Ancient and modern communities as reciprocal analogues

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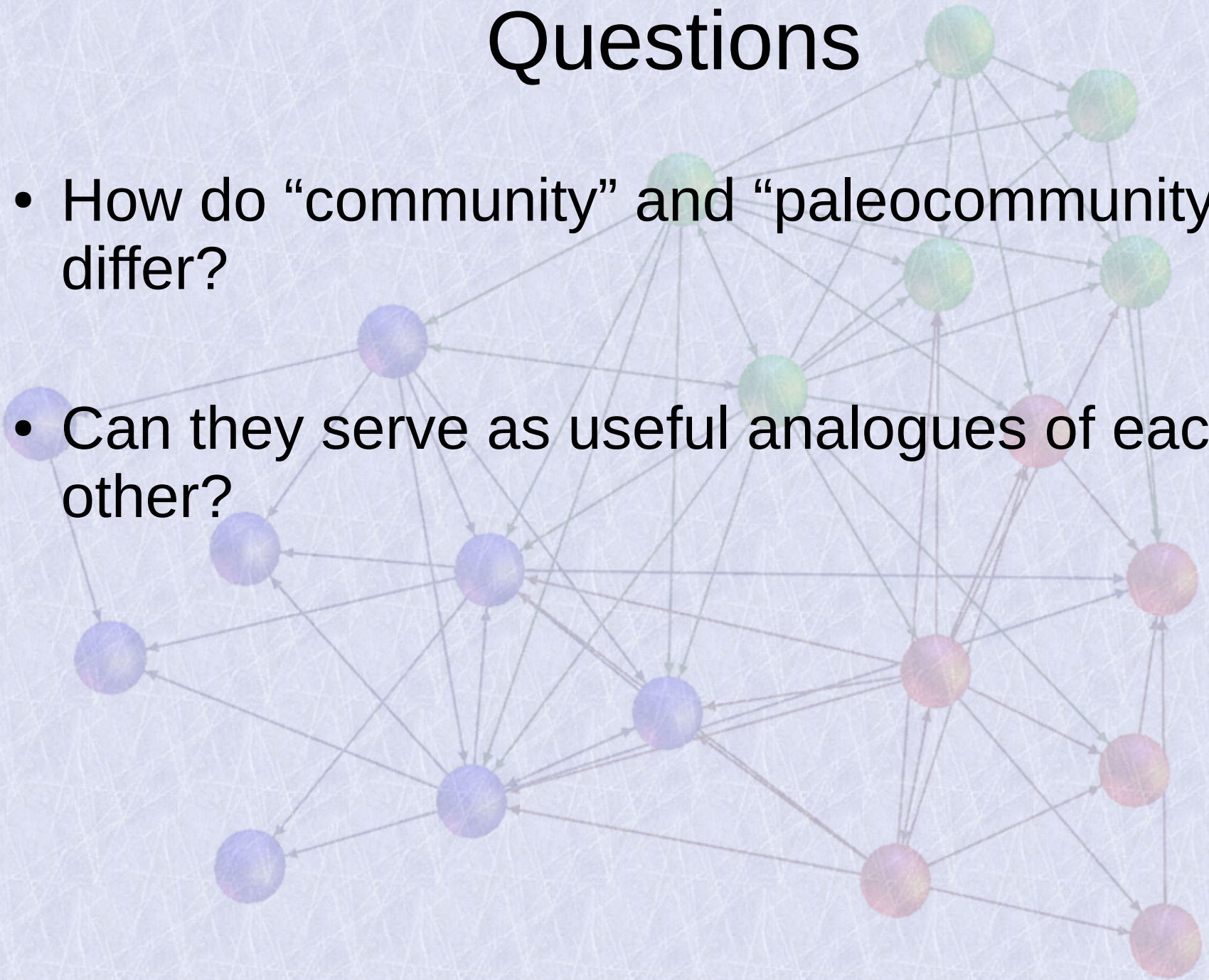
Questions

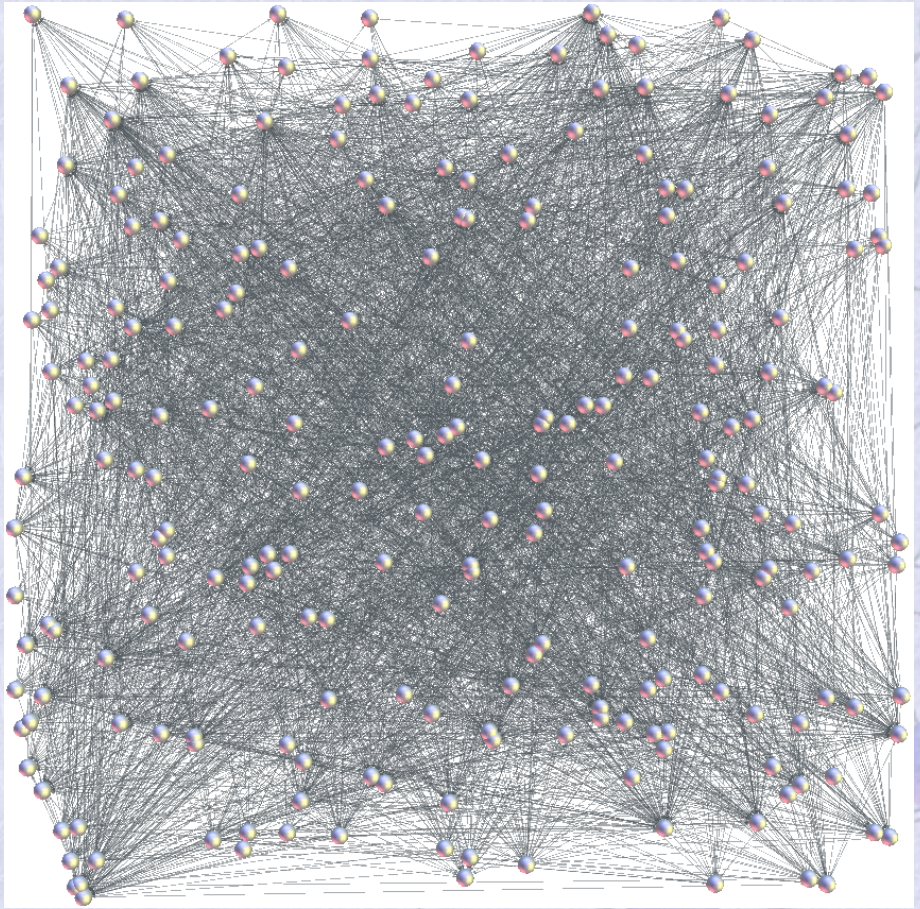
- How do “community” and “paleocommunity” differ?
- Can they serve as useful analogues of each other?



Outline

- Structure
  - Compare modern and (simulated) fossil Caribbean coral reef communities
- Dynamics
  - Paleocommunity stability and persistence; L. Permian – E. Triassic terrestrial ecosystem

Jamaican coral reef community



(*Roopnarine and Hertog, 2012)*

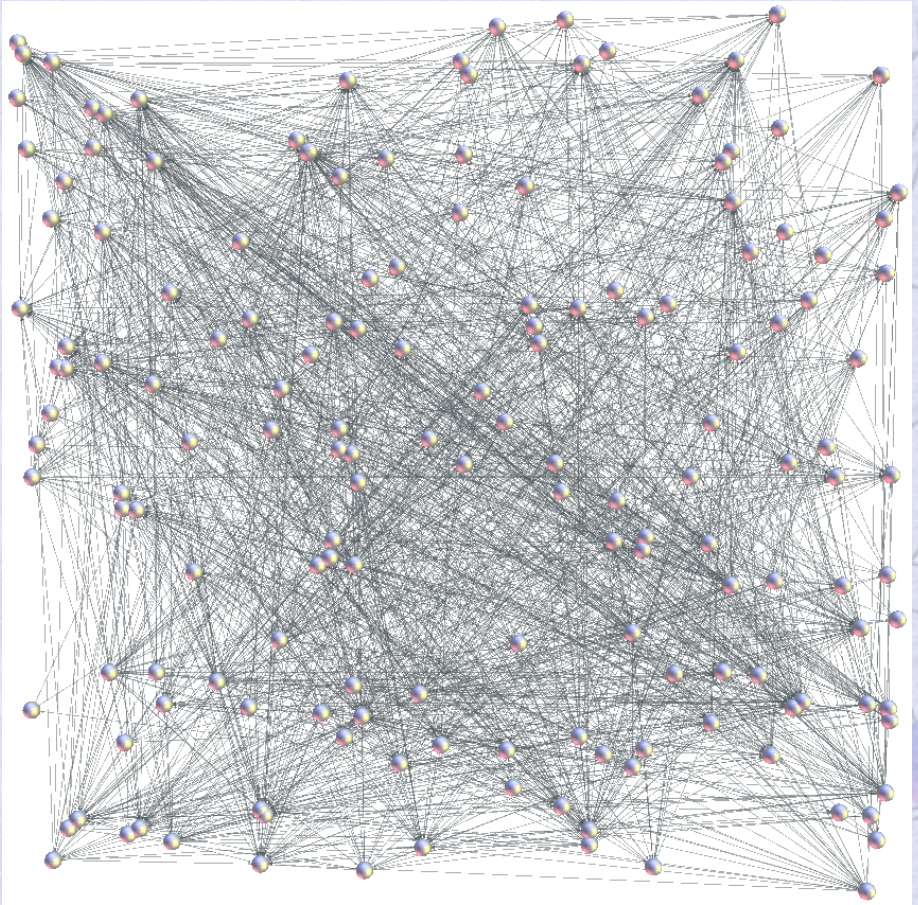
- 756 species
- 249 nodes/guilds
- 4105 predator-prey interactions
- C = 0.066

“Fossilize” the web

- Include species with generic representation in the fossil record.
  - PaleoBiology Database
  - Relax geographic occurrence limits
- Poorly represented groups because of
  - Body composition, e.g. sheet macroalgae
  - Body size, e.g. nano-zooplankton
  - Taxonomic difficulties, e.g. sponges

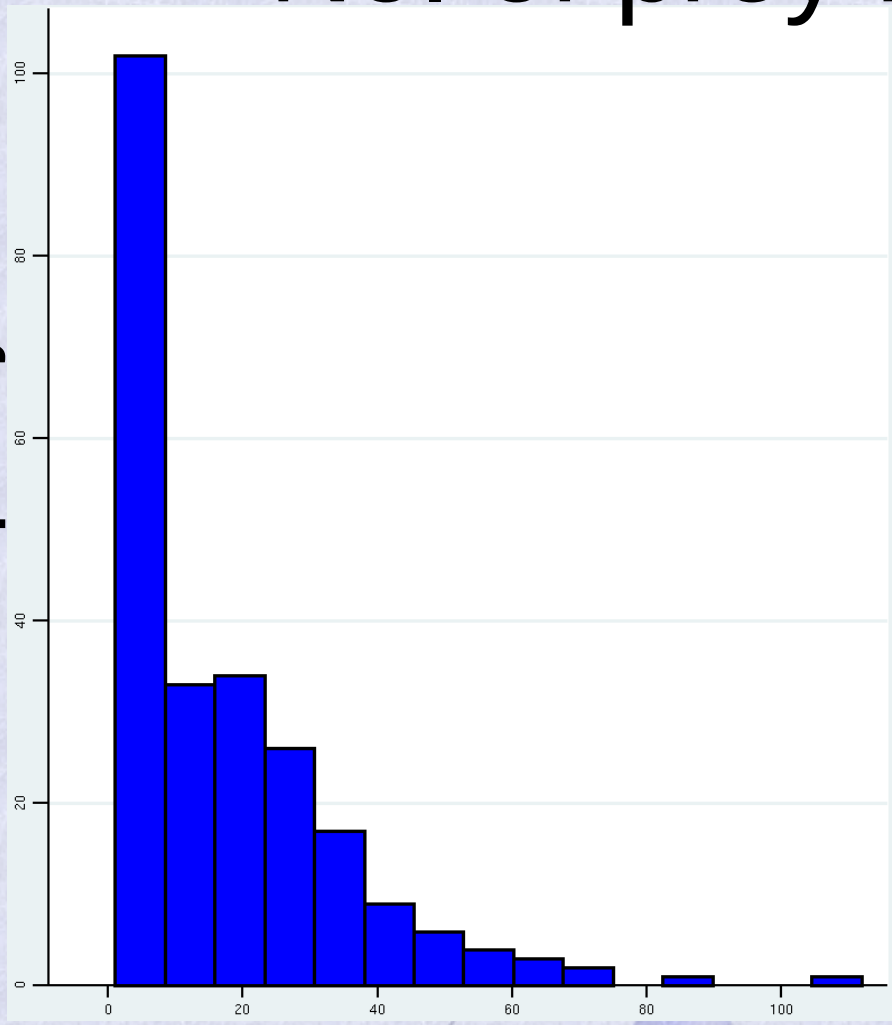
What do we lose?

