Untangling the Complexity of Priority Effects in Multispecies Communities

Chuliang Song, Tadashi Fukami, Serguei Saavedra

Department of Biology, McGill University
Department of Ecology and Evolutionary Biology, University of Toronto

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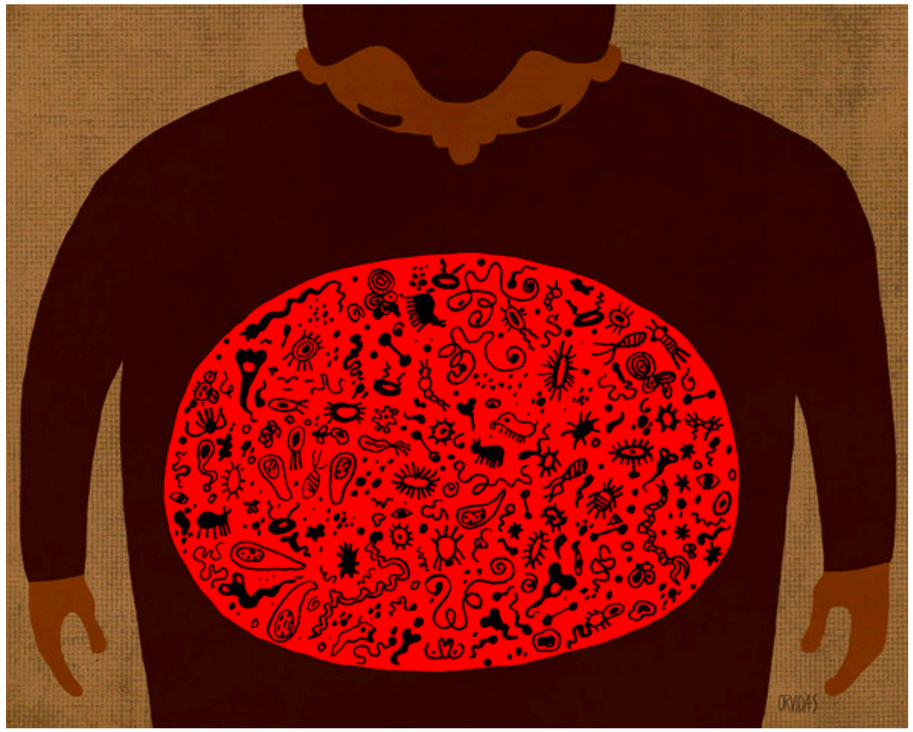
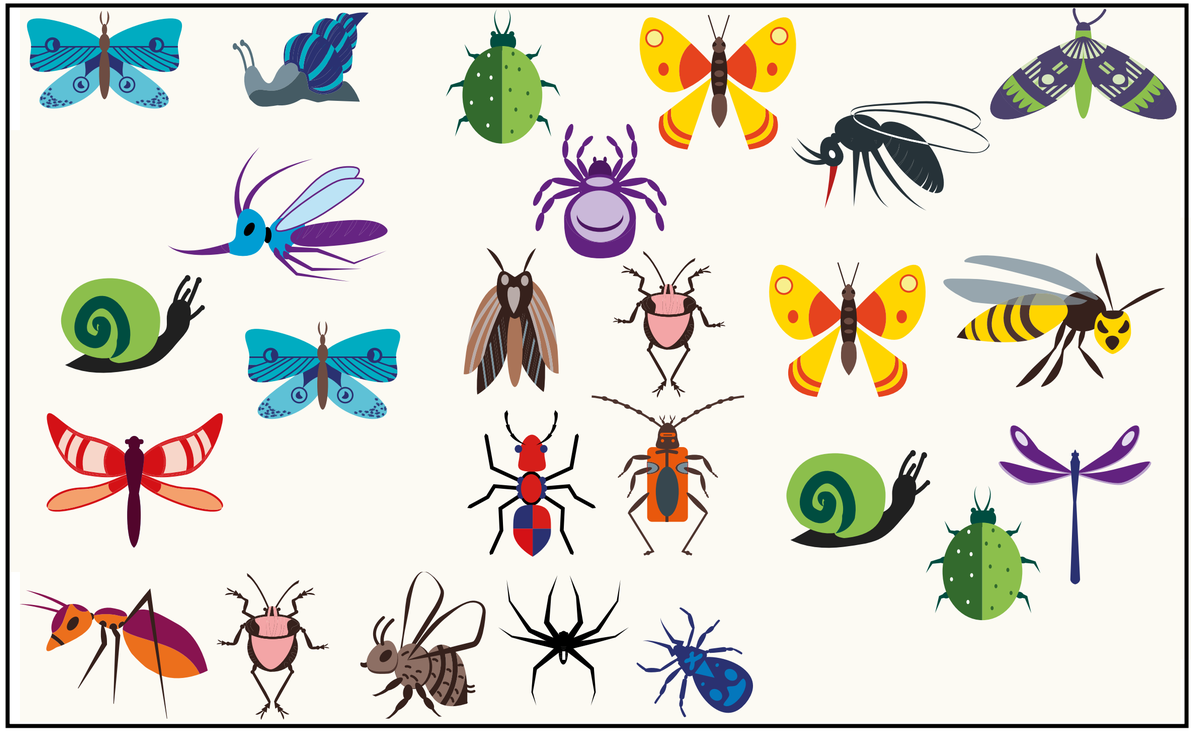
Ecological communities are structured by assembly processes

