Animal Breeding in a nutshell

Where to Go

Breeding objectives

How to get there

Trait measurement

- Which traits
- Which animals
    - Males / females
    - Progeny test
    - Nucleus / commercial

--Genotypings

Estimation of breeding value

- Phenotypes
- Pedigree
- BLUP
- Genetic Markers

Reproductive technology

- Artificial Insemination
- MOET
- JIVET
- Cloning

Selection, culling & Mating

- Index / EBV's
- Balancing merit and inbreeding
- Other issues

Issues related to optimal design

- Increase in genetic merit — Select as few as possible; Select across ages
- Inbreeding — …but select not too few
- Crossbreeding — Exploit this?
- Breeding objective
- Connections
- Measurement strategies
- Reproduction technology
- Running Cost

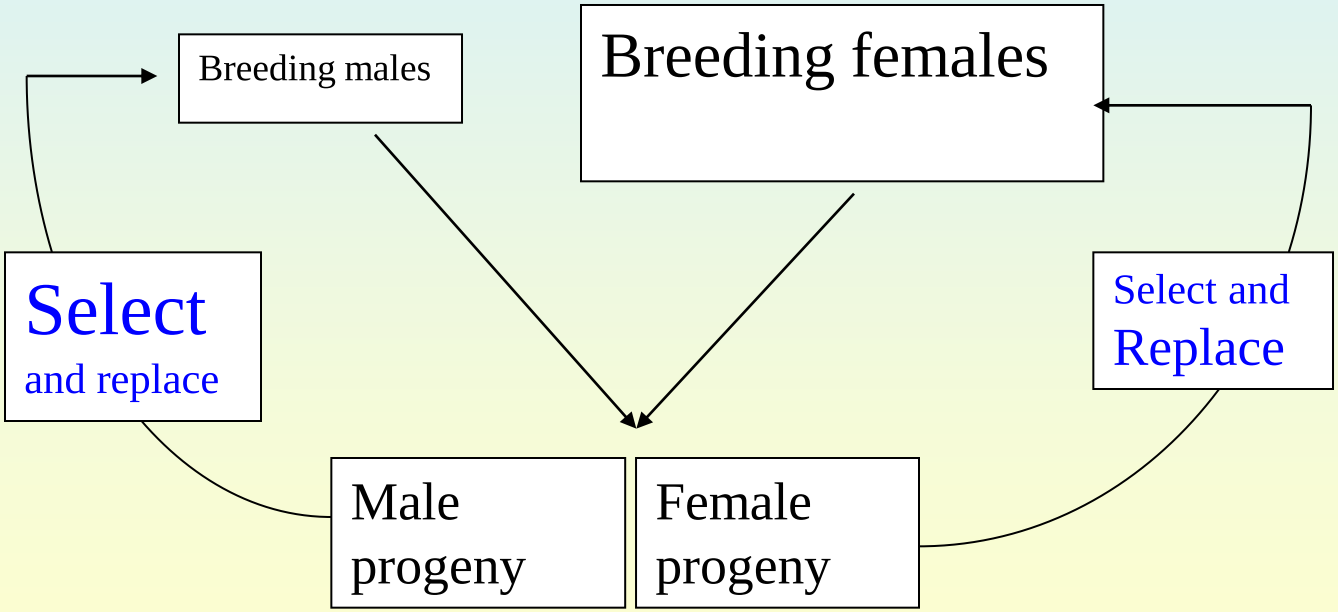
Aspects that need to be balanced:

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

- 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 (e.g. see exercise with AGES in GENEUP.
- Selection intensity versus inbreeding
- The relative emphasis in selection for multiple traits
- Cost versus benefits

