Using Heifer Data to Make Better Culling Decisions

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Topics to Cover and Discuss

- Can we use data contained in the record system (DC305) to make good culling decisions?
  - What data are useful predictors?
  - What impact does culling heifers have on the cost of raising for the ones that successfully complete the raising process and calve?
  - What is the value of using data during the heifer raising period to cull heifers at high risk for poor first lactation performance?

Herd Data Analysis

- Two large dairy herds from two geographically diverse areas of US
- Heifers born during 2013 were evaluated using records from DC305
- Backups were dated July 26, 2016
- Goals:
  - Determine if potential culling candidates can be accurately identified during the heifer rearing process
  - What is the value of using this approach if there are more heifers than needed in the pipeline?

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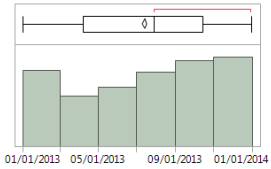
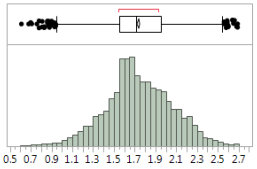
Descriptive Data – All Heifers that Had Current Dairy Gain 2 (CDG2), Predicted Transmitting Ability – Milk (PTAM), and Current Dairy Gain 3 (CDG3) Recorded

BDAT



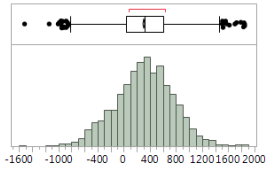
CDG2



Quantiles		
100.0%	maximum	2.69
99.5%		2.52
97.5%		2.34375
90.0%		2.15
75.0%	quartile	1.95
50.0%	median	1.71
25.0%	quartile	1.55
10.0%		1.34
2.5%		1.12
0.5%		0.8865
0.0%	minimum	0.61

Summary Statistics	
Mean	1.7357888
Std Dev	0.3127782
Std Err Mean	0.0051672
Upper 95% Mean	1.7459197
Lower 95% Mean	1.7256578
N	3664

PTAM



Quantiles		
100.0%	maximum	1849
99.5%		1402.075
97.5%		1133
90.0%		858.5
75.0%	quartile	602
50.0%	median	324
25.0%	quartile	29.25
10.0%		-277
2.5%		-553.375
0.5%		-817.4
0.0%	minimum	-1519

Summary Statistics	
Mean	310.77047
Std Dev	434.71285
Std Err Mean	7.1816584
Upper 95% Mean	324.85091
Lower 95% Mean	296.69002
N	3664

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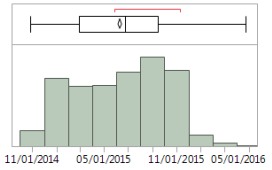
Descriptive Data – All Heifers that Had CDG2, PTAM, and CDG3 Recorded

FDAT



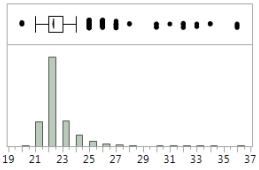
Quantiles

100.0%	maximum	36
99.5%		29.87
97.5%		25
90.0%		24
75.0%	quartile	23
50.0%	median	22
25.0%	quartile	22
10.0%		21
2.5%		21
0.5%		21
0.0%	minimum	20

Summary Statistics

Mean	22.340856
Std Dev	1.2568878
Std Err Mean	0.0215175
Upper 95% Mean	22.383044
Lower 95% Mean	22.298667
N	3412

AGEFR



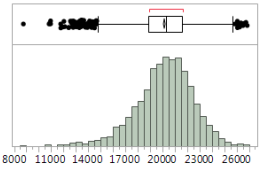
Quantiles

100.0%	maximum	26860
99.5%		25348.2
97.5%		24160
90.0%		22802
75.0%	quartile	21620
50.0%	median	20320
25.0%	quartile	18855
10.0%		17238
2.5%		15079
0.5%		12735.9
0.0%	minimum	8750

Summary Statistics

Mean	20139.047
Std Dev	2258.7576
Std Err Mean	39.219033
Upper 95% Mean	20215.943
Lower 95% Mean	20062.151
N	3317