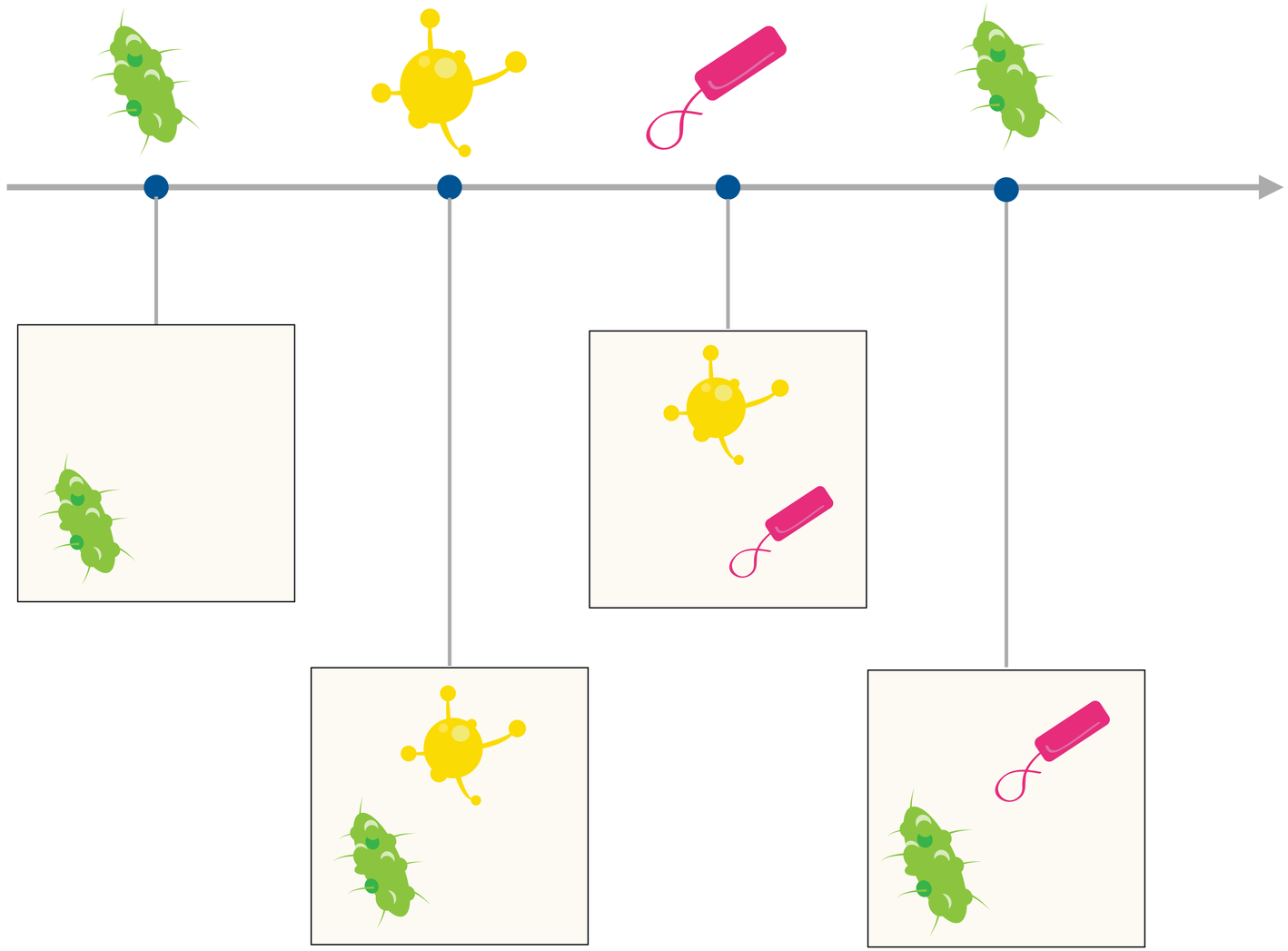


Ken Orvidas, *New York Times* (2014)



Chace et al., *Nature* (2020)

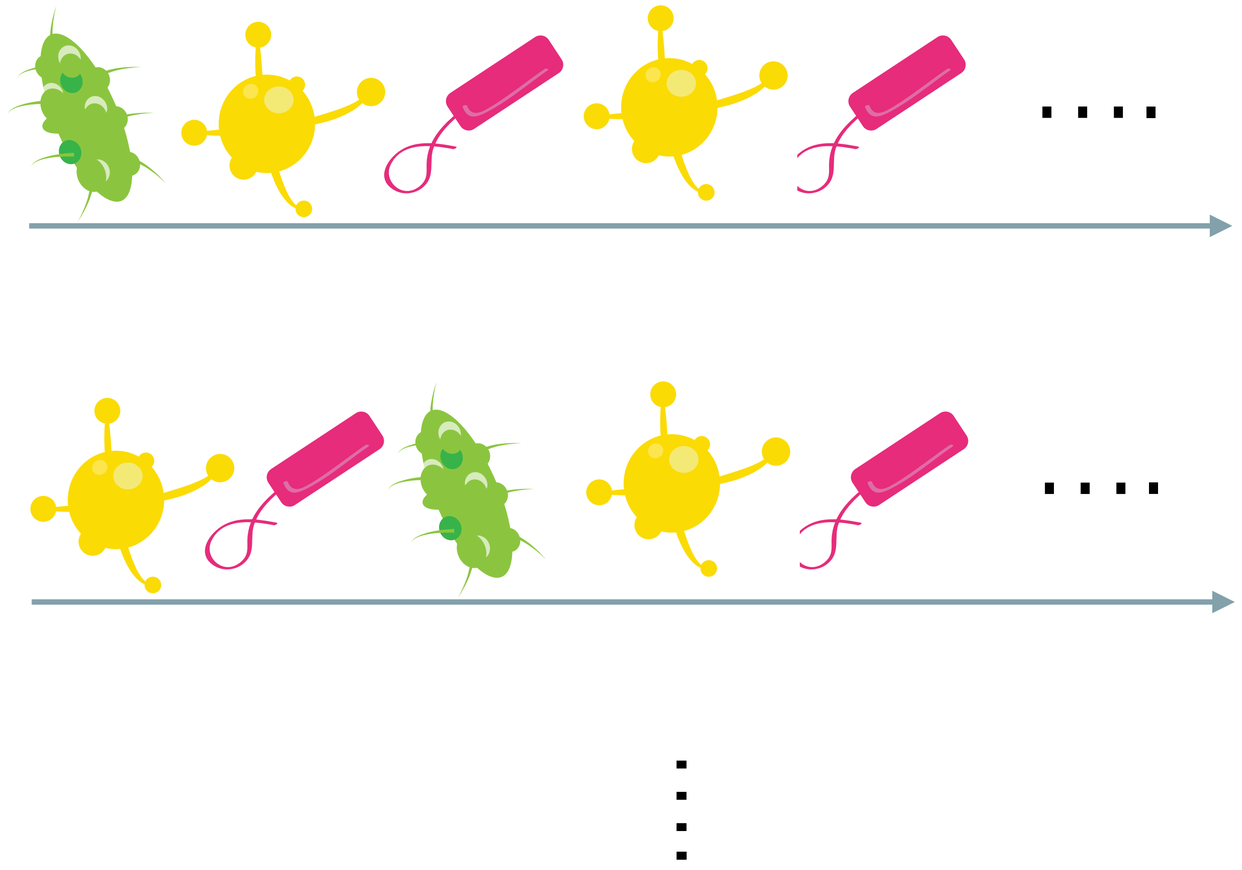
Species compositions are structured by assembly history



