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Tools For Managing Genetic Variation

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Genetic Variation

- Genetic variation is a valuable resource
  - » allows further progress
  - » acts as a buffer against unforeseen events
- Requires to be ‘treasured’
  - » conserved when not of immediate use
  - » use for generating sustainable genetic gain
  - » not to be wasted

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- But what tools do we need?

Genetic Variation Within Breed

- Risks from loss of diversity can be measured by ‘rate of inbreeding’
  - » denoted ΔF
- Tools for managing genetic variation within a breed manage ΔF

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Why Do We Need New Tools?

Nicholas & Smith (1987)

- A landmark paper in livestock breeding
- Looked at use of technology in dairy cattle
  - » Multiple Ovulation & Embryo Transfer
  - » Cloning
- Showed increased ΔG through
  - » increased selection intensity
  - » use of relatives for evaluation
- Loss of diversity, ΔF, measured by Wright's formula
  - » classic formula, for random selection!

Nicholas & Smith (1987)

- This was not unusual pre 1990's
- Theory could predict ΔG
- Theory could not predict ΔF for such schemes!

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What Has Changed?

New Tools: Theory

- New theories relate both ΔG and ΔF to 'long-term genetic contribution'

- *An individual's long term genetic contribution, r_i, is the proportion of the future gene pool contributed by the ancestor*

New Tools: Theory

$$\Delta G = \Sigma_{individuals}\ r_i a_i$$

$$\Delta F = {}^{1}/_{4}\ \Sigma_{individuals}\ r_i^2$$

- a_i is the individual's Mendelian sampling term -

  it is the bit of variation that makes us unique, different from our full sibs

New Tools: Theory

- These advances allow us to plan ahead
  - » predict what ΔF will be in a breeding scheme
  - » predict the consequence of a change of management
  - » predict the consequence of introducing technology

New Tools: Practice

- But what about breeding decisions day-to-day?
  - » e.g.

  Which animal should I breed from?

  Should I use the animal a lot or just a little?

  This animal is high merit but it already has a full sib selected!

New Tools: Practice

- Optimum Contribution Selection
- Solves precisely this practical problem

  maximise ΔG *with* ΔF *equal to a pre-set value*
- Identifies which animals to breed from and the optimum numbers of offspring

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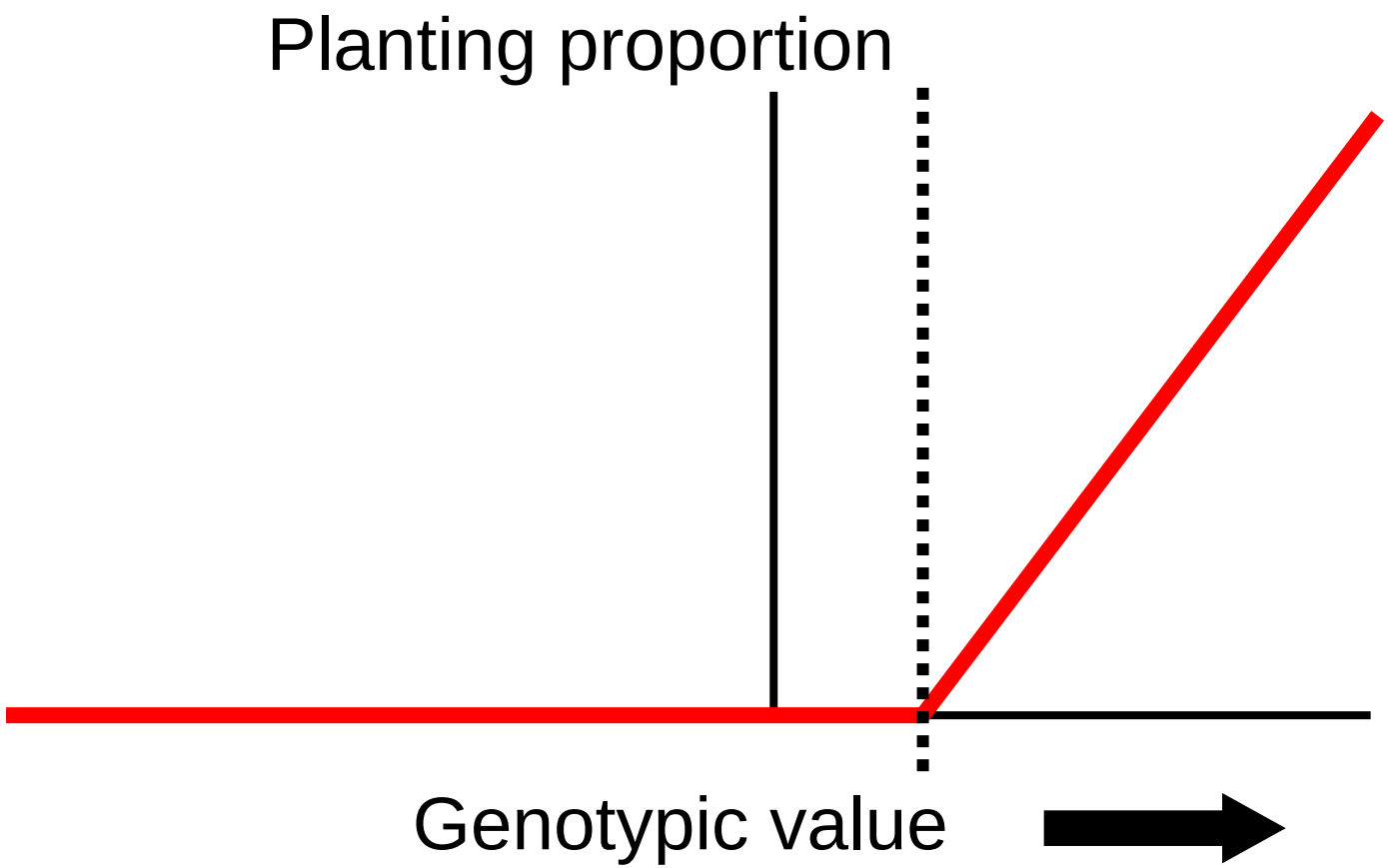
How Does Optimum Contributions Work?

