Do ecological interactions impact geographic distributions of species?

2016 ESA Annual Meeting, Fort Lauderdale

Wednesday, August 10

Kévin Cazelles http://kevincazelles.fr 

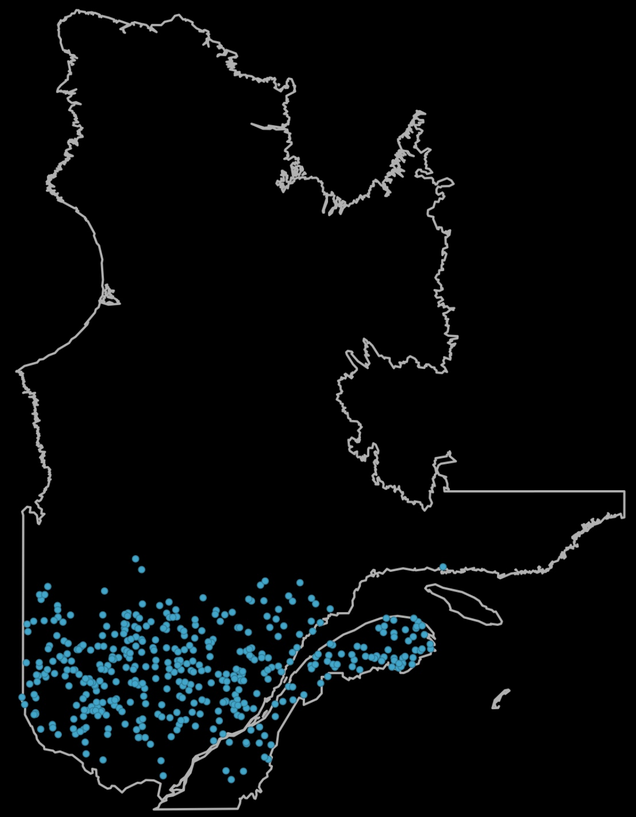
Nicolas Mouquet, David Mouillot & Dominique Gravel

CONTEXT

Biogeography and ecological interactions

Geographic distribution

Species A



Species B

Four categories of factors shaping distributions

1. Climatic + edaphic

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2. Dispersion (landscape structure / dispersion capacities)

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3. Ecological interactions

Four categories of factors shaping distributions

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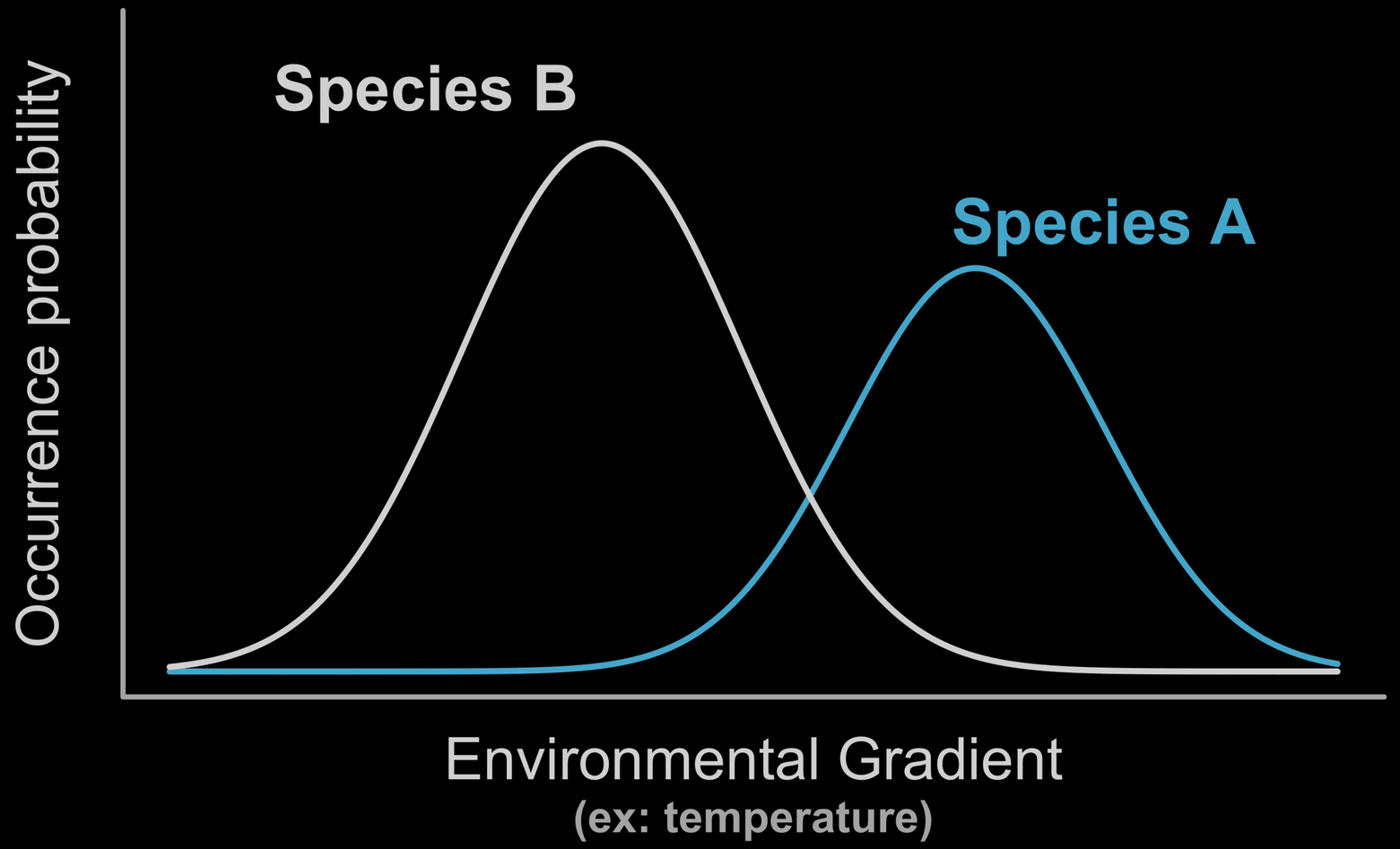
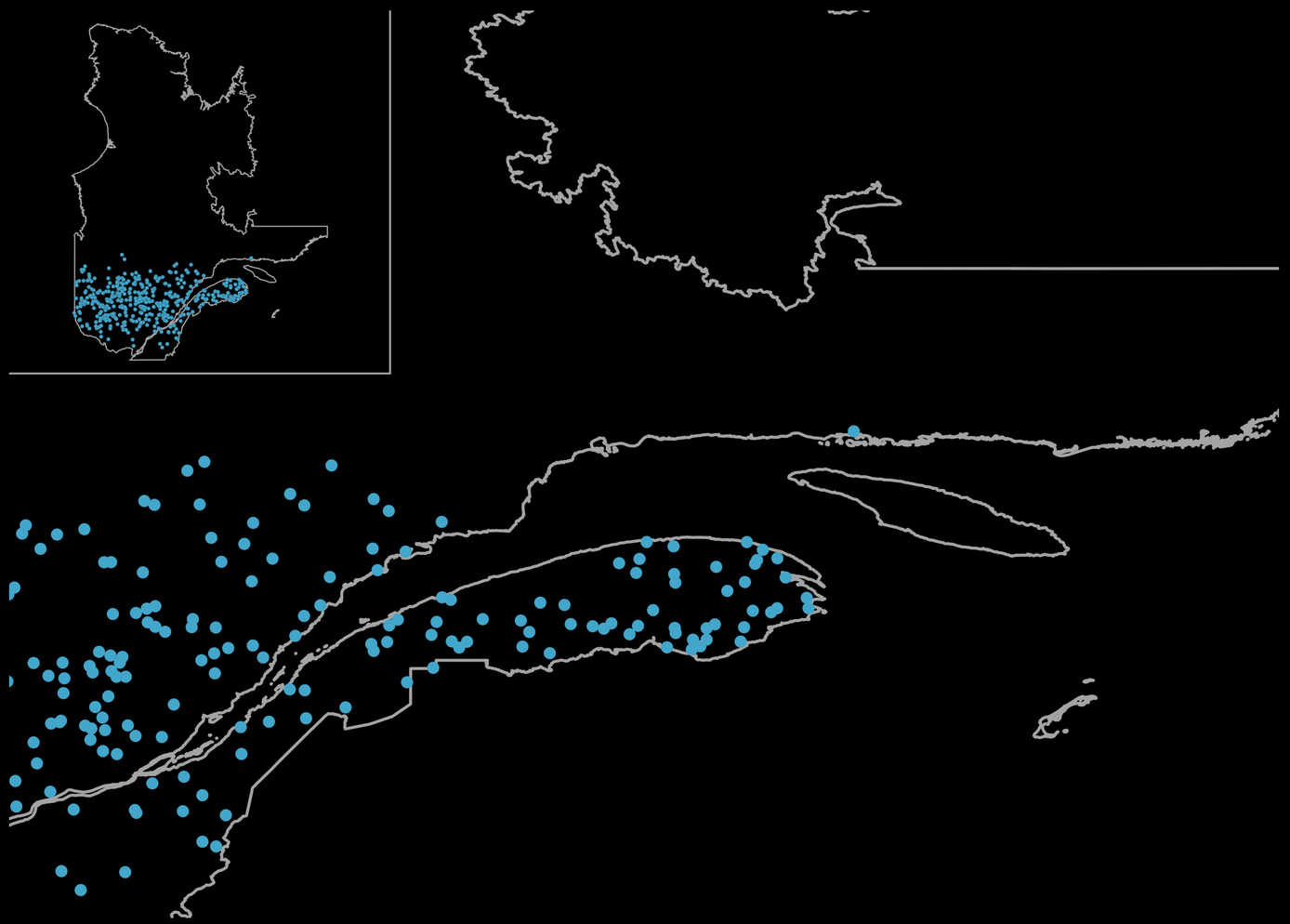
4. Evolution