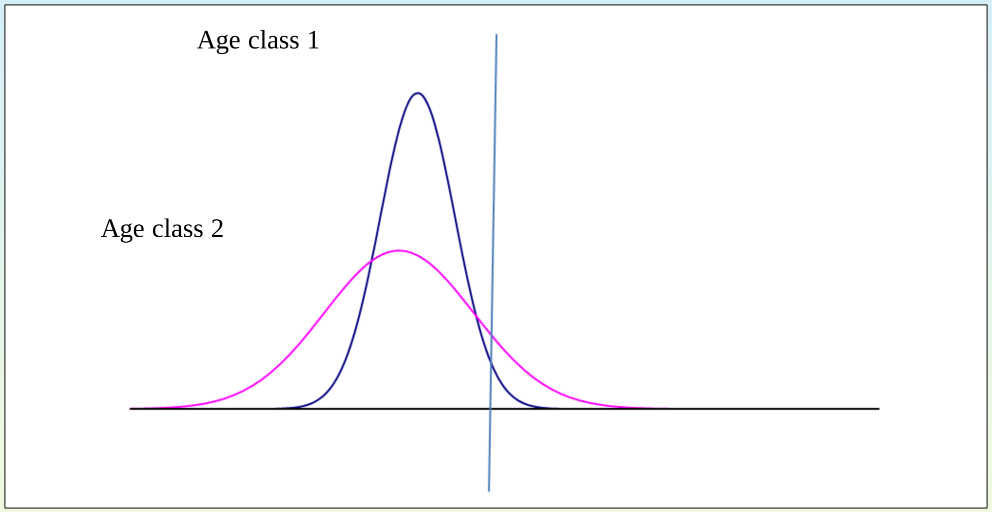
Design examples

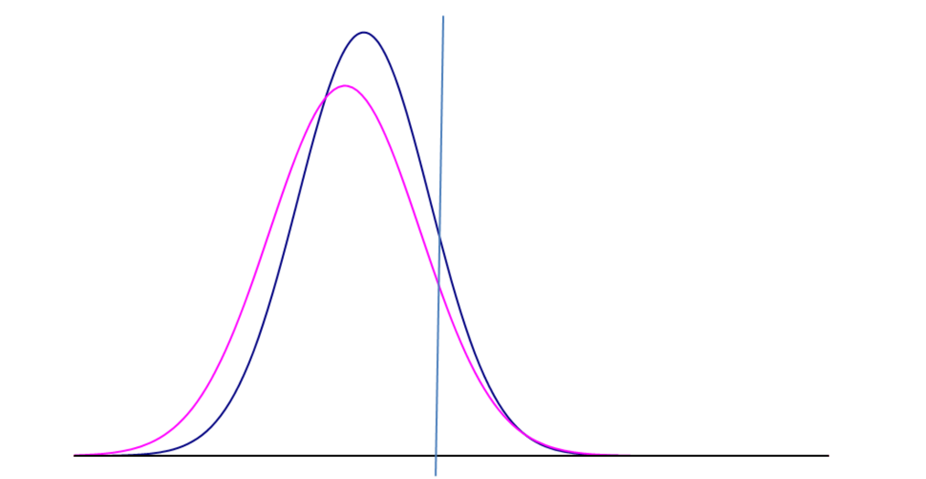
- One-tier breeding program



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

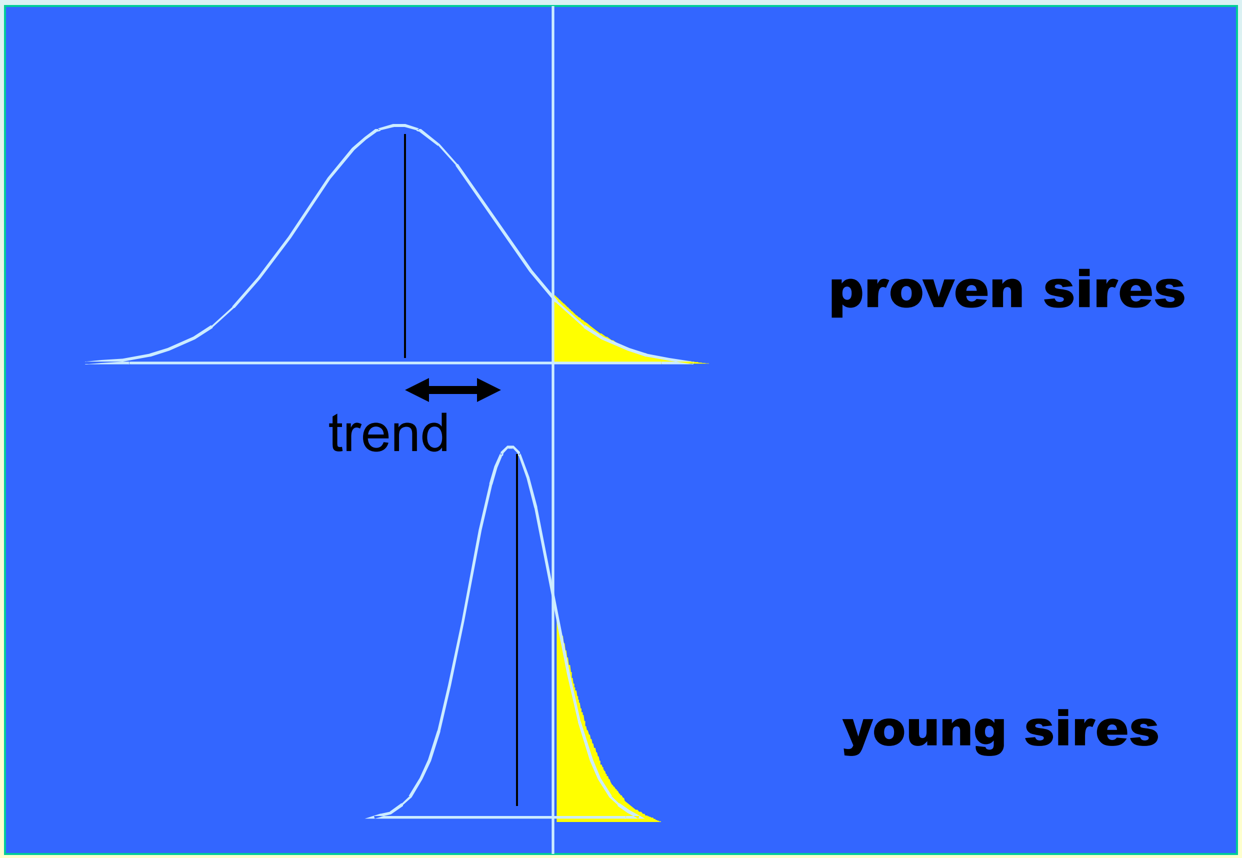
With genomic selection

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

Genetic Evaluation helps

BLUP EBV Optimizes generation interval

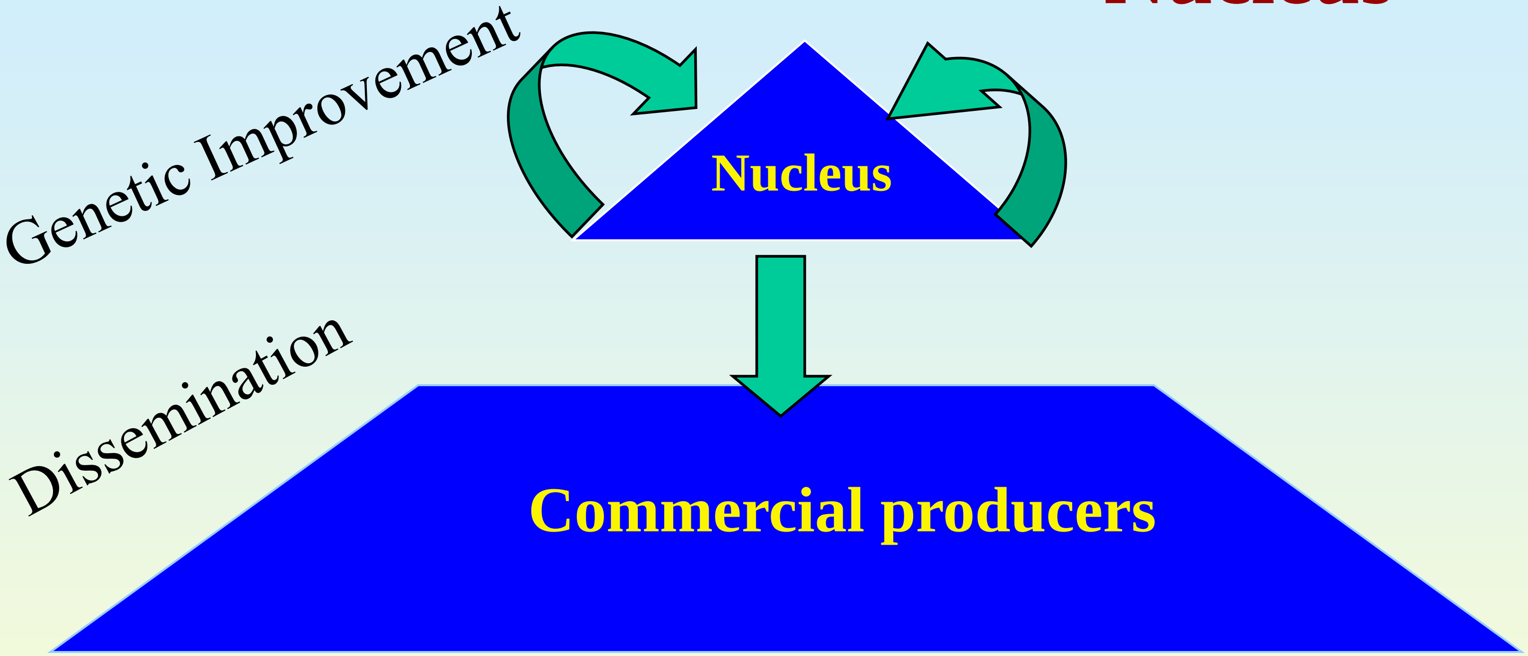
- Dilemma between young and old sires



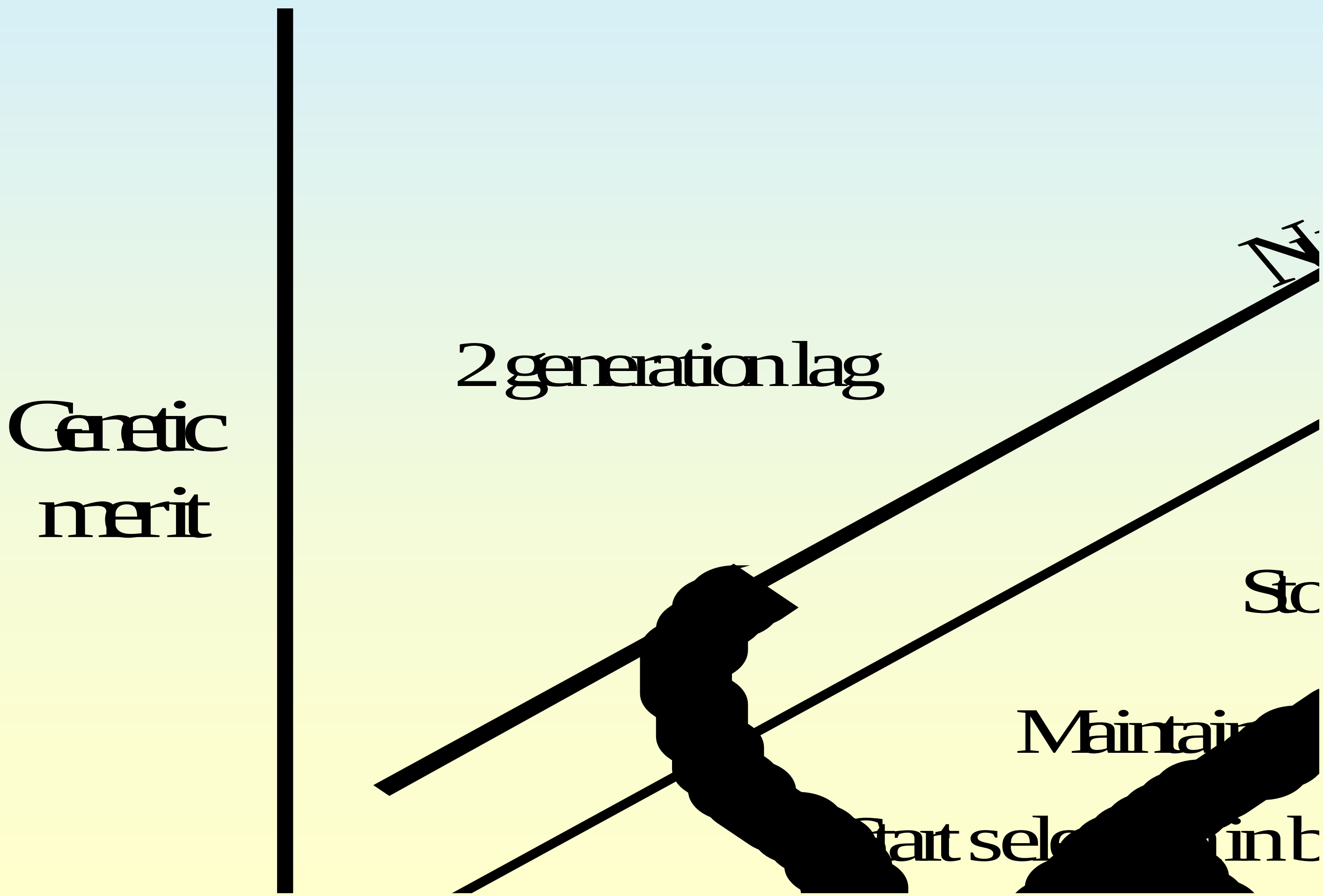
Truncation Point

