Total Genetic Resource Management

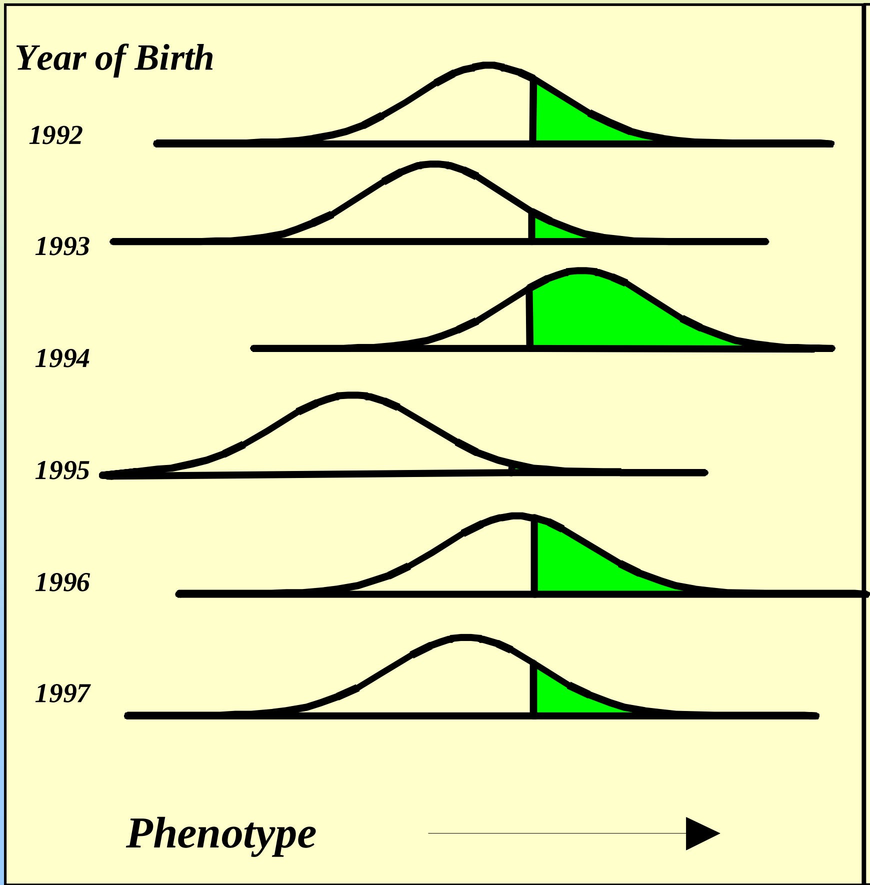
TGRM

Rules-based approach to Design

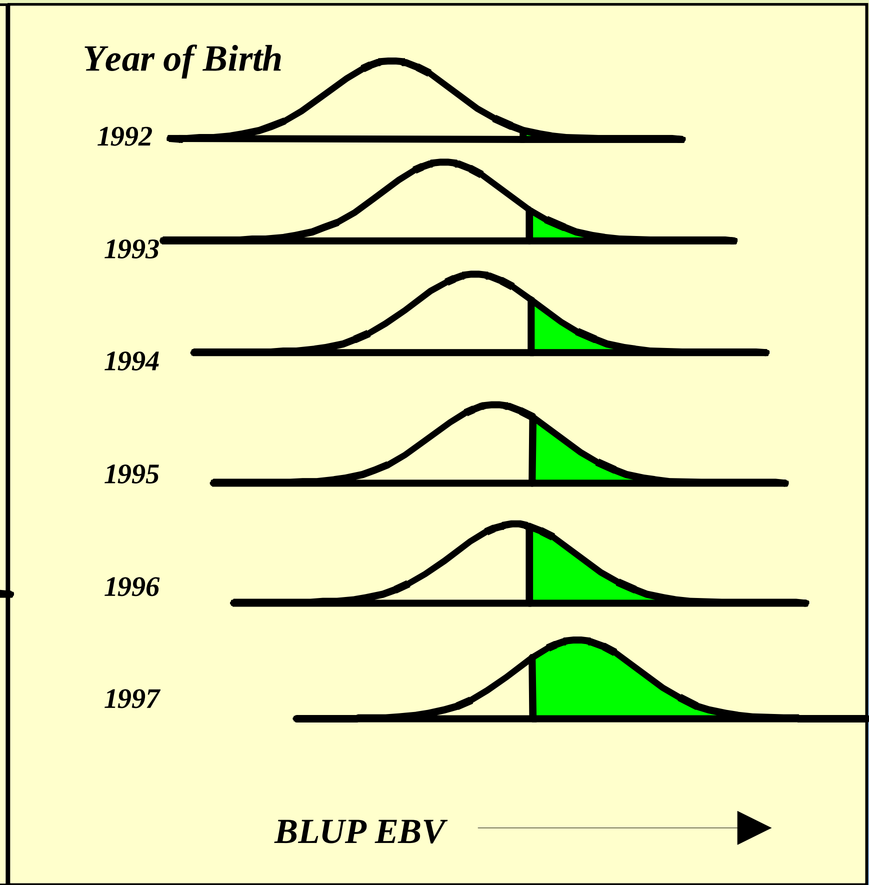
- Different methods have been developed for handling different animal breeding issues (eg. selection, inbreeding, crossing).
  - When we try to mix different methods (or mix different rules) we are likely to miss the best overall design.
- Following strict rules leads to missed opportunities. We should:
  - Fine-tune the rules as appropriate
  - Break the rules when appropriate

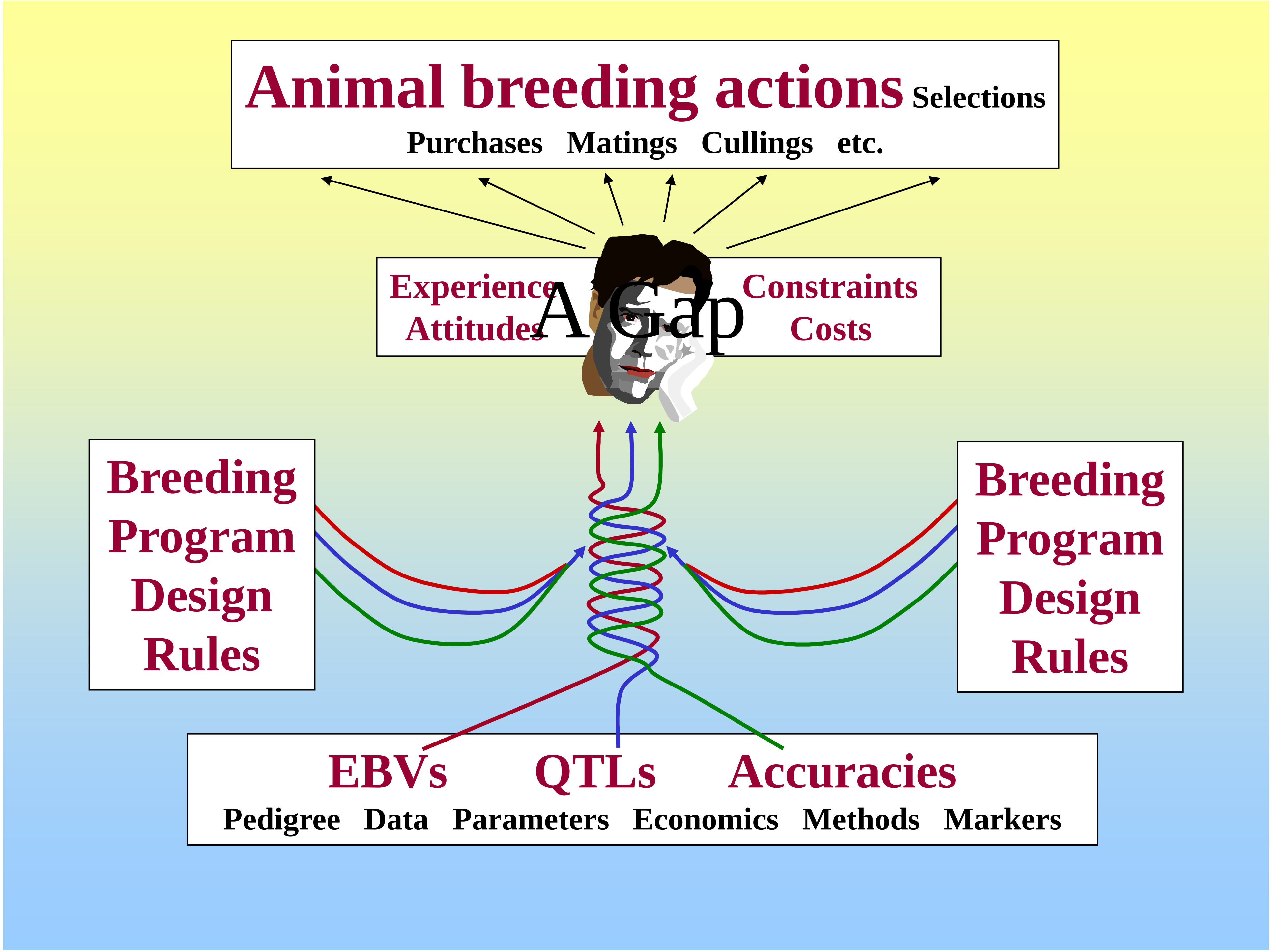
A genetic evaluation system helps to design breeding programs.