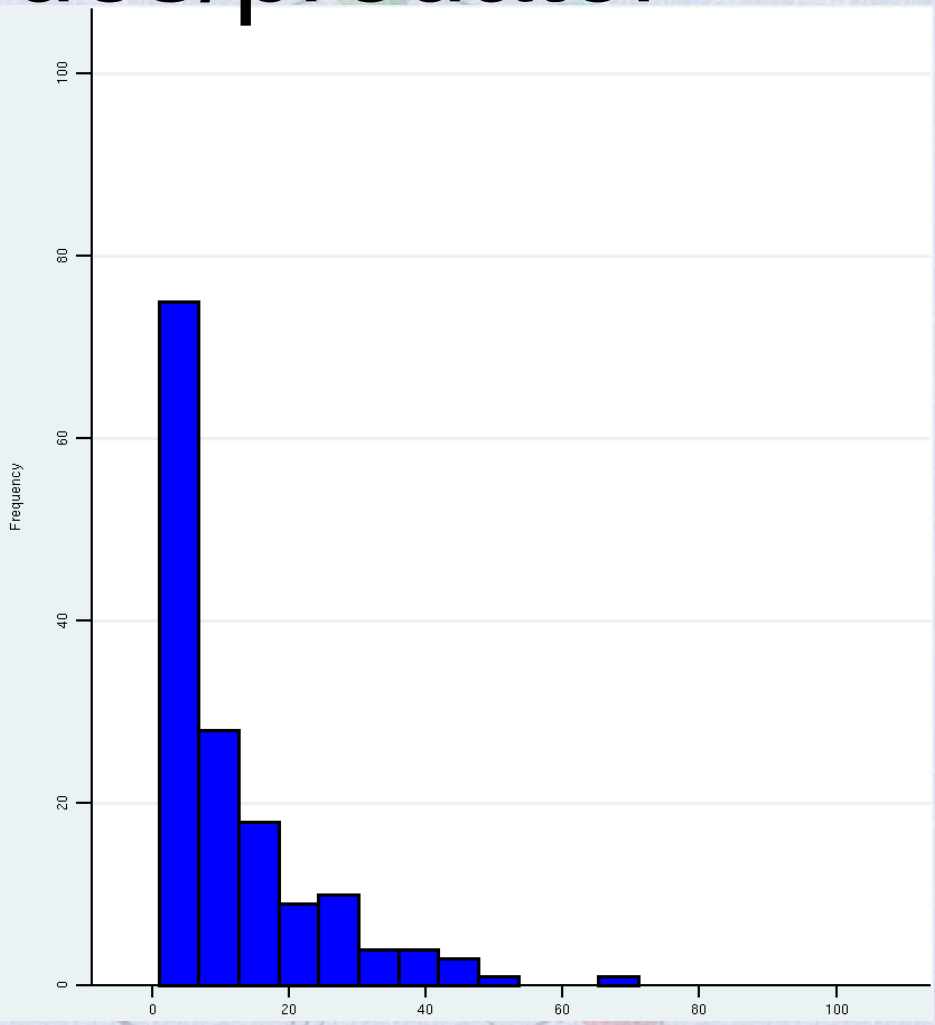
Jamaican fossil coral reef



- 441 species (756)
- 163 nodes/guilds (249)
- 1737 interactions (4105)
- C = 0.065 (0.066)

No. of prey nodes/predator

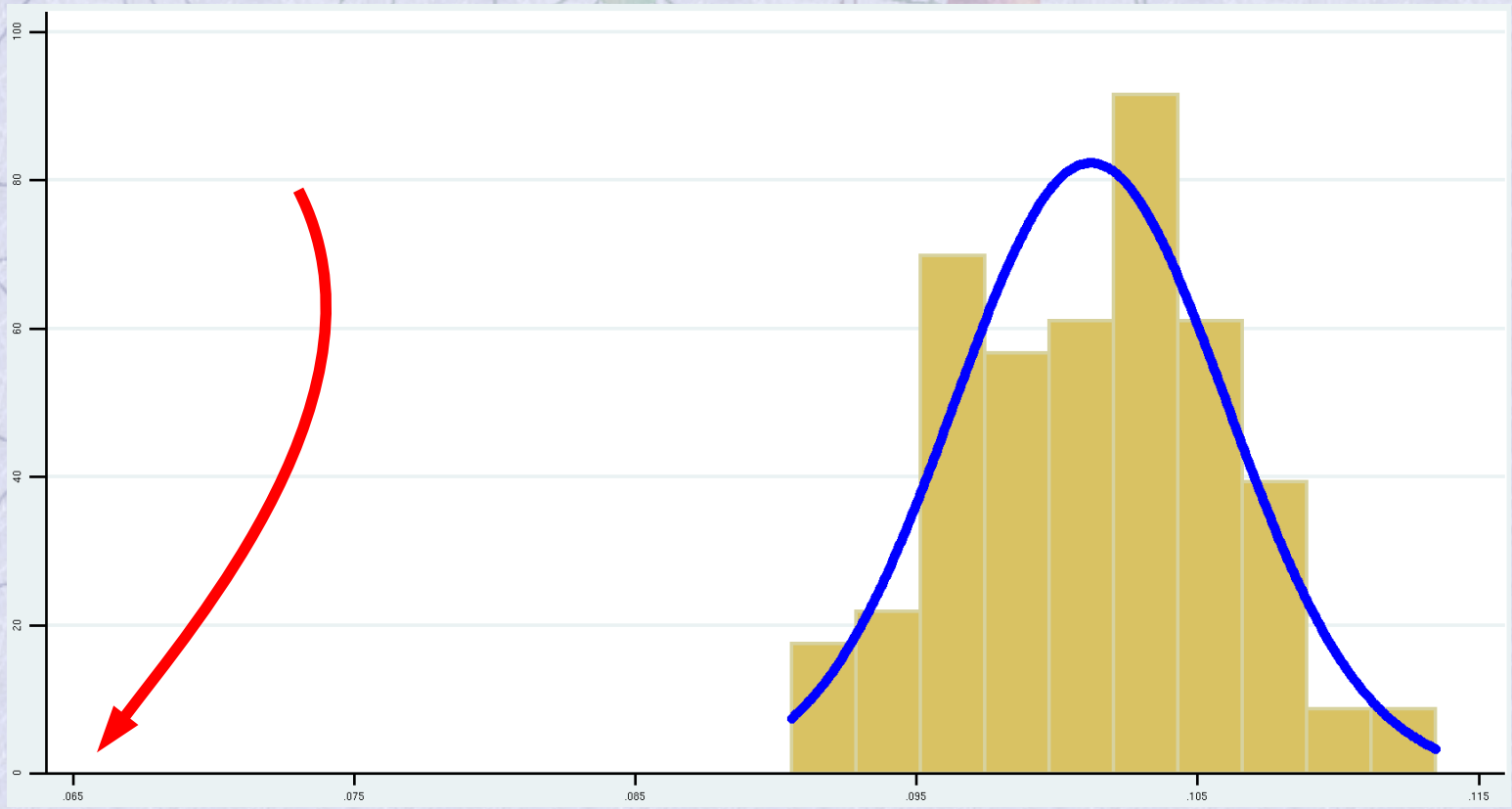




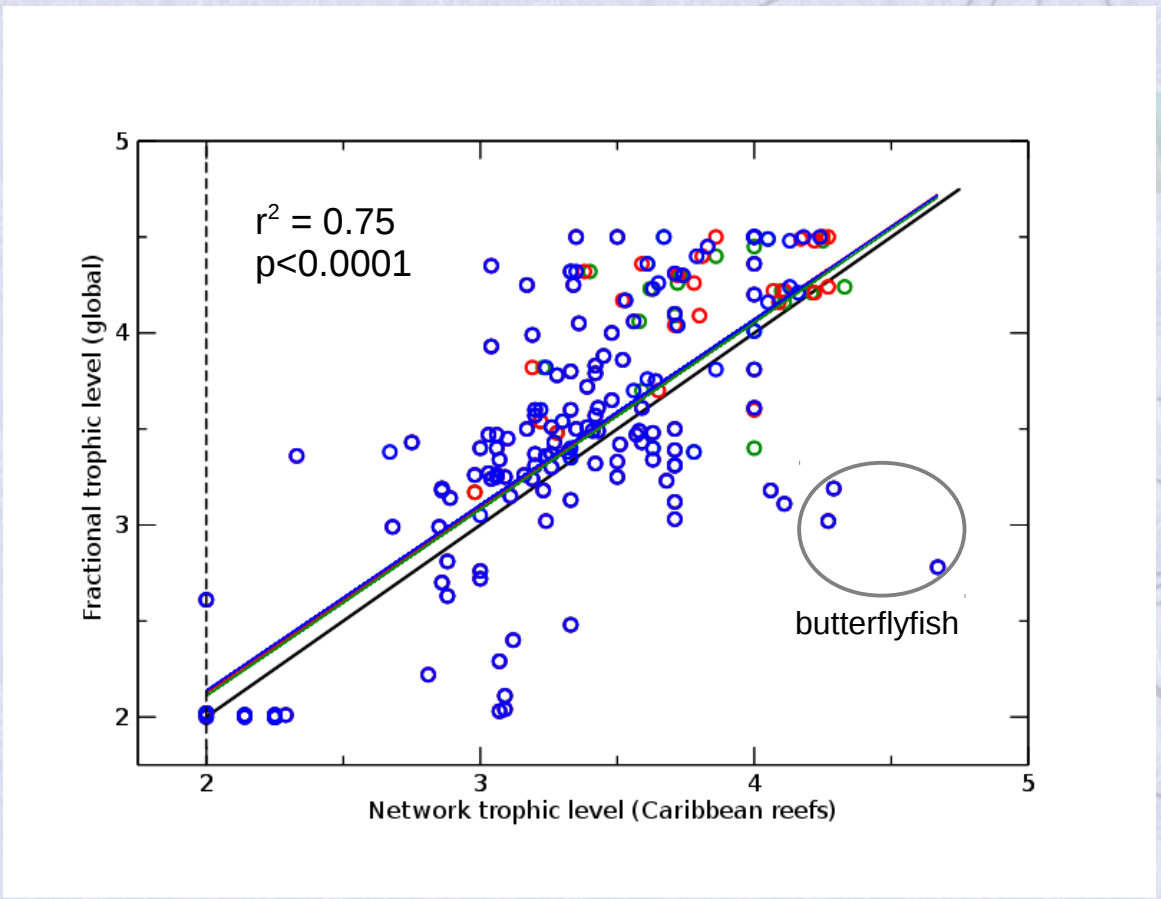
Extant

Fossil

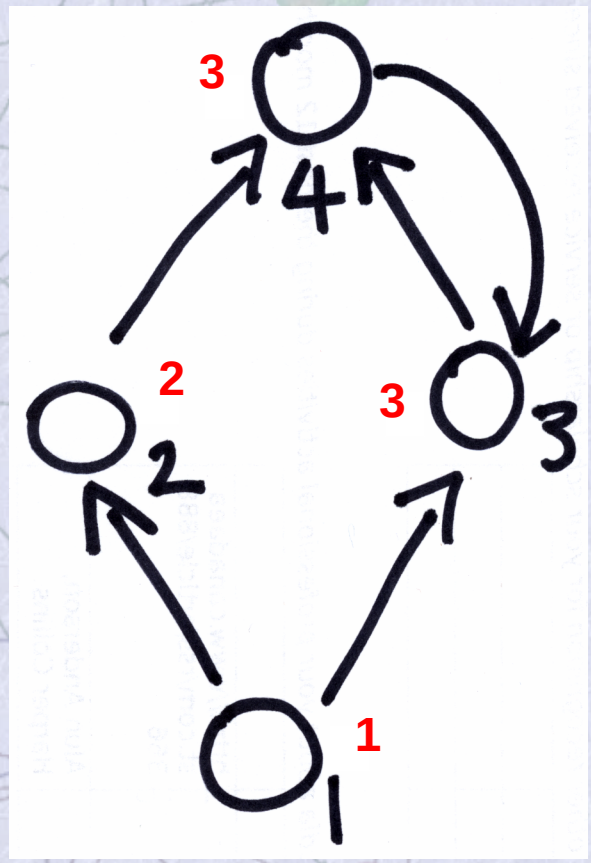
- Species lost as function of species properties, not community properties.
- Simulated fossilizations (n=100):



