TROPICAL-TEMPERATE GRADIENTS OF SPECIES AND GENETIC DIVERSITY (IN THE AMERICAN CORDILLERA)

CHAZ HYSENI

ORISE Rsrch. Fellow

US Forest Service

Camilo

Calderón-Acevedo

Rutgers U.

Isaac

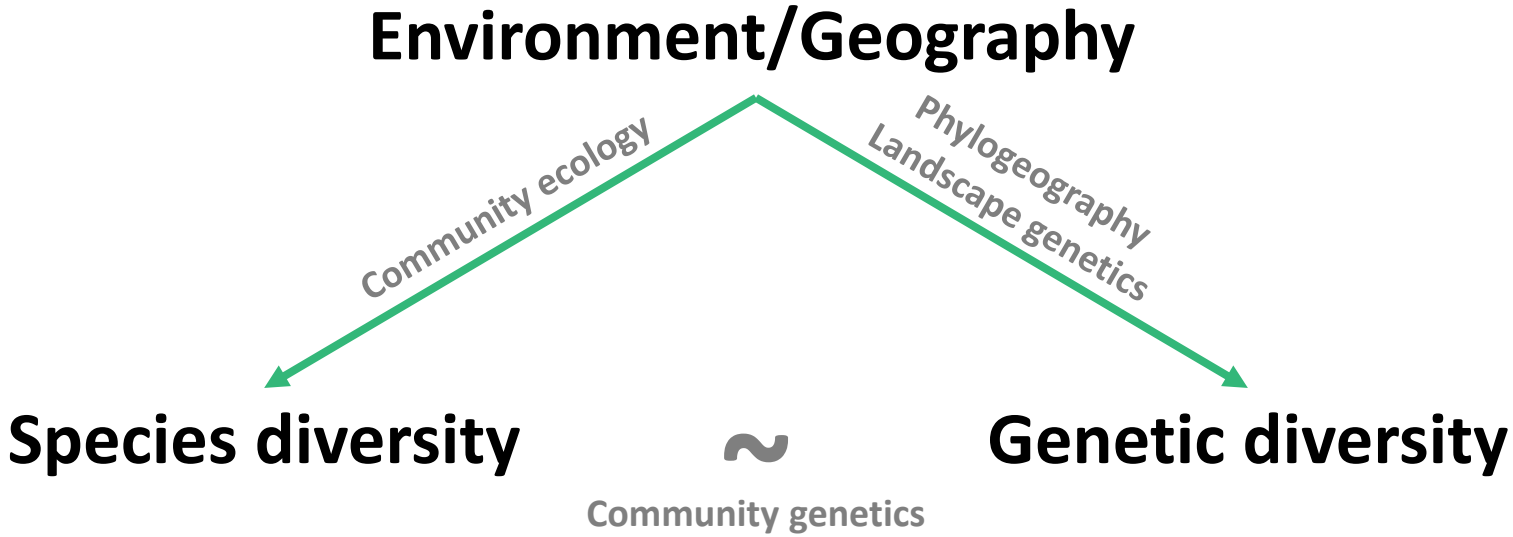
Overcast

U. of Maine

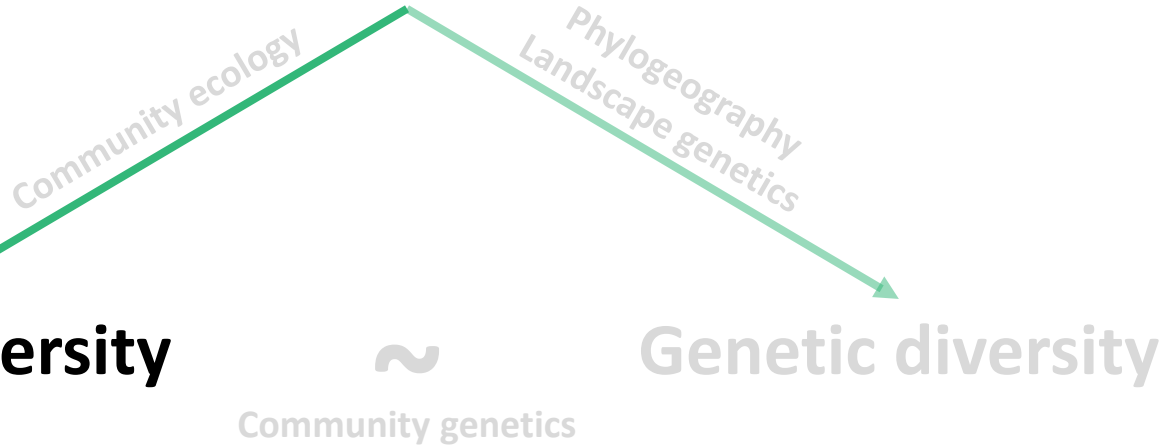
Marcelo

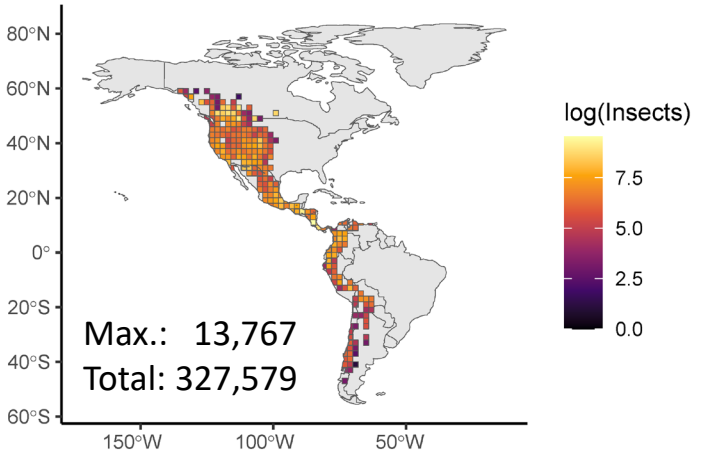
Gehara

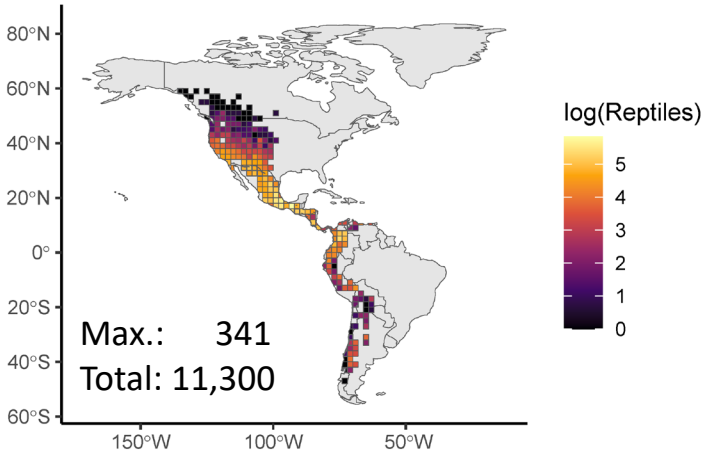
Rutgers U.

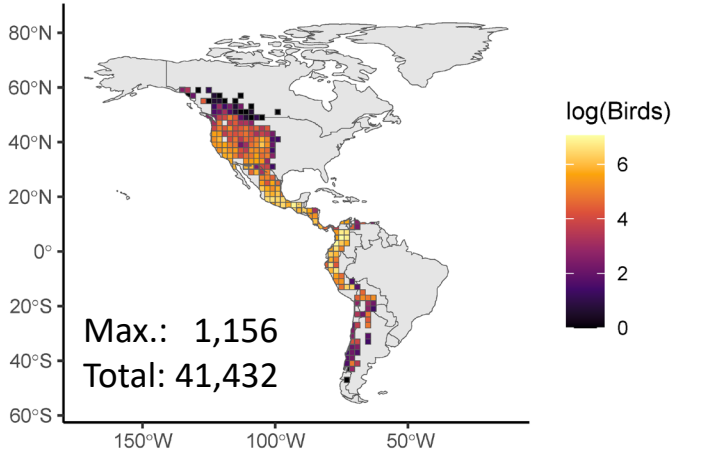

Environment/Geography
Community ecology
Phylogeography
Landscape genetics
Species diversity
~
Genetic diversity
Community genetics

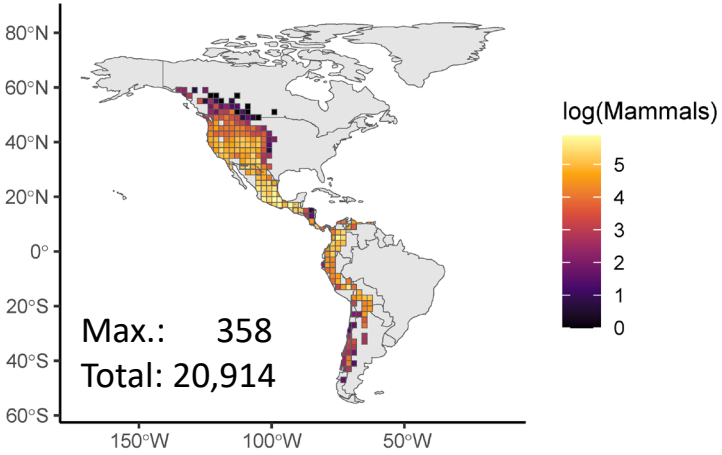
Macroecology: global-scale using **GBIF** data

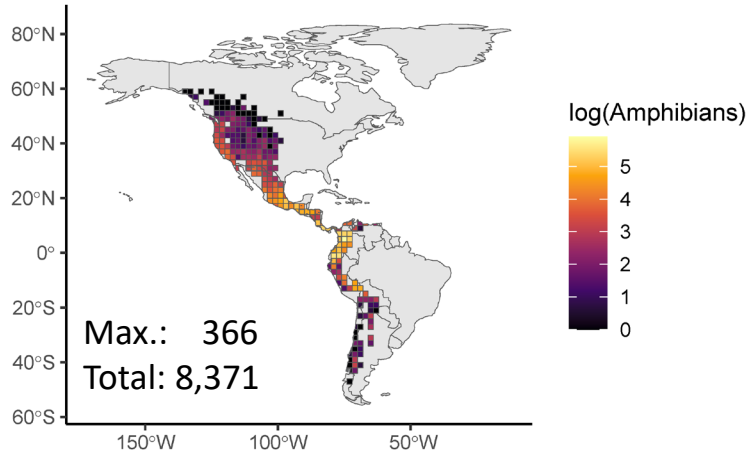


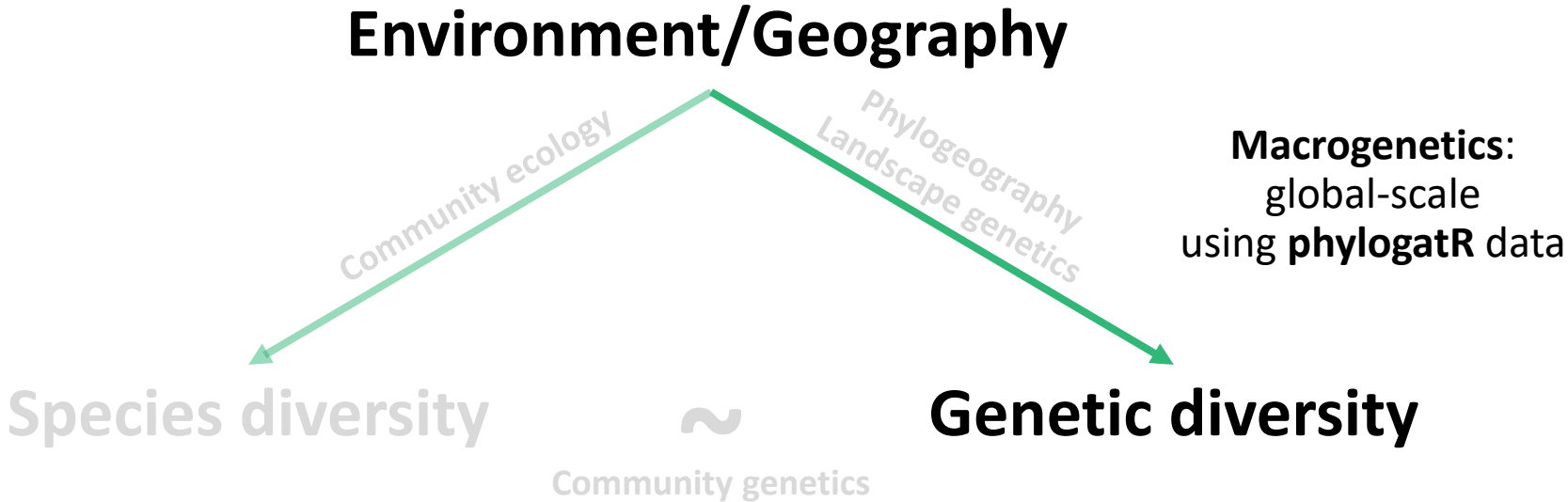

80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
150°W
100°W
50°W
Max.: 13,767
Total: 327,579
log(Insects)
7.5
5.0
2.5
0.0


80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
150°W
100°W
50°W
Max.: 341
Total: 11,300
log(Reptiles)
5
4
3
2
1
0


80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
150°W
100°W
50°W
Max.: 1,156
Total: 41,432
log(Birds)
6
4
2
0


80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
150°W
100°W
50°W
Max.: 358
Total: 20,914
log(Mammals)
5
4
3
2
1
0


80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
150°W
100°W
50°W
Max.: 366
Total: 8,371
log(Amphibians)
5
4
3
2
1
0



Macrogenetics:
global-scale
using **phylogatR** data

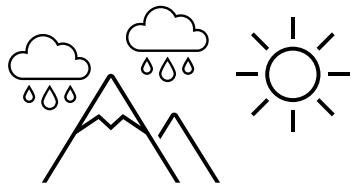
Macrogenetics (global-scale **genetic diversity**)

phylogatR

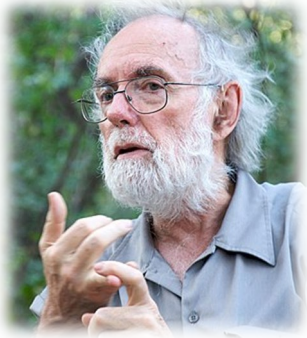
Tara Pelletier
Radford U.