Select on phenotype

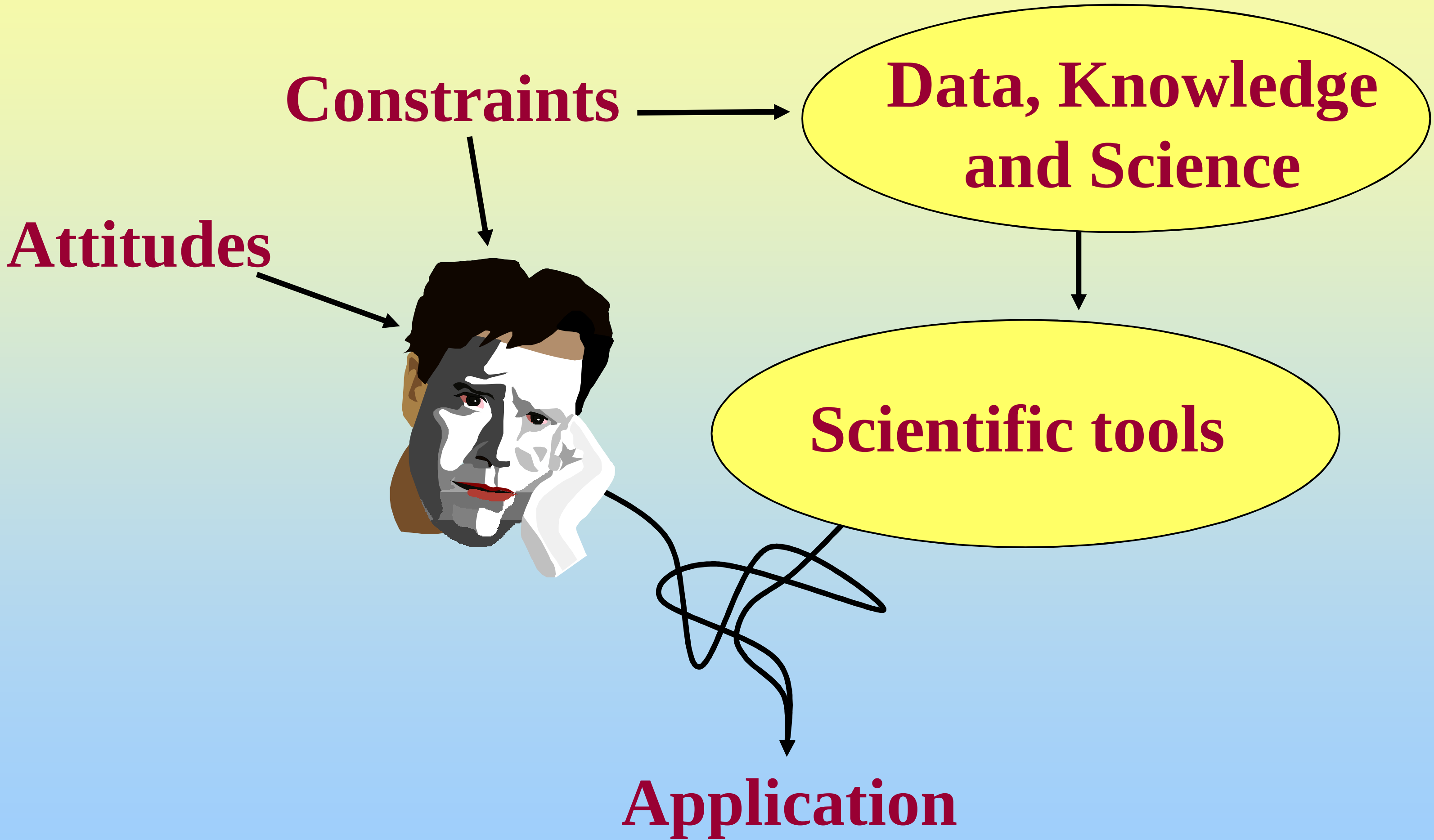


Select on EBV

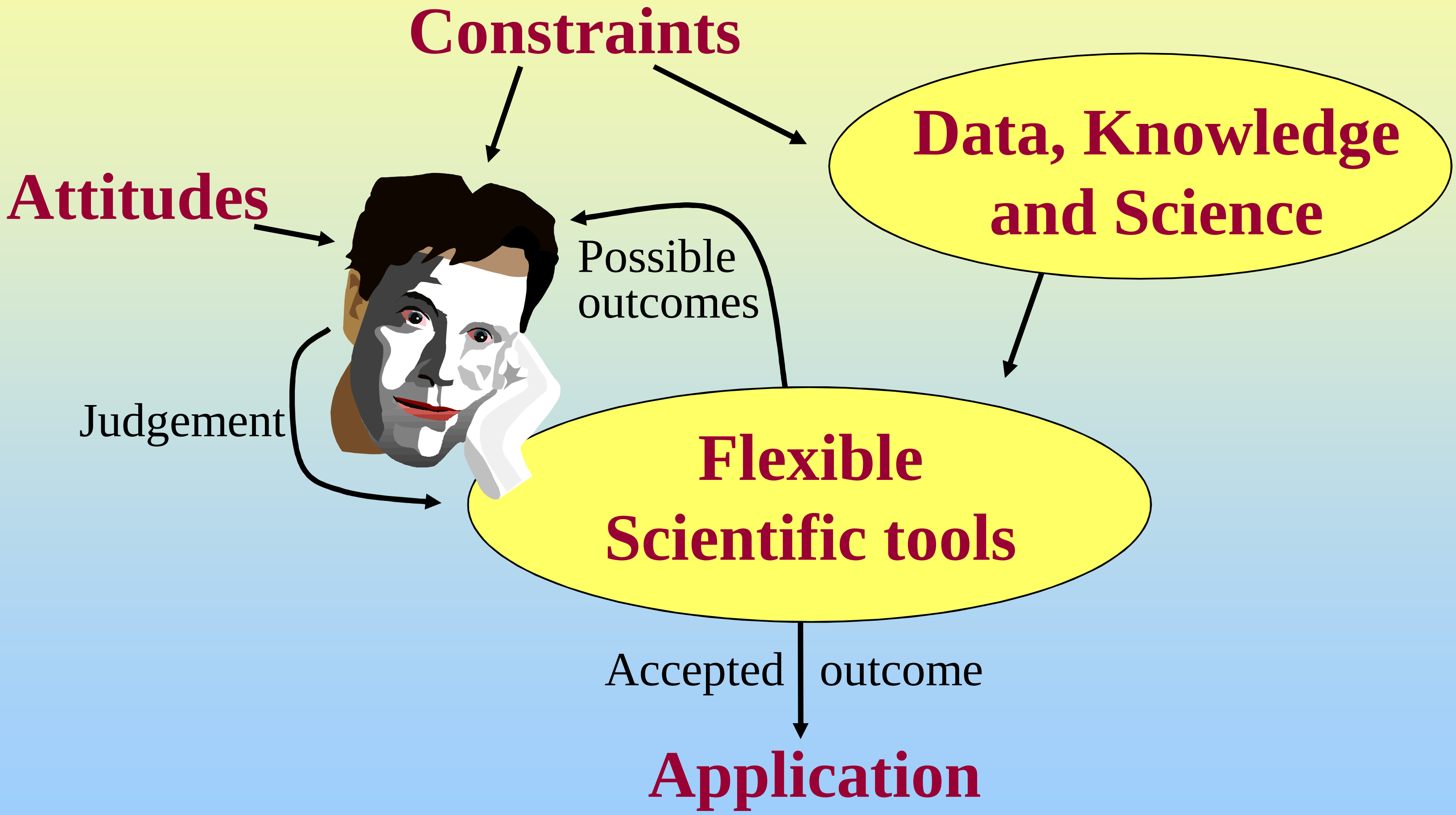



Animal breeding actions Selections
Purchases Matings Cullings etc.
Experience
Attitudes
A Gap
Constraints
Costs
Breeding Program Design Rules
Breeding Program Design Rules
EBVs QTLs Accuracies
Pedigree Data Parameters Economics Methods Markers

A classic decision system



A Dynamic Tactical Decision System



Key actions for Animal Breeders

- Selection

- Mating

Σ = "Mate selection"

Mating List - Netscape

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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

Document: Done

"Total Genetic Resource Management"

Covers …

- Selection
- Crossbreeding
- Costs
- Genetic diversity
- Optimal selection
- Progeny inbreeding
- Connection between herds
- Limits on reproduction
- Marker Assisted Selection
- Use of AI, MOET, IVF
- Corrective mating
- Managing trait distribution
- Funding limits
- Quarantine barriers
- **Logistical constraints**
- **etc**

TGRM approach ...

A candidate solution ...

Bull→ Cow↓	1	2	3	4 ...
1	mate	mate	-	mate
2	mate	-	-	-
3	-	mate	-	-
4 ...	-	-	-	mate