Network trophic level

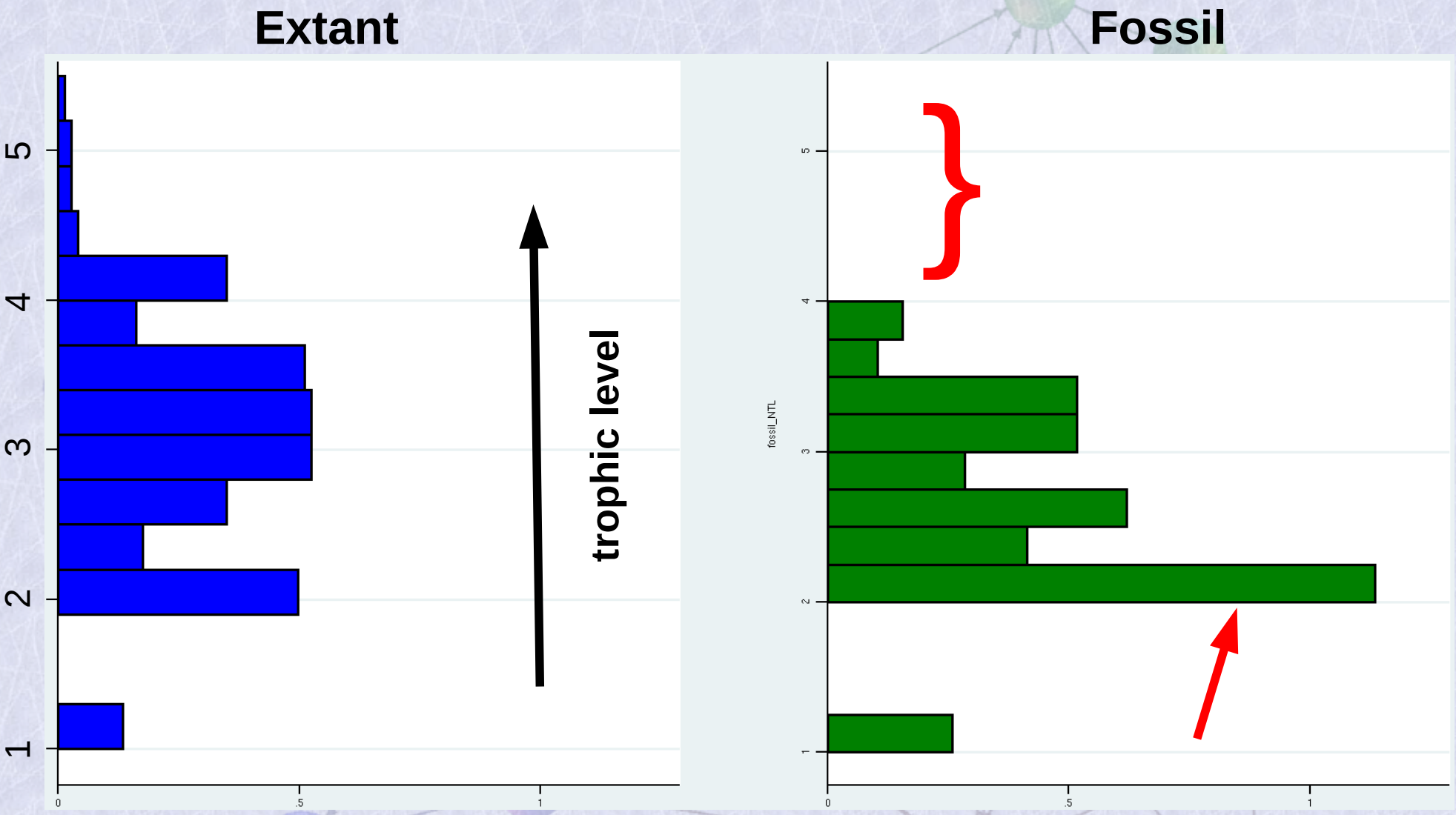


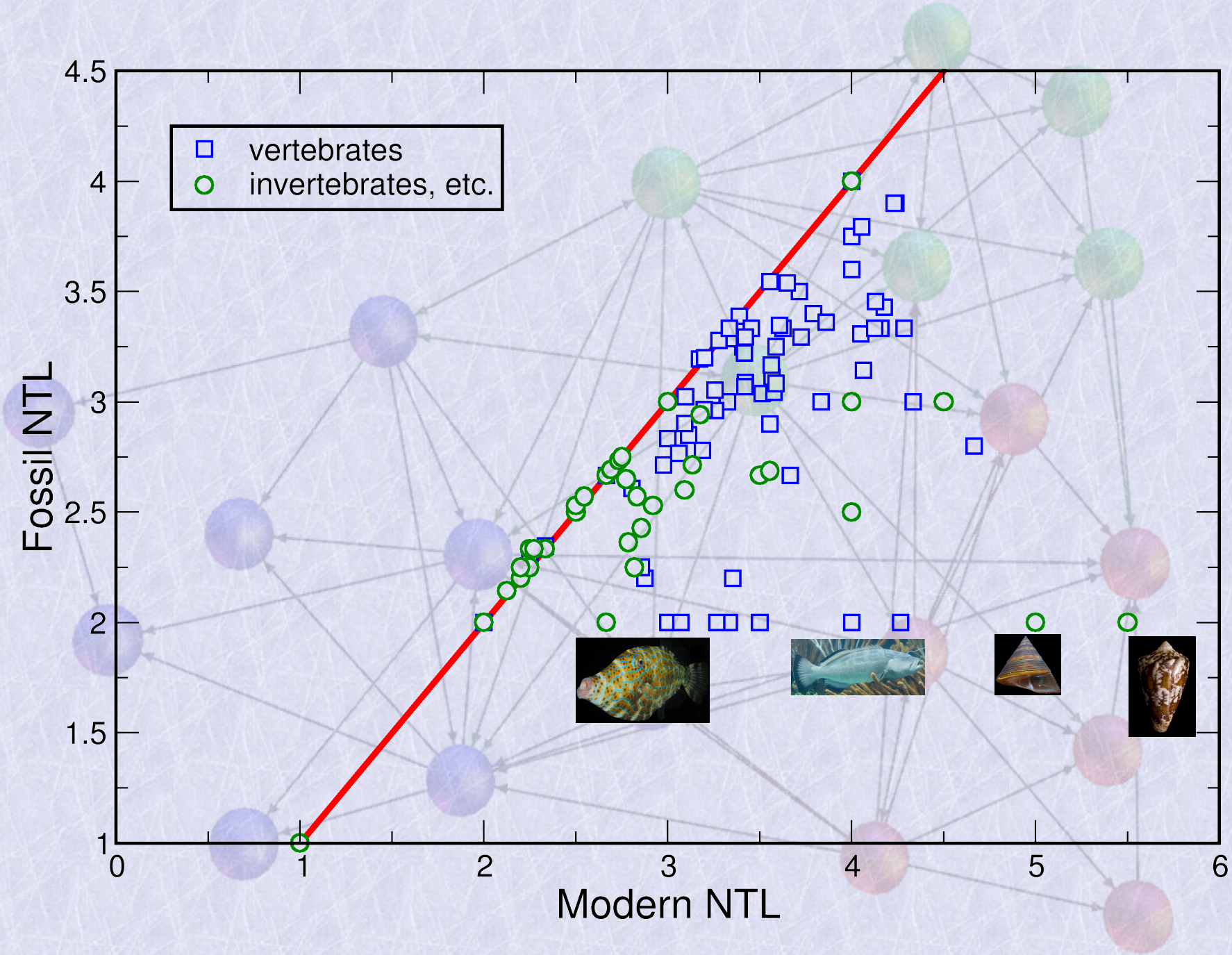
(*ftl data from Romanuk et al., 2011*)



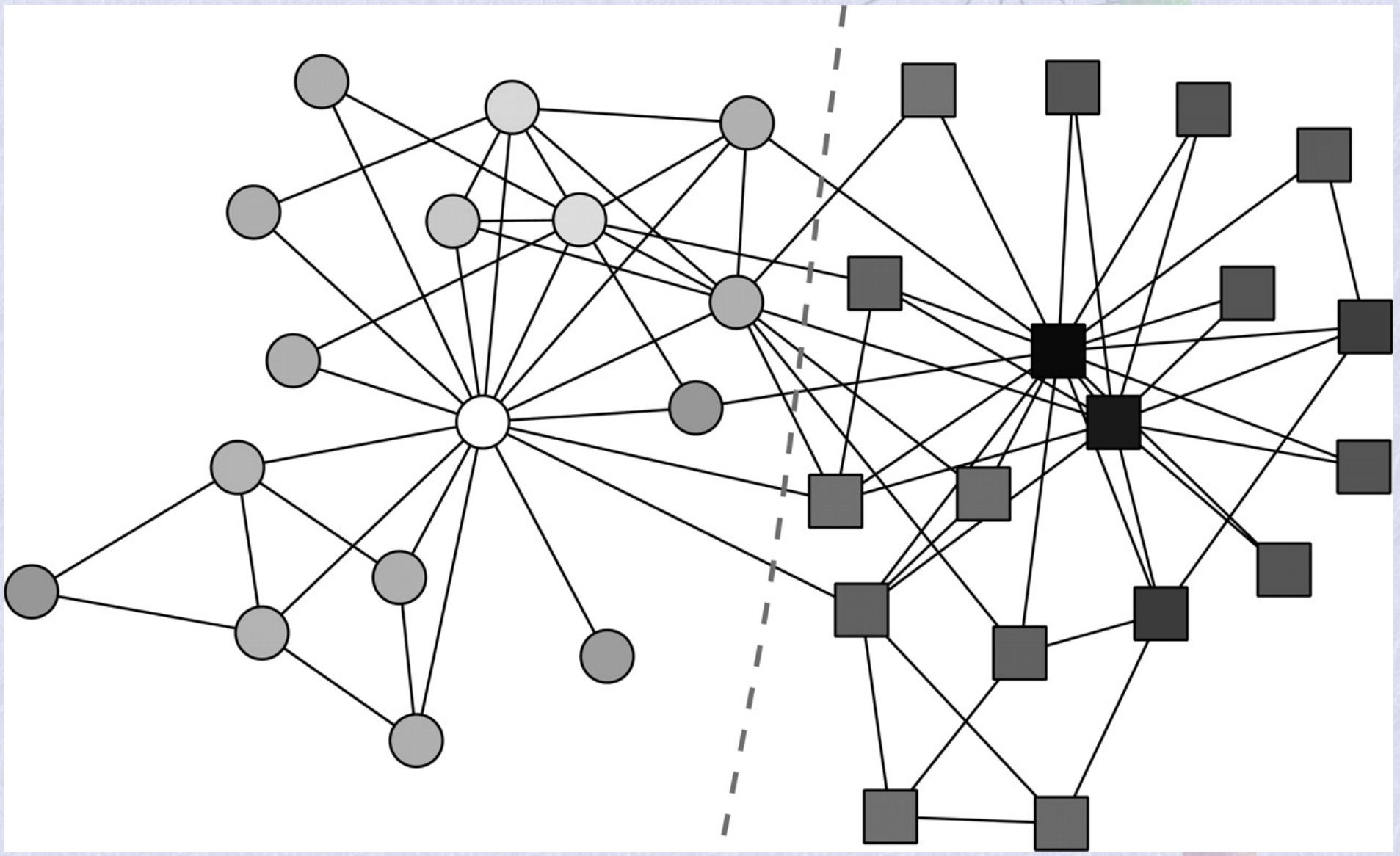
$$ntl = 1 + \frac{1}{r}\sum_{i}^{S} a_{ij} l_j$$

(*Roopnarine, 2014*)

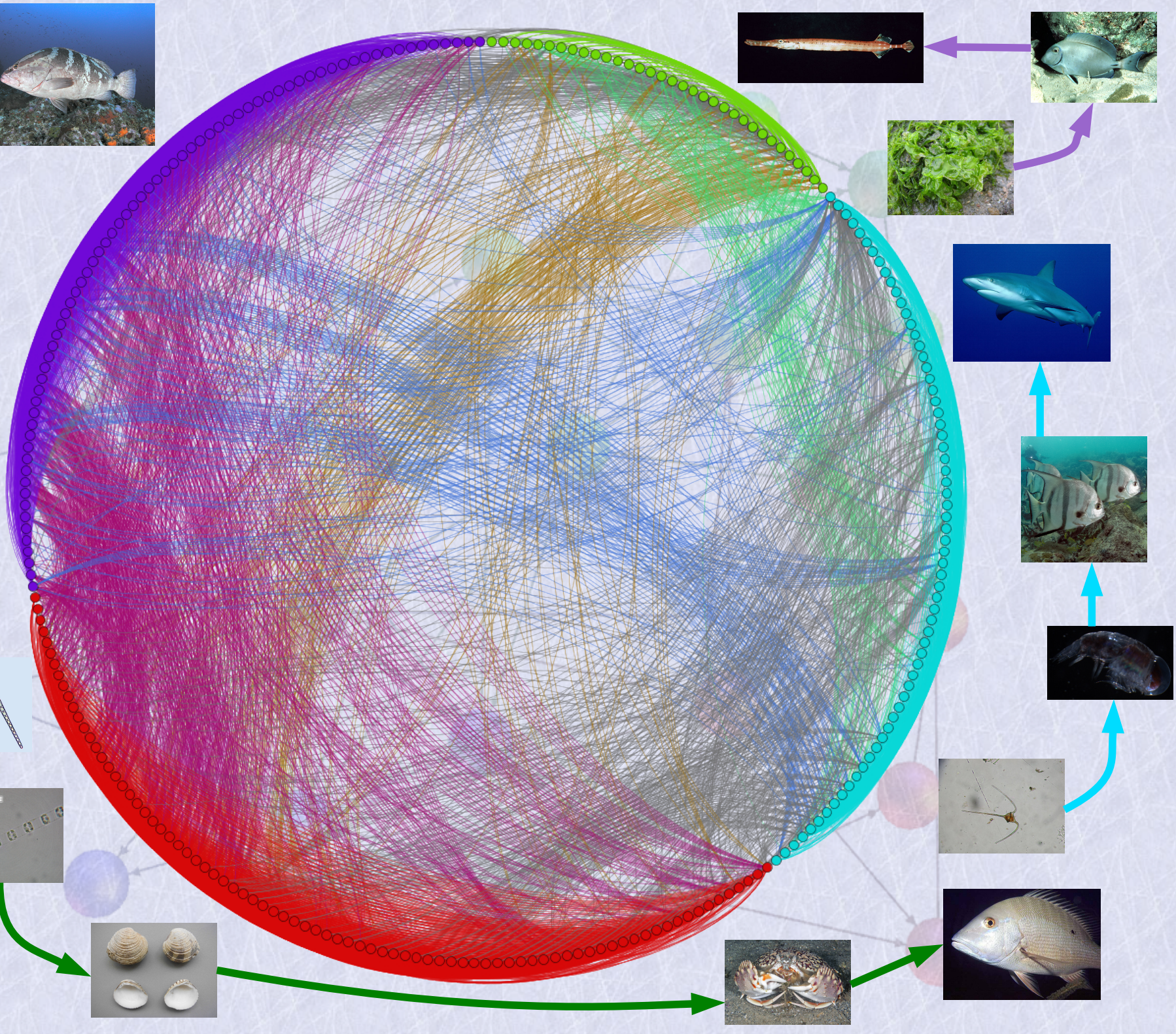

Extant
Fossil
trophic level
fossil_NTL
1
2
3
4
5
0
.5
1


vertebrates
invertebrates, etc.
Fossil NTL
Modern NTL
4.5
4
3.5
3
2.5
2
1.5
1
0
1
2
3
4
5
6

