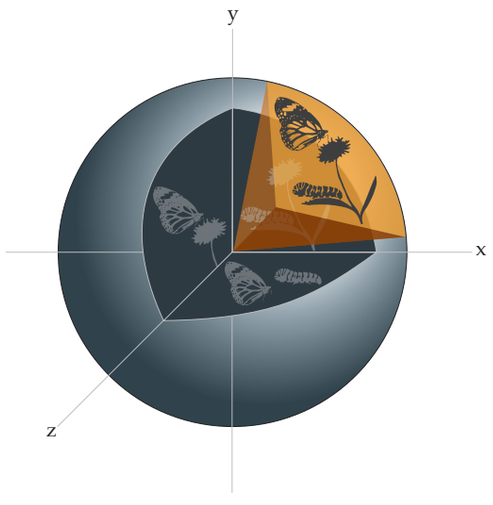
Structural changes within trophic levels are constrained by within-family assembly rules at lower trophic levels

Chuliang Song

Department of Civil and Environmental Engineering, MIT

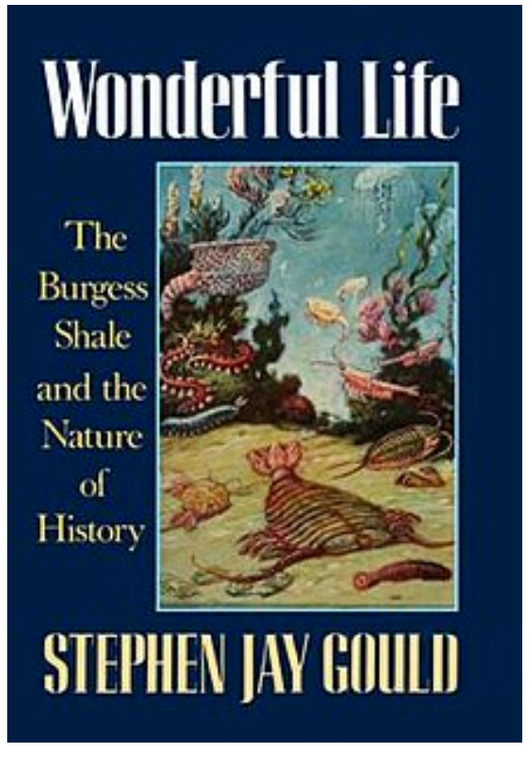


STRUCTURAL ECOLOGY

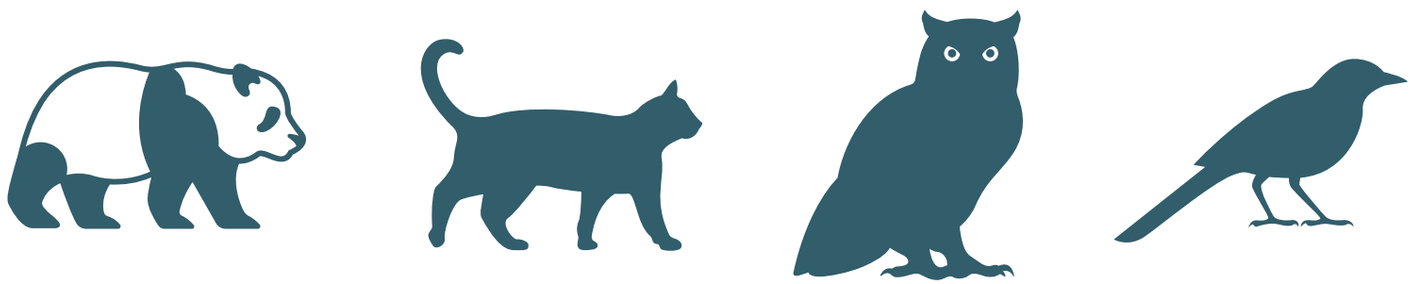
08/07/2018, ESA Annual Meeting

Replay the tape of life & Historical contingency

Stephen J. Gould

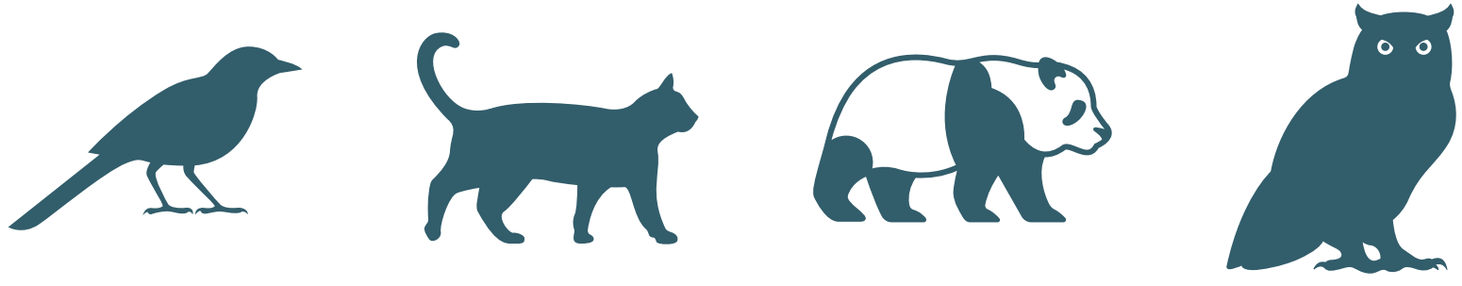


Observed world



Observed arrival order

Alternative world**s**



Alternative arrival order

Q1: How does the observed arrival order affect community persistence?