Tara Pelletier, Danielle Parsons, Sydney Decker, Stephanie Crouch, Eric Franz, Jeffrey Ohrstrom, Bryan Carstens. 2022.
PhylogatR: *Phylogeographic data aggregation and repurposing*.
Molecular Ecology Resources. [In Revision]

https://phylogatr.org/



JANZEN HYPOTHESIS

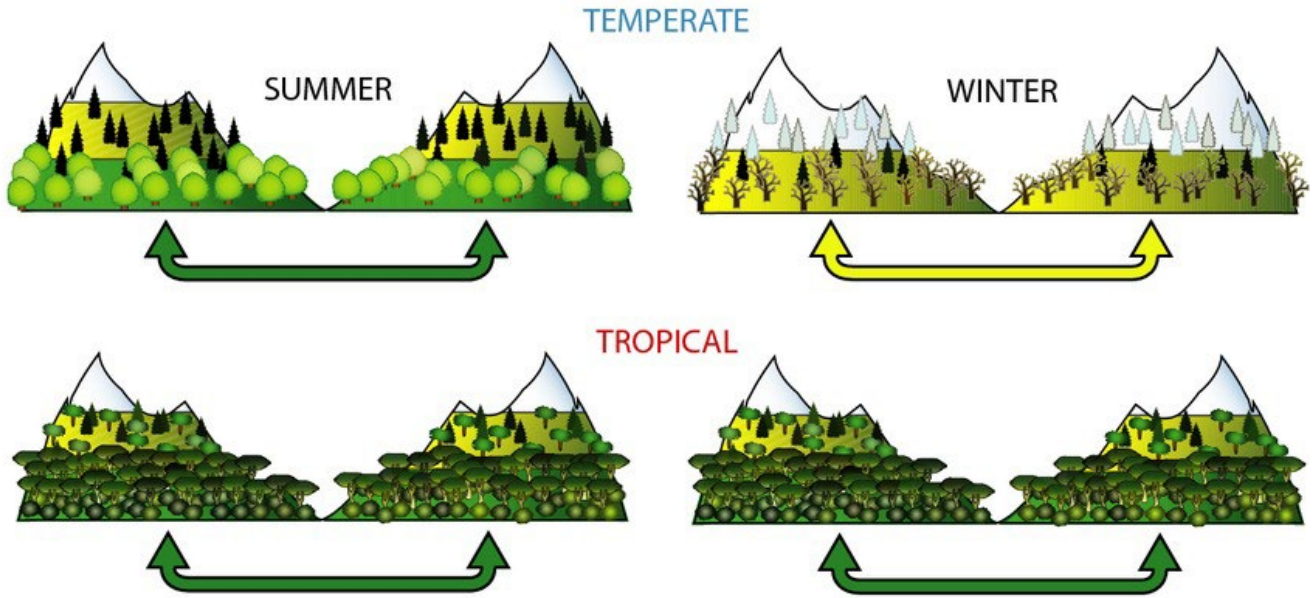


Vertical migration constraints:

tropics
(deeper valleys; higher mountain passes)
vs.
temperate zones

Altitudinal Species Range: Tropical vs. Temperate

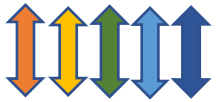
Mountain passes are higher in the tropics (Janzen, 1967)



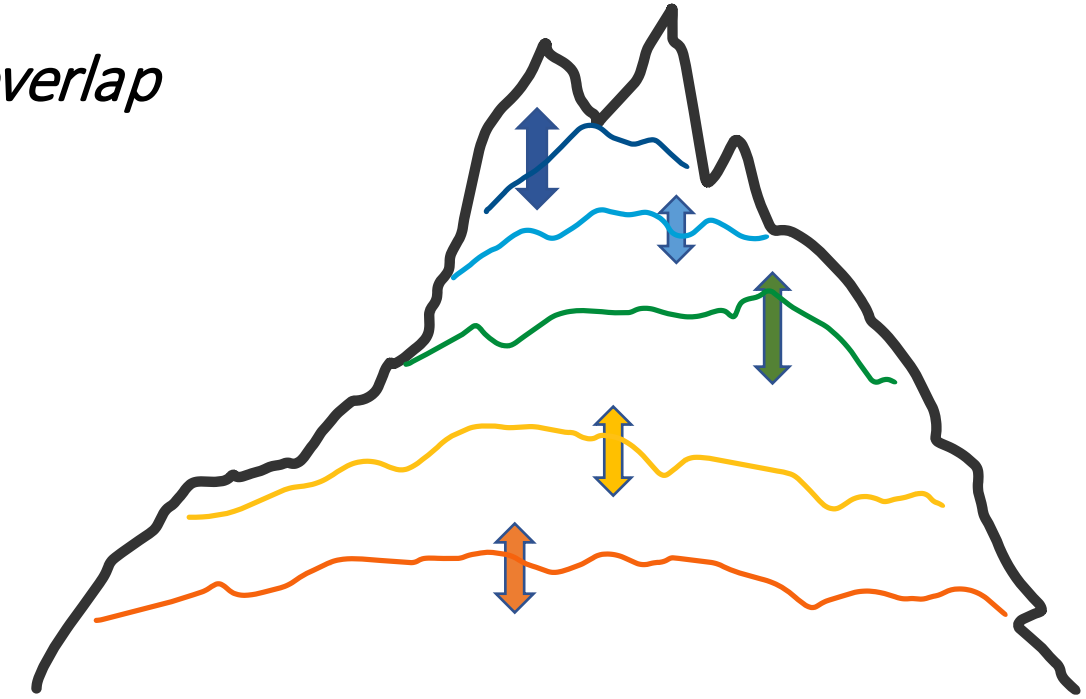
Modified from Brown 2014

Altitudinal Species Range: Tropical

LOW thermal overlap



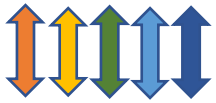
Altitudinal Species Range



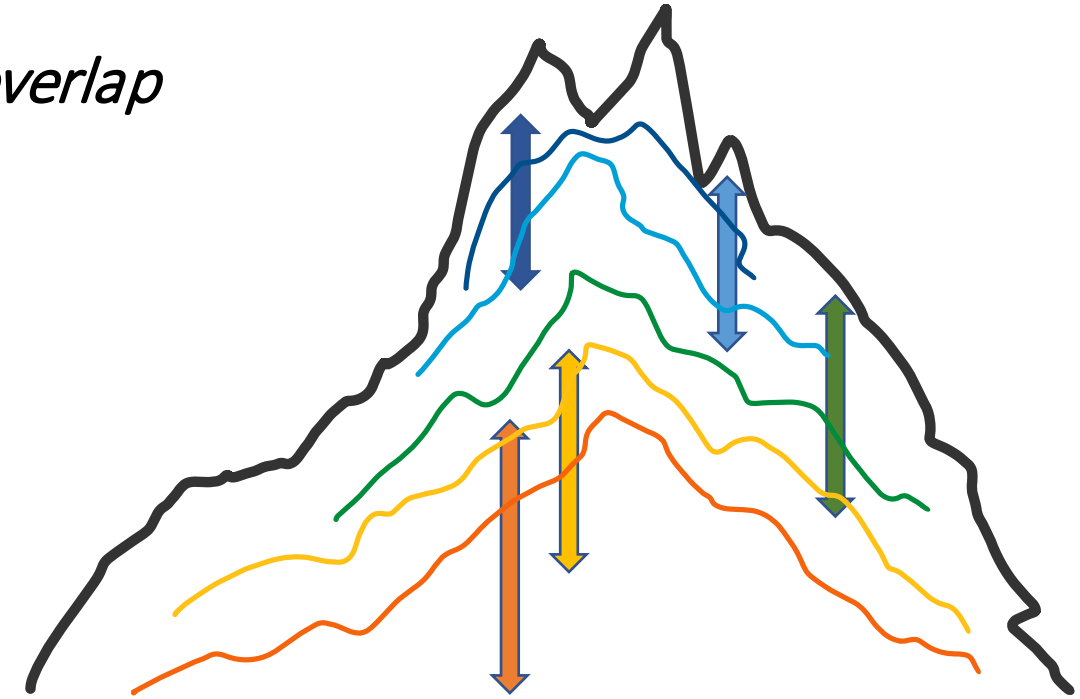
January ***Annual Temp. Variation*** December

Altitudinal Species Range: Temperate

HIGH thermal overlap



Altitudinal Species Range



January ***Annual Temp. Variation*** December

The American Cordillera:

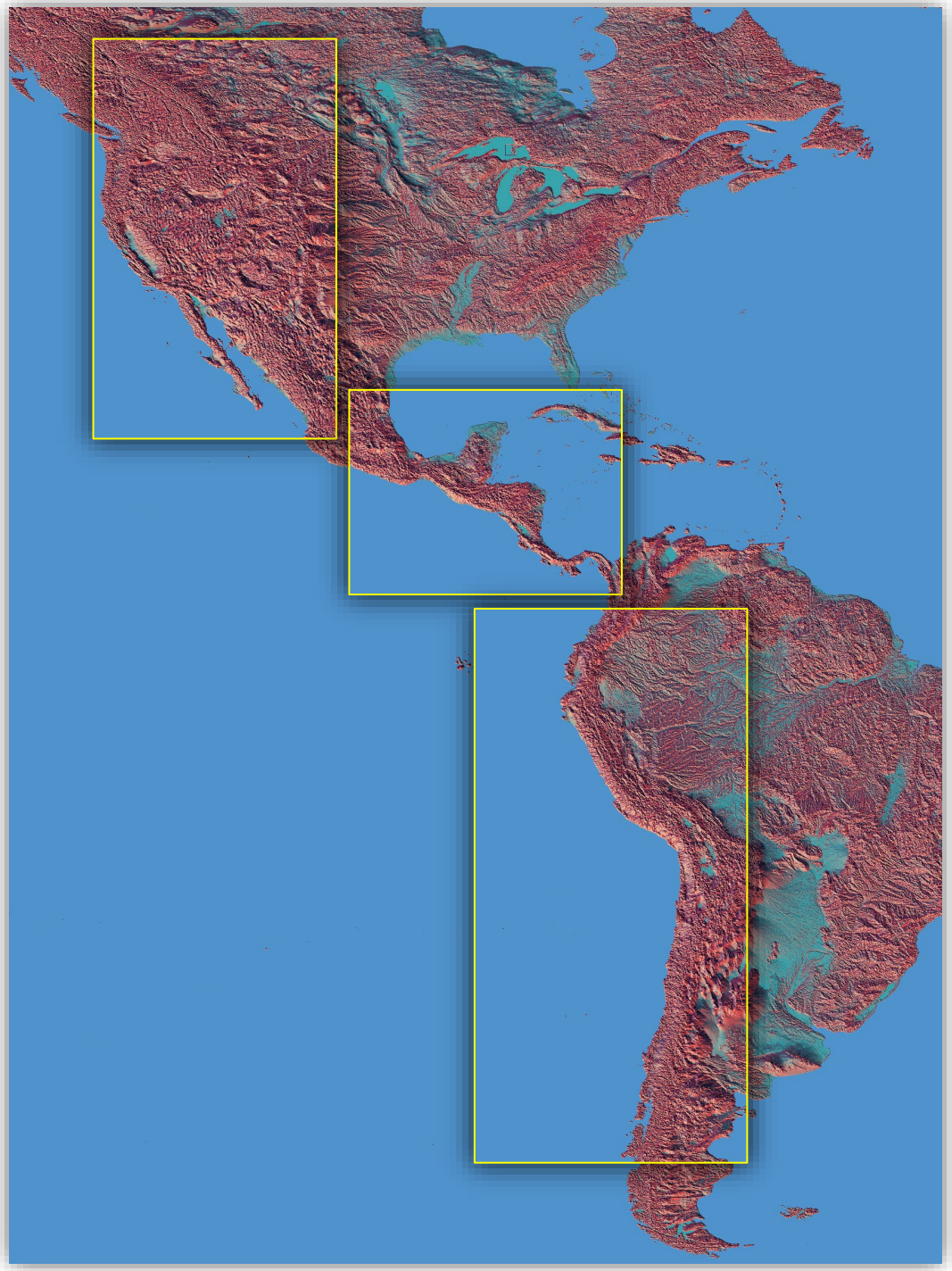
North American Cordillera:

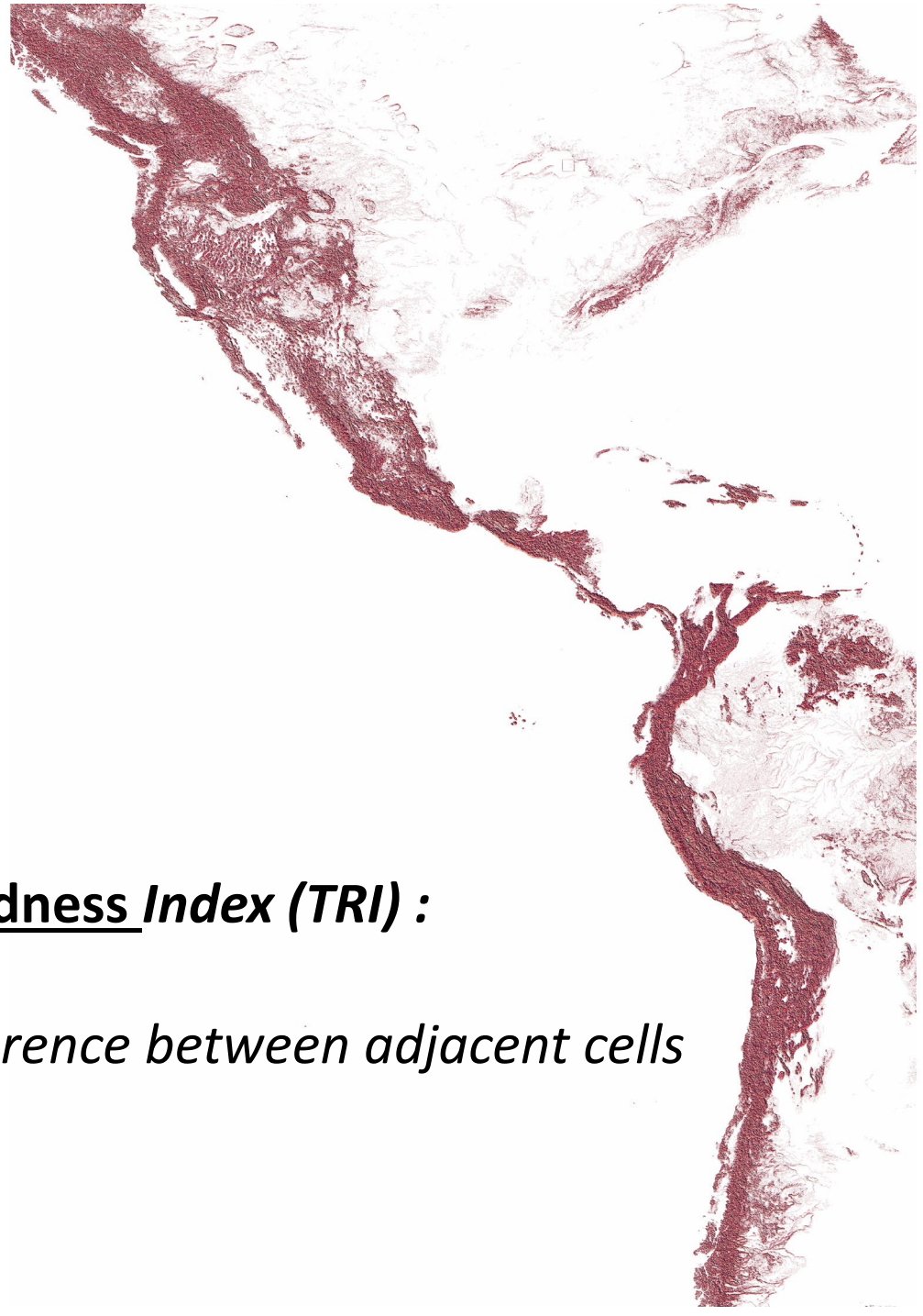
Rocky Mts.,

Sierra Madre,

Central American mountain ranges

Andes Mts. in South America





Terrain* <u>Ruggedness</u> *Index (TRI) :

amount of elevation difference between adjacent cells

Janzen Hypothesis Testing:

NULL:

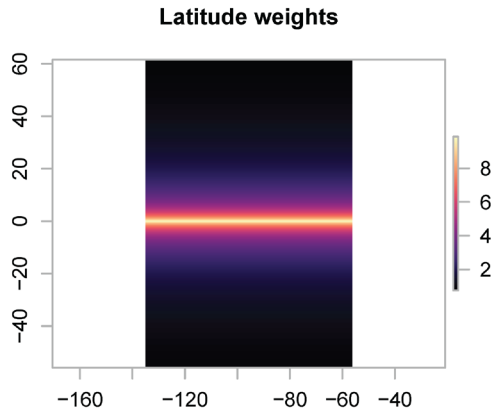
unweighted ruggedness

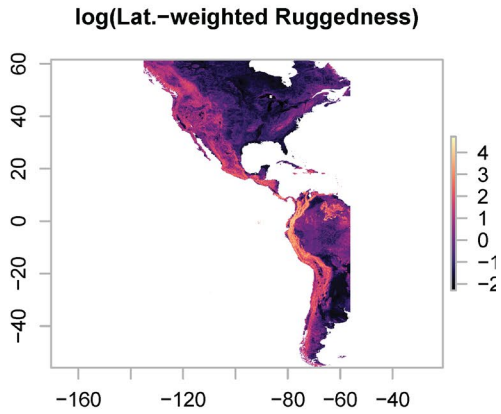
vs.

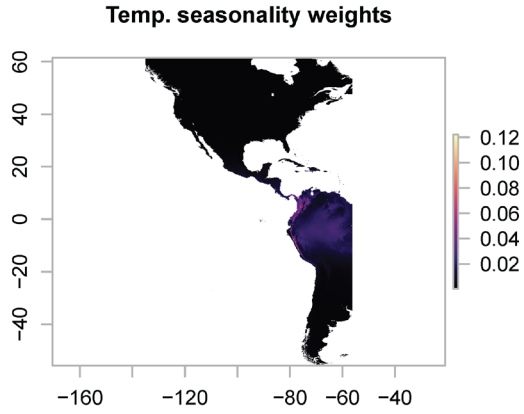
ALTERNATIVE:

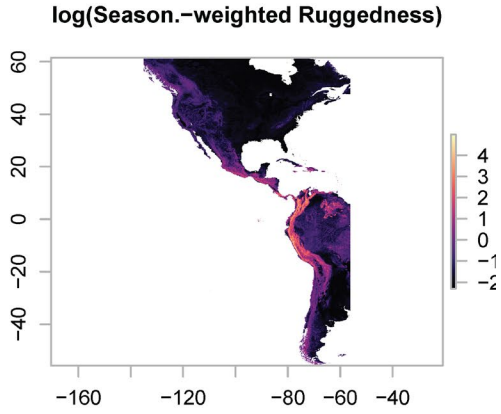
latitude/
seasonality[1]/
isothermality[2]
weighted
ruggedness

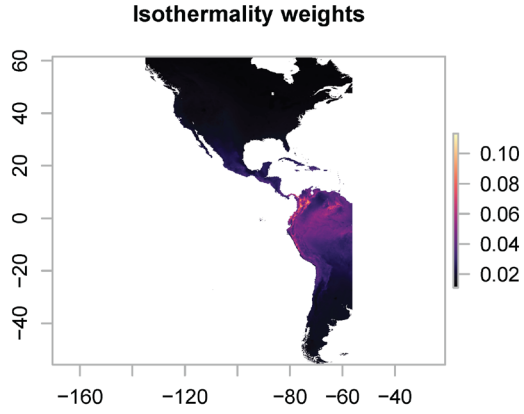
[1] std. dev. of annual temp.
[2] daily/annual temp. range

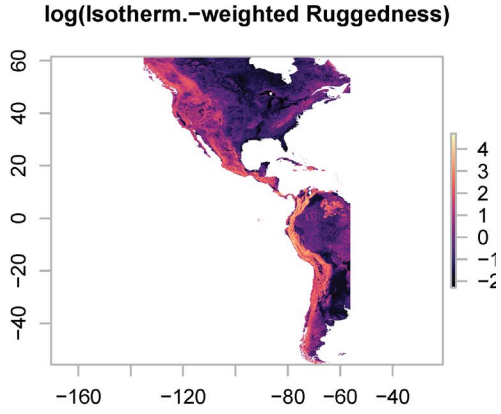


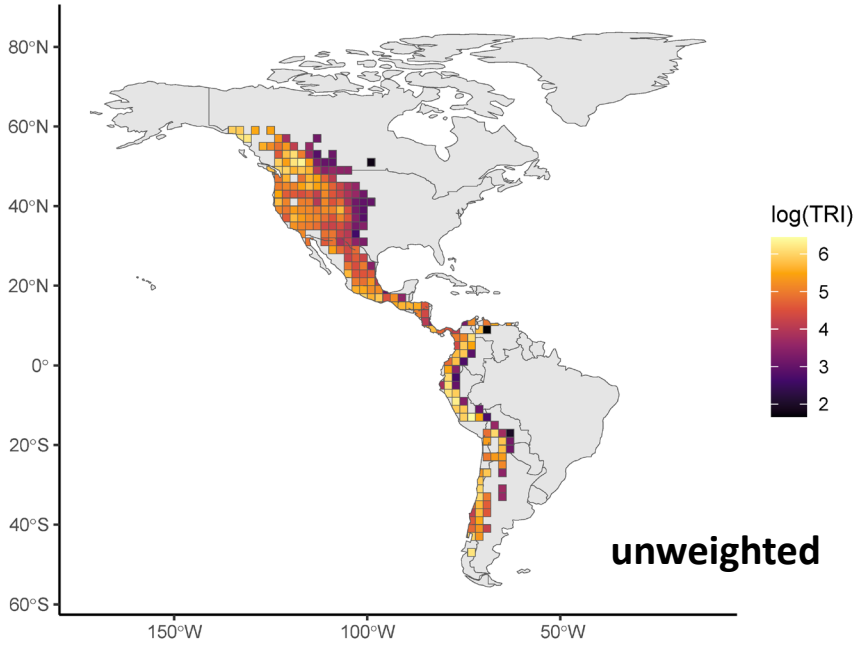




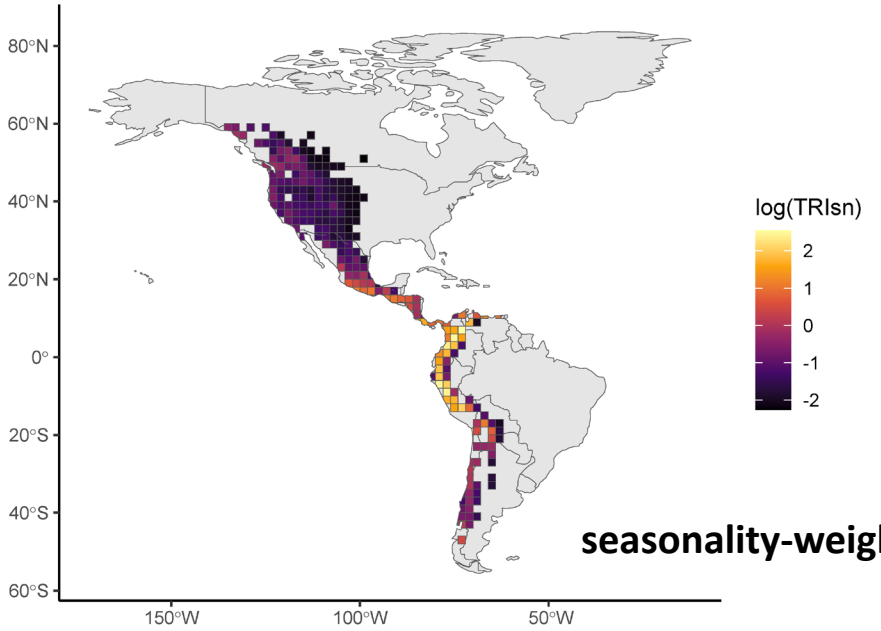




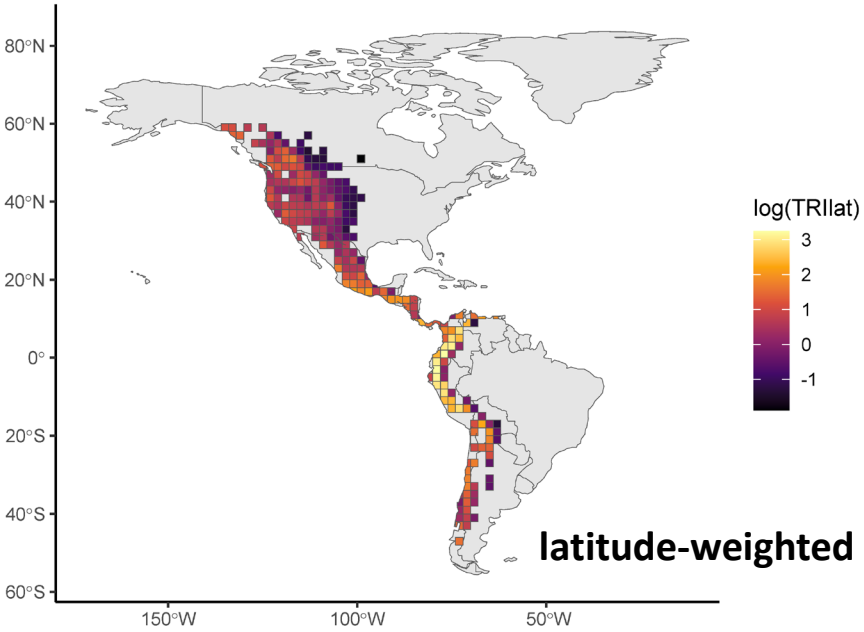




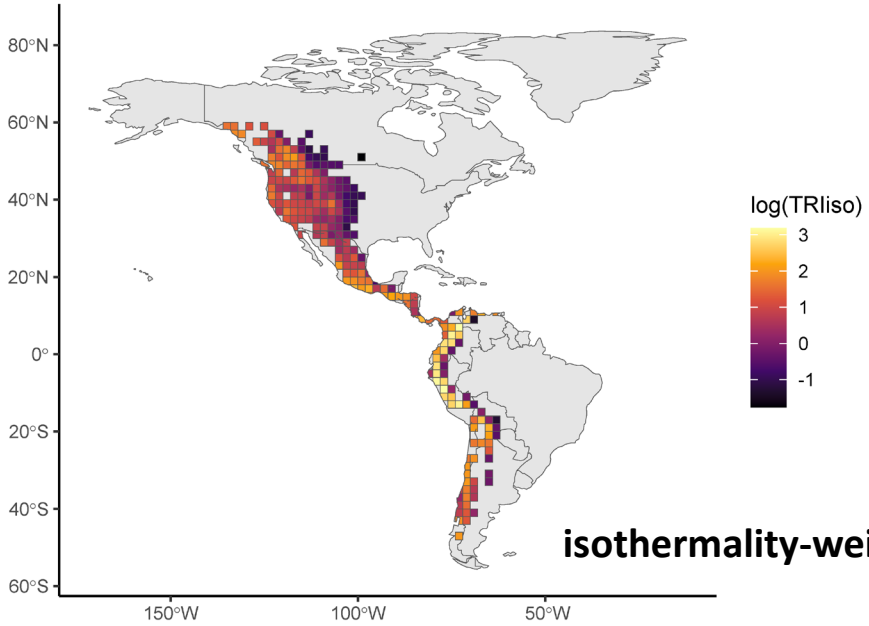
unweighted



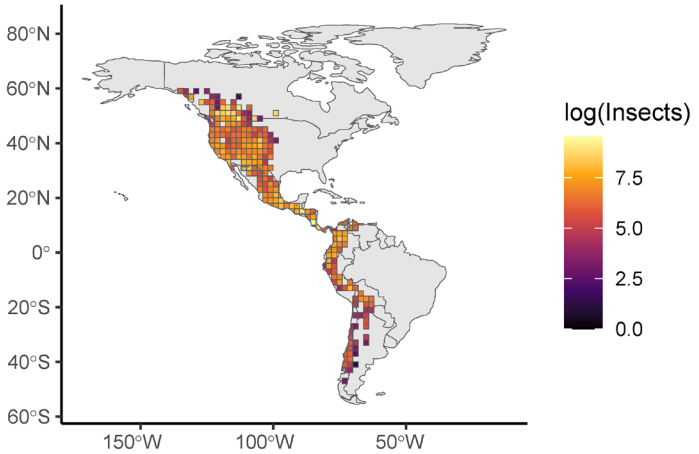
seasonality-weighted



latitude-weighted

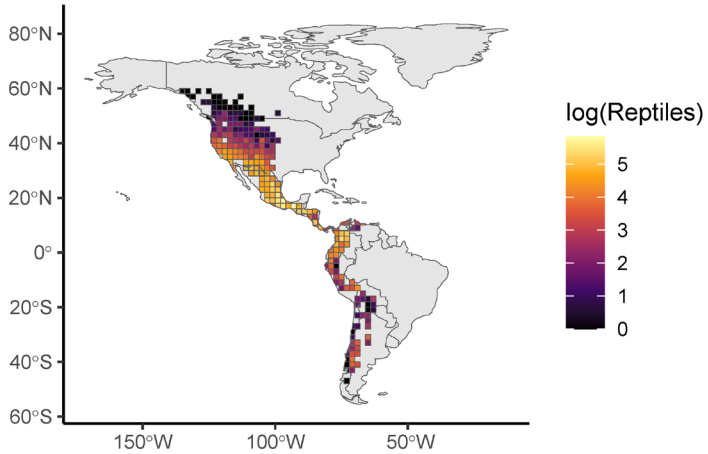


isothermality-weighted



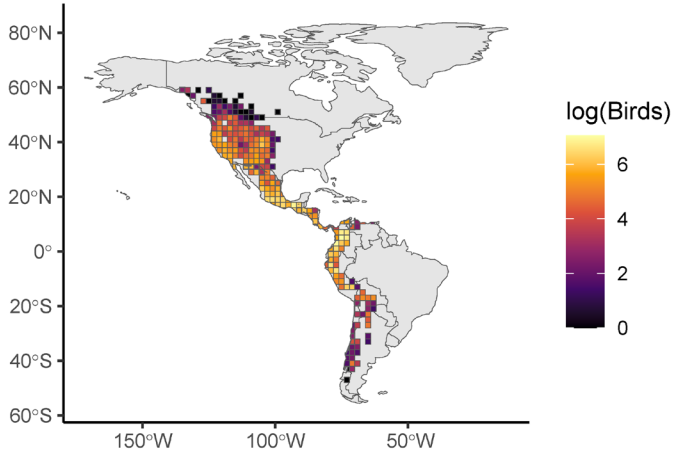
log(Insects)