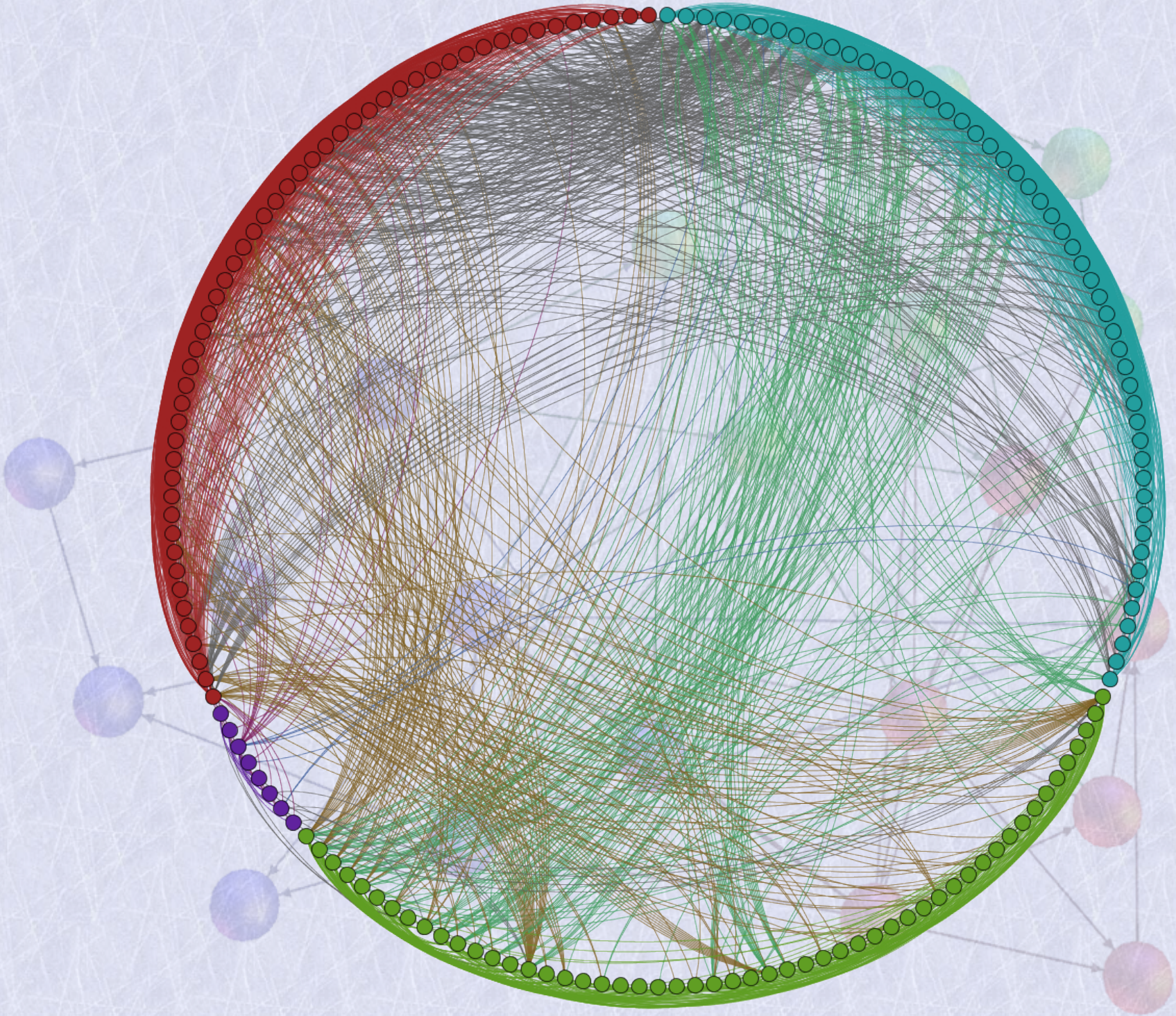
Higher-level structure: Modularity



Newman (2006)



Fishbase,
Wikipedia,
AlgaeBase



Summary

- **Preservation of structure moderately good.**
  - Link distributions & connectance preserved.
  - Higher-level modularity preserved.
  - Trophic chains shortened.
  - Trophic levels reduced.

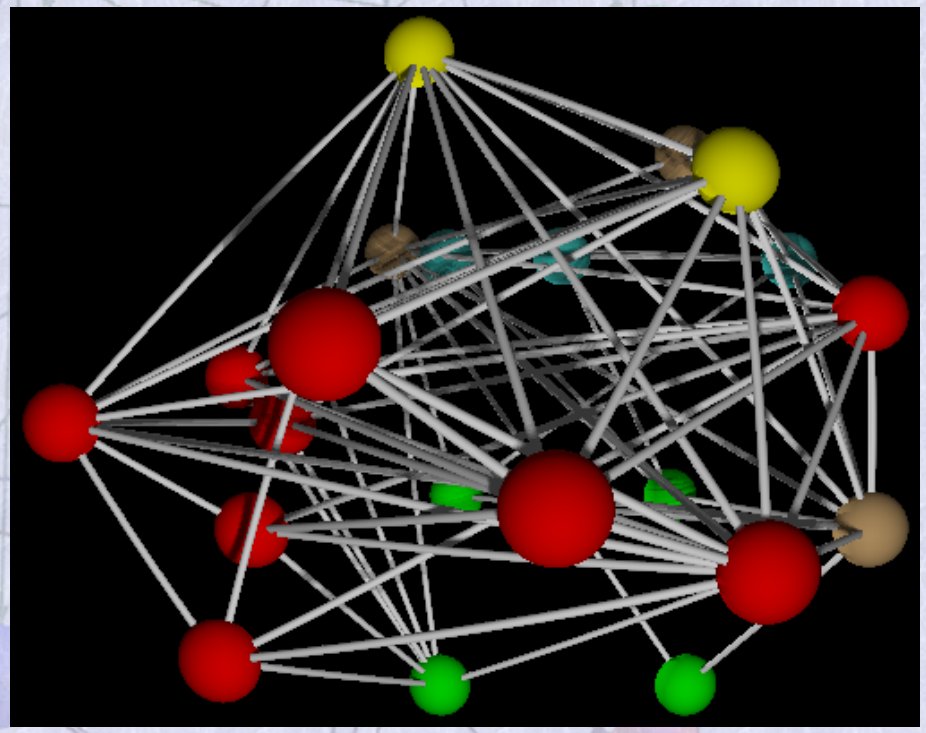
Community dynamics

Can we then understand how paleocommunities functioned?

Paleocommunity dynamics

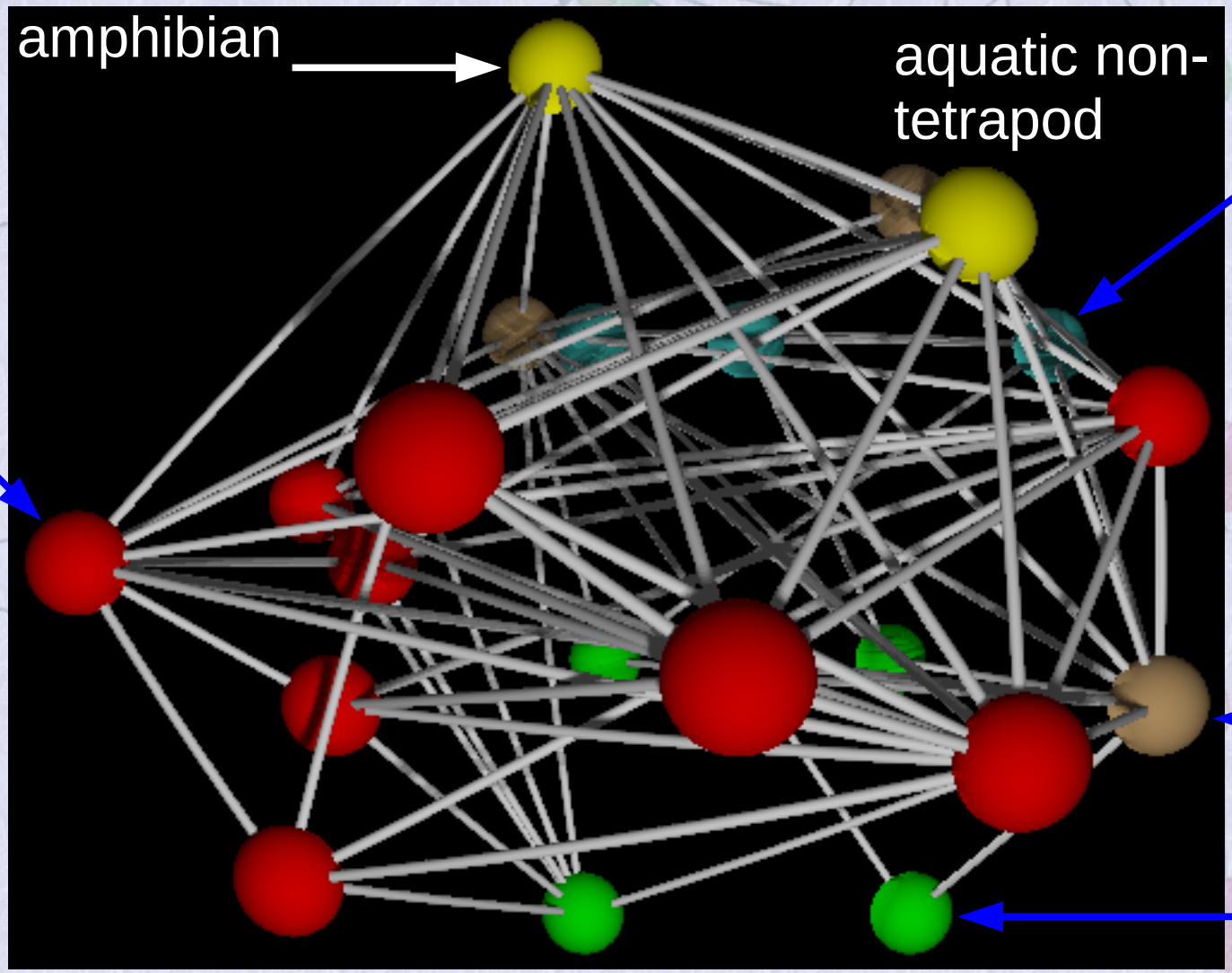
- Taxon richness
- Functional diversity
- Partition of richness among functions

