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Performance of Genetic Distance Metrics in Gravity and General Mixed Effects Models

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Performance of genetic distance metrics in gravity and general mixed effects models

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What are the genetic responses to fragmentation?

- Connectivity can help maintain occupied patches, genetic structure, and metapopulations

- What drives connectivity?
  - Connectivity can be influenced by at-site and between-site characteristics

- How do we determine connectivity?
  - Gene flow correlated to resistance surfaces

Issues with Genetics in Landscape Genetics

- Currently used genetic metrics were not developed for Landscape Genetics

- How long does it take to see a response to fragmentation with genetics?

- Are we selecting the correct connectivity model given the system?

Issues with Genetics in Landscape

Genetic Metrics

- Dps, Bray-Curtis, and PCA perform well for individual genetic metrics[1]

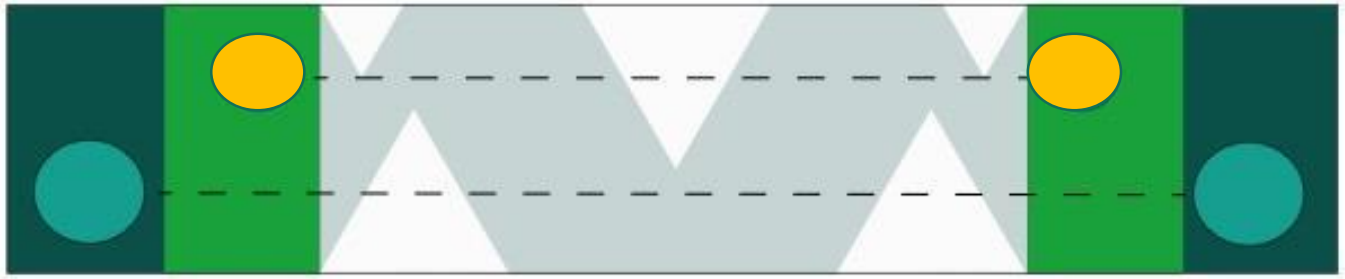
- How do population genetic metrics perform?
  - Dps – Allele
  - Fst – Heterozygosity
  - PCA (2-axes) – Ordinal
  - Cavalli-Sforza Kinship Coefficient (Dkf) – kinship
  - Nei's D – differentiation from drift and mutation