Design examples

Closed Nucleus

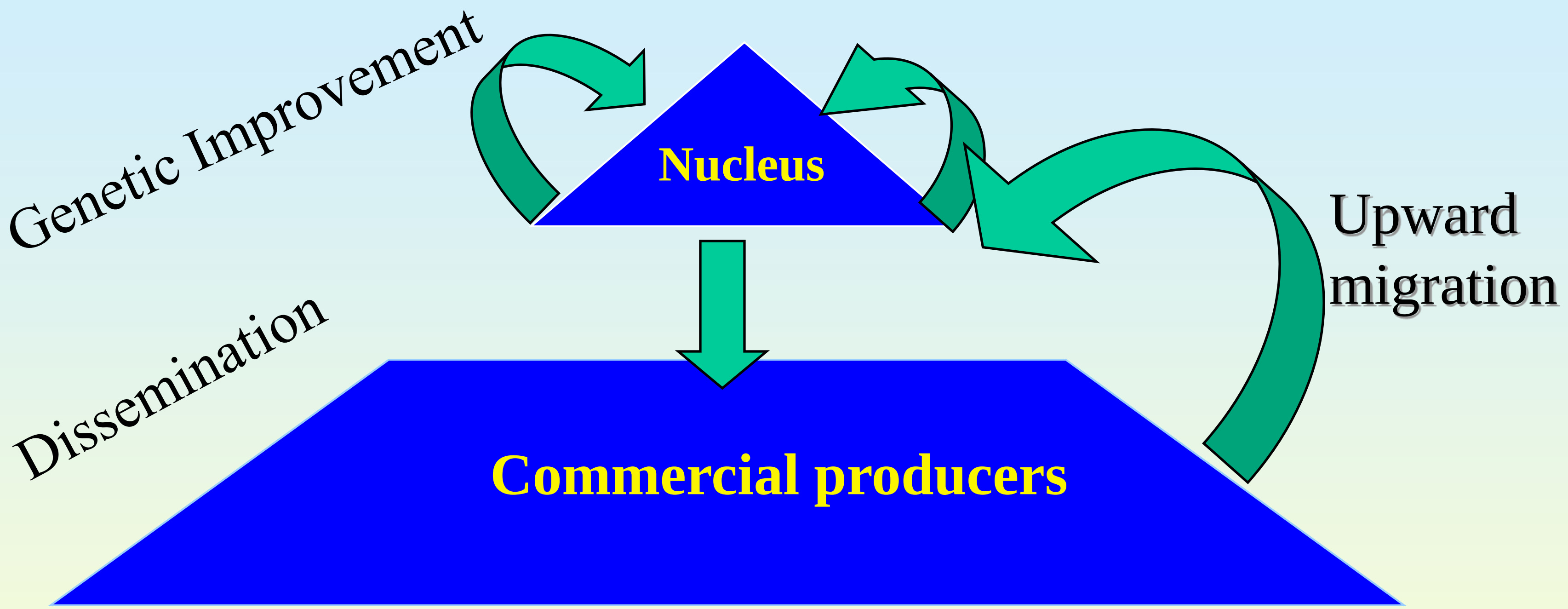


Closed nucleus breeding schemes



Design examples

Open Nucleus



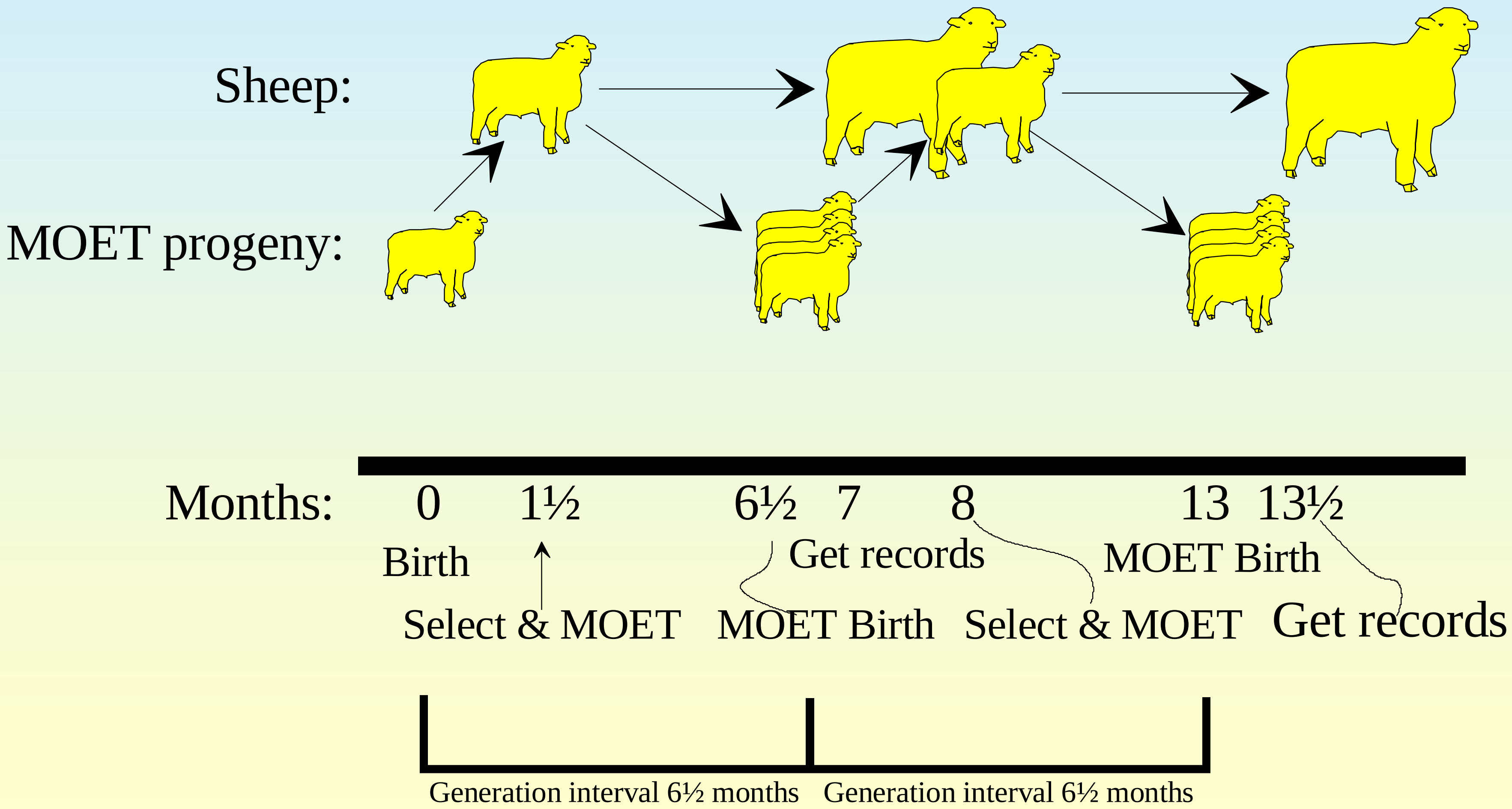
More genetic improvement (about 15%)

Data collection (records/pedigree) also needed in base but usually more intensive in nucleus

Reproductive technologies

- Reproductive boosting
  - Artificial insemination, AI
  - Multiple Ovulation and Embryo Transfer, MOET
  - Oocyte Pickup
  - Juvenile In Vitro Embryo Transfer, JIVET
- Sexing of semen and embryos
- Cloning
- Whizzy Genetics - breeding in a test-tube

Juvenile sheep MOET/JIVET



Genetic gain versus genetic diversity

- 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
  - Because early selection requires family information (parent average)

Why restrict inbreeding

- Avoid loss of genetic variation/genetic diversity
- Inbreeding depression
- Increase of homozygotes with deleterious recessives
- Inbreeding is closely associated with risk (and genetic drift)

How to restrict inbreeding?