2NDP



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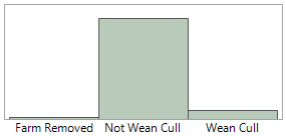
Created Culling Criteria for Post-Weaning Evaluation

- First, eliminated the heifers that died/were sold by dairies prior to 63 days of age
- Then, if below the lower quartile for both CDG2 (1.55) *AND* PTAM (29), identified them as "Wean Cull"

Wean Cull



Frequencies

Level	Count	Prob
Farm Removed	30	0.00819
Not Wean Cull	3359	0.91676
Wean Cull	275	0.07505
Total	3664	1.00000

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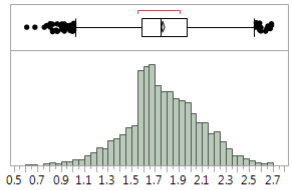
Not Culled at Weaning

CDG2

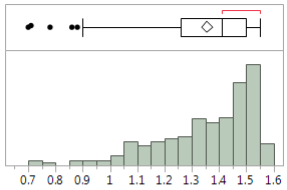


Quantiles		
100.0%	maximum	2.69
99.5%		2.522
97.5%		2.36
90.0%		2.17
75.0%	quartile	1.97
50.0%	median	1.75
25.0%	quartile	1.59
10.0%		1.39
2.5%		1.15
0.5%		0.91
0.0%	minimum	0.61

Summary Statistics	
Mean	1.7681066
Std Dev	0.3019021
Std Err Mean	0.0052091
Upper 95% Mean	1.7783199
Lower 95% Mean	1.7578933
N	3359

Culled at Weaning

CDG2



Quantiles		
100.0%	maximum	1.55
99.5%		1.55
97.5%		1.55
90.0%		1.53
75.0%	quartile	1.5
50.0%	median	1.41
25.0%	quartile	1.26
10.0%		1.096
2.5%		0.936
0.5%		0.7038
0.0%	minimum	0.7

Summary Statistics	
Mean	1.3567273
Std Dev	0.1734331
Std Err Mean	0.0104584
Upper 95% Mean	1.3773163
Lower 95% Mean	1.3361382
N	275

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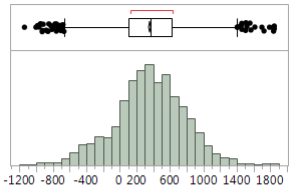
Not Culled at Weaning

PTAM

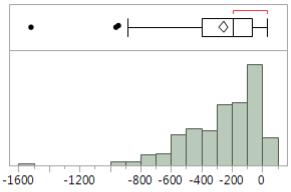


Quantiles		
100.0%	maximum	1849
99.5%		1421.6
97.5%		1144
90.0%		870
75.0%	quartile	624
50.0%	median	363
25.0%	quartile	109
10.0%		-203
2.5%		-522
0.5%		-763.4
0.0%	minimum	-1142

Summary Statistics	
Mean	355.65585
Std Dev	414.99314
Std Err Mean	7.1603775
Upper 95% Mean	369.69499
Lower 95% Mean	341.61671
N	3359

Culled at Weaning

PTAM



Quantiles		
100.0%	maximum	28
99.5%		27.62
97.5%		24
90.0%		-10.8
75.0%	quartile	-69
50.0%	median	-196
25.0%	quartile	-398
10.0%		-565.6
2.5%		-765.8
0.5%		-1306.96
0.0%	minimum	-1519

Summary Statistics	
Mean	-255.1164
Std Dev	230.25721
Std Err Mean	13.885032
Upper 95% Mean	-227.7815
Lower 95% Mean	-282.4513
N	275

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Developed Three Different Models to Assess for Consideration in Selecting the "Wean Culls"

- Original Approach – Below the lower quartile cut points for CDG2 and PTAM
- More Selective: Below the same cut point AND had Pneumonia recorded by 60 d of age
- Less Selective: Below the same cut point OR had Pneumonia recorded by 60 d of age