Insight comes from a different Nordic problem!

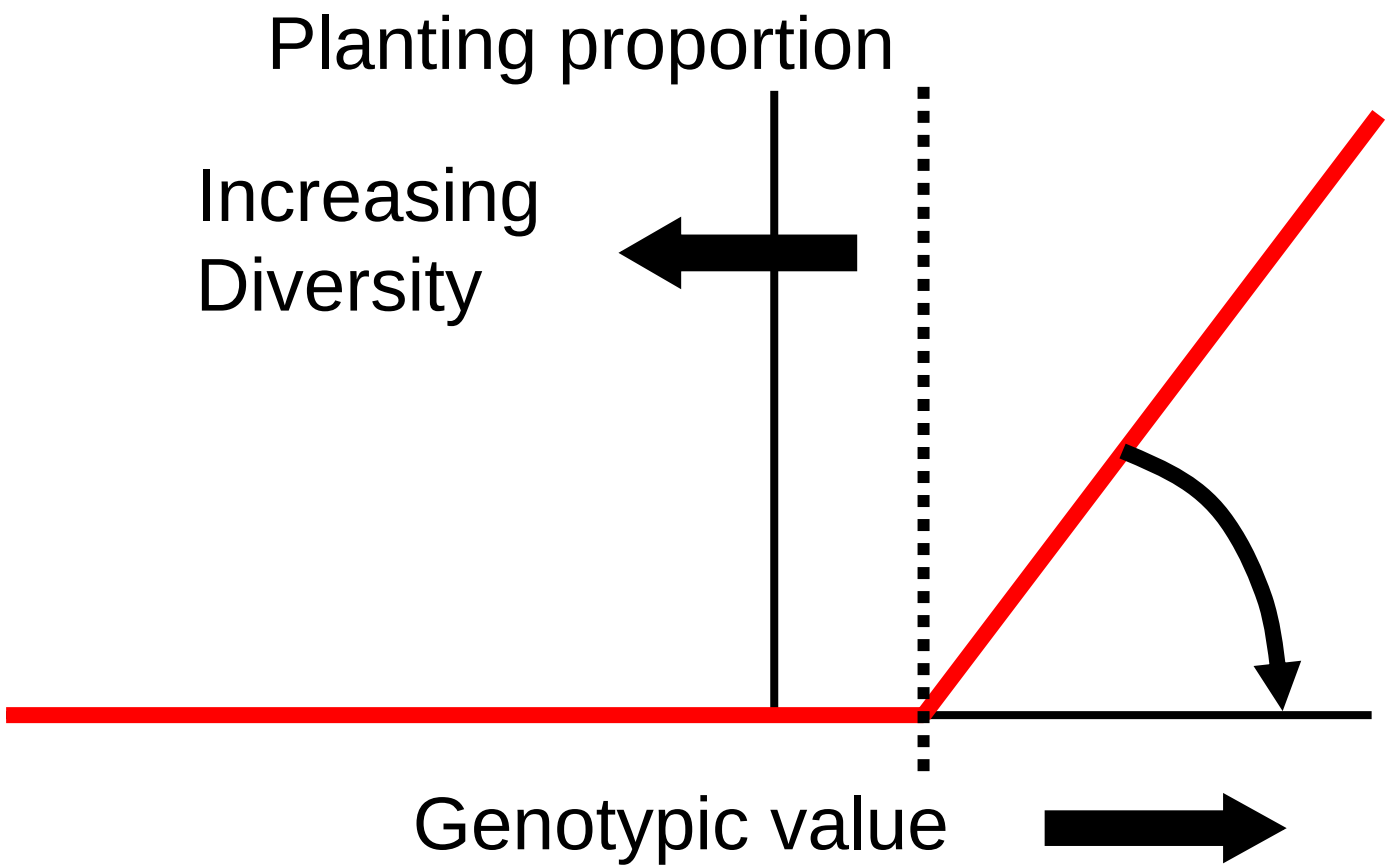
Lindgren's Forestry Problem

- T clones of a tree species
- Each clone has well established genetic value G_i
- Plant a forest with clone i having proportion p_i
- Maximize commercial value $V = \Sigma_{clones}\ p_i G_i$
- Minimum diversity required to reduce risks defined by $\gamma < (\Sigma_{clones}\ p_i^2)^{-1}$