- Mating policies mostly affect
  - progeny inbreeding *(short term)*
  - but not *long term* rate of inbreeding ΔF
  - The long term inbreeding rate depends on *effective population size*
- Long term inbreeding is restricted by restricting the average co-ancestry among selected parents

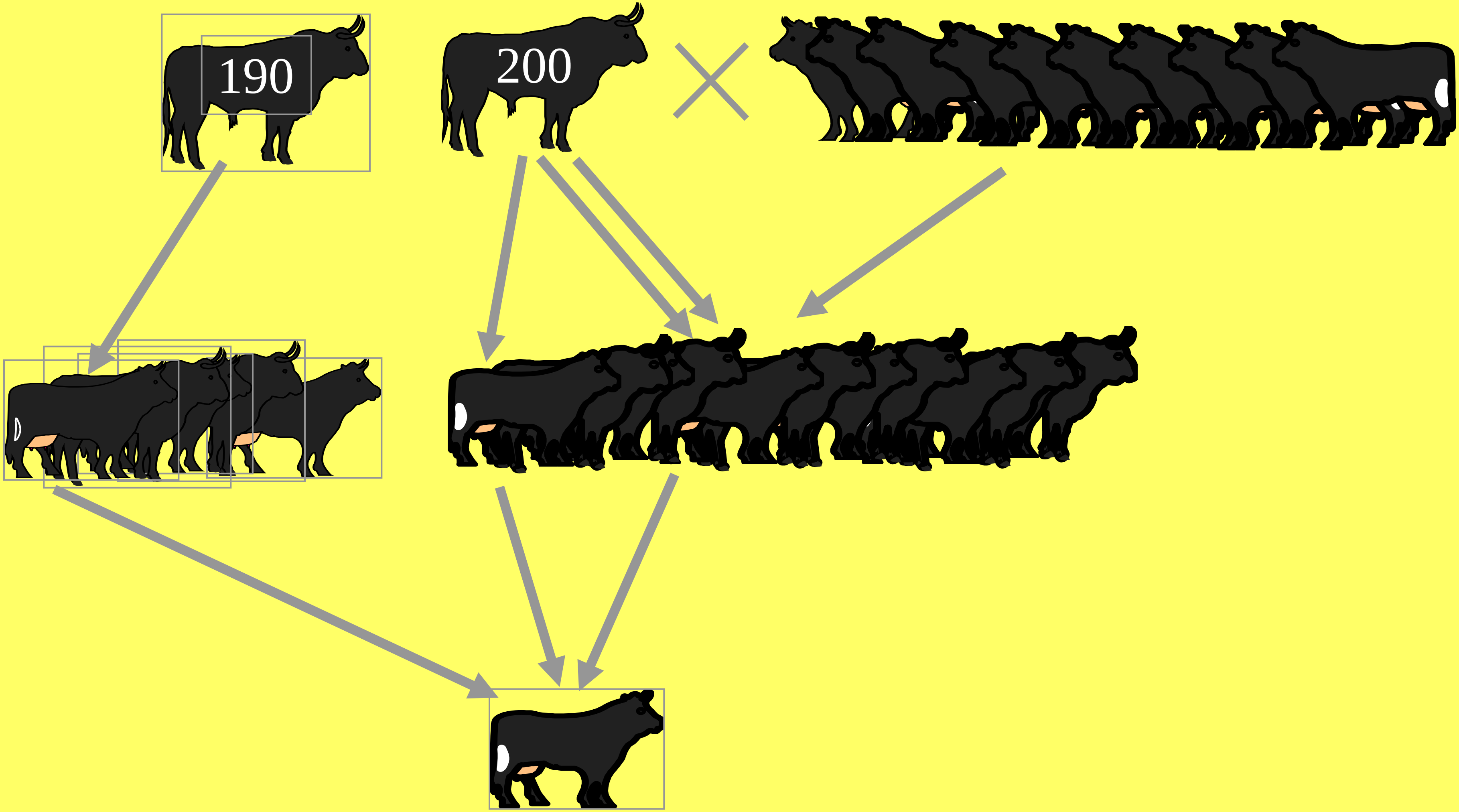
Calculating Effective Population Size: Ne