7.5
5.0
2.5
0.0



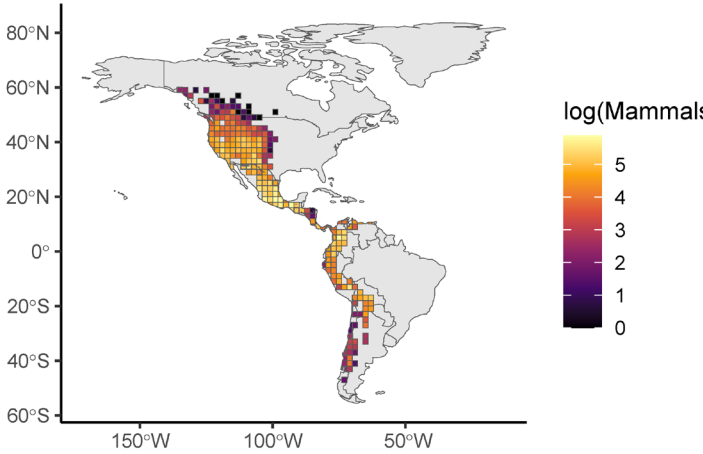
log(Reptiles)

5
4
3
2
1
0



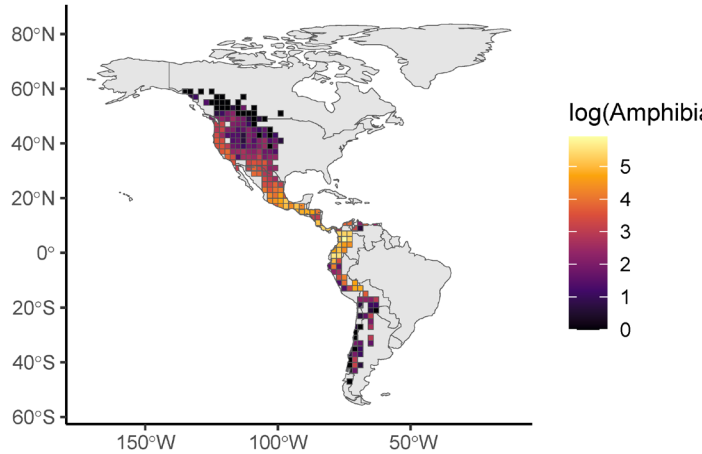
log(Birds)

6
4
2
0



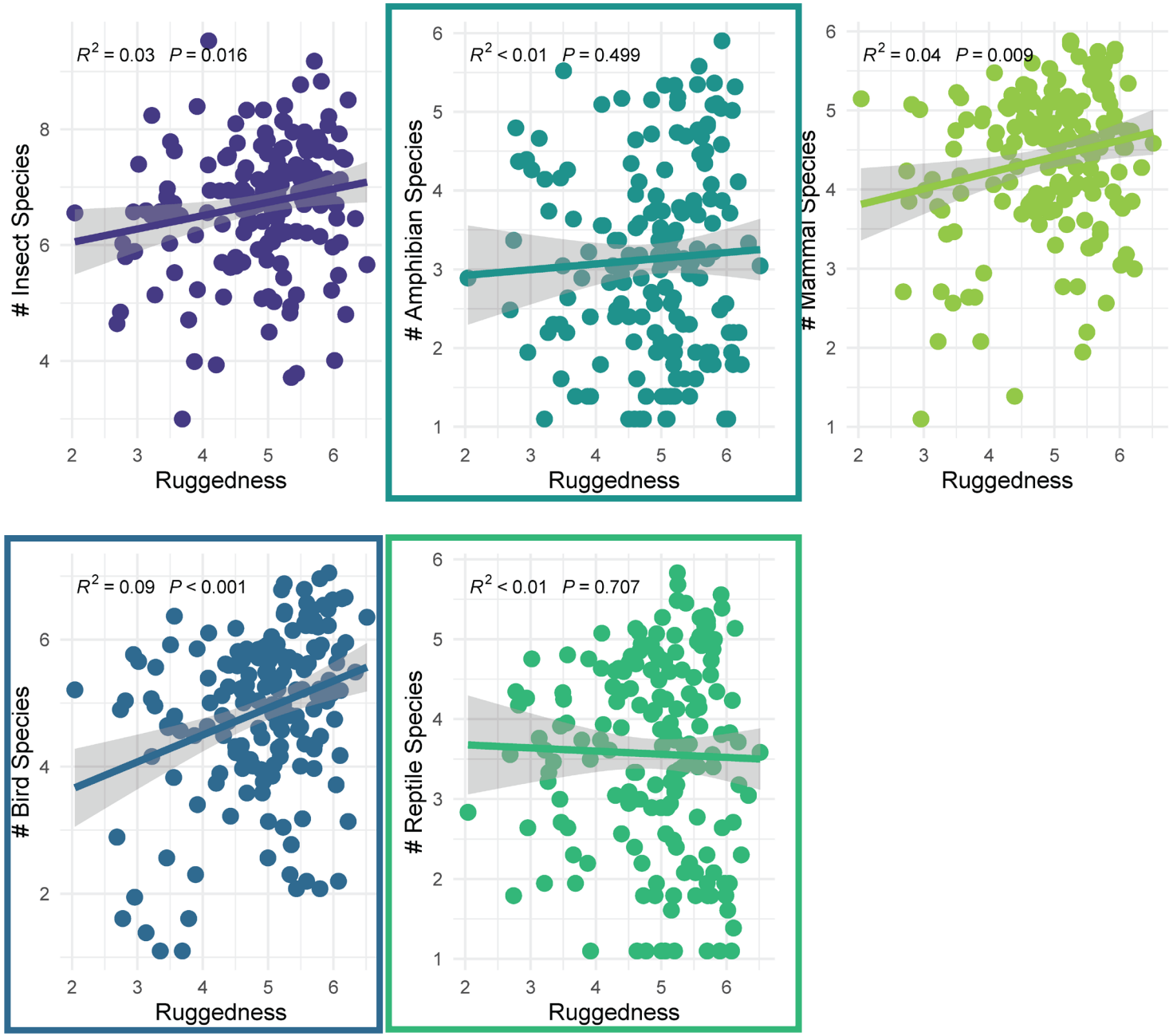
log(Mammals)