1. Climatic

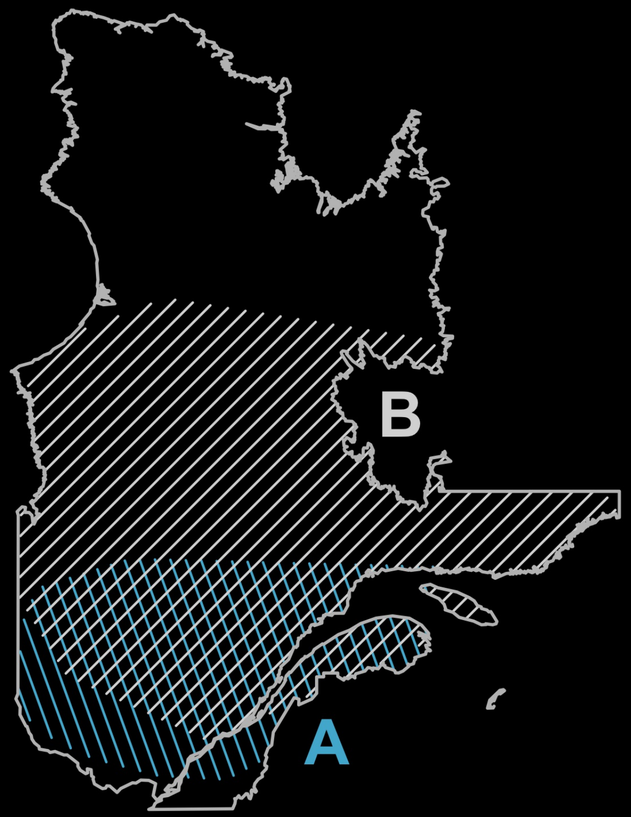

Species B
Species A
Occurrence probability
Environmental Gradient
(ex: temperature)

2. Dispersion

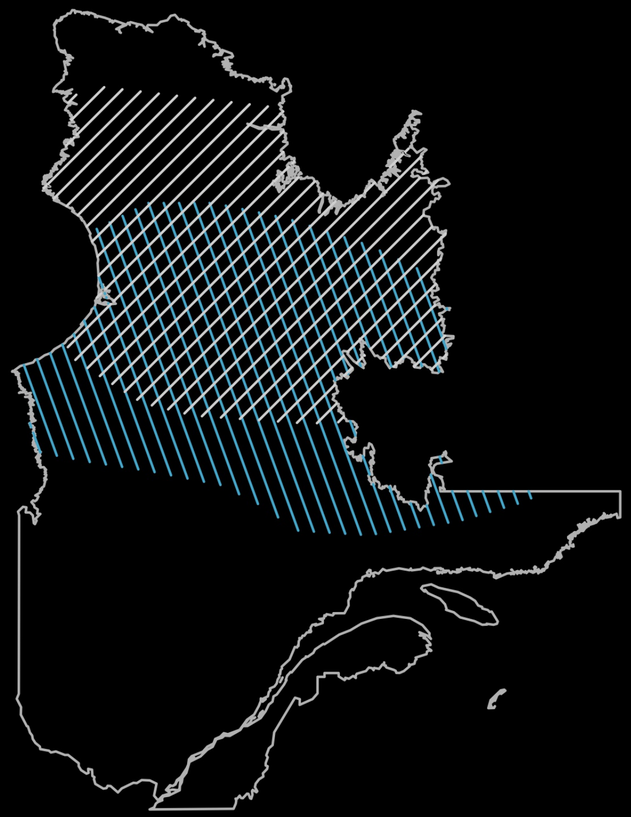


Species Distribution Models

Today



Tomorrow



3. Ecological interactions

- B feeds on A

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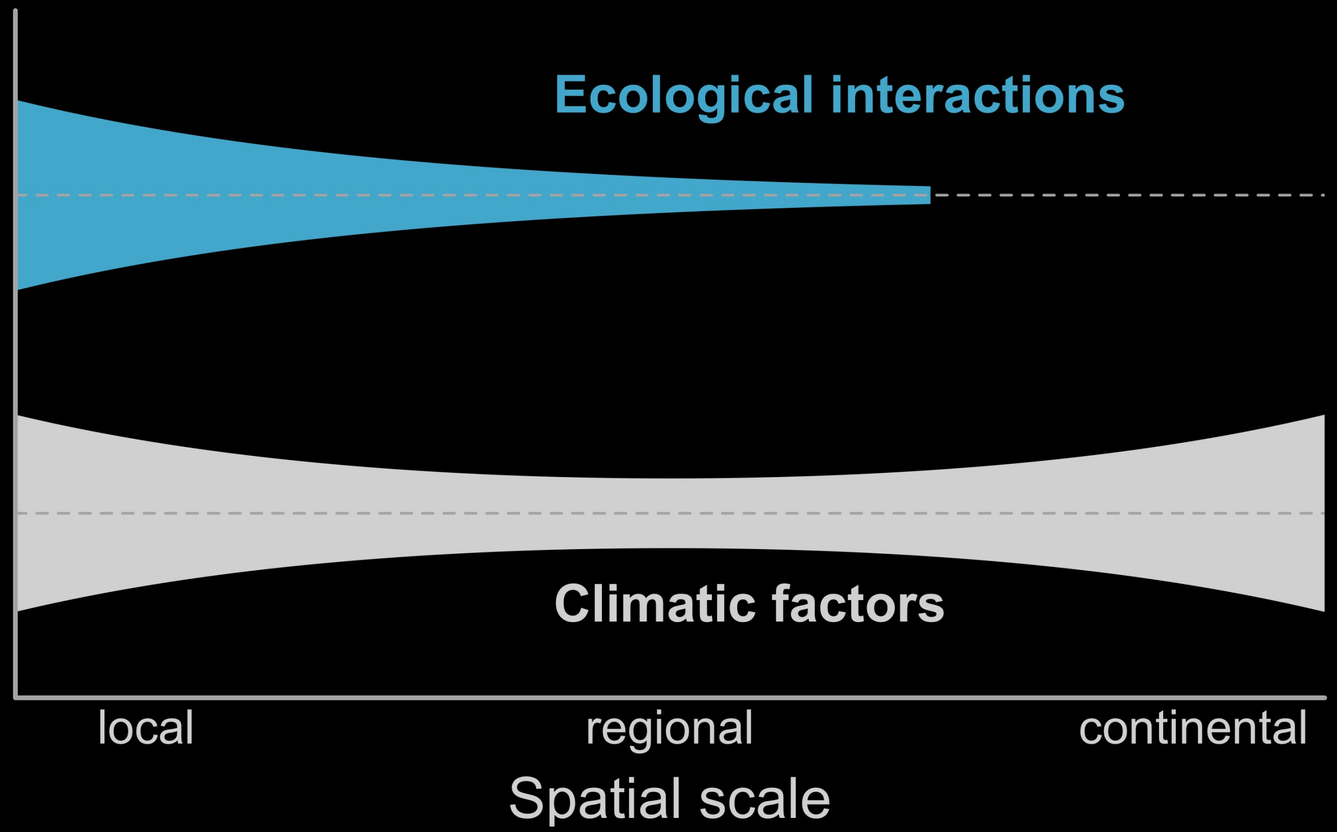
- B feeds on A

- Extinction probabilities impacted

A matter of spatial scale?



McGill, B. J. (2010). *Science*.

