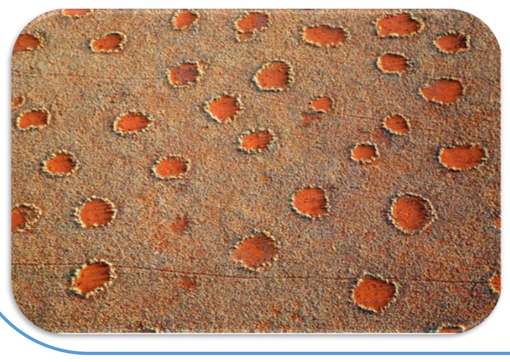
Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

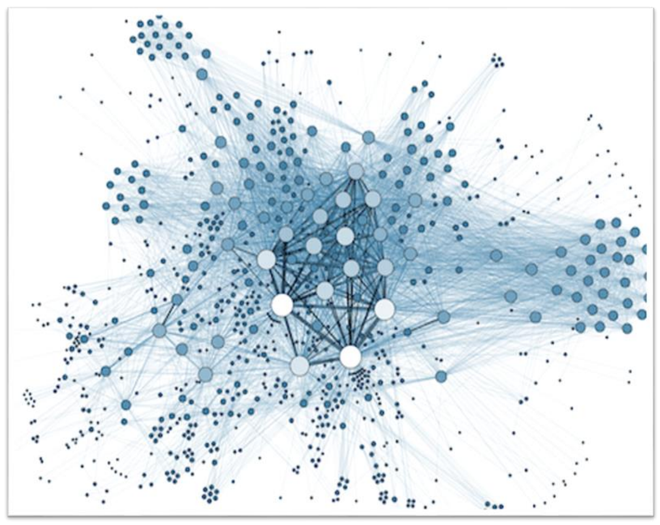
Network-mediated diffusion induces disordered self-organization in vegetation

Natural pattern formation

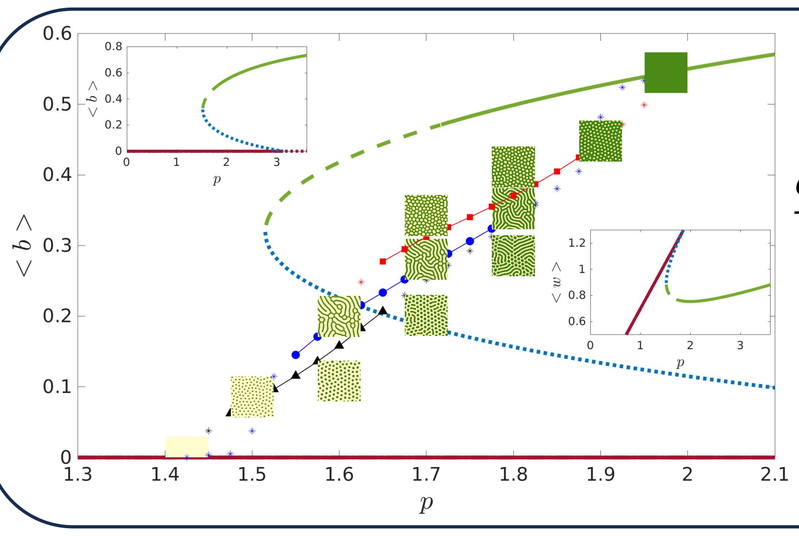


In drylands, the **interaction between short-range mutualism and long-range competition** for the limited resources leads to the emergence of vegetation patterns. They are a form of ecosystem self-organization to cope with water scarcity.

