Do interactions matter at biogeographical scale?

Kévin Cazelles[1 2]

CSEE, Saskatoon, 2015/05/22

Nicolas Mouquet[1], **David Mouillot**[3], **Dominique Gravel**[2].

[1] ISEM, CNRS UMR 5554, Université Montpellier II
[2] Département de Biologie, Université du Québec à Rimouski
[3] ECOSYM, CNRS-IRD-IFREMER UMR 5119, Université Montpellier II

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- However in 1998, in Nature ...

Making mistakes when predicting shifts in species range in response to global warming

Andrew J. Davis*, Linda S. Jenkinson*, John H. Lawton†, Bryan Shorrocks* & Simon Wood†‡

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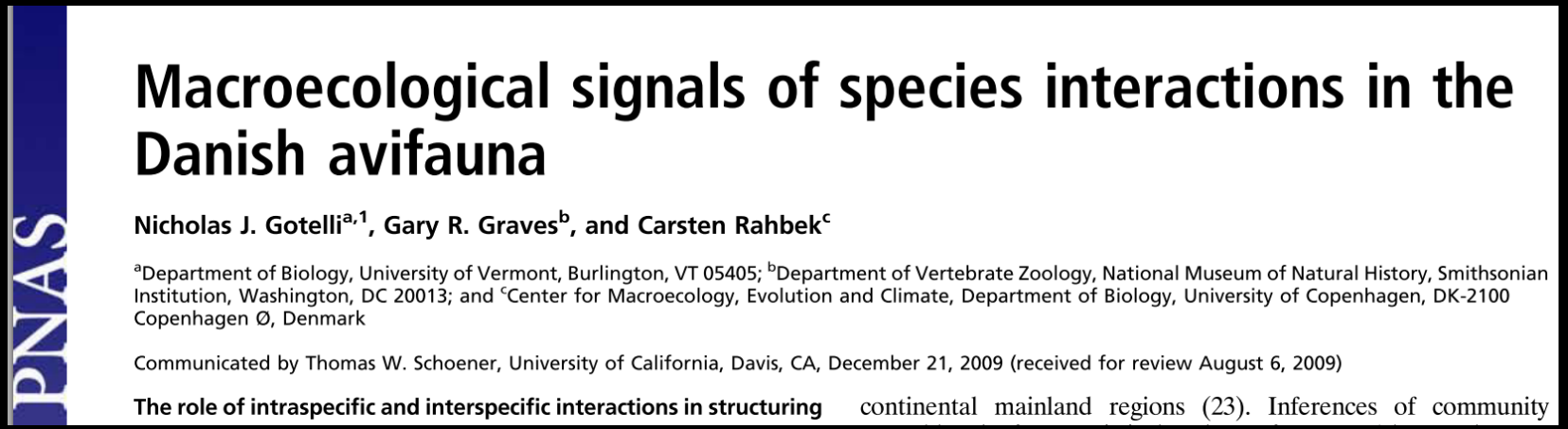


PNAS

Macroecological signals of species interactions in the Danish avifauna

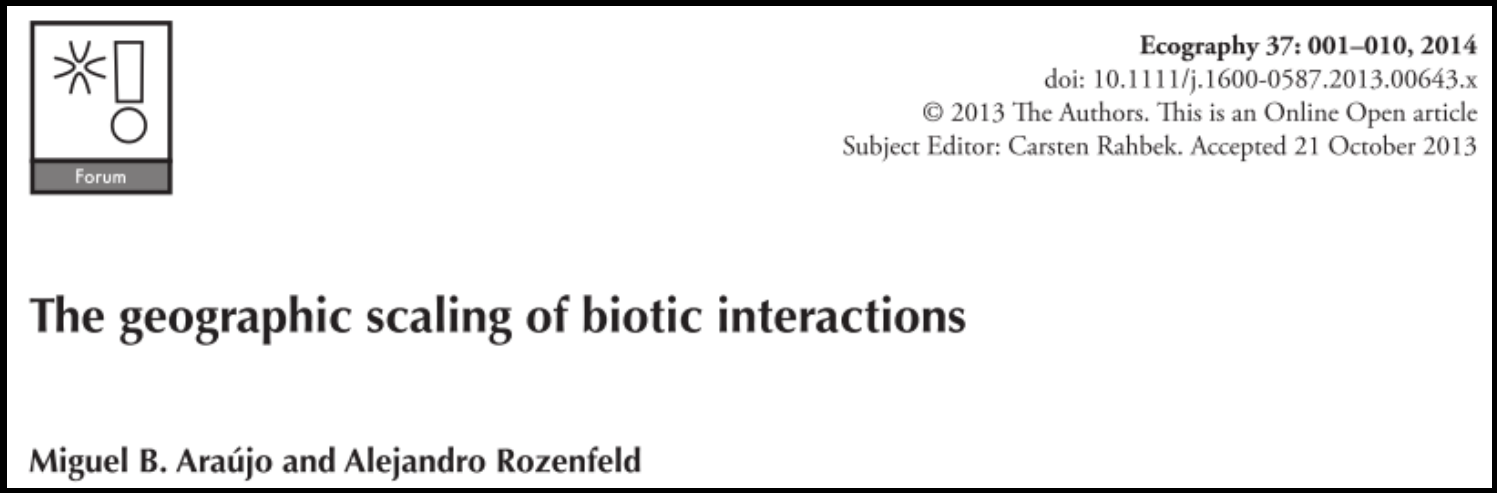
Nicholas J. Gotelli[a,1], Gary R. Graves[b], and Carsten Rahbek[c]

[a]Department of Biology, University of Vermont, Burlington, VT 05405; [b]Department of Vertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, DC 20013; and [c]Center for Macroecology, Evolution and Climate, Department of Biology, University of Copenhagen, DK-2100 Copenhagen Ø, Denmark

Communicated by Thomas W. Schoener, University of California, Davis, CA, December 21, 2009 (received for review August 6, 2009)

The role of intraspecific and interspecific interactions in structuring continental mainland regions (23). Inferences of community

- Fundamental questions:
  How interaction consequences propagate over spatial scales ?



