Towards a probabilistic understanding of transformations of species interactions

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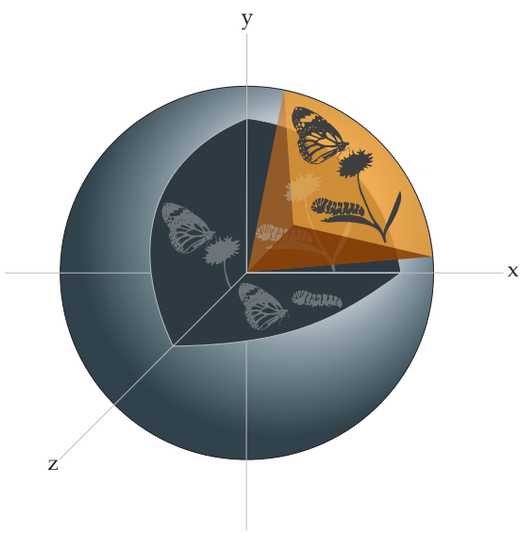


STRUCTURAL ECOLOGY

No species is an island

Competitive

Antagonistic

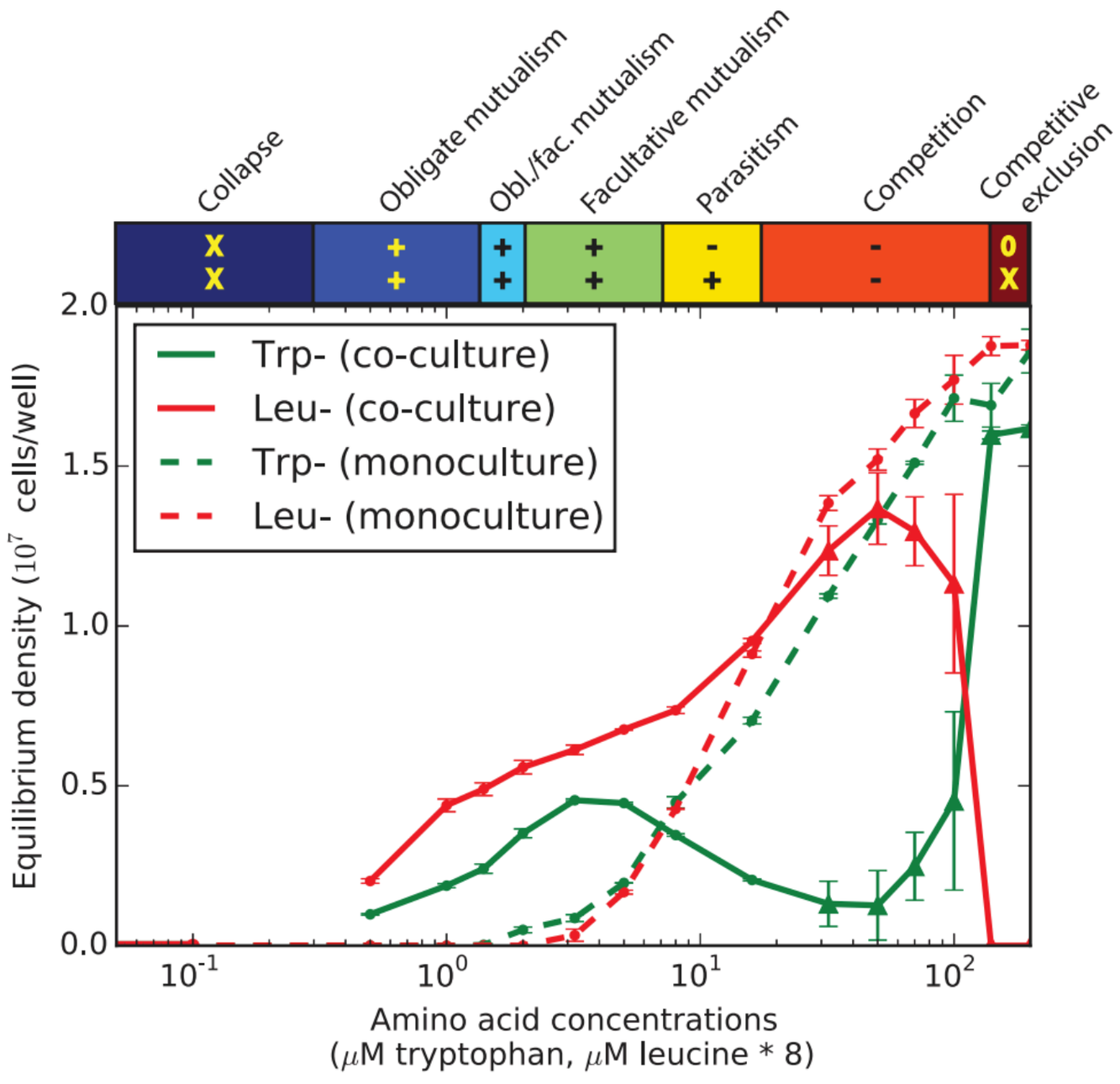
Mutualistic

Building blocks of ecological communities