Bondesson's Solution



Bondesson's Solution



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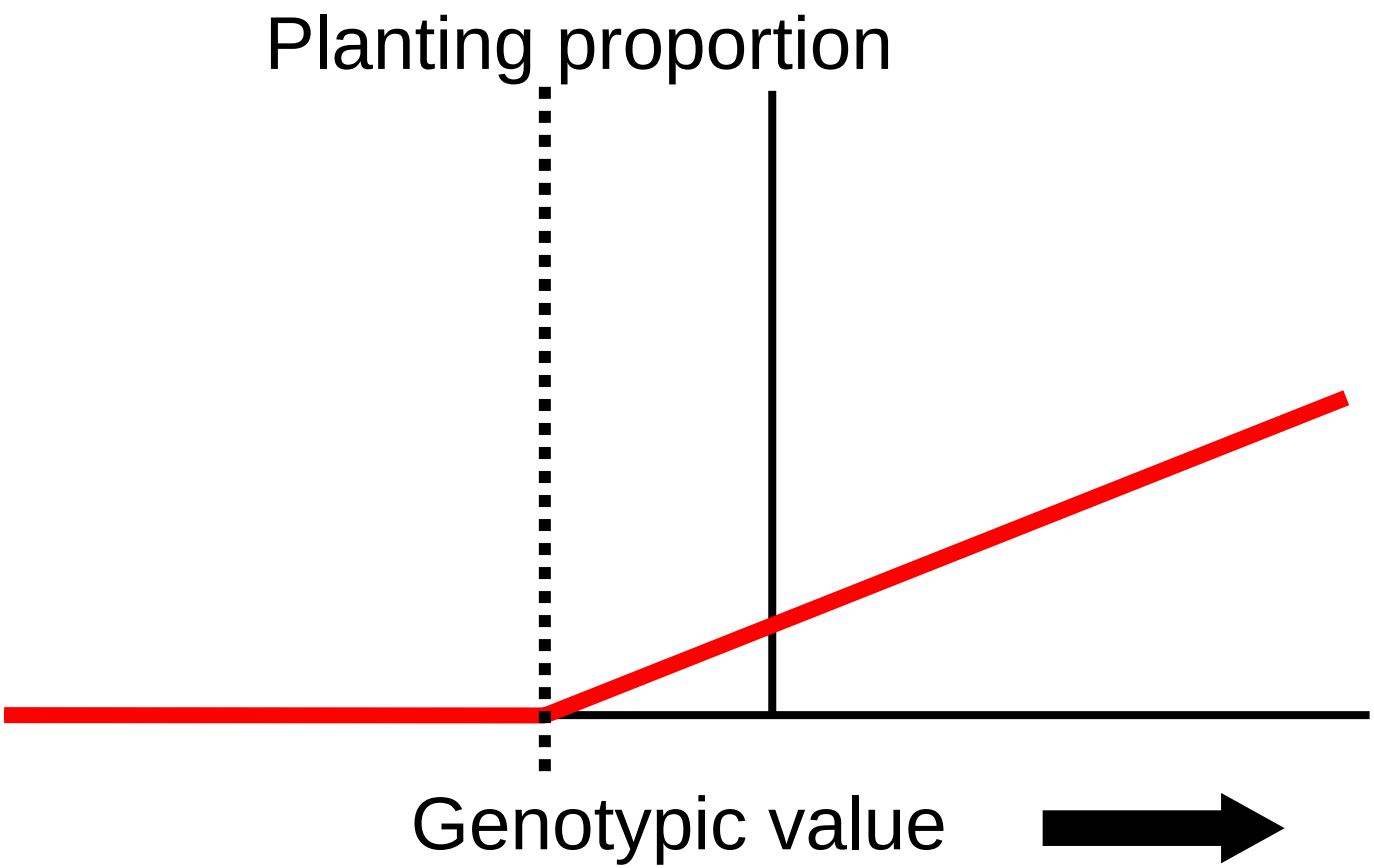