[… one breed or a mixture of breeds]

Evaluate for (eg.) ...

- Progeny merit
  - EBV, inbreeding, heterosis ...
- Genetic diversity
  - including long-term inbreeding.
- Connection across herds
  - plus dispersal to comm. herds.
- Costs
  - AI and MOET, stock purchase ...
- Logistical factors
  - paddocks, stock movements ...
- Broken constraints
  - fund limits, quarantine barriers ...

Sum to give dollar value of this solution

Try to find a better solution

A mate selection objective function:

$$\frac{x'G}{2M} + \lambda\frac{x'Ax}{4M^2} + \phi F + \chi C - cost \;+ \text{practical constraints} +++$$

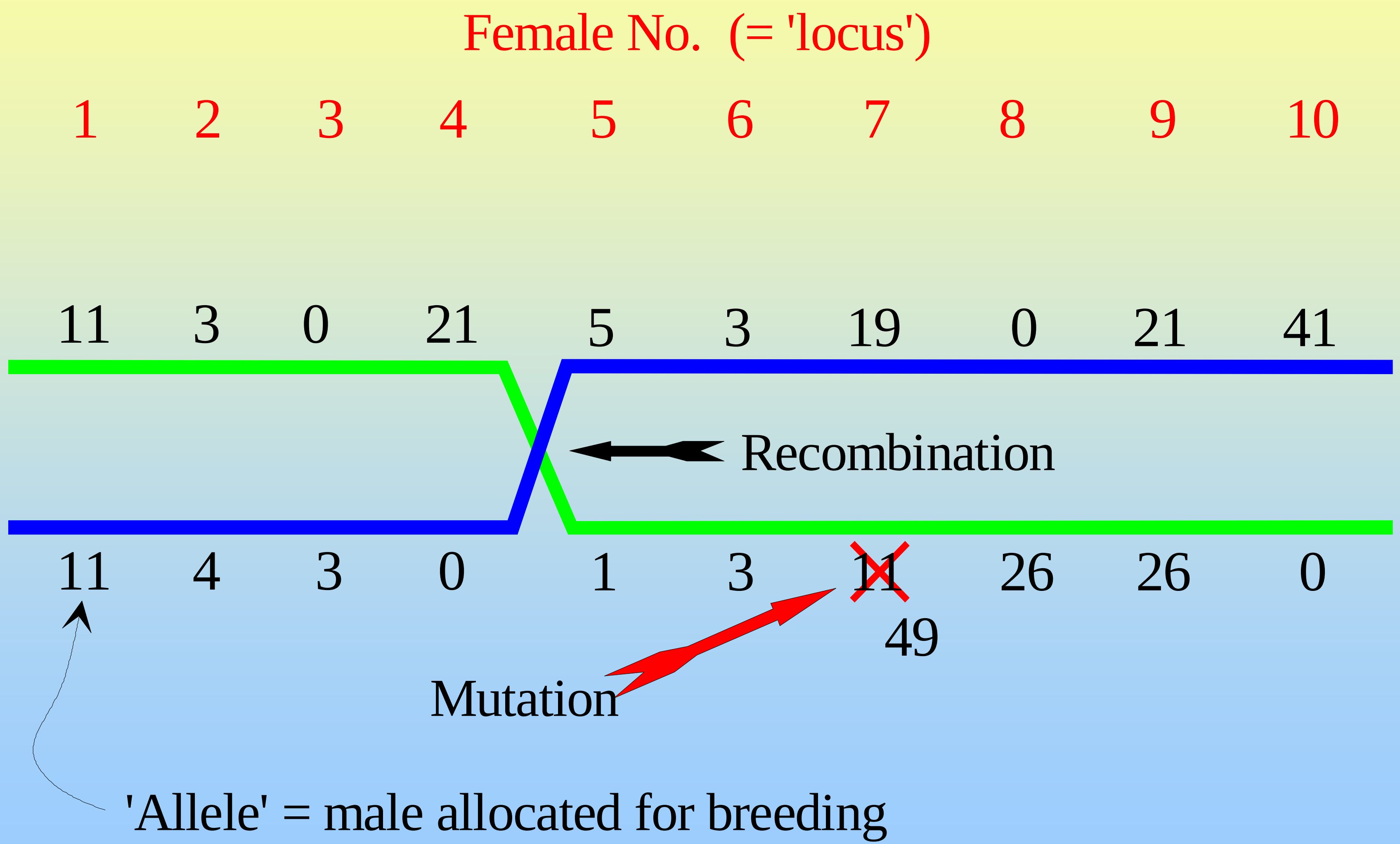
$x'G$	is the weighted mean EBV of selected parents
x	is a vector of number of matings to be made by each candidate. We need this to be handle to handle mating.
M	is the total number of matings to be made
$x'Ax/4M^2$	is the weighted mean coancestry of selected parents.
λ	is a weighting factor that is typically negative, to discourage low effective population sizes.
A	is the numerator relationship matrix.
ϕ	is the weighing on progeny inbreeding (F).
χ	is the weighing on progeny heterosis (C)
$cost$	is the cost of the mating policy implied by x.