Shirk et al. 2017 in *Mol Ecol.*

Ecological Drivers

Between Site
Isolation by resistance

At Site
Isolation by environment

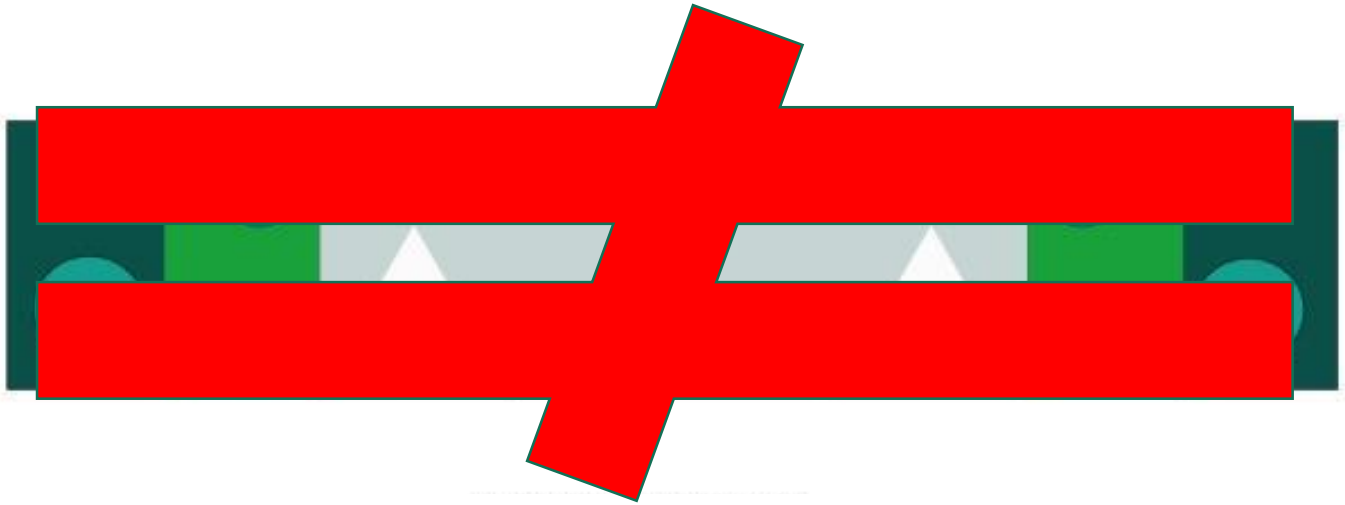


At Site and between site
Gravity

Ecological Drivers

Between Site
Isolation by resistance

At Site
Isolation by environment



At Site and between site
Gravity

Hypotheses

- Time
  - Short duration: Allele frequency based
  - Long duration: Heterozygozity based
- Landscape
  - More landscape structure: He based GD metrics
  - Less landscape structure: Allele frequency based GD metrics