Types of species interactions are not fixed

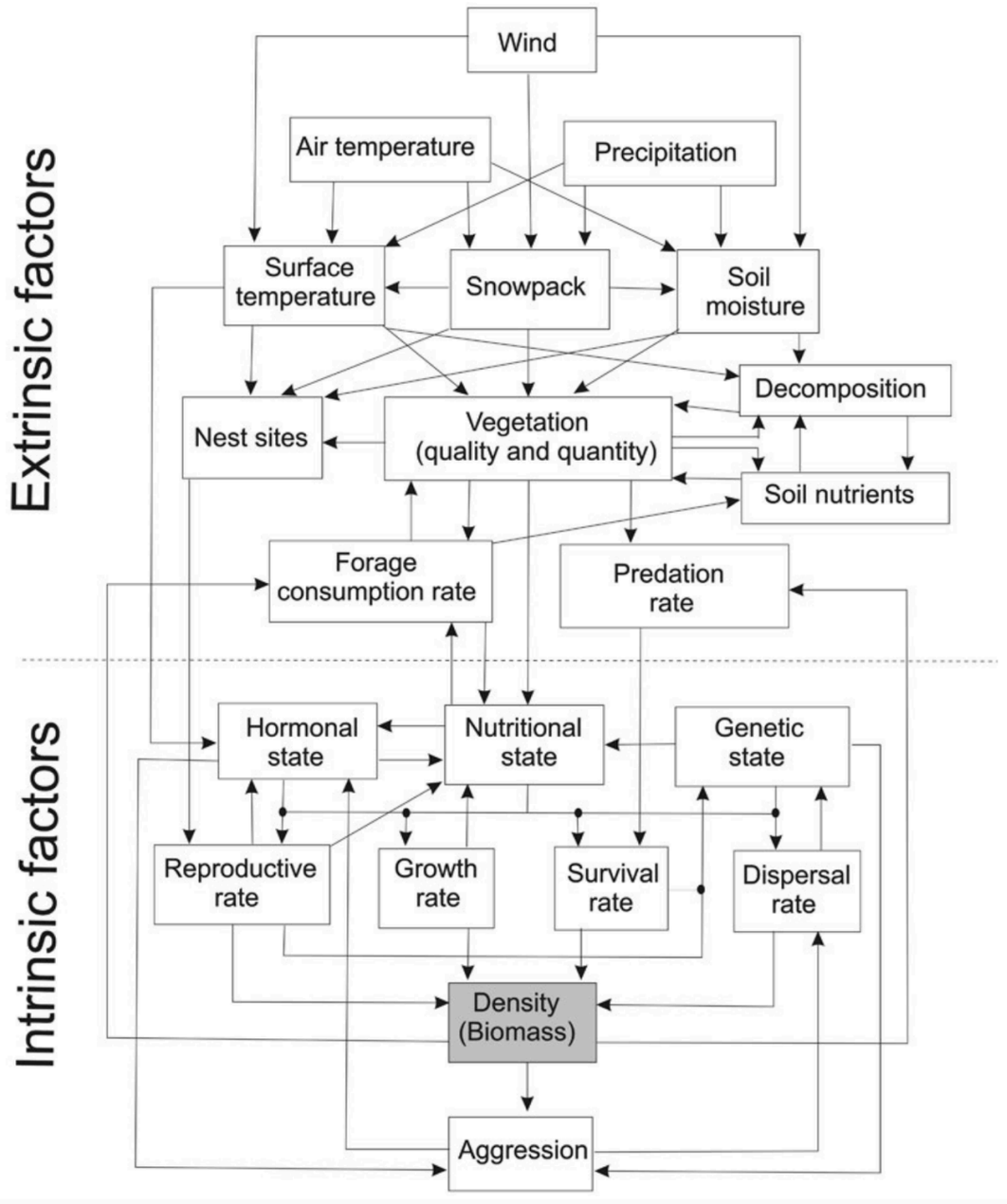
Callway et al., *Nature* (2002)

Mechanistic approach: understanding the origin of the transformation



Hoek et al., *PLOS Biology* (2016)

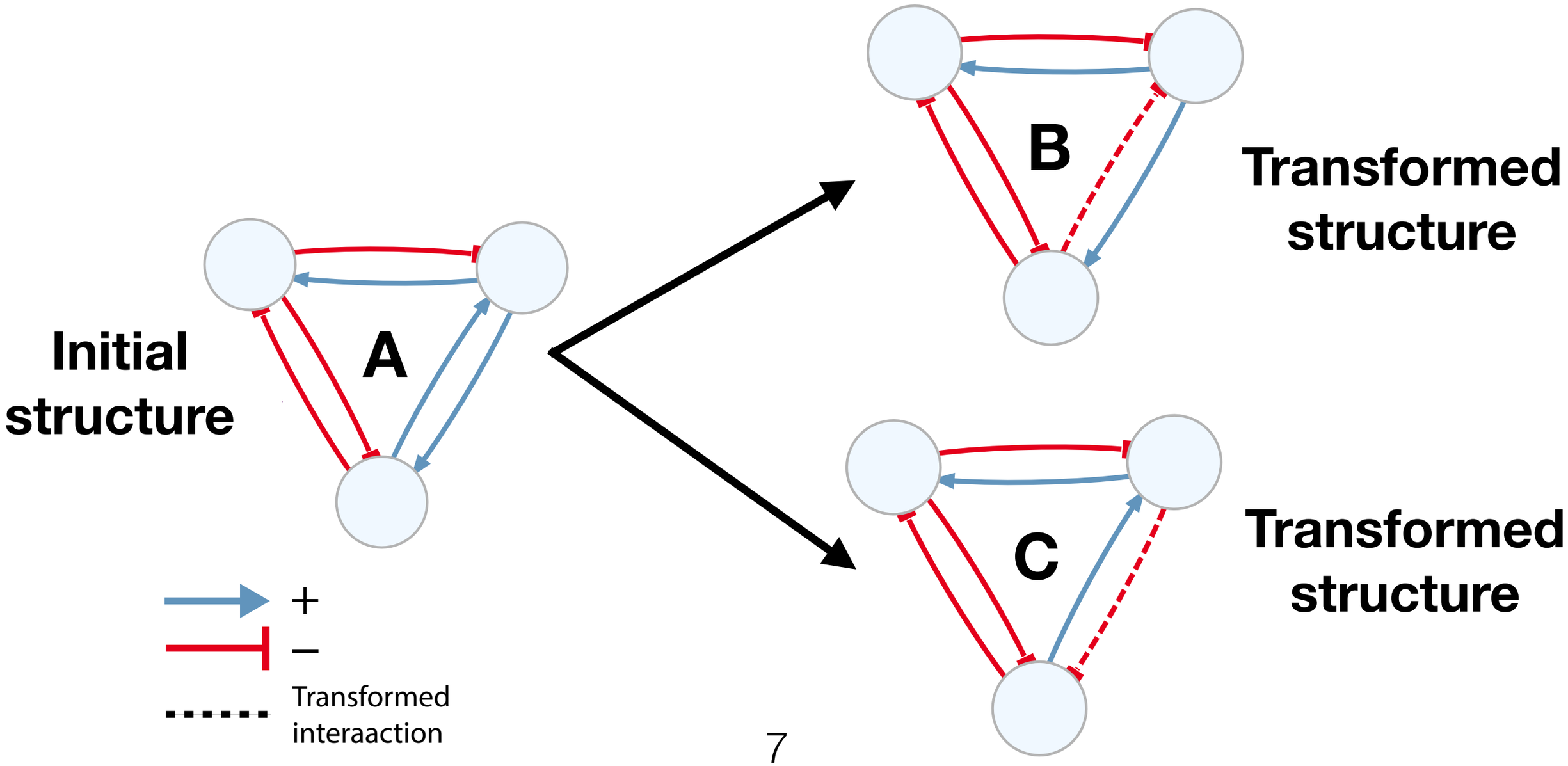
Detailed mechanistic understanding (*why*) ⇏ Predictive power in multispecies community (*when*)