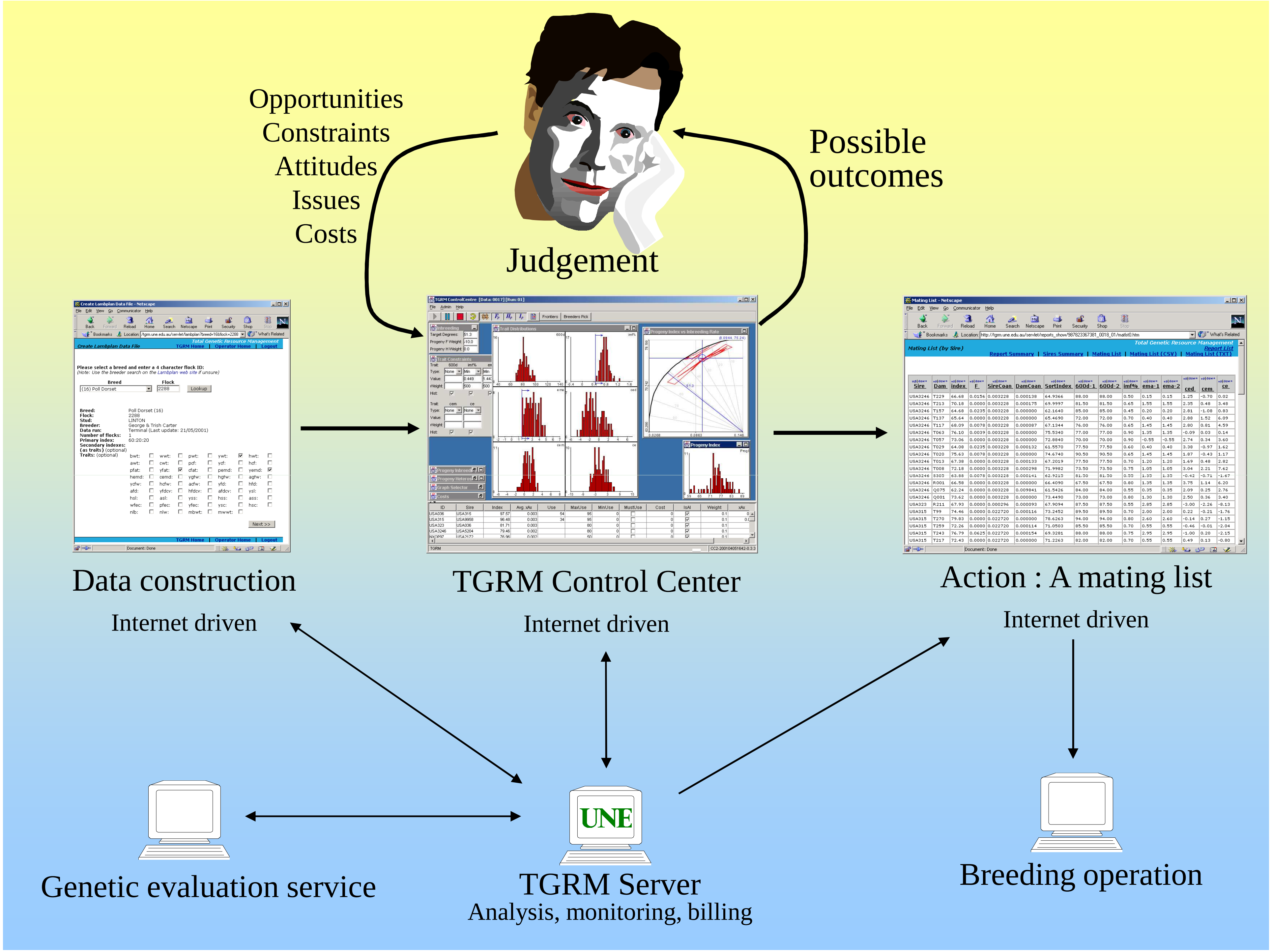
xGxAx.xls …

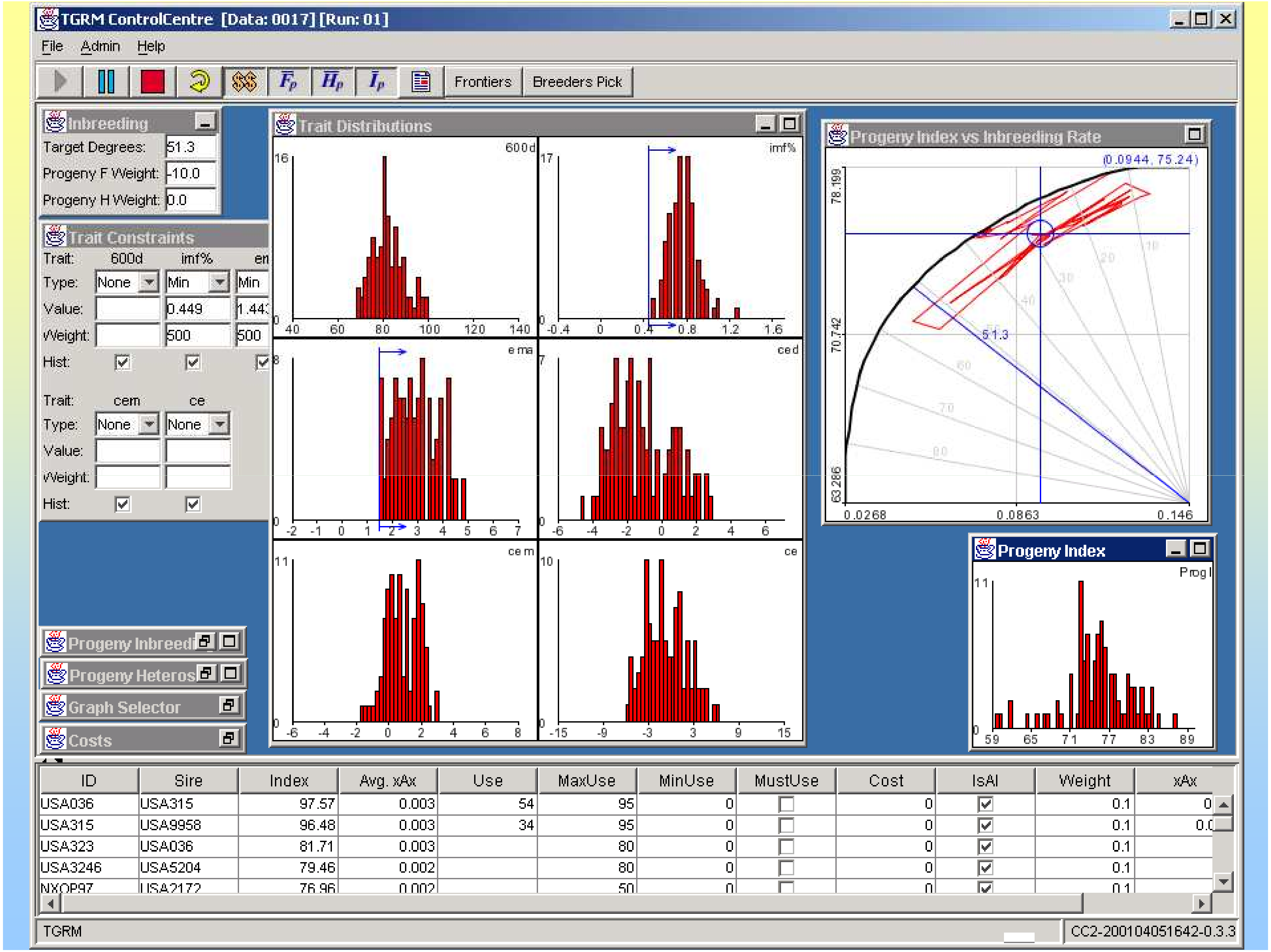
Vector x: Number of matings

Source of animals	Animal#	x = Matings	
Male candidates	**1**	**0**	$\sum =$ Target number of matings
	2	**21**	
	3	**33**	
	4	**0**	
	5	**175**	
	6	**0**	
	7	**0**	
	8	**0**	
	…	**…**	
Female candidates	**101**	**0**	$\sum =$ Target number of matings
	102	**1**	
	103	**1**	
	104	**1**	
	105	**0**	
	106	**0**	
	107	**0**	
	108	**8**	
	…	**…**	