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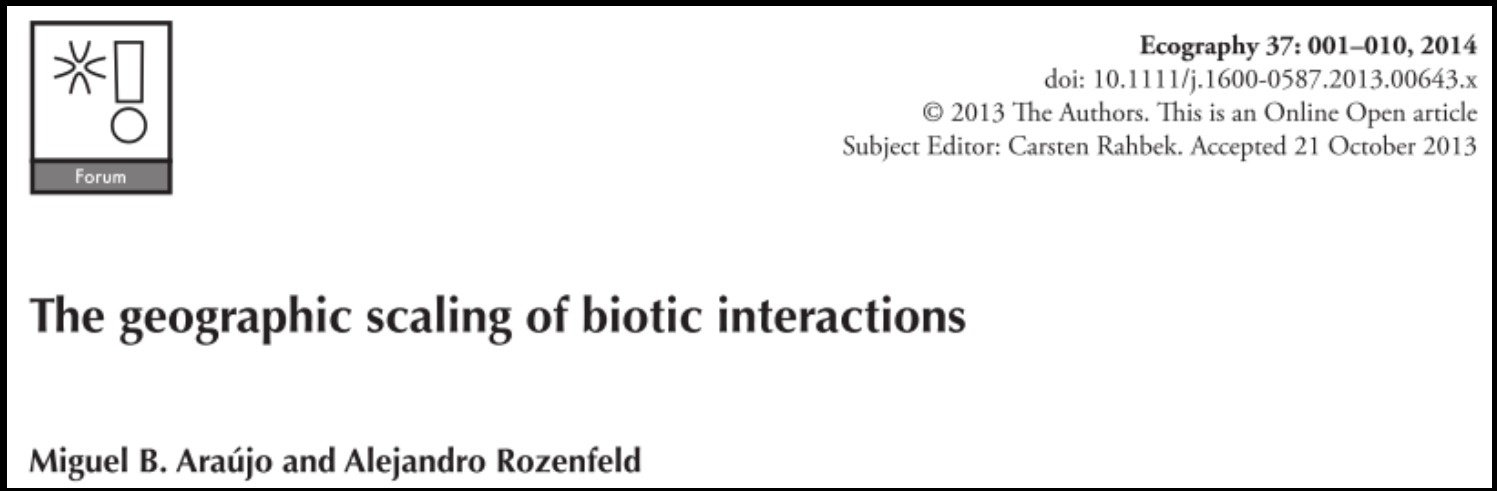

What does a co-occurrence mean ?

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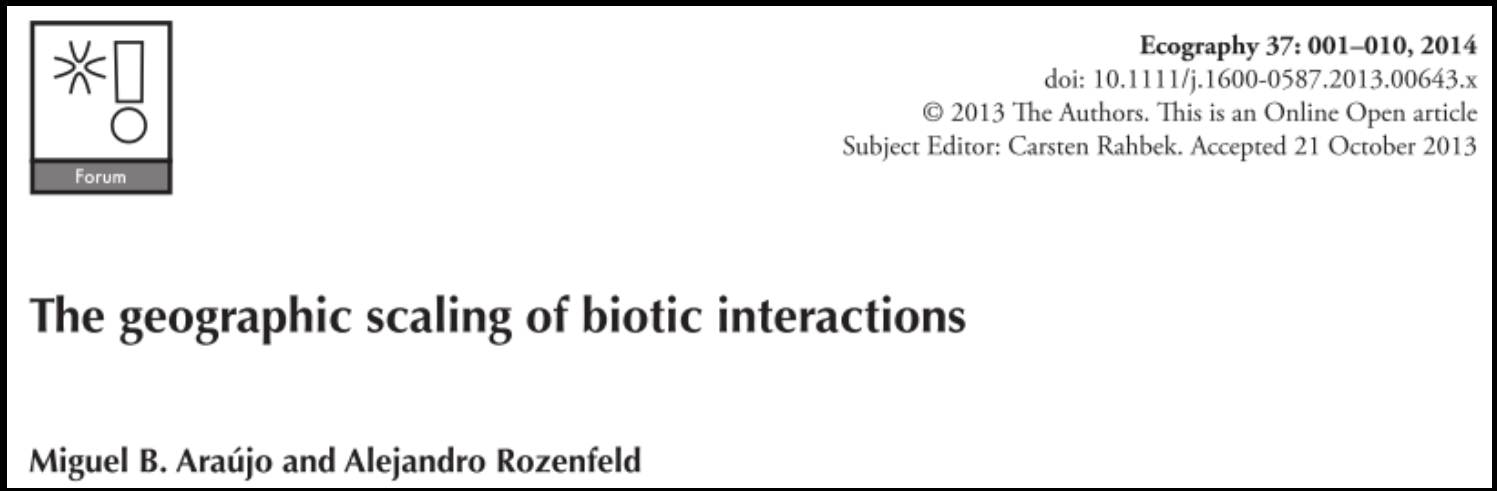

  What does a co-occurrence mean ?

- The Theory of Biogeography may require some changes !

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1. **Movement**: dispersal capacities of species, φ

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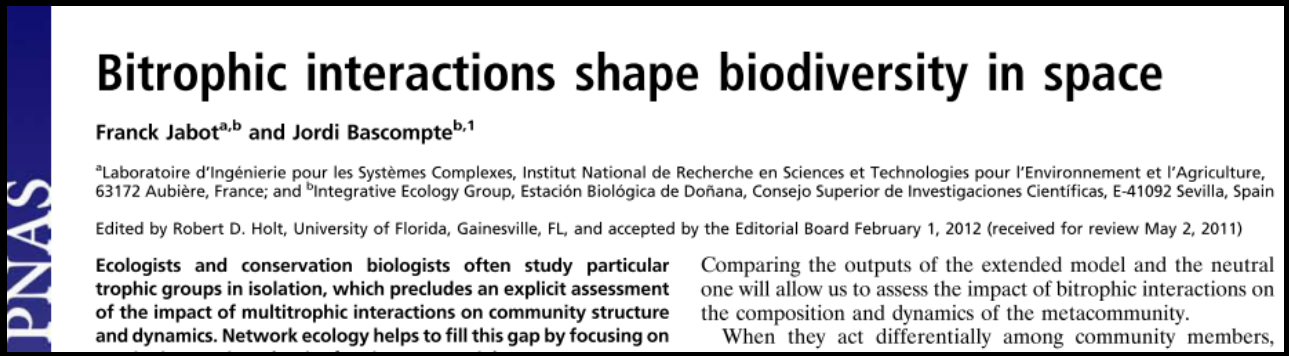