Selection Analogy

- Compare expressions of gain

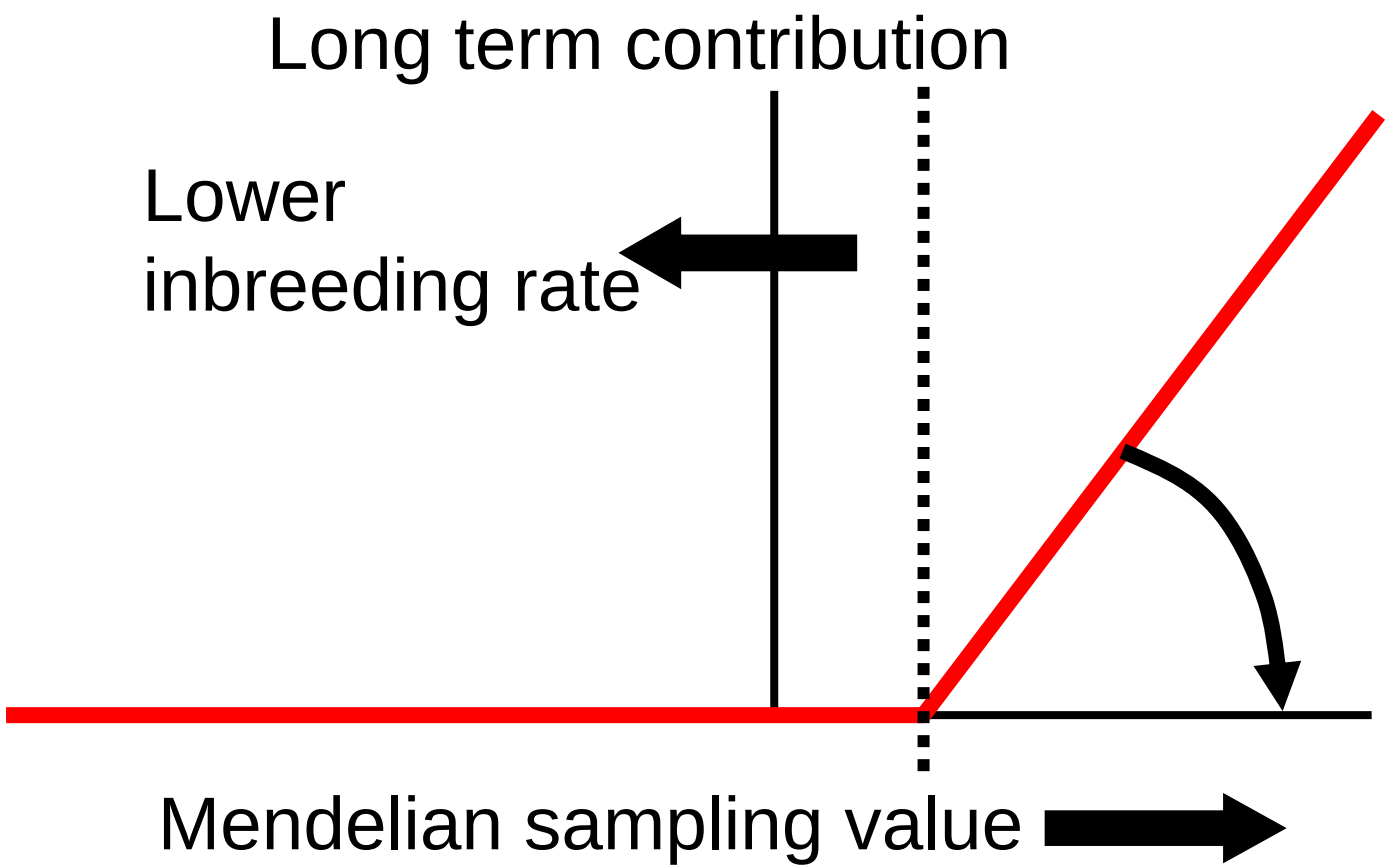
$$V = \Sigma_{clones}\ p_i G_i \quad \& \quad \Delta G = \Sigma_{individuals}\ r_i a_i$$