Genetic algorithm for mate selection

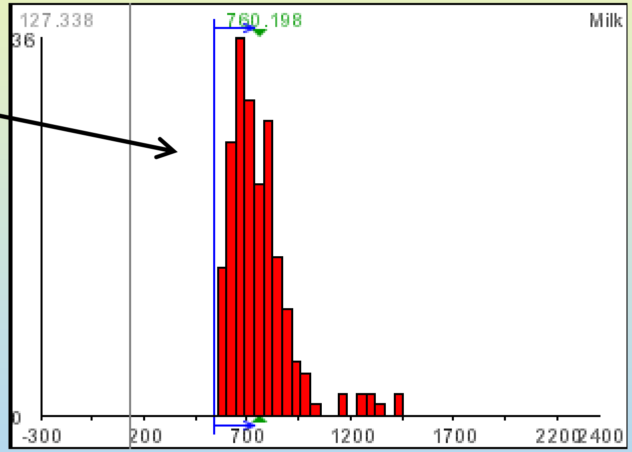



Opportunities
Constraints
Attitudes
Issues
Costs
Judgement
Possible outcomes
Data construction
Internet driven
TGRM Control Center
Internet driven
Action : A mating list
Internet driven
UNE
Genetic evaluation service
TGRM Server
Analysis, monitoring, billing
Breeding operation


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 1.44
Weight: 500 500
Hist:
Trait: cem ce
Type: None None
Value:
Weight:
Hist:
Progeny Inbreedi
Progeny Heteros
Graph Selector
Costs
Trait Distributions
600d
imf%
ema
ced
cem
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
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
USA315 USA9958 96.48 0.003 34 95 0 0 0.1
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

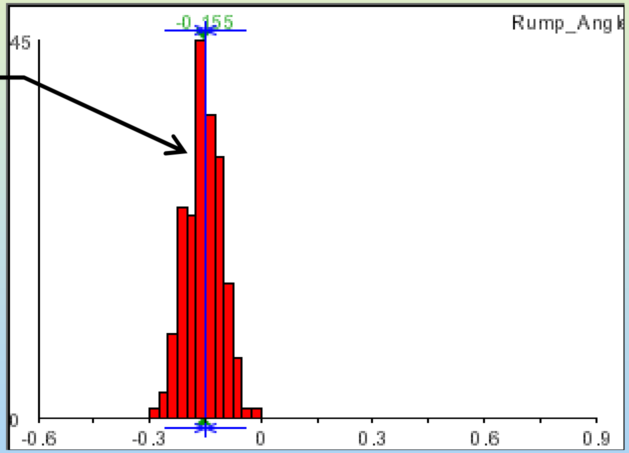
All progeny are predicted to be above the restriction of +545Kg



Predicted progeny Milk EBVs

Achieving Trait Constraints

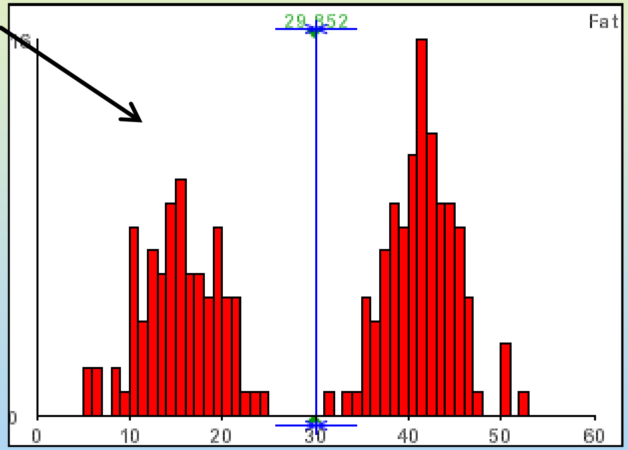
All progeny are predicted to be narrowly distrubute about -0.15 degrees



