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THE UNIVERSITY of EDINBURGH
Royal (Dick) School of
Veterinary Studies

Selection for robustness:

Exploring the value genomic prediction, reaction norms and phenotyping strategies

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Biotechnology and
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SMAll RuminanTs breeding
for Efficiency and Resilience

Introduction

- Resilience: Stay productive under challenging condition
- Production = (P. potential) + (env. challenge) * resilience
- Random regression (RR) models
- Aim: highly resilient animals with high production potential

Roadblocks

- Unknown environmental challenge level → Reaction norm (RN) models
- Sparse dataset (one record per individual, e.g., carcass weight)

Genomic predictions can be beneficial

Objectives

- ✓ Quantifying of benefits of genomic prediction in RR/RN models
- ✓ Evaluating Factors affecting accuracy and bias of GEBV (uncertainty in challenge level, phenotyping strategies)
- ✓ Assessing response to selection in different selection strategies

Using a simulation study

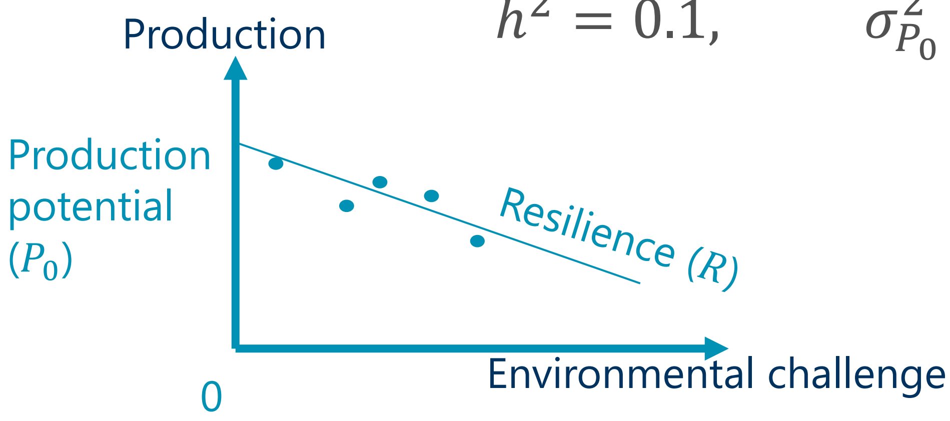
Model for phenotype

- Phenotype = production potential + resilience * (challenge level)

$$P = p_0 + P_R \cdot X$$

$$P = (\mu_0 + A_0 + E_0) + (\mu_R + A_R + E_R) \cdot X$$

$$h^2 = 0.1, \qquad \sigma^2_{P_0} = \sigma^2_{P_R} = 1 \qquad \rho = -0.5, (0.0, 0.5),$$



A: additive genetic

μ: population average

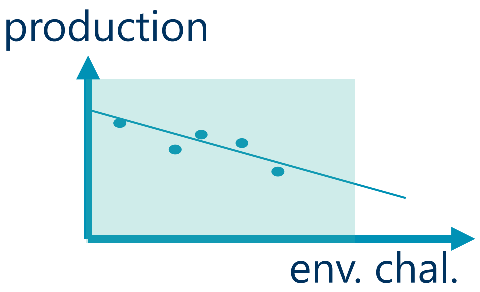
E: environmental deviation

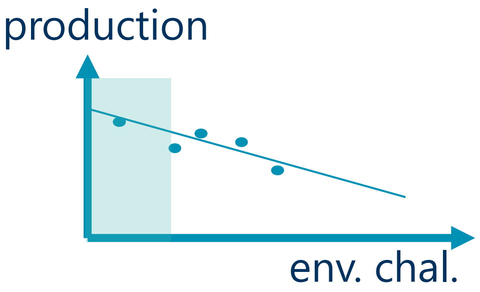
Genomic simulation of underlying traits

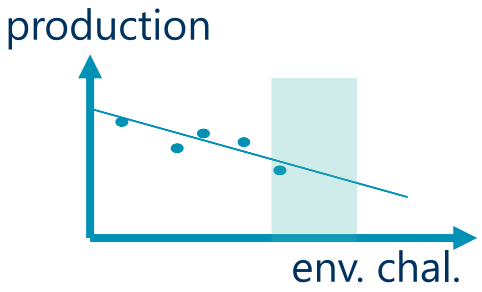
- Simulation study using genome of a sheep population (large half-sibs small full-sibs families)
- 26 chromosomes, 500 QTL/chromosome, LD structure matched to literature data
- Two pedigree structure
  - 3 generations without selection: effect of parameters on accuracy of EBV in animal model
  - 10 generations with selection: response to selection