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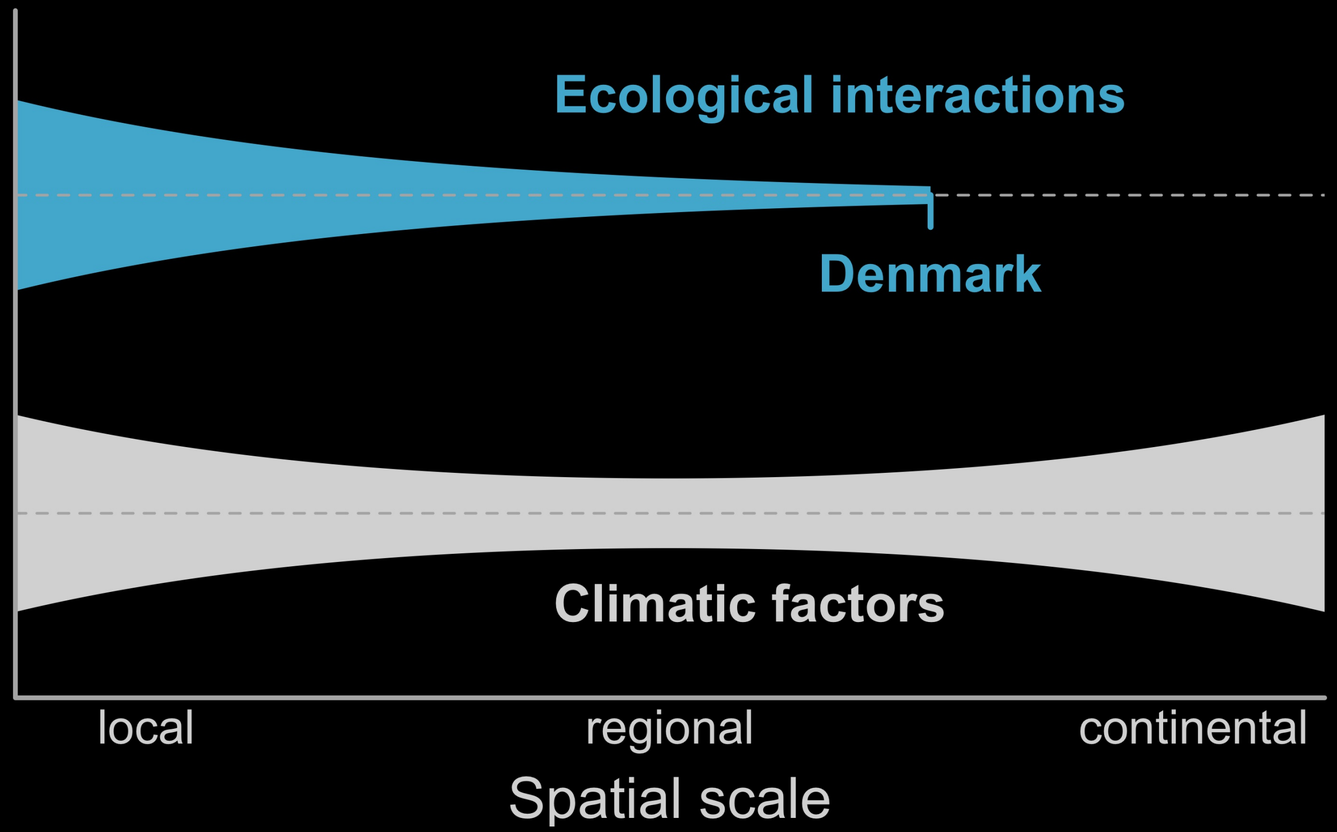

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Gotelli, N. J. (2010). *PNAS*.

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THEORY

Interactions and co-occurrence

Co-occurrence

- Observed co-occurrence : $P(X_A, X_B)$

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$P(X_A, X_B)$ vs. $P(X_A)P(X_B)$

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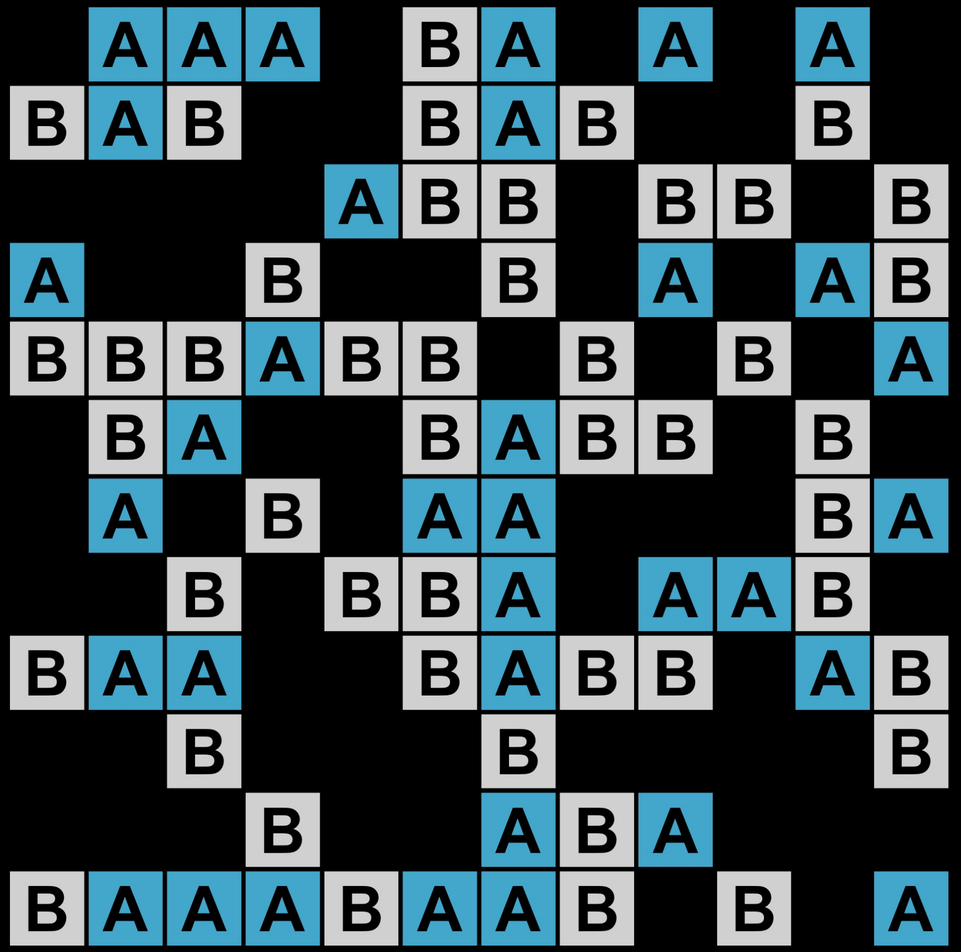
$P(X_A, X_B)$ vs. $P(X_A)P(X_B)$

Historically, species in competition Diamond, 1975

→ *Checkerboard* distribution

→ *C-score*

Checkerboard distribution



Z-score (standardized co-occurrence)

$$\frac{\text{"observed co-occurence"} - \mu}{\sigma}$$

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2. Environmental conditions are taken into account (SDM)

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   a. Generalised Linear Model (GLM)

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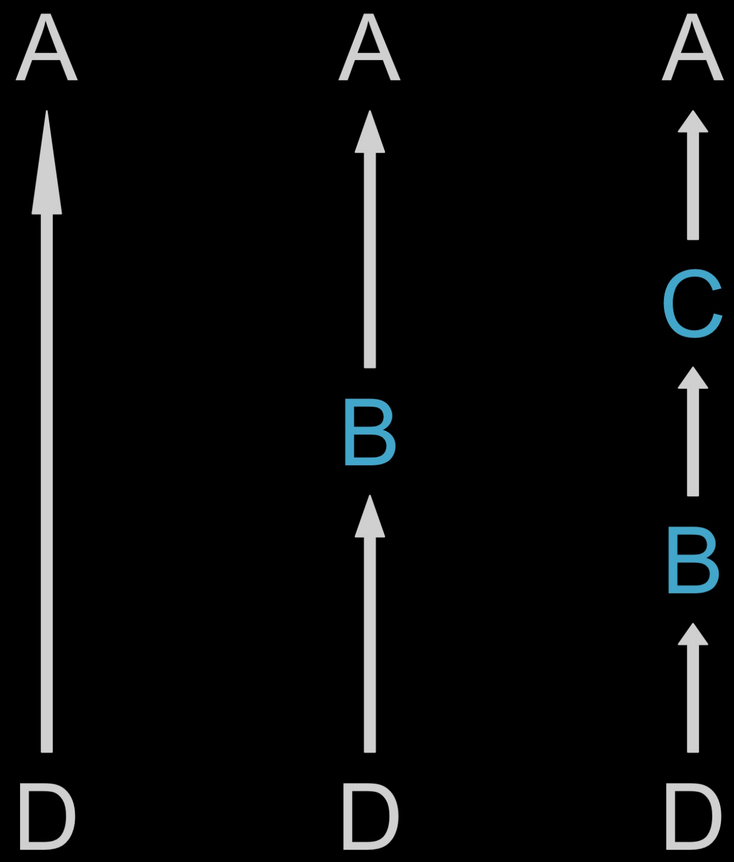
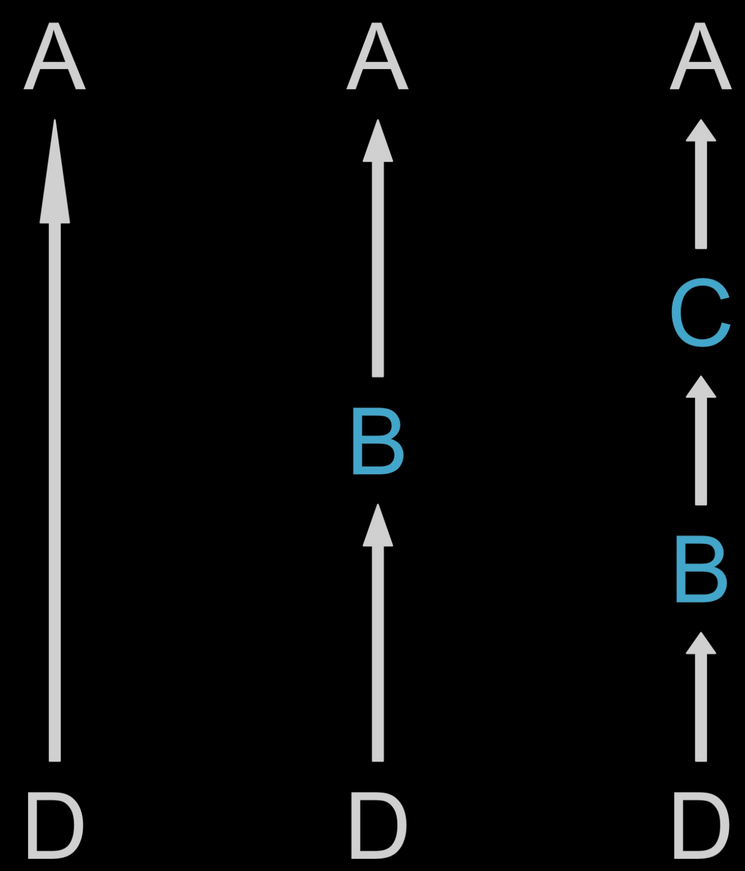
Scenarios