PNAS

Bitrophic interactions shape biodiversity in space

Franck Jabot[a,b] and Jordi Bascompte[b,1]

[a]Laboratoire d'Ingénierie pour les Systèmes Complexes, Institut National de Recherche en Sciences et Technologies pour l'Environnement et l'Agriculture, 63172 Aubière, France; and [b]Integrative Ecology Group, Estación Biológica de Doñana, Consejo Superior de Investigaciones Científicas, E-41092 Sevilla, Spain

Edited by Robert D. Holt, University of Florida, Gainesville, FL, and accepted by the Editorial Board February 1, 2012 (received for review May 2, 2011)

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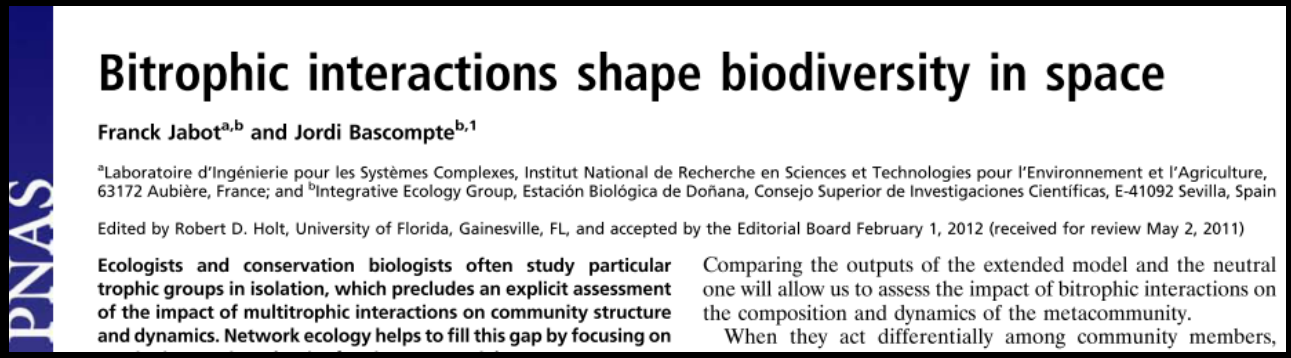

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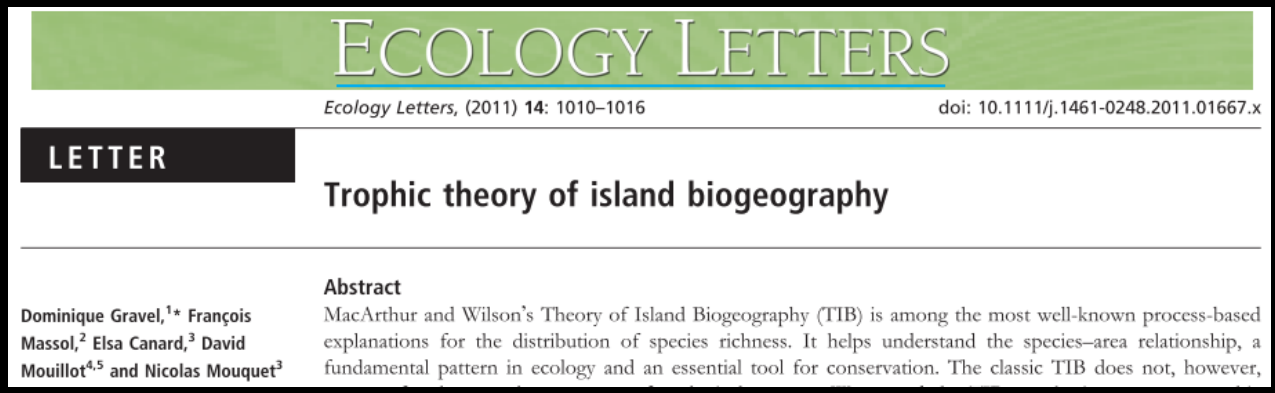
- Trophic extension of the Theory of Island Biogeography (TTIB):



ECOLOGY LETTERS

Ecology Letters, (2011) **14**: 1010–1016 doi: 10.1111/j.1461-0248.2011.01667.x

LETTER

Trophic theory of island biogeography

Dominique Gravel,[1]* François Massol,[2] Elsa Canard,[3] David Mouillot[4,5] and Nicolas Mouquet[3]

Abstract

MacArthur and Wilson's Theory of Island Biogeography (TIB) is among the most well-known process-based explanations for the distribution of species richness. It helps understand the species–area relationship, a fundamental pattern in ecology and an essential tool for conservation. The classic TIB does not, however,

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- Supporting the development of the theory of Biogeography

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- Generalizing the TTIB model to any kind of networks
- Adding environmental gradients

Theory of Island Biogeography (1967)