Simulations

Landscape
Q Rule

Ecological
Driver
At-site, at-site/bt site, between site

Genetics
CDPOP

Genetic Distance Metric

Similarity
Dps

Kinship Based
Dkf

Ordination
PCA

He based
F_{ST}

Allele freq based
Nei's D

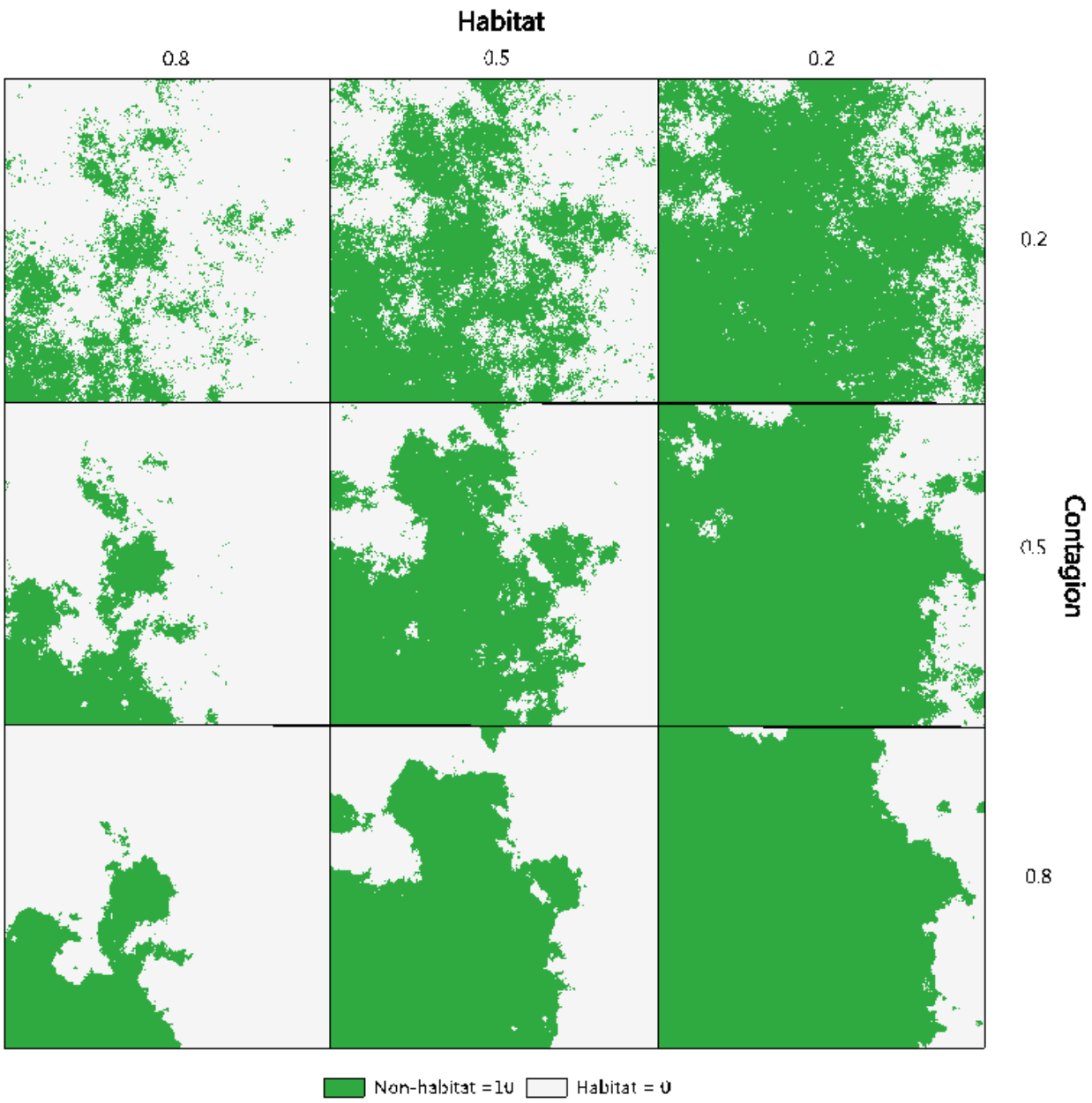
Analytic Method

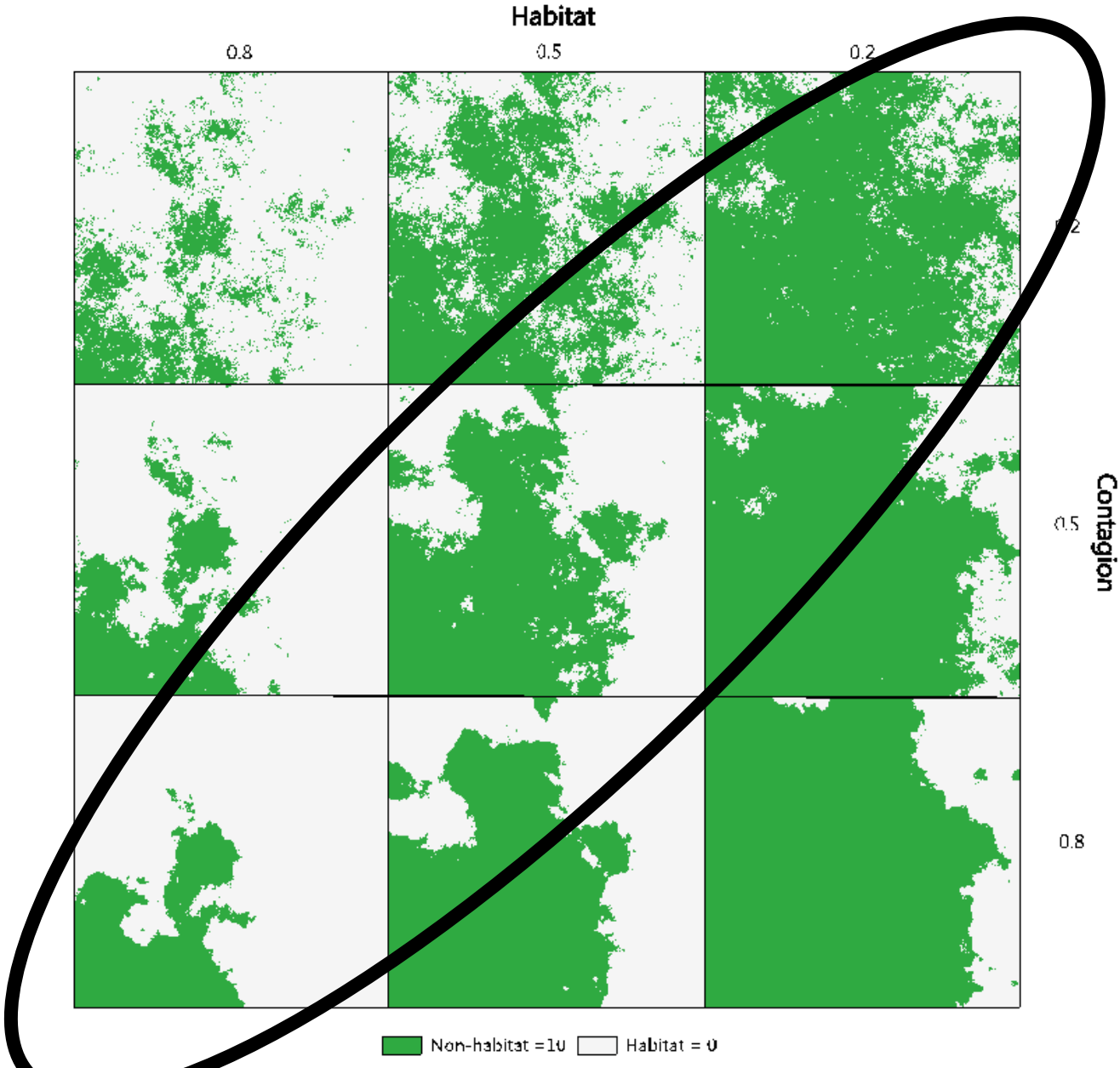
Gravity model
At-site & Between site

GLMM
Between site

Final Output

Model selection/
Parameter weight
(AIC)