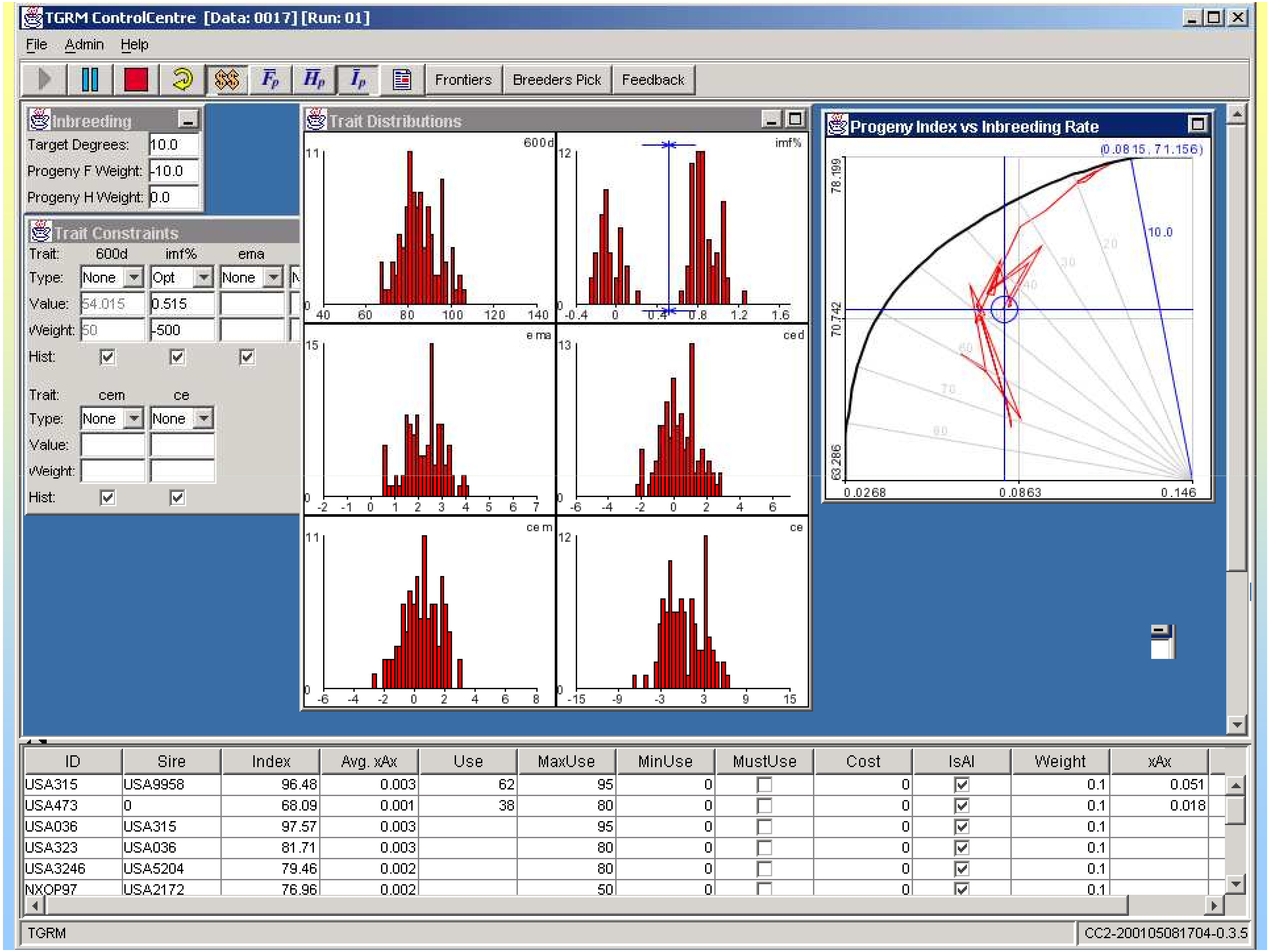
Predicted progeny Rump Angle EBVs

Achieving Trait Constraints

Targeting two different objectives in one cycle of matings



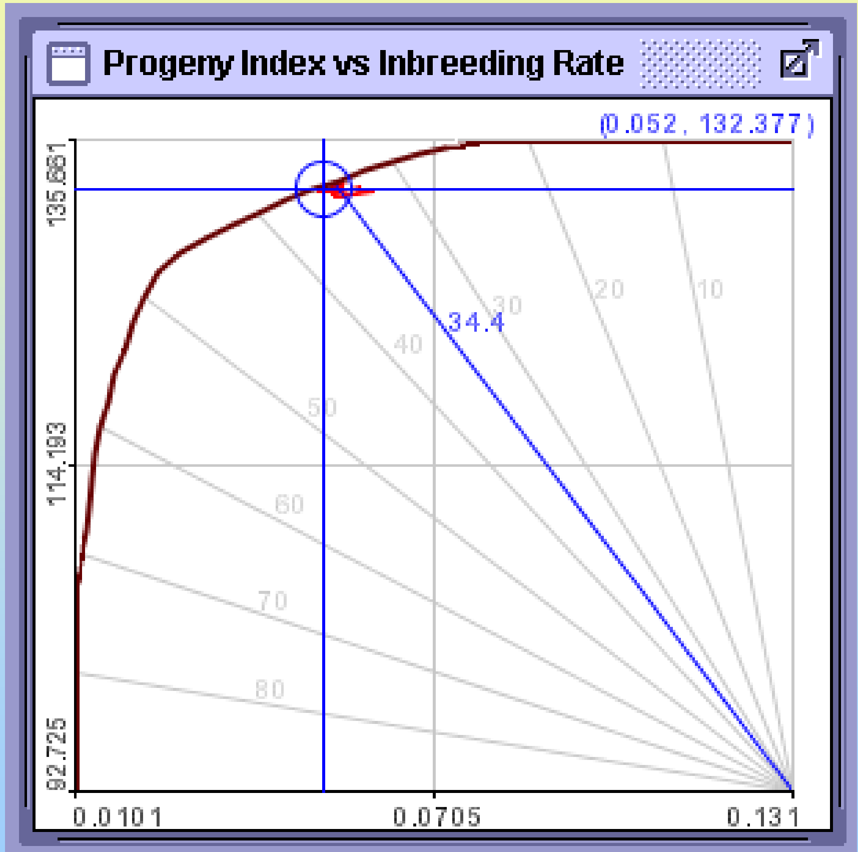
Predicted progeny Fat EBVs


TGRM ControlCentre [Data: 0017] [Run: 01]
File Admin Help
Frontiers
Breeders Pick
Feedback
Inbreeding
Target Degrees: 10.0
Progeny F Weight: -10.0
Progeny H Weight: 0.0
Trait Constraints
Trait: 600d imf% ema
Type: None Opt None
Value: 54.015 0.515
Weight: 50 -500
Hist:
Trait: cem ce
Type: None None
Value:
Weight:
Hist:
Trait Distributions
600d
imf%
ema
ced
cem
ce
Progeny Index vs Inbreeding Rate
(0.0815, 71.156)
10.0
78.199
70.742
63.286
0.0268
0.0863
0.146
ID Sire Index Avg. xAx Use MaxUse MinUse MustUse Cost IsAI Weight xAx
USA315 USA9958 96.48 0.003 62 95 0 0 0.1 0.051
USA473 0 68.09 0.001 38 80 0 0 0.1 0.018
USA036 USA315 97.57 0.003 95 0 0 0.1
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
CC2-200105081704-0.3.5