Accounting for unequal sex ratio

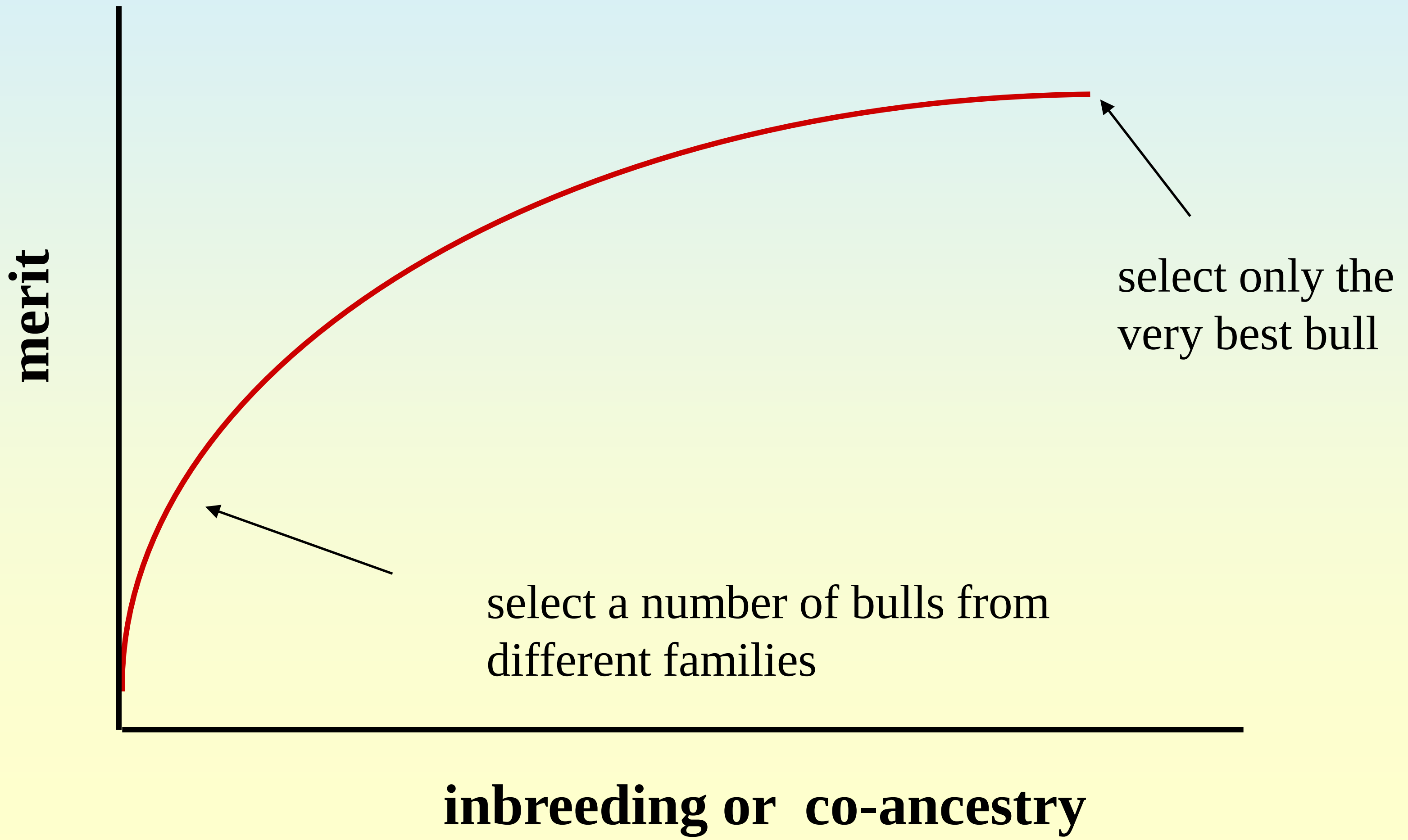
$$Ne = \frac{4.N_m.N_f}{N_m + N_f}$$

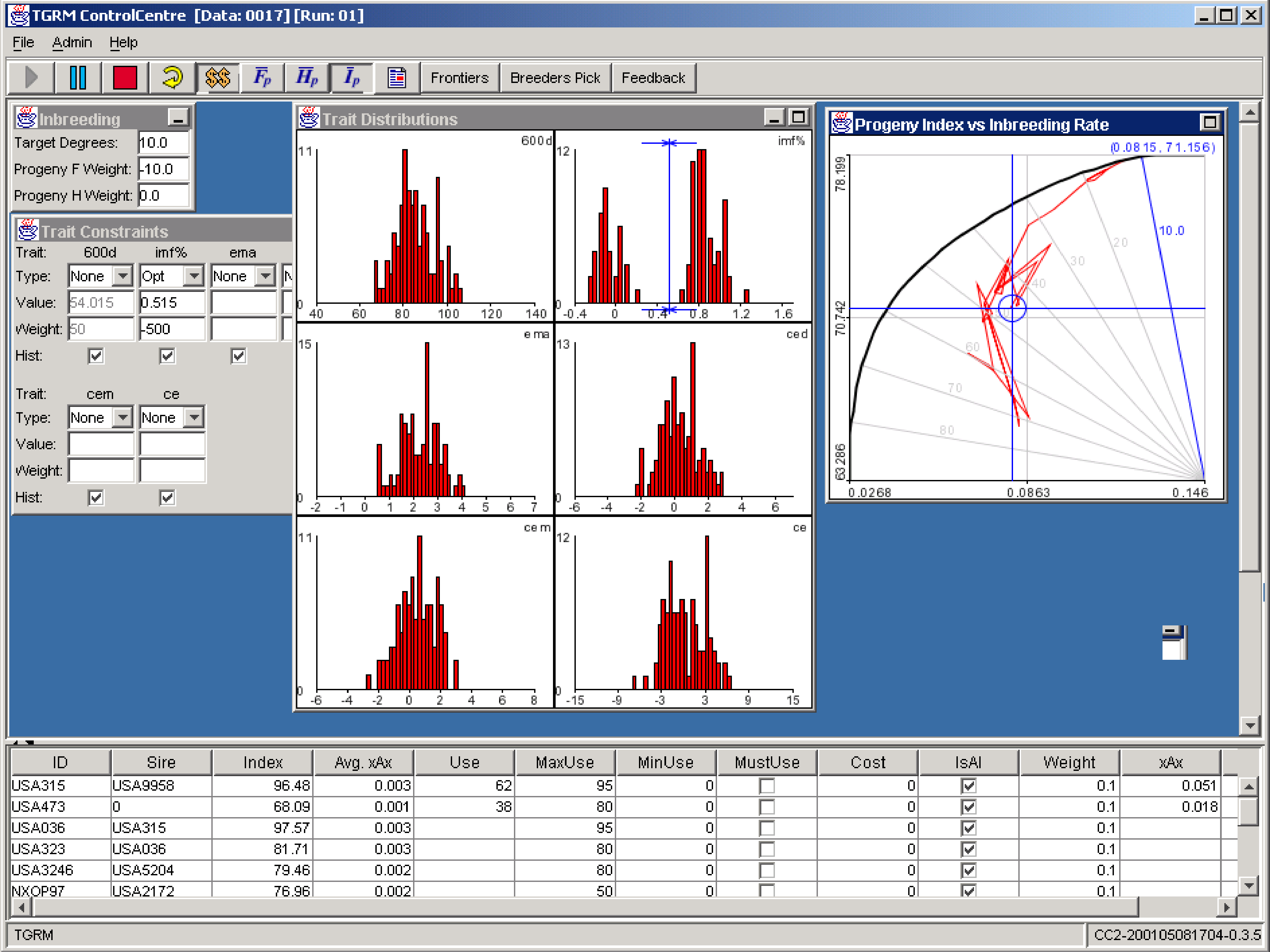
- Effective pop'n size (Ne) reduces towards sex with fewer breeding individuals

