Topological conditions drive stability in meta-ecosystems

Network Days: bridging micro with macro

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October 25, 2024

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Topological conditions drive stability in meta-ecosystems

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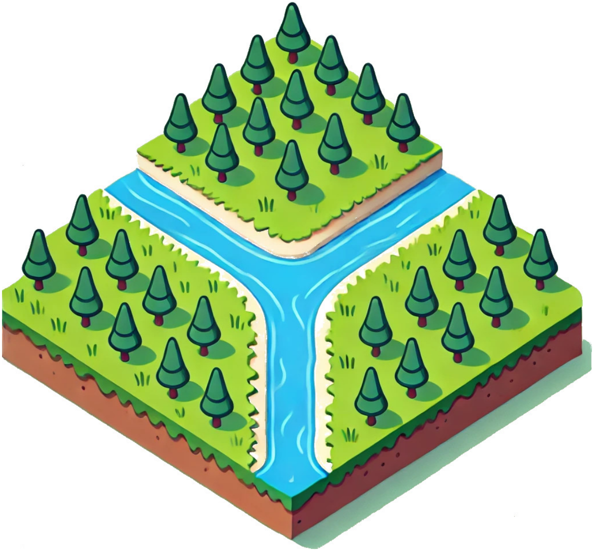
Phys. Rev. Research **6**, 043055 – Published 23 October 2024

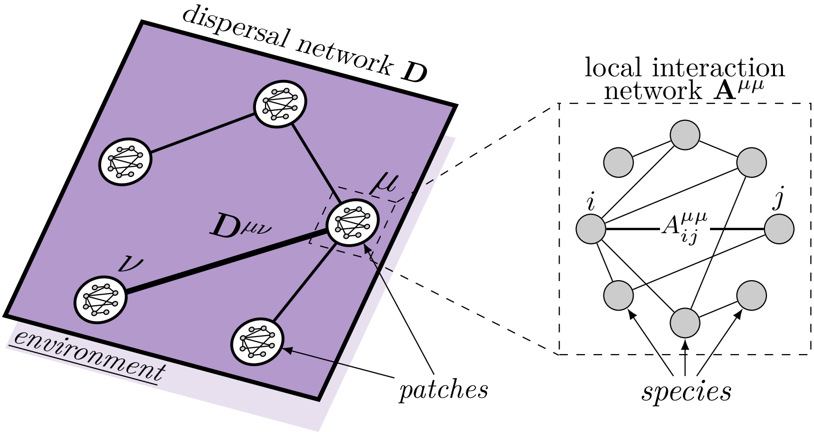
`https://doi.org/10.1103/PhysRevResearch.6.043055`

Meta-ecosystems

What are they?



More formally...



Meta-ecosystems

Even more formally...

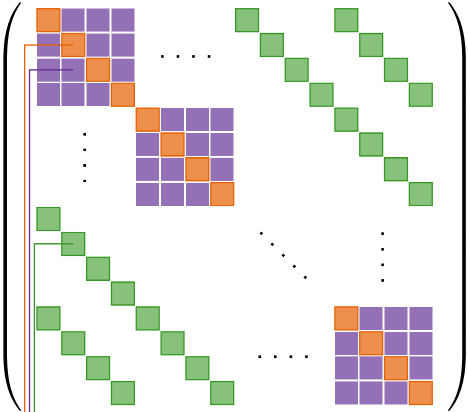
S species, M patches

community matrix of the form

$$\mathbf{J} = \underbrace{\mathbf{R}}_{\text{growth}} + \underbrace{\mathbf{A}}_{\text{interaction}} + \underbrace{\mathbf{D}}_{\text{dispersal}}$$

Community matrix

$\mathbf{J} =$



$$J_{ii}^{\mu\mu} = R_{ii}^{\mu\mu} + A_{ii}^{\mu\mu} + D_{ii}^{\mu\mu}$$

$$J_{ij}^{\mu\mu} = A_{ij}^{\mu\mu}$$

$$J_{ii}^{\mu\nu} = D_{ii}^{\mu\nu}$$

Stability

Consider linear stability $\rightarrow$ eigenvalues

$$\lambda_1 = \max_i \mathrm{Re}\lambda_i$$

stability criterion

$$\mathrm{Re}\lambda_1 < 0$$

for $M = 1$, May criterion
[May (1972)]

$$\sigma\sqrt{cS} < b - r$$

self-interaction

growth

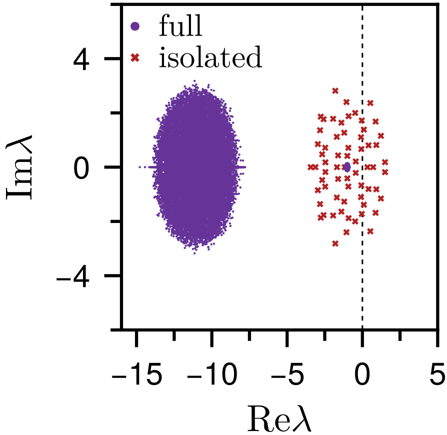
for M, large dispersal rate γ
[Gravel, Massol, and Leibold (2016)].