Habitat
0.8
0.5
0.2
0.2
0.5
0.8
Contagion
Non-habitat = 10
Habitat = 0


Habitat
0.8
0.5
0.2
Contagion
0.5
0.8
Non-habitat = 10
Habitat = 0

GLMM vs Gravity

- Gravity allows incorporation of at-site predictors impacting geneflow
- GLMM only incorporates between-site environmental costs
- **Gravity prediction:**
  - Increased genetic signature if population size is impacted by habitat metrics
- **GLMM prediction:**
  - Increased model performance if equal population sizes and only between site govern genetic exchange

Analyses

GLMM

$$Y = \underbrace{\boldsymbol{\beta}\, x}_{\text{Fixed effects}} + \underbrace{\boldsymbol{\gamma}\, u}_{\text{Random effects}} + \boldsymbol{\varepsilon}$$

- Fixed effects:
  - landscape resistance cost, Euclidean distance
- Random effect: population

Analyses

GLMM

$$Y = \underbrace{\beta\, x}_{\text{Fixed effects}} + \underbrace{\gamma\, u}_{\text{Random effects}} + \varepsilon$$

- Fixed effects:
  - landscape resistance cost, Euclidean distance
- Random effect: population

Gravity model

$$Y = \underbrace{k x^{\alpha} a^{\beta} e^{-\gamma}}_{\text{Fixed effects}} + \underbrace{\gamma\, u}_{\text{Random effects}} + \varepsilon$$

- Fixed effects:
  - x = Euclidean distance between populations,
  - a = at site characteristic affecting production of migrants,
  - e = landscape resistance cost distance matrix
- Random effect: population