1. Sites are identical (Homogeneous, Veech 2013)
2. Environmental conditions are taken into account (SDM)
   a. Generalised Linear Model (GLM)
   b. Random Forest (RF)

Shorthest path

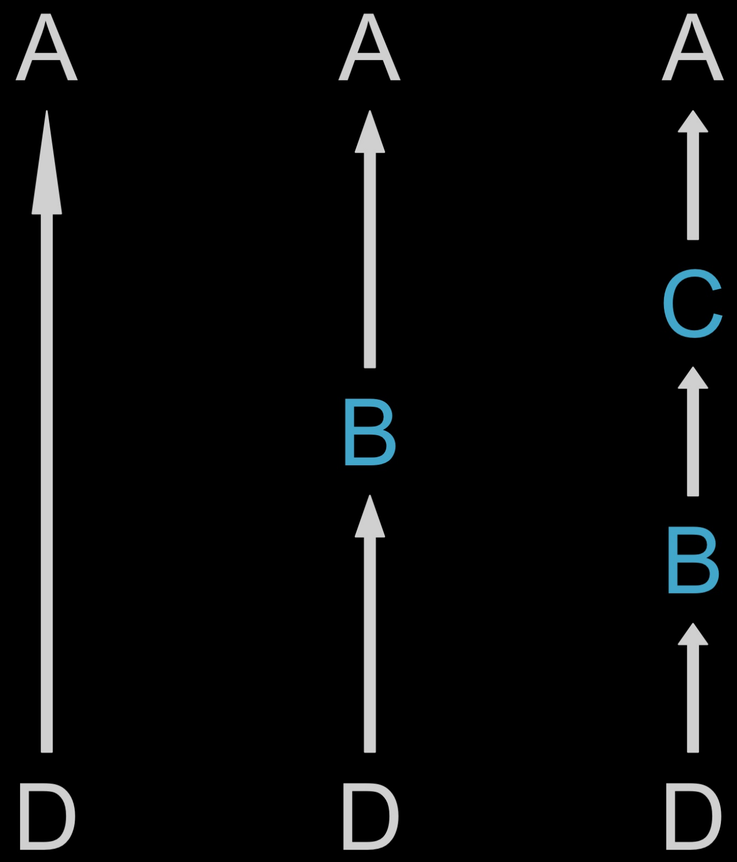


Shorthest path



	A	B	C	D
A	0	1	0	0
B	1	0	1	0
C	0	1	0	1
D	0	0	1	0

Shorthest path



	A	B	C	D
A	0	1	0	0
B	1	0	1	0
C	0	1	0	1
D	0	0	1	0

	A	B	C	D
A	0	1	2	3
B	1	0	1	2
C	2	1	0	1
D	3	2	1	0

Shortest path + co-occurrence

1. Distributions + network

→ Nice datasets

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2. SDM for all species

→ Integrating physiological requirements

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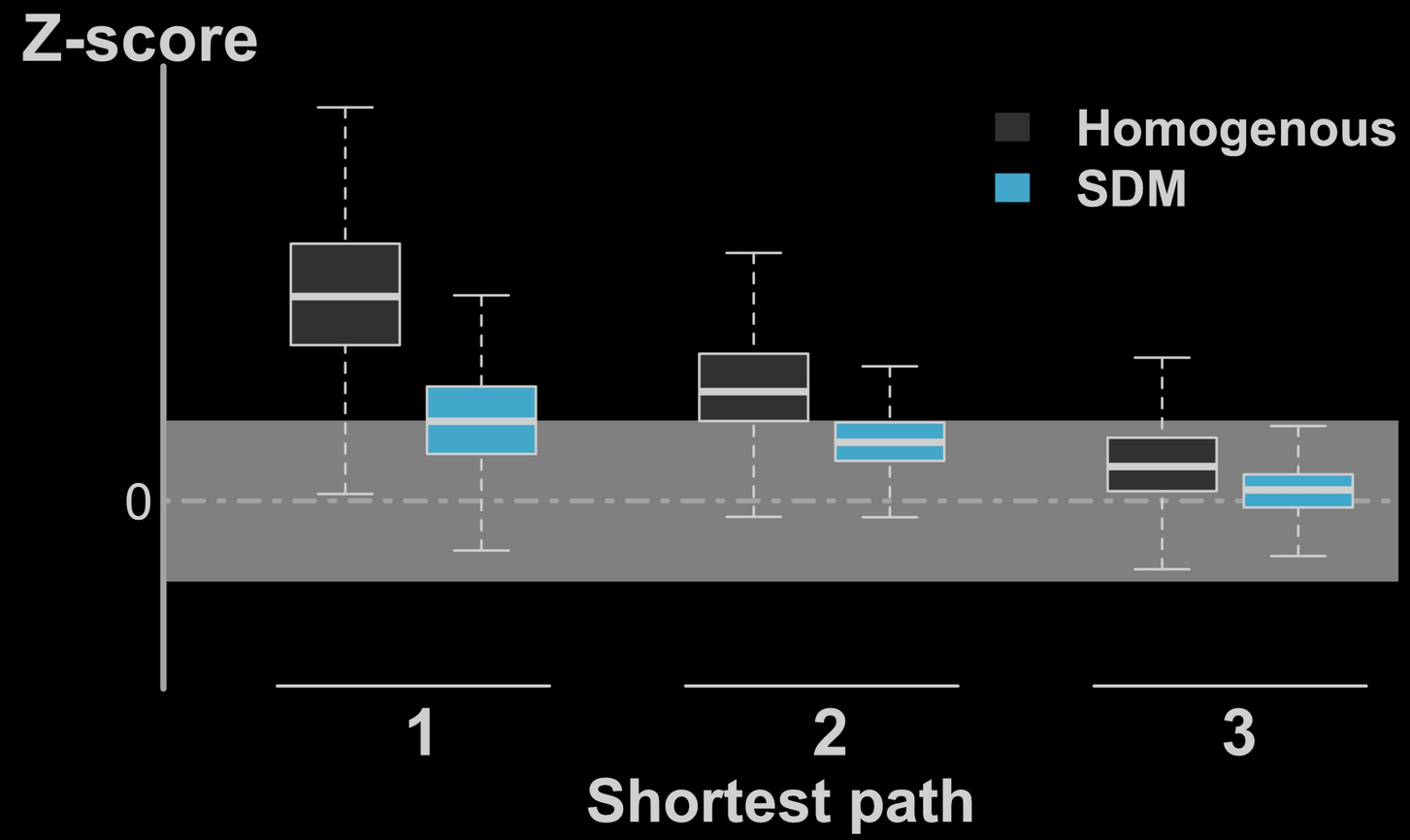
→ Shortest path for all pairs and mean degree in

Shortest path + co-occurrence

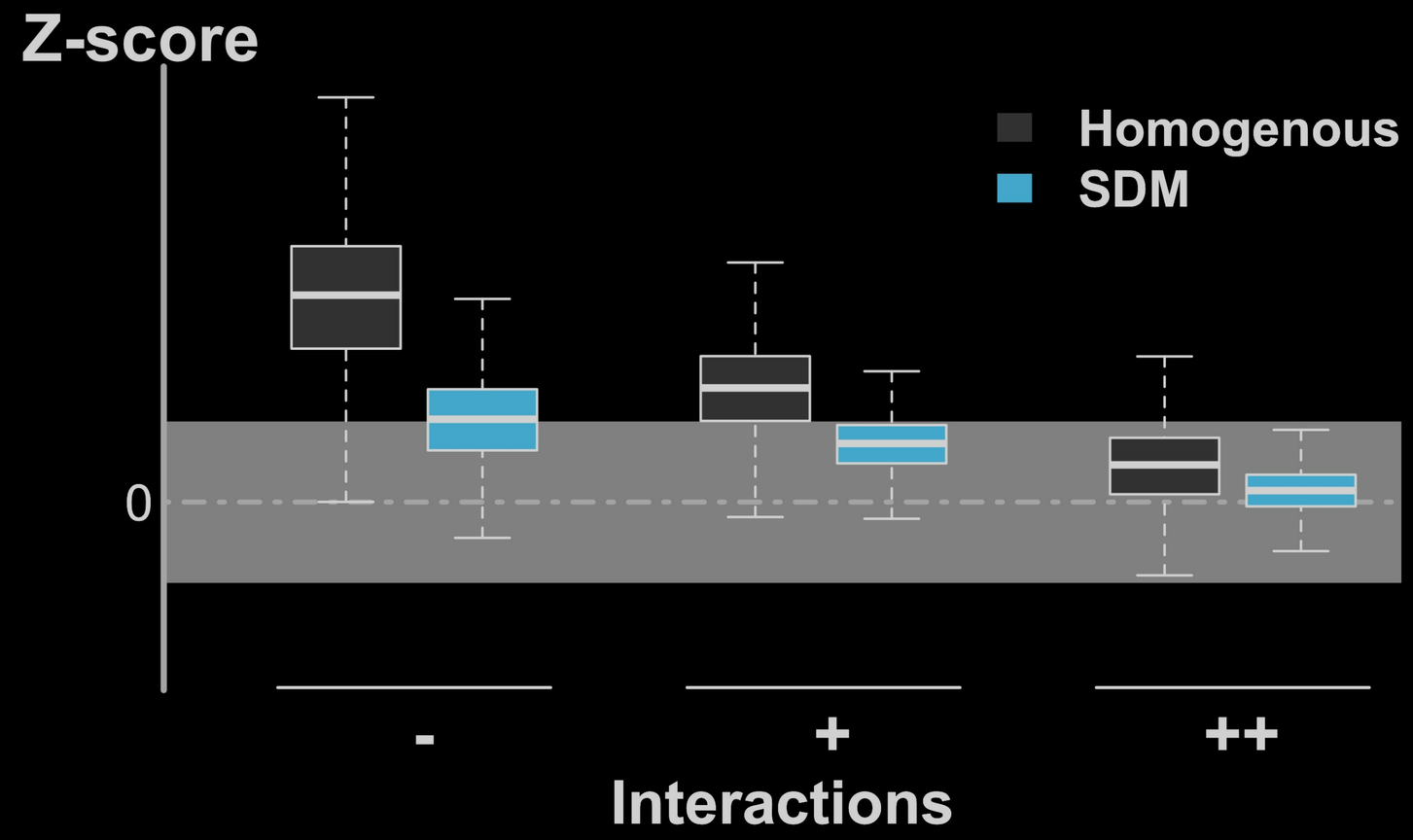
1. Distributions + network
   → Nice datasets
2. SDM for all species
   → Integrating physiological requirements
3. Network topology
   → Shortest path for all pairs and mean degree in
4. Co-occurrence for all pairs (3 scenarios)
   → Look at distribution of Z-score