(*Roopnarine, 2012)*

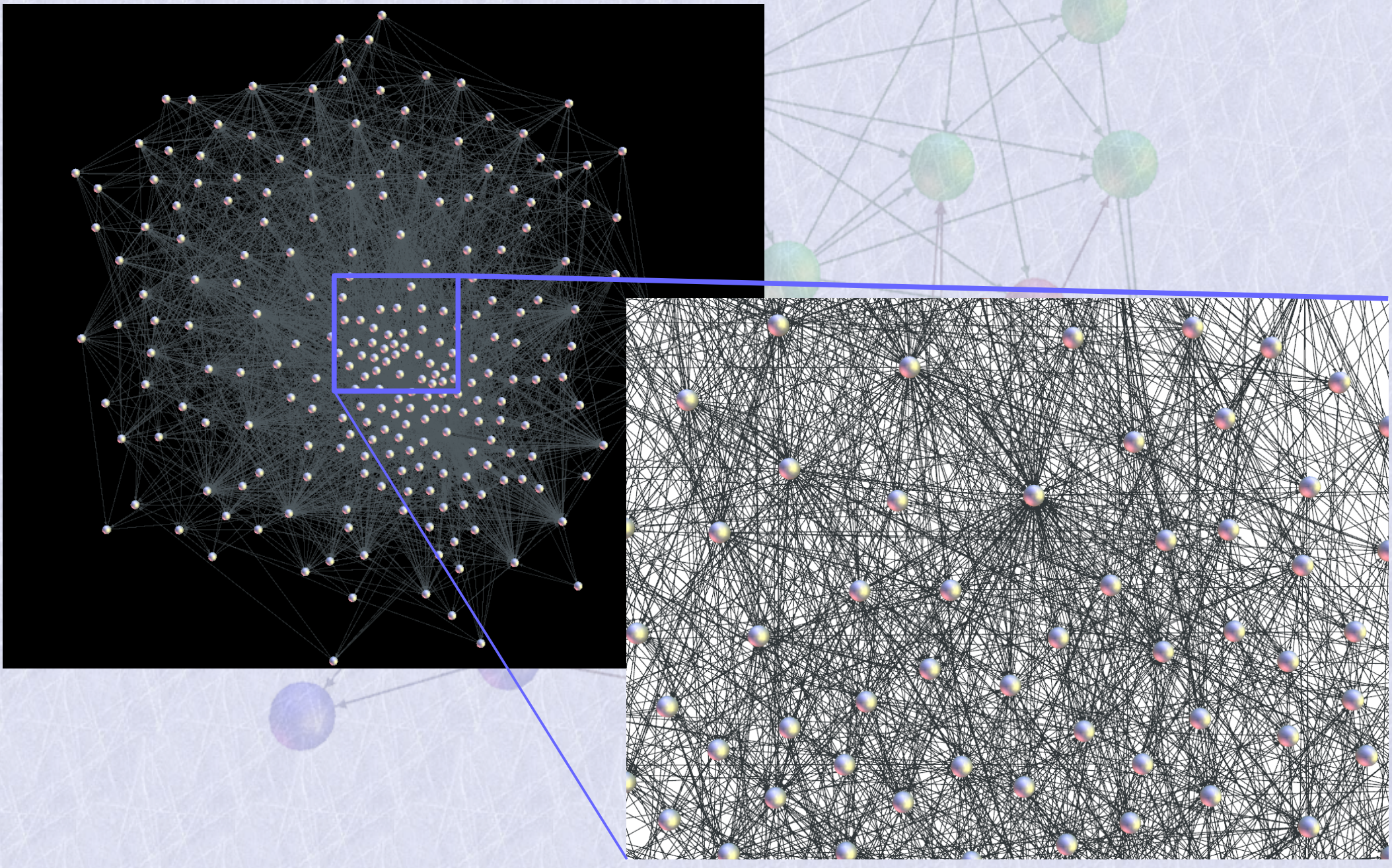


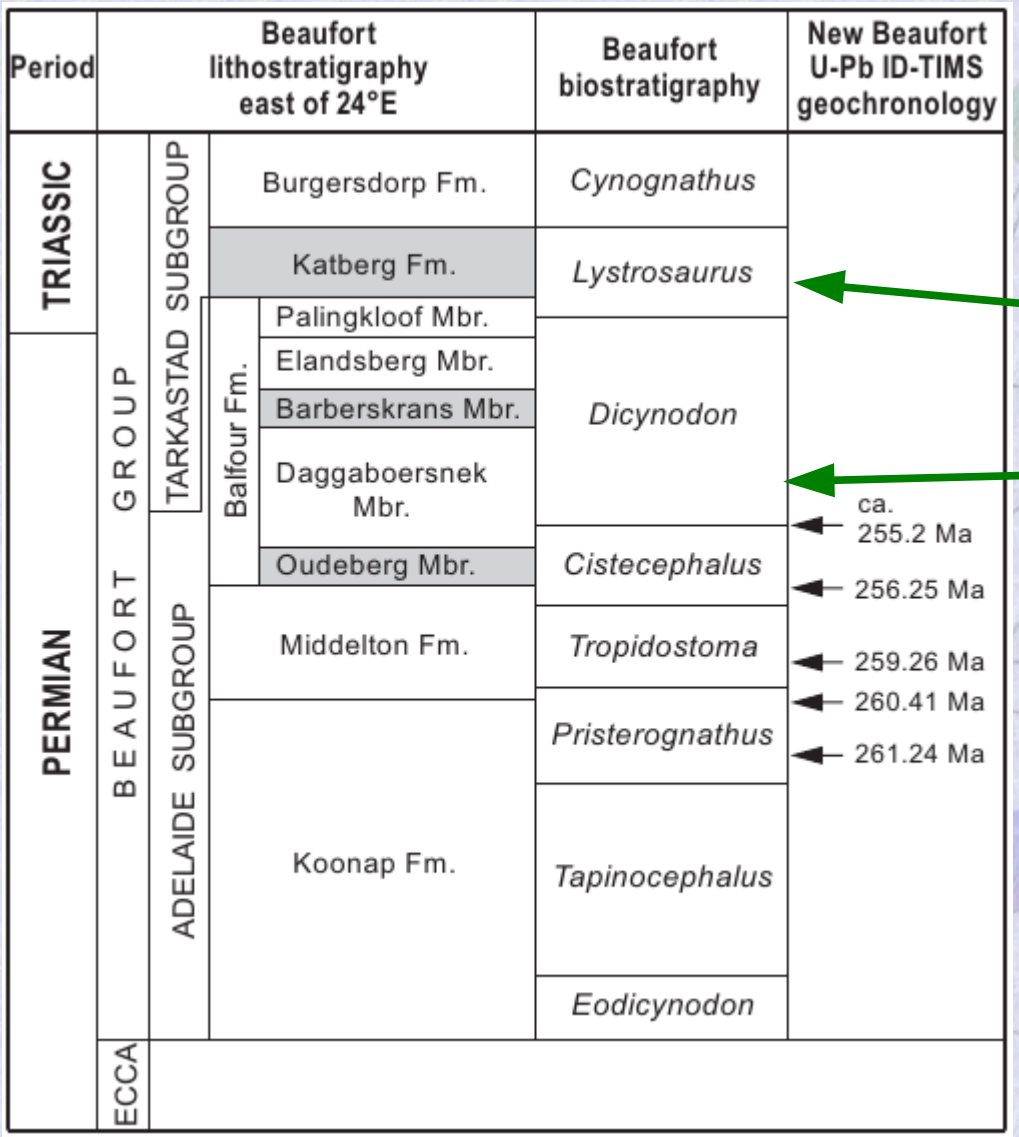
(*Roopnarine et al., 2007*)

Paleocommunity reconstruction

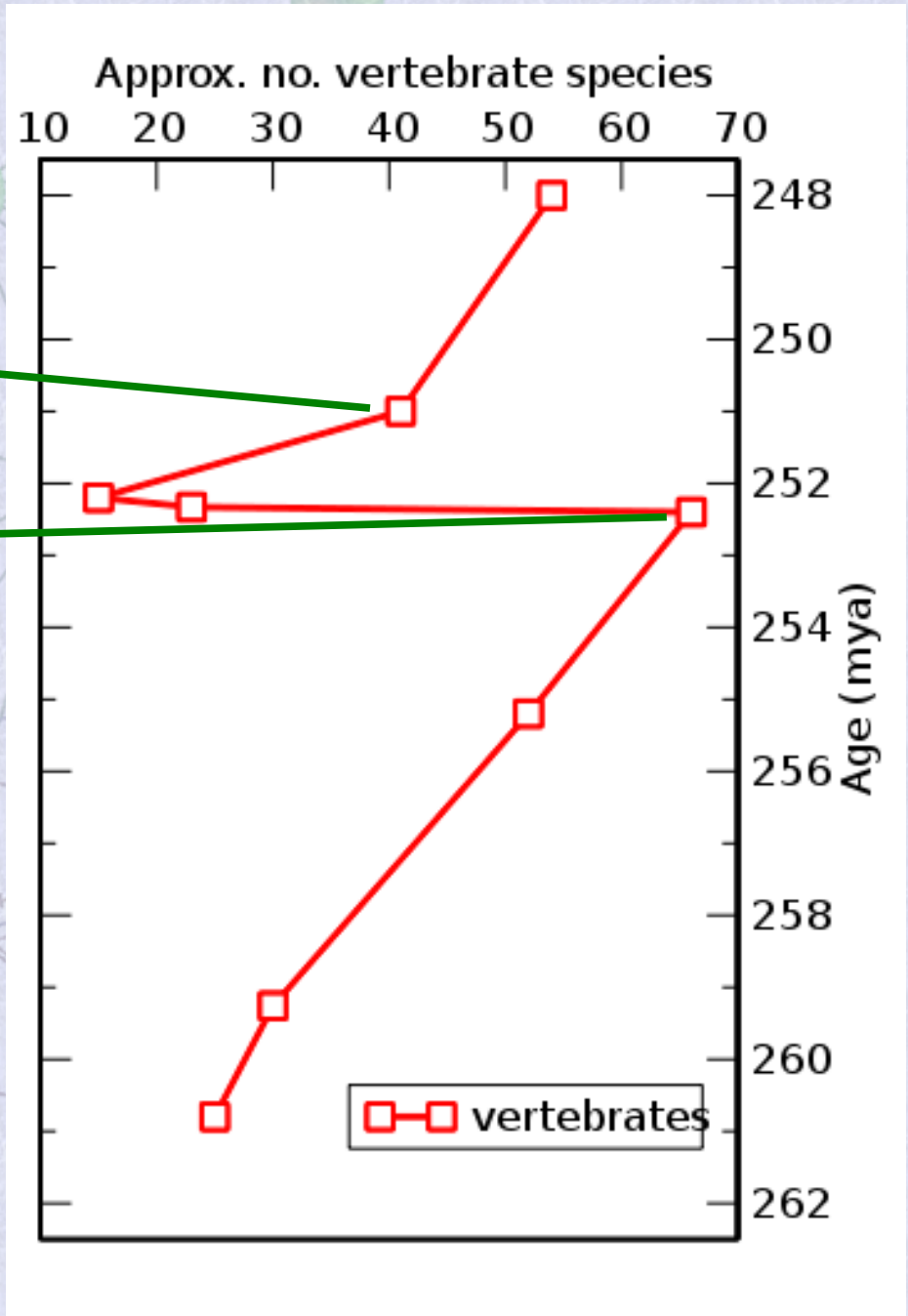


Late Permian, Karoo



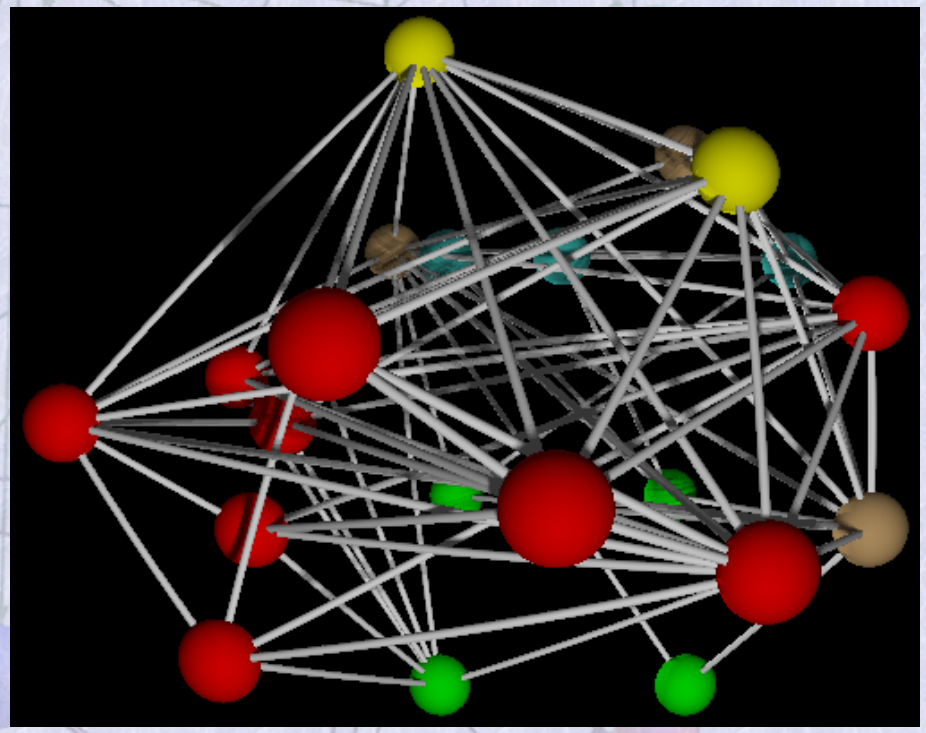


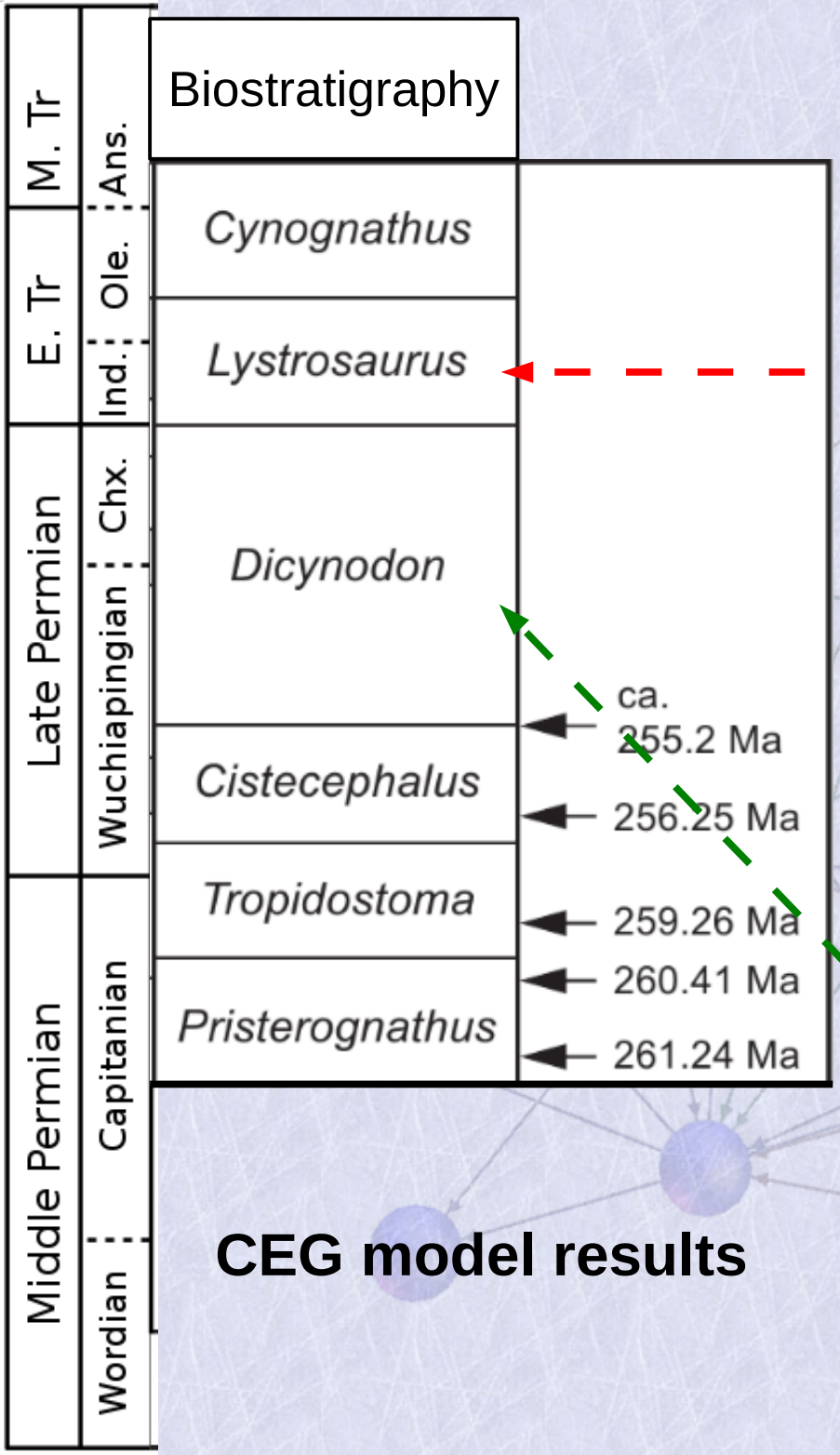
(*Rubidge et al., 2013*)