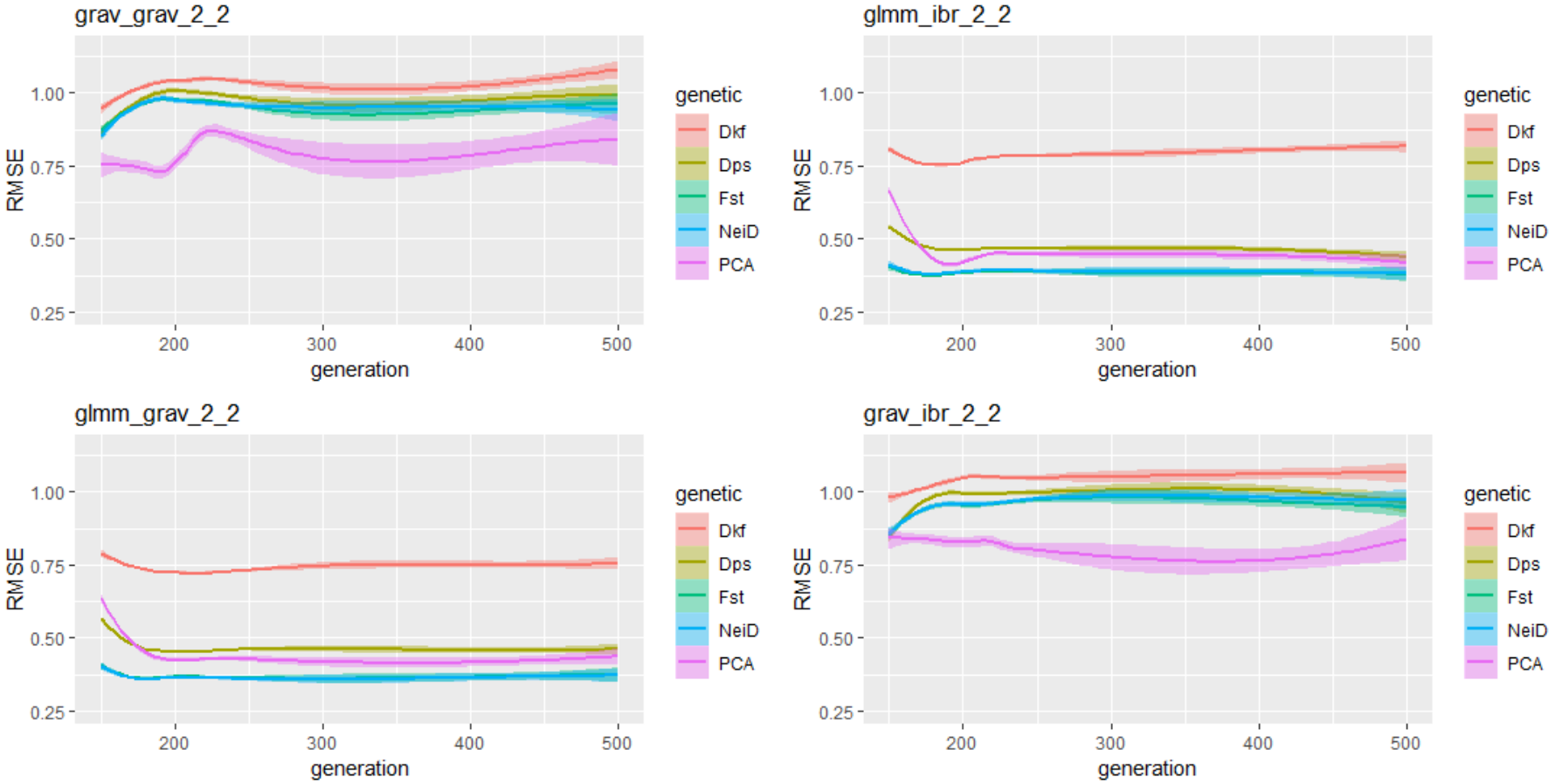
Results –RMSE con .2, hab .2

Gravity Driver

IBR Driver

Correct Model

Wrong Model



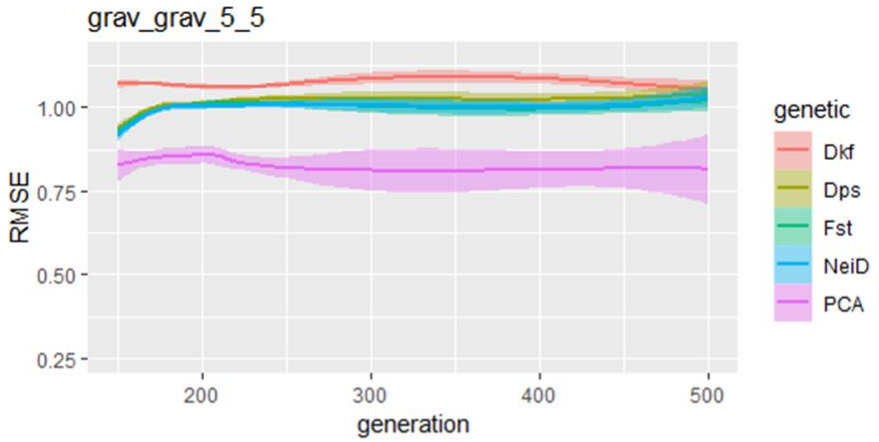
Results –RMSE con .5, hab .5

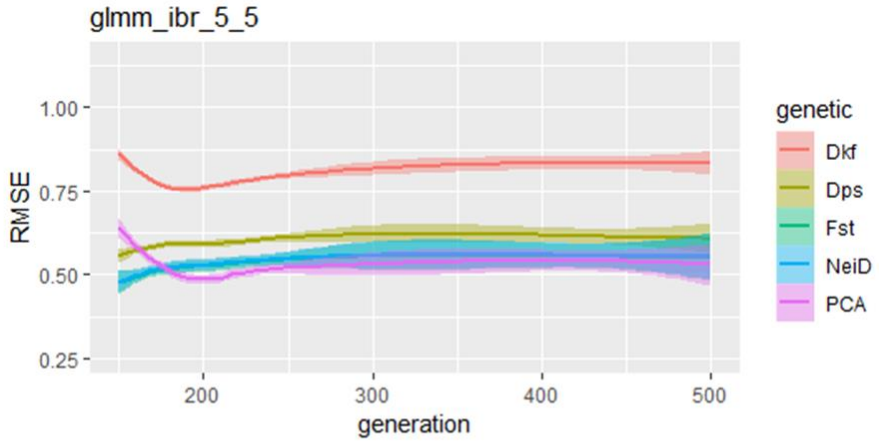
Gravity Driver

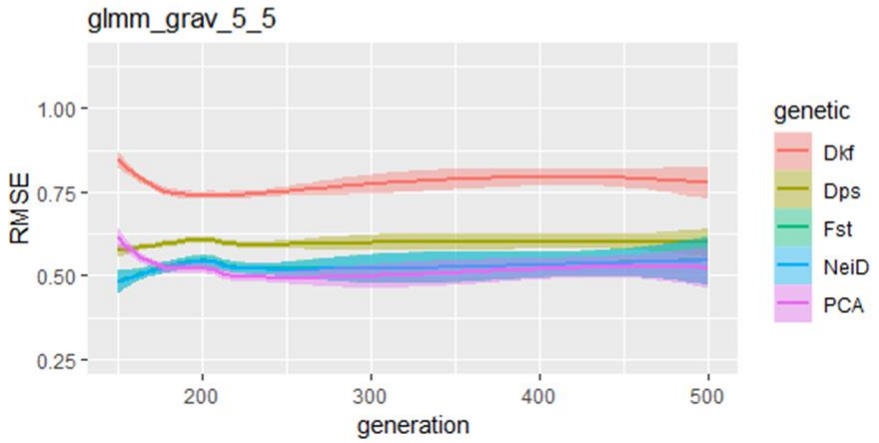
IBR Driver

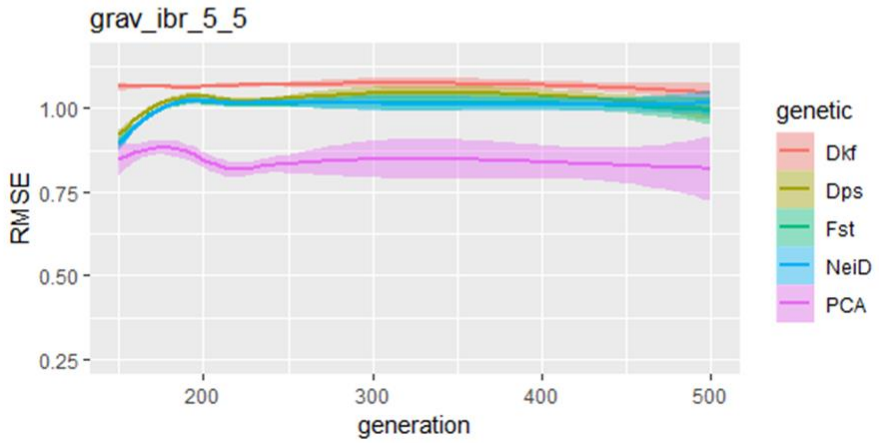
Correct Model