Currie, *Global Ecol. Biogeogr.* (2019)

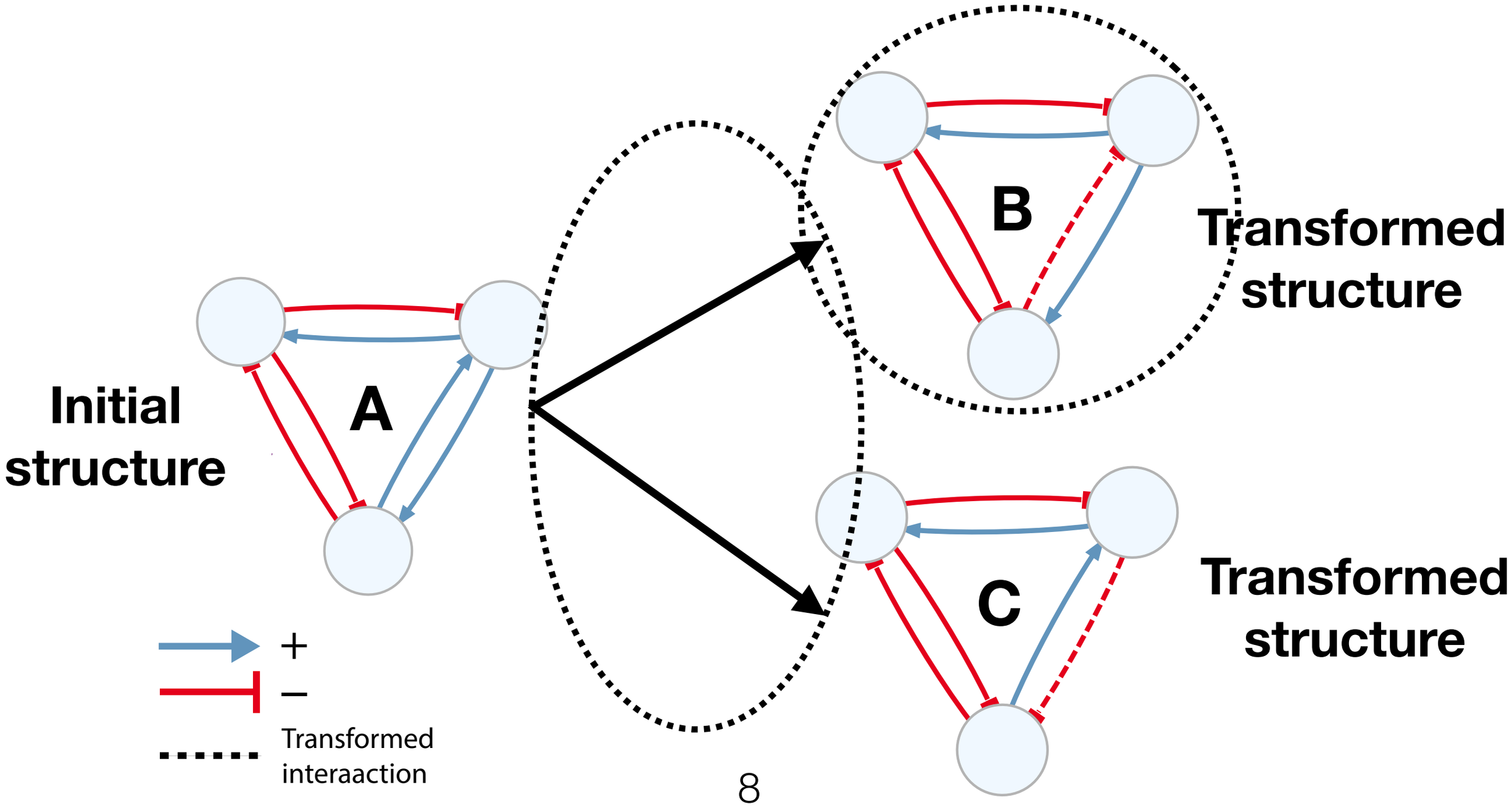
Moving from a mechanistic approach to a probabilistic one

Transformation in multispecies community



Disentangle the transformation probability

$$\mathbb{P}\textbf{(Transformation)} = \mathbb{P}\textbf{(Transition)} * \mathbb{P}\textbf{(Persistence)}$$