- Compare expressions of diversity

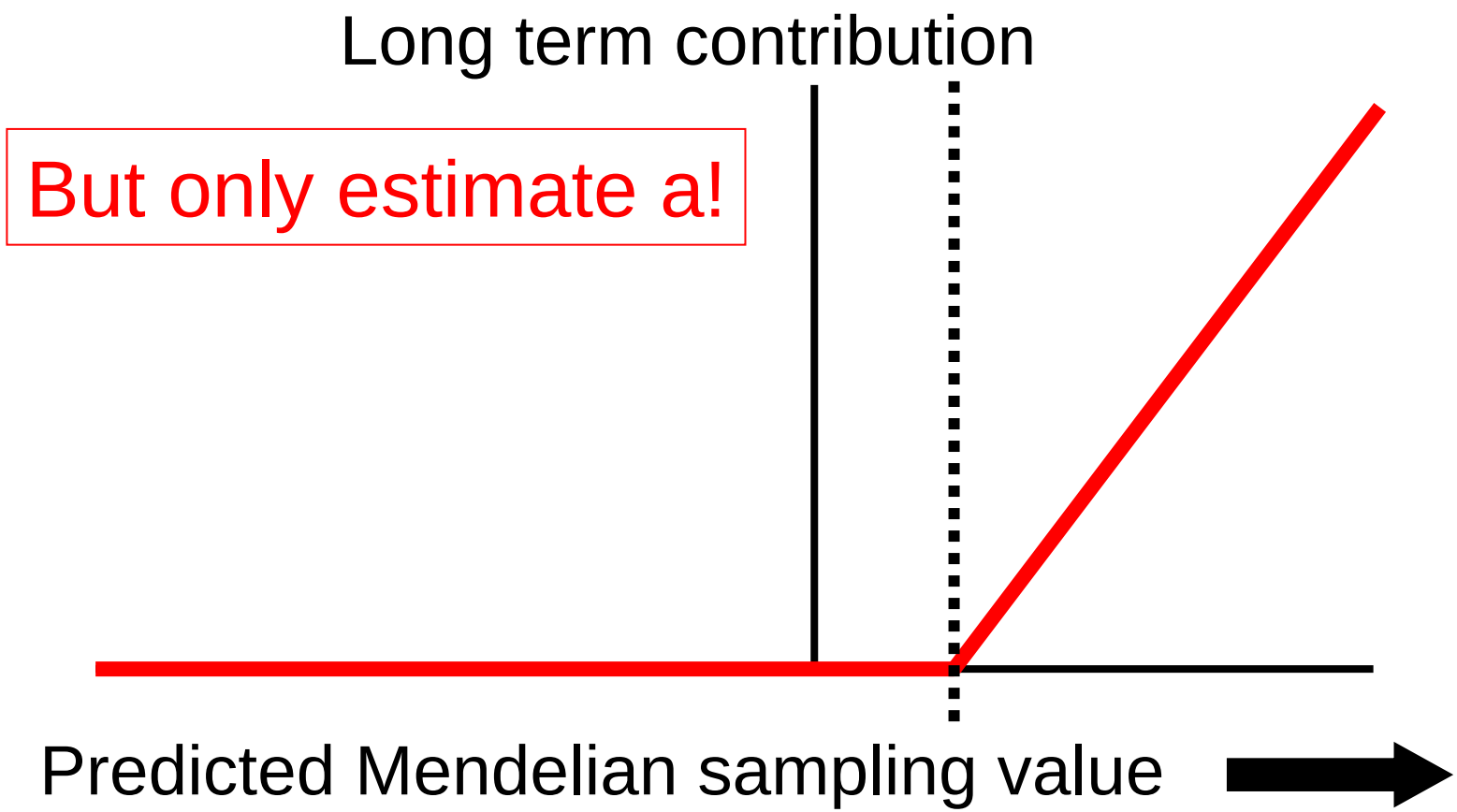
$$\gamma = (\Sigma_{clones}\ p_i^2)^{-1} \quad \& \quad \Delta F = {}^1/_4\ \Sigma_{individuals}\ r_i^2$$

p_i	corresponds to	r_i
G_i	corresponds to	a_i
γ	corresponds to	$(4 \Delta F)^{-1}$