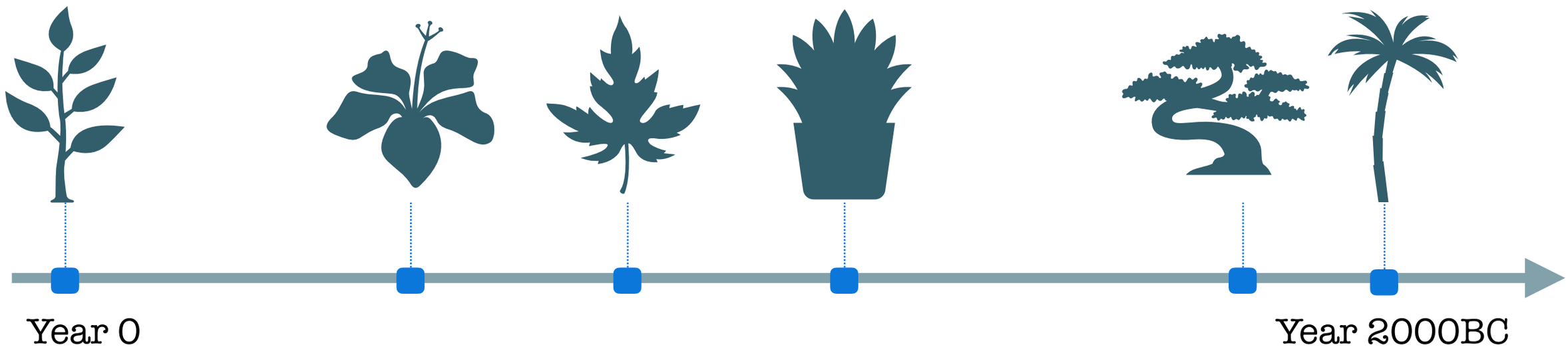
Q2: In which alternative worlds can we detect the same effect?