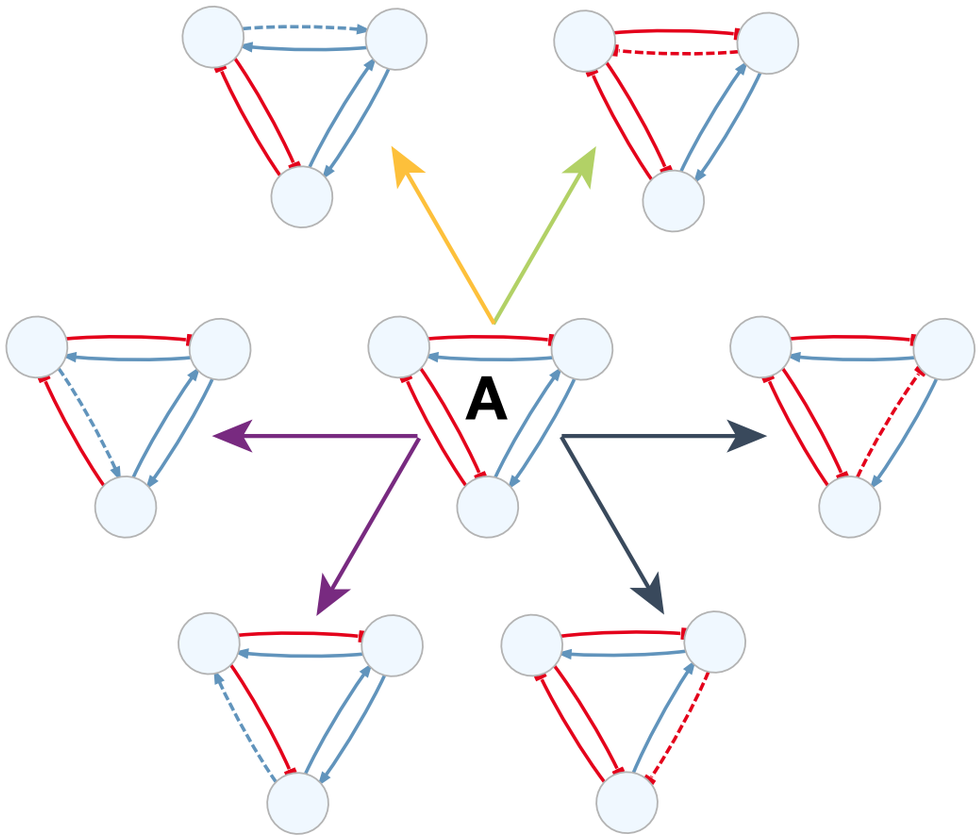


How to estimate transition probability

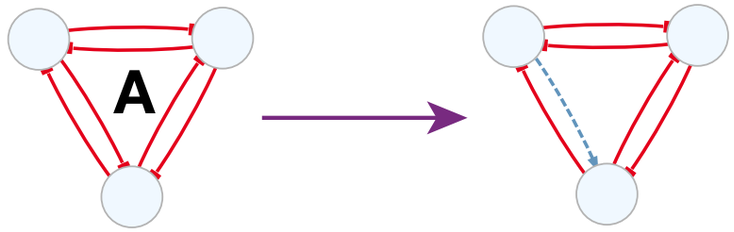
Transition probability

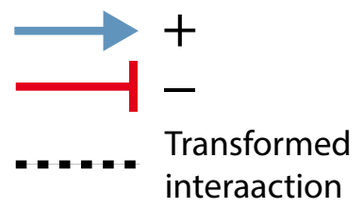
Number of potential transitions depend on the diversity of interaction types

(i) . multiple potential transitions



(ii) . single potential transition



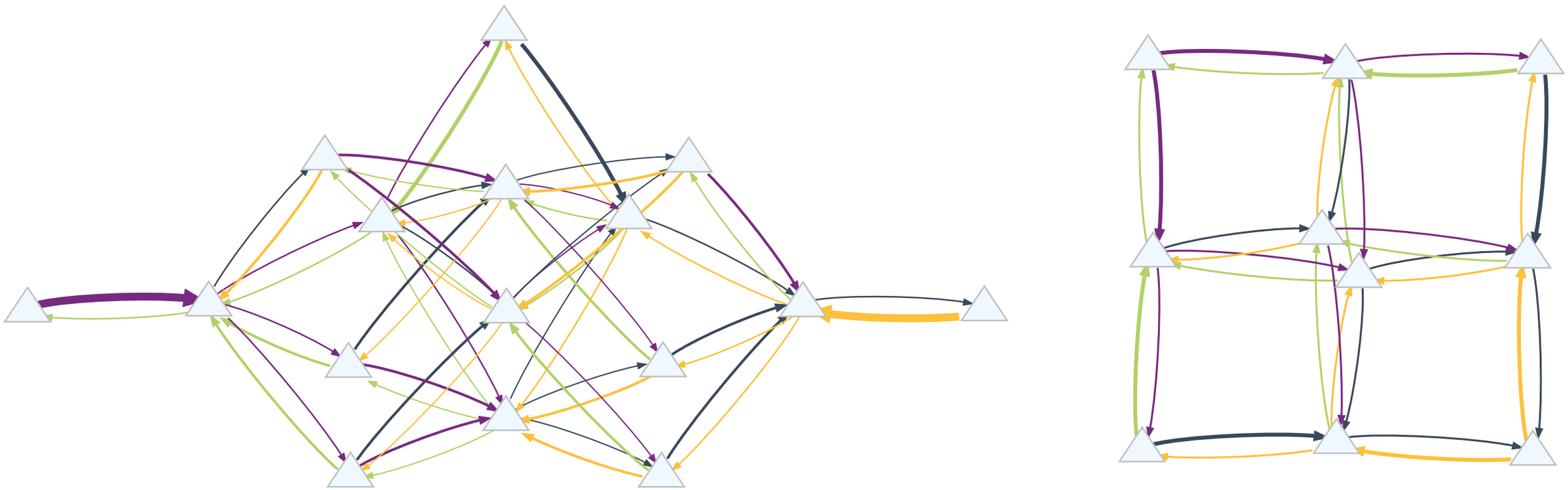


(+,–)→(+,+)
(+,–)→(–,–)
(+,+)→(+,–)
(–,–)→(+,–)