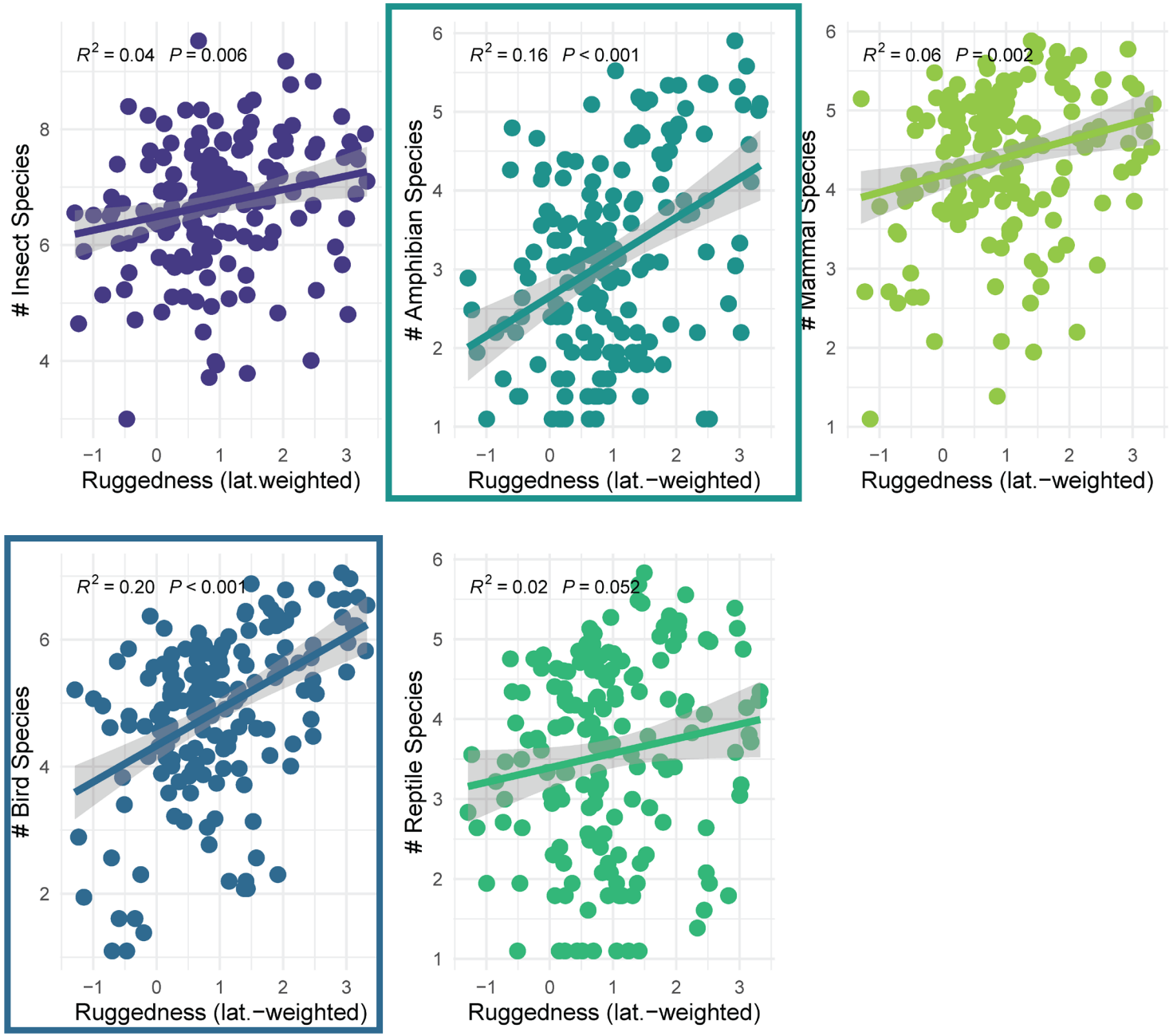
5
4
3
2
1
0

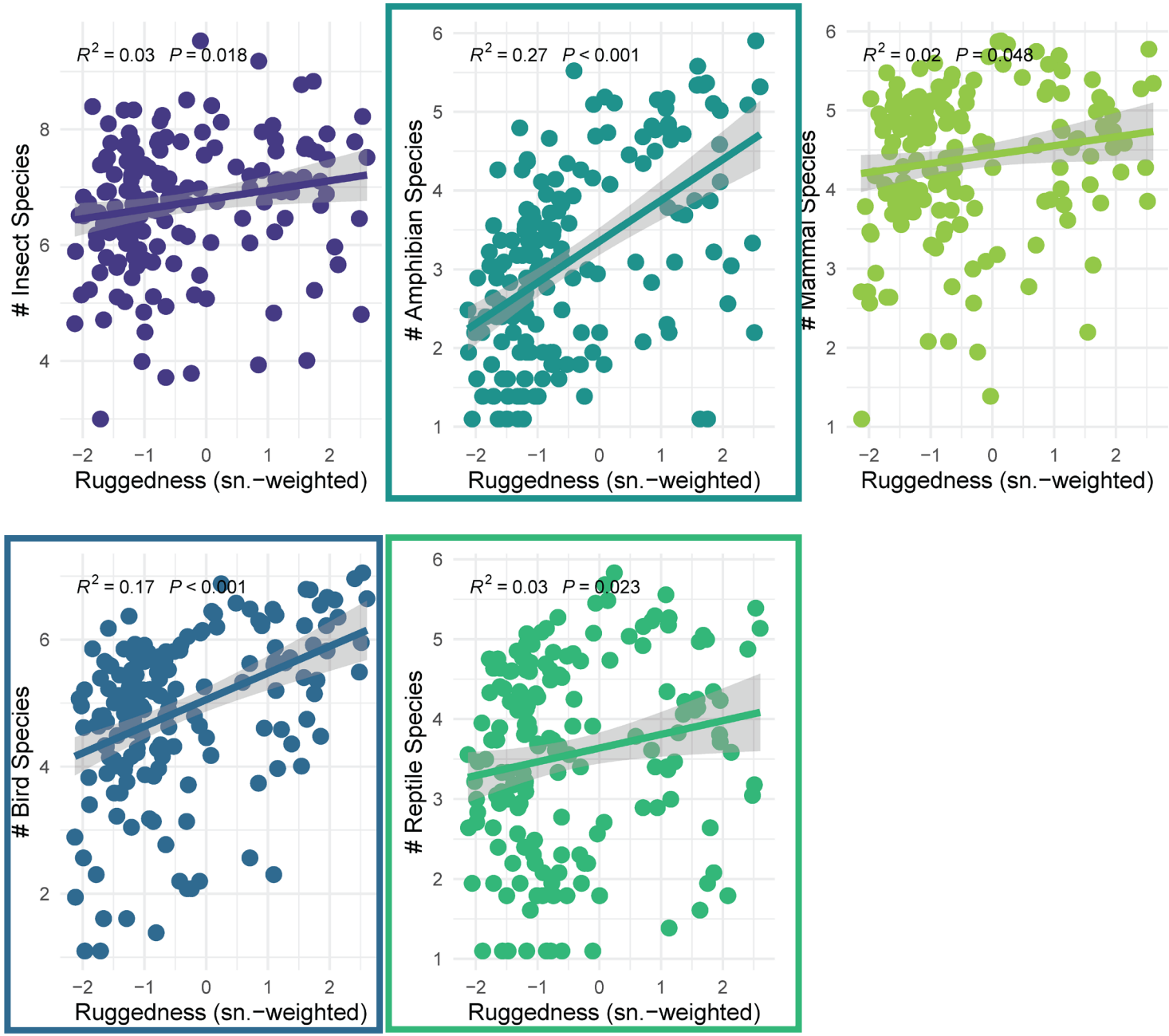


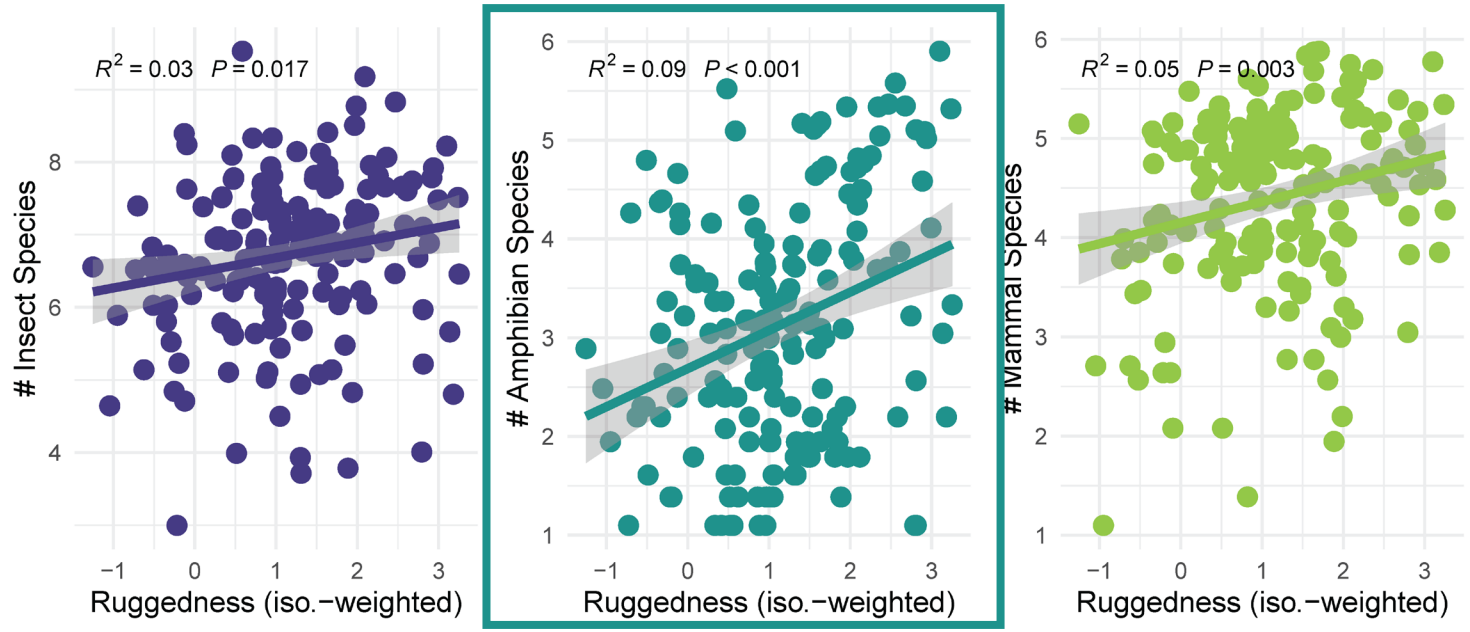
log(Amphibians)

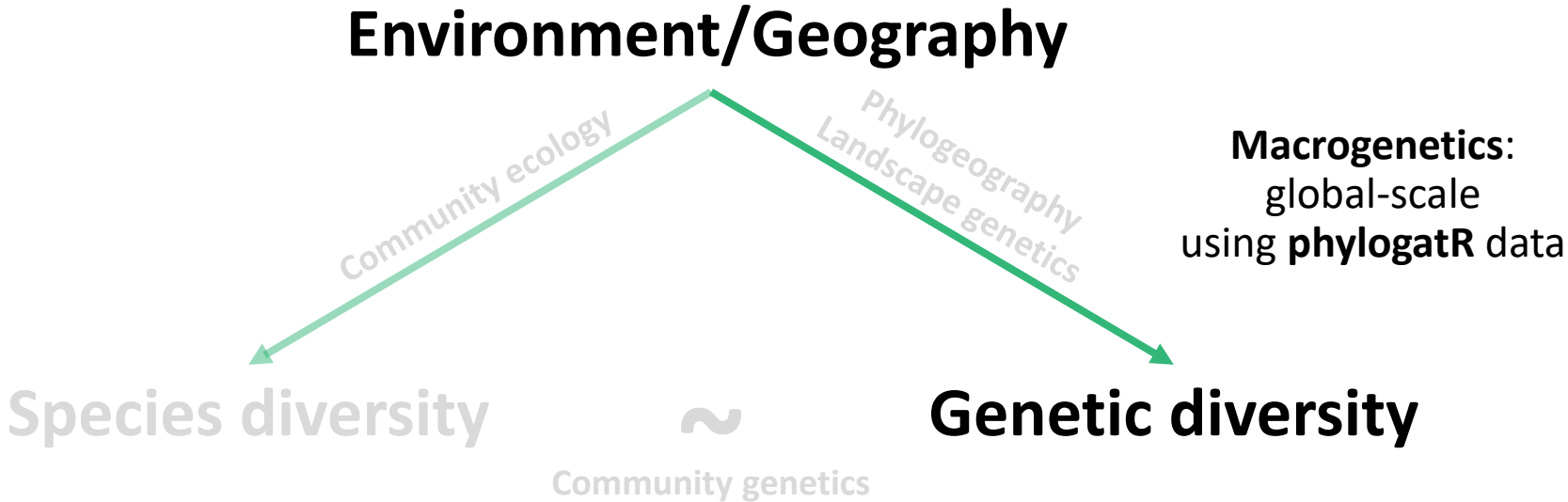
5
4
3
2
1
0


R^2 = 0.03 P = 0.016
Insect Species
Ruggedness
R^2 < 0.01 P = 0.499
Amphibian Species
Ruggedness
R^2 = 0.04 P = 0.009
Mammal Species
Ruggedness
R^2 = 0.09 P < 0.001
Bird Species
Ruggedness
R^2 < 0.01 P = 0.707
Reptile Species
Ruggedness


R^2 = 0.04 P = 0.006
Insect Species
Ruggedness (lat.weighted)
R^2 = 0.16 P < 0.001
Amphibian Species
Ruggedness (lat.−weighted)
R^2 = 0.06 P = 0.002
Mammal Species
Ruggedness (lat.−weighted)
R^2 = 0.20 P < 0.001
Bird Species
Ruggedness (lat.−weighted)
R^2 = 0.02 P = 0.052
Reptile Species
Ruggedness (lat.−weighted)


R^2 = 0.03 P = 0.018
Insect Species
Ruggedness (sn.−weighted)
R^2 = 0.27 P < 0.001
Amphibian Species
Ruggedness (sn.−weighted)
R^2 = 0.02 P = 0.048
Mammal Species
Ruggedness (sn.−weighted)
R^2 = 0.17 P < 0.001
Bird Species
Ruggedness (sn.−weighted)
R^2 = 0.03 P = 0.023
Reptile Species
Ruggedness (sn.−weighted)


R^2 = 0.03 P = 0.017
Insect Species
Ruggedness (iso.−weighted)
R^2 = 0.09 P < 0.001
Amphibian Species
Ruggedness (iso.−weighted)
R^2 = 0.05 P = 0.003
Mammal Species
Ruggedness (iso.−weighted)
R^2 = 0.16 P < 0.001
Bird Species
Ruggedness (iso.−weighted)
R^2 < 0.01 P = 0.236
Reptile Species
Ruggedness (iso.−weighted)



Macrogenetics:
global-scale
using **phylogatR** data

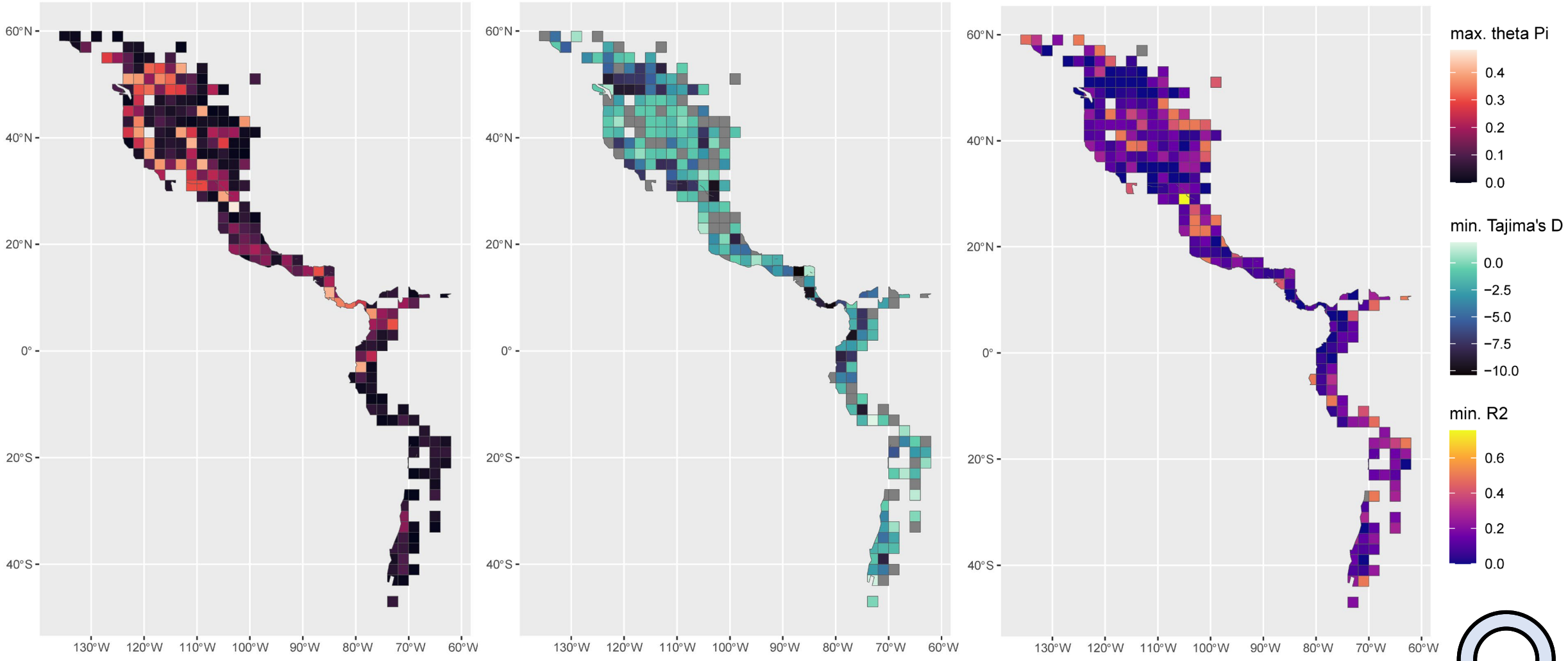
Population size changes

LOW values = population growth

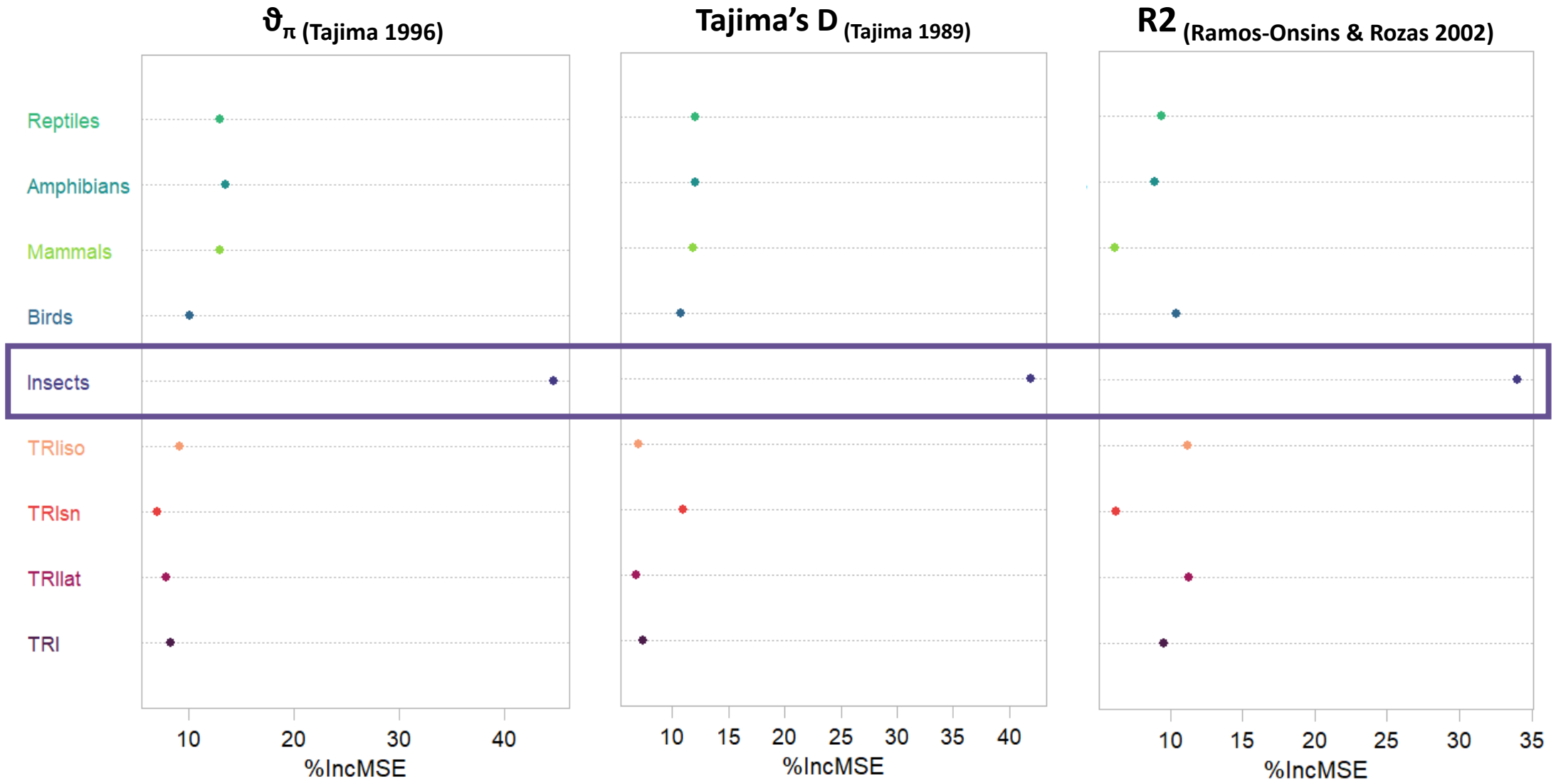
ϑ_π (Tajima 1996)