Created A Model To Predict 2nd305 Milk Using Variables Available At The Time Of Weaning

Original Approach:

Effect Summary

Source	LogWorth	PValue
Birth Month[Herd2]	34.381	0.00000
Wean Cull	14.303	0.00000
Herd2	3.262	0.00055 ^

Summary of Fit

RSquare	0.089305
RSquare Adj	0.082666
Root Mean Square Error	2163.383
Mean of Response	20139.05
Observations (or Sum Wgts)	3317

Wean Cull

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
Not Wean Cull	20261.560	41.33466	20236.7
Wean Cull	19127.840	140.76887	18941.3

Created A Model To Predict 2nd305 Milk Using Variables Available At The Time Of Weaning

More Selective:

Below cut points AND pneumonia prior to 60 days

Effect Summary

Source	LogWorth	PValue
Birth Month[Herd2]	35.893	0.00000
Herd2	4.499	0.00003 ^
Wean Cull w/Pneu	4.101	0.00008

Summary of Fit

RSquare	0.076576
RSquare Adj	0.069843
Root Mean Square Error	2178.45
Mean of Response	20139.05
Observations (or Sum Wgts)	3317

Wean Cull w/Pneu

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
Not Wean Cull	20203.893	40.74502	20159.2
Wean Cull	18955.677	314.63083	18794.3

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Created A Model To Predict 2nd305 Milk Using Variables Available At The Time Of Weaning

Less selective:

Below cutpoints OF pneumonia prior to 60 days

Effect Summary

Source	LogWorth	PValue
Birth Month[Herd2]	35.695	0.00000
Wean Cull +/- Pneumonia	12.571	0.00000
Herd2	2.149	0.00710 ^

Summary of Fit

RSquare	0.087134
RSquare Adj	0.080478
Root Mean Square Error	2165.961
Mean of Response	20139.05
Observations (or Sum Wgts)	3317

Wean Cull +/- Pneumonia

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
Not a Wean Cull	20306.172	43.392436	20286.8
Wean Cull	19547.492	96.211535	19460.4

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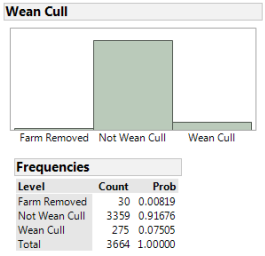
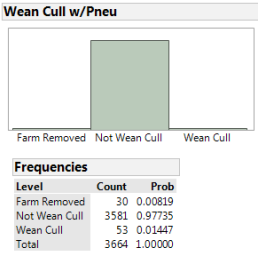
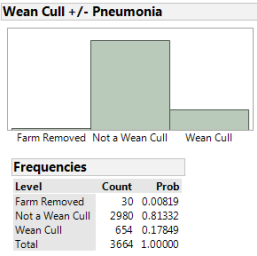
Also Considered Two Additional Different Approaches for Selecting "Wean Culls"

	Original Approach	More Selective: Below Cut Points AND Pneumonia by 60 d	Less Selective: Below Cut Points OR Pneumonia by 60 d
			
	Frequencies Level / Count / Prob Farm Removed 30 0.00819 Not Wean Cull 3359 0.91676 Wean Cull 275 0.07505 Total 3664 1.00000	**Frequencies** Level / Count / Prob Farm Removed 30 0.00819 Not Wean Cull 3581 0.97735 Wean Cull 53 0.01447 Total 3664 1.00000	**Frequencies** Level / Count / Prob Farm Removed 30 0.00819 Not a Wean Cull 2980 0.81332 Wean Cull 654 0.17849 Total 3664 1.00000
Not Wean Cull minus Wean Cull (LS Means)	1134 lb	1248 lb	759 lb
Not Wean Cull minus Full Population (LS Means)	567 lb	624 lb	379 lb

