Optimizing Breeding Programs

Effect of Reproductive Technologies and Measurement

Decisions in breeding programs

Where to go? breeding objective (which traits)

Who and what to measure? performance, DNA test

genetic evaluation

Who to select and mate? reproductive technol.

gains vs inbreeding

Making genetic progress is about

Selecting only the very best

Selecting accurately

$$R = \frac{i_m r_m + i_f r_f}{L_m + L_f} \sigma_A$$

Keeping generation intervals short

Reproductive rates affect all of the above!

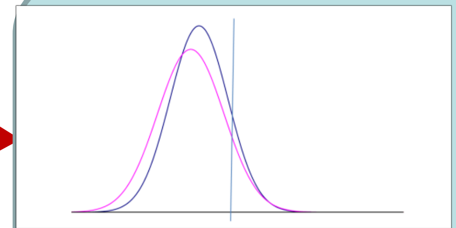
Aspects that need to be balanced:

$$\frac{i_m r_{IAm} + i_f r_{IAf}}{L_m + L_f} \sigma_A$$

- Selection accuracy versus generation interval
  - Short generation intervals are good for fast progress, but young breeding animals have lower EBV accuracy
- Selection accuracy versus selection intensity
  - Money available for testing (either performance or DNA) can be used to test a few animals accurately, or to test more animals with lower accuracy. For example, testing fewer young bulls but giving them more test progeny.
- Selection intensity versus generation interval
  - Selecting fewer animals for breeding each year and keeping those longer
- Selection intensity versus inbreeding
- The relative emphasis in selection for multiple traits
- Cost versus benefits