A 2000-year long registry of plant arrivals

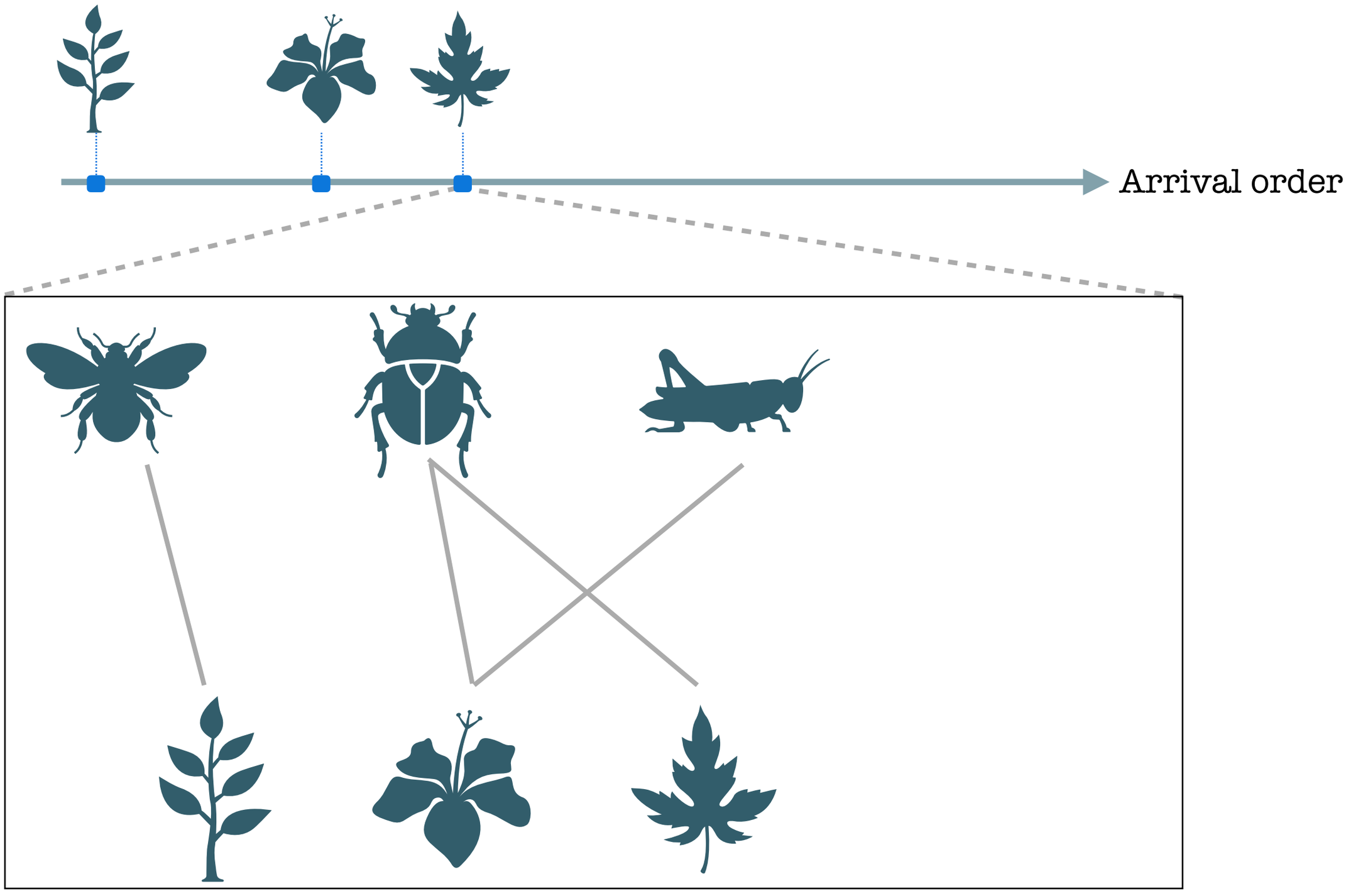
Pearse & Altermatt, *Ecology*, 2013

Temporal structure of herbivore-plant community

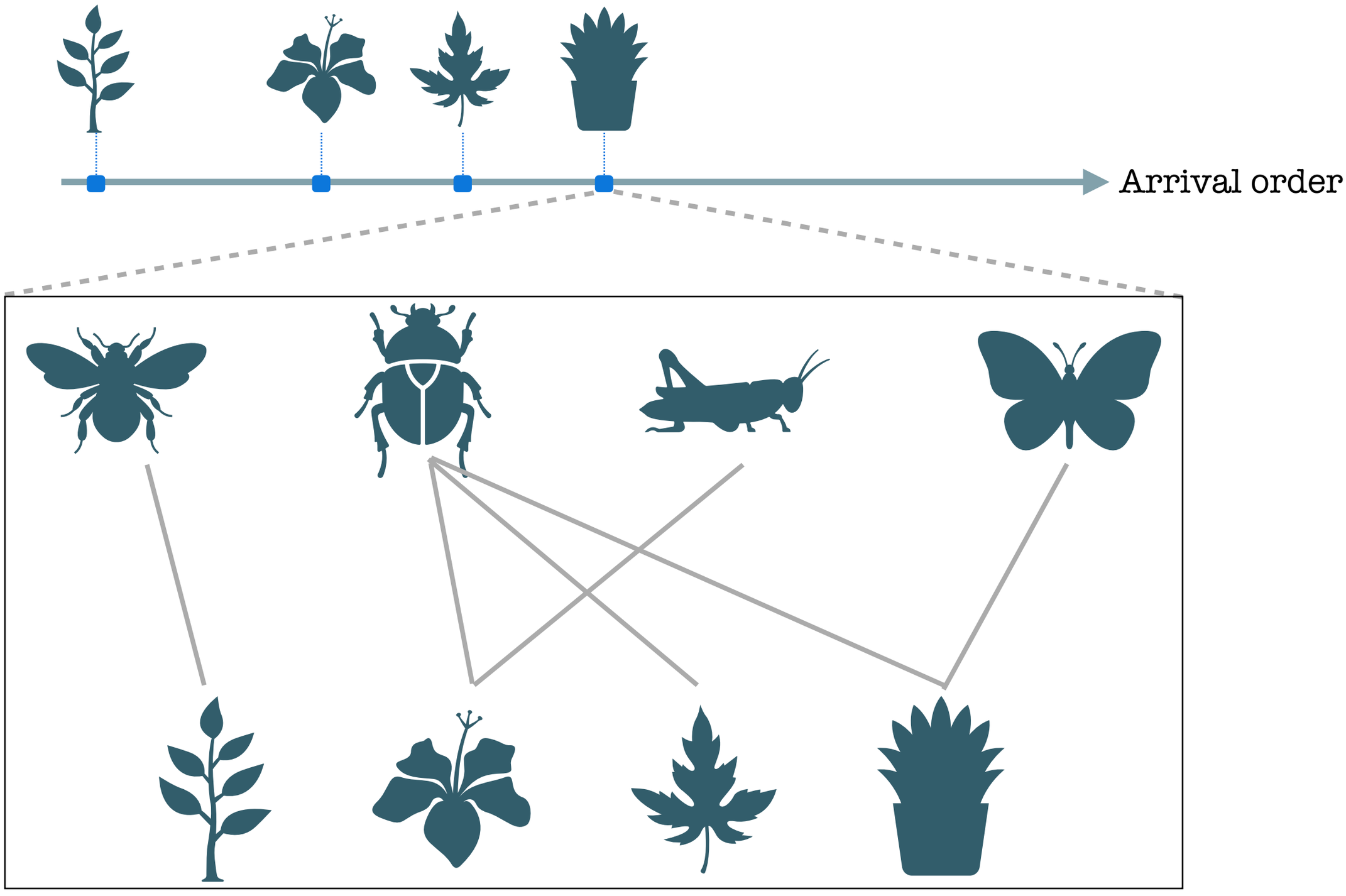
Introduction year of non-native plants over 2000 years



Structure of herbivore-plant community at each time



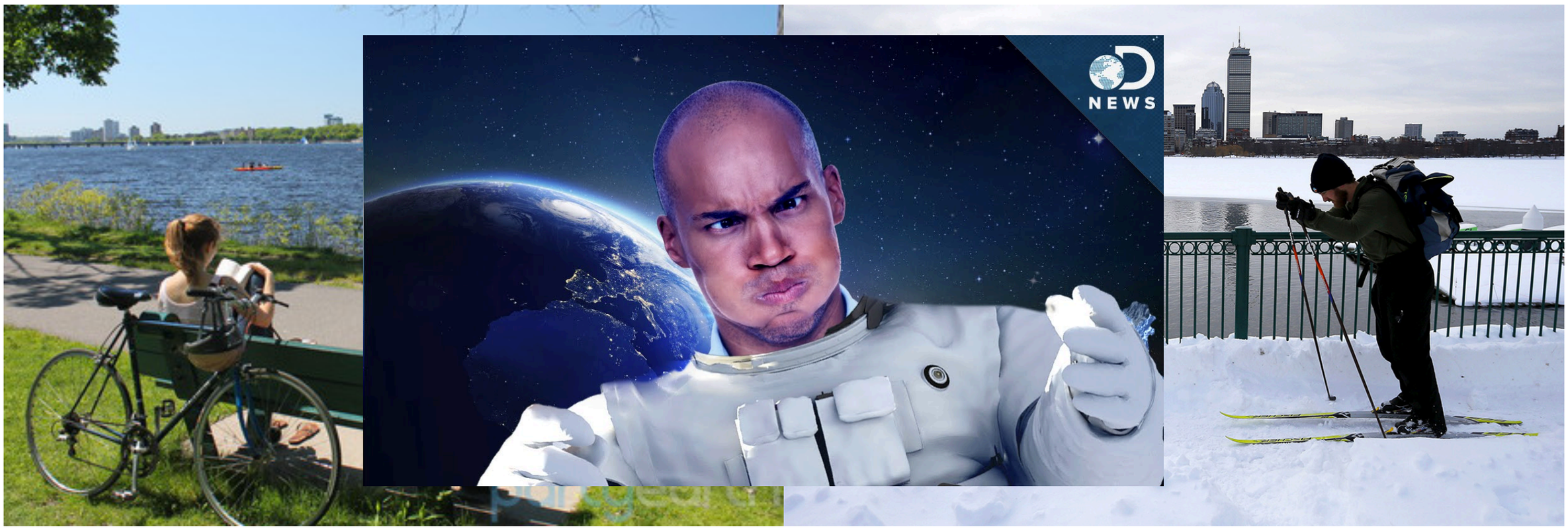
Structure of herbivore-plant community changes with new introduced plant