Assembly history
(the order of species arrivals)

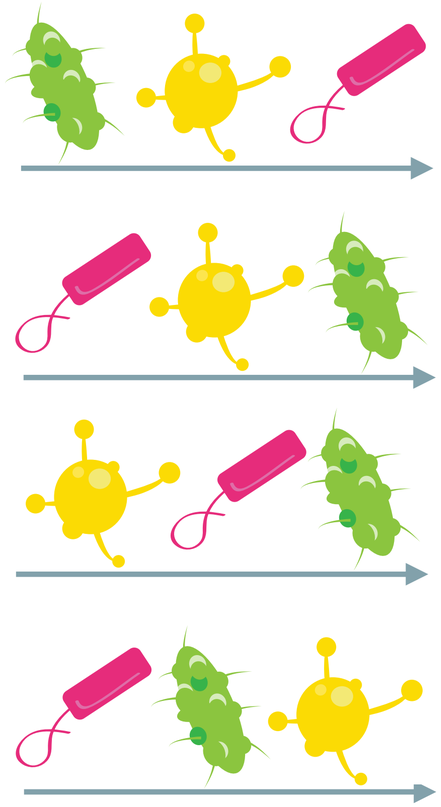
Species compositions
(which species are present)

It is hard or even impossible to know *a priori* which assembly history will take place