1. The theory of MacArthur and Wilson is often summarized as follows:

$$\frac{dS}{dt} = c(P - S) - eS$$

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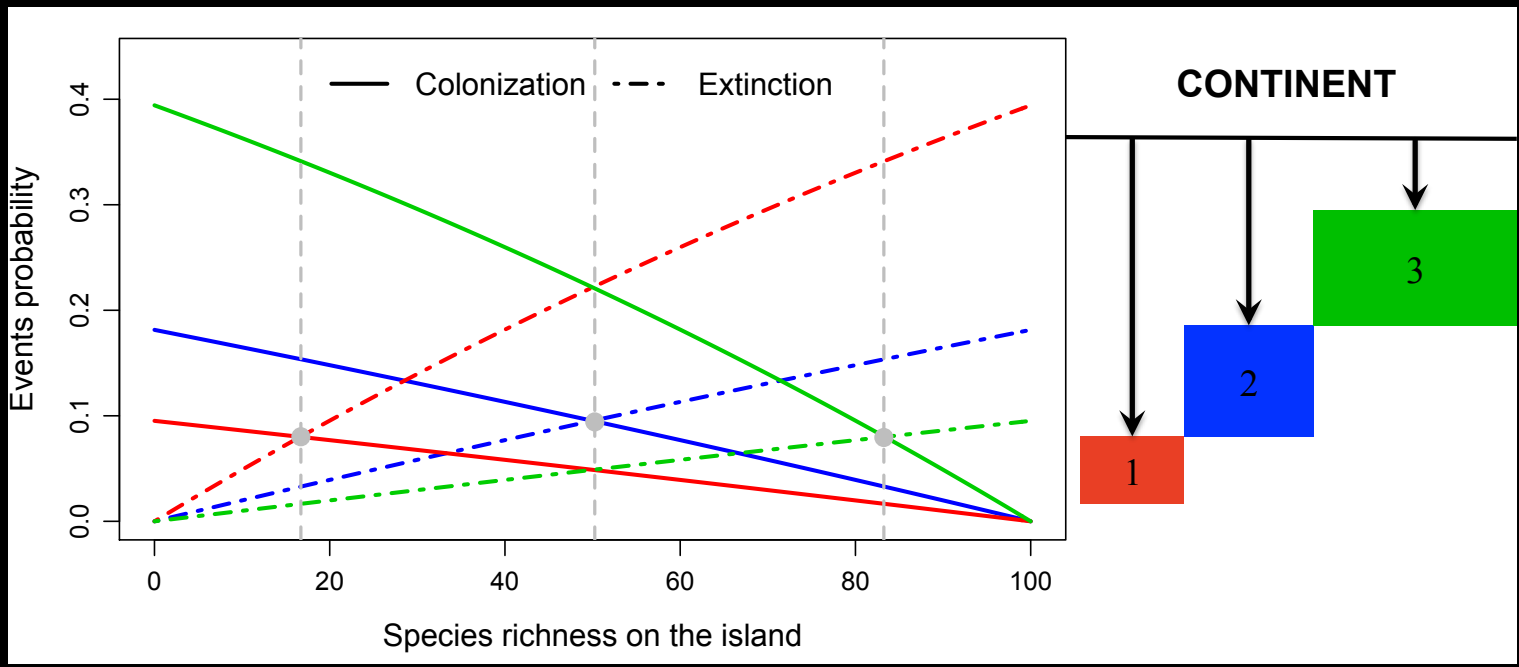
2. Equilibrium reached for:

$$S_{eq} = P\frac{c}{c + e}$$



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- Let us consider 2 species 1 and 2
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- How to switch from X_t to X_{t+dt} ?
- Markov chain !

Transition Matrix of the Markov Chains

For independent species:

	$(X_{1,t+dt}, X_{2,t+dt})$			
$(X_{1,t}, X_{2,t})$	$(1,1)$	$(1,0)$	$(0,1)$	$(0,0)$
$(1,1)$	$(1-e_1dt)(1-e_2dt)$	$(1-e_1dt)e_2dt$	$e_1dt(1-e_2dt)$	e_1dte_2dt
$(1,0)$	$(1-e_1dt)c_2dt$	$(1-e_1dt)(1-c_2dt)$	e_1dtc_2dt	$e_1dt(1-c_2dt)$
$(0,1)$	$c_1dt(1-e_2dt)$	c_1dte_2dt	$(1-c_1dt)(1-e_2dt)$	$(1-c_1dt)e_2dt$
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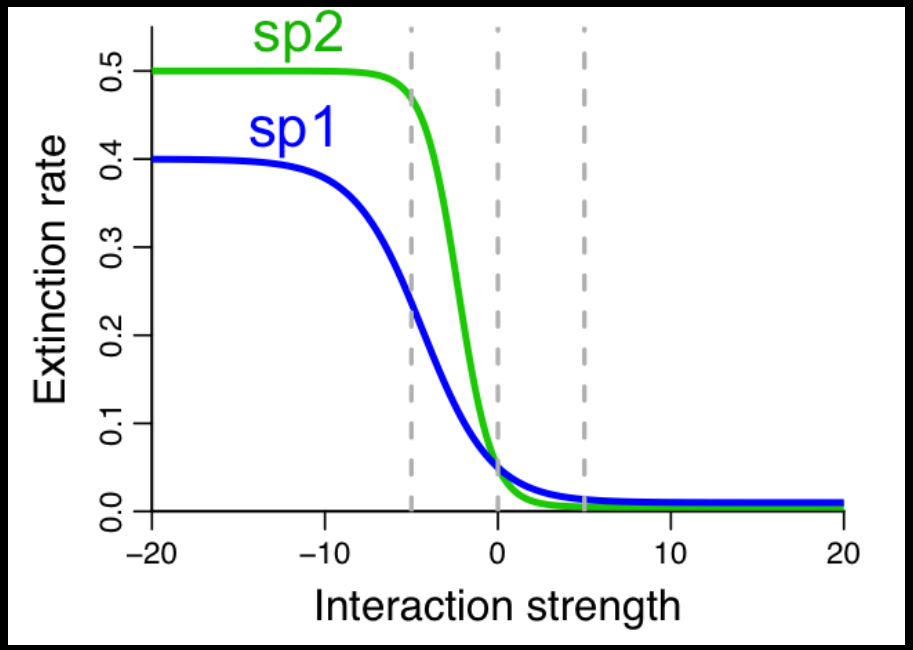
- Generally applicable to n species.
- Probabilities of all communities at the equilibrium.

- How interactions impact presence probabilities ?

$$(\text{Interaction Strength})_t = BX_t$$



- Without interaction, we get the classical model.