Ideal Selection



Practical Management



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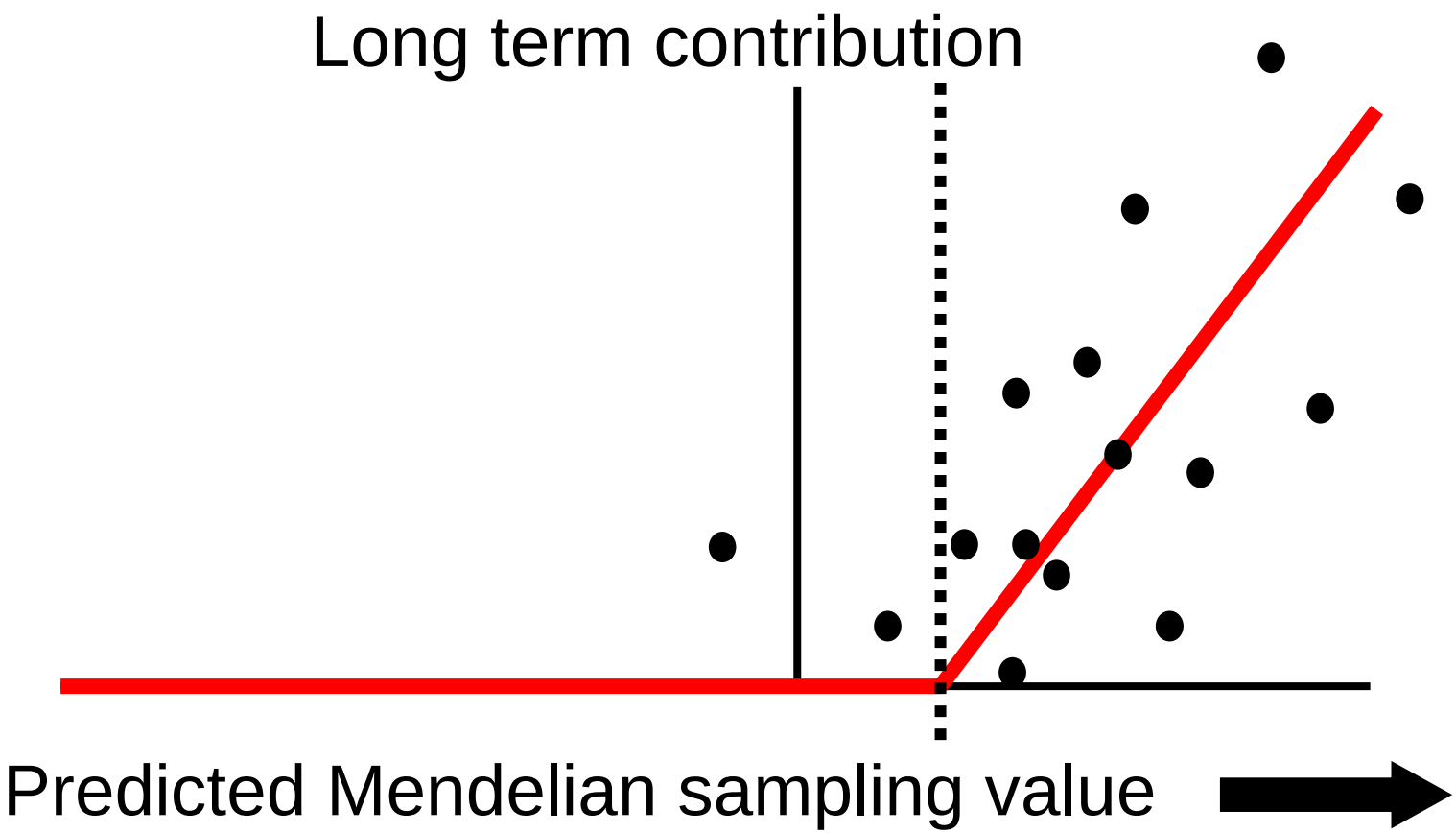
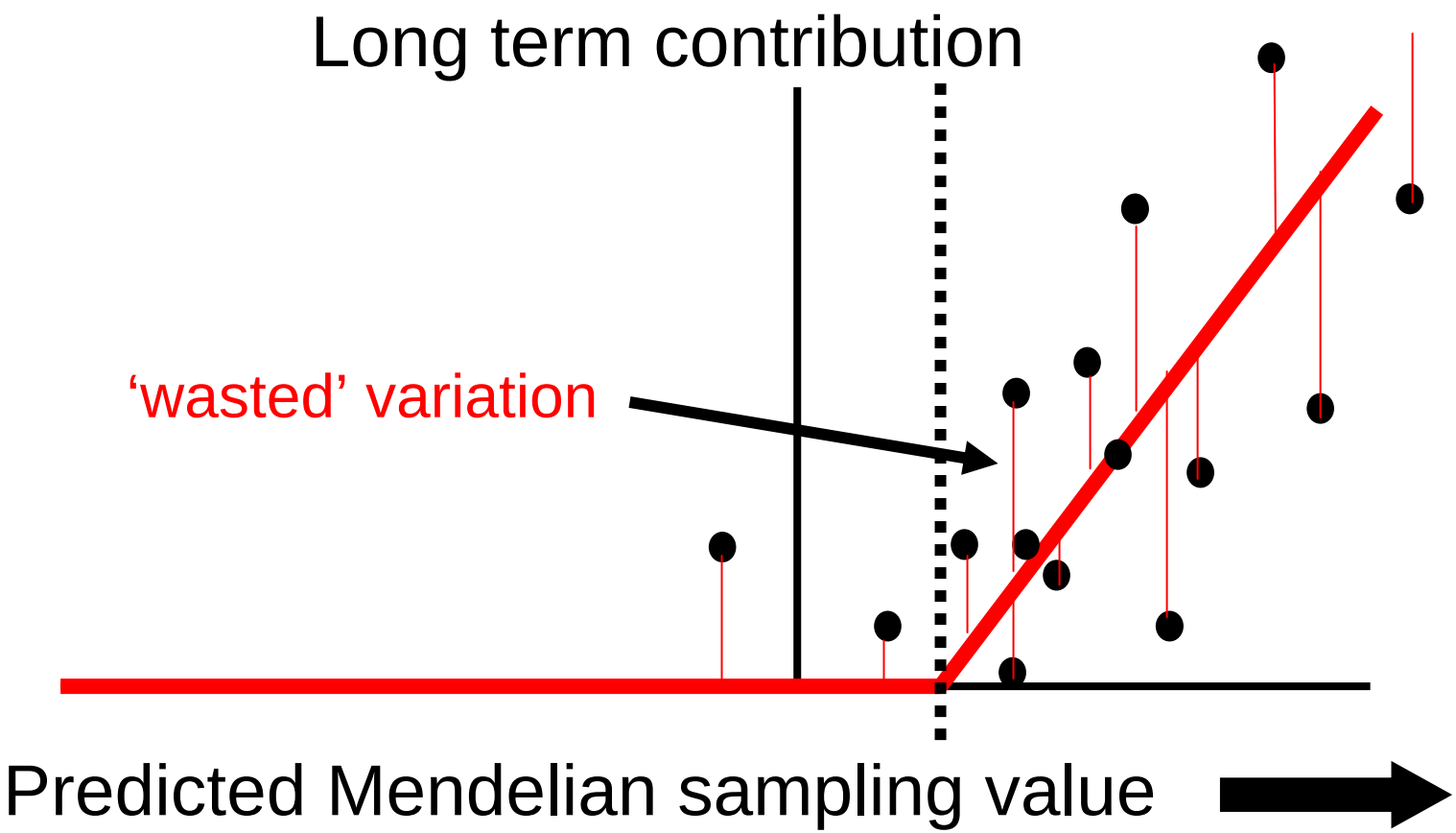