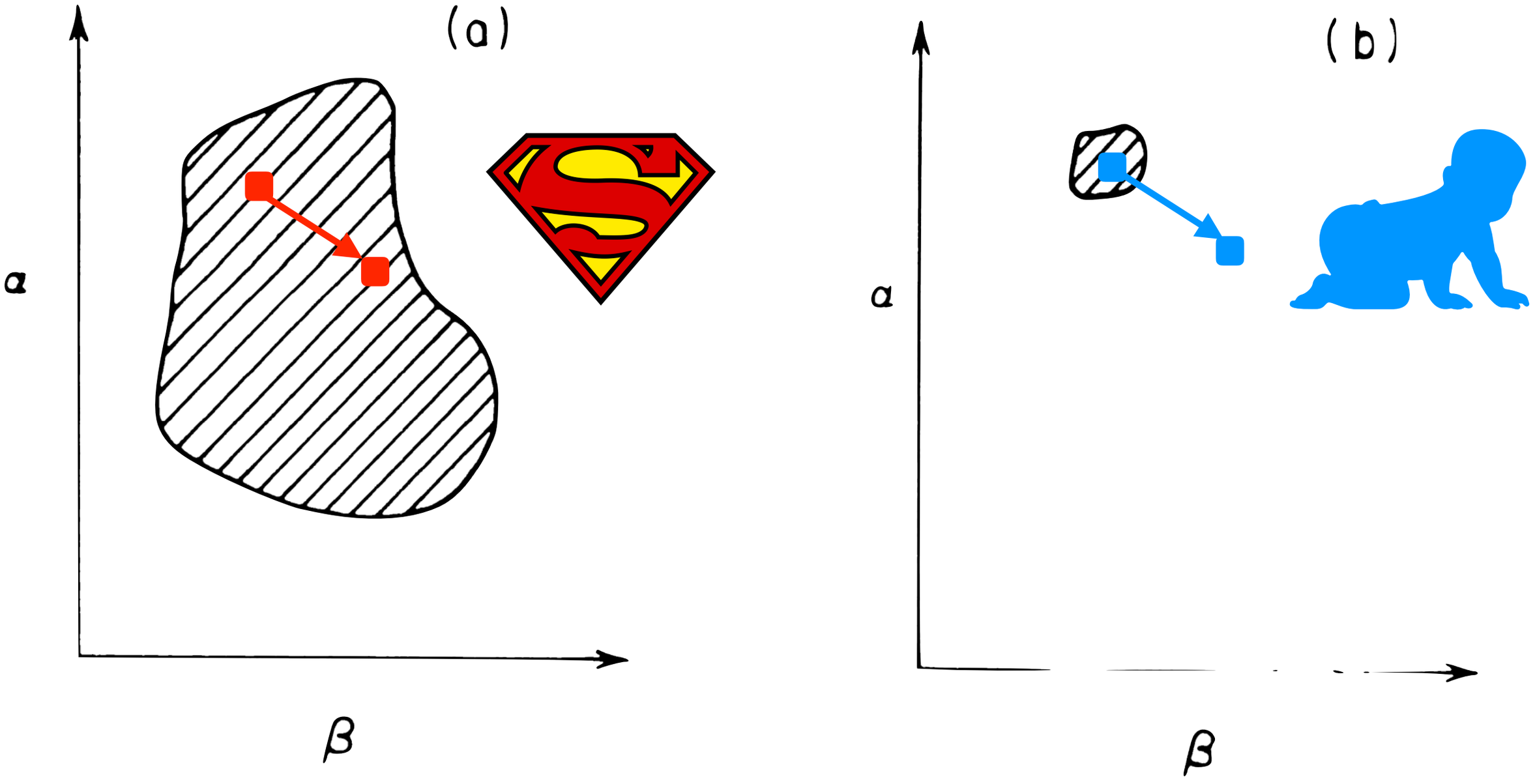
How does changes in community structure affect community persistence？

What is Structural Stability of Persistence?

- The full range of environmental conditions (parameter values) compatible with the persistence of an ecological community

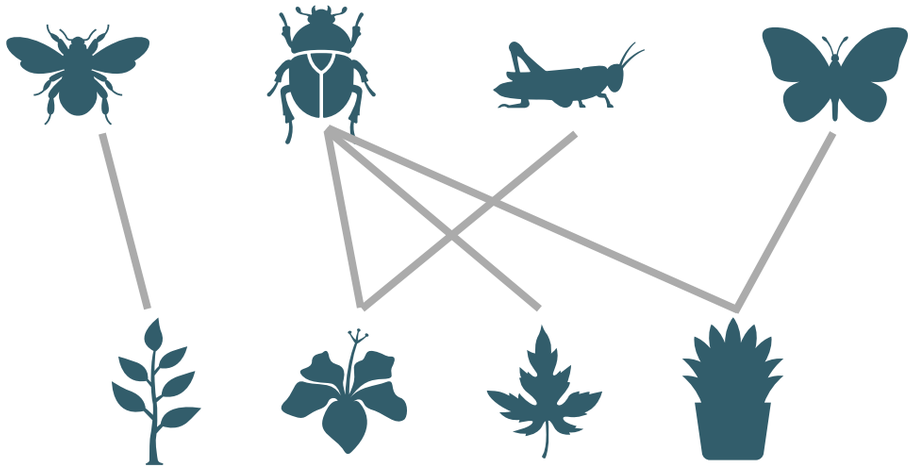


Larger structural stability = Better chance to persist



May, *Stability in ecosystems: some comments* (1975)