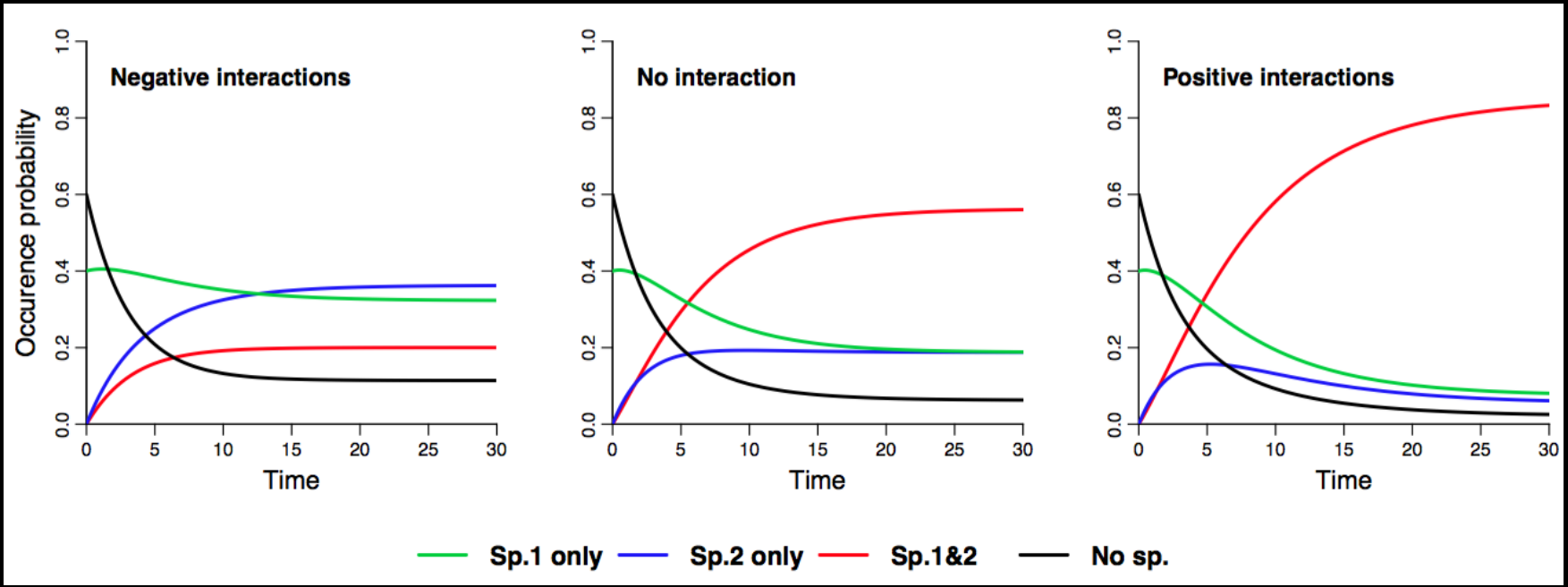
Given:

- ecological network

We get:

- Presence probabilities of all communities at equilibrium
- Any probability defined as a sum of the latter, *e.g.* the presence probability of any species

Example with two species



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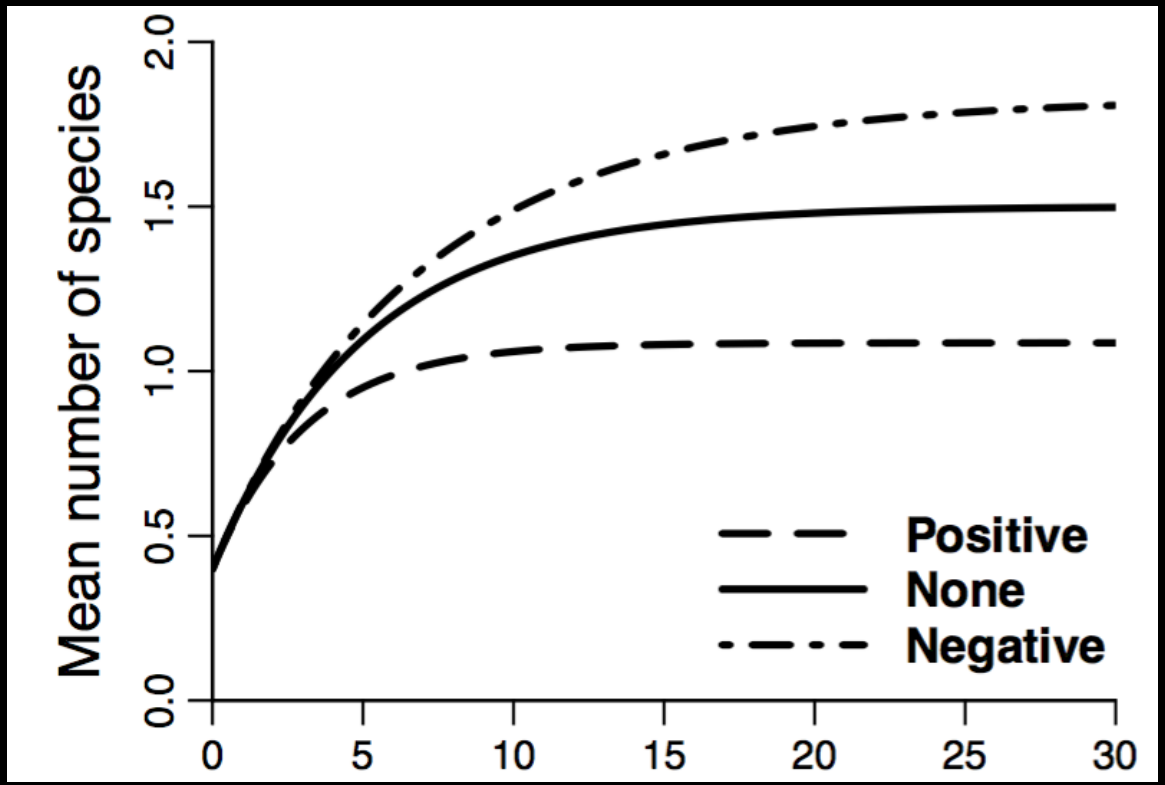