Expectations



Cazelles K., *et al.* (2016) *Journal of Theoretical Ecology.*

Expectations



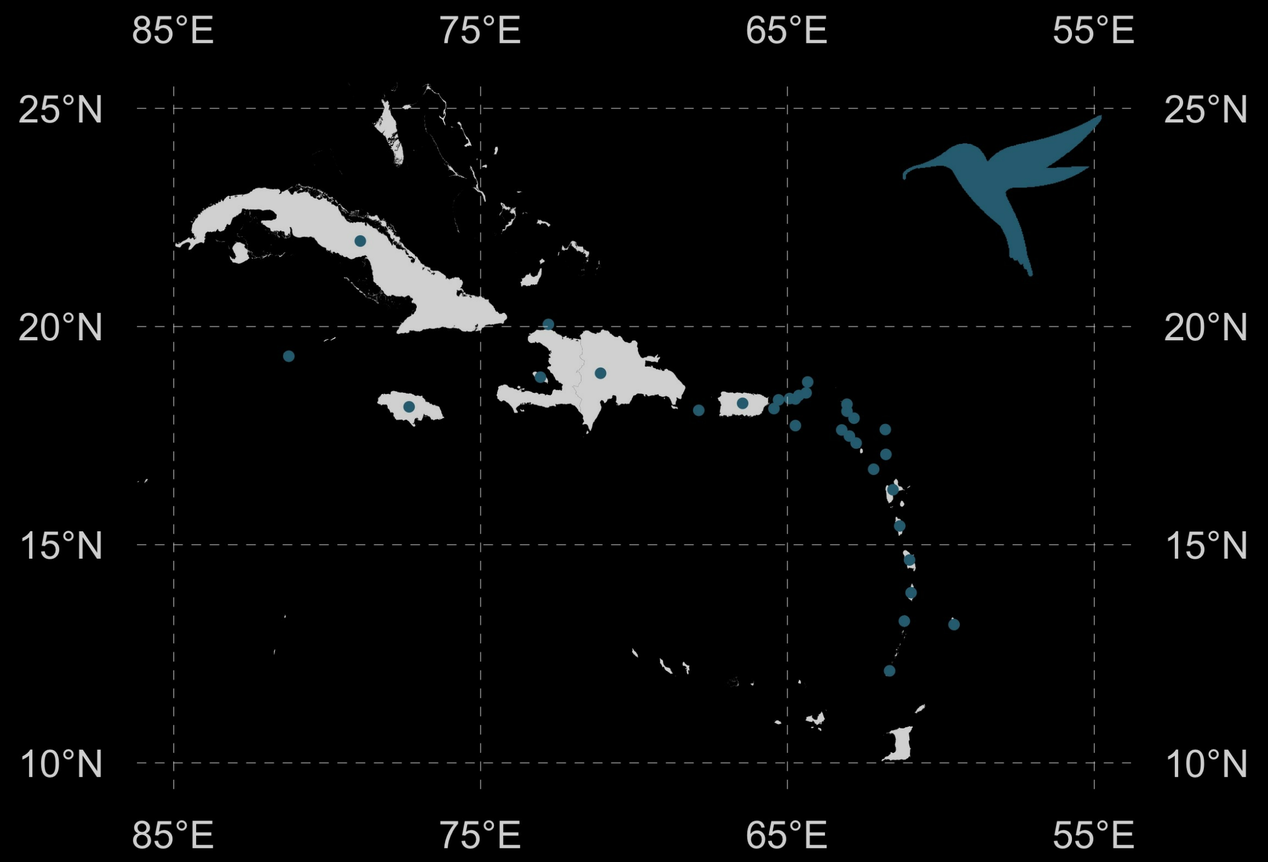
Cazelles K., *et al.* (2016) *Journal of Theoretical Ecology.*

APPLICATION

Real datasets

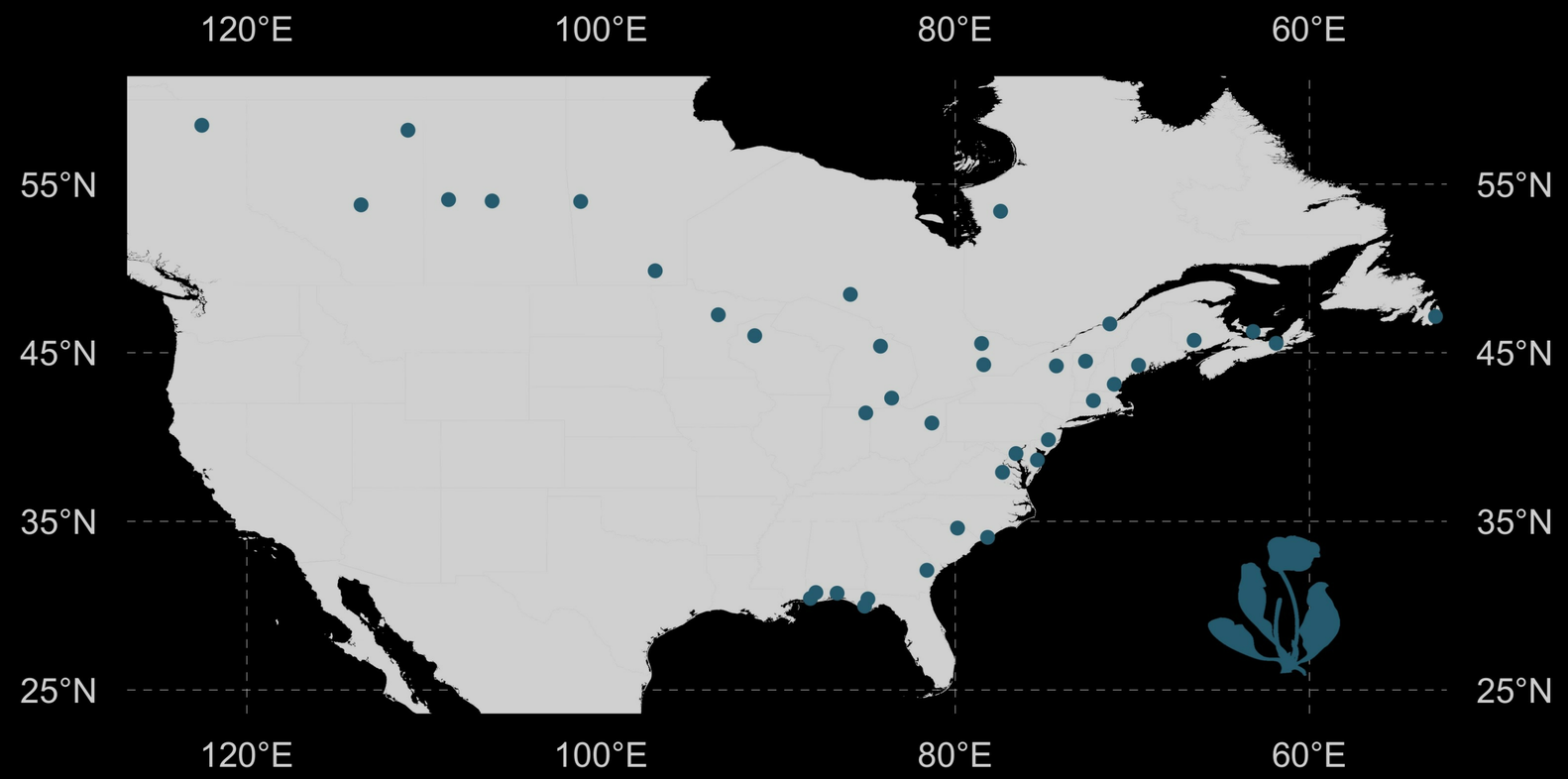
Salix / Herbivores / Parasitoids (>150 species)