$$\mathbb{P}(\text{transition}) = \frac{1}{L_A}$$

Transition probability

Transition diagram for 3-species modules



Biotic structure

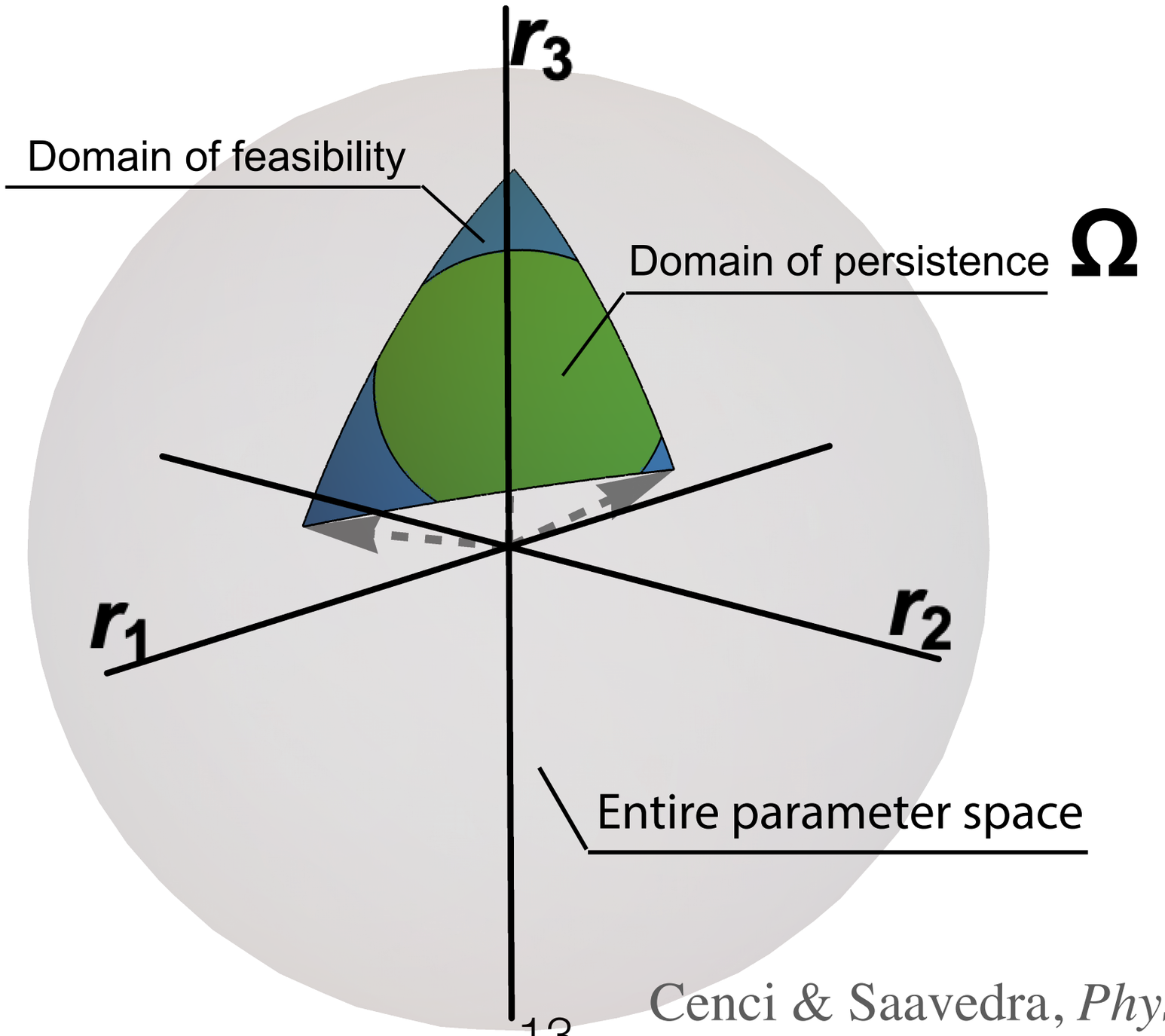
Transition probability

(+,−)→(+,+)
(+,−)→(−,−)
(+,+)→(+,−)
(−,−)→(+,−)