Practical Management



New Tools: Conclusions (1)

- We can manage genetic variation optimally as we make selections
- Historical 'balance' of ΔG with ΔF was seen as losing gain for lower inbreeding
- Optimum Contributions is 'win-win'

  ΔG *is maximised for the target* ΔF

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New Tools: Conclusions (2)

- There has been another genetic revolution – nothing to do with DNA!
- 20 years ago the chances of selection were determined by the candidates family
  - » *the aristocracy*
- *Today the chances of selection are determined by what new merit a candidate brings to population*
  - » *a meritocracy*

New Tools: Are All Problems Solved?

- 20 years ago could predict ΔG but not predict ΔF
- Now if a breeder uses optimum contributions we know ΔF but cannot predict ΔG!
  - » we know it is best but not how much better

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What New Tools Might The Future Bring?

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The Other Genetic Revolution

- Can genetic selection waste less variation?

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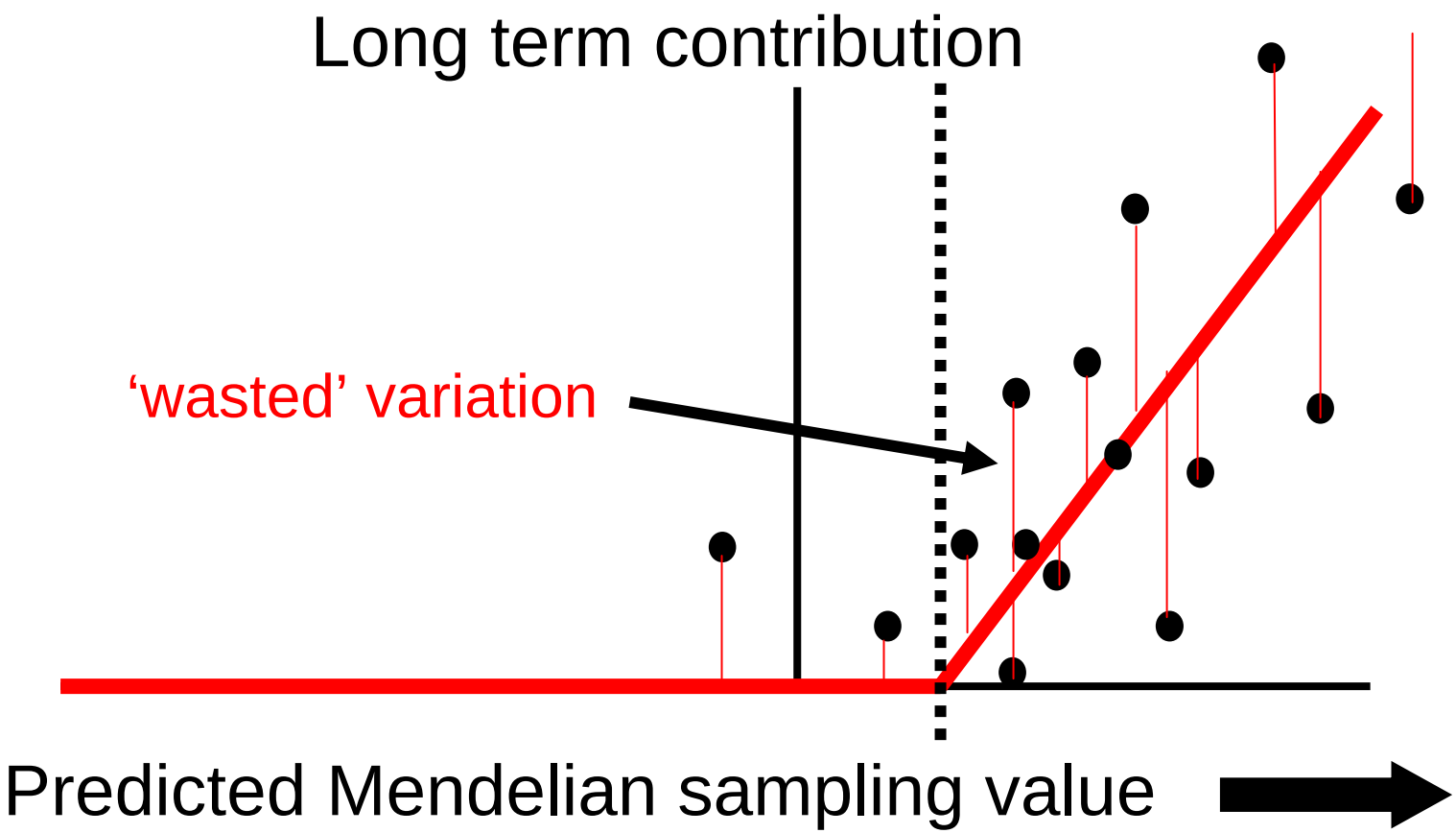
- Can genetic selection waste less variation?
- Yes!
- The DNA revolution has brought with it high throughput cost-effective genotyping
  - » 50,000 marker genotypes per animal for $200!
  - » rapid results
- Use these for ‘Genomic Selection’
  - » use phenotypic data to estimate marker effects
  - » use the estimated marker effects to predict breeding values