Tajima's D (Tajima 1989)

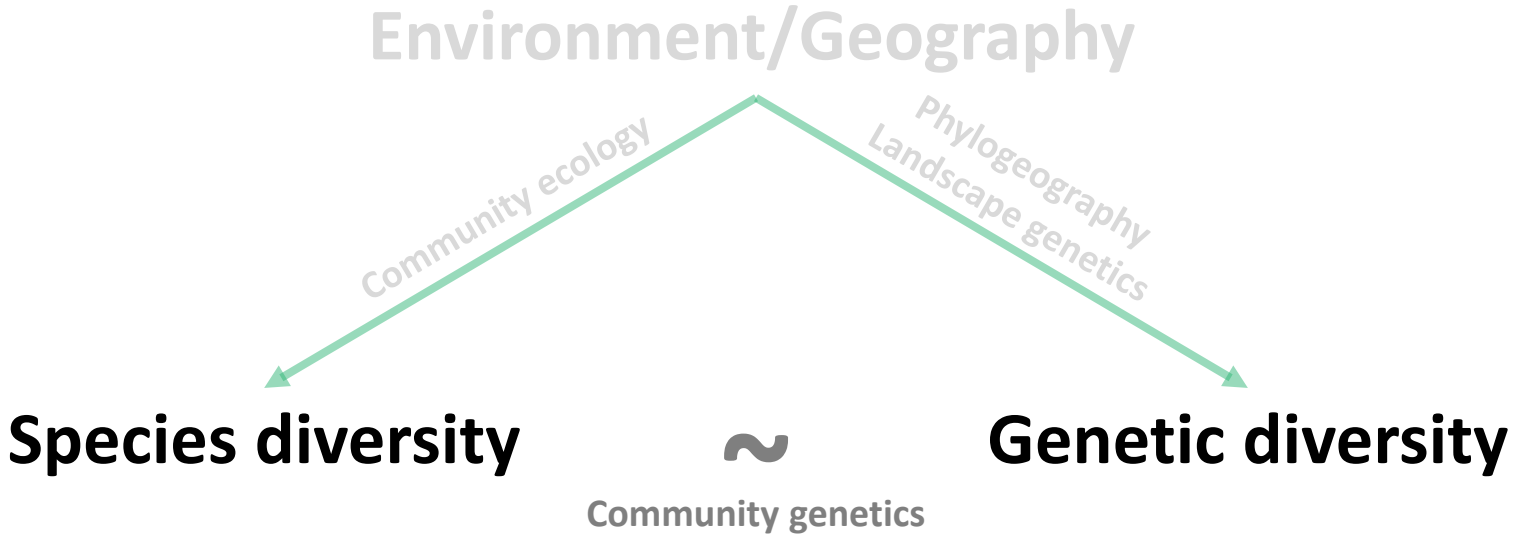
R2 (Ramos-Onsins & Rozas 2002)

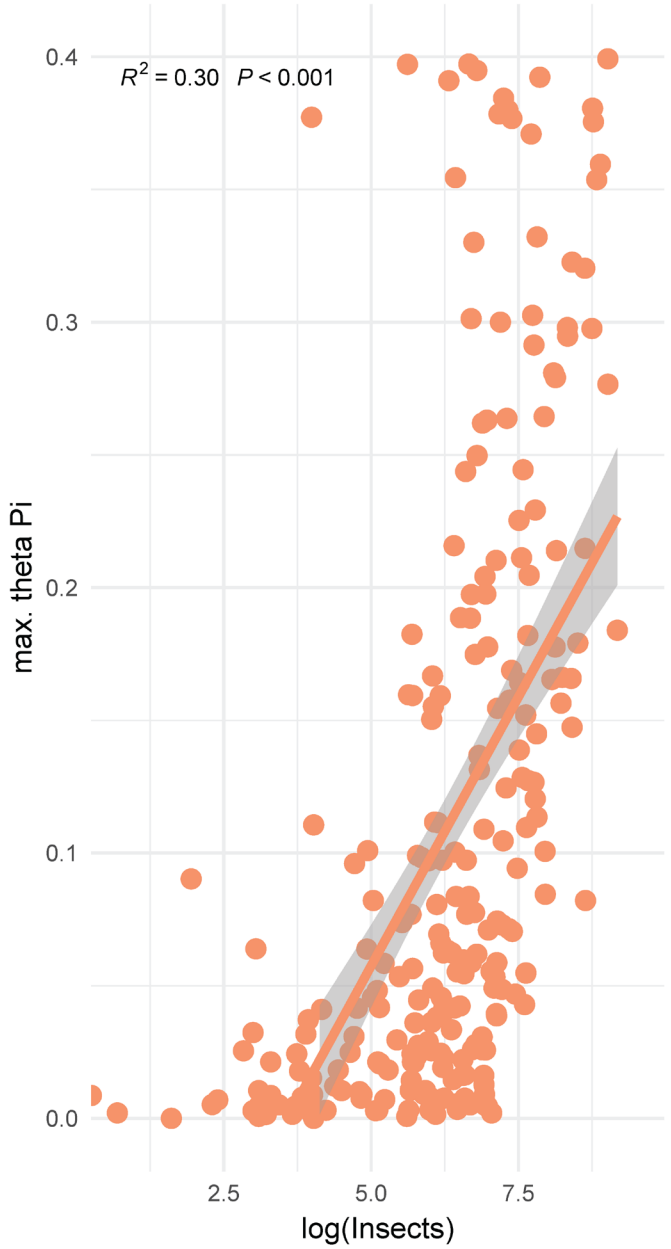


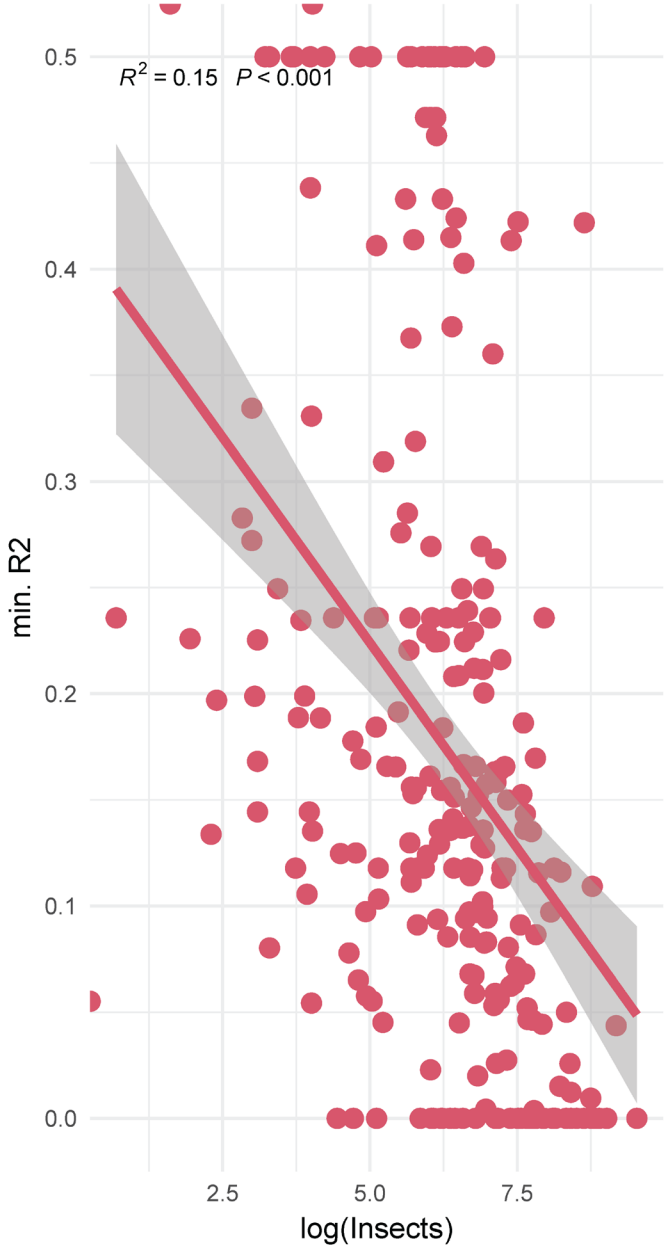
Random forest modeling: variable importance (response: genetic)