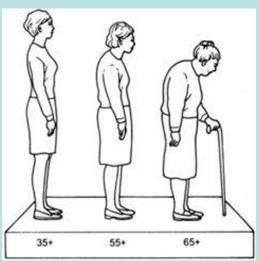
Aspects that need to be balanced

Selection accuracy



Selection intensity

$$\frac{i_m r_{IAm} + i_f r_{IAf}}{L_m + L_f}\sigma_A$$

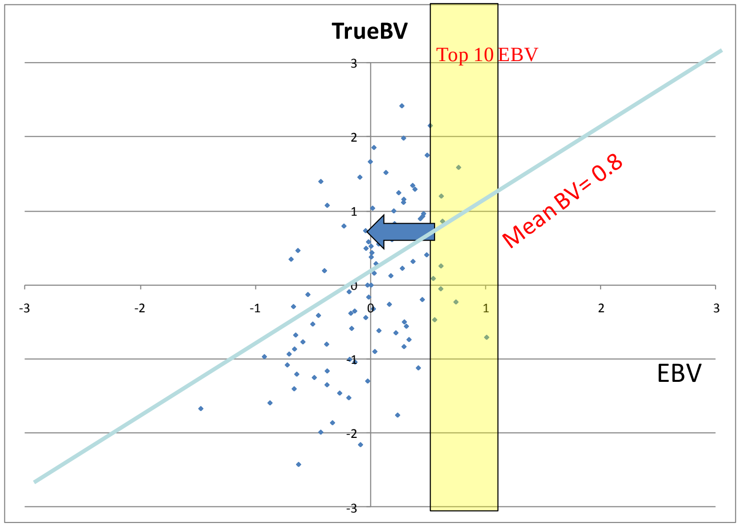


Generation Interval

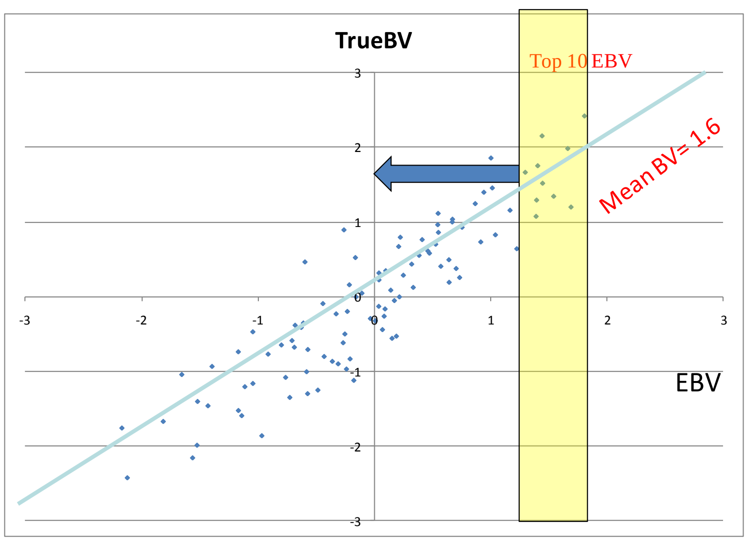
Inbreeding

Multiple traits

Cost Benefit



Accuracy = 45%

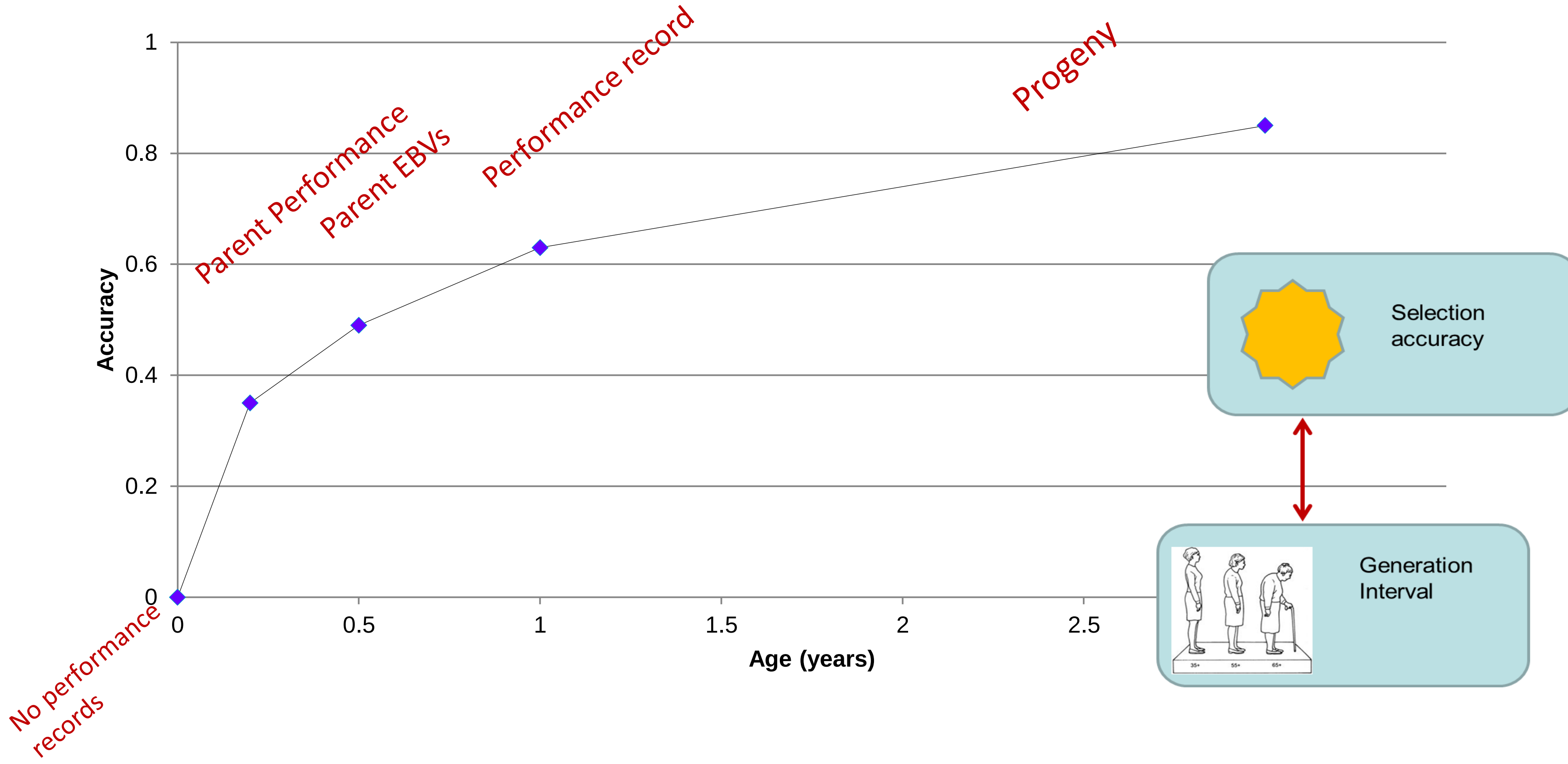


Selection accuracy

the more accuracy, the more response

Accuracy of predicting a breeding value

- increases as an animal gets older

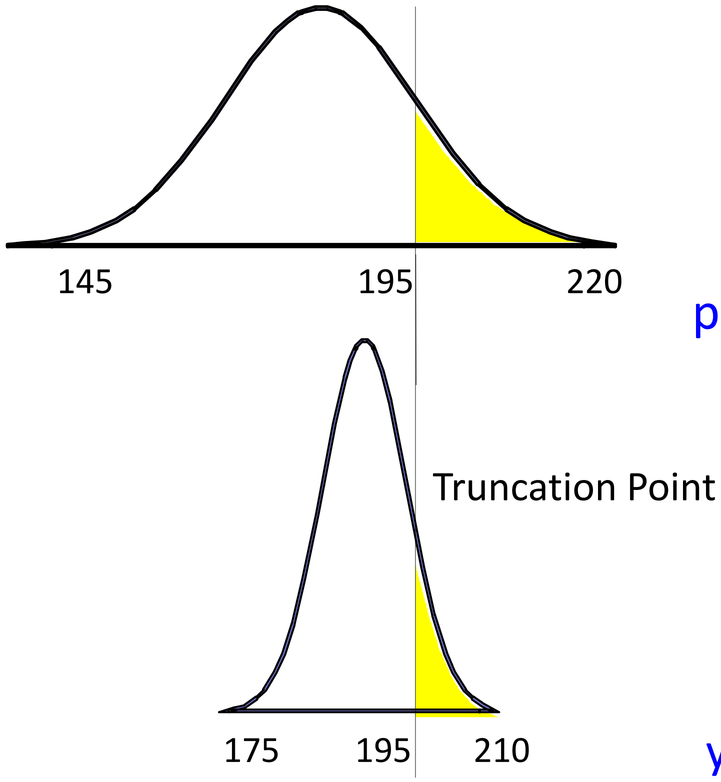


Assumed heritability = 25%

Need to balance accuracy and generation interval!

BLUP helps selecting between old and young bulls

- EBVs can be compared directly over age classes
- Selection on BLUP EBVs optimizes generation interval



proven sires

young sires

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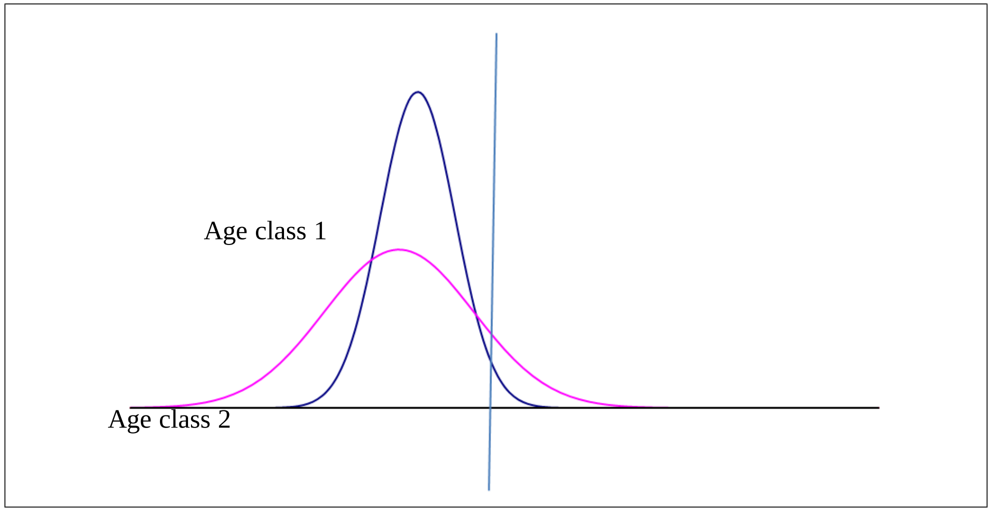
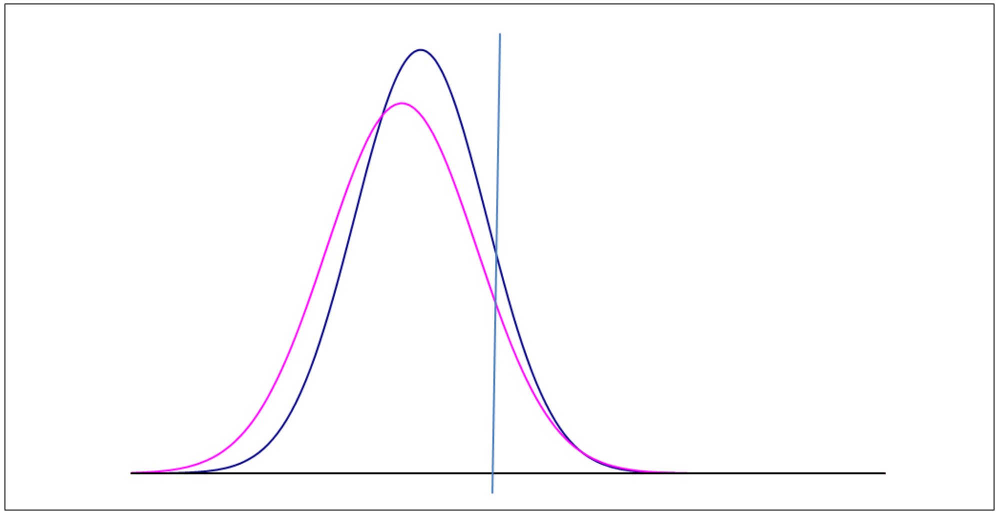
Optimizing age structure





Accuracy changes with age class !

Without genomic selection

ageclass	N in group	mean	SD	Nr Selected
1	50	10.20	0.4	2.7
2	50	10.00	0.8	7.3

Accuracy

With genomic selection

ageclass	N in group	mean	SD	Nr Selected
1	50	10.20	0.7	5.4
2	50	10.00	0.8	4.6

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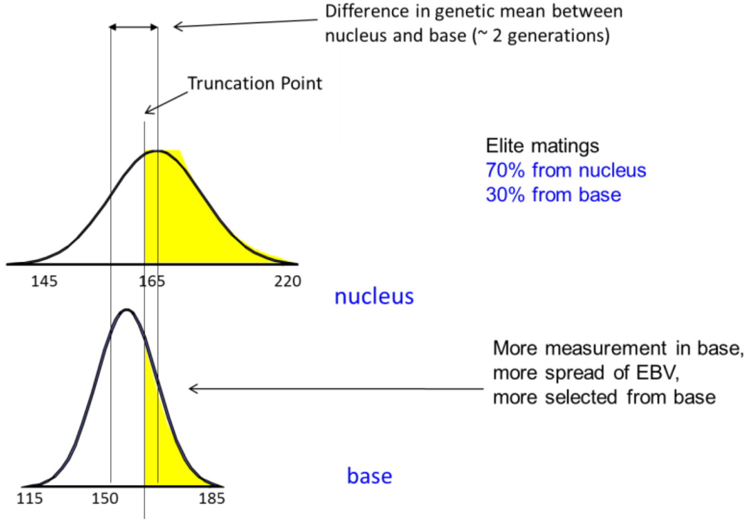
Open nucleus systems

- Select the best animals from lower tiers to compete for being nucleus parents

- degree of 'openness depends on
  - difference between nucleus and commercial
  - spread of their breeding values