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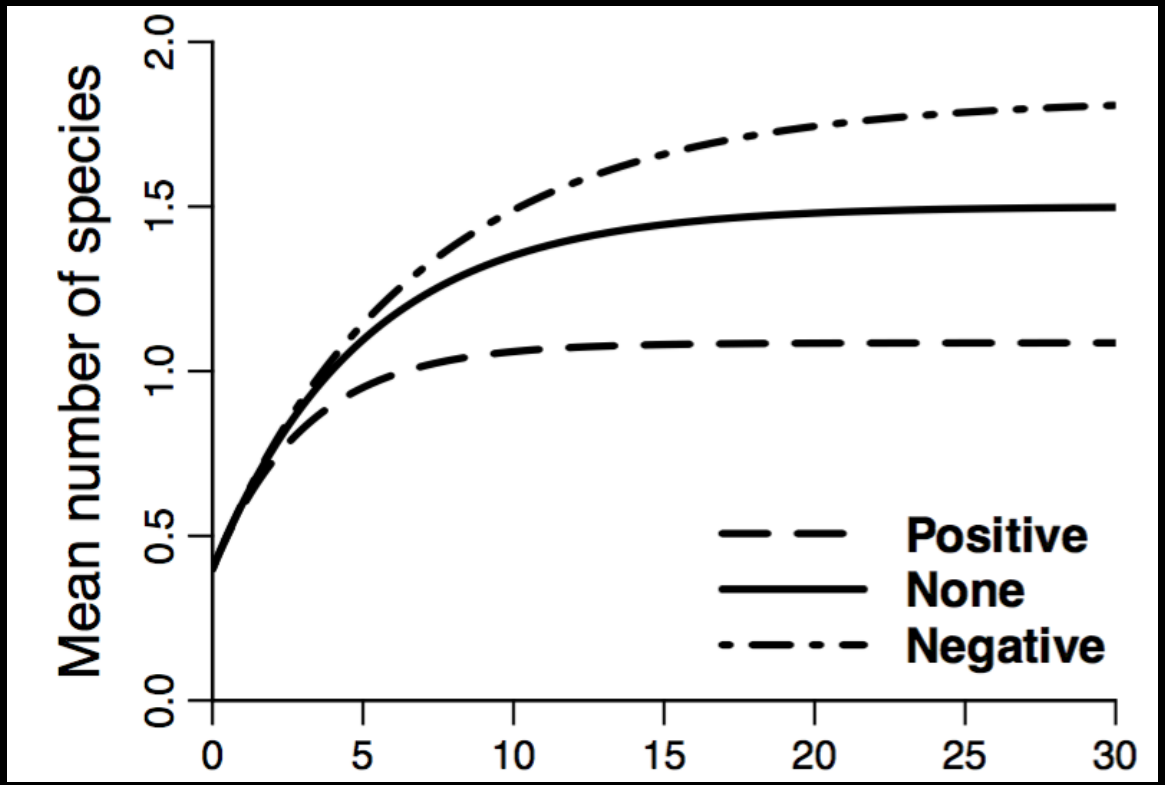
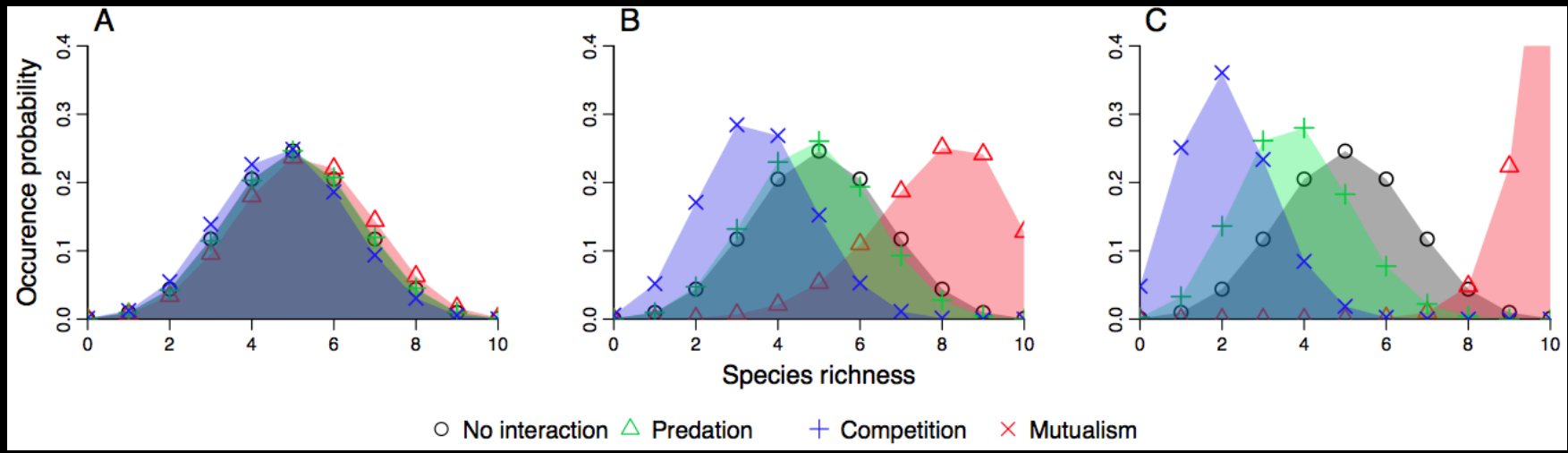


Exploration for networks of 10 species (niche model).

