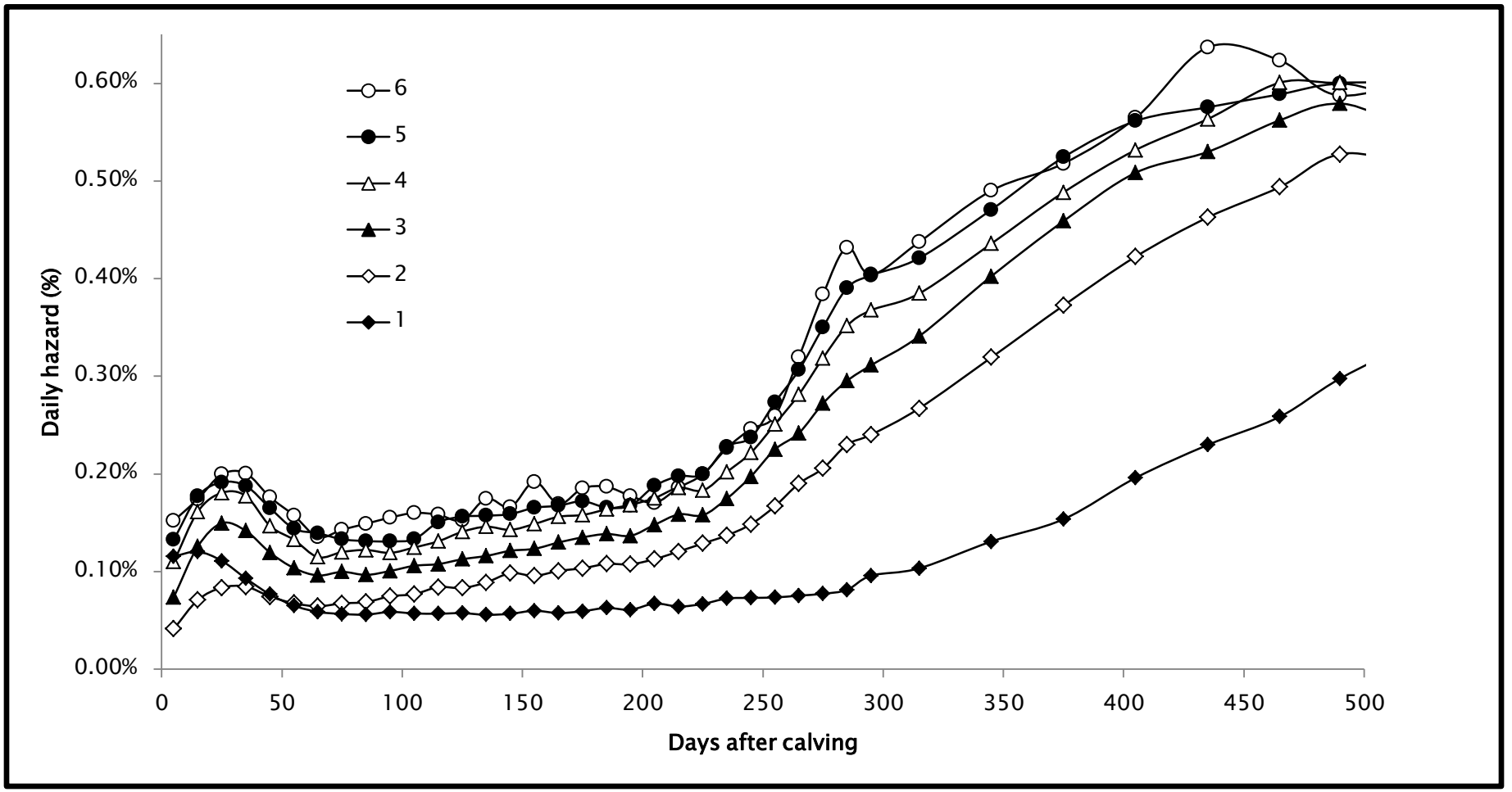
http://dairymgt.info/pregnancy/

Number of offspring depends on reproductive performance



Eg., better repro = 1 more callving

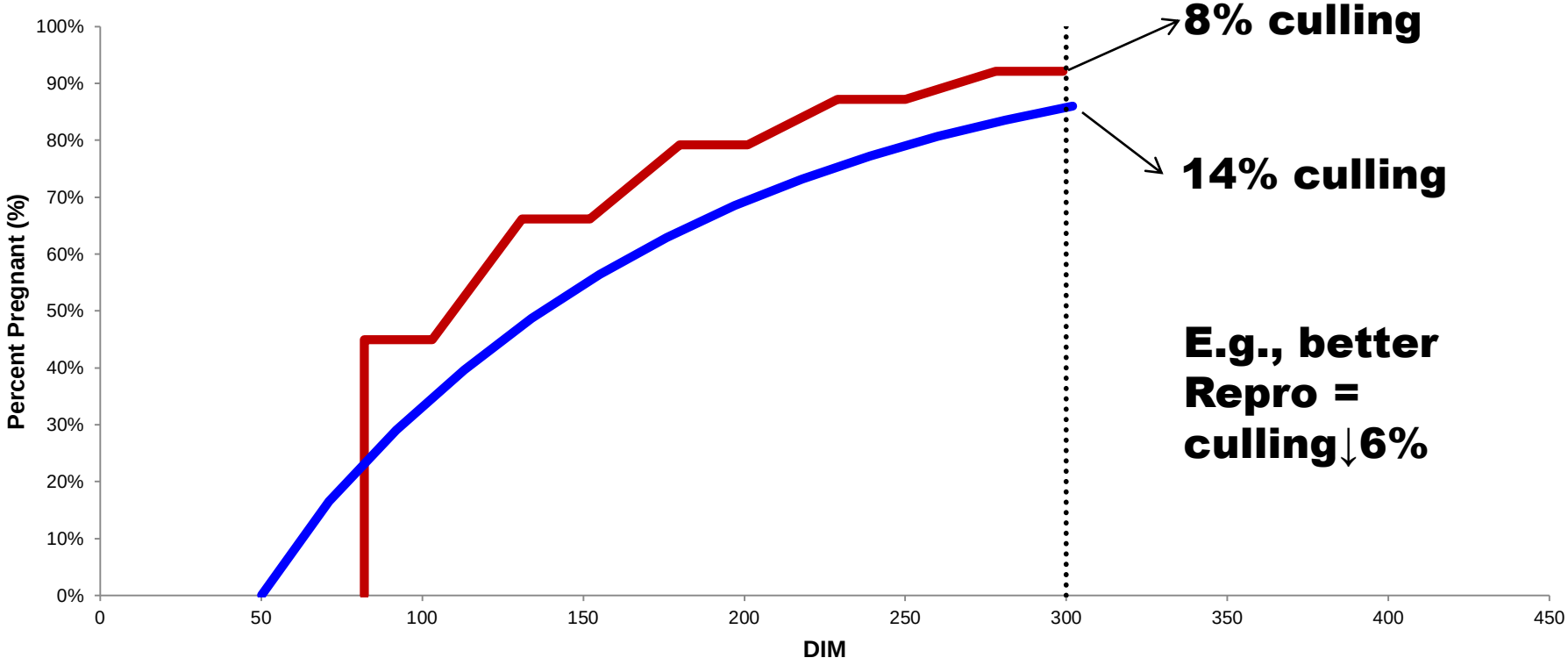
Involuntary culling and mortality depends on reproductive performance



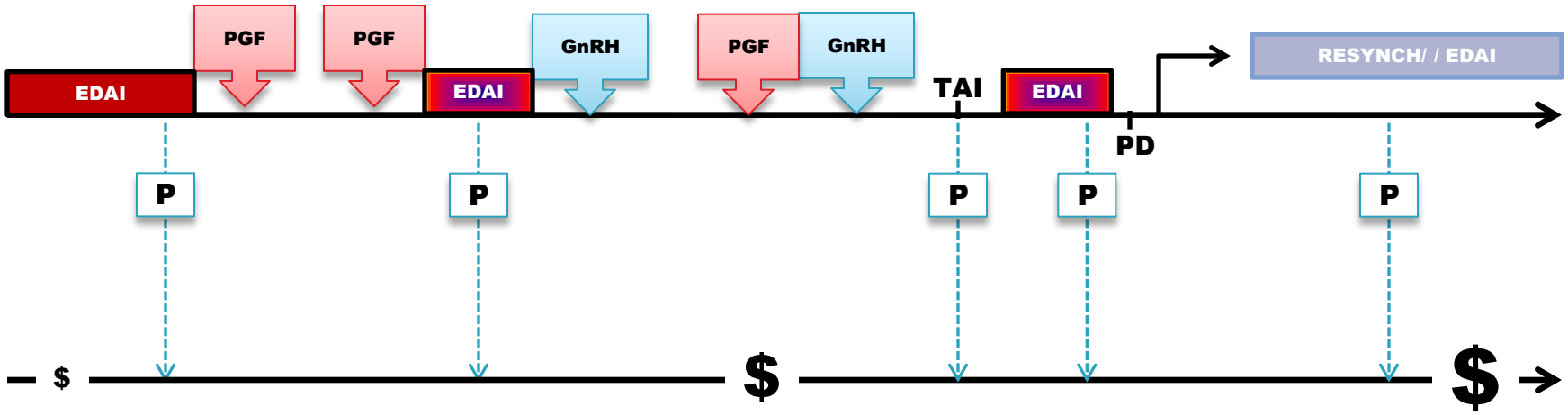
E.g., 2nd parity 60 d after 340 d = ↑21% cull risk

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	DIM	Define Lactation Curves Below		
1	15	61	86	89
2	45	81	107	111
3	75	90	110	114
4	105	94	107	108
5	135	93	100	102
6	165	90	92	97
7	195	91	84	91
8	225	87	77	84
9	255	85	74	79
10	285	83	65	78
11	315	78	62	81
12	345	72	53	75
13	375	68	52	67
14	405	63	59	66
15	435	51	51	49
16	465	51	43	52
17	495	51	35	47
18	525	47	30	43
19	555	44	25	38

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

	Current	Start day	Alternative	Start day
1st Service Postpartum	Double-Ovsynch	Fri	Double-Ovsynch	Fri
2nd 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 1st TAI	(d)	82	82	
Interbreeding Interval	(d)	42	49	
Heat Bred Before 1st TAI	(%)	0%	0%	50%
CR Heat Bred Before 1st TAI	(%)	0%	0%	33%
Heat Bred After 1st TAI	(%)	0%	0%	50%
CR Heat Bred After 1st TAI	(%)	0%	0%	30%
CR 1st Service TAI	(%)	45%	45%	
CR 2nd+ Services TAI	(%)	30%	39%	
nterval	(mo)	14.1		
od	(d)	70		