How to estimate persistence probability

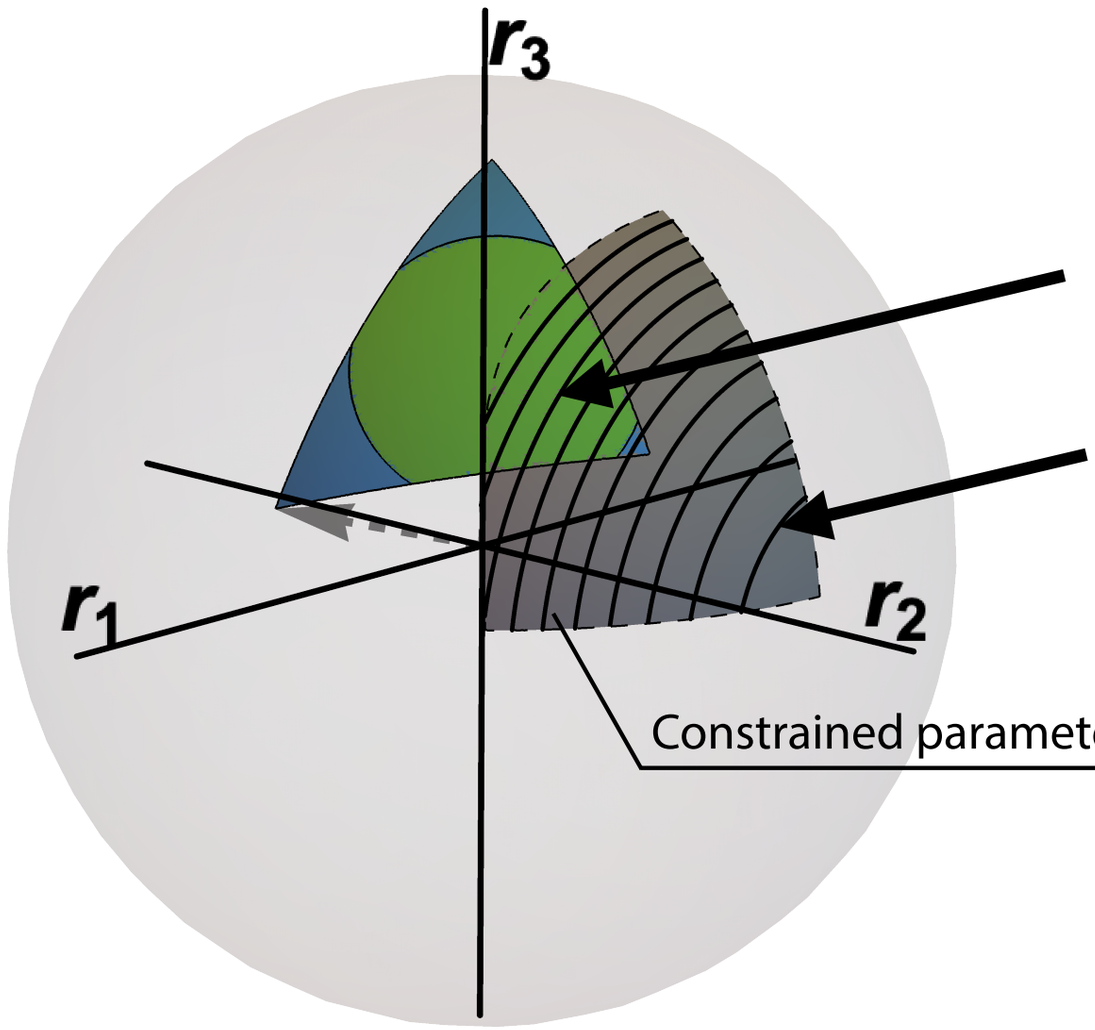
Persistence probability

Domain of persistence **Ω**



Cenci & Saavedra, *Phys. Rev. E* (2018)
Song et al., *J. Theo. Bio.* (2018)

(conditioned) Persistence probability



$$\frac{\Omega(\mathbf{A} \cap \mathcal{C})}{\Omega(\mathcal{C})}$$

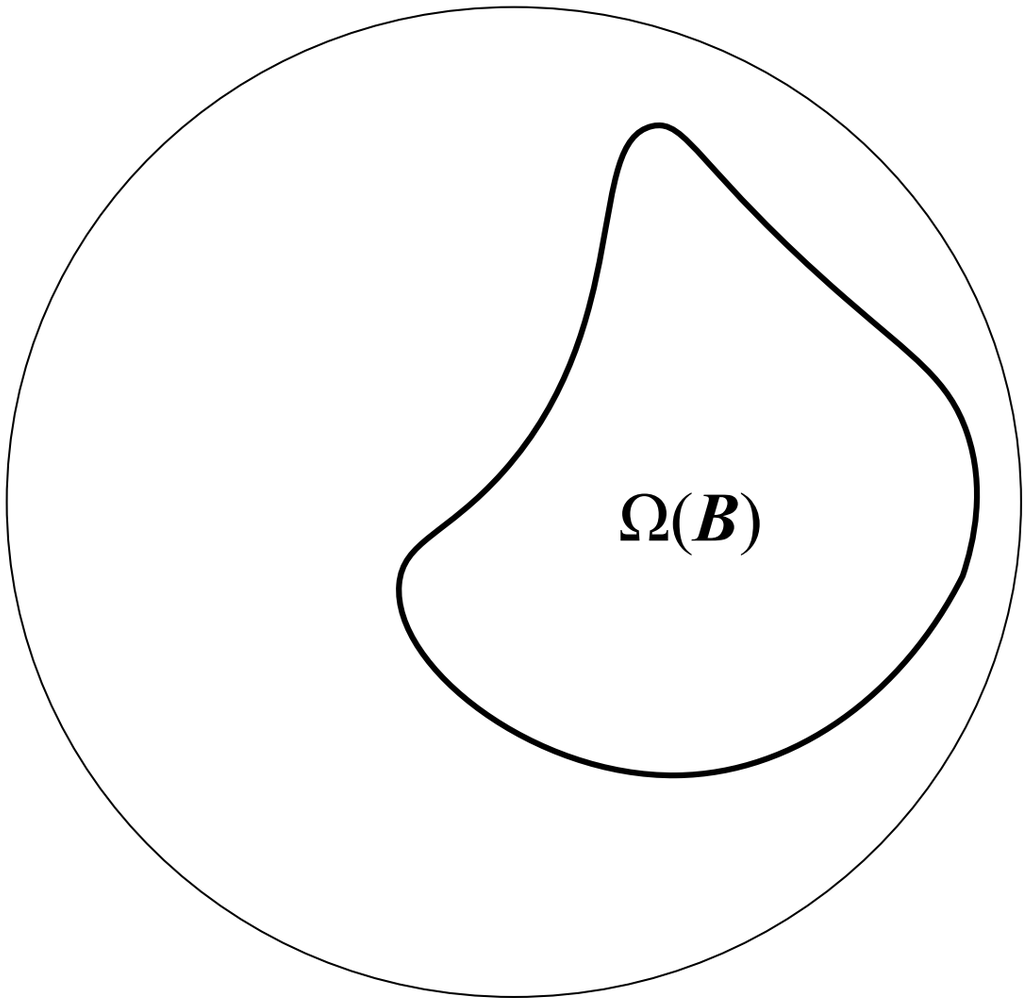
$$\mathbb{P}(\text{persistence}) = \Omega(\mathbf{A}|\mathcal{C}) = \frac{\Omega(\mathbf{A} \cap \mathcal{C})}{\Omega(\mathcal{C})}$$