How to quantify structural stability



Community structure

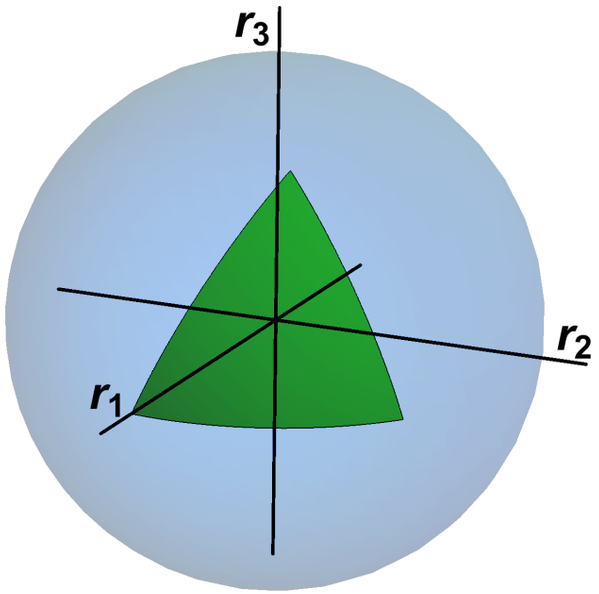
Species abundance — interaction strength

$$\frac{dX_i}{dt} = X_i(r_i + \sum_{j=1}^{S} a_{ij}X_j)$$

intrinsic growth rate

Community dynamics

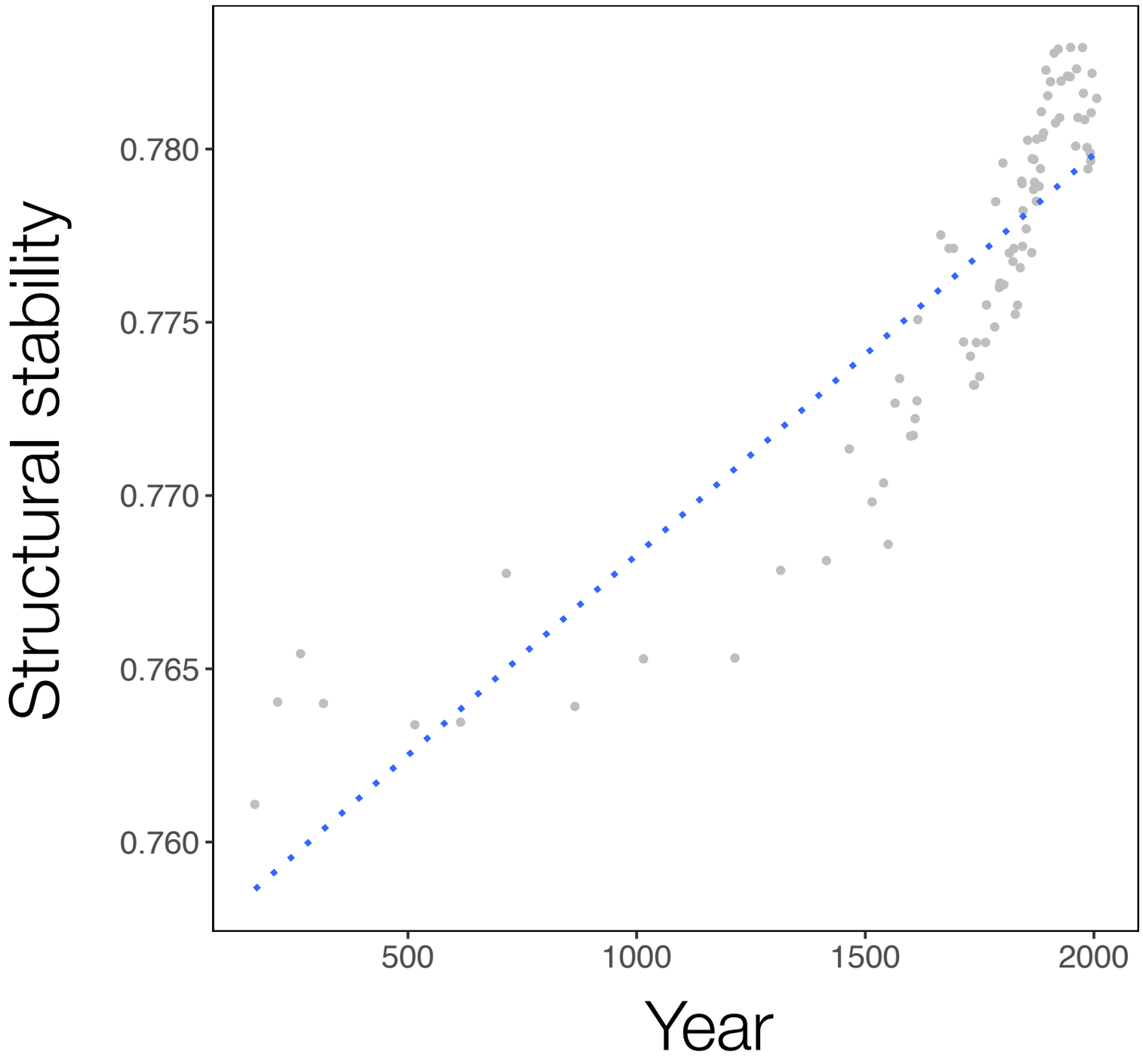
Environmental conditions
compatible with persistence



Structural stability := $\frac{\text{Green area}}{\text{Blue area}}$

Song et al., *J. of Theoretical Biology* (2018)