Continued the analysis with the Original Approach

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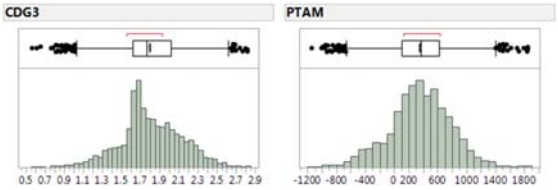
Next, "Removed" the "Wean Cull" Heifers and the Farm-Removed Heifers Prior to 120-d and Re-Evaluated the Performance of the Remaining Heifers at 120 d of Age



Quantiles

100.0%	maximum	2.82
99.5%		2.592
97.5%		2.43
90.0%		2.23
75.0%	quartile	2.02
50.0%	median	1.76
25.0%	quartile	1.62
10.0%		1.41
2.5%		1.16
0.5%		0.91
0.0%	minimum	0.56

Summary Statistics

Mean	1.8004853
Std Dev	0.3183688
Std Err Mean	0.0054932
Upper 95% Mean	1.8112556
Lower 95% Mean	1.7897149
N	3359

Quantiles

100.0%	maximum	1849
99.5%		1421.6
97.5%		1144
90.0%		870
75.0%	quartile	624
50.0%	median	363
25.0%	quartile	109
10.0%		-203
2.5%		-522
0.5%		-763.4
0.0%	minimum	-1142

Summary Statistics

Mean	355.65585
Std Dev	414.99314
Std Err Mean	7.1603775
Upper 95% Mean	369.69499
Lower 95% Mean	341.61671
N	3359

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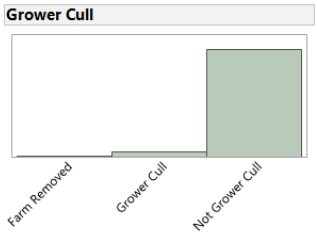
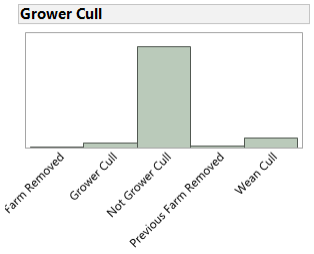
Created Culling Criteria for Grower Evaluation

- If below the lower quartile for CDG2 (1.62) and PTAM (109), identified them as “Grower Cull”





Frequencies

Level	Count	Prob
Farm Removed	3	0.00089
Grower Cull	144	0.04287
Not Grower Cull	3212	0.95624
Total	3359	1.00000

Frequencies

Level	Count	Prob
Farm Removed	3	0.00082
Grower Cull	144	0.03930
Not Grower Cull	3212	0.87664
Previous Farm Removed	30	0.00819
Wean Cull	275	0.07505
Total	3664	1.00000

N Missing 6992
5 Levels

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Grower Cull – Predicted 2nd305M Performance Using Data Available at ~4 Months of Age

Effect Summary

Source	LogWorth	PValue
Birth Month[Herd2]	31.066	0.00000
Grower Cull	4.863	0.00001
Herd2	3.126	0.00075 ^
Dummy variable	0.019	0.95687

Summary of Fit

RSquare	0.075812
RSquare Adj	0.068215
Root Mean Square Error	2172.422
Mean of Response	20236.68
Observations (or Sum Wgts)	3067

Grower Cull

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
Grower Cull	19520.523	1105.3159	19327.1
Not Grower Cull	20359.426	1089.0788	20278.9

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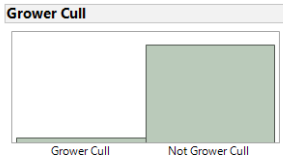
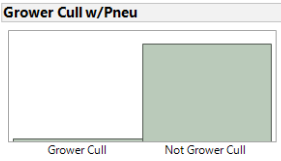
Repeated the Three Different Selective Models as with the Weaning Evaluation

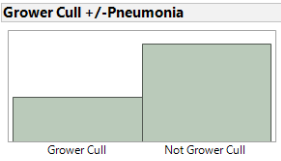
Original Approach	More Selective: Below Cut Points AND Pneumonia by 120 d	Less Selective: Below Cut Points OR Pneumonia by 120 d



Frequencies		
Level	Count	Prob
Grower Cull	144	0.04287
Not Grower Cull	3215	0.95713
Total	3359	1.00000