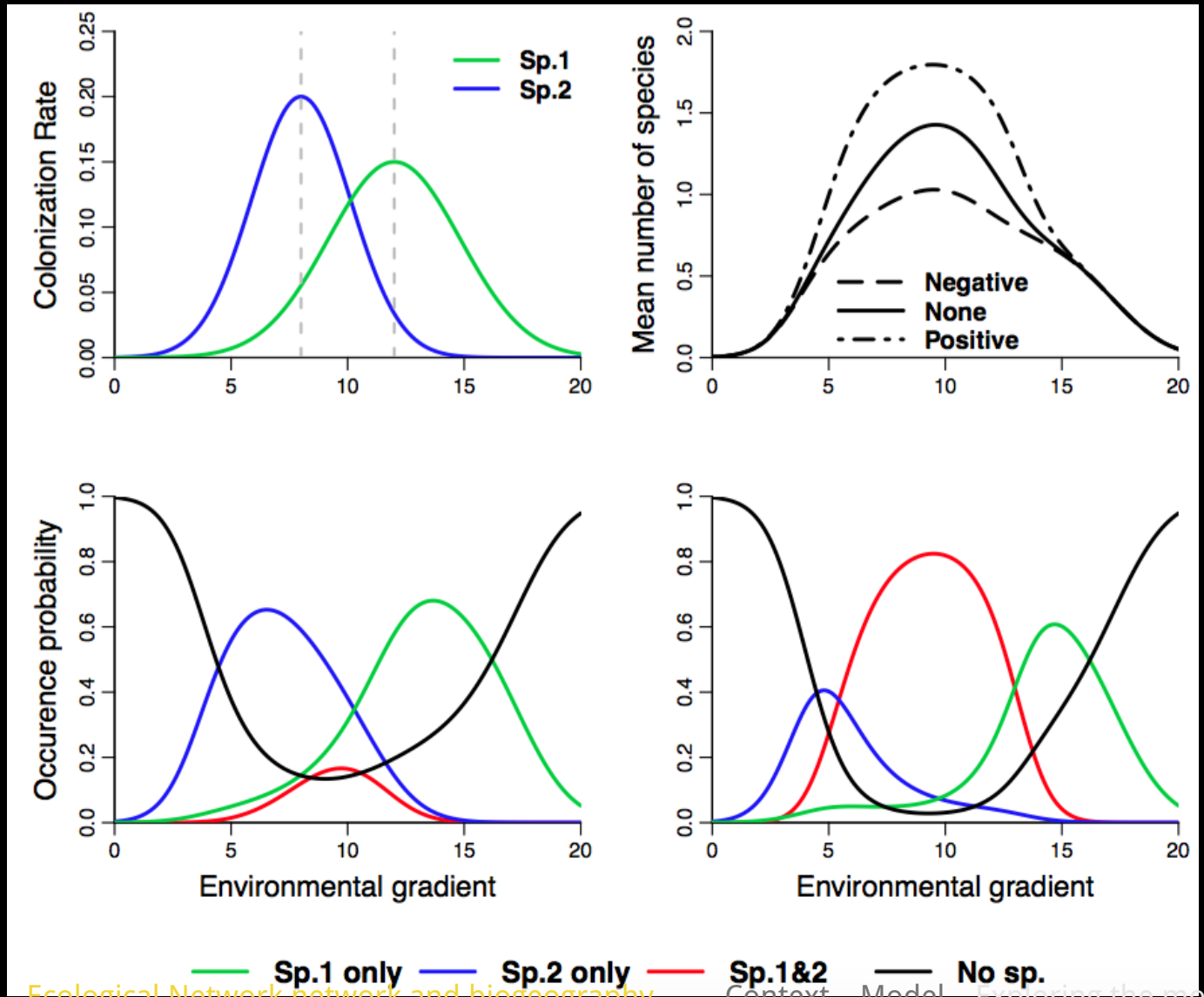
Interaction affects probability of assemblages

$$\mathbb{P}(S_{eq} = n) = \sum_{i \mid |S_i|^2 = n} \mathbb{P}(X_{eq} = S_i)$$



From A to C we increase the interaction strengths.

Environmental gradient + interaction



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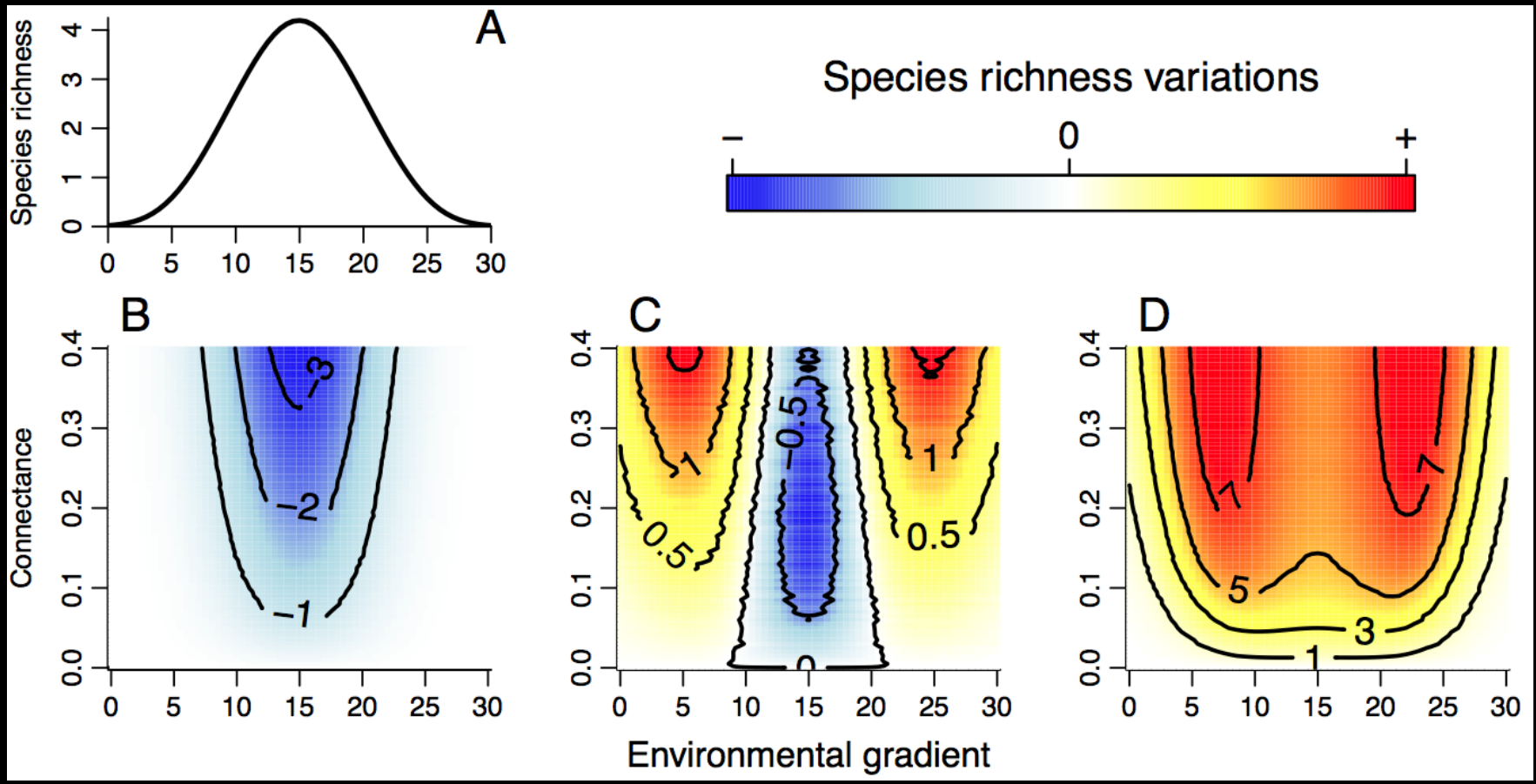

Towards applications ?