Predictability of species compositions under uncertain assembly history

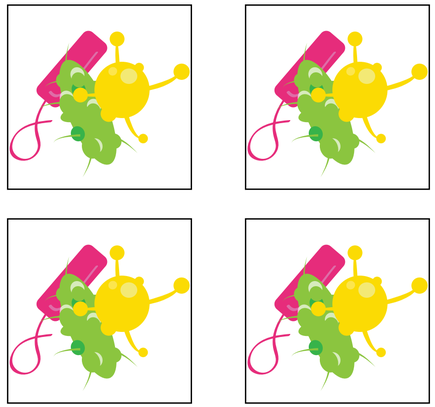
Assembly history



Species compositions

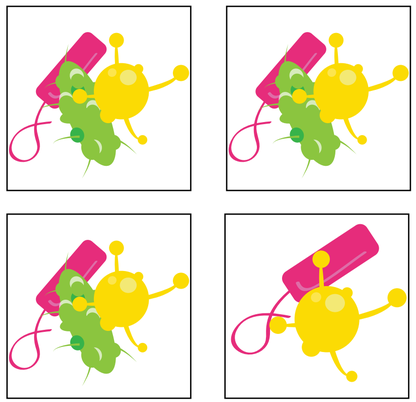
No priority effects

Ecological system 1

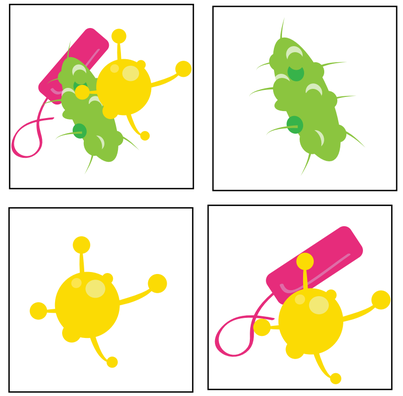


Priority effects

Ecological system 2



Ecological system 3

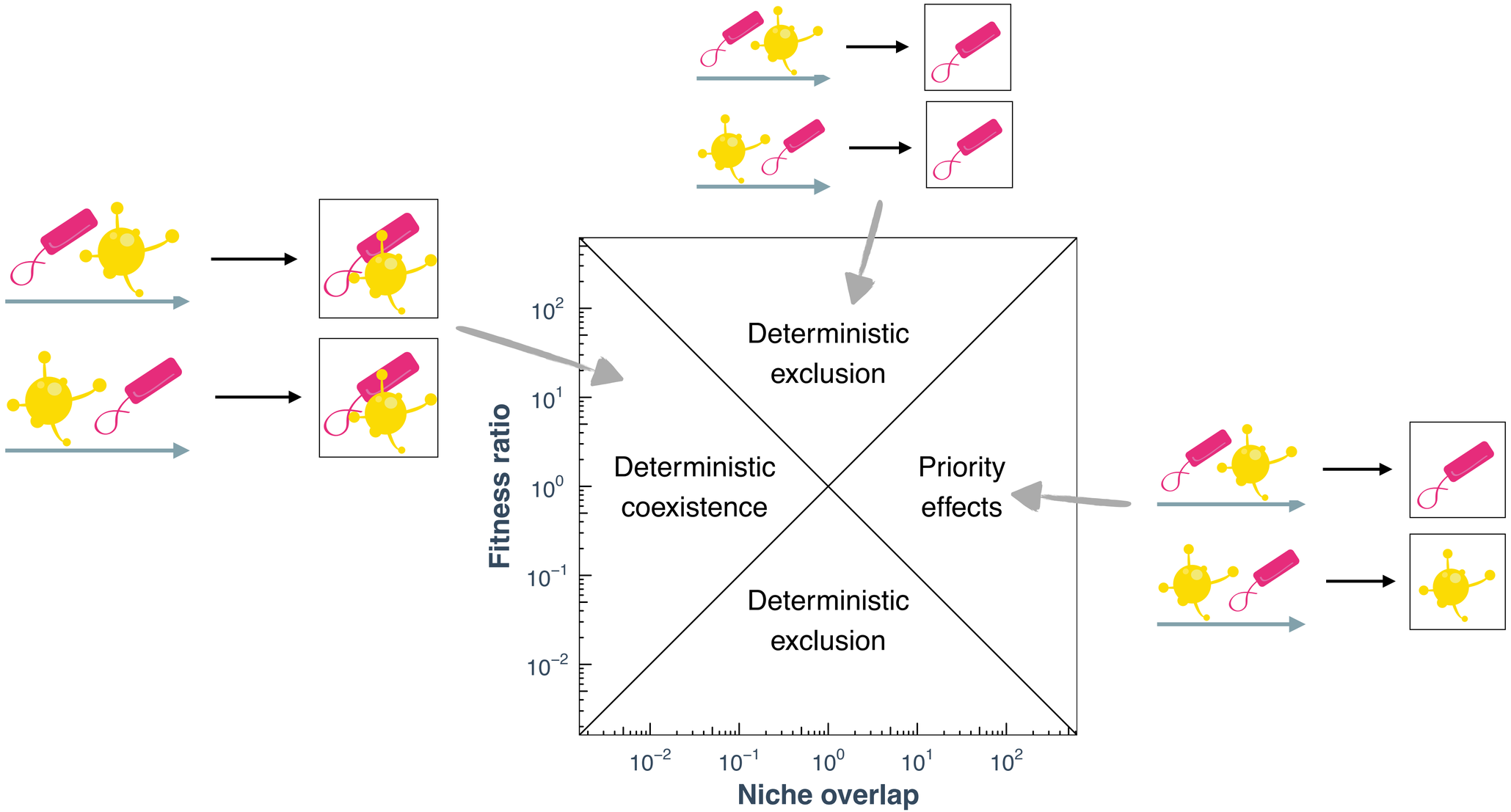


More predictable

Less predictable

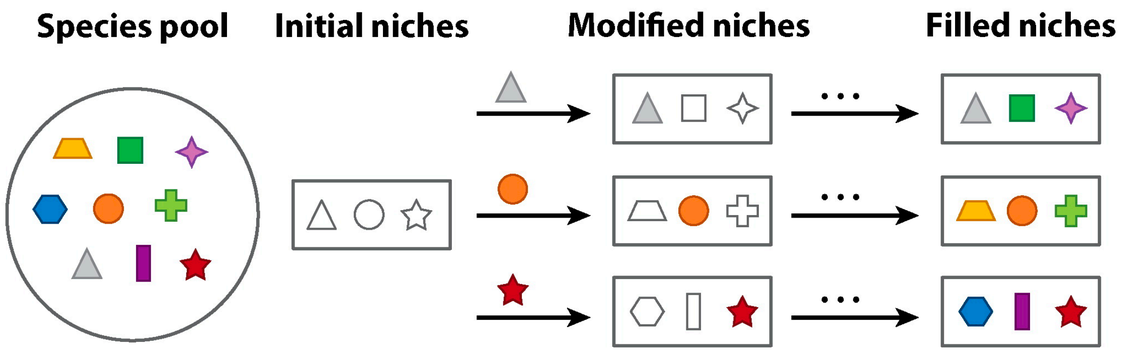