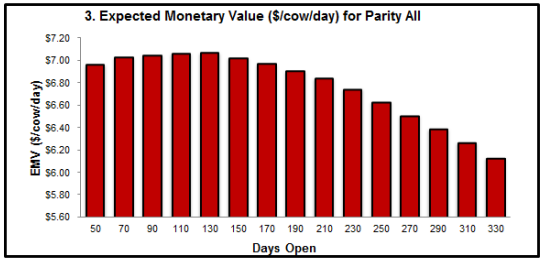
UW-Dairy Repro$
Victor E. Cabrera & Julio O. Giordano
Department of Dairy Science

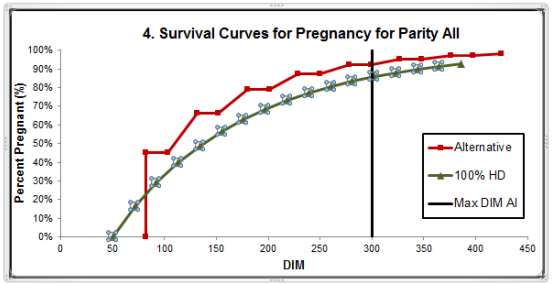
1. Productive and Economic Parameters Summary

Cows in Parity All	(#)	1688
Rolling Herd Average (RHA)	(lb/cow/y)	30000
Milk Price	($/cwt)	16.97
Average Value New Born	($)	74
Heifer Replacement Value	($)	1,288
Salvage Value	($)	624

2. Reproductive Programs Summary

	Current	Alternative	Baseline
1st Service Postpartum	Double-Ovsynch	Double-Ovsynch	Heat Breeding
2nd 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 1st TAI	0%	0%	50%
CR Heat Bred Before 1st TAI	0%	0%	33%
Heat Bred After 1st TAI	0%	0%	50%
CR Heat Bred After 1st TAI	0%	0%	30%
CR 1st Service TAI	45%	45%	
CR 2nd+ 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





UW-DairyRepro$: Reproductive performance

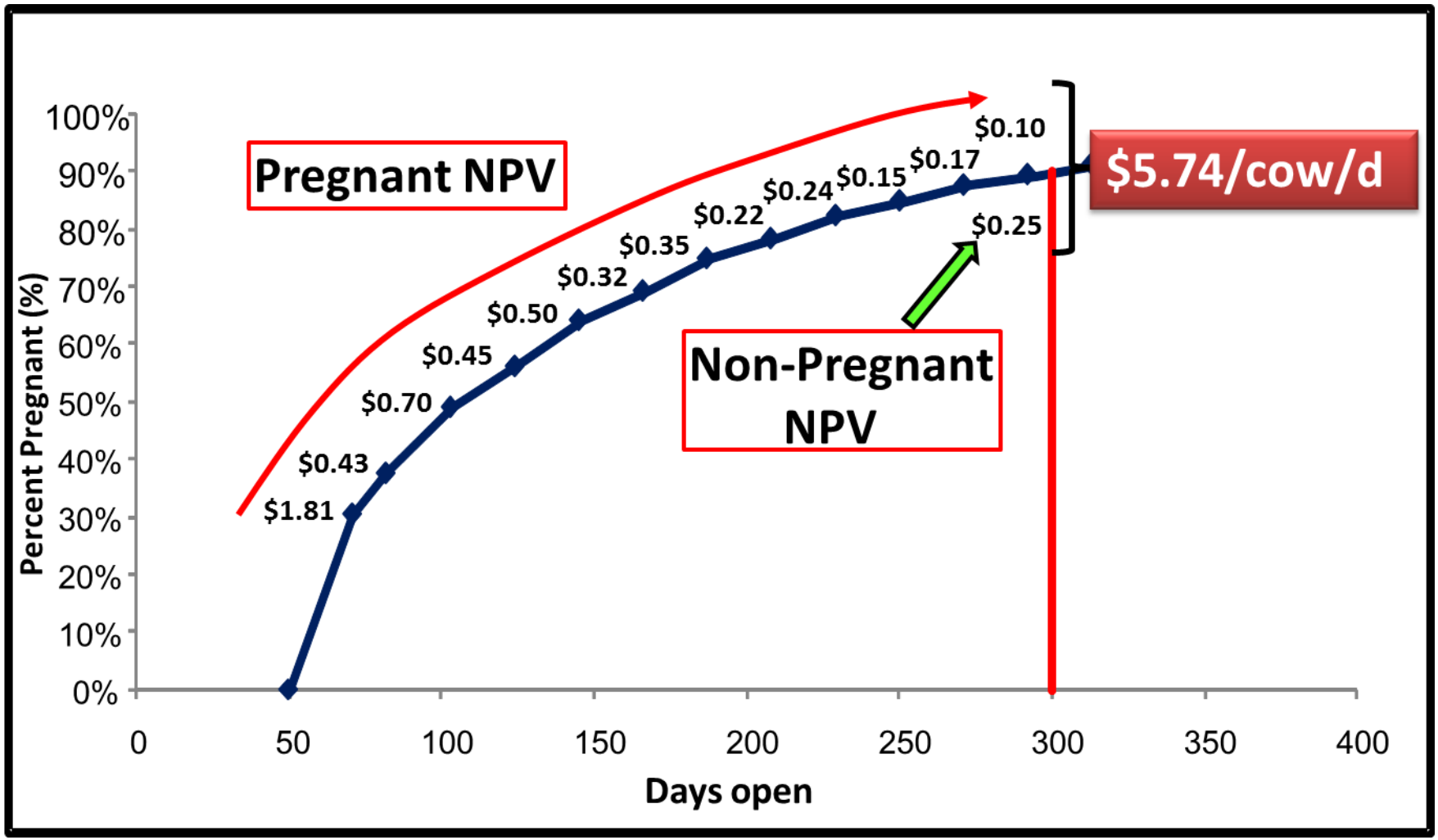
$$P_s = (P/AI)_s * (SR)_s \rightarrow NP_s = 1 - \sum P_s$$

$$SR_s = BE_s * B_s$$

$$BE_s = (1 - P_{s-1})$$

	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%
1st 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%
2nd 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