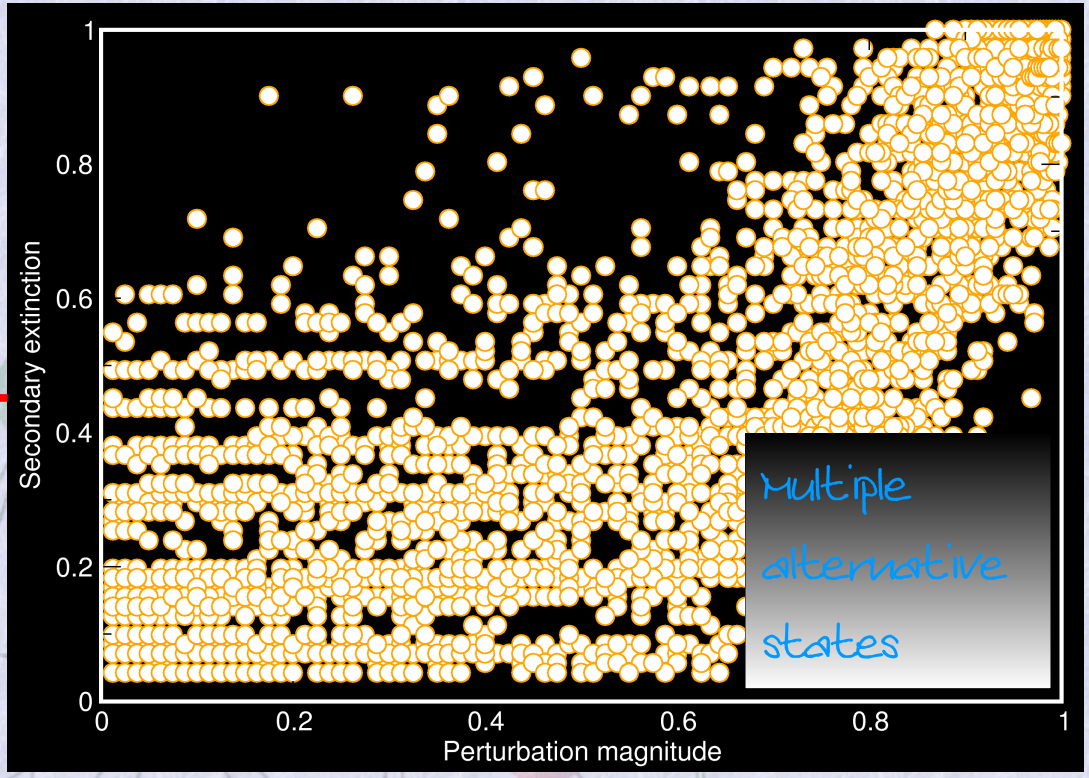


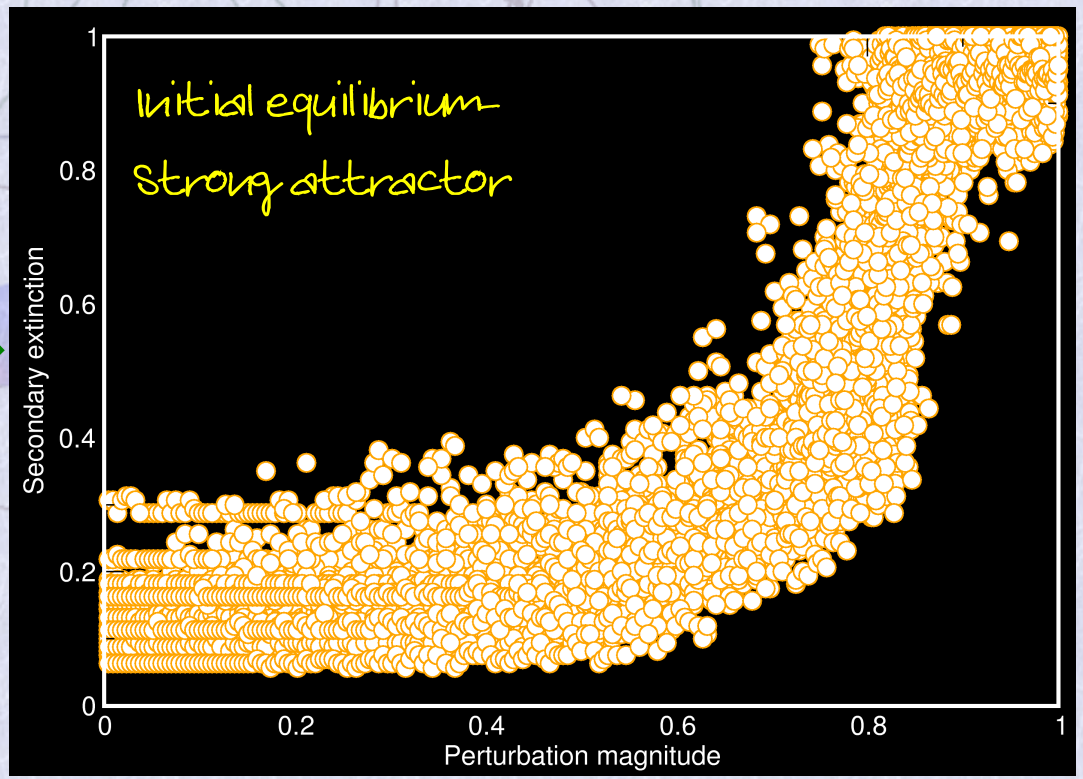
Deletion stability - CEG model

- Species in energetic steady state
- Perturbation extreme: removal of web component
- Closed system