$$\sigma\sqrt{cS/M} < b - r$$

#patches

Results

Isolated nodes and connected components

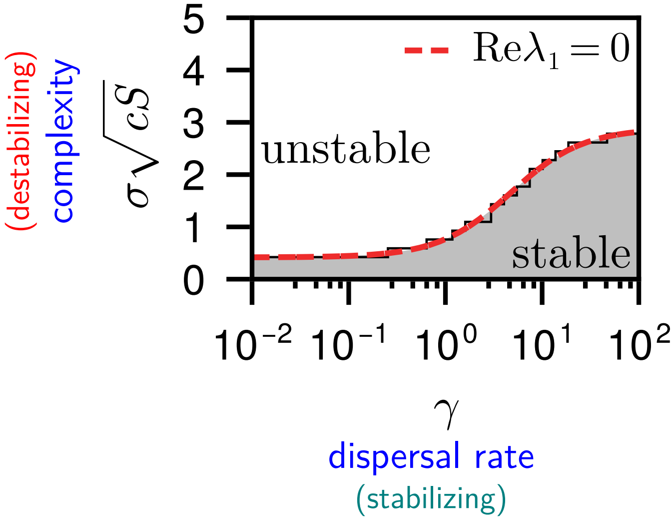


assume connected networks (Tishby et al. 2019)

Results

Dispersal networks and stability: dispersal rate γ

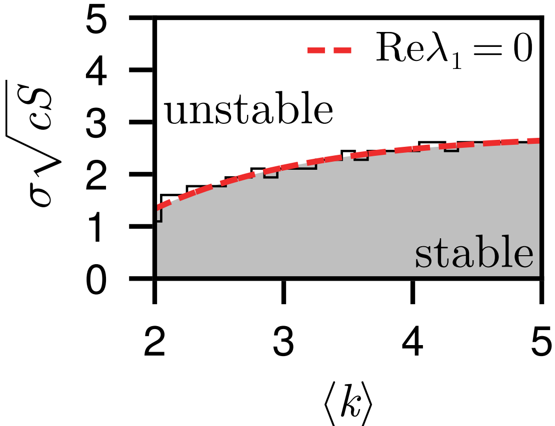
(Poisson deg. distribution) $\langle k \rangle = 3$



Results

Dispersal networks and stability: edge density $\langle k \rangle$

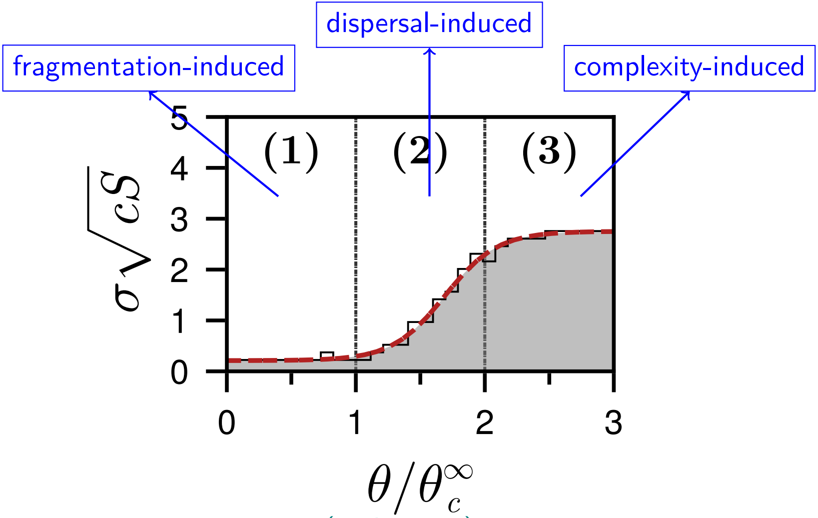
(Poisson deg. distribution) $\gamma = 10$



(stabilizing)

random geometric graphs

edge if distance $< \theta$

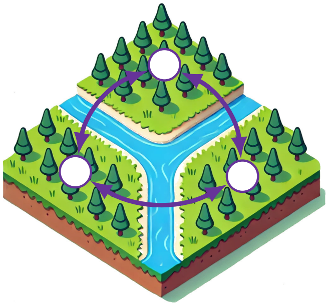


(stabilizing)

Take home messages 🏠

Meta-ecosystems and stability

1. species interactions matter!
2. network topology matters!
3. dispersal matters!
4. edge density fosters stability
5. fragmentation fosters instability



THANK YOU FOR YOUR ATTENTION

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Nauta, Johannes and Manlio De Domenico, 2024,
"Topological Conditions Drive Stability in Meta-Ecosystems," *Phys. Rev. Res.*,
DOI: `10.1103/PhysRevResearch.6.043055`