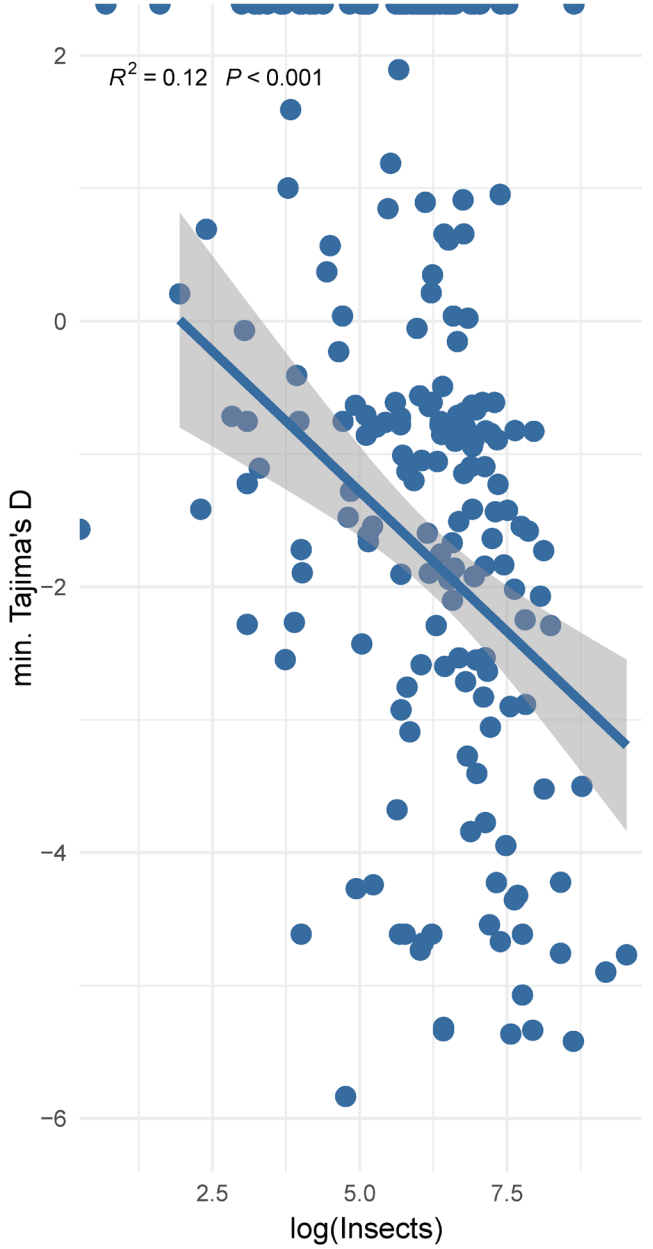


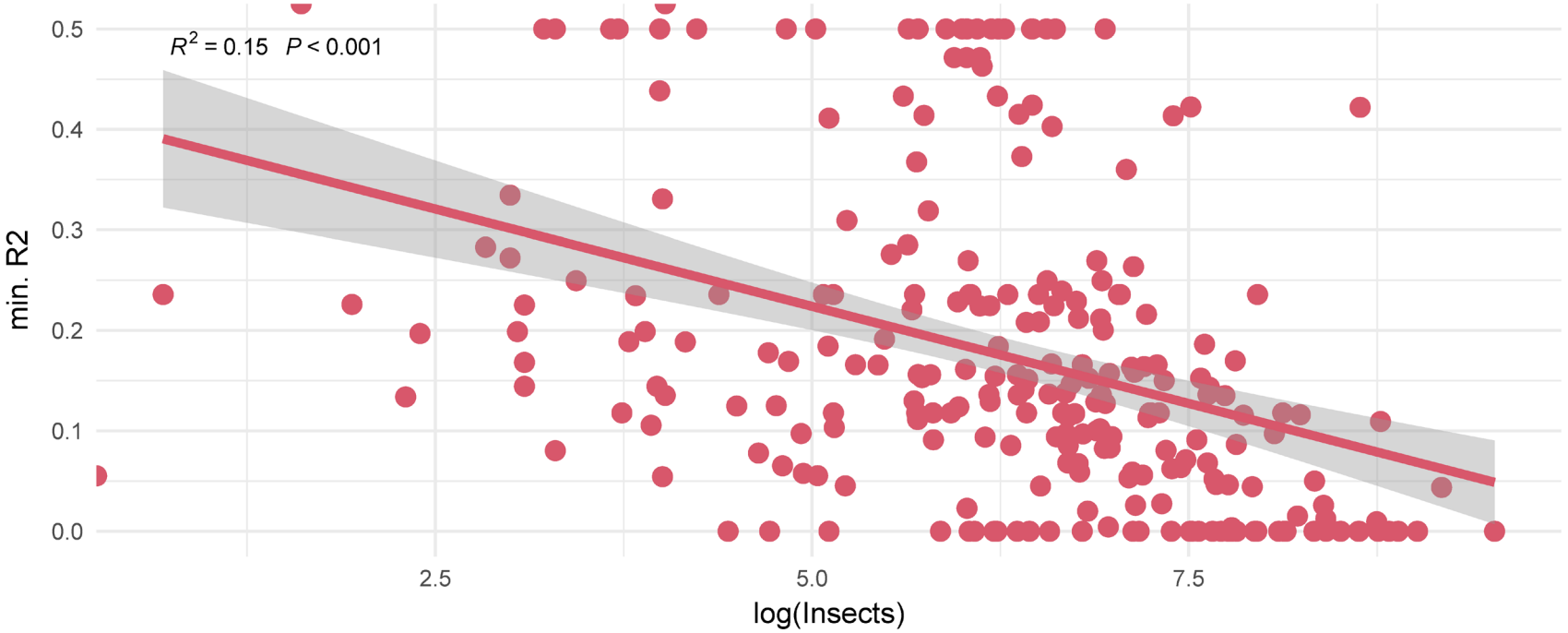
% increase in (M)ean (S)quared (E)rror

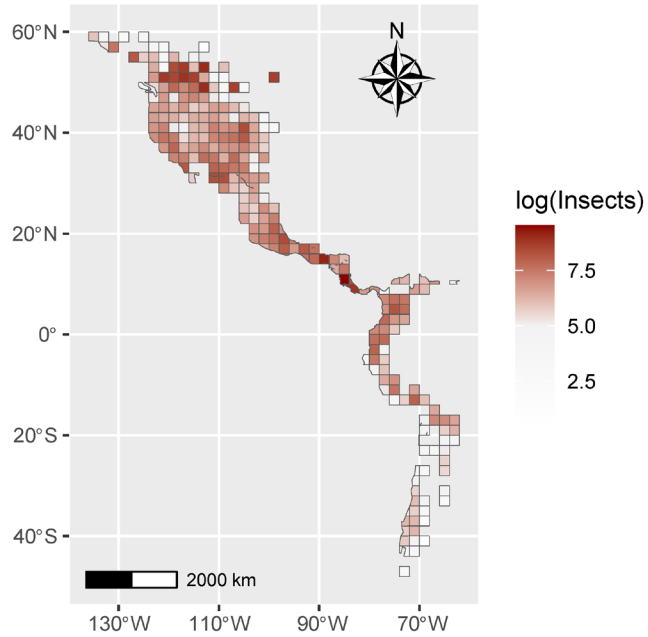

Environment/Geography
Community ecology
Phylogeography
Landscape genetics
Species diversity
~
Genetic diversity
Community genetics

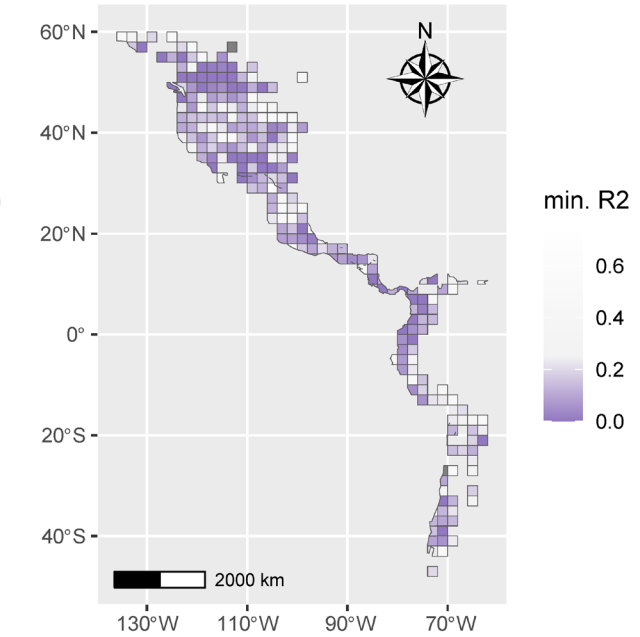

R^2 = 0.30 P < 0.001
max. theta Pi
0.4
0.3
0.2
0.1
0.0
2.5
5.0
7.5
log(Insects)


R^2 = 0.15 P < 0.001
min. R2
0.5
0.4
0.3
0.2
0.1
0.0
2.5
5.0
7.5
log(Insects)


R^2 = 0.12 P < 0.001
min. Tajima's D
2
0
−2
−4
−6
2.5
5.0
7.5
log(Insects)

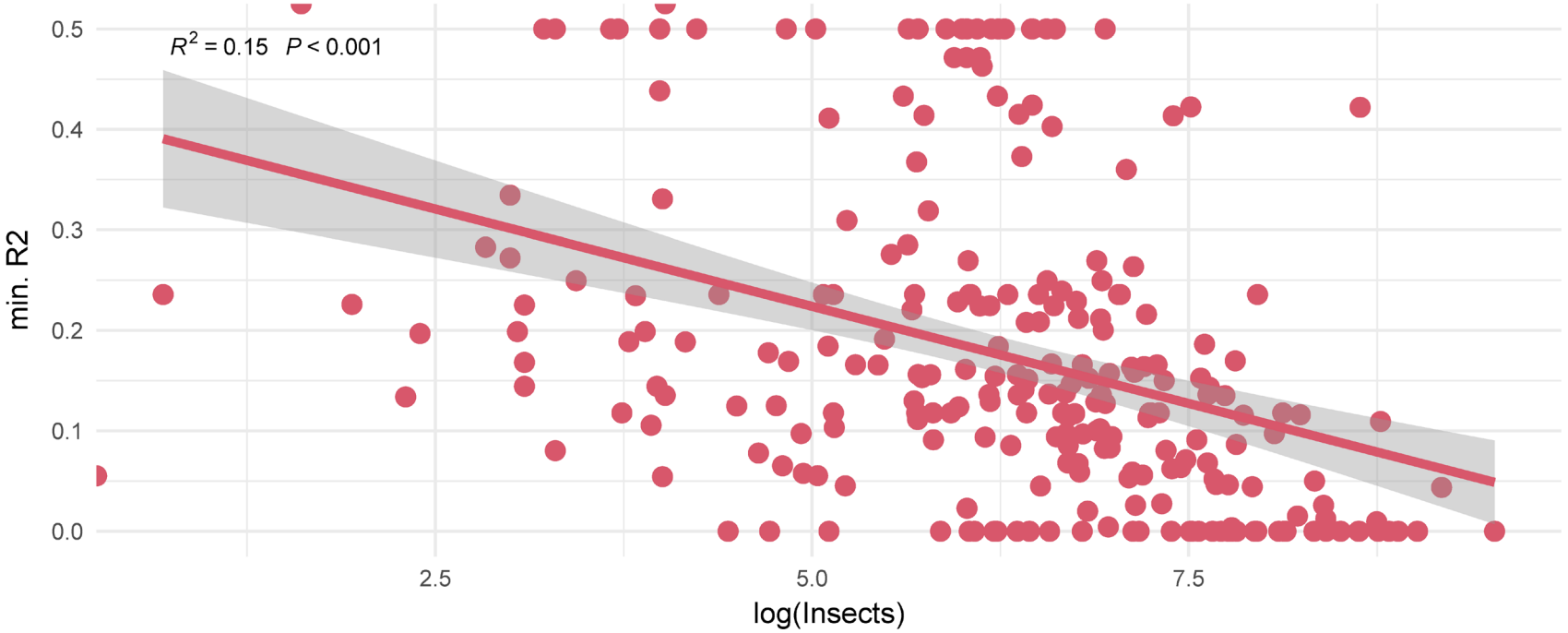

$R^2 = 0.15$ $P < 0.001$
min. R2
0.5
0.4
0.3
0.2
0.1
0.0
2.5
5.0
7.5
log(Insects)

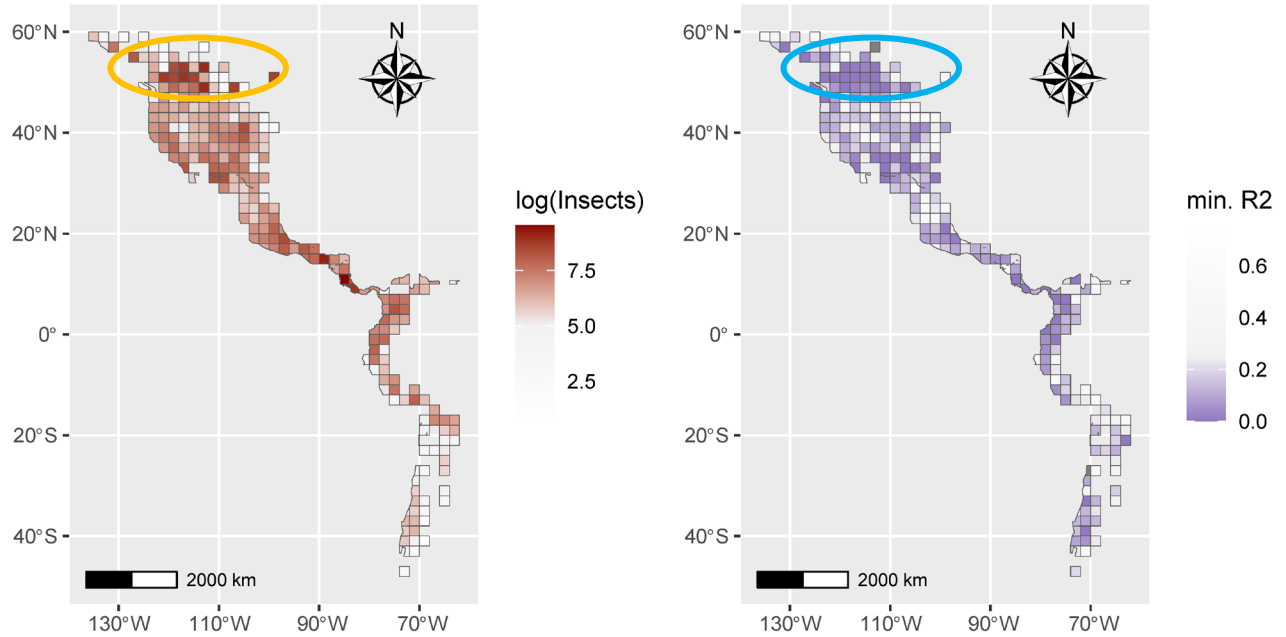

60°N
40°N
20°N
0°
20°S
40°S
N
2000 km
130°W
110°W
90°W
70°W


log(Insects)
7.5
5.0
2.5

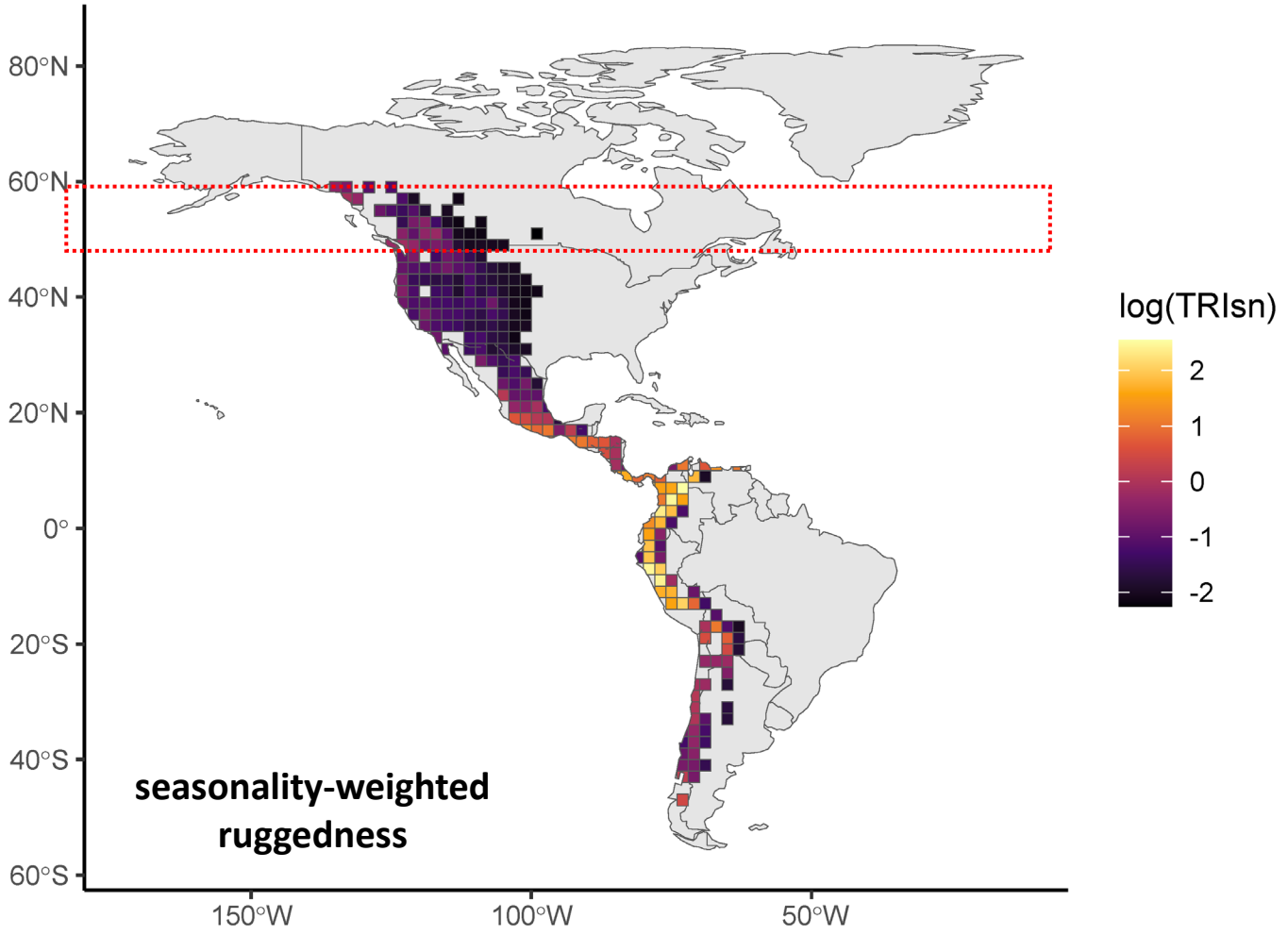
60°N
40°N
20°N
0°
20°S
40°S
N
2000 km
130°W
110°W
90°W
70°W