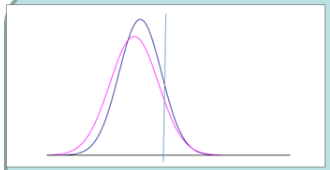
- Open to nuclei



Best to select on EBV, irrespective of accuracy /genotyped or not / age

	birth year	genotyped	progeny	EBV	acc
Kevin	2009	Y	0	+124	71
Tony	2005	N	345	+119	97
Bob	2009	N	0	+117	63
John	2008	N	45	+113	85
Paul	2006	N	1087	+112	99
Geoff	2009	Y	0	+106	40
Malcolm	2007	N	67	+105	89

Example of BLUP selection



Selection intensity

inbreeding

Terminals - Top 150

Analysis Date Friday, 15 June 2001

LAMBPLAN

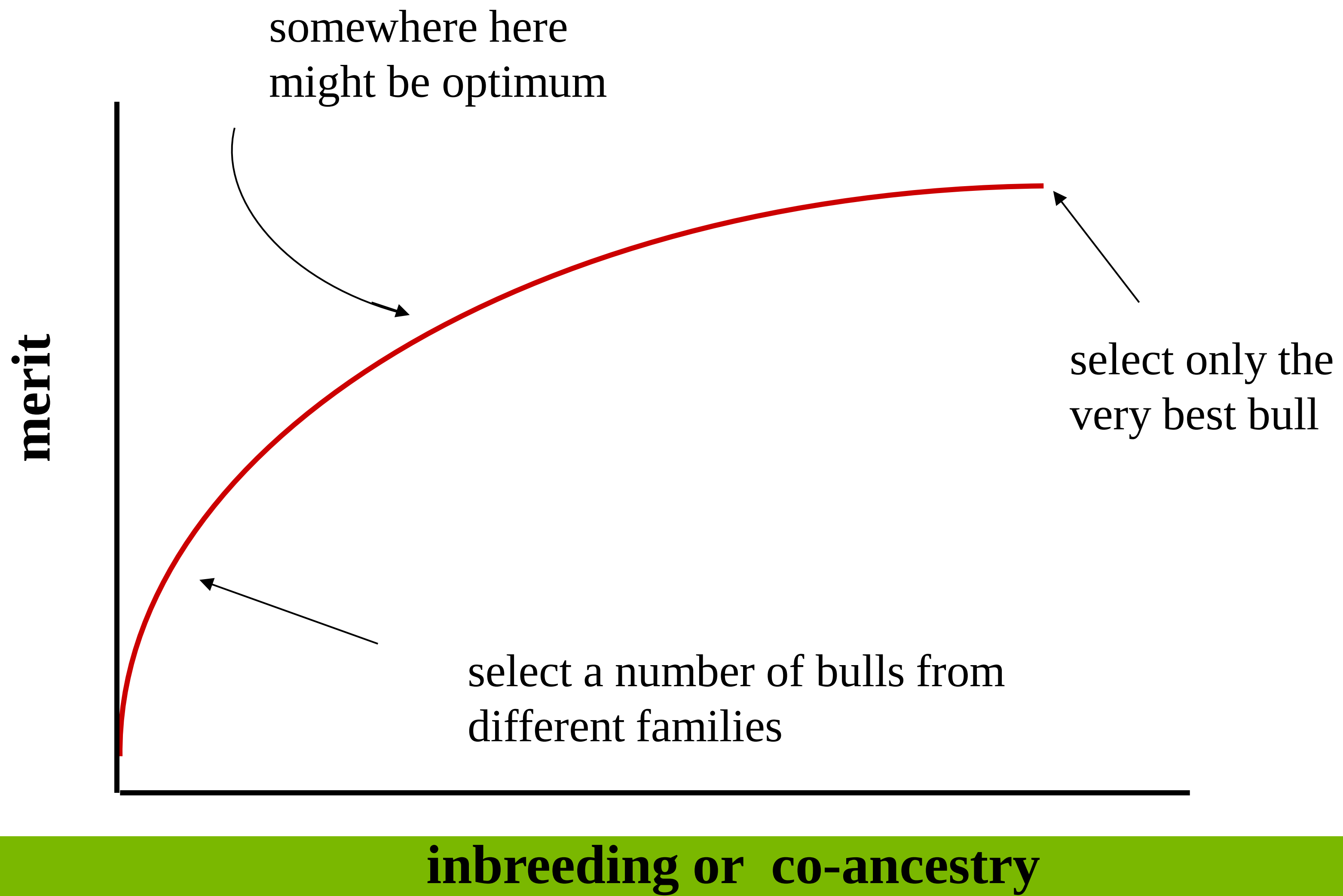
Sires

ID	Stud of breeding	Wwt	Pwwt	Ywt	Pfat	Pemd	Carcase +	Progeny	Inbreeding & Accuracies Coeff	Weight	Carcase	Sire	Sire of Dam
161972-1999-990196	HILLCROFT FARMS	5.46	14.95	14.94	-1.19	1.62	226.64	38	0.133	83	70	1619721998980093	163000199393013
162368-1998-980211	KURRALEA	6.60	12.39	12.69	-0.89	2.50	215.20	1148		97	96	1623681994940260	8600401992920
162204-1999-990453	BETHELREI	8.52	13.38	15.87	-1.18	1.11	211.75	224		93	89	8601221993930205	1619721995950
161972-1998-980093	HILLCROFT FARMS	5.15	14.40	16.00	-1.08	0.25	207.51	12		80	74	1630001993930134	1603361992920
161972-1998-980527	HILLCROFT FARMS	8.46	13.45	10.97	-1.66	-0.47	204.10	25		85	76	1619721996960091	1630001993930
860122-1993-930205	OHIO	6.95	11.94	13.72	-1.60	0.49	203.76	1522		98	97	8601221992920200	8601221987870
161143-1999-990204	DERRYNOCK	8.39	12.10	12.19	-0.49	2.19	203.60	38		82	76	1623681998980211	164000199393041
160060-1996-960004	ANNA VILLA	8.56	14.90	16.18	-0.48	0.24	200.47	151		93	87	1632801992920016	1623541990900584
161143-1999-990201	DERRYNOCK	5.43	11.83	11.14	-1.19	0.83	199.83	39		83	77	1623681998980211	1613151995950042
230034-1997-970904	BURWOOD	4.98	11.01	8.82	-2.27	-0.55	198.82	380	0.003	96	92	2300091994940171	2300341994940314
163677-2000-000140	FELIX	6.69	13.56	13.36	-0.59	0.61	197.98	56		70	63	1619721995950289	1600341994940020
160060-1997-970115	ANNA VILLA	6.30	14.47	11.69	-0.42	0.24	196.90	118		90	83	1600601996960004	1600601992920057
162204-1999-990394	BETHELREI	7.42	12.97	14.27	-1.03	0.14	196.85	24		82	74	8601221993930205	1622041996960579
161143-1999-990064	DERRYNOCK	5.10	11.20	10.10	-0.72	1.60	196.01	18		80	74	1623681998980211	1640001994940317
161972-1996-960020	HILLCROFT FARMS	5.32	12.96	10.66	-0.80	0.36	195.20	83		88	75	1630001993930134	
160185-1996-960001	JOLMA	6.19	10.29	10.42	-1.56	0.63	194.57	101		90	83	1630001993930134	1613151991910870
161235-1997-970830	POLLAMBI	7.10	10.69	10.35	-0.88	1.50	194.54	34		87	79	1700991993930002	1612351991910691
163677-1999-990307	FELIX	7.09	12.52	11.59	-1.29	-0.47	192.45	54		83	74	8601221993930205	1636771994940008
162368-1999-990290	KURRALEA	5.53	10.84	10.58	-0.62	1.59	192.11	68		69	62	1623681998980211	1630001993930160
860074-1995-950044	ADELONG	7.17	14.47	13.22	-0.80	-0.94	191.15	448		96	94	8600741993930189	
163000-1998-980575	RENE	7.59	12.01	13.06	-0.50	0.99	190.92	12		71	60	1623681994940260	8600371992920165
162368-1997-970443	KURRALEA	6.58	12.13	7.96	-1.00	0.08	190.69	178		88	83	1640001993930411	8600401992920175
160034-1999-991208	MOSSLEY	5.52	13.45	10.27	-0.53	0.04	190.41	17	0.003	78	70	1621001998980130	1600341994940171
161437-1999-990006	WARBURN	5.41	10.97	10.93	-1.21	0.37	190.26	14		73	65	1604621994940012	1640001993930411