10 Hummingbirds / 52 host plants on 32 islands

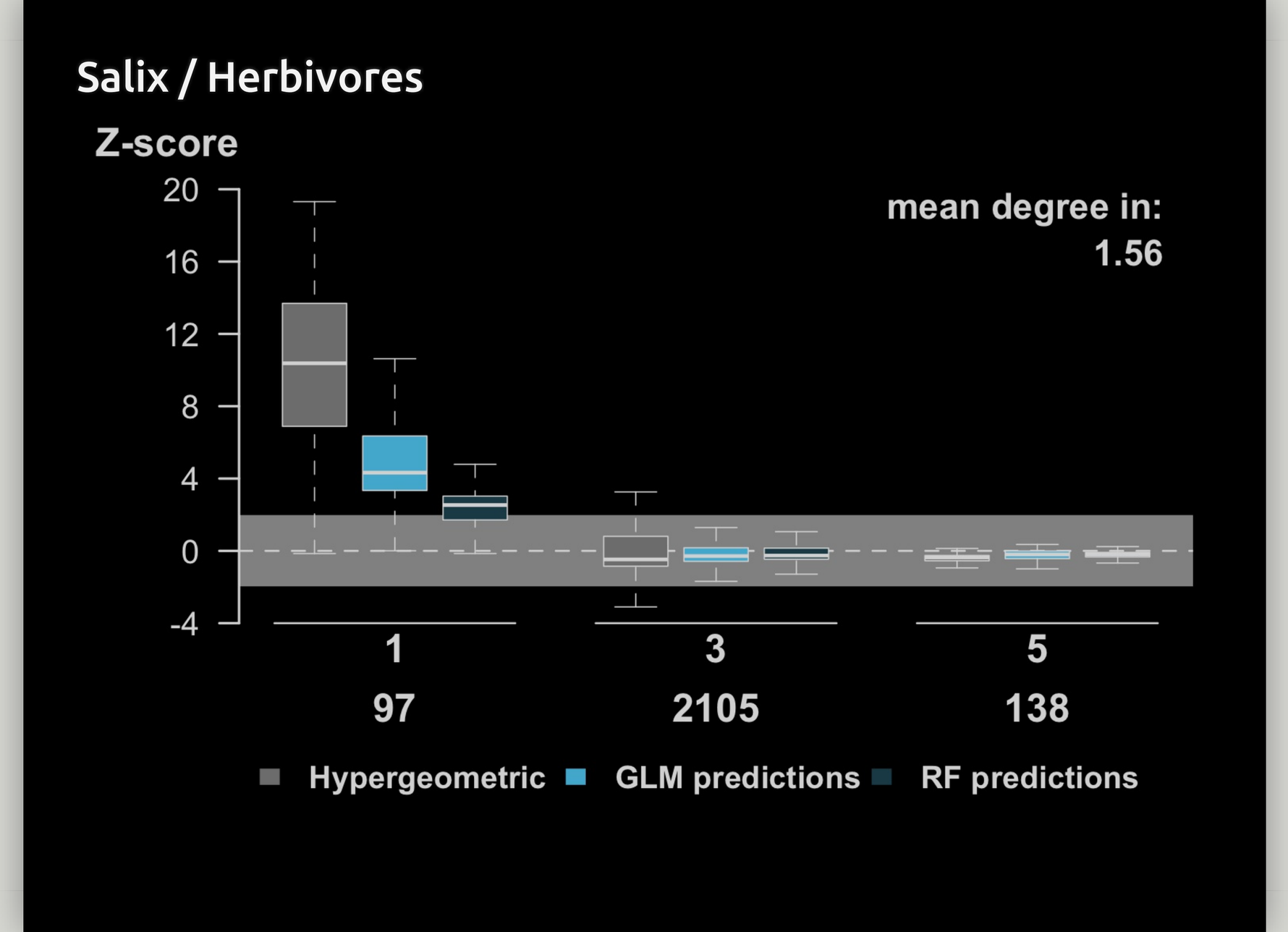


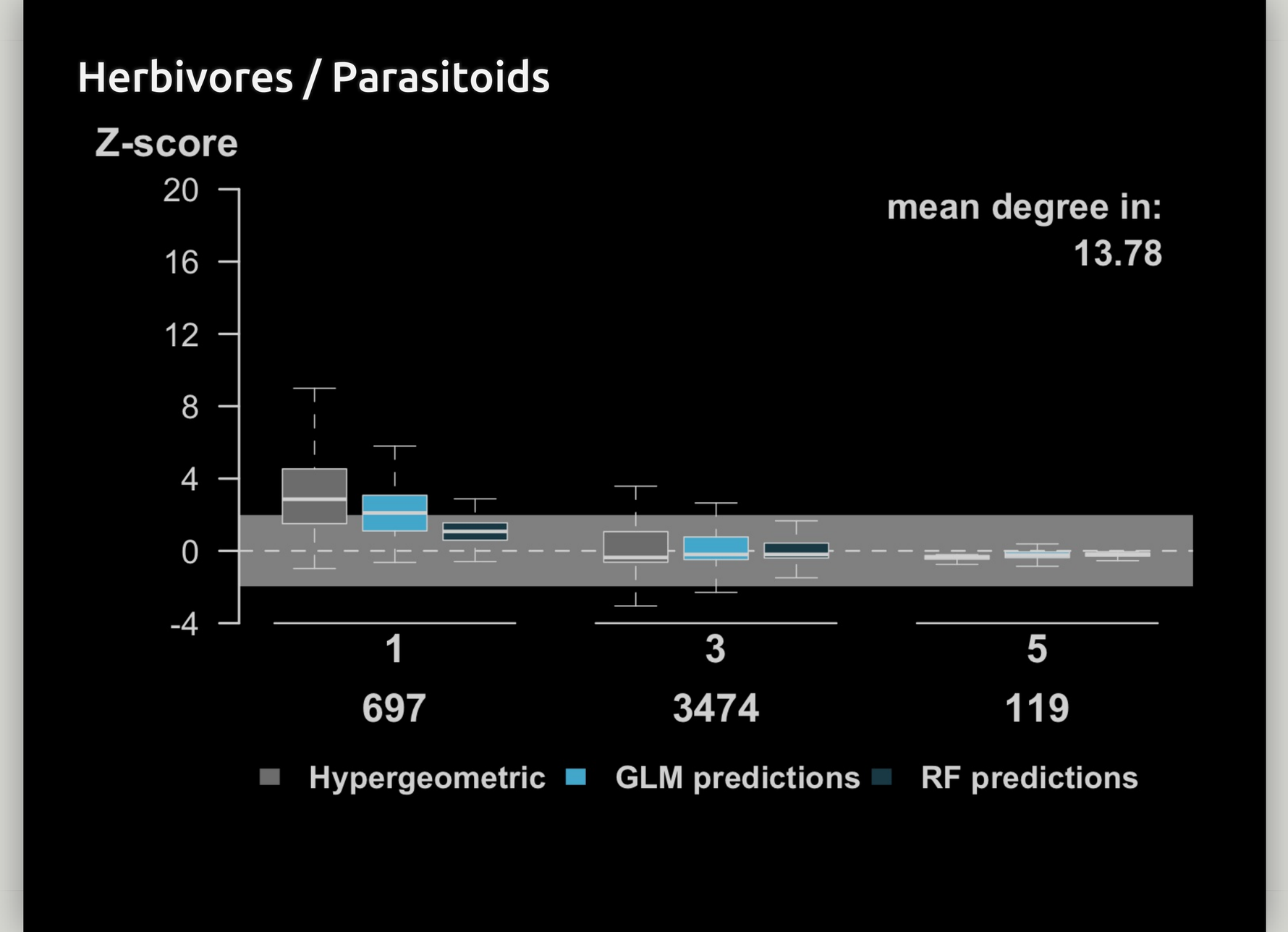
Martín González., *et al.* (2015). *Global Ecology and Biogeography*

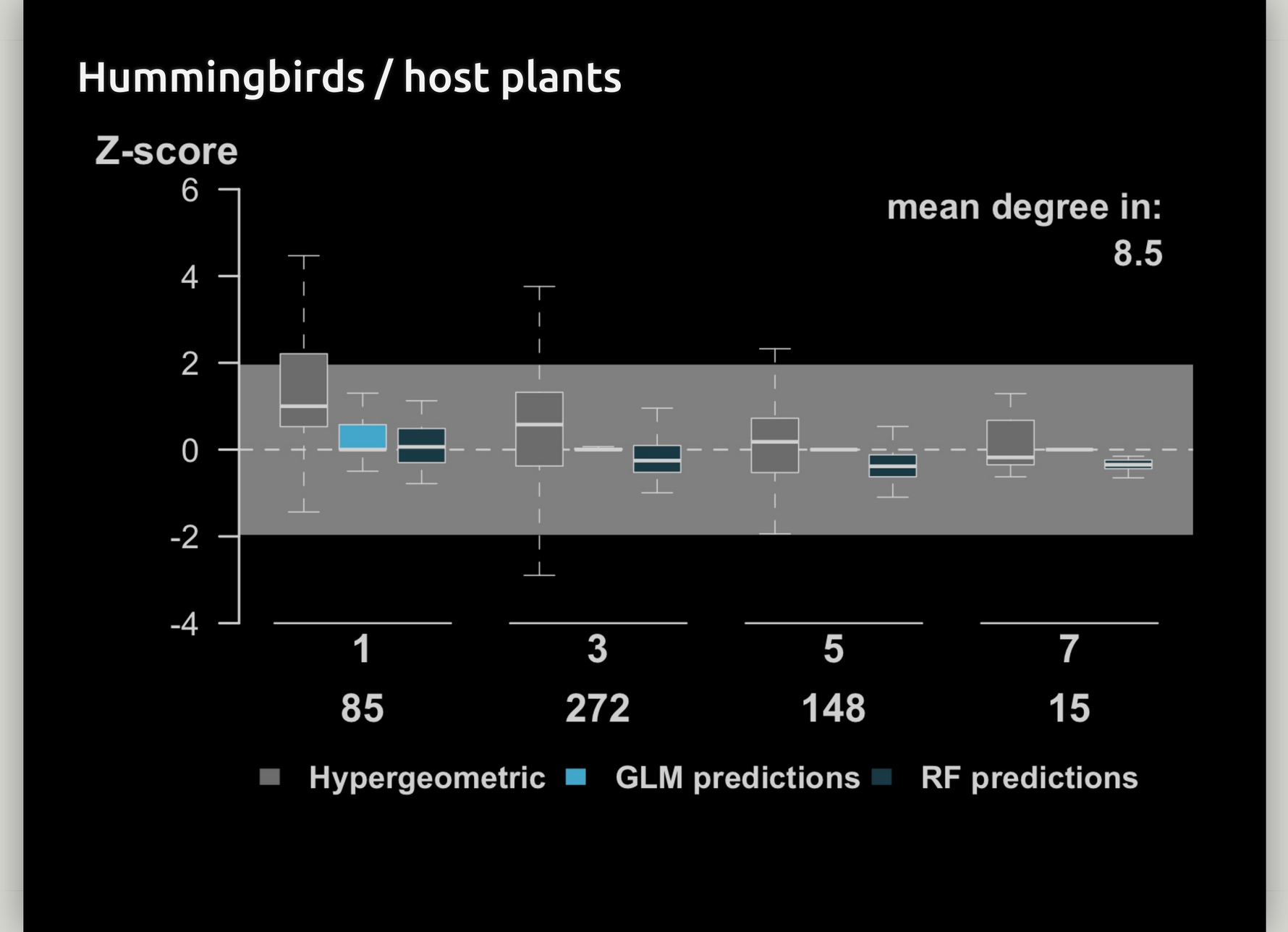
Micro-organisms community of the Pitcher plants leafs (>50 species)