What makes an ecological community more or less predictable under uncertain assembly history?

Parametric approach to understand ecological assembly via a **fixed** structure of species interactions



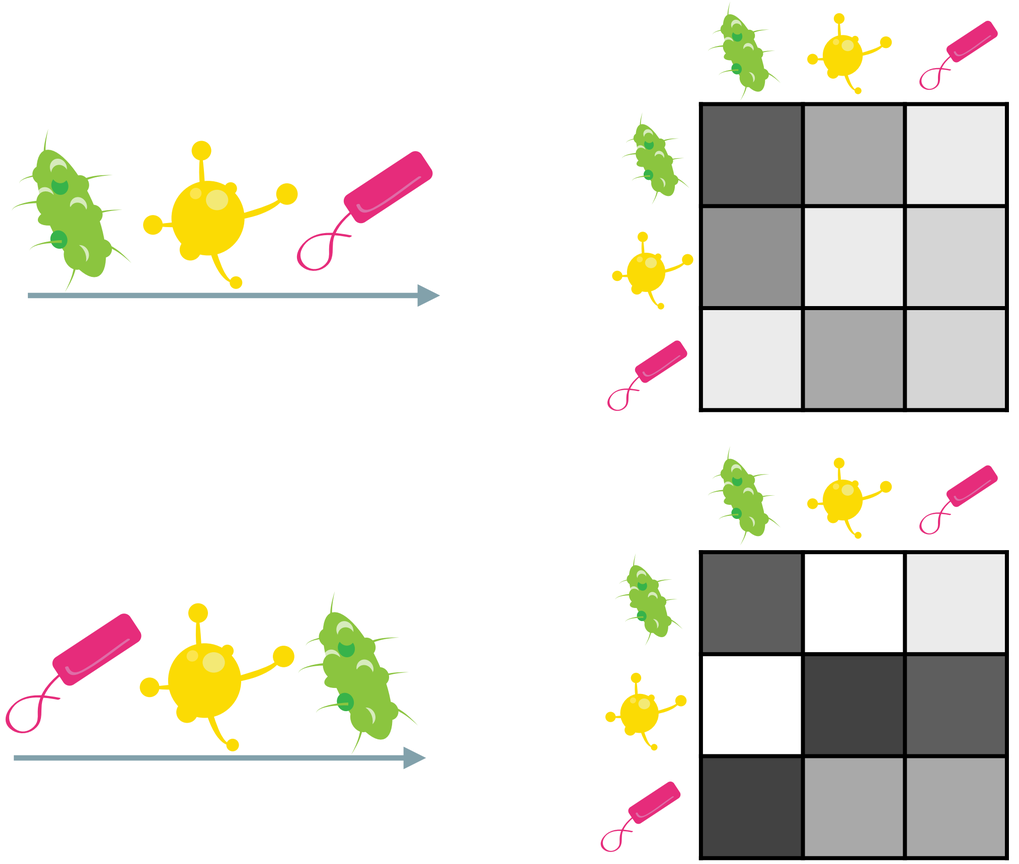
The structures of species interactions are **sensitive** to assembly history

Assembly history changes the niche relationship



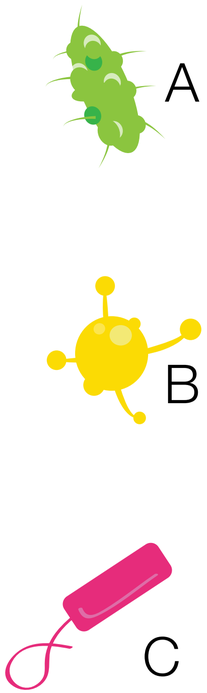
Tadashi Fukami, *Annual Review of Ecology, Evolution, and Systematics* (2015)