Simulation of challenge level

- Whole environment range (wide = [0,2] , narrow = [0,1], [1,2], [4,5])

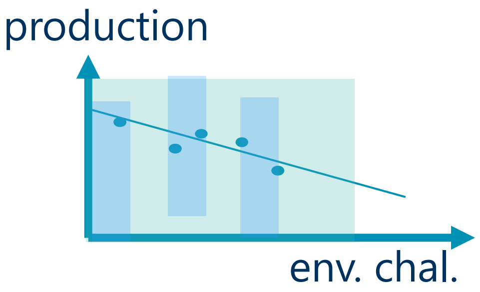


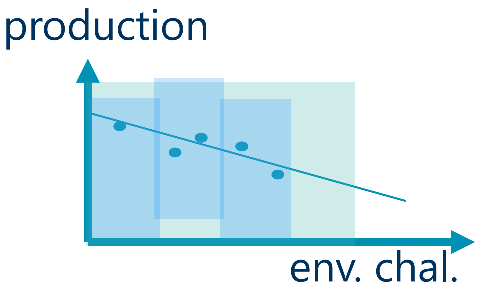


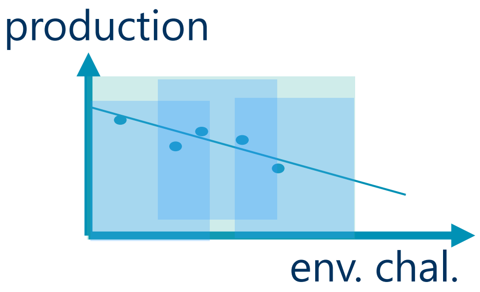


- A herd is subset of whole environmental range (e.g., whole environment [0, 2], herd = [0.3, 0.6])

  Herd heterogeneity = 10%, 20%, 30%







- Challenge level for an individual is defined by the herd it lives in.

  Random (siblings do not live together), Clustered (siblings live together), Assortative (clustered + correlation)

Scenarios for selection

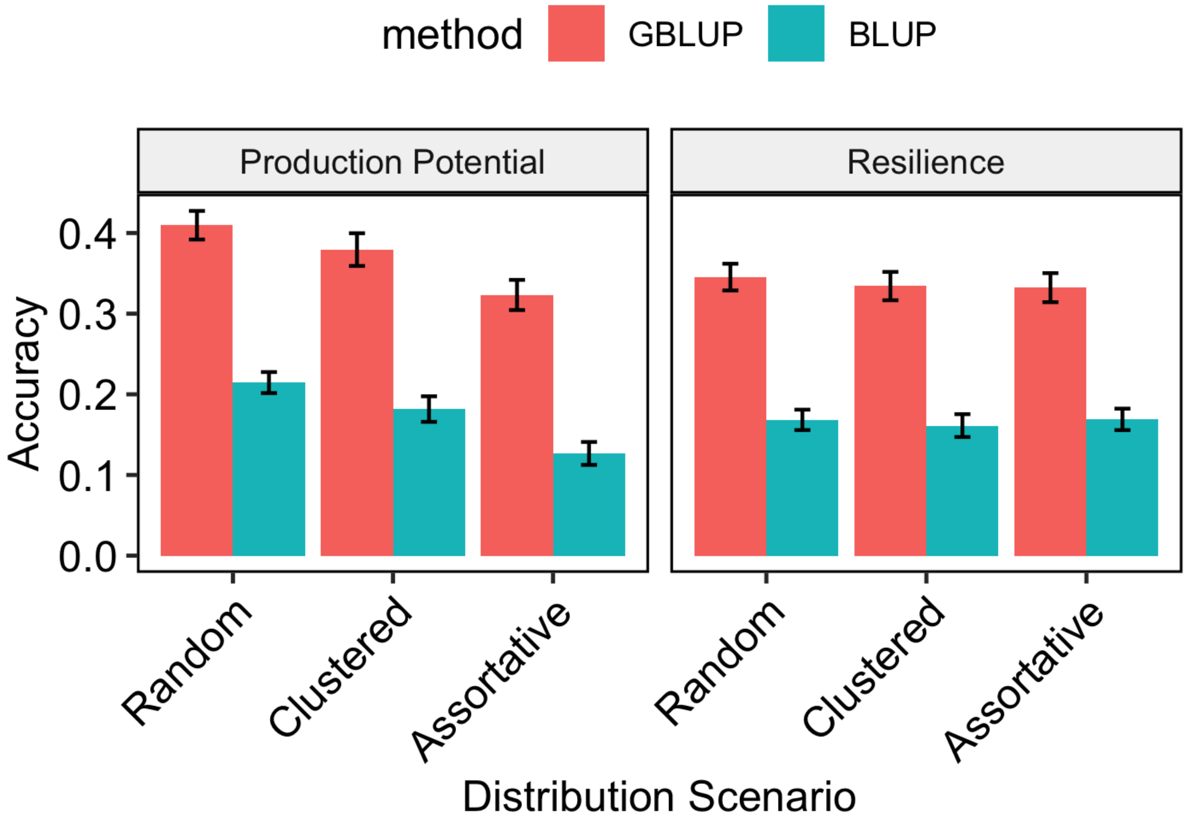
1. Genomic prediction for A_R and A_0 using RN model and index