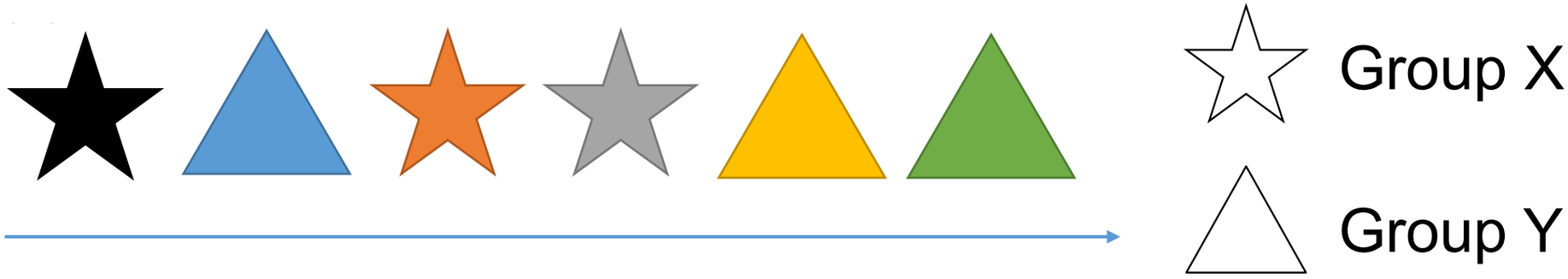
Structural stability generally increased as the community assembled over 2000 years



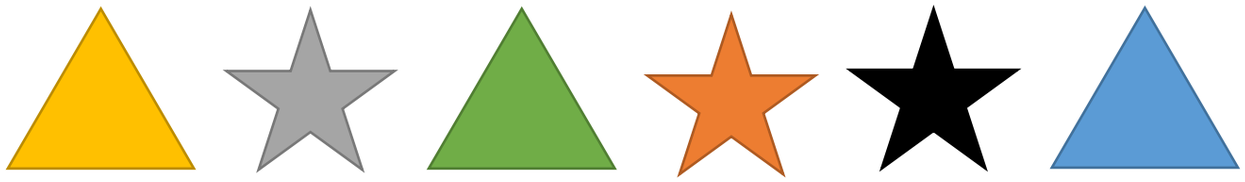
Would this positive trend be detected in any alternative world?