Assembly history → Structure of species interactions

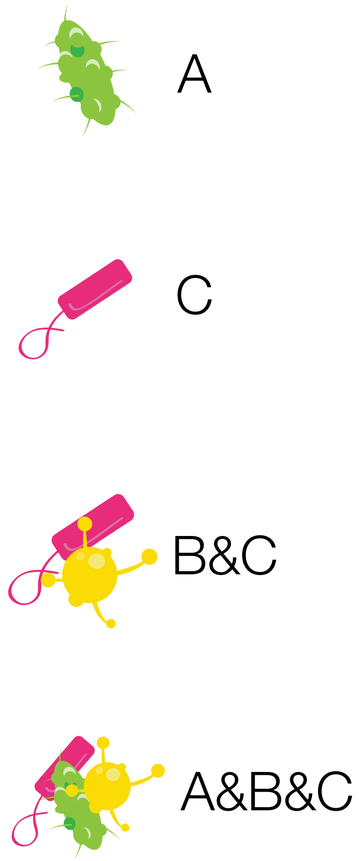


Assembly graph =
How species composition changes after species invasions

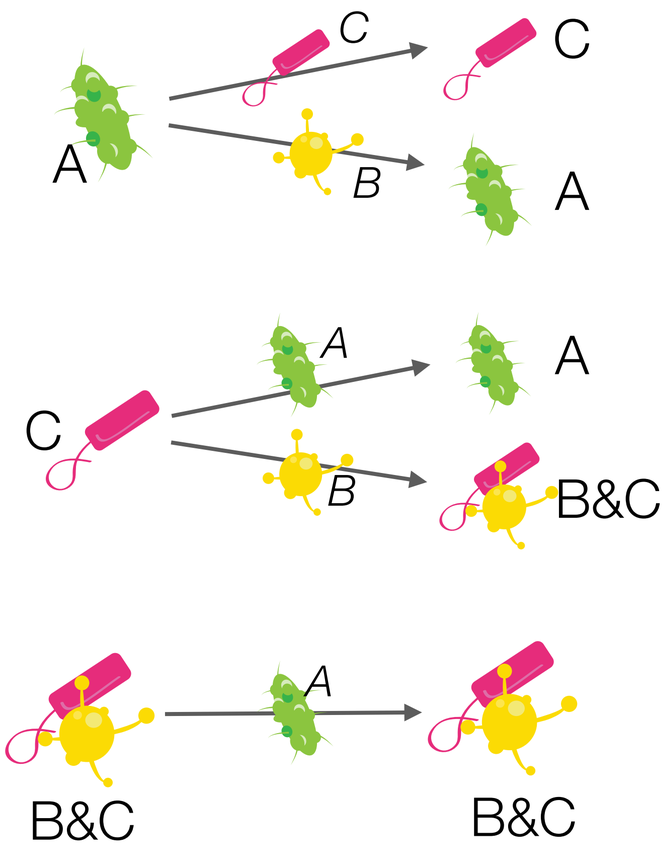
Species pool



Coexistent combination



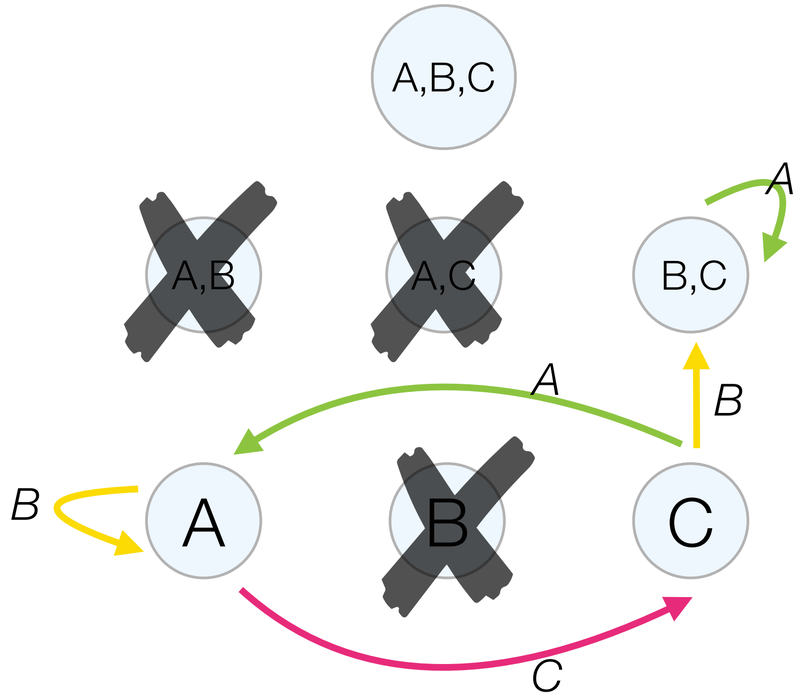
Assembly pattern



Assembly graph

Node: species composition

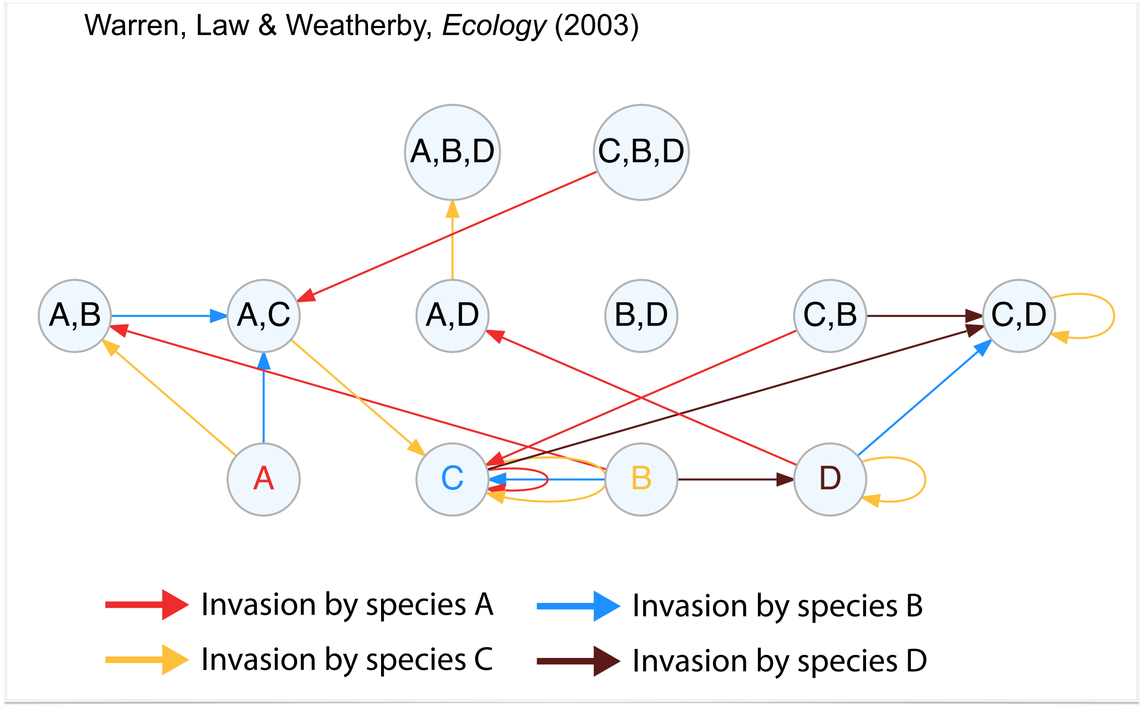
Edge: composition change after invasion



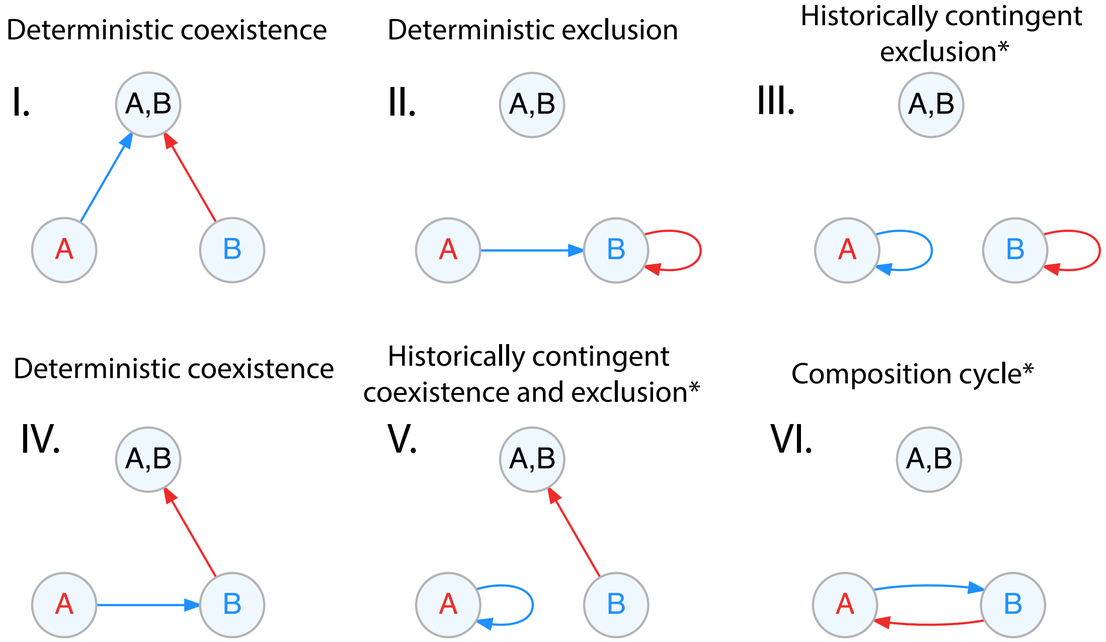
Warren et al., *Ecology* (2003)
Song et al, *Ecology Letters* (2021)