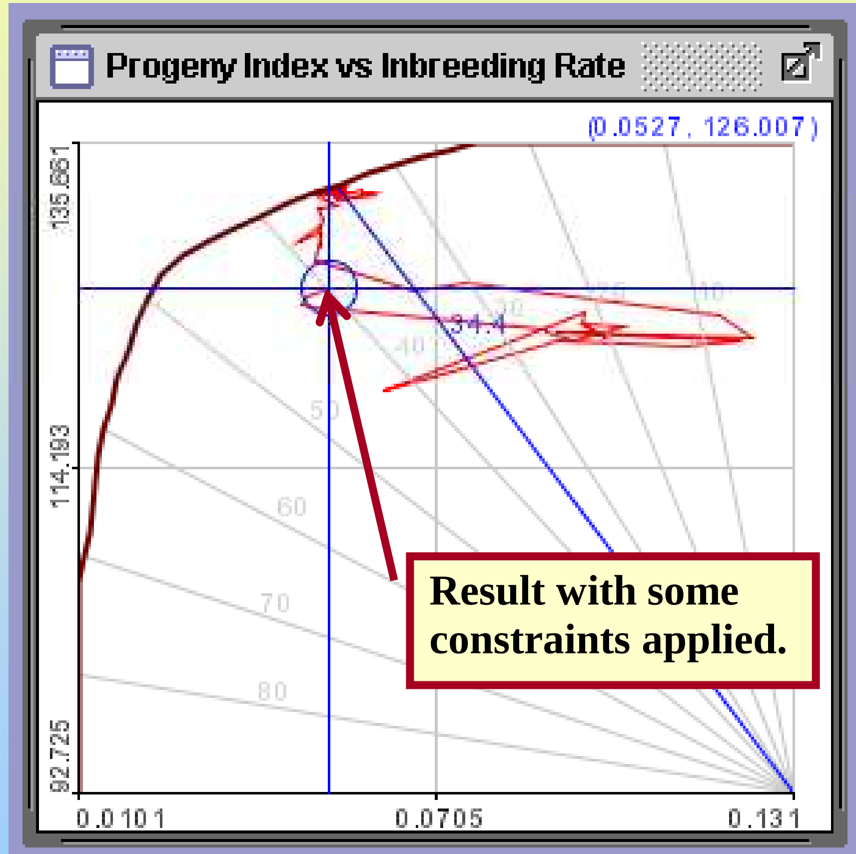
Imposing constraints

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

Predicted progeny index

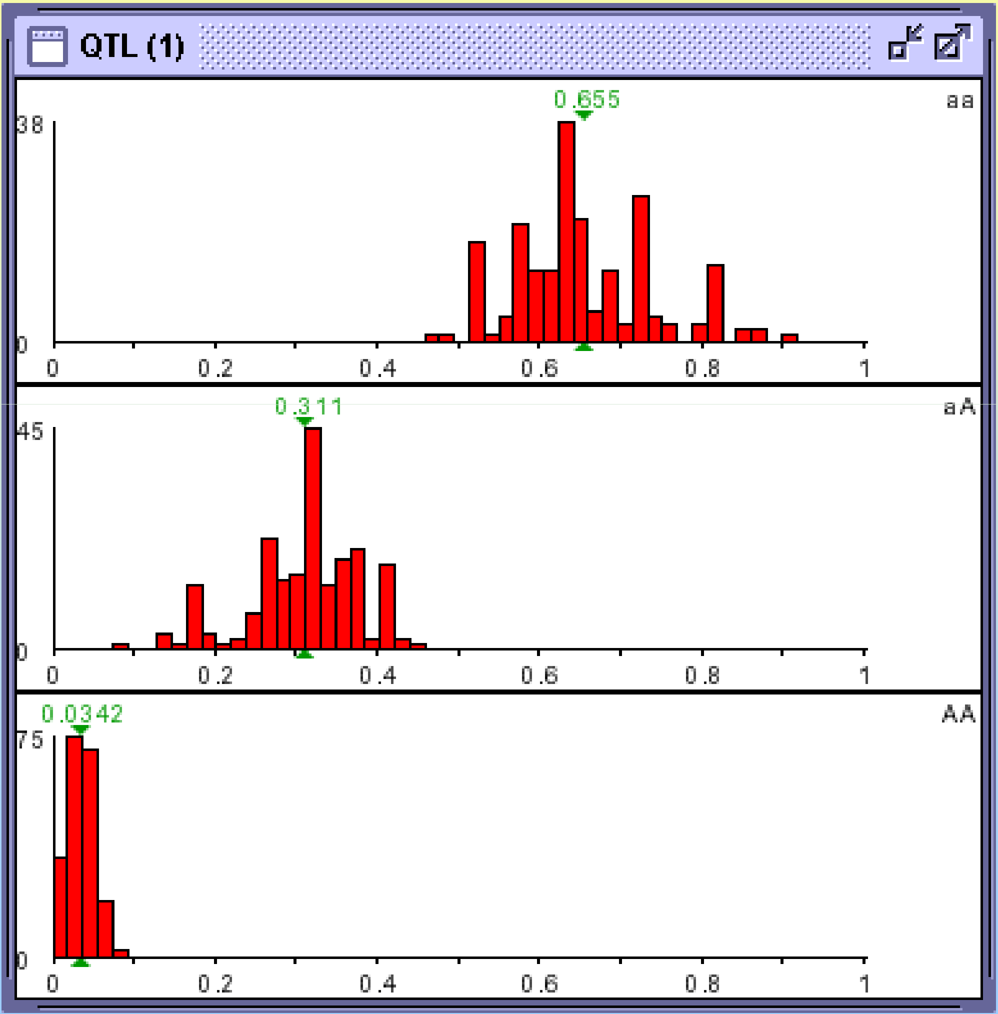


Mean parental coancestry



Mean parental coancestry

MAS: Targetting QTL/gene outcomes



Mating List - Netscape

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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

Document: Done

Use of sires across flocks

Sire	EBV	Sire of Sire	Uses	Flock				
				5001	5002	5003	5004	5008
2350011996961011	148.51	1700171993930114	125	28	48	0	13	36
2350011996961017	143.62	1700171993930114	44	0	0	0	0	44
2350021996962003	146.45	1700171993930114	89	0	24	0	0	65
2350021996962048	138.64	1600341994940171	33	0	0	0	0	33
2350031994943086	131.72	0	71	0	8	40	23	0
2350031995953035	130.58	0	57	0	22	0	35	0
2350031996963053	151.18	1700171993930114	113	0	19	54	0	40
2350031996963054	144.70	1700171993930114	38	0	0	0	0	38
2350031996963057	140.70	1600341994940171	90	0	10	19	0	61
2350031996963071	146.24	1700171993930114	83	0	45	18	20	0
2350031997973113	131.09	1618901992920099	38	0	0	38	0	0
2350031997973201	142.59	2350031996963059	33	0	0	33	0	0
2350031997973256	153.40	2350031996963057	37	0	0	37	0	0
2350041996964066	134.92	2350021994942107	73	11	0	62	0	0
2350041996964183	133.67	2350021994942107	70	0	20	28	6	16
2350081996960176	133.76	1600341994940171	33	0	0	33	0	0
		TOTALS:	1027	39	196	362	97	333

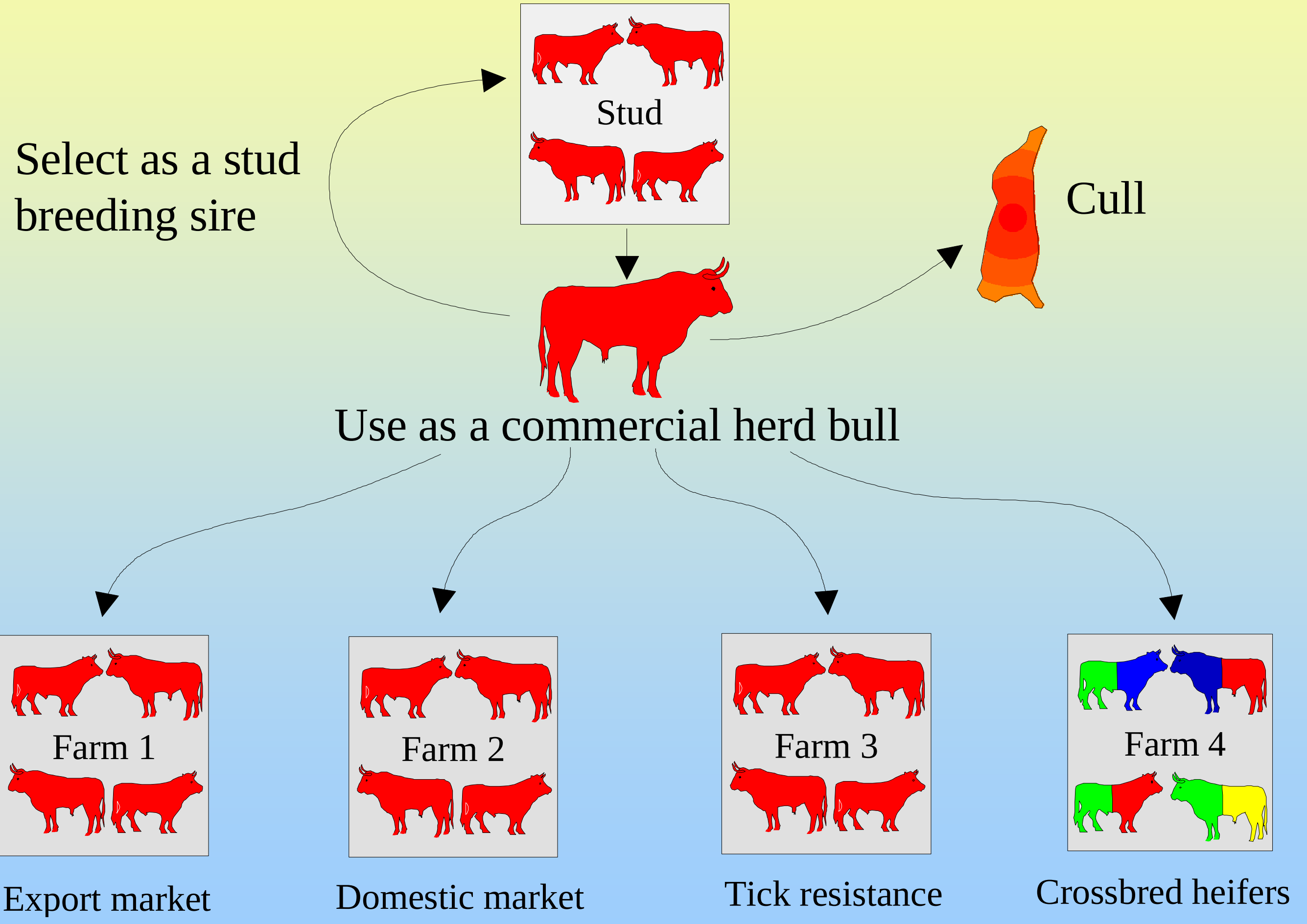
Examples of Costs that can be accommodated

- Reproductive costs.
  - AI, MOET, JIVET
  - find breakeven costs
- Seedstock purchase costs
  - rationalise the balance between price and value
- Seedstock maintainance costs
  - optimise herd size
- Limits on funds available