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

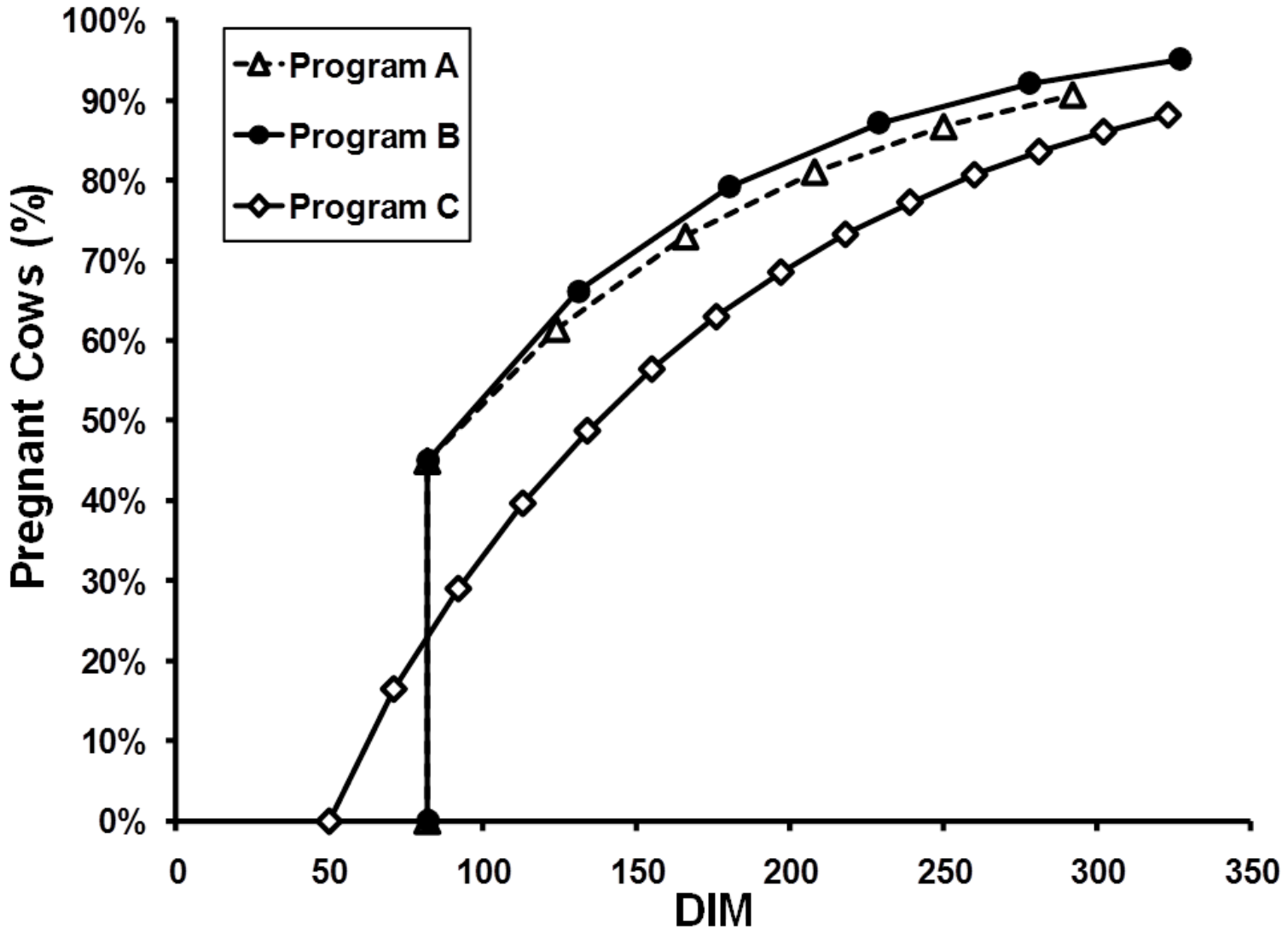
Giordano et al., Unpublished

UW-DairyRepro$: Results

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

Giordano et al., Unpublished

UW-DairyRepro$: Results



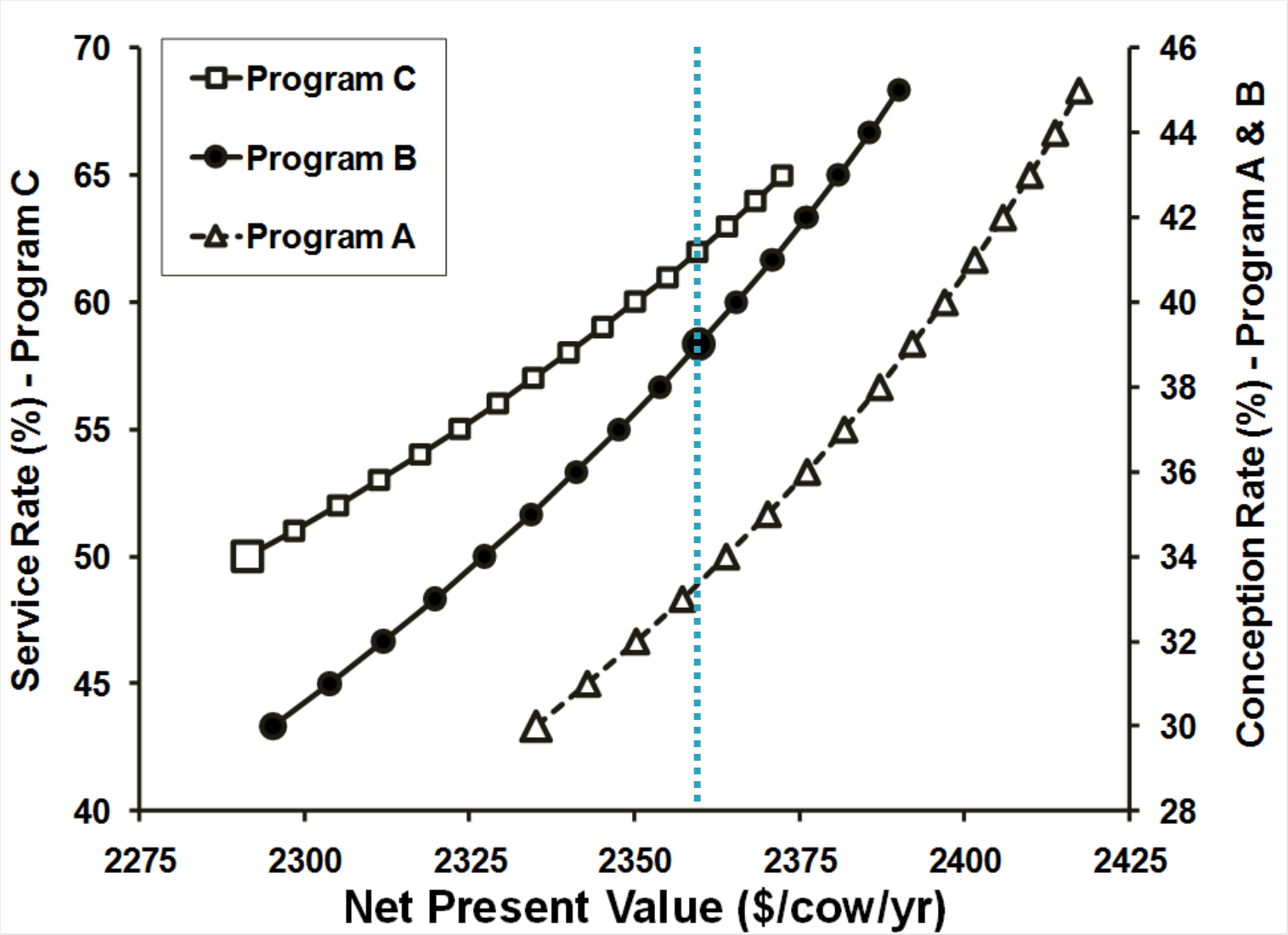
Giordano et al., Unpublished

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	**2622.69**	**2633.44**	**2560.99**
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	**-287.77**	**-274.43**	**-283.76**
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	**-54.36**	**-58.19**	**-36.67**
First service AI service cost[1]	29.17	29.23	13.06
Second and subsequent AI service cost[1]	21.0	29.23	13.06
Income from newborn	**54.56**	**56.09**	**50.92**
Value of reproductive program (NPV)	**2335.13**	**2356.91**	**2291.48**
Value over 100% ED program	**-43.65**	**-65.43**	