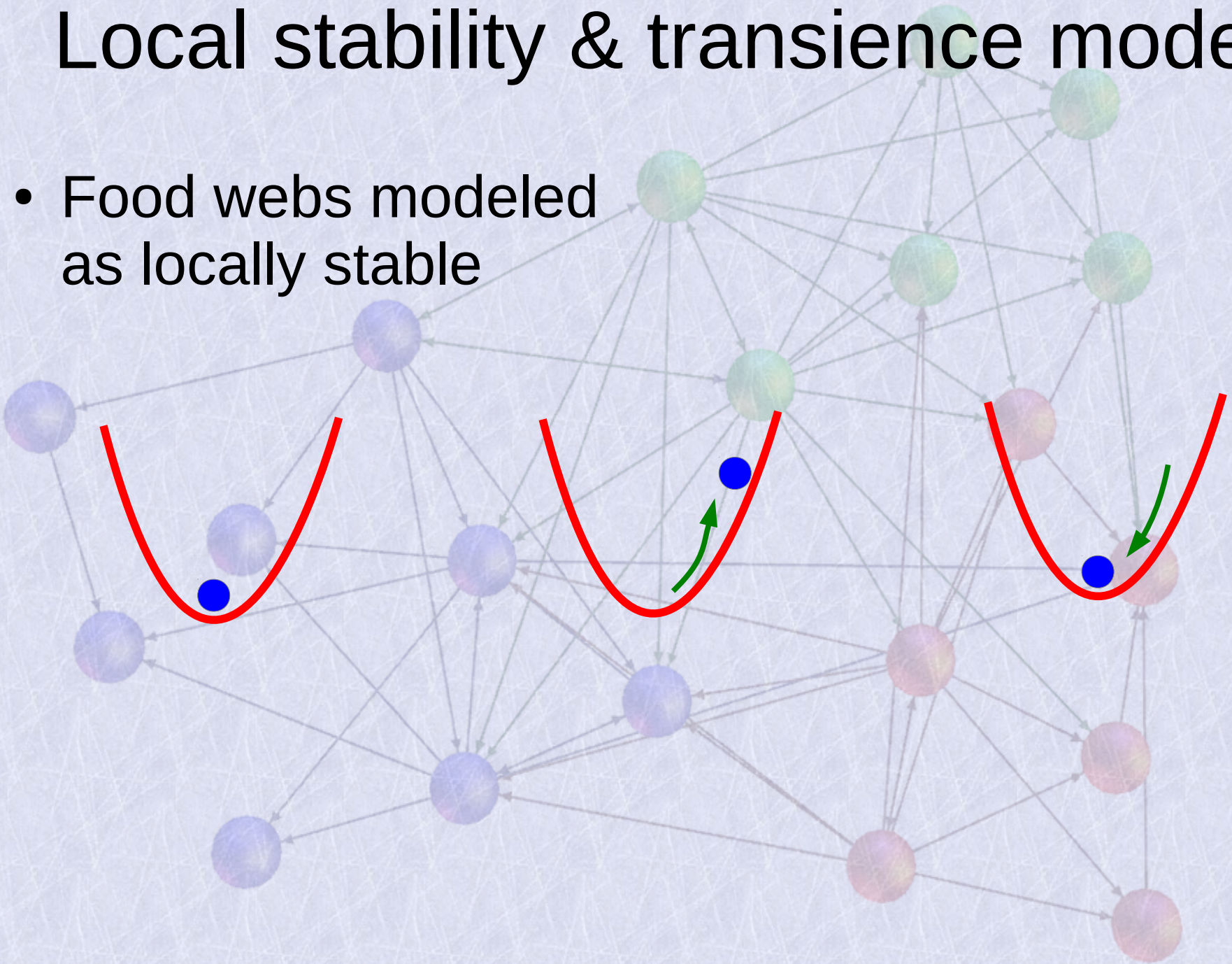




CEG model results

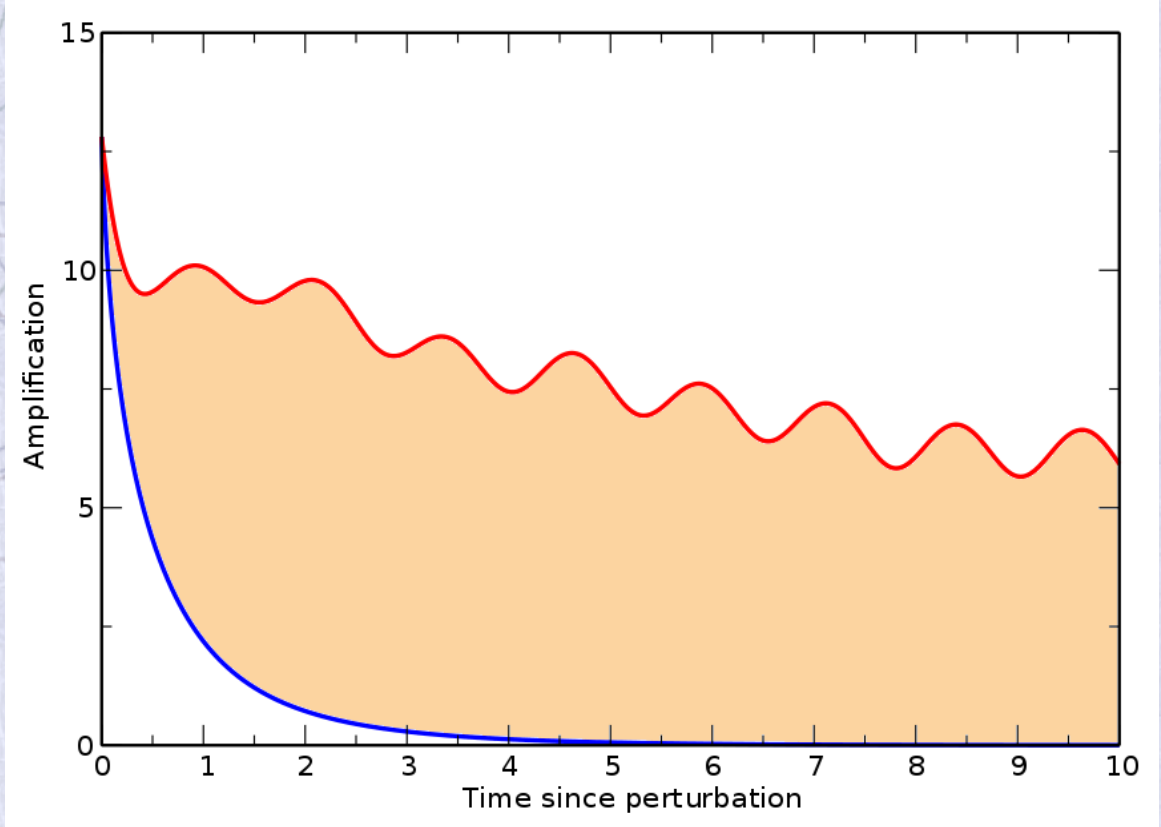
Local stability & transience model

- Food webs modeled as locally stable

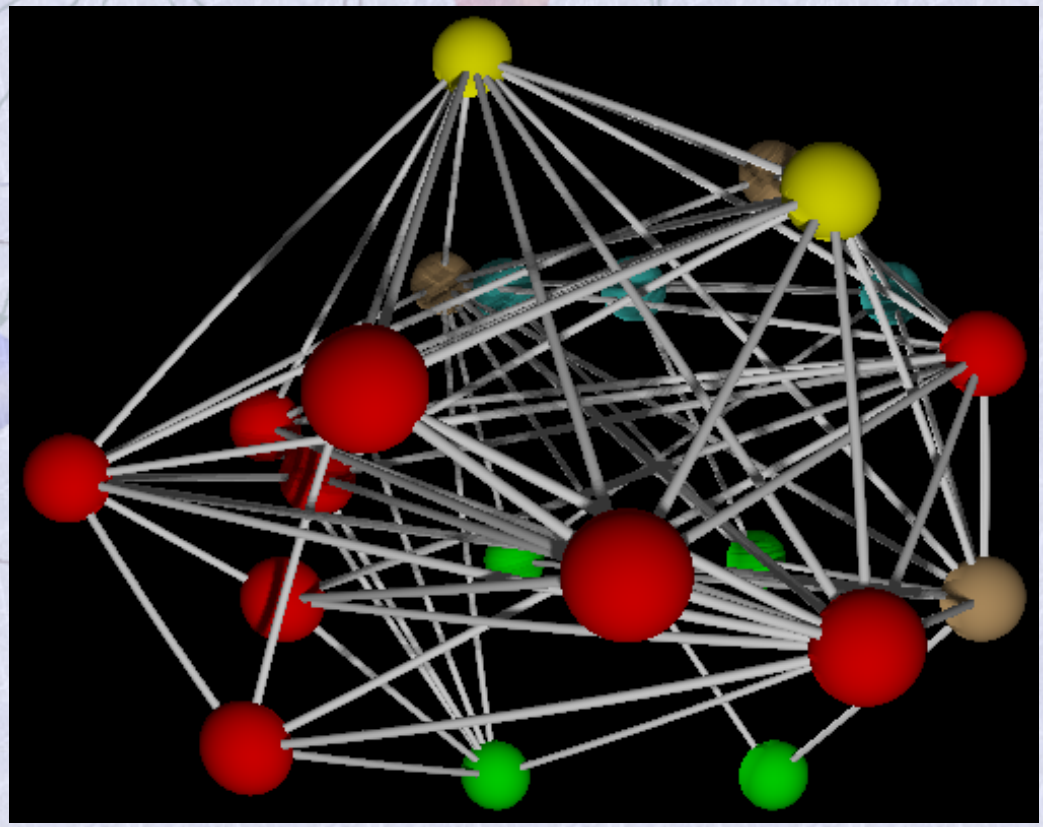


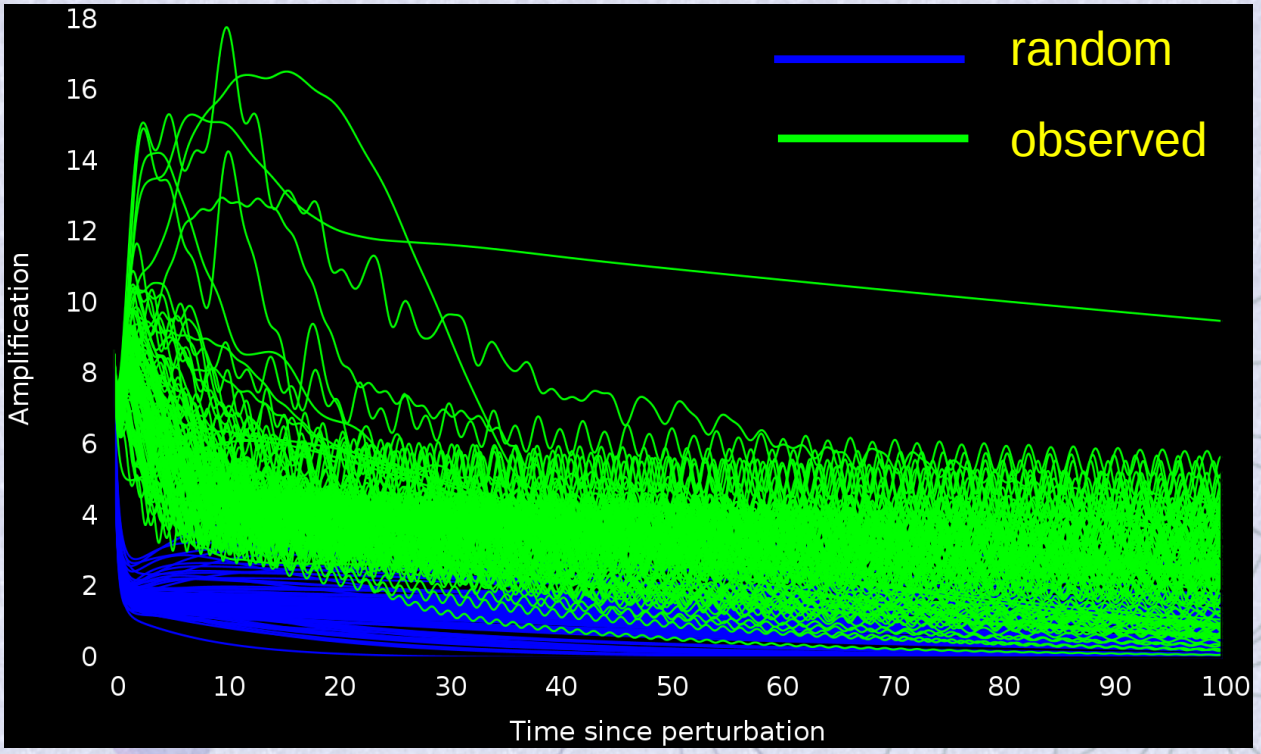
Local stability & transience model

- Food webs modeled as locally stable
- Examine response to demographic perturbations in ecological time



What is the effect of functional partitioning?



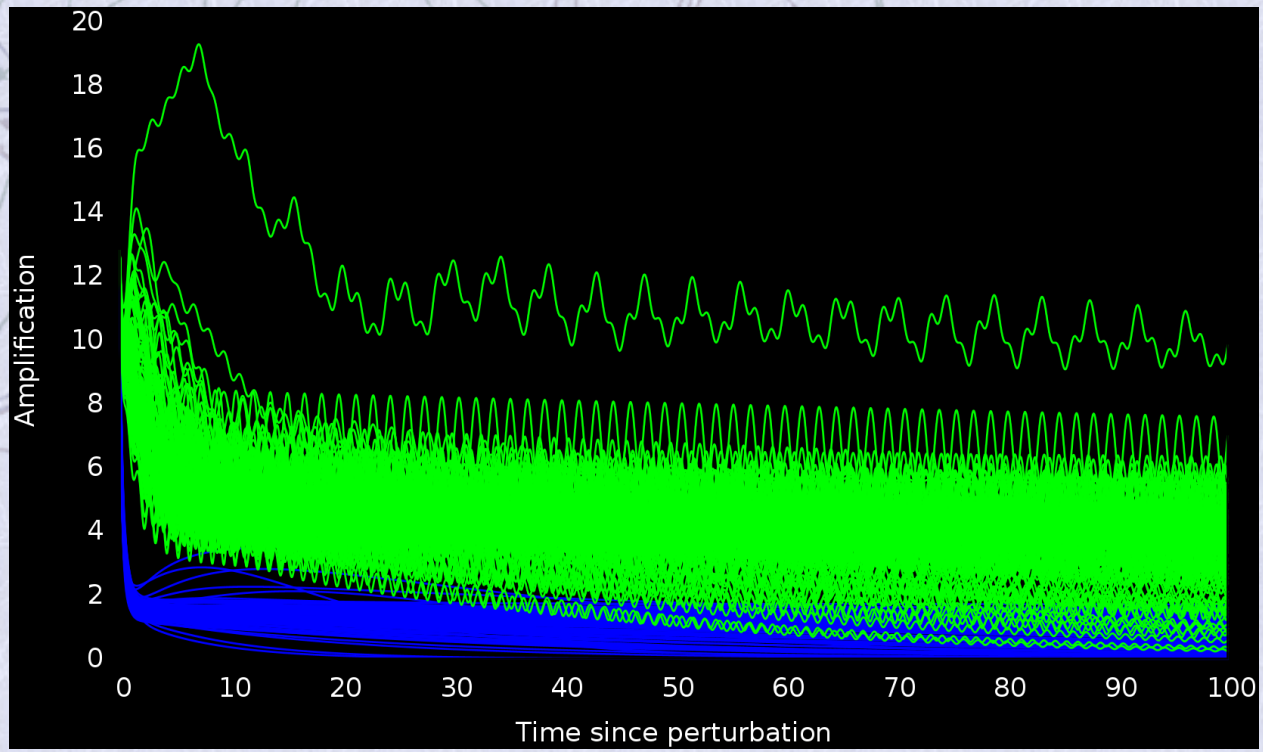


E. Triassic

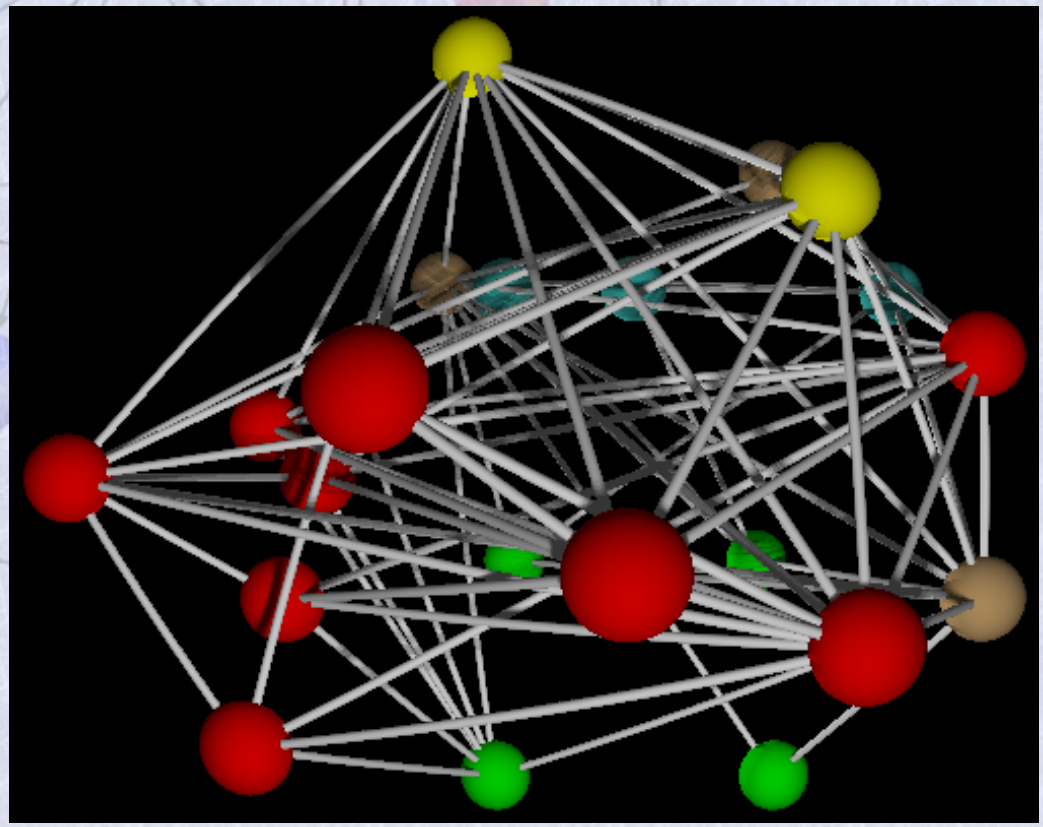
- Greater max. amplification
- More reactive