$$\text{Index} = b\widehat{A_R} + (1-b)\widehat{A_0}$$

2. Genomic prediction using a conventional model (no RN)

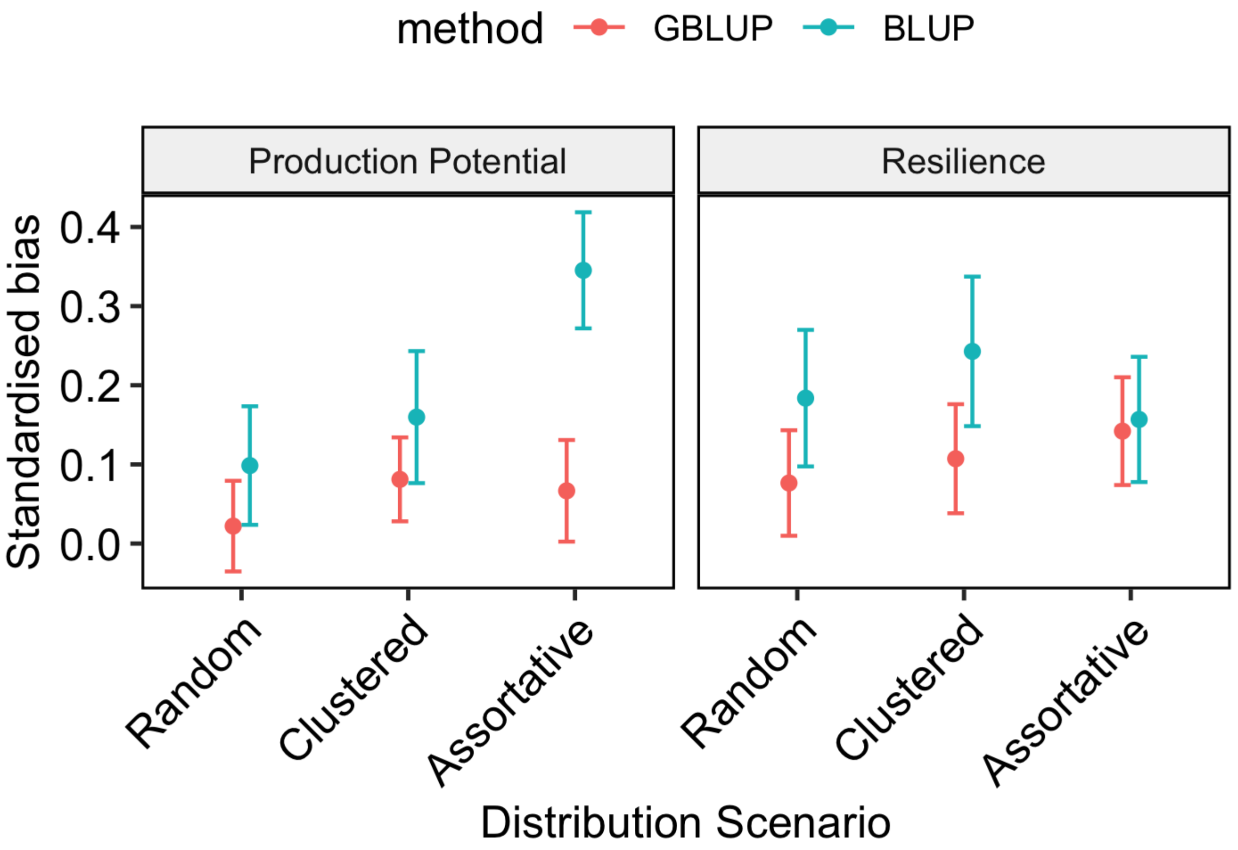
$$y = \mu + \hat{h} + \hat{A} + E$$

Effect of distribution scenarios and genomic prediction on accuracy