Frequencies		
Level	Count	Prob
Grower Cull	60	0.01786
Not Grower Cull	3299	0.98214
Total	3359	1.00000



Frequencies		
Level	Count	Prob
Grower Cull	1038	0.30902
Not Grower Cull	2321	0.69098
Total	3359	1.00000

Not Grower Cull minus Grower Cull (LS Means)	839 lb	930 lb	331 lb
Not Grower Cull minus Full Population (LS Means)	478 lb	660 lb	253 lb

Continued the analysis with the Original Approach

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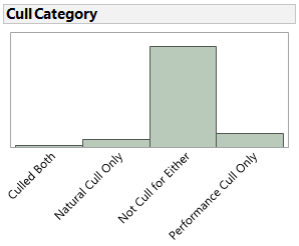
Finally, Evaluated Which Heifers Survived Through Breeding and Gestation to Actually Calve Into the Herd

Final results were based on using the original models at weaning and at 120 d



Frequencies		
Level	Count	Prob
Culled Both	16	0.00437
Natural Cull Only	224	0.06114
Not Cull for Either	3021	0.82451
Performance Cull Only	403	0.10999
Total	3664	1.00000

- "Culled Both" and "Natural Cull Only" did not actually calve – so, no milk weights
- "Performance Culls":
  - Predicted to produce 1064 lb less 2nd305 Milk ($p<0.01$)
  - 1.33 X higher culling risk by 300 DIM ($p=0.055$)
  - 6% less likely to become pregnant by 300 DIM ($p=0.32$)
- "Not Performance Cull" heifers predicted to produce 286 lb more 2nd305 milk relative to whole populations LS Means

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Assuming that We Can Predict Which Heifers will be of Lower Value, What is the Impact on the Cost of Raising?

- To examine this question, created three scenarios:
  - Cull selected heifers post-weaning
  - Cull selected heifers post-weaning and post-grower
  - Cull selected heifers post-weaning and at springer stage

- Assumptions used:
  - Housing costs are fixed: i.e., with additional selective culling, cost/remaining heifer for cost of housing increases
  - Labor costs are partially fixed: i.e., with additional selective culling, cost/remaining heifer are treated as 50% fixed, 50% vary based on # of heifers

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Cost of Raising Heifers ($/Heifer Calving) Scenario 1: Cull Selected Heifers at Post-Weaning

- Assumed that a 70-d old heifer is sold for $350:

Baseline scenario

Weight at 1st service, lbs	Proportional mortality adjustment						
	25%	50%	75%	100%	125%	150%	200%
750	1,989	1,999	2,010	2,020	2,030	2,041	2,063
770	2,018	2,028	2,039	2,049	2,059	2,070	2,092
790	2,048	2,058	2,068	2,078	2,089	2,099	2,122
810	2,077	2,088	2,098	2,108	2,119	2,129	2,152
830	2,108	2,118	2,128	2,139	2,149	2,160	2,182
850	2,138	2,148	2,159	2,169	2,180	2,191	2,213
870	2,169	2,180	2,190	2,201	2,211	2,222	2,245

Culling scenario

Weight at 1st service, lbs	Proportional mortality adjustment						
	25%	50%	75%	100%	125%	150%	200%
750	2,029	2,040	2,052	2,063	2,074	2,086	2,111
770	2,058	2,069	2,081	2,092	2,104	2,116	2,141
790	2,088	2,099	2,111	2,122	2,134	2,146	2,171
810	2,118	2,129	2,141	2,152	2,164	2,176	2,201
830	2,148	2,160	2,171	2,183	2,195	2,207	2,232
850	2,179	2,191	2,202	2,214	2,226	2,238	2,263
870	2,210	2,222	2,234	2,246	2,257	2,270	2,295

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Cost of Raising Heifers ($/Heifer Calving)
Scenario 1: Cull Selected Heifers at Post-Weaning (70-d old)

