Distinguishing different forms of competition
in a mechanistic model of eco-evolutionary dynamics
Master 1 Thesis

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2nd July 2020

Context

- Biodiversity shaped by both ecology and evolution; timescales overlap

- Different forces shape the community (environment, competition, neutral)

The MESS Model

- Simulation of a metapopulation
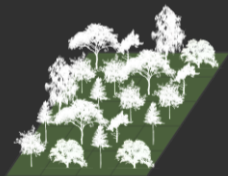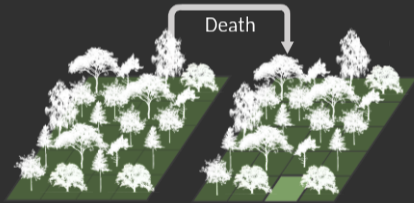- Local community filled with one species (original invasion)

Figure: Rosindell et al 2011

The MESS Model

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- 1 death per time step.

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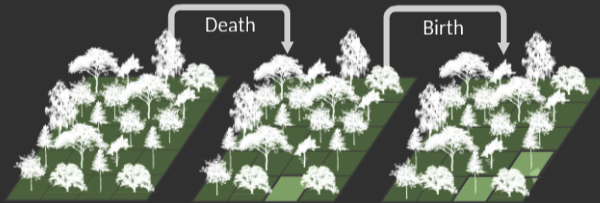- 1 death per time step. Replaced by a birth from a parent in the island

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The MESS Model

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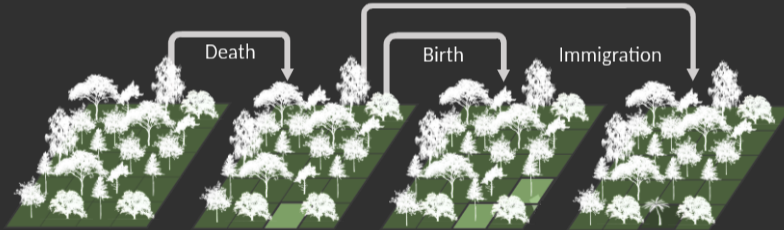

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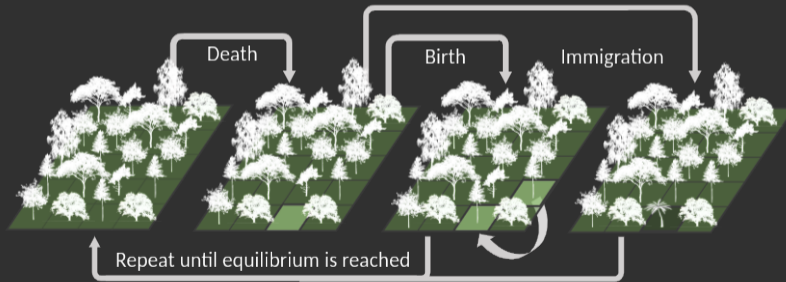- Occasional speciation on the island

Figure: Rosindell et al 2011

What do we observe ?

- Summary statistics: species richness, abundances, genetic diversity, trait variation
- 3 models for the death probabilities:
  - neutral (uniform probability)

  - competition : $P(z_i) = \exp^{-\frac{(z_i - \bar{z})^2}{s_E}}$

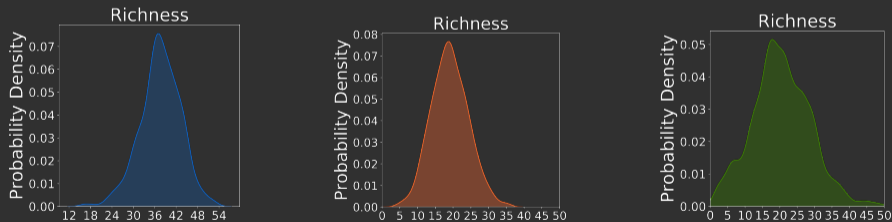 - environmental filtering : $P(z_i) = 1 - \exp^{-\frac{(z_i - z_E)^2}{s_E}}$

Figure: Richness distribution (1500 simualtions) in the neutral, competition and fitlering cases

Problematic

Could an accurate description of the biodiversity

indicate the major force at stake in a community ?

Problem statement

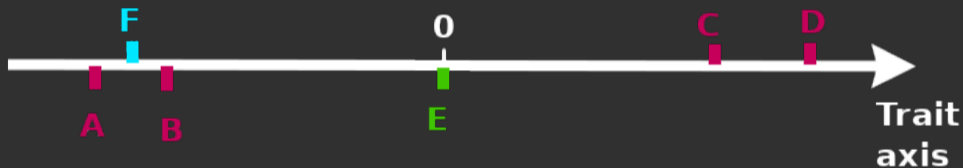- Mean competition too unrealistic ?

Figure: Visualisation of species in the trait space

- Community assembly not discrete ? (some individuals virtually immortal)

Project

Pairwise competition

- Niche theory : pairwise competition

$$P(z_i) = \sum_{j \neq i} \exp^{-\frac{(z_i - z_j)^2}{s_E}}$$

- ⚠ Very costly in computation time → necessary code optimisation

- Intra- and interspecific competition should differ ?