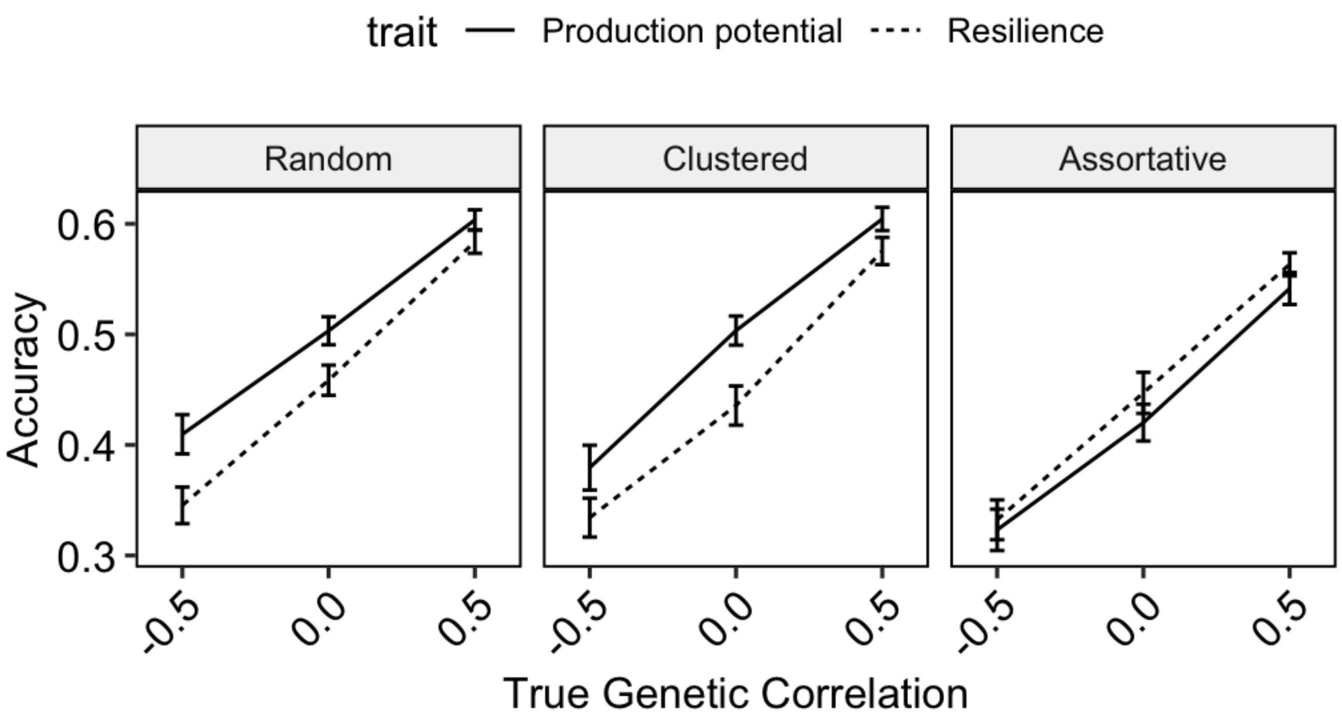
- GBLUP (up to 150%) better than BLUP
- Greater for production potential than for resilience
- Distribution of offspring across herds does NOT affect accuracy of resilience
- Random allocation gives best accuracy for production potential