These are sibs so might not select all of them as flock sire

Balancing inbreeding and merit

This graph will look different for each population



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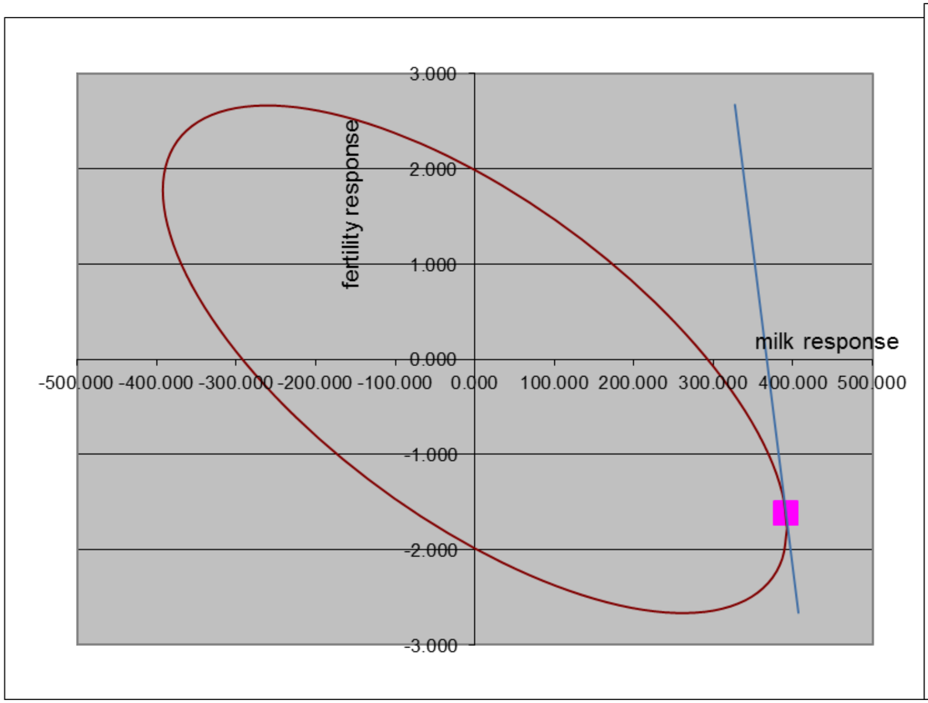
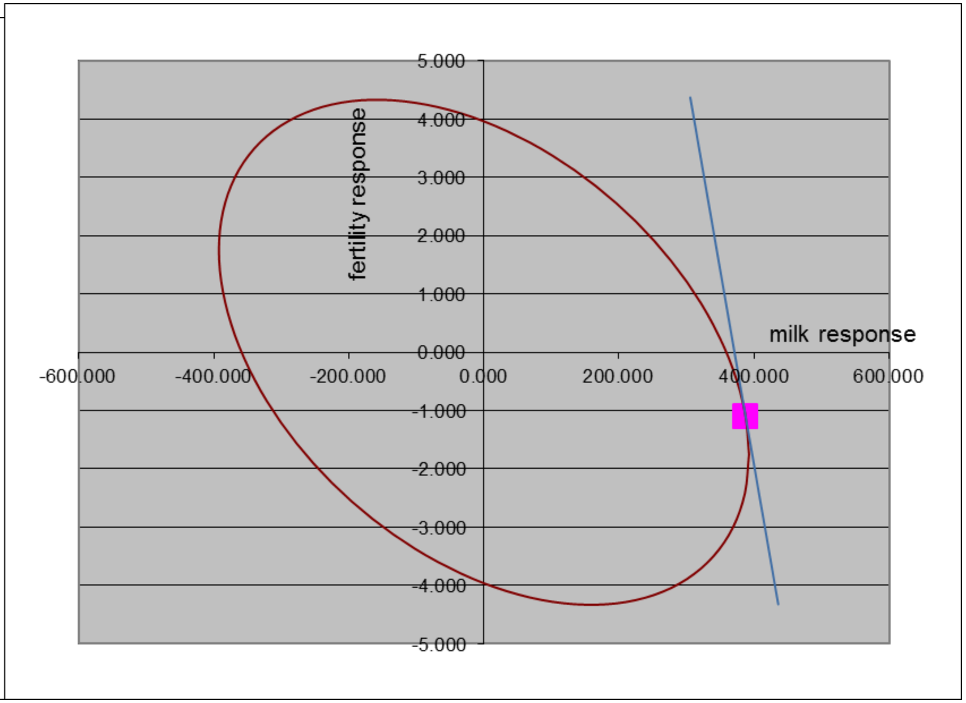
Balancing Traits, weights and information

Multiple traits





Effect of Reproductive Technologies

Making genetic progress is about

Selecting only the very best

Selecting accurately

$$R = \frac{i_m r_m + i_f r_f}{L_m + L_f} \sigma_A$$

Keeping generation intervals short

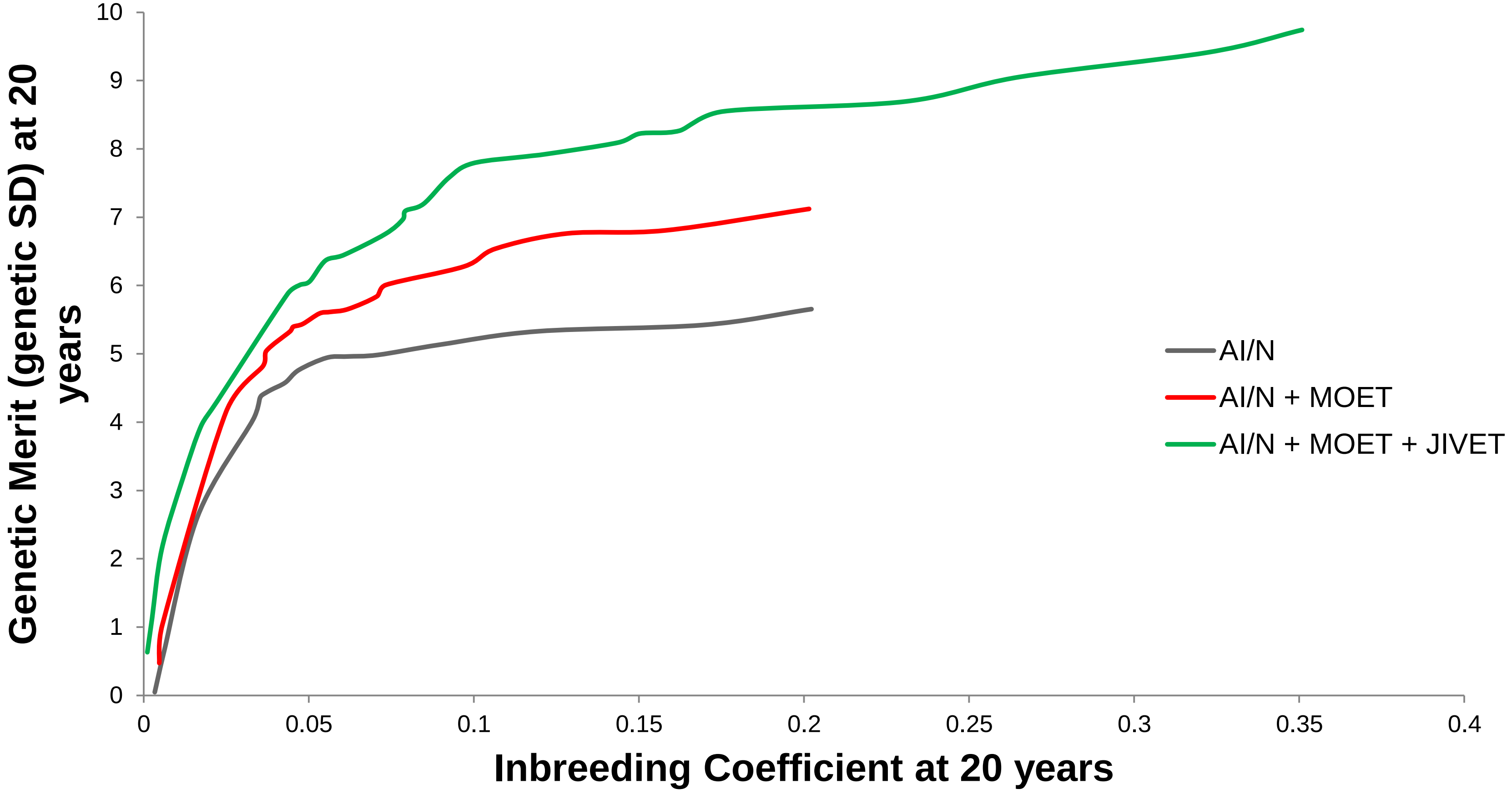
Reproductive rates affect all of the above!