Biotic structure

constrained parameter space

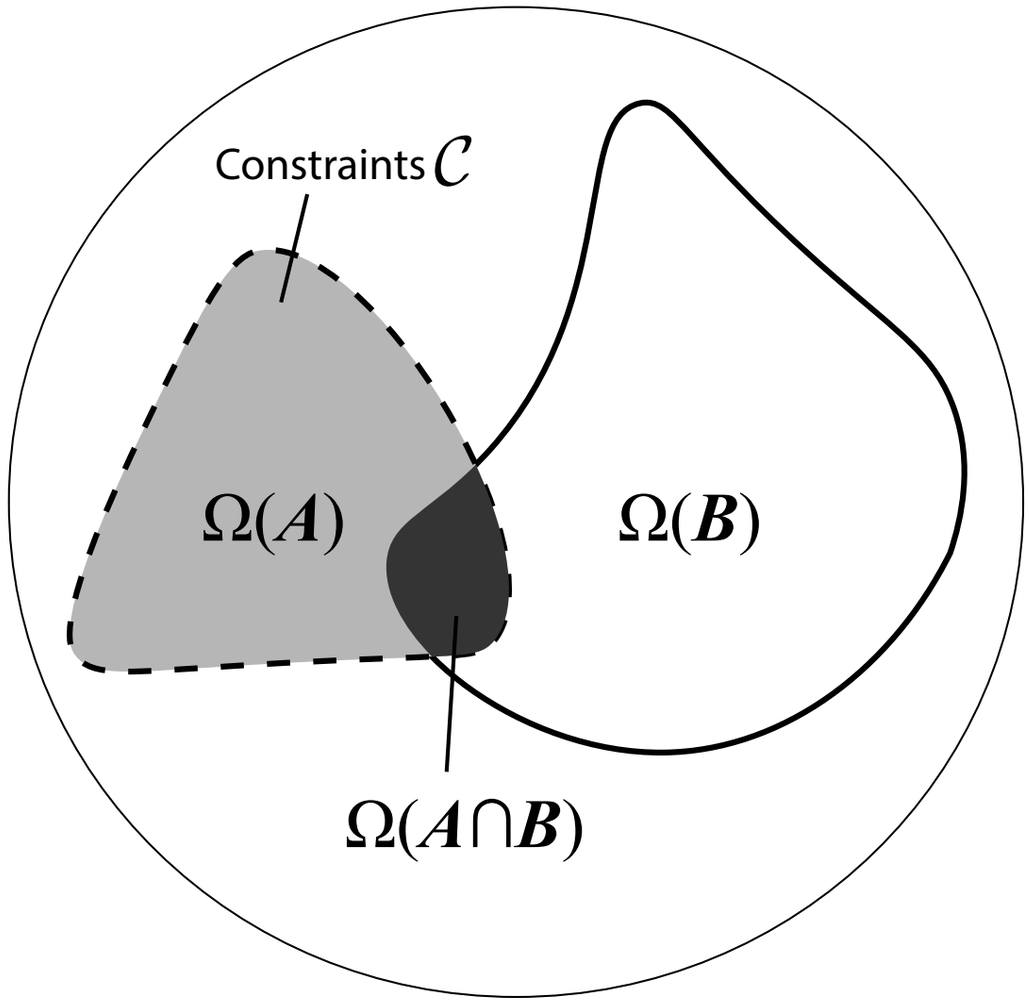
Persistence probability from ***A*** → ***B*** in two extreme scenarios

Highly changing environment



$$\mathbb{P}(\text{persistence}) = \Omega(\mathbf{B})$$

Relatively fixed environment

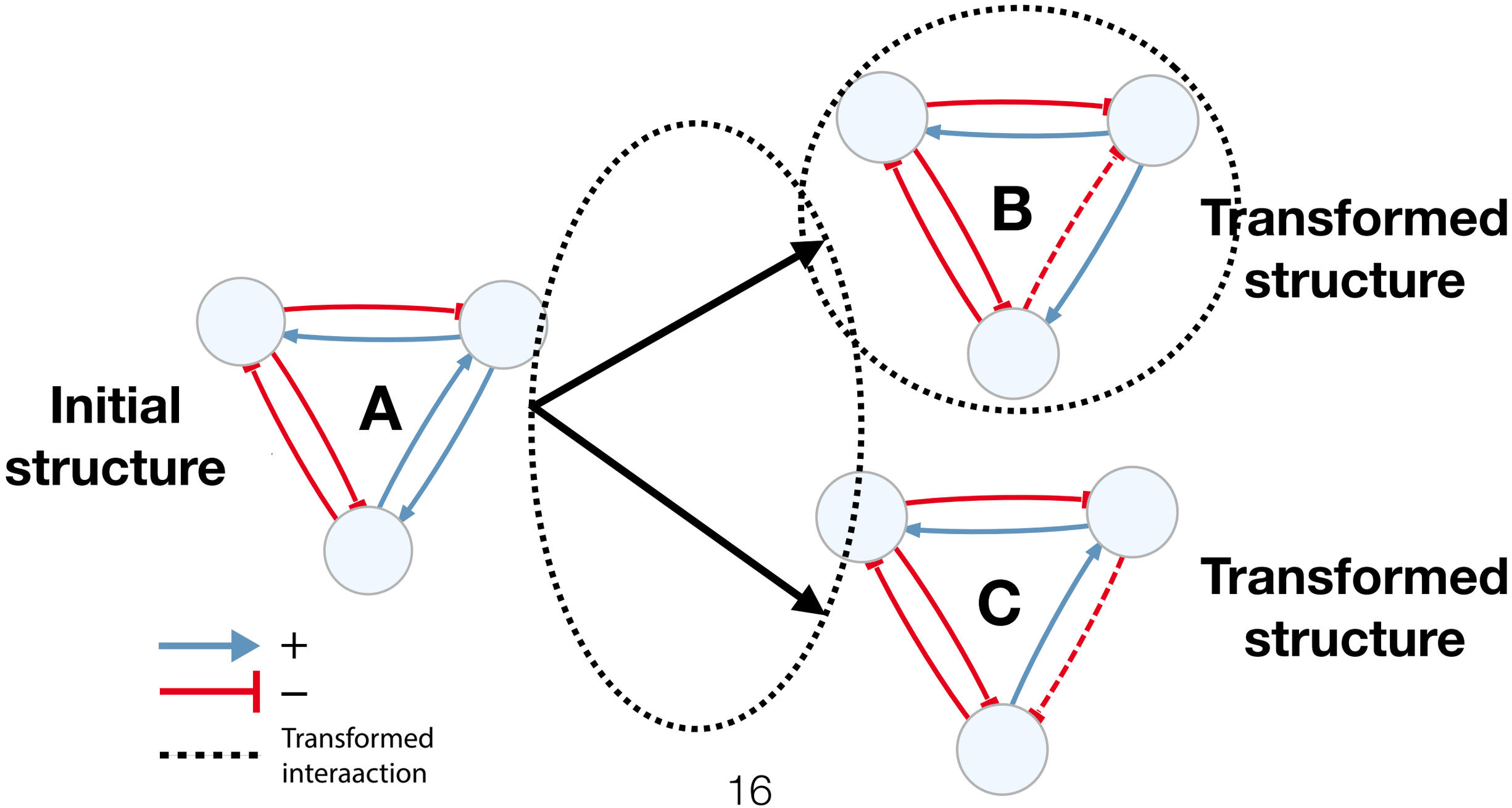


$$\mathbb{P}(\text{persistence}) = \frac{\Omega(\mathbf{A} \cap \mathbf{B})}{\Omega(\mathbf{A})}$$