Interaction matrix

$$P(z_i) = \sum_{j \neq i} -\alpha_{ij} \exp^{-\frac{(z_i - z_j)^2}{s_E}}$$

- Enables various kind of interaction: α_{ij} (positive or negative), weight the interaction

Interaction matrix

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- Enables various kind of interaction: α_{ij} (positive or negative), weight the interaction

- ⚠ If intraspecific competition $<$ interspecific competition then it behaves pathologically

Continuous community assembly model
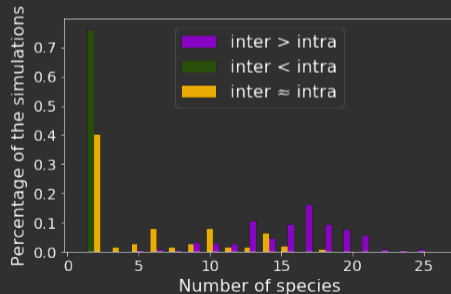
Figure: Representation of the continuous community assembly model
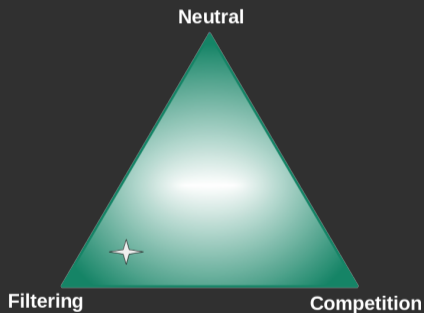
Instead of having a model fixed for the whole simulation, it can vary from one time step to the other:

- 90% Filtering
- 5% Competition
- 5% Neutral

Results
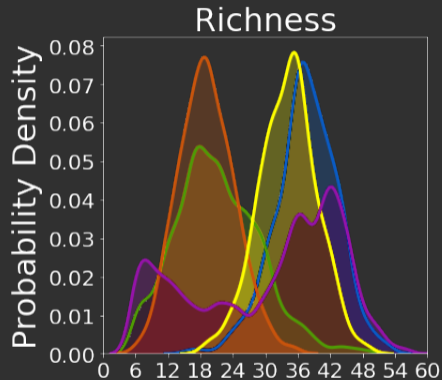
Behavior of the pairwise competition and interaction matrix models

Figure: Species richness for over 1000 simulations generated under neutral, mean competition, pairwise competition, interaction matrix and environmental filtering scenarios with time fixed at 500 generations.
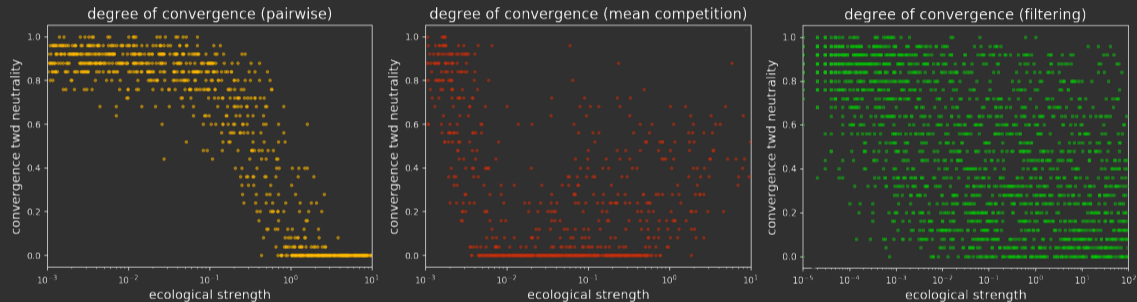
Emergeant neutrality ?

Figure: Amount of measured "neutrality" for different ecological strength
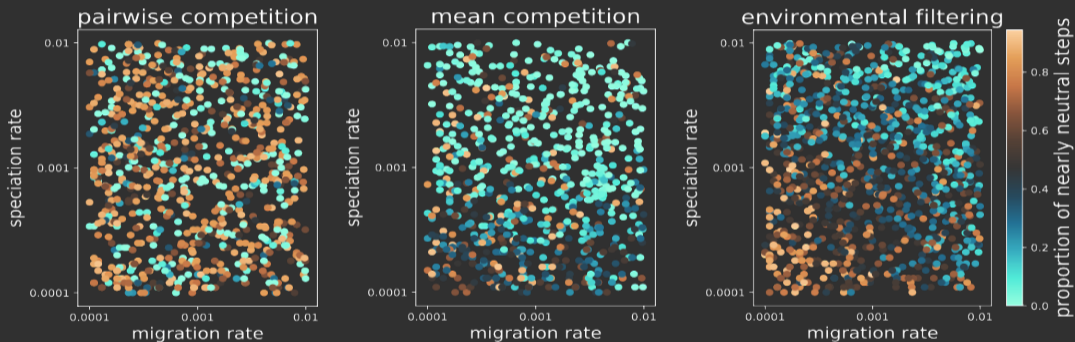
Emergeant neutrality ?