Patterns on networks



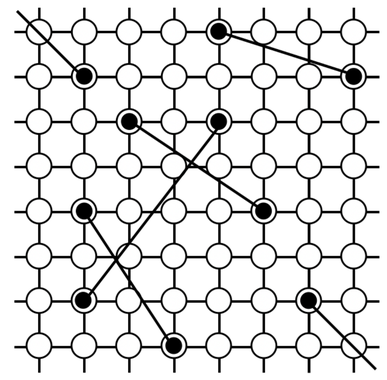
Recent studies have shown that similar mathematical models lead to **pattern formation over networks**. These studies have focused mostly on **large random network** with no connection to pattern formation in natural systems



$$\frac{\partial b}{\partial t} = \gamma w b(1-b)(1+\eta b)^2 - b + \nabla^2 b \rightarrow \phi_b$$

$$\frac{\partial w}{\partial t} = p - \frac{\nu w}{1+\varrho b} - \gamma w b(1+\eta b)^2 + d_w \nabla^2 w \rightarrow \phi_w$$

We start from a **reaction-diffusion vegetation model** producing regular vegetation patterns and allow the **diffusive terms** to operate over **increasingly complex network structures.** Simulating **heterogenous, anisotropic diffusion** of either biomass or water.



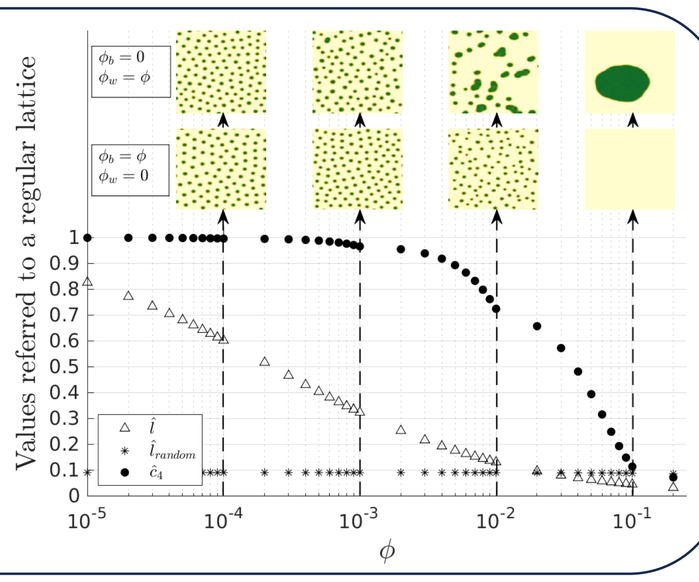
ϕ = n° of shortcuts

Watts-Strogatz small-world network model [3]

Low ϕ ($\phi \lesssim 10^{-3}$) — Regular grid → $c_4 \approx c_{4,lattice}$, $l << l_{random}$ → Local diffusion → Regular patterns

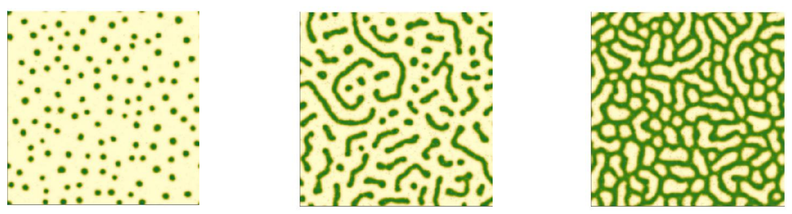
Intermediate ϕ ($10^{-3} \lesssim \phi \lesssim 0.05$) — Small world network → $c_4 \approx c_{4,lattice}$, $l \approx l_{random}$ → Global and local diffusion → Disordered patterns