min. R2
0.6
0.4
0.2
0.0

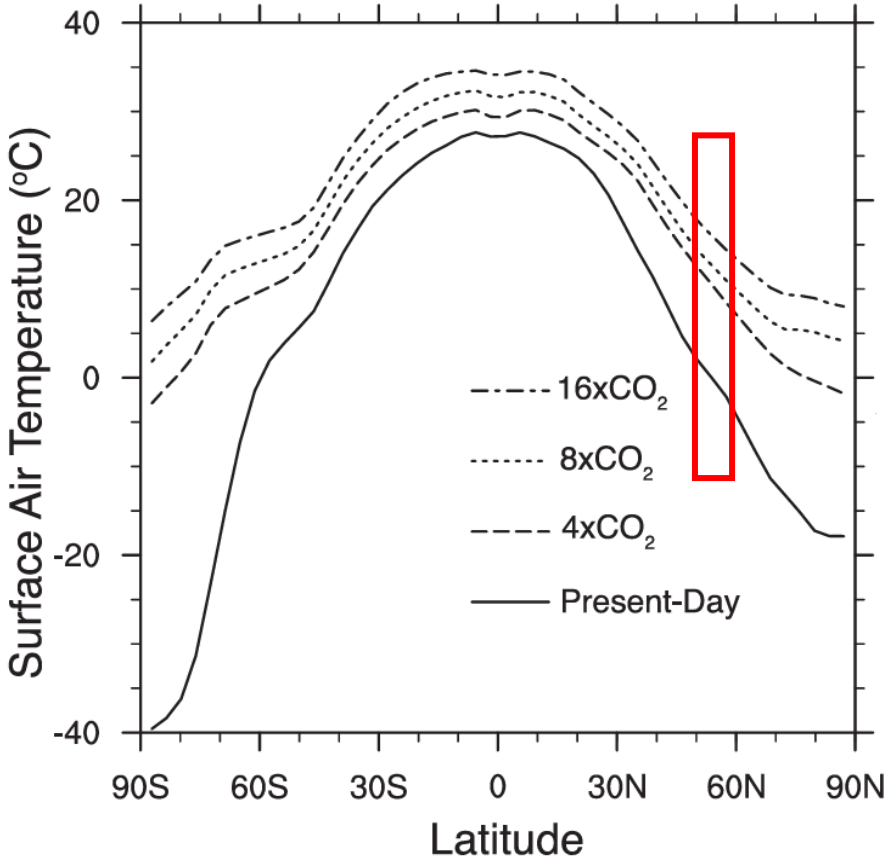

$R^2 = 0.15$ $P < 0.001$
min. R2
0.5
0.4
0.3
0.2
0.1
0.0
2.5
5.0
7.5
log(Insects)


60°N
40°N
20°N
0°
20°S
40°S
N
2000 km
130°W
110°W
90°W
70°W
log(Insects)
7.5
5.0
2.5
min. R2
0.6
0.4
0.2
0.0

Present-day **low seasonality** at high latitudes

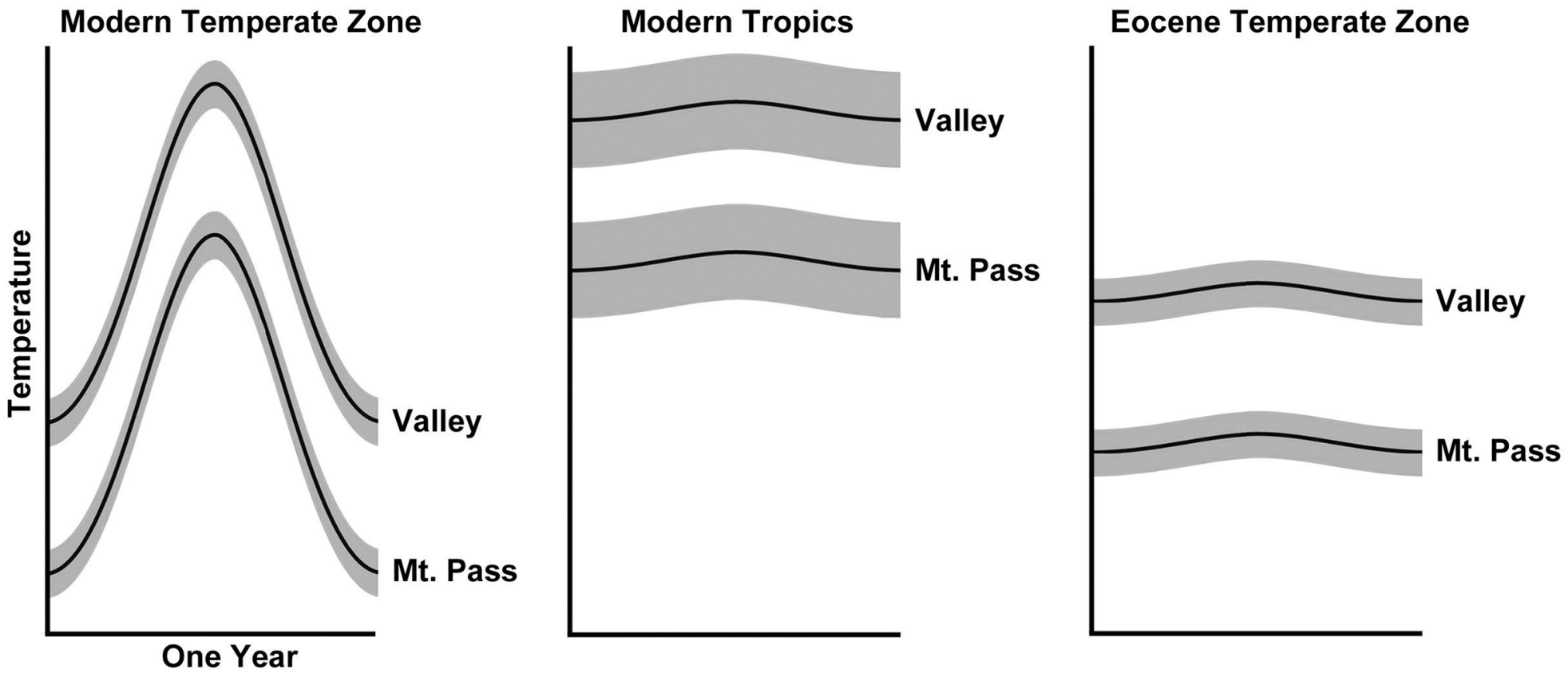


Temperate zones warmer in Eocene (56-34 mya)



From Winguth et al. 2010

Low thermal overlap in Eocene temperate zones

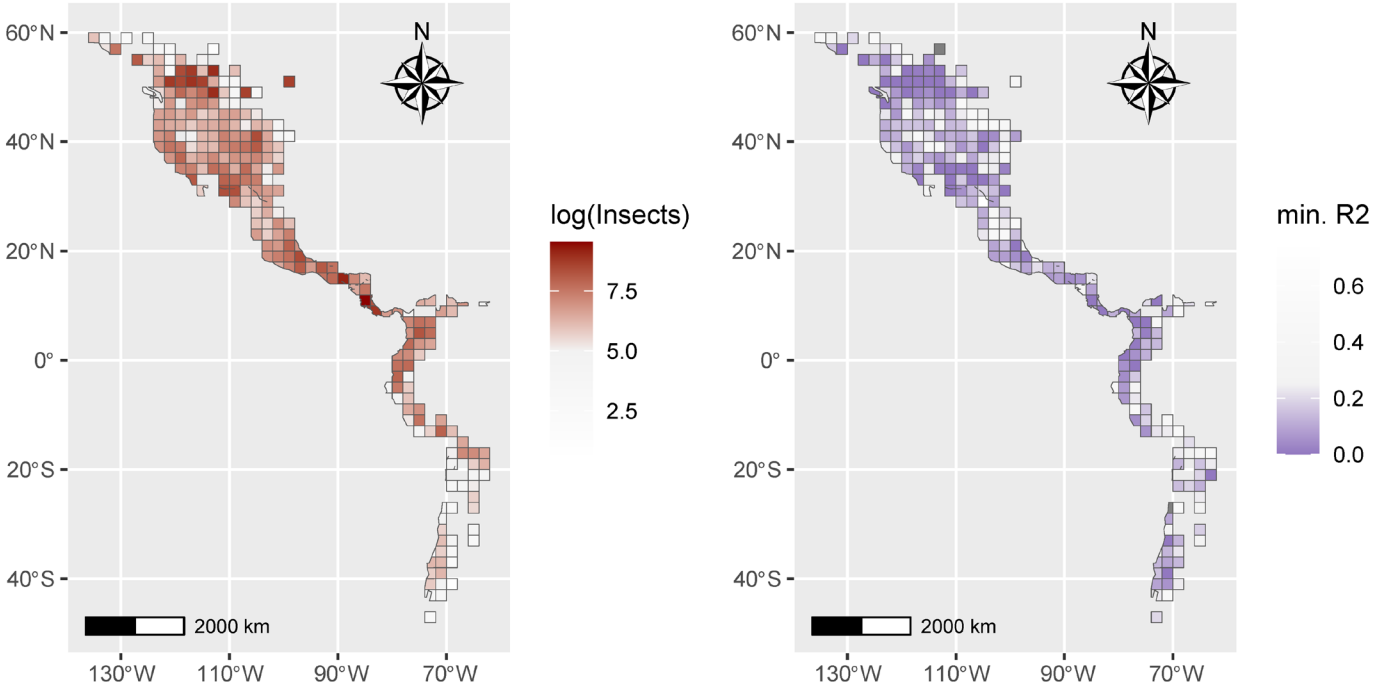


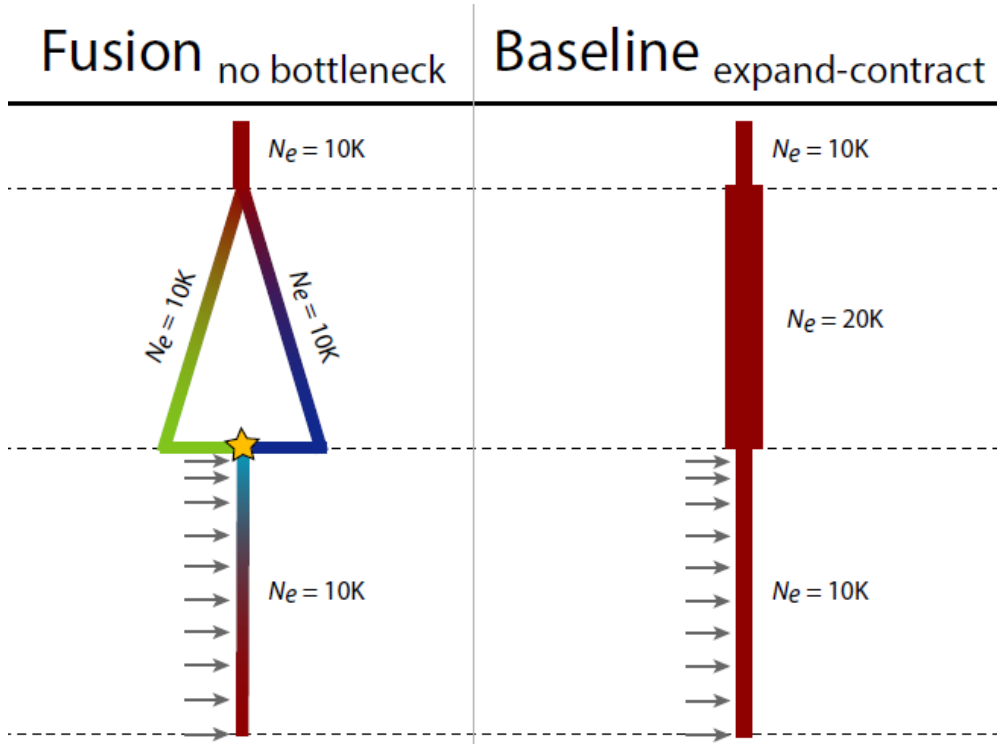
From Archibald et al. 2013; hypothesized annual temperature variation for Eocene temperate zones

TBD: **Reverse speciation / lineage fusion**

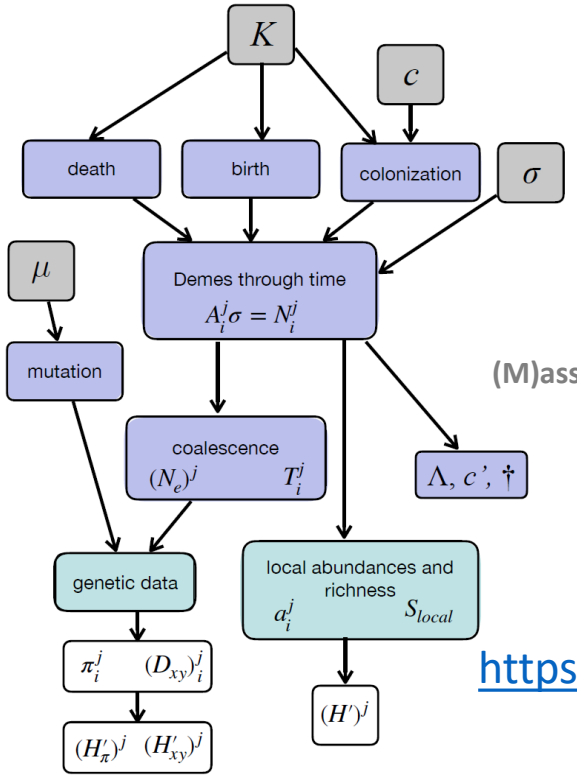
SPACE: Low thermal overlap reduces connectivity among populations → speciation

TIME: What happens when thermal overlap/connectivity changes over time?
Gene flow/admixture/lineage fusion?





From Garrick, Hyseni, Arantes 2020; lineage fusion



(M)assive (E)co-evolutionary (S)ynthesis (S)imulations

https://isaacovercast.github.io/software/

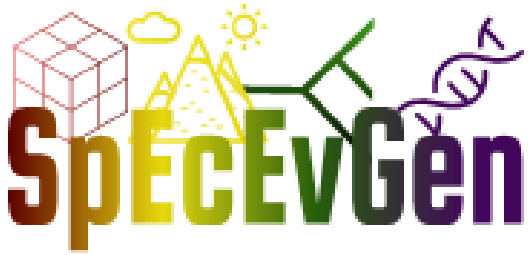
Species diversity ~ Genetic diversity

Community genetics

Simulations:

NO TIME TO TALK ABOUT TODAY

THANK YOU



- Chaz HYSENI
- chaz.hyseni@gmail.com
- https://specevgen.net/