Genetic gain versus genetic diversity

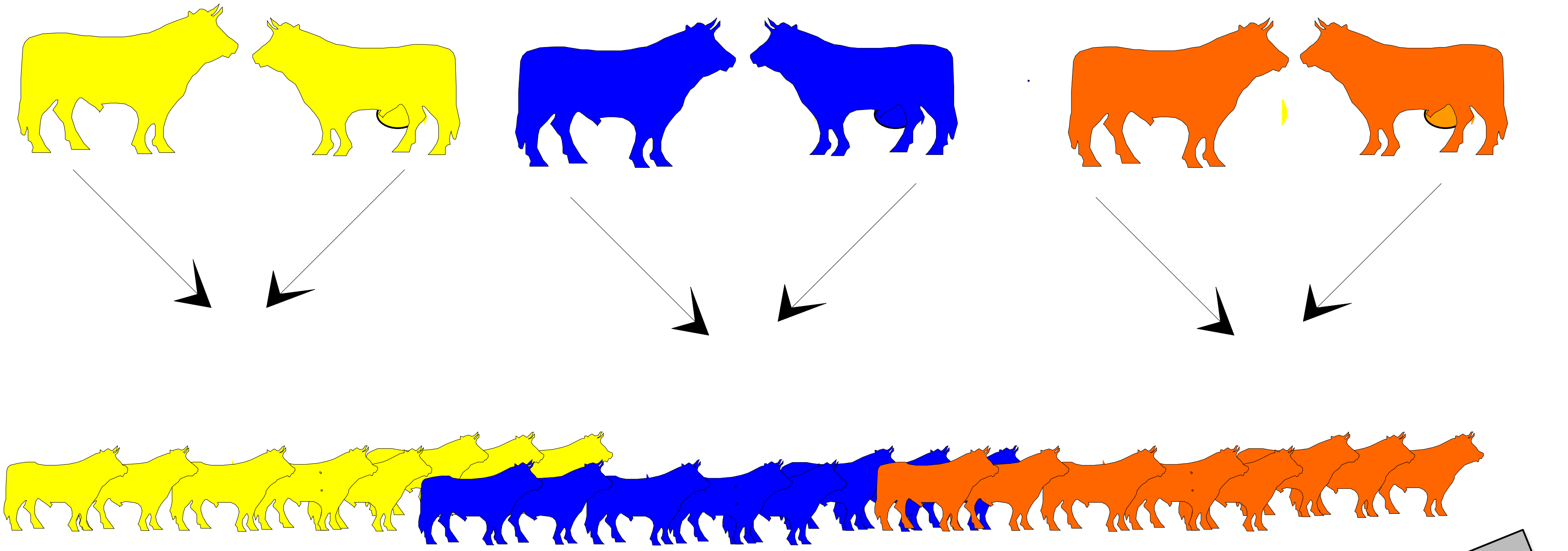
- Early selection can only be based on family information
- Sustainable breeding programs require optimal selection balancing genetic gain and genetic diversity
- Potential short term benefits from reproductive technologies are inhibited by the need to maintain diversity

Genetic Gain vs Inbreeding After 20 Years

Tom Granleese et al., AAABG 2013



Between versus within family selection

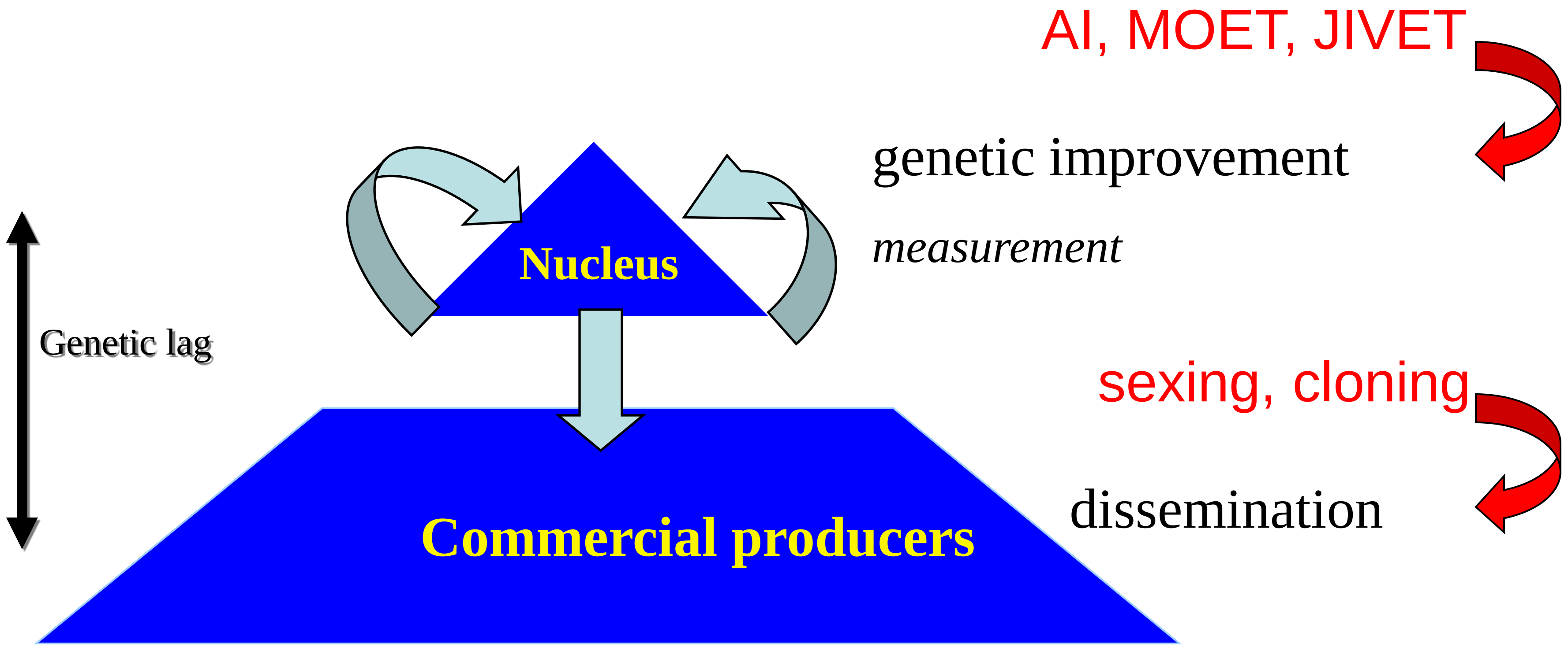


Own information (performance or *genotype*):

More variation within families

More within-family selection – ***less inbreeding***

Reprod technol. In a breeding design context



Proportion of females assigned technologies

at 1% ΔdF per gen

	AI/N	MOET	JIVET	Total Females*	Males Used*	Females per male
Early Trait						
With GS	0.29	0.28	**0.43**	85	19	4.5
NO GS	0.34	0.36	**0.30**	88	20	4.4
Late Trait						
With GS	0.31	0.26	**0.43**	88	14	6.3
NO GS	0.34	0.35	**0.31**	89	15	6.0
Dairy						
With GS	0.38	0.28	**0.34**	218	39	5.6
NO GS	0.47	0.35	**0.18**	237	41	5.8

GS SHIFTS PROPORTION

Compensate female lack of diversity with more sire diversity

Granleese et al., AAABG 2013

SHEEP CRC

Optimizing use of repro technologies

Proportion Captured	AI	MOET	JIVET	Dams Used	G/yr ($)	L
0.06	0.95	0.00	0.05	261	$2.26	1.87
0.32	0.77	0.04	0.19	221	$2.82	1.46
0.64	0.36	0.10	0.54	136	$3.96	1.21

Importance of Trait measurement

1 The ultimate response of a trait will depend on:

choice

its relative economic weighting

accuracy of its EBV

correlation with other EBVs

genetic parameters

We can control these

what has been measured

This includes genomic information!

