Regime shifts in spatially extended eco-systems

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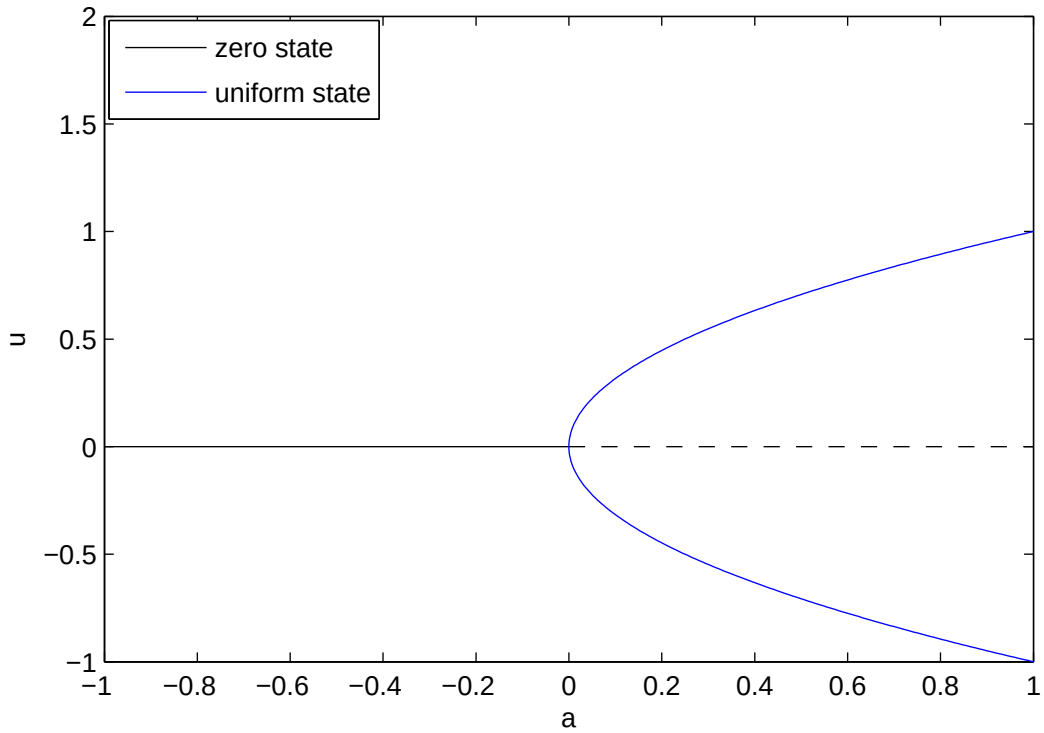
Bifurcation Graph

Simple ODE:

$$d_t u = au - u^3 \tag{1}$$



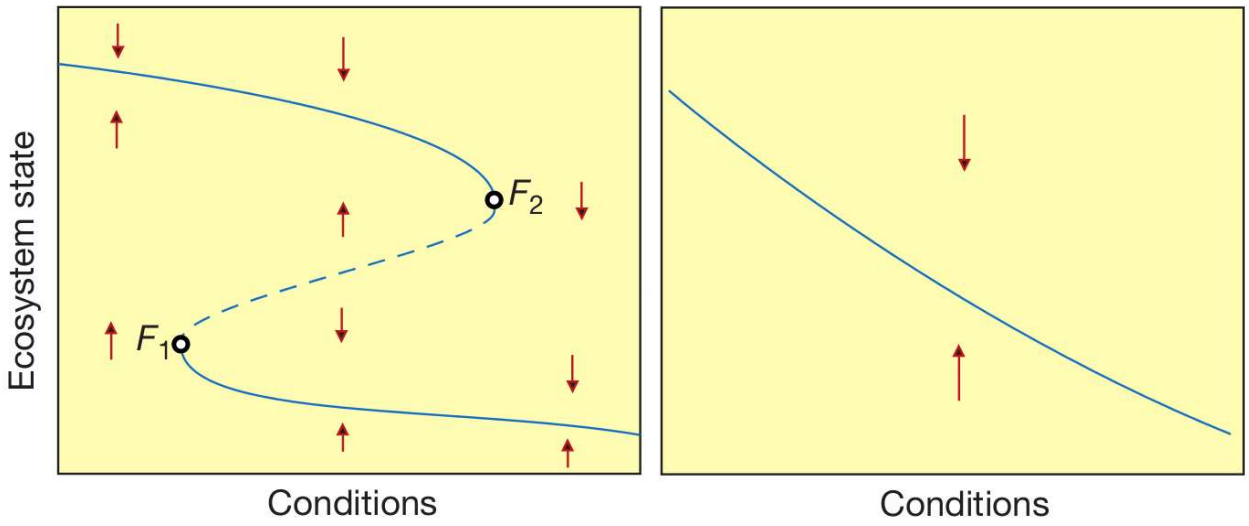
For $a > 0$ there are 3 solutions

Regime Shifts

Classical view of changes in a dynamical system:

Large, abrupt and reversible (Catastrophic)

Small and reversible



Regime Shifts Dynamics

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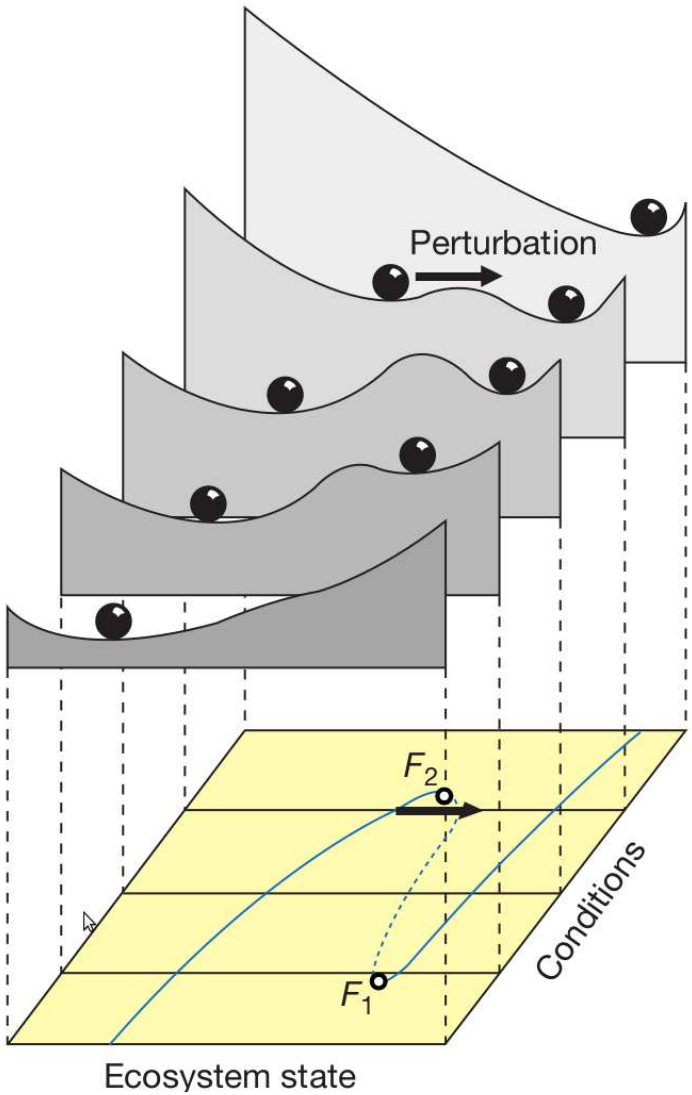
Basics