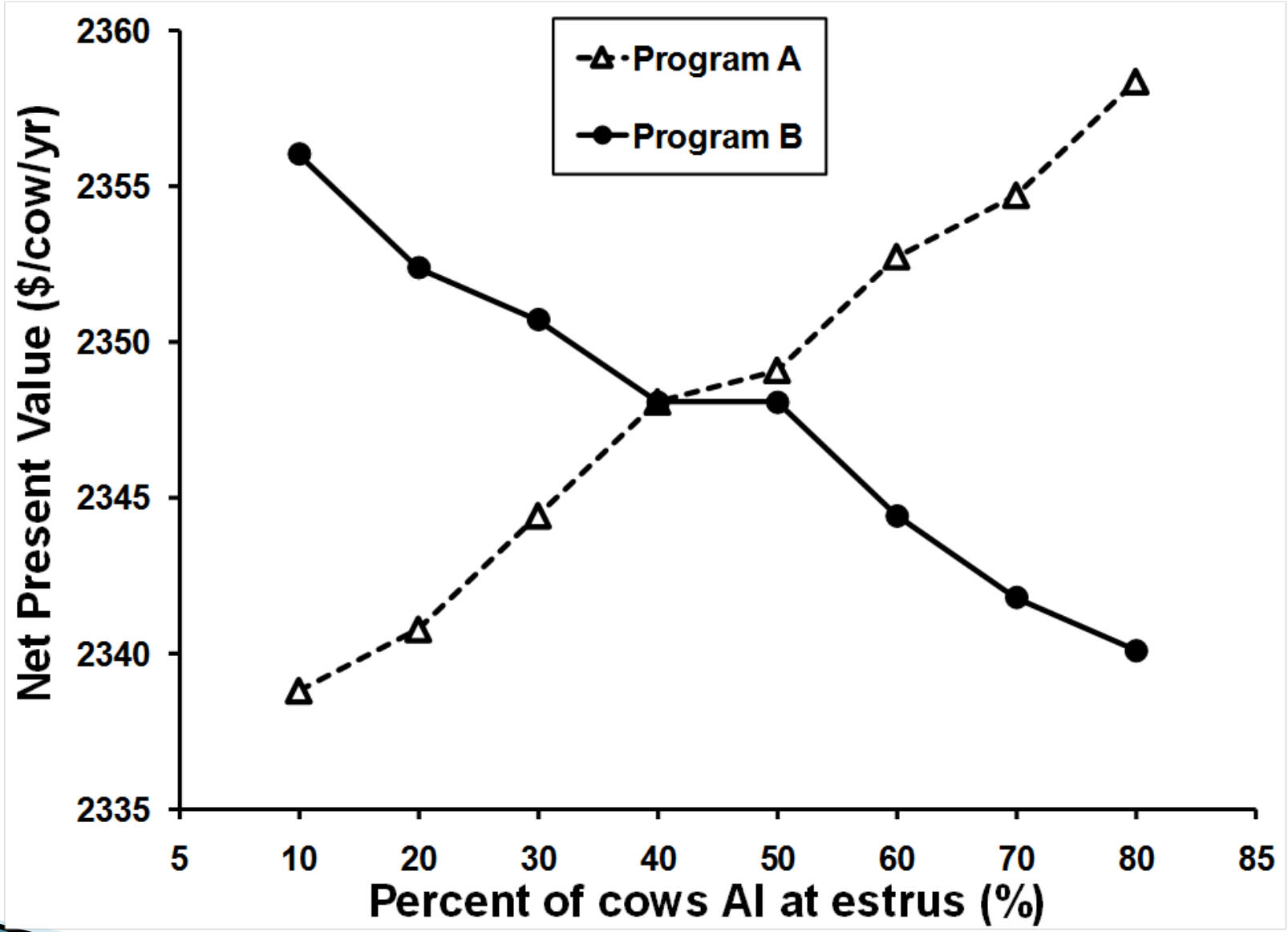
Giordano et al., Unpublished

UW-DairyRepro$: Results



Giordano et al., Unpublished

UW-DairyRepro$: Results



Giordano et al., Unpublished

Adjusted Partial Cash Flows (APCF)

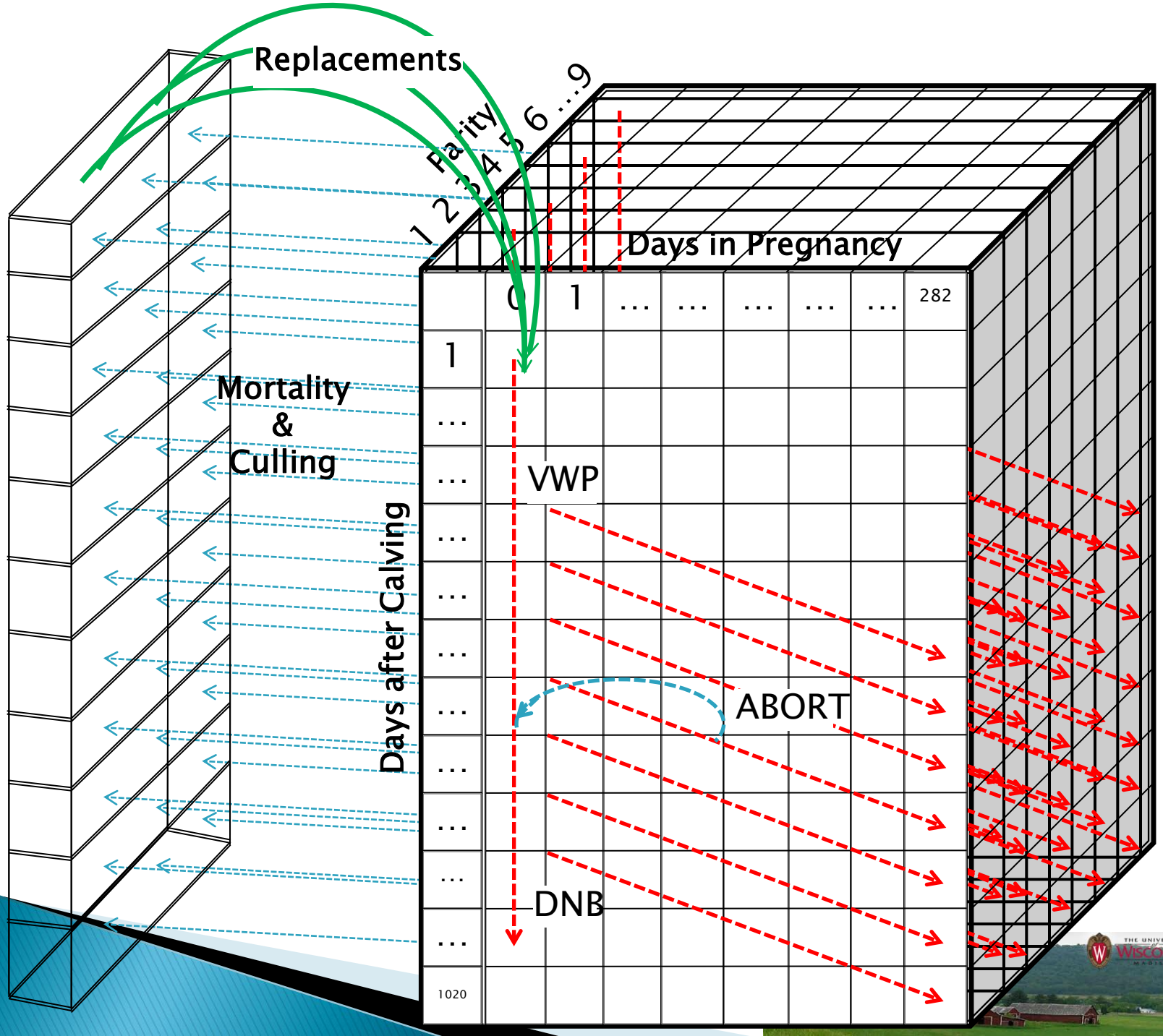
Strengths

- 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)