Wrong Model







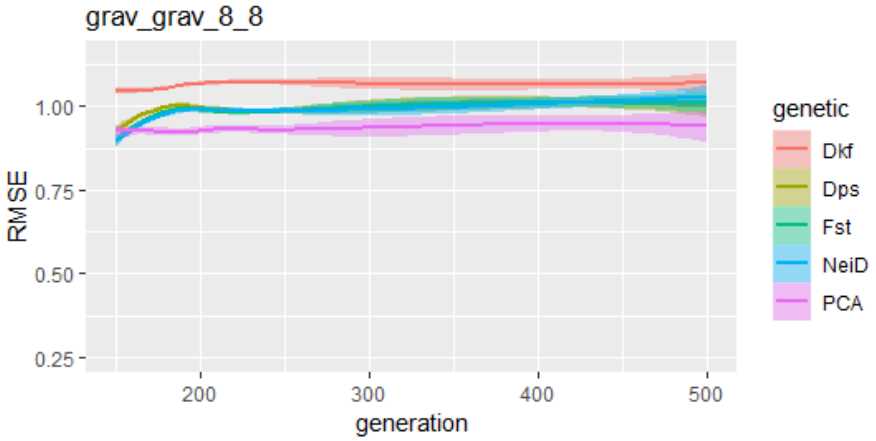


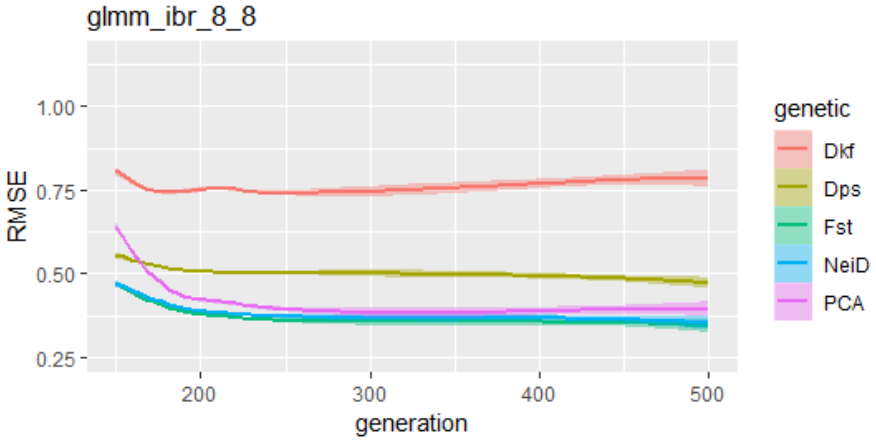
Results –RMSE con .8, hab .8

Gravity Driver

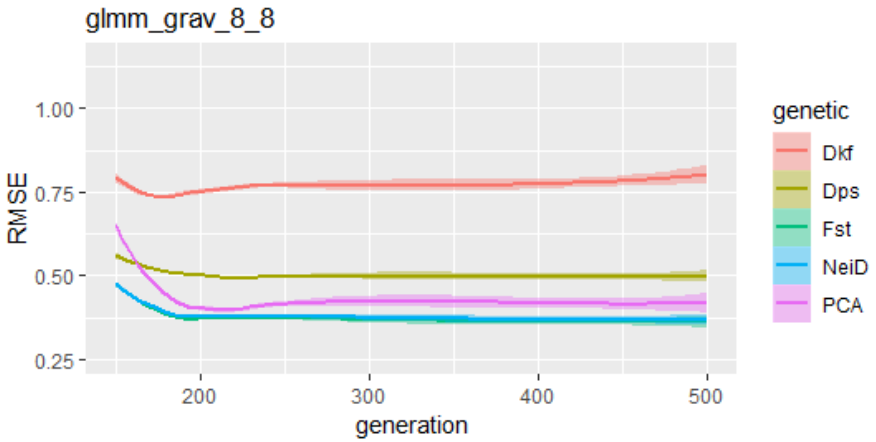
IBR Driver

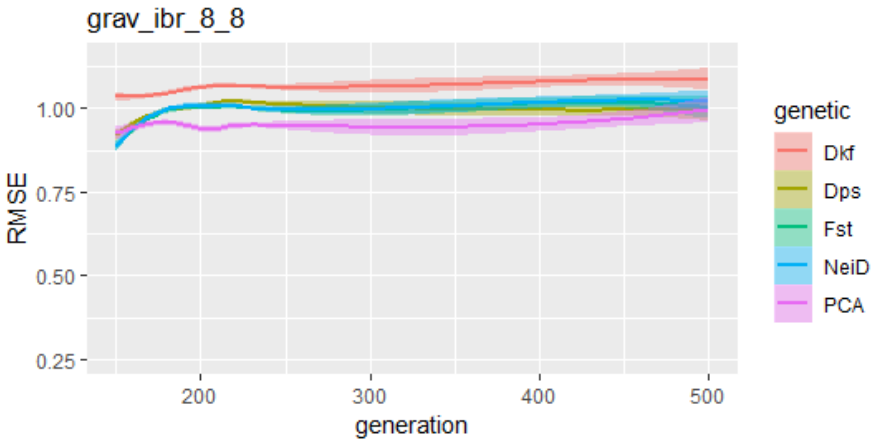
Correct Model





Wrong Model





Discussion

- PCA has limited assumptions around use
- Fst assumes Hardy-Weinberg Equilibrium
- GLMM had lower RMSE than gravity models, even for our predicted correct models
- Expand habitat contagion/habitat combinations and time window

Acknowldegements

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Erin Landguth

Landscape Genetics-DGS 2016

Questions?

Follow this link:

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