Effect of distribution scenarios and genomic prediction on accuracy and bias



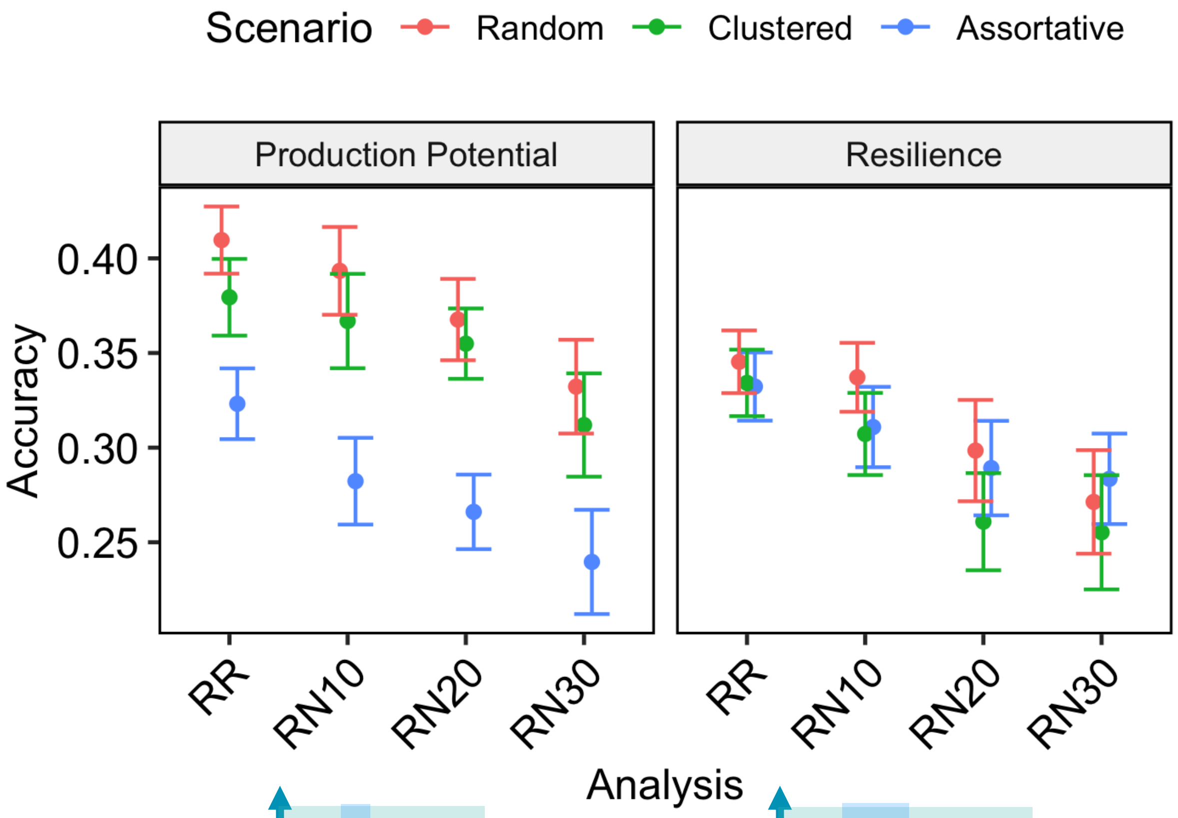
- GBLUP less biased than BLUP
- Bias on the EBV of resilience does NOT depend on how offspring are distributed across herds
- EBV from random allocation scenario are less biased

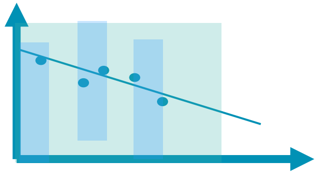
Effect of genetic correlation

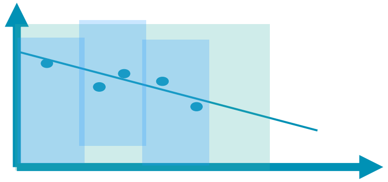


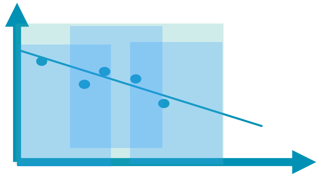
- Accuracy $\propto (1 + \rho)$
- No change in accuracy of resilience at across distribution scenarios at different genetic correlation
- No systematic trend on the bias at different genetic correlations

Effect of uncertainty in challenge levels









- The more heterogenous the herds, the lower the accuracy
- Best accuracy for production potential obtainable from random allocation scenario
- Accuracy of production potential is compromised

Accumulative genetic gain after 10 generations of selection

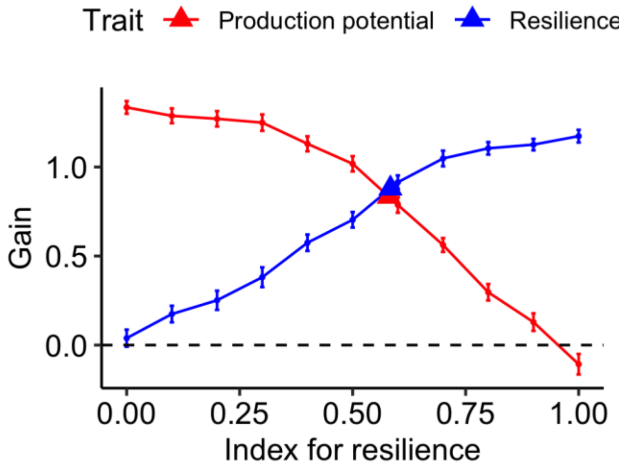
- For wide range of environments:

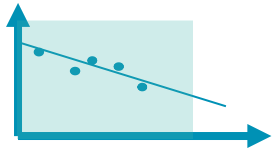
  Conventional models are as good as RN models (improve both traits)

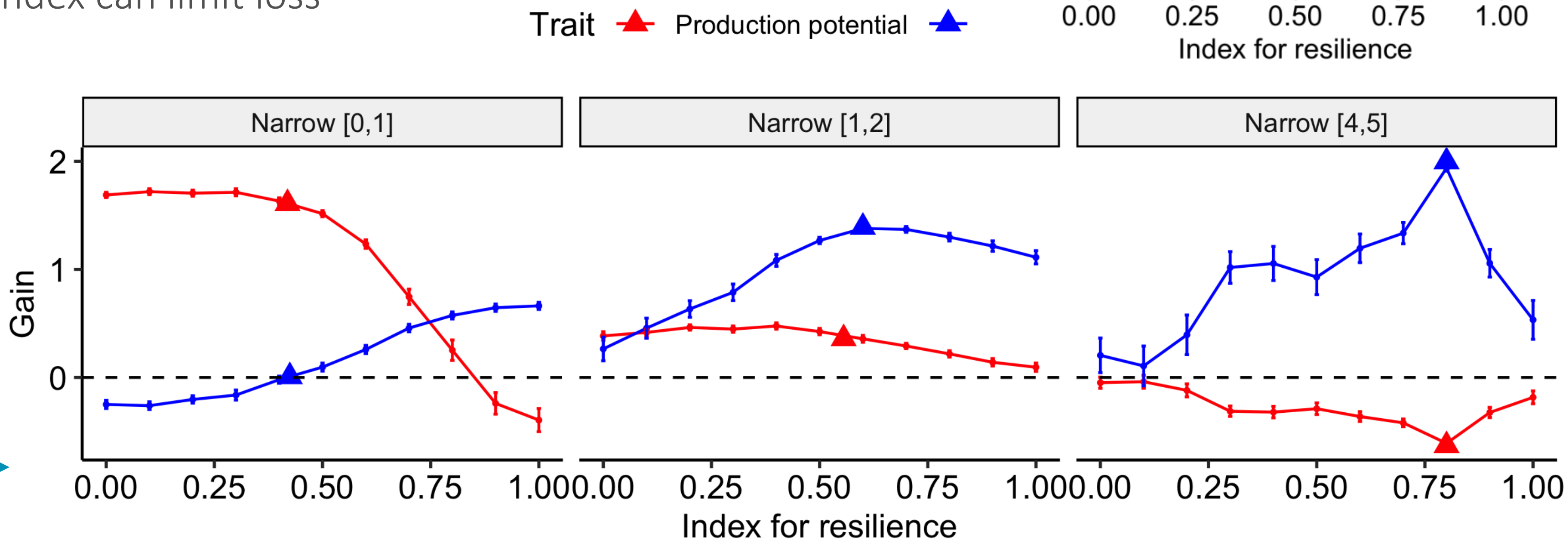
- For narrow range of environments:

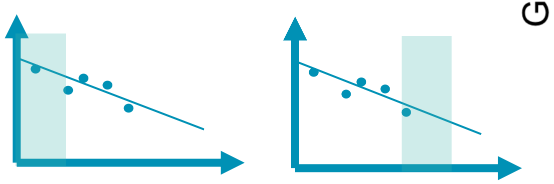
  Conventional model may have detrimental effect on one trait

  RN models with appropriate index can limit loss









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Conclusions

- Selection for resilience and production potential greatly benefits from genomic prediction
- Uncertainty in challenge level decreases accuracy but EBVs can be estimated relatively accurate which makes selection possible
- Random allocation of families across environments gives the best accuracy and bias for (G)EBV of production potential (but that it doesn’t affect accuracy of resilience)
- Genetic gain for production potential and resilience is largely affected by locations at where the phenotypes are collected from. Gain in both traits is easier when the phenotypes are collected from a wide rage of environments.

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