Cost = Culling Scenario - Baseline scenario

Heifer calf value at birth, $/hd	Vol cull, $/hd culled						
	$200	$250	$300	$350	$400	$450	$500
$100	$48	$43	$39	$34	$29	$24	$20
$150	$53	$48	$44	$39	$34	$29	$25
$200	$58	$54	$49	$44	$39	$35	$30
$250	$64	$59	$54	$49	$44	$40	$35
$300	$69	$64	$59	$54	$50	$45	$40
$350	$74	$69	$64	$59	$55	$50	$45
$400	$79	$74	$69	$65	$60	$55	$50

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Cost of Raising Heifers ($/Heifer Calving)
Scenario 2: Cull Selected Heifers at Post-Weaning AND at Post-Grower Phase

- Assumed that a 70-d old heifer is sold for $350 and a 130-d old heifer is sold for $450:

Baseline scenario

Weight at 1st service, lbs	Proportional mortality adjustment						
	25%	50%	75%	100%	125%	150%	200%
750	1,989	1,999	2,010	2,020	2,030	2,041	2,063
770	2,018	2,028	2,039	2,049	2,059	2,070	2,092
790	2,048	2,058	2,068	2,078	2,089	2,099	2,122
810	2,077	2,088	2,098	2,108	2,119	2,129	2,152
830	2,108	2,118	2,128	2,139	2,149	2,160	2,182
850	2,138	2,148	2,159	2,169	2,180	2,191	2,213
870	2,169	2,180	2,190	2,201	2,211	2,222	2,245

Culling scenario

Weight at 1st service, lbs	Proportional mortality adjustment						
	25%	50%	75%	100%	125%	150%	200%
750	2,052	2,063	2,076	2,088	2,100	2,114	2,140
770	2,081	2,093	2,105	2,118	2,130	2,143	2,170
790	2,111	2,123	2,135	2,148	2,160	2,174	2,200
810	2,141	2,153	2,166	2,178	2,190	2,204	2,231
830	2,172	2,184	2,196	2,209	2,221	2,235	2,262
850	2,203	2,215	2,228	2,240	2,252	2,266	2,294
870	2,234	2,246	2,259	2,272	2,284	2,298	2,325

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Cost of Raising Heifers ($/Heifer Calving)
Scenario 2: Cull Selected Heifers at Post-Weaning AND at Post-Grower Phase

- Assumed that a 70-d old heifer is sold for $350 and a 130-d old heifer is sold for $450:

Value = Culling Scenario - Baseline scenario

Heifer calf value at birth, $/hd	Performance Culls, $/hd culled						
	$200	$250	$300	$350	$400	$450	$500
$100	$69	$64	$59	$54	$49	$44	$39
$150	$77	$72	$67	$62	$57	$52	$47
$200	$85	$80	$75	$70	$65	$60	$55
$250	$93	$88	$83	$78	$73	$68	$63
$300	$101	$96	$91	$86	$81	$76	$71
$350	$109	$105	$100	$95	$90	$85	$80
$400	$118	$113	$108	$103	$98	$93	$88

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Scenario 3: Cull Selected Heifers at Post-Weaning AND at Springer Phase

- Assumed that a 70-d old heifer is sold for $350 and a springer (45 days from calving) is sold for $2000:

Baseline scenario

Weight at 1st service, lbs	Proportional mortality adjustment						
	25%	50%	75%	100%	125%	150%	200%
750	1,989	1,999	2,010	2,020	2,030	2,041	2,063
770	2,018	2,028	2,039	2,049	2,059	2,070	2,092
790	2,048	2,058	2,068	2,078	2,089	2,099	2,122
810	2,077	2,088	2,098	2,108	2,119	2,129	2,152
830	2,108	2,118	2,128	2,139	2,149	2,160	2,182
850	2,138	2,148	2,159	2,169	2,180	2,191	2,213
870	2,169	2,180	2,190	2,201	2,211	2,222	2,245