Replacements
Parity
1 2 3 4 5 6 ...9
Days in Pregnancy
0 1 282
1
...
...
VWP
...
...
...
...
...
ABORT
...
...
...
DNB
...
1020
Days after Calving
Mortality
&
Culling

Daily Markov Chains: Case study

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

Cabrera and Giordano, 2010

Daily Markov Chains: Case study

	Program 1	Program 2	Program 3
Type of program	100 % HD	100 % TAI	HD + TAI
1st Service Program	Estrous Detection	Presynch-Ovsynch	Presynch-Ovsynch
2nd Service Program	Estrous Detection	D32 Resynch	D32 Resynch
Bred at estrus before 1st TAI (%)			60
CR Bred at estrus before 1st TAI (%)			28
Bred at Estrus after1st TAI (%)			60
CR Bred at estrus after1st TAI (%)			28

Cabrera and Giordano, 2010

Daily Markov Chains: Case study

Type of program	Program 1 100 % HD	Program 2 100 % TAI	Program 3 HD + TAI
1st Service Program	Estrous Detection	Presynch–Ovsynch	Presynch–Ovsynch
2nd Service Program	Estrous Detection	D32 Resynch	D32 Resynch
CR 1st Service TAI (%)		42	32
CR 2nd + Service TAI (%)		30	28
HD rate 1st AI (%)	50		
CR 1st AI (%)	30		
HD rate ≥ 2nd AI (%)	50		
CR ≥ 2nd AI (%)	28		

Cabrera and Giordano, 2010

Daily Markov Chains: Results

Type of program	Program 1 100 % HD	Program 2 100 % TAI	Program 3 HD + TAI
1st parity cows (%)	42.20	33.94	38.60
2nd parity cows (%)	25.84	24.73	25.44
3rd parity cows (%)	15.49	17.14	16.28
4th parity cows (%)	8.63	11.14	9.74
5th parity cows (%)	4.61	6.96	5.60
6th parity cows (%)	2.17	3.78	2.82
7th parity cows (%)	0.74	1.51	1.04
8th parity cows (%)	0.25	0.60	0.38
9th 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 (%)	12	17	15
72 d VWP 21-d PR (%)	---	21	---
Herd pregnant cows[1] (%)	44.65	52.12	48.24
Days open[2] (d)	147	130	134
Average DIM[3] (d)	187	178	182
Lactating population (%)	90	88	89

[1]Animals that were ≥ 35 d in gestation
[2]Average number of days in milk at which cows became pregnant
[3]Average number of days in milk of all herd

Cabrera and Giordano, 2010

Daily Markov Chains: Results

	Program 1 100 % HD	Program 2 100 % TAI	Program 3 HD + TAI
	--------$/cow/yr-------		
Value of reproductive program	2,546.63	2,584.29	2,571.19
Value over 100% HD	---	37.66	24.56
Income from newborn	187.59	217.34	202.04
Culling and mortality cost	-191.57	-171.76	-183.26
Reproductive program cost	-46.47	-66.56	-50.07
Milk income over feed cost	2,597.08	2,605.26	2,602.48