Summary of the probabilistic approach

$$1/L_A * \Omega(\mathbf{B}|\mathcal{C})$$

$$\mathbb{P}\textbf{(Transformation)} = \mathbb{P}\textbf{(Transition)} * \mathbb{P}\textbf{(Persistence)}$$



Why this probabilistic disentanglement can be useful for context-dependency?

Sources of context-dependency

Biotic structure

$\mathbb{P}$ **(Transition)**

Phenomenological species interactions

Abiotic conditions

$\mathbb{P}$ **(Persistence)**

Probabilistic estimation of environmental variability

Computationally feasible

Reconciling empirical findings

Contrasting results on transformations

Mutualism is the ***most*** likely to transform
in **laboratory** experiments.

Review and Synthesis | Free Access

How context dependent are species interactions?

Scott A. Chamberlain ✉, Judith L. Bronstein, Jennifer A. Rudgers

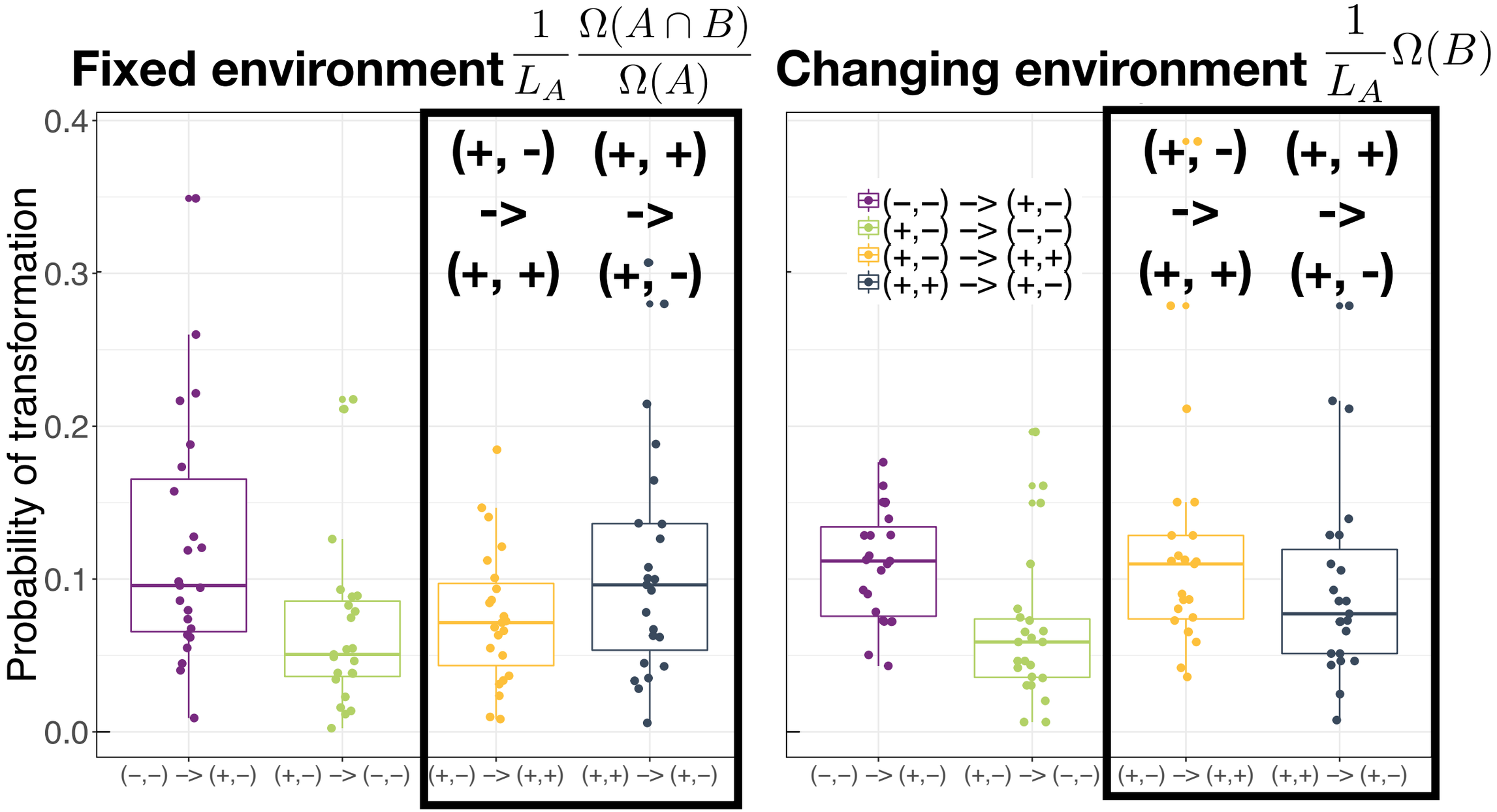
Mutualism is the ***least*** likely to transform
in **nature**.

Opinion

Mutualisms Are Not on the Verge of Breakdown

Megan E. Frederickson[1,*]

Inevitable trade-off



A larger domain of persistence
gives advantage to persistence in a changing environment,
but also opens door to more transitions in a fixed environment.

Take home message

- We advocate for a probabilistic approach to provide a null expectation of transformation probability

- The probabilistic approach disentangles the transformation probability into (quantifiable) transition and persistence probabilities

- This framework reconciles why mutualism persists in nature despite being most likely to transform in laboratory experiments

Acknowledgement

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