Males / generation	2	2	2	5	20	1
Females / generation	2	20	200	200	200	99999
N	4	22	202	205	220	100,000
Ne	4	7.3	7.9	19.5	72.7	4


190
200

Balancing inbreeding and merit

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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
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Trait Distributions
600d
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ced
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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

Economic evaluation of breeding programs

Benefit: dG.N accumulates each year

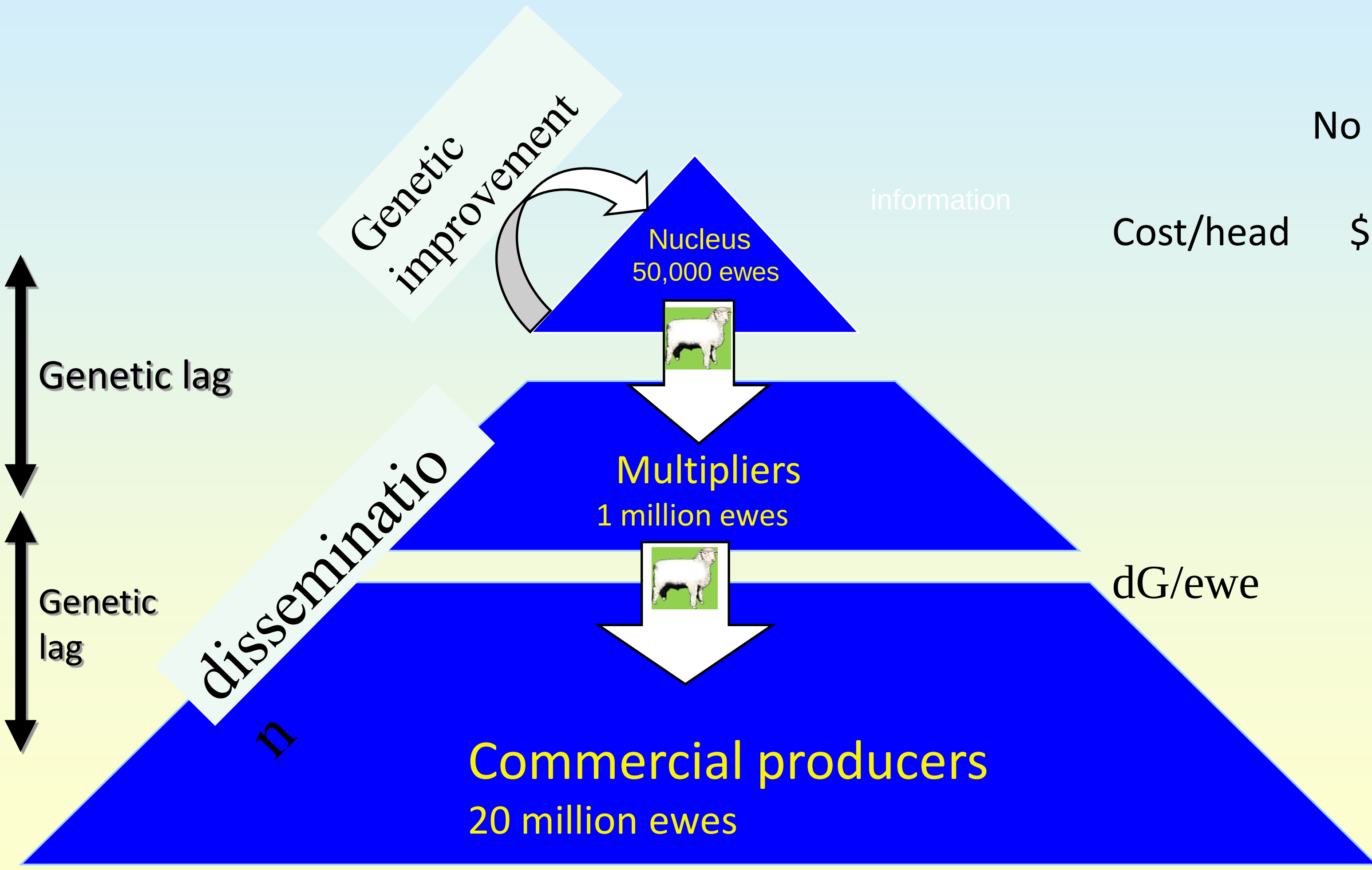
Cost C

Future returns are discounted: $1/r^t$

in year t $(N.t.dG - C).(1/r^t)$.

year	Genetic Mean ($)	Benefit (M)	Cost (M)	discount factor	NPV (M$)
1	0	0	0.5	1.00	-0.50
2	1	20	0.5	0.95	18.57
3	2	40	0.5	0.91	35.83
4	3	60	0.5	0.86	51.40
5	4	80	0.5	0.82	65.40
6	5	100	0.5	0.78	77.96
7	6	120	0.5	0.75	89.17
8	7	140	0.5	0.71	99.14