A universe of alternative worlds with purely random arrival orders

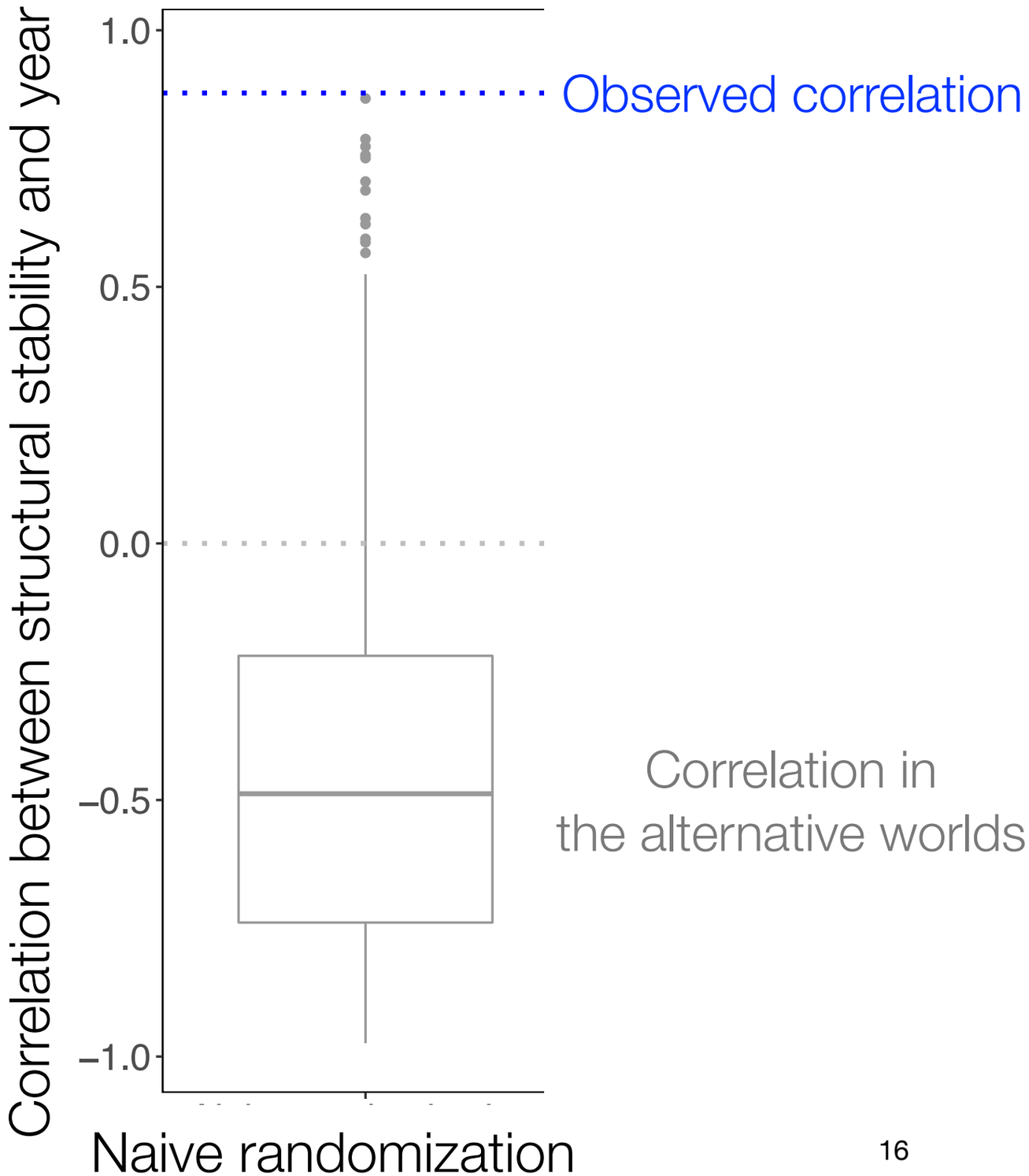
Observed arrival order of plants

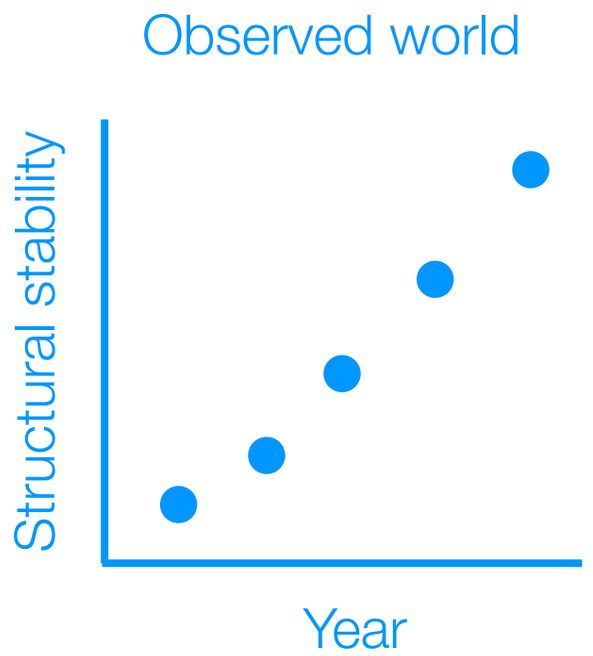


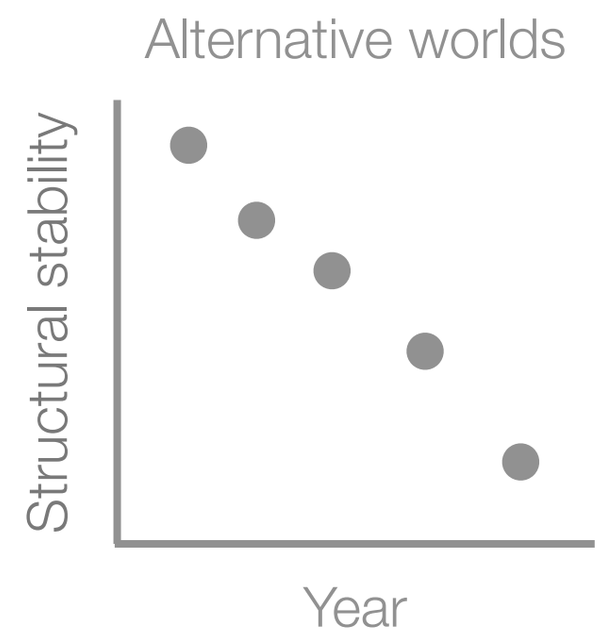
- Random reshuffling the order



Structural stability is most likely to decrease if the arrival order is purely random



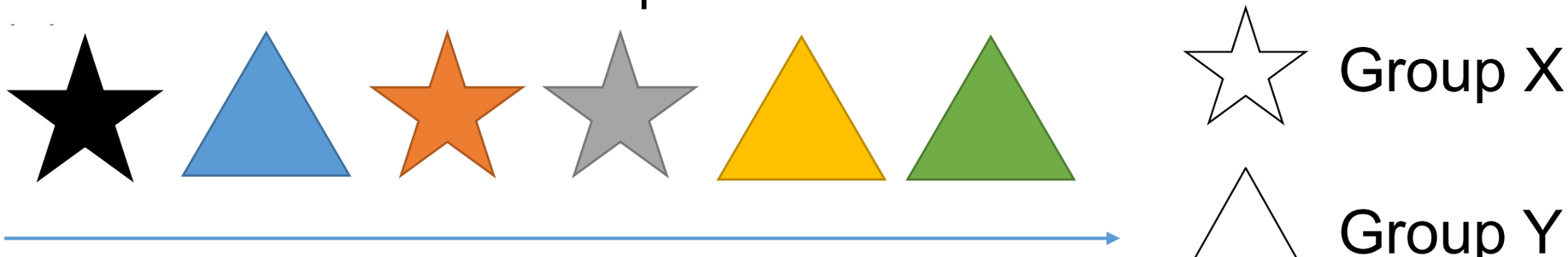




In which alternative worlds
can we detect
the observed positive trend?

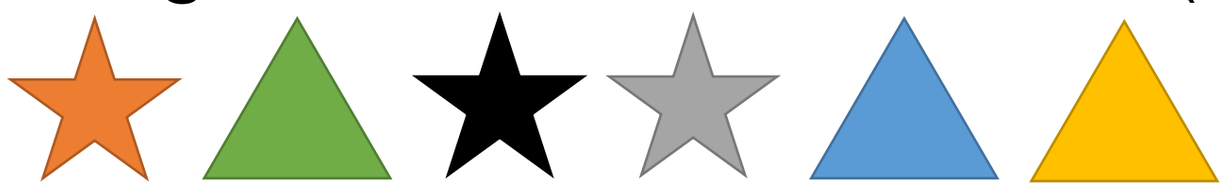
Universes of alternative worlds with assembly rules of plant arrivals