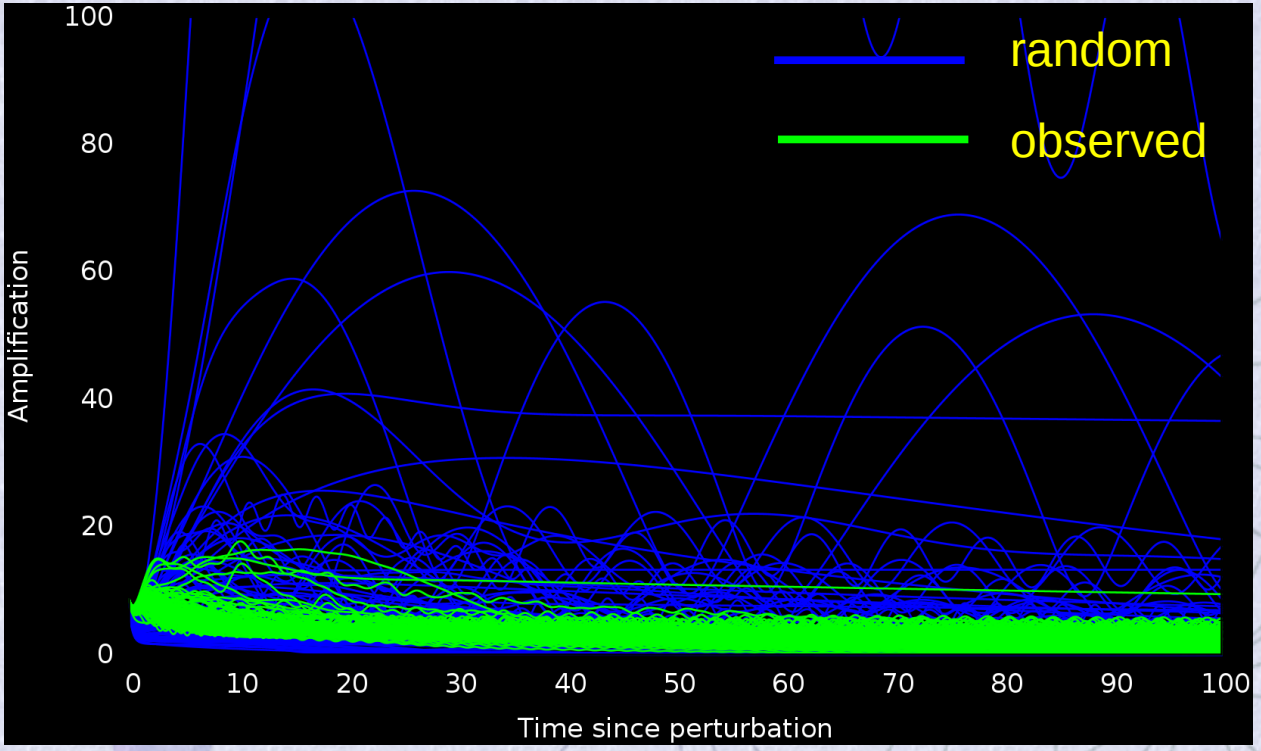
L. Permian

- No difference
  - Resilience
  - Max. amplification
- More reactive



What is the effect of pattern of functional partitioning?



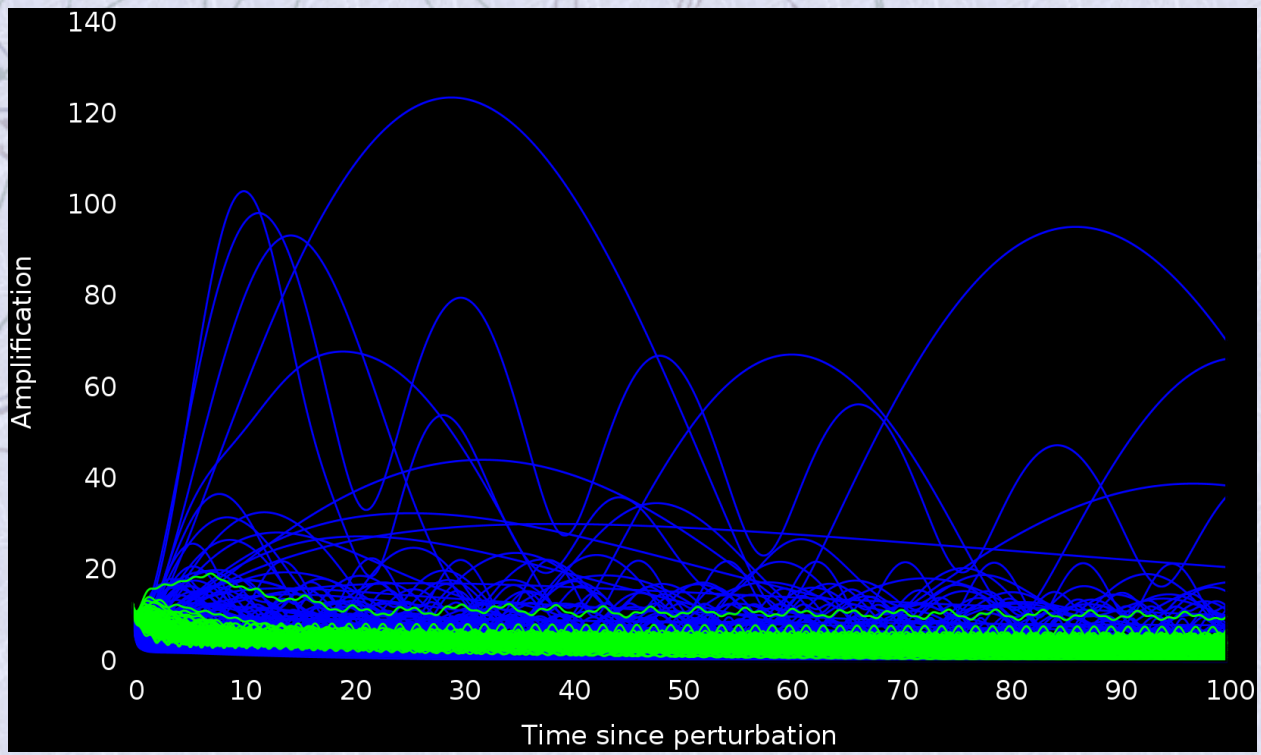


E. Triassic

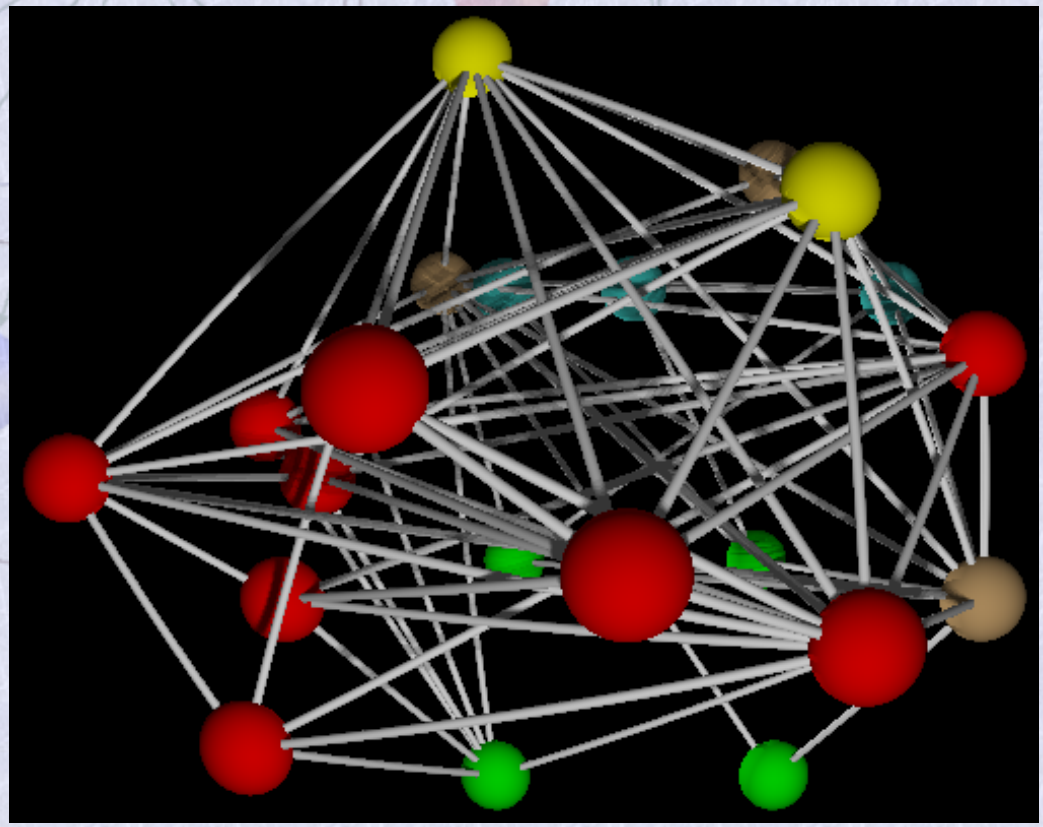
- More resilient
- Less amplification
- Less reactive

L. Permian

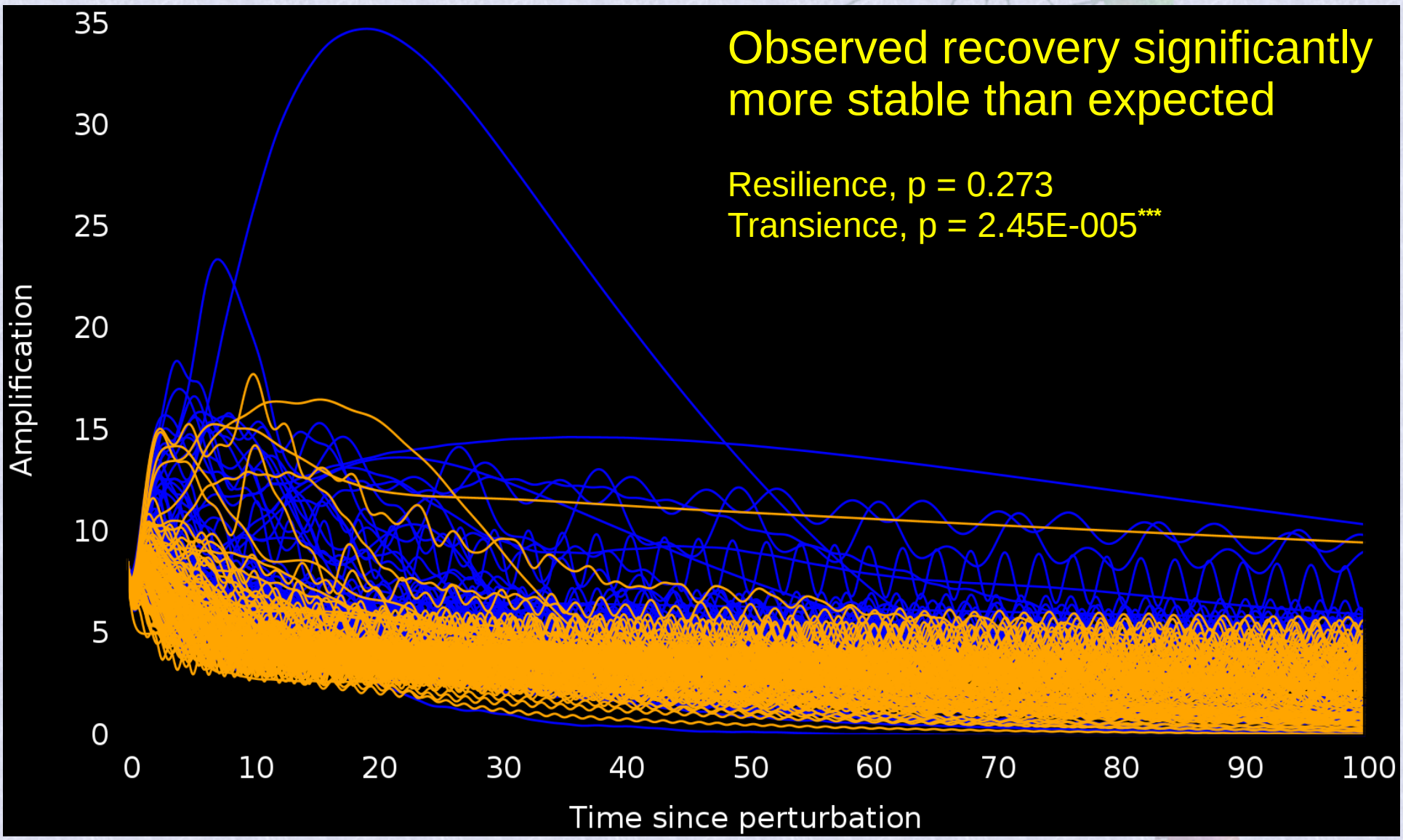
- More resilient
- Less amplification
- Less reactive



What is the effect of taxon richness?



RECOVERY


Observed recovery significantly more stable than expected
Resilience, p = 0.273
Transience, p = 2.45E-005***
Amplification
Time since perturbation
0
5
10
15
20
25
30
35
0
10
20
30
40
50
60
70
80
90
100

Hypothesis

- **Community dynamics bias patterns of evolution, extinction and persistence.**
  - Functional compartmentalization reduces community stability.
  - “Real” patterns of functional compartments significantly more stable than random.
  - Recovery after mass extinctions constrained by community dynamics. (more on Tuesday...)

- Acknowledgments
  - Ken Angielczyk, Rachel Hertog
  - NSF-CMG 0530825 to Roopnarine, Wang
  - NSF-EAR 1336986 to Angielczyk, Roopnarine, Sidor, Tabor

- References

  - Roopnarine, P. D. 2014. Humans are apex predators. *PNAS* doi/10.1073/pnas.1323645111.
  - Roopnarine, P. D. 2012. Red Queen for a day: models of symmetry and selection in paleoecology. *Evol. Ecol*. 26:1-10.
  - Roopnarine, P. D. and R. Hertog. 2012. Detailed food web networks of three Greater Antillean coral reef systems: The Cayman Islands, Cuba and Jamaica. *Dataset Papers in Ecol*. 23, 9 p.

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