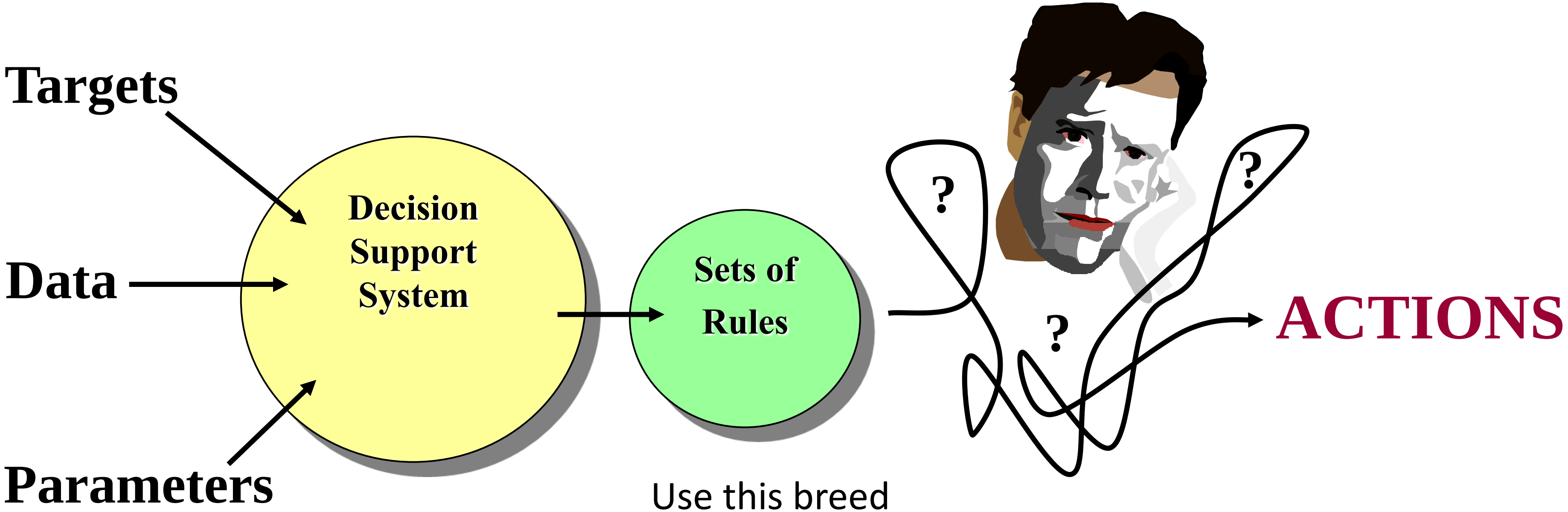
Evaluating Breeding programs

- Deterministic vs Stochastic Simulation
- Optimization strategies

Implementation of programs ...

- Rules-based approach:
  - "Start joining on 1st February"
  - "Use best 10 rams mated to best 400 ewes"
  - "Set up a rotational cross"
- Tactical approach
  - Maximise impact of selection and mating, based on ***prevailing*** animals, markets, costs, constraints and opportunities.

Rules-based approach to Design



Use this breed

Select on EBV

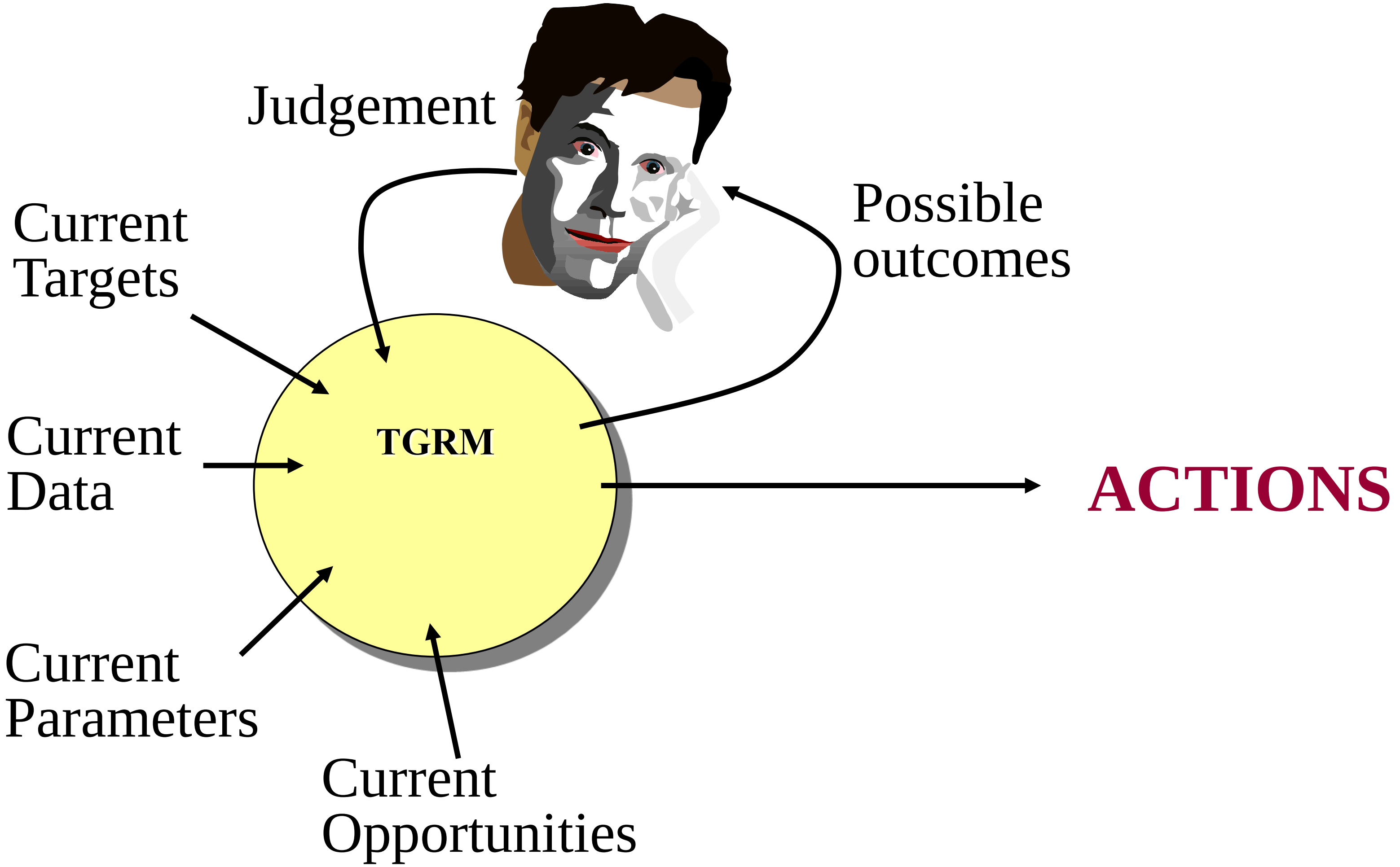
Age at culling

Connect herds

…etc.