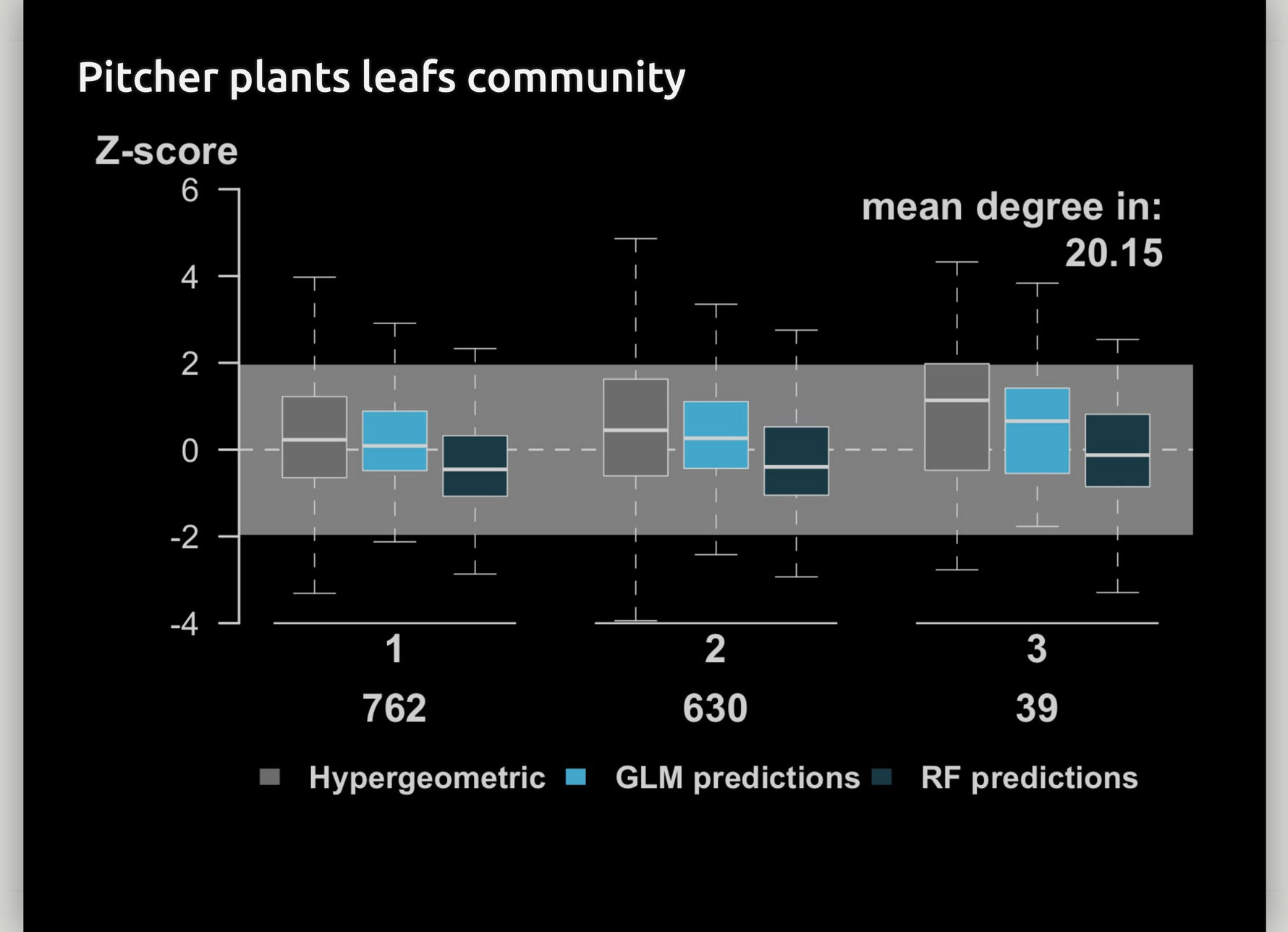


Baiser, B., *et al.* (2012). *Global Ecology and Biogeography*


Salix / Herbivores
Z-score
20
16
12
8
4
0
-4
mean degree in:
1.56
1
97
3
2105
5
138
Hypergeometric
GLM predictions
RF predictions


Herbivores / Parasitoids
Z-score
20
16
12
8
4
0
-4
mean degree in:
13.78
1
3
5
697
3474
119
Hypergeometric
GLM predictions
RF predictions


Hummingbirds / host plants
Z-score
6
4
2
0
-2
-4
mean degree in:
8.5
1
3
5
7
85
272
148
15
Hypergeometric
GLM predictions
RF predictions


Pitcher plants leafs community
Z-score
6
4
2
0
-2
-4
mean degree in:
20.15
1
762
2
630
3
39
Hypergeometric
GLM predictions
RF predictions

CONCLUSION

Integrating interaction in biogeography

So, do ecological interactions impact geographic distributions of species?

YES

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Can we detect them is static occurrence data?

→ it may be a matter of network topology.

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Can we detect them is static occurrence data?

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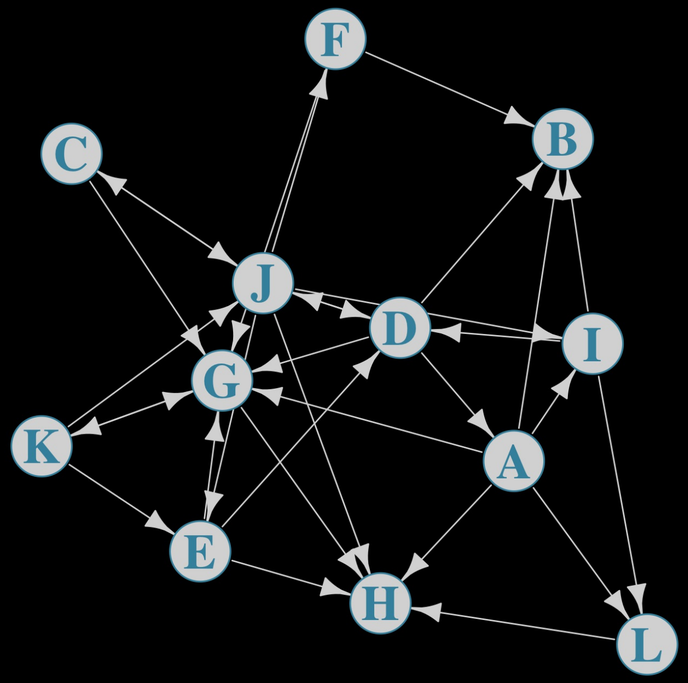
1. → in networks with high connectance, species can be considered as independent.

2. → species separated by more than one link can be considered as independent.

Are our predictions reliable?



Tomorrow

Are our predictions reliable?

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→ as long as interactions are abundant enough

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→ if species assemblages move together

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→ as long as interactions are abundant enough

→ if species assemblages move together

→ How likely it is?

Not very much I guess.