Culling scenario

Weight at 1st service, lbs	Proportional mortality adjustment						
	25%	50%	75%	100%	125%	150%	200%
750	2,024	2,036	2,048	2,060	2,072	2,084	2,110
770	2,055	2,066	2,078	2,090	2,102	2,115	2,141
790	2,085	2,097	2,109	2,122	2,134	2,146	2,172
810	2,117	2,129	2,141	2,153	2,165	2,178	2,204
830	2,149	2,161	2,173	2,185	2,197	2,210	2,237
850	2,181	2,193	2,205	2,218	2,230	2,243	2,270
870	2,213	2,226	2,238	2,251	2,263	2,276	2,303

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Scenario 3: Cull Selected Heifers at Post-Weaning AND at Springer Phase

- Assumed that a 70-d old heifer is sold for $350 and a springer (45 days from calving) is sold for $2000:

Cost = Culling Scenario - Baseline scenario

Heifer calf value at birth, $/hd	Performance Culls, $/hd culled						
	$200	$250	$300	$350	$400	$450	$500
$100	$43	$38	$33	$28	$23	$18	$13
$150	$51	$46	$41	$36	$31	$26	$21
$200	$60	$55	$50	$45	$40	$35	$30
$250	$68	$63	$58	$53	$48	$43	$38
$300	$77	$72	$67	$62	$57	$52	$47
$350	$85	$80	$75	$70	$65	$60	$55
$400	$93	$88	$83	$78	$73	$68	$63

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What is the Predicted Value of the Calving Heifers? (based on modeled least square means results)

Modeled differences between heifers at different evaluation points

Category	P305, lbs	Chg, lbs	Chg, %[1]	NPV, $[2]	Chg, $
Least sq means for all heifers (baseline for wean cull comparison):					
	19,695	Base		2100	
Wean Cull Scenario					
CDG2 and PTAM model: Not culled	20,262	567	103%	2285	185
CDG2 and PTAM model: Performance culled	19128	(567)	97%	1916	-184
Least sq means for all heifers (baseline for grower cull comparison):					
	19881	Base		2100	
Grower Cull Scenario					
CDG3 and PTAM model: Not culled	20301	420	102%	2236	136
CDG3 and PTAM model: Performance culled	19462	-419	98%	1963	-137
Least sq means for all heifers (baseline for full model comparison, includes new model variables):					
	19932	Base		2100	
Full model (both wean and grower culling)					
Not Culled	20354	422	102%	2236	136
Performance Culled	19509	-423	98%	1963	-137

[1] Percent difference applied to all parities

[2] Economic model was calibrated such that NPV for base scenarion equals $2,100

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Estimated Value Minus Raising Cost for Each Scenario (using modeled least square means estimates)

	Scenario 1: Cull Selected Heifers at Post-Weaning			Scenario 2: Cull Selected Heifers at Post-Weaning and Post-Grower			Scenario 3: Cull Selected Heifers at Post-Weaning and at Springer Stage		
	Baseline	Scenario	Net	Baseline	Scenario	Net	Baseline	Scenario	Net
Total Raising Cost per Heifer Calving	$2,108	$2,152	$44	$2,108	$2,178	$70	$2,108	$2,153	$45
Predicted Value per Heifer Calving	$2,100	$2,285	$185	$2,100	$2,236	$136	$2,100	$2,236	$136
Net Benefit (or Cost) of Scenario			$141			$66			$91

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Outcomes of Heifers in Modeled Exercise

	Actual Results		Performance Culling	
Total Heifers Starting			3664	
Heifers Culled after Weaning			275	8%
Heifers Culled after Grower			144	4%
Heifers Sold/Died by Farm	243	7%	243	7%
Total Heifers Actually Calving	3421	93%	3002	82%

- Very low actual culling level:
  - 93% of heifers in system calved
- With performance culling:
  - 82% of heifers in system calved
  - Must have extra heifers (or be willing to purchase heifers) to make this approach work

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Summary

- This early-stage modeling exercise demonstrates that with good data and careful analyses, selective pressure can be applied to replacement programs to improve the quality of heifers calving
- MUST have extra heifers for this program to work
- MUST have good records to make more accurate decisions
- This approach needs to be repeated across herds to validate the process
- Highly unlikely that a single modeling approach will work across all herds
  - Will need to develop customized approaches for each herd

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Thanks For Your Attention!

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