Nonparametric assembly graph captures the full landscape of ecological assembly

An empirical assembly graph

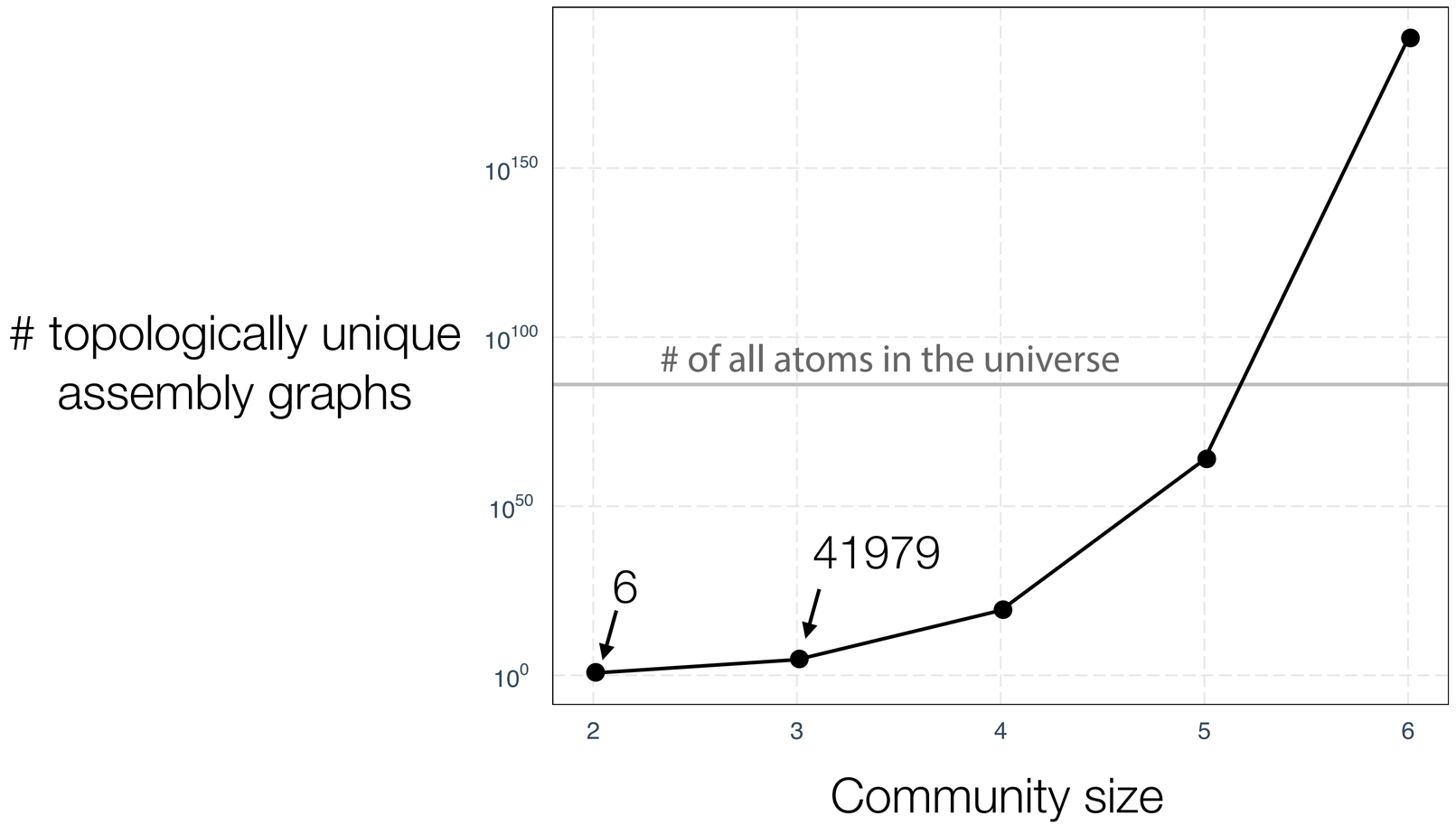


Nonparametric approach



Song et al, *Ecology Letters* (2021)

Diversity of priority effects in multispecies communities



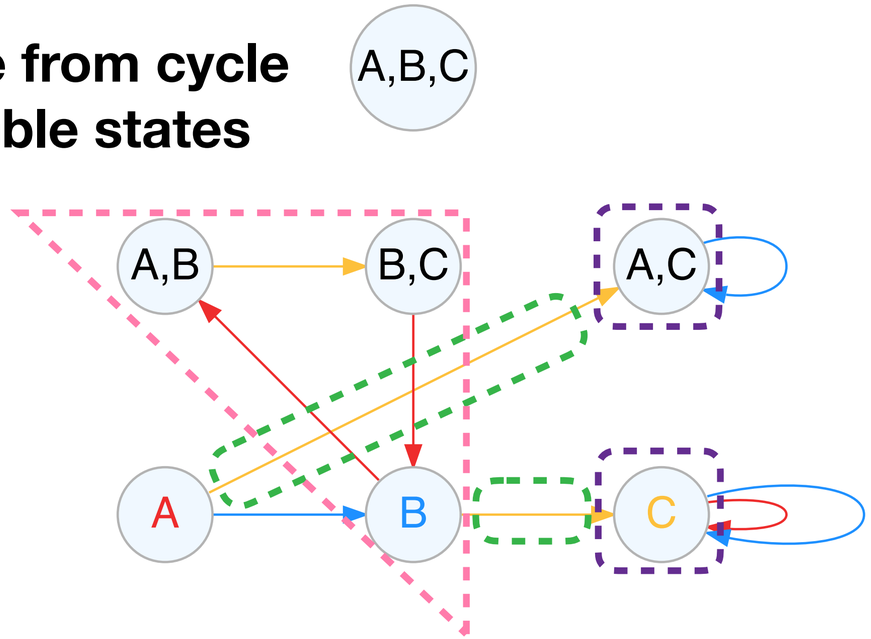
Seeking regularity in the sea of possibilities:
Four dynamical sources (topological features) in assembly graphs