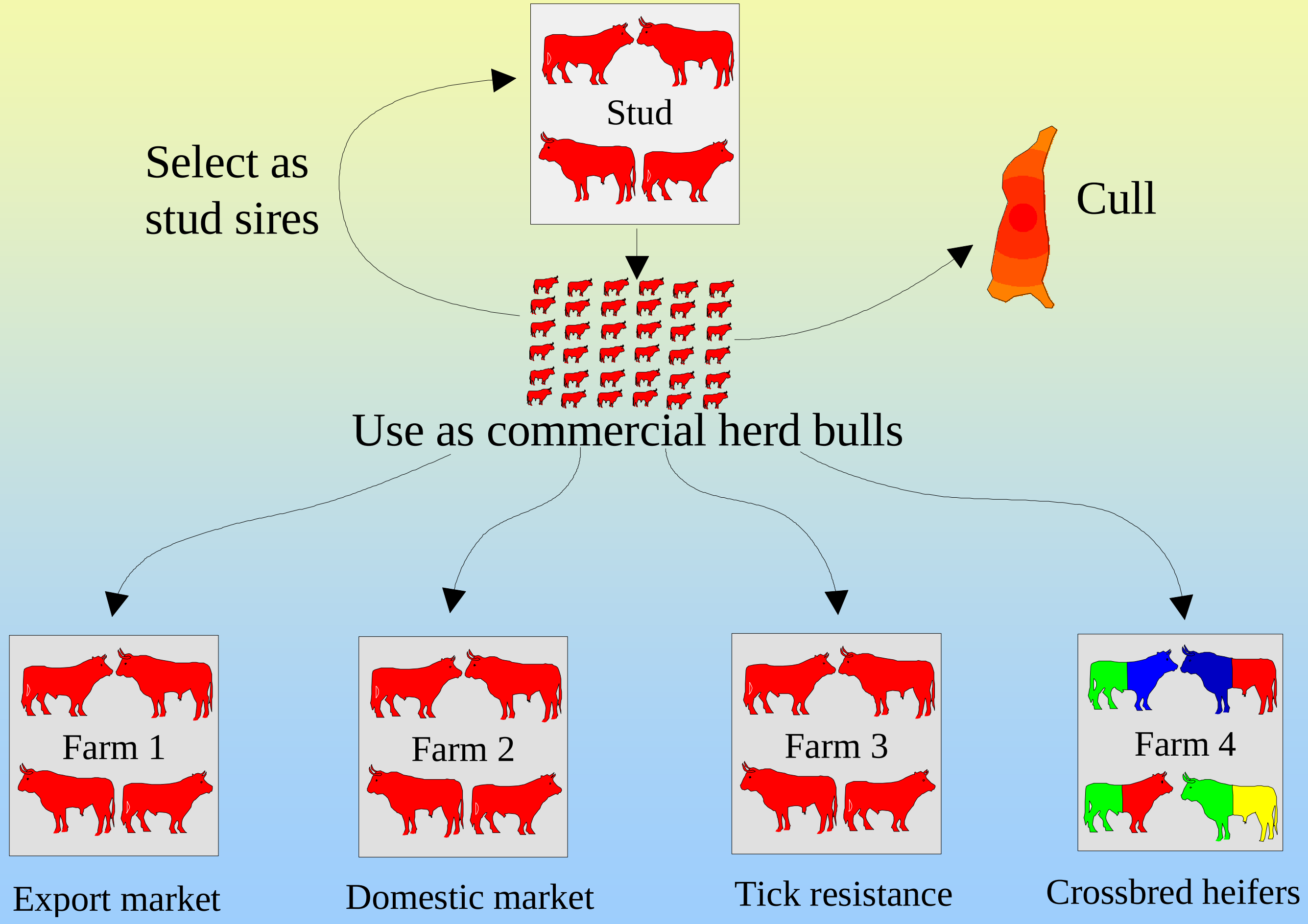
Examples of other factors that can be controlled.

- Mating logistics
  - number and size of mating paddocks
  - “don’t migrate young rams”
  - “put young ewes only to old rams”
- Opportunities and constraints
  - “Lets consider using this New Zealand sire”
  - “I want to use all my 50 doses of this ram’s semen”
  - “Use this link sire for at least 25 matings”
  - “Don’t use any one bull for less than 25 matings”
- Desired outcomes
  - narrow variation in birthweight, fat, etc
  - corrective matings

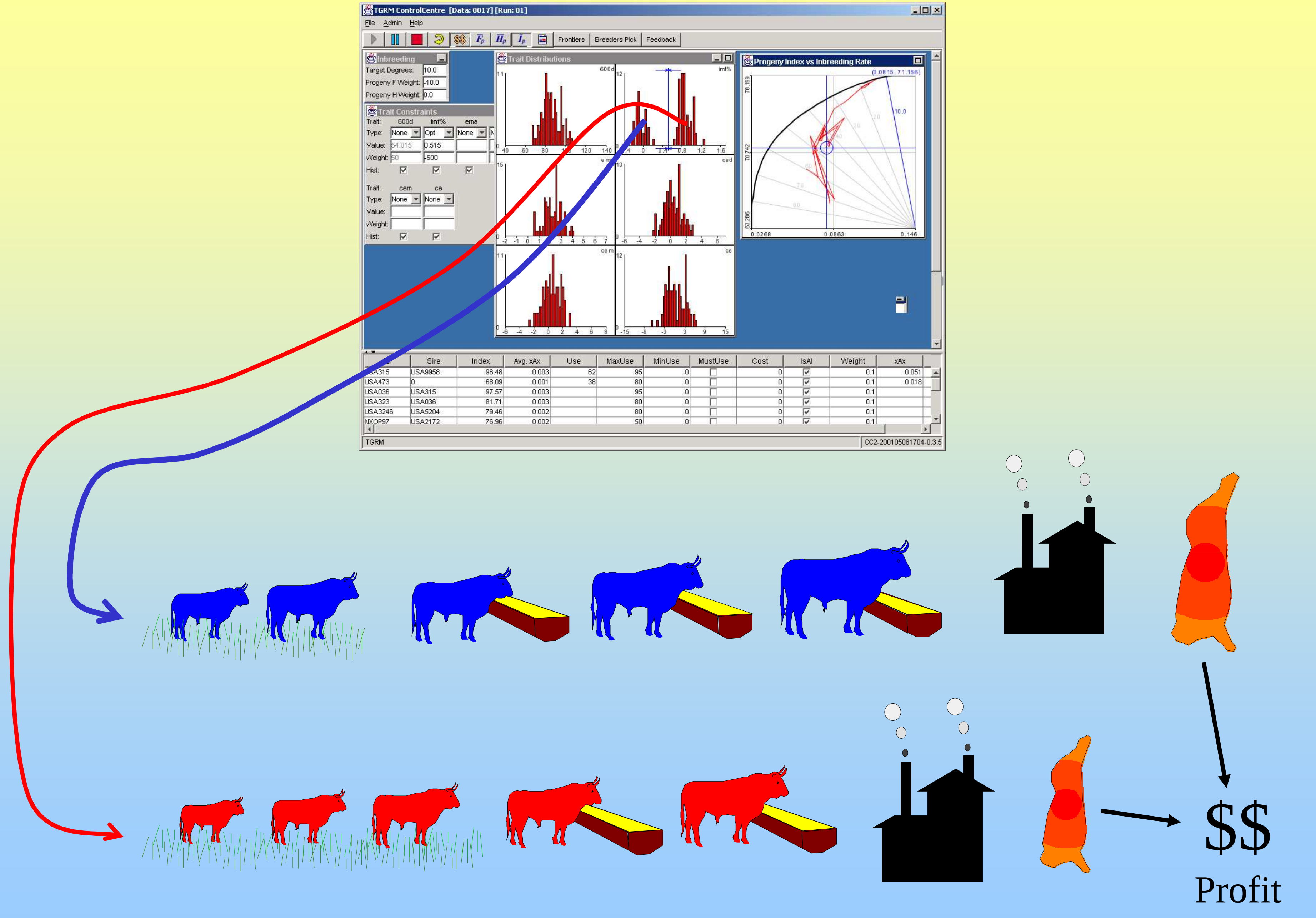
The fate of a stud-born bull ...



The fate of many stud-born bulls ...



Breeding program




The End