Observed arrival order of plants



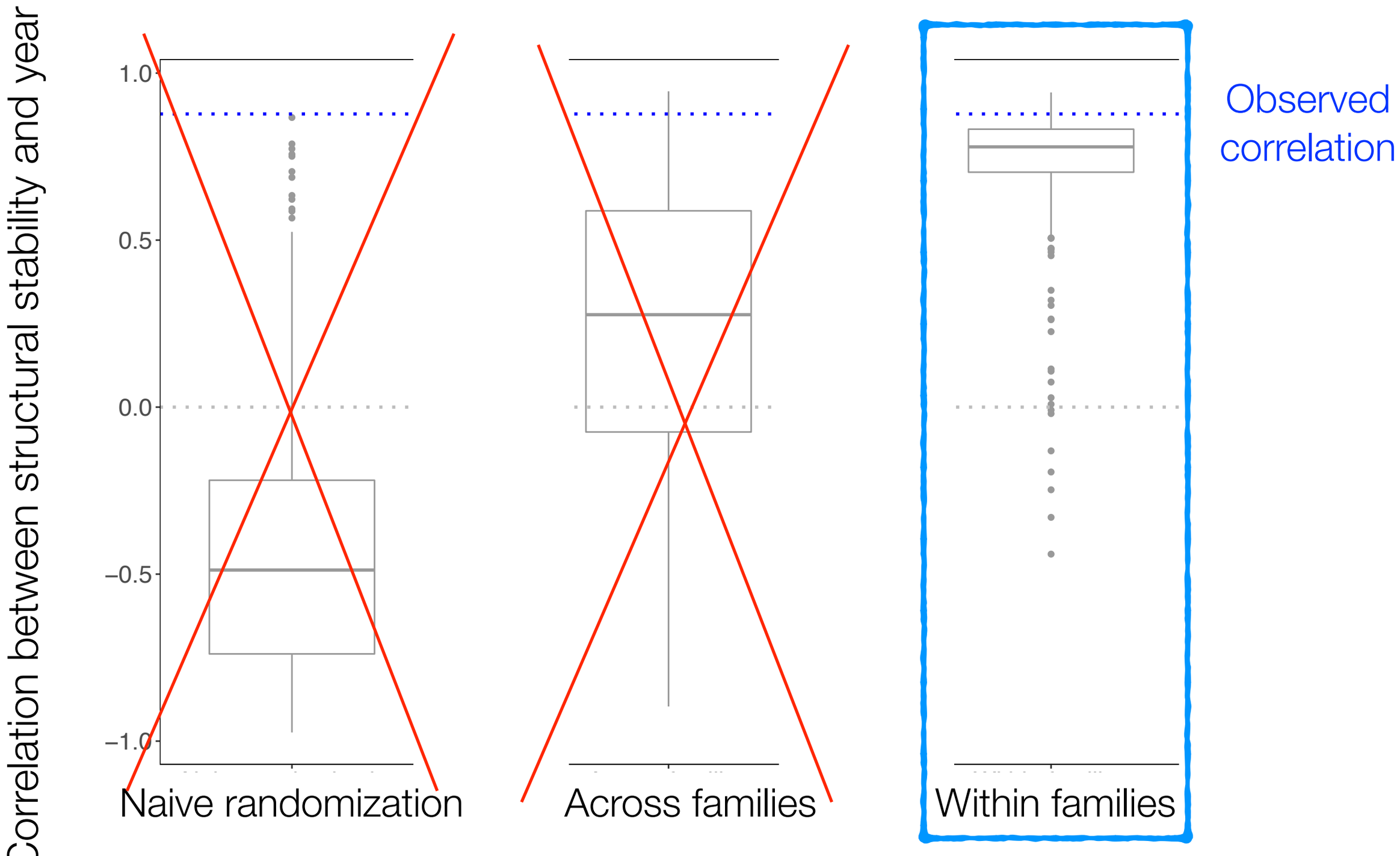
- Random reshuffling the order

- Preserving the order of families (Niche Modification)



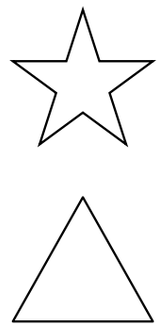
- Preserving the order within families (Niche Preemption)

Which assembly rule can exhibit the observed trend?



Arrival order of closely related (but not of distantly related) plant species determines the observed trend

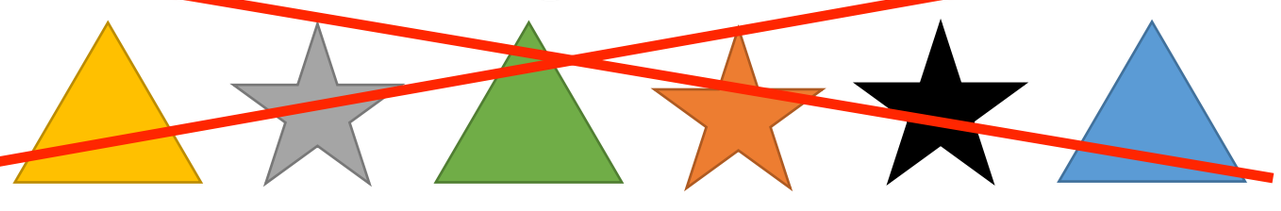
Observed arrival order of plants



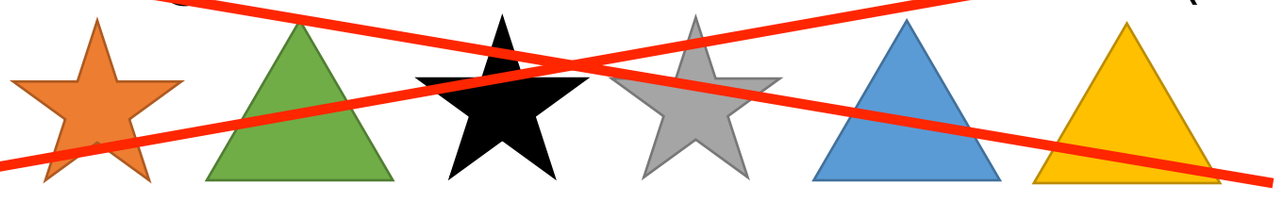
Group X

Group Y

- Random reshuffling the order



- Preserving the order of families (Niche Modification)



- Preserving the order within families (Niche Preemption)

Take home message

- Q1: How does the observed arrival order affect community persistence?
- A1: Structural stability generally increased as the community assembled over the time period of 2000 years
- Q2: In which alternative worlds can we detect the same effect?
- A2: The order of introduction of closely-related (but not of distantly-related) plants is likely to be responsible for the observed increasing trend

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Cover Caption: Tussock moth larva (*Elkneria pudibunda*) feeding on red oak (*Quercus rubra*), introduced to Europe about 300 years ago.
Photo Credit: Florian Altermatt

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Chuliang_Song