Cabrera and Giordano, 2010

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

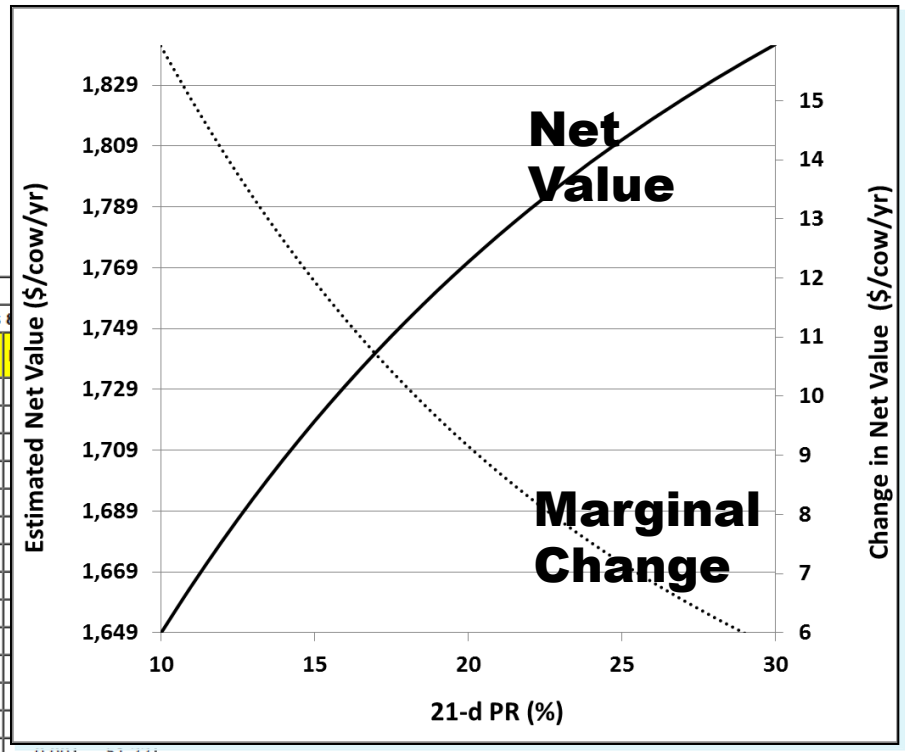
V.E. Cabrera

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

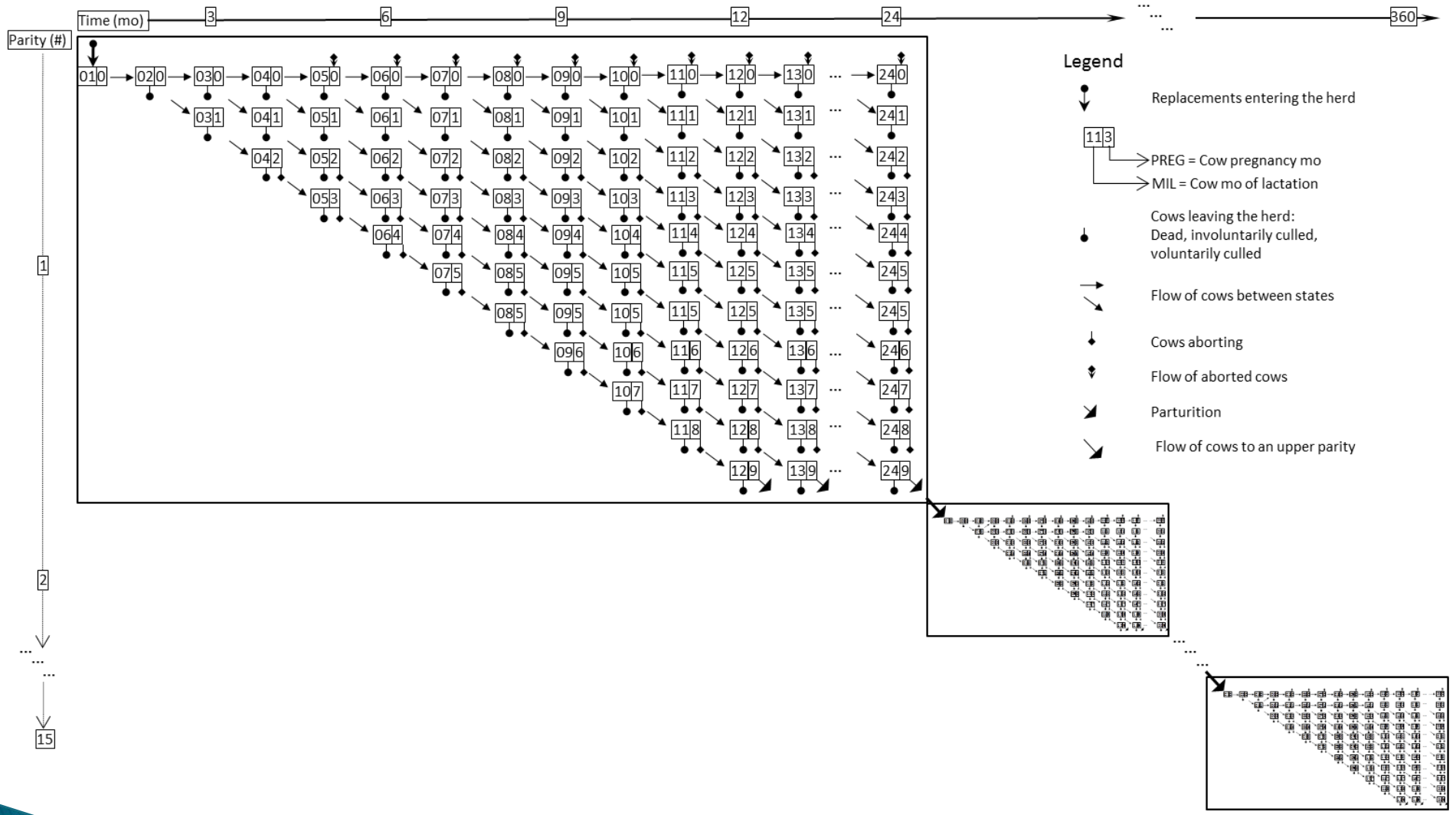
Month in Milk	Month in Pregnancy												Revenues $			
	0	1	2	3	4	5	6	7	8	9	Cull Cows		IOFC	Cull		
	Lactation 1															
1	3.35										0.14		453.19	-66.23		
2	3.21										0.09		594.15	-43.03		
3	2.56	0.56									0.05		616.65	-26.48		
4	2.06	0.45	0.56								0.05		603.35	-22.81		
5	1.67	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
	Lactation 2															
1	2.24															



http://dairymgt.info/markov/

Dynamic Programming (DP)

DP in a Linear Program Framework



Cabrera, 2010

DP in a Linear Program Framework

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

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

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

Cabrera et al., Unpublished

Dynamic Programming: Case Study

	Reproductive Program (1st TAI 2nd+TAI)	VWP 1st TAI (d)	Interbreeding Interval (d)	Method of PD[2]	CR[3] (%)	CR (%)	Cost[4] ($)	Cost[4] ($)
					1st TAI	2nd+TAI	1st TAI	2nd 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

Cabrera et al., Unpublished

Dynamic Programming: Results

	Reproductive Program (1st TAI 2nd+TAI)	Maximum Net Return		1st Parity DIM to last Service	1st Parity Number of Services	2nd Parity DIM to last Service	2nd Parity Number of Services	≥3rd Parity DIM to last Service	≥3rd Parity Number of Services
		($/cow/yr)	Rank	(d)	(#)	(d)	(#)	(d)	(#)
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

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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

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

Thanks