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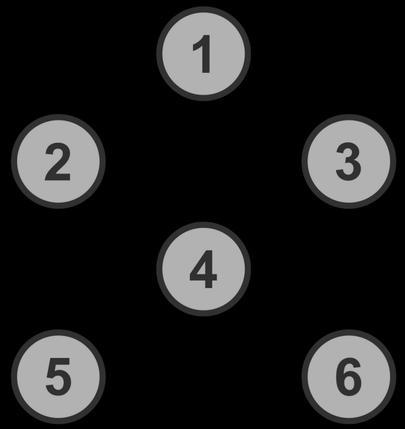

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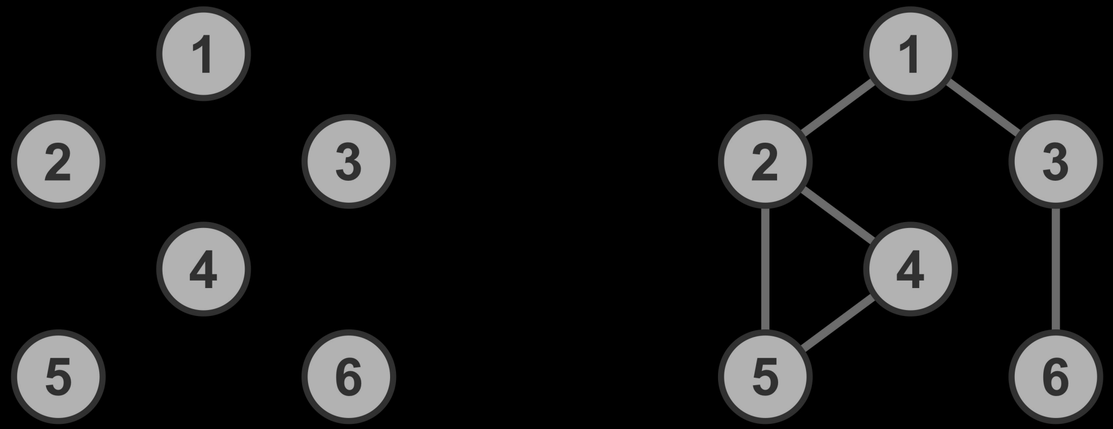

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- Tomas Roslin
- Benjamin Baiser
- Bo Dalsgaard
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- Allan Timmermann
- Ana M Martín González
- Andrea Baquer

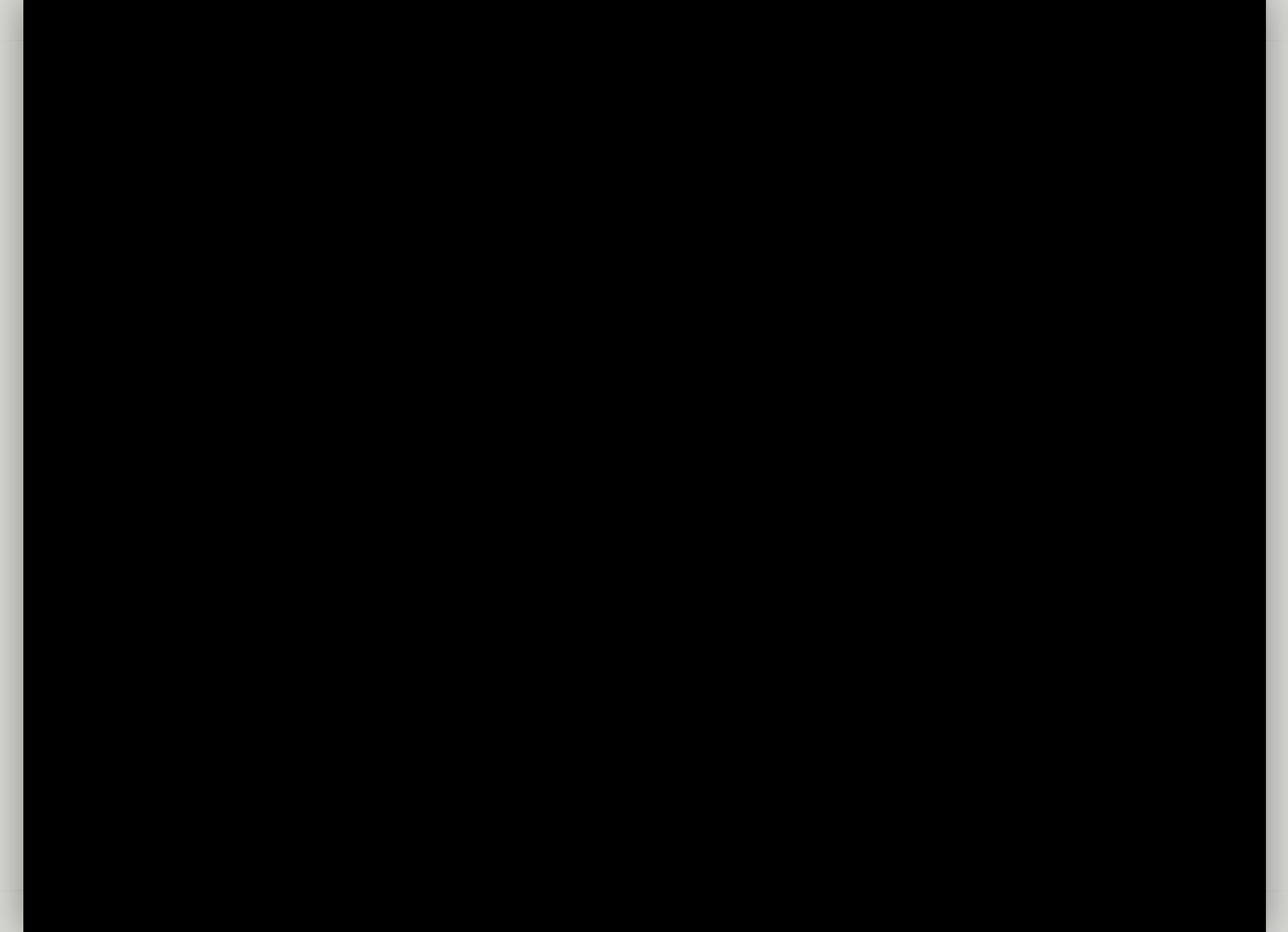
Funding agencies

- FRQNT

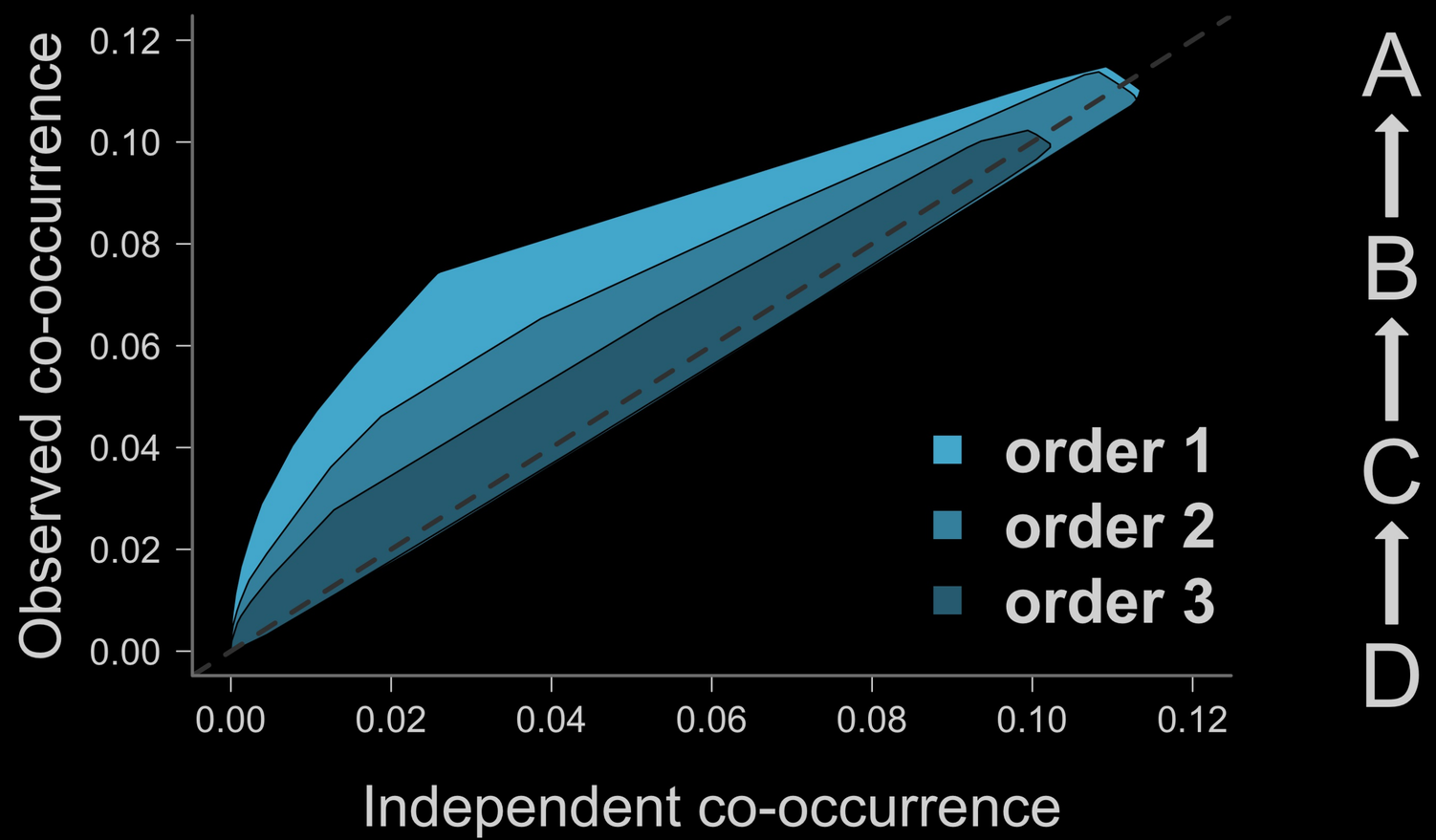
- Frontenac

THANK YOU FOR YOUR ATTENTION

Any question?



Co-occurrence and shortest path



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