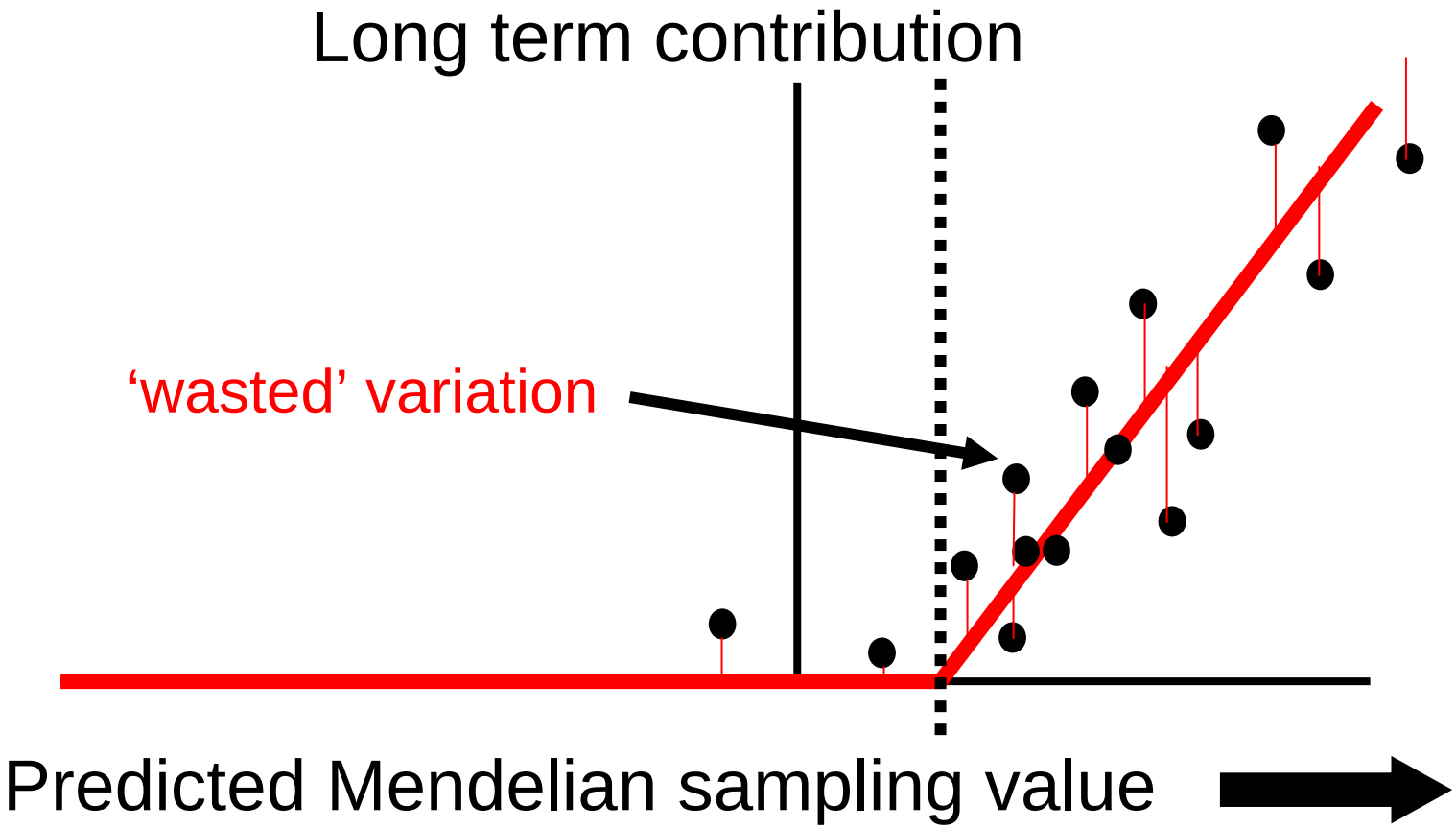
The Other Genetic Revolution

- Genomic Selection produces more accurate breeding values at younger ages
- BUT the additional comes from more accurate predictions of Mendelian sampling values

Without Genomic Selection



Potential With Genomic Selection



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Potential of Genomic Selection

- Deliver ΔG with less 'wasted variation', less ΔF

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Potential of Genomic Selection

- Deliver ΔG with less 'wasted variation', less ΔF
- The challenge of the next decade!

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... And Finally

Retirement

In my Norsk ordbok

English '*retirement*' = Norsk '*isolasjon*'

Retirement

In my Norsk ordbok

English '*retirement*' = Norsk '*isolasjon*'

'*isolasjon*' sounds like '*isolation*' in English ??!!

I hope I have found the wrong word, Erling!

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Lykke til med fratredelsen din Erling!