Alternative stable states

Alternative transient paths

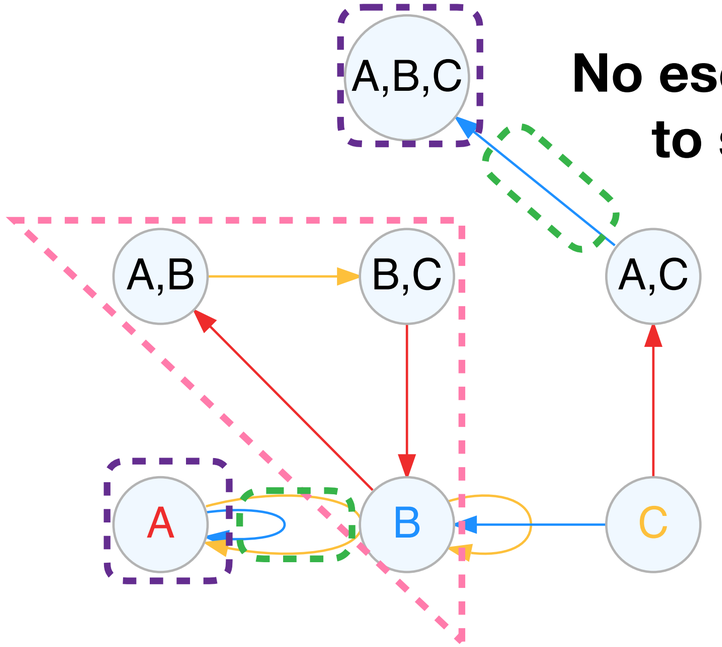
Composition cycles

Escape from cycle to stable states



Predictability = .78

No escape from cycle to stable states



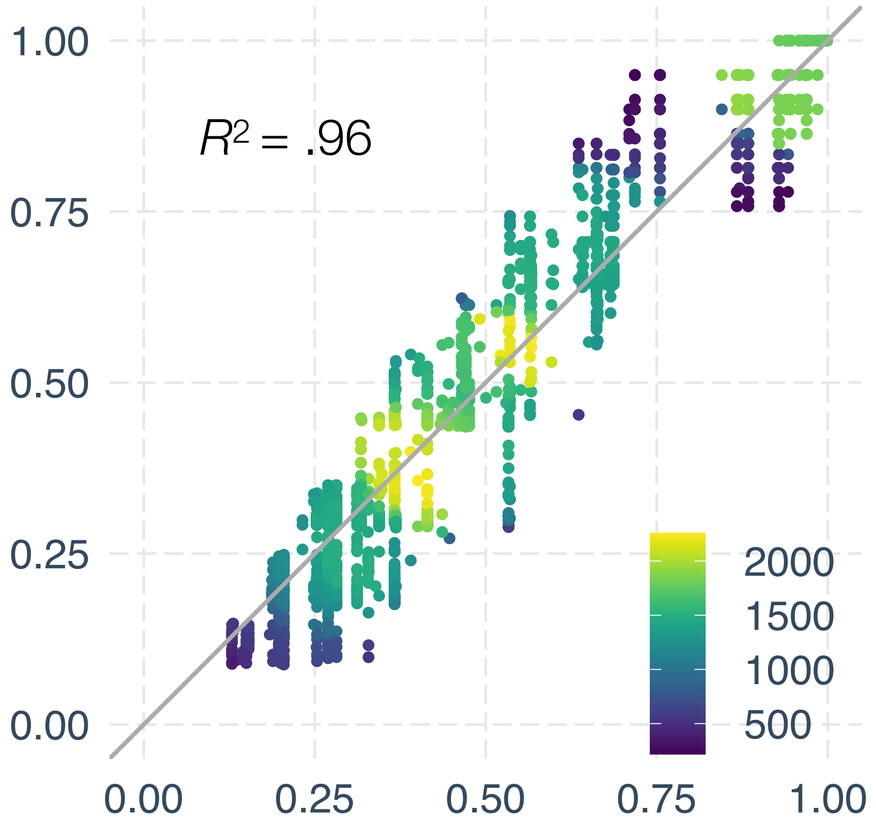
Predictability = .18

Invasion by species *A*

Invasion by species *B*

Invasion by species *C*

Four dynamical sources (topological features) explain the predictability of priority effects

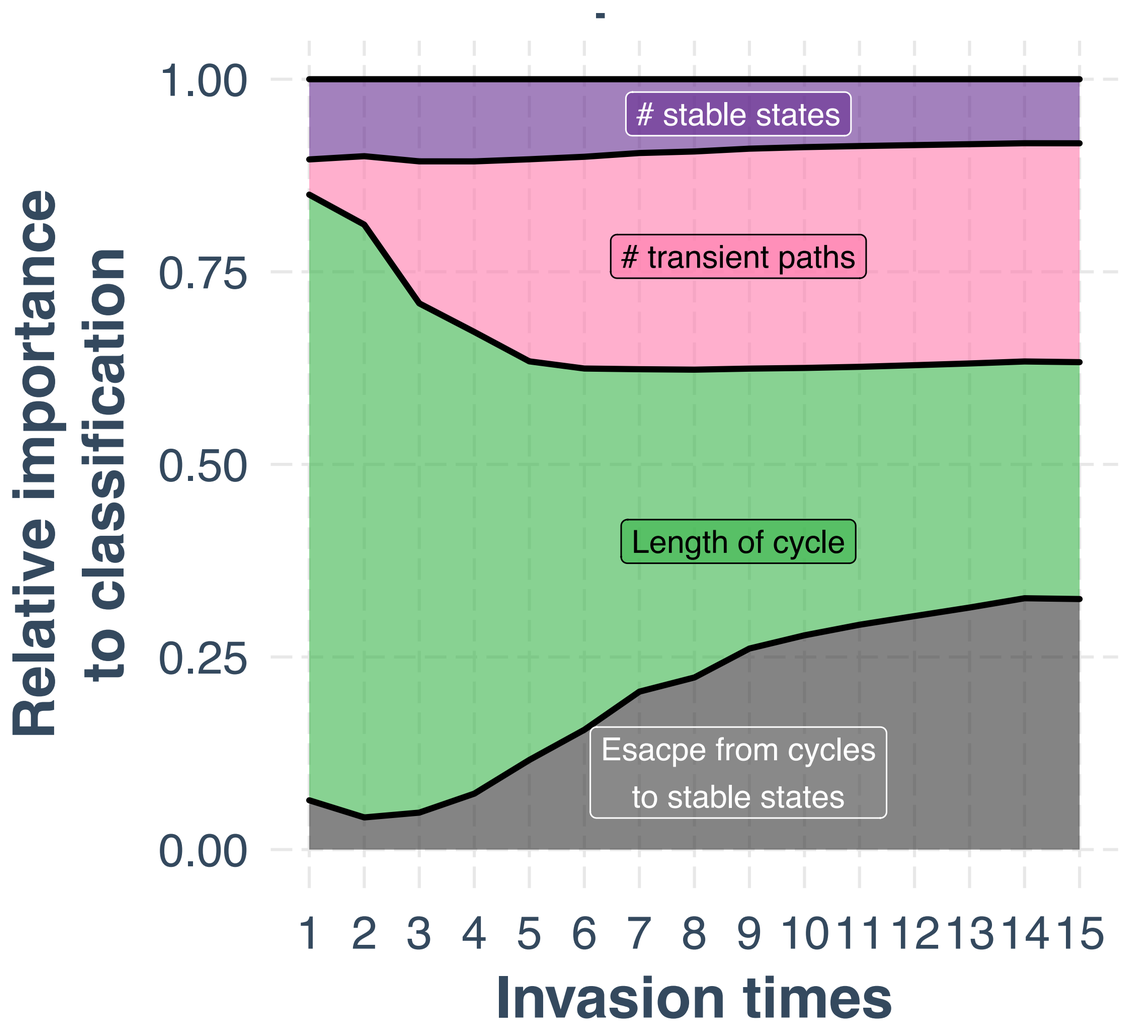


Classified predictability
(from topological features only)

Observed predictability
(direct simulation on the assembly graph)

Song et al, *Ecology Letters* (2021)

Relative importance of dynamical sources in explaining the predictability of priority effects



Song et al, *Ecology Letters* (2021)

Take-home message

- **Formulation**: A non-parametric graph-based formalism to study priority effects
- **Diversity**: Super exponential increase with community size.
- **Classification**: Priority effects can be classified by decomposing them into four basic dynamical sources:
  - ✳ The number of alternative stable states
  - ✳ The number of alternative transient paths
  - ✳ The length of composition cycles
  - ✳ The interaction between alternative stable states and composition cycles.

Thanks!

Serguei Saavedra
MIT

Tadashi Fukami
Stanford

Chuliang_Song

clsong.com