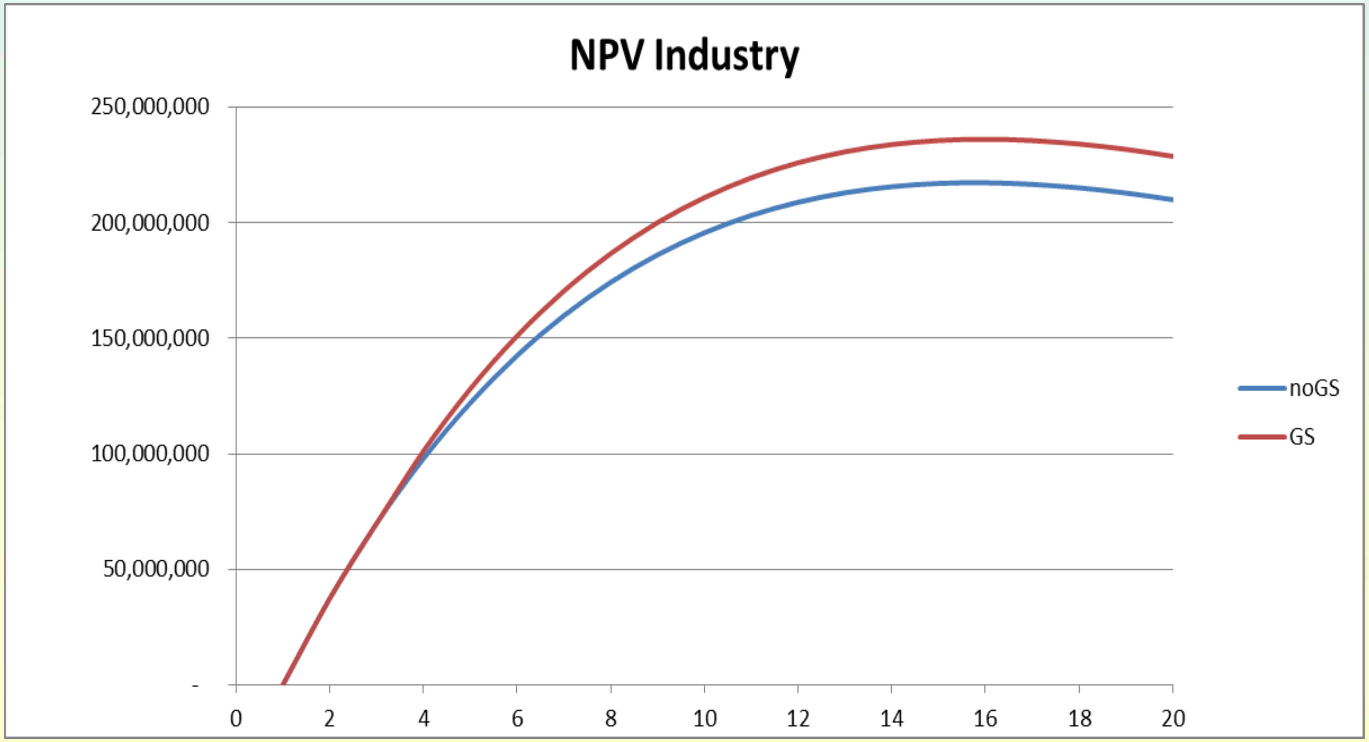
Cost - Benefit



	No GS	GS
Cost/head	$10	$60
dG/ewe	$2	$2.2

Cost-Benefit industry wide

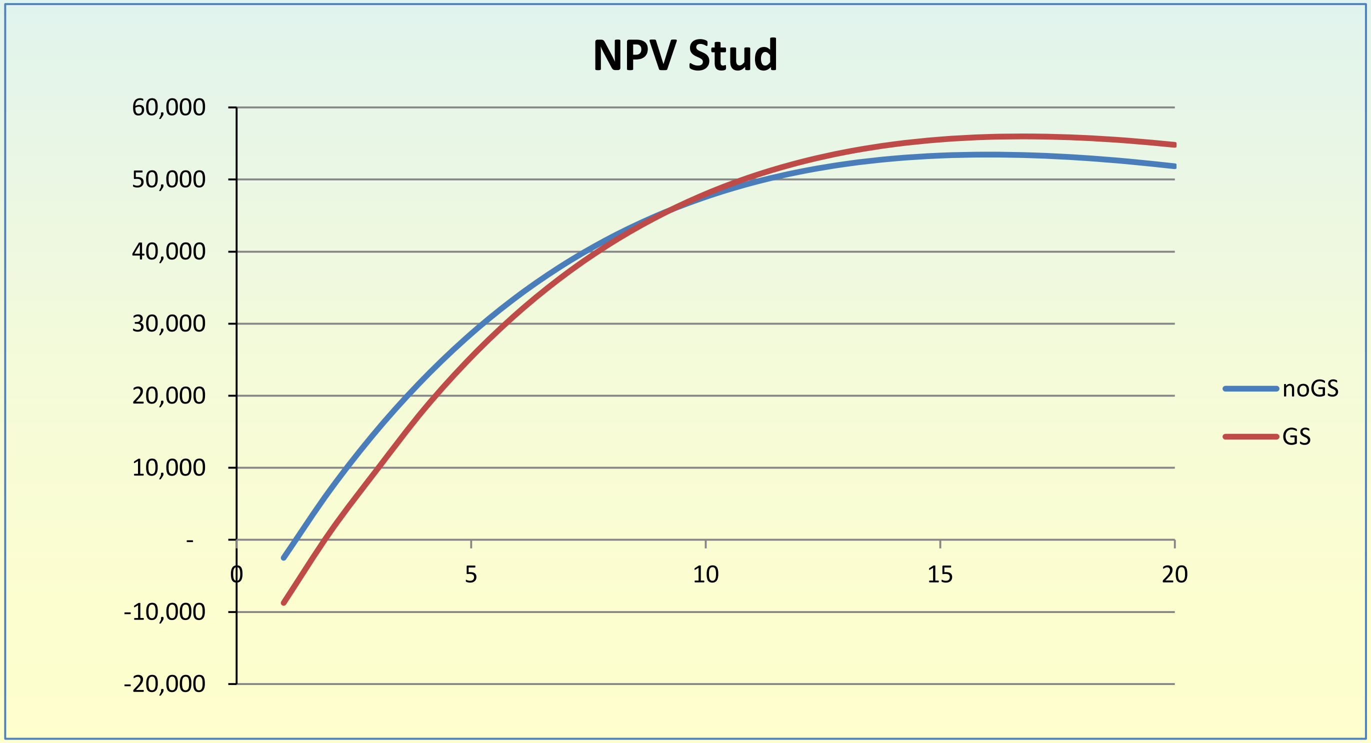
	No GS	GS
Cost	$0.5 M	$ 1.65 M
dG	$40 M	$ 44 M



50k Nuc ewes
20M Comm

Cost-Benefit Stud

	No GS	GS
Cost	$ 5 k	$17.5 k
dG	$20 k	$ 22 k



500 Nuc ewes
10k Comm