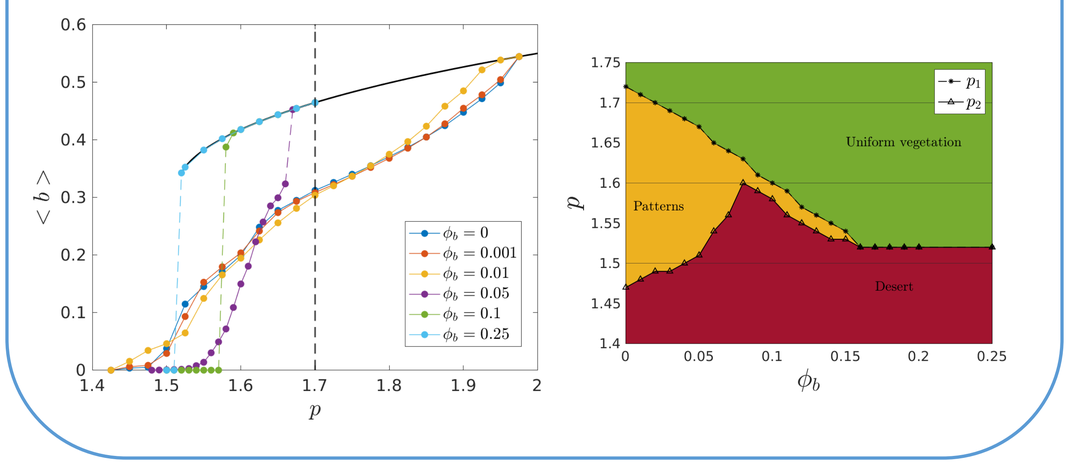
High ϕ ($0.05 \lesssim \phi$) — Random network → $c_4 << c_{4,lattice}$, $l \approx l_{random}$ → Global diffusion → Single patch/uniform states



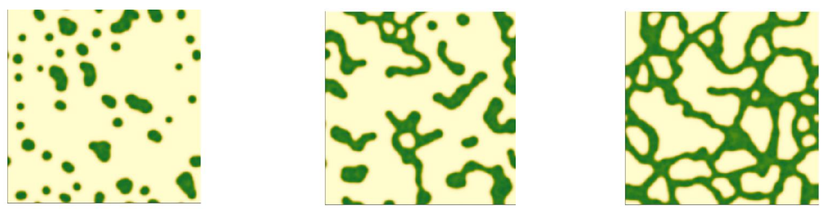
Two kinds of disordered self-organization with different implications for ecosystem resilience

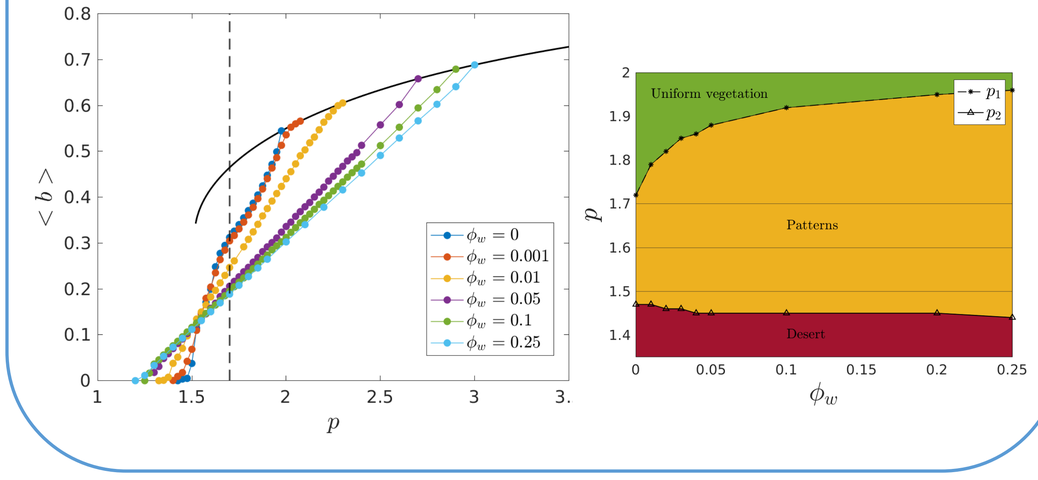
Low-regularity patterns (intermediate ϕ_b)





Irregular, broad patch/gap size distribution patterns (intermediate ϕ_w)





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