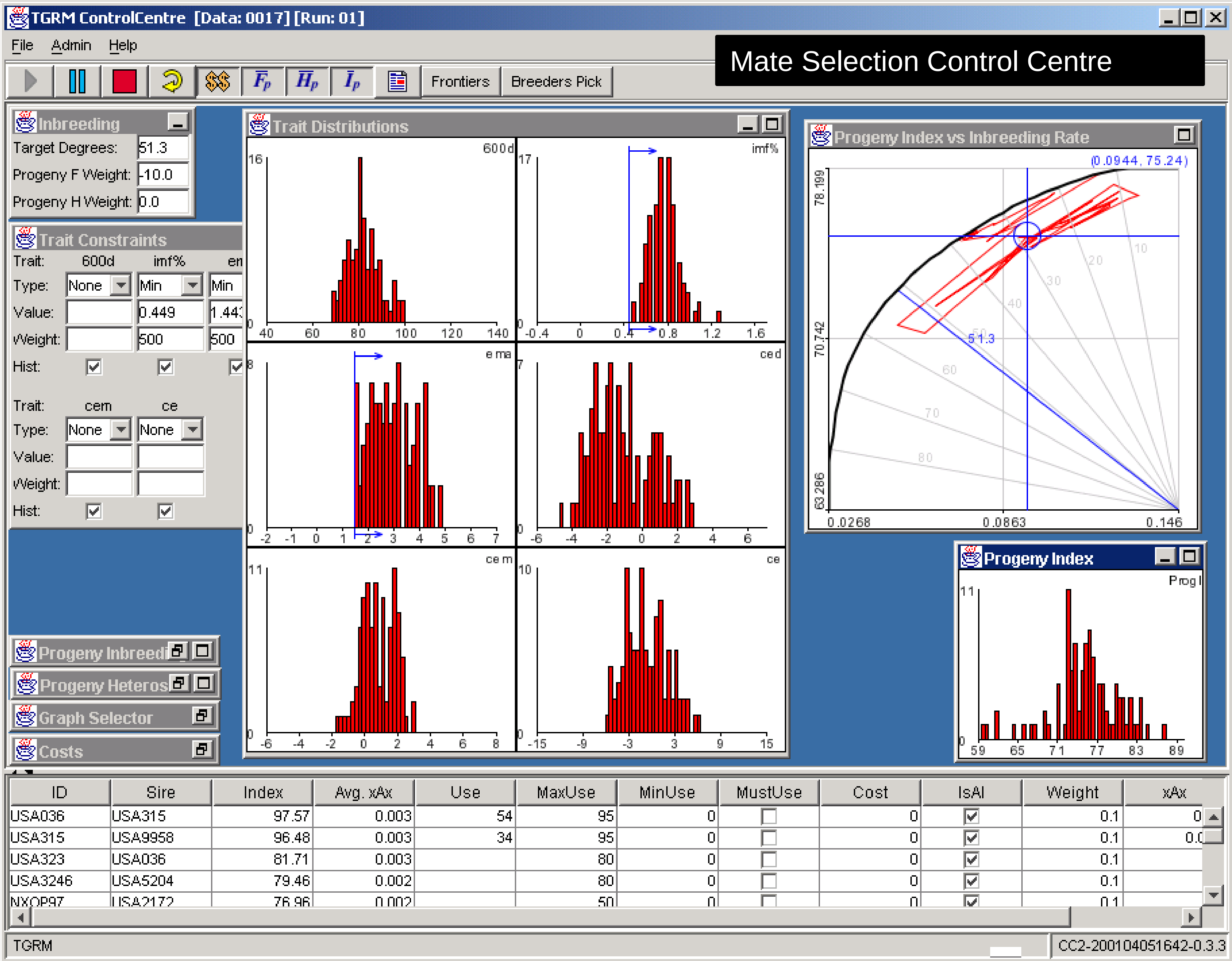
Tactical approach to Design

Action Decision Systems



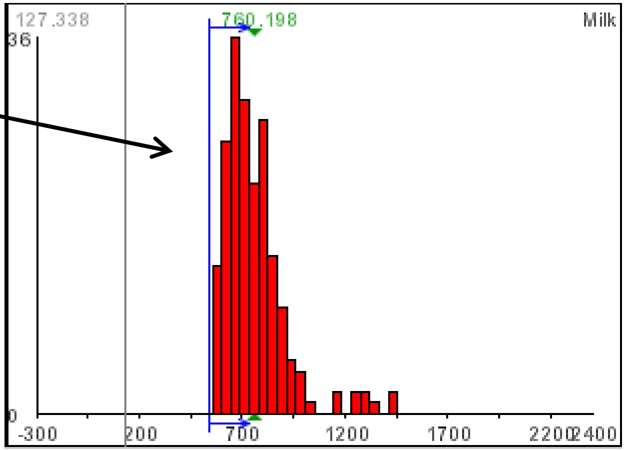
Mate allocations ...

EPD Cost	+1 0	+2 10	+10 10
+10 0	311	312	335
+25 3	341	322	322
+20 2	309	330	345


Mate Selection Control Centre
TGRM ControlCentre [Data: 0017] [Run: 01]
File
Admin
Help
Frontiers
Breeders Pick
Inbreeding
Target Degrees: 51.3
Progeny F Weight: -10.0
Progeny H Weight: 0.0
Trait Constraints
Trait: 600d imf% em
Type: None Min Min
Value: 0.449 1.443
Weight: 500 500
Hist:
Trait: cem ce
Type: None None
Value:
Weight:
Hist:
Trait Distributions
600d
imf%
e ma
ced
ce m
ce
Progeny Index vs Inbreeding Rate
(0.0944, 75.24)
78.199
70.742
63.286
0.0268
0.0863
0.146
51.3
Progeny Index
Prog I
Progeny Inbreedi
Progeny Heteros
Graph Selector
Costs
ID | Sire | Index | Avg. xAx | Use | MaxUse | MinUse | MustUse | Cost | IsAI | Weight | xAx
USA036 | USA315 | 97.57 | 0.003 | 54 | 95 | 0 | | 0 | | 0.1 | 0
USA315 | USA9958 | 96.48 | 0.003 | 34 | 95 | 0 | | 0 | | 0.1 | 0.0
USA323 | USA036 | 81.71 | 0.003 | | 80 | 0 | | 0 | | 0.1 |
USA3246 | USA5204 | 79.46 | 0.002 | | 80 | 0 | | 0 | | 0.1 |
NXOP97 | USA2172 | 76.96 | 0.002 | | 50 | 0 | | 0 | | 0.1 |
TGRM
CC2-200104051642-0.3.3

Achieving Trait Constraints

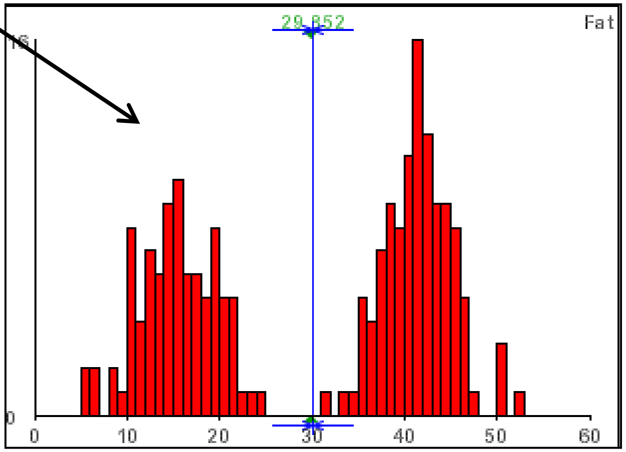
All progeny are predicted to be above the restriction of +545Kg