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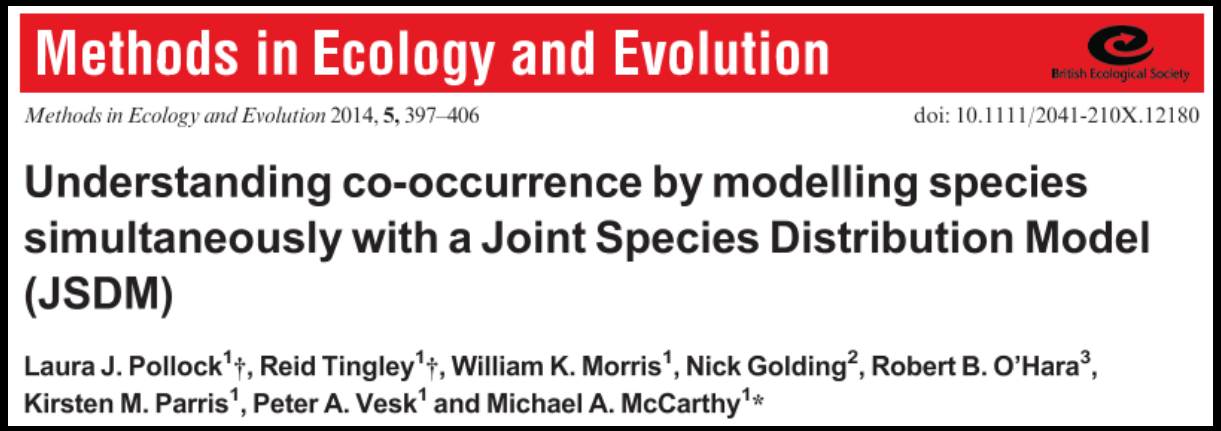
- Theoretical foundations for emerging approaches:



Methods in Ecology and Evolution

British Ecological Society

Methods in Ecology and Evolution 2014, **5**, 397–406 doi: 10.1111/2041-210X.12180

Understanding co-occurrence by modelling species simultaneously with a Joint Species Distribution Model (JSDM)

Laura J. Pollock[1]†, Reid Tingley[1]†, William K. Morris[1], Nick Golding[2], Robert B. O'Hara[3], Kirsten M. Parris[1], Peter A. Vesk[1] and Michael A. McCarthy[1]*

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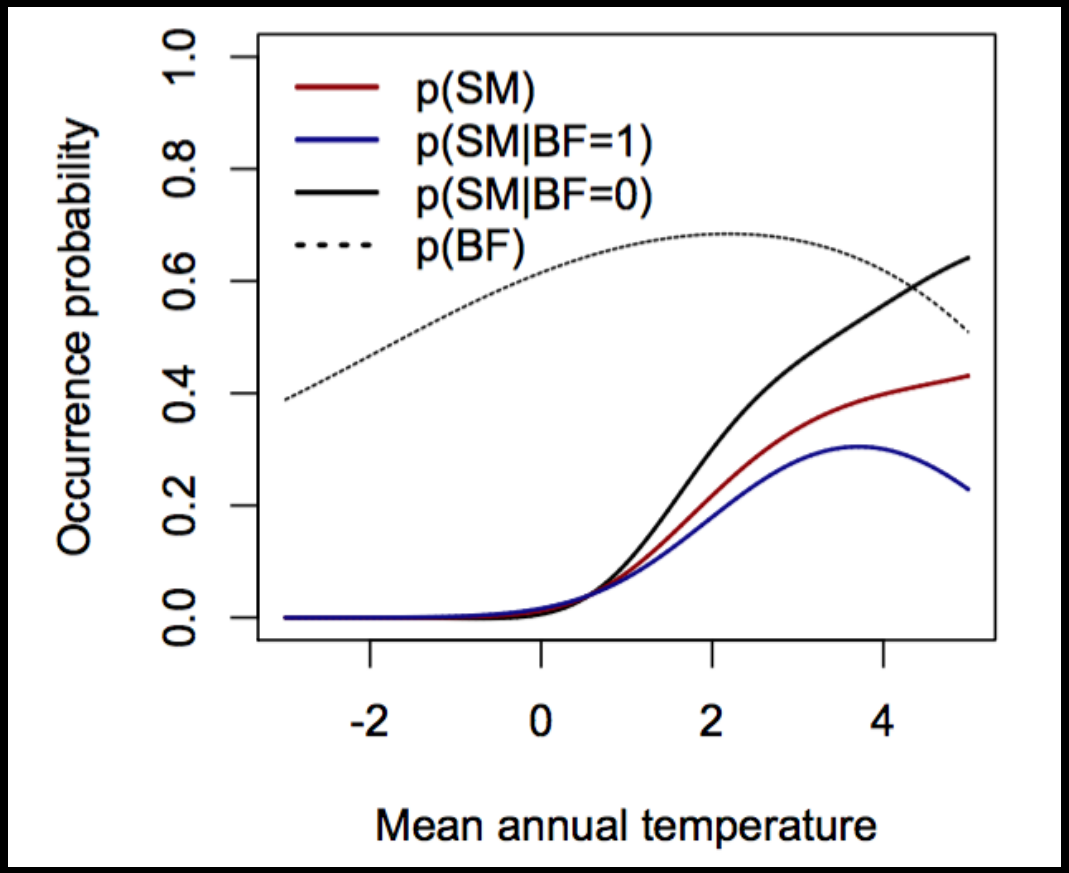
- Are correlations sufficient to capture “signals” and conclude ?

- Conditional probabilities of occurrence along environmental gradients



BF = Balsam Fir, SM = Sugar Maple

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