Figure: Amount of measured "neutrality" for various migration and speciation rates
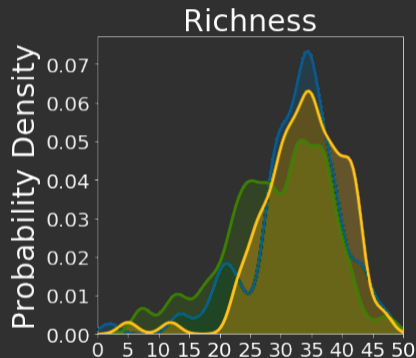
Continuous model

Figure: Effect of varying speciation rate and community assembly model on species richness (continuous version). Colors are following the majority model for the simulation : competition, fitlering or neutral

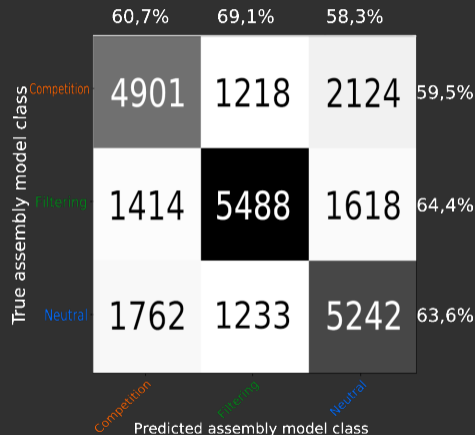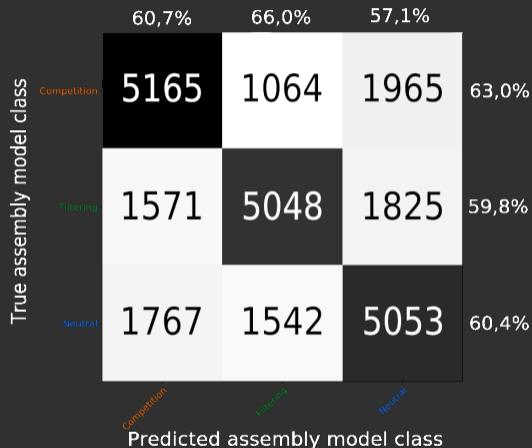# Can we infer the community assembly model ?

Figure: Confusion matrices for the pairwise (left) and interaction matrix (right) models.
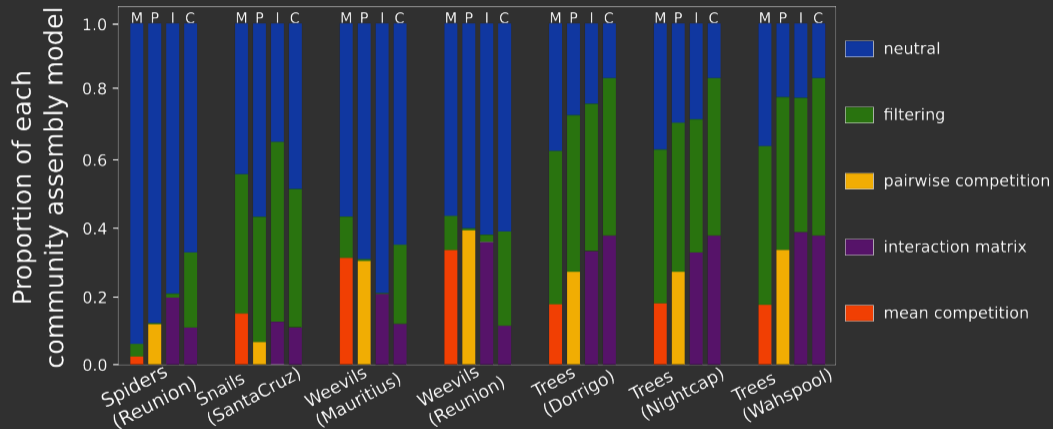
Empirical data analysis

Figure: Predicted model for each set of empirical data : the original prediction (M), the prediction for the pairwise competition model (P), for the interaction matrix (M) and the continuous model (C).

Perspectives & Future directions

- 2D trait fitness

- Moving or more complex fitness landscape

- Non-fixed MetaCommunity

- Character displacement and more realistic evolution
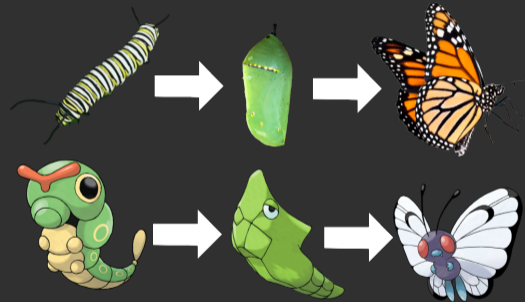
And a paper in writing !

Acknowledgment

Isaac Overcast - Postdoc iBioGen - IBENS

James Rosindell - Reader in Biodiversity Theory - Imperial College

Hélène Morlon - CNRS research director iBioGen - IBENS

The End