Predicted progeny Milk EBVs

Achieving Trait Constraints

Targeting two different objectives in one cycle of matings

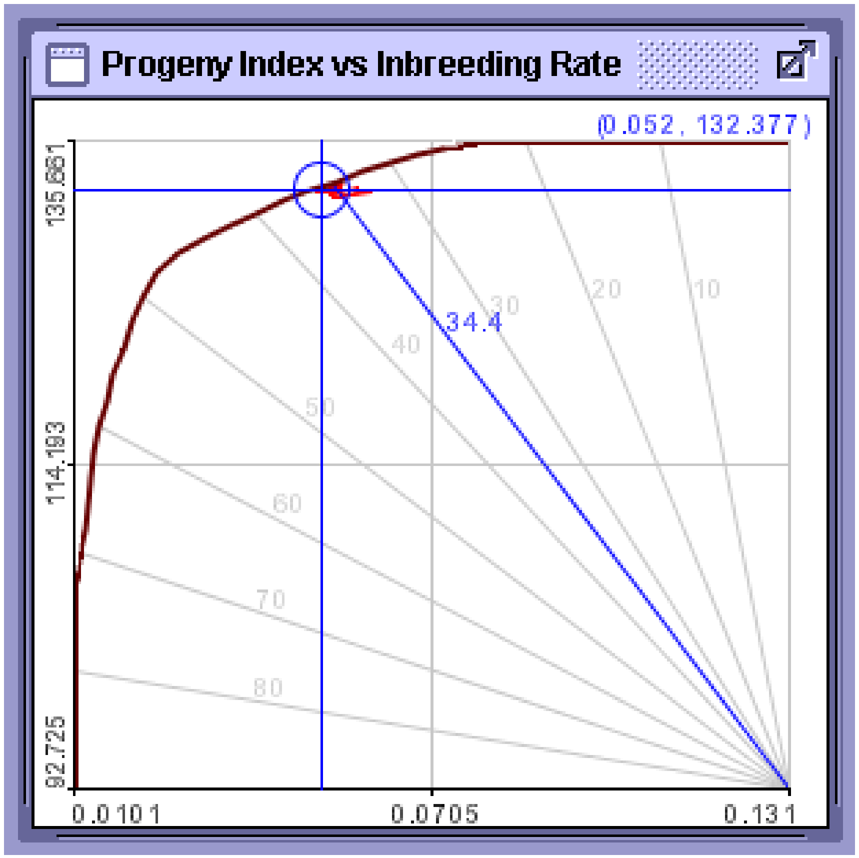


Predicted progeny Fat EBVs

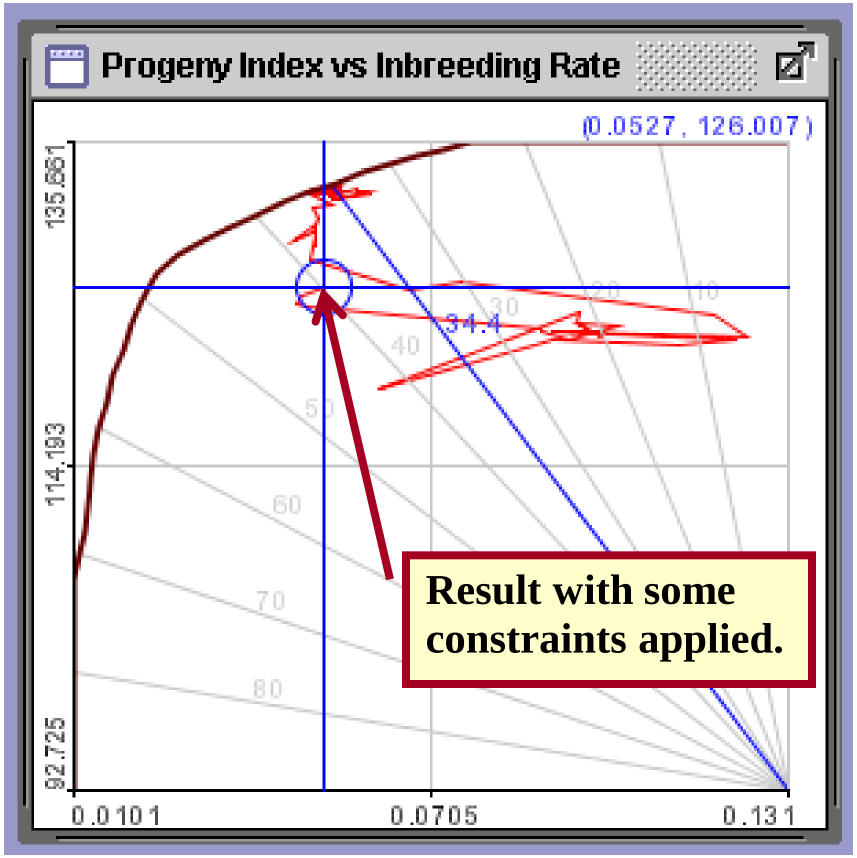
Imposing constraints

(eg. Sire use, QTL outcome, trait distributions)

Predicted progeny index



Mean parental coancestry



Mean parental coancestry

Output: Mating List

Mating List - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://tgrm.une.edu.au/servlet/reports_show/987823367381_0018_01/matlst0.htm What's Related

Total Genetic Resource Management

Mating List (by Sire)

Report List

Report Summary | Sires Summary | Mating List | Mating List (CSV) | Mating List (TXT)

up|down Sire	up|down Dam	up|down index	up|down F	up|down SireCoan	up|down DamCoan	up|down SortIndex	up|down 600d-1	up|down 600d-2	up|down imf%	up|down ema-1	up|down ema-2	up|down ced	up|down cem	up|down ce
USA3246	T229	66.68	0.0156	0.003228	0.000138	64.9366	88.00	88.00	0.50	0.15	0.15	1.25	-0.70	0.02
USA3246	T213	70.18	0.0000	0.003228	0.000175	69.9997	81.50	81.50	0.65	1.55	1.55	2.35	0.48	3.48
USA3246	T157	64.68	0.0235	0.003228	0.000000	62.1640	85.00	85.00	0.45	0.20	0.20	2.81	-1.08	0.83
USA3246	T137	65.64	0.0000	0.003228	0.000000	65.4690	72.00	72.00	0.70	0.40	0.40	2.88	1.52	6.09
USA3246	T117	68.09	0.0078	0.003228	0.000087	67.1344	76.00	76.00	0.65	1.45	1.45	2.80	0.81	4.59
USA3246	T063	76.10	0.0039	0.003228	0.000000	75.5340	77.00	77.00	0.90	1.35	1.35	-0.09	0.03	0.14
USA3246	T057	73.06	0.0000	0.003228	0.000000	72.8840	70.00	70.00	0.90	-0.55	-0.55	2.74	0.34	3.60
USA3246	T029	64.08	0.0235	0.003228	0.000132	61.5570	77.50	77.50	0.60	0.40	0.40	3.38	-0.97	1.62
USA3246	T020	75.63	0.0078	0.003228	0.000000	74.6740	90.50	90.50	0.65	1.45	1.45	1.87	-0.43	1.17
USA3246	T013	67.38	0.0000	0.003228	0.000133	67.2019	77.50	77.50	0.70	1.20	1.20	1.69	0.48	2.82
USA3246	T008	72.18	0.0000	0.003228	0.000298	71.9982	73.50	73.50	0.75	1.05	1.05	3.04	2.21	7.62
USA3246	S305	63.88	0.0078	0.003228	0.000141	62.9215	81.50	81.50	0.55	1.35	1.35	-0.42	-0.71	-1.67
USA3246	R001	66.58	0.0000	0.003228	0.000000	66.4090	67.50	67.50	0.80	1.35	1.35	3.75	1.14	6.20
USA3246	Q075	62.24	0.0000	0.003228	0.009841	61.5426	84.00	84.00	0.55	0.35	0.35	2.09	0.25	2.76
USA3246	Q001	73.62	0.0000	0.003228	0.000000	73.4490	73.00	73.00	0.80	1.30	1.30	2.50	0.36	3.40
USA323	R211	67.93	0.0000	0.000296	0.000093	67.9094	87.50	87.50	0.55	2.85	2.85	-3.00	-2.26	-8.13
USA315	T99	74.46	0.0000	0.022720	0.000116	73.2452	89.50	89.50	0.70	2.00	2.00	0.22	-0.21	-1.76
USA315	T270	79.83	0.0000	0.022720	0.000000	78.6263	94.00	94.00	0.80	2.60	2.60	-0.14	0.27	-1.15
USA315	T259	72.26	0.0000	0.022720	0.000114	71.0503	85.50	85.50	0.70	0.55	0.55	-0.46	-0.01	-2.04
USA315	T243	76.79	0.0625	0.022720	0.000154	69.3281	88.00	88.00	0.75	2.95	2.95	-1.00	0.20	-2.15
USA315	T217	72.43	0.0000	0.022720	0.000000	71.2263	82.00	82.00	0.70	0.55	0.55	0.49	0.13	-0.80

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The End