Front Dynamics

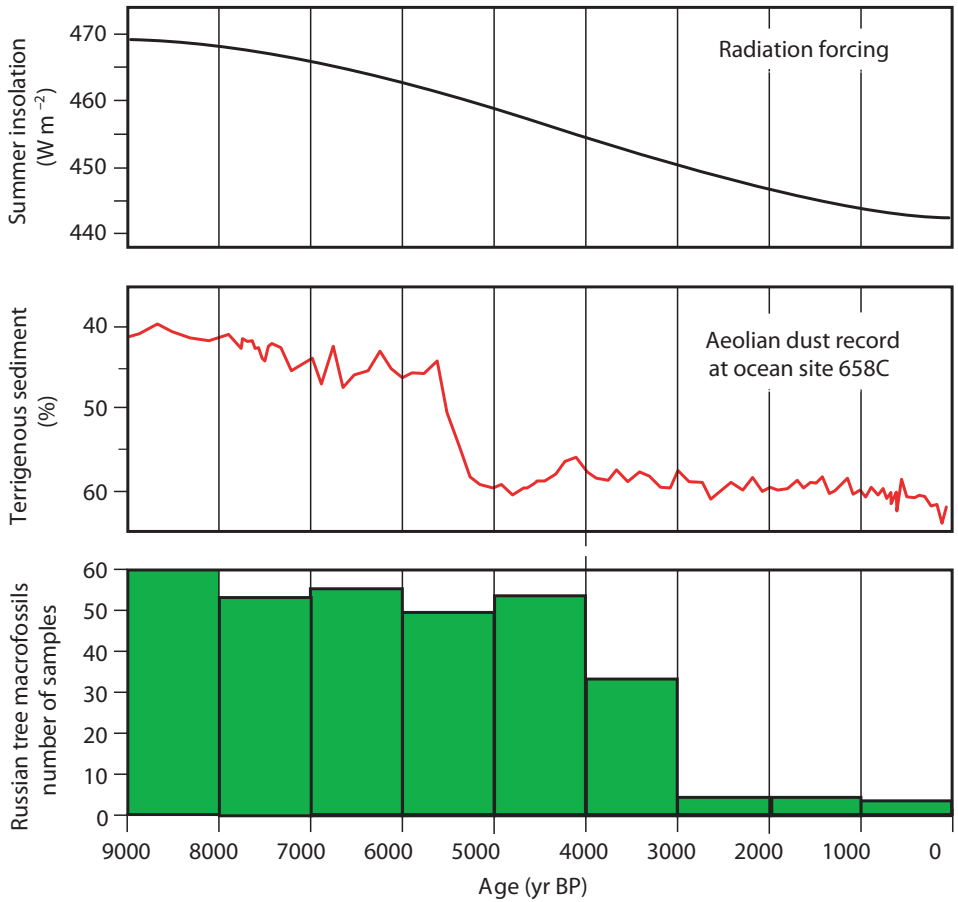
Pattern Formation

Results and Discussion



In Eco-systems

Rapid desertification - "Green Sahara":

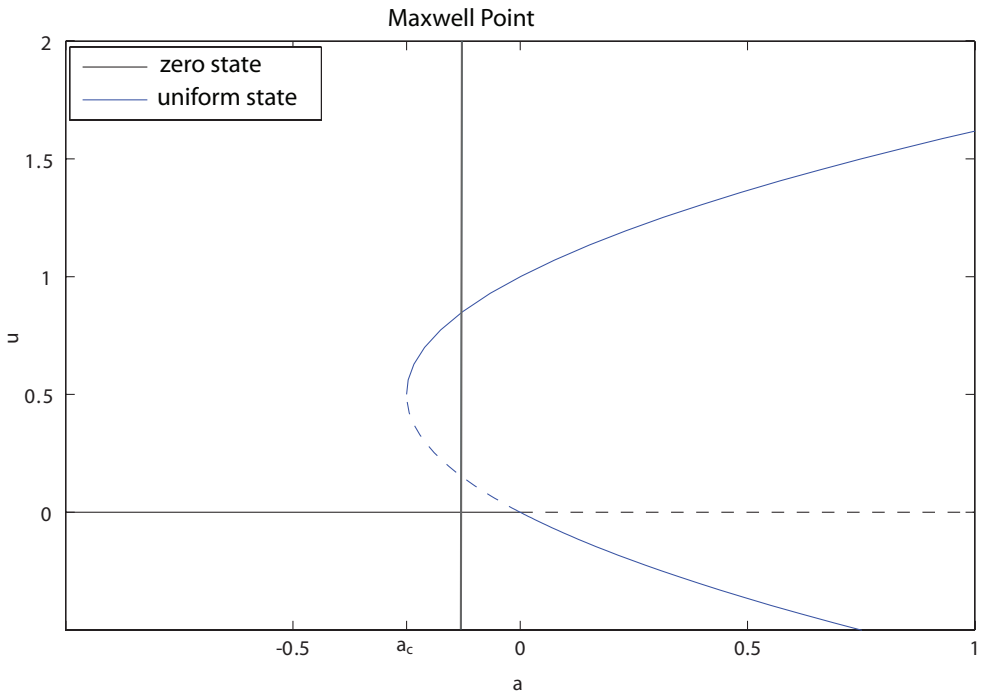


(Claussen 2008)

Simple Spatial Model

Reaction-Diffusion PDE:

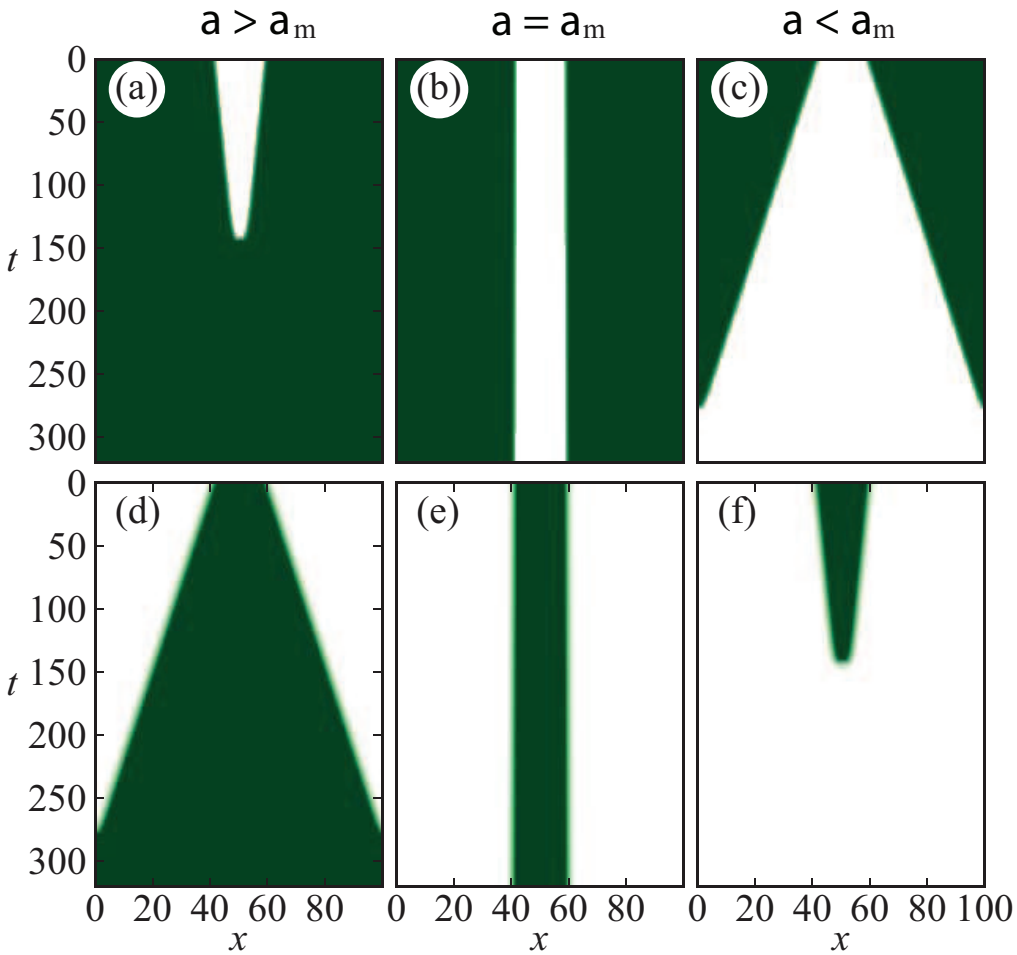
$$\partial_t u = au + bu^2 - u^3 + D\nabla^2 u \tag{2}$$



Maxwell point inside the bi-stability range

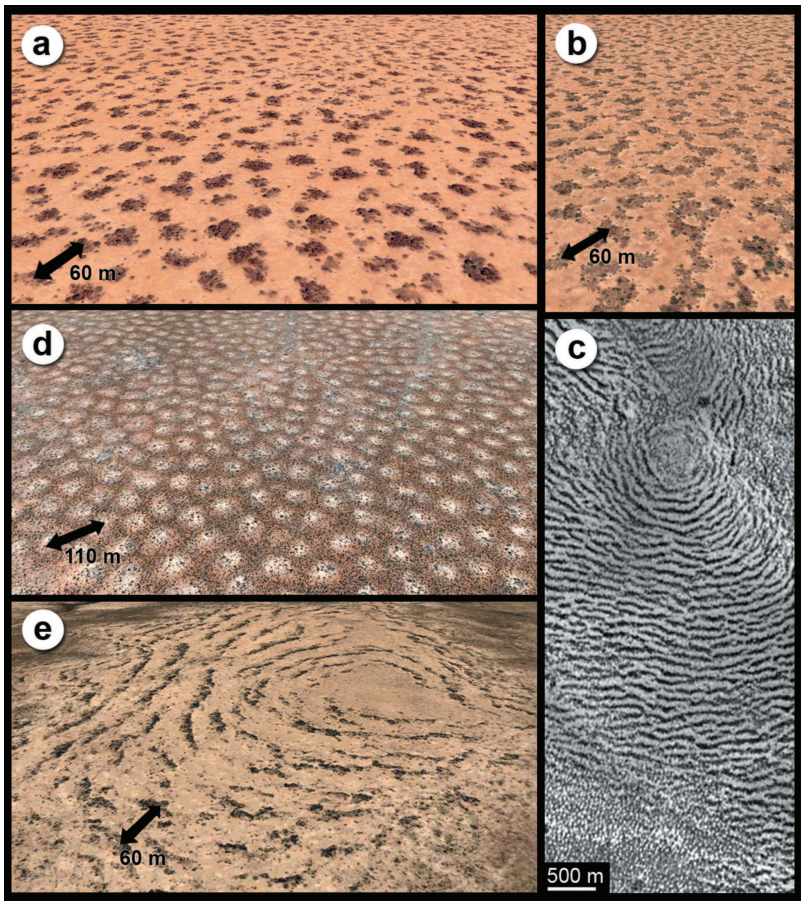
Maxwell Point

Different behavior across the Maxwell point



Patterned Vegetation

Patterns in dry-land vegetation:
Spots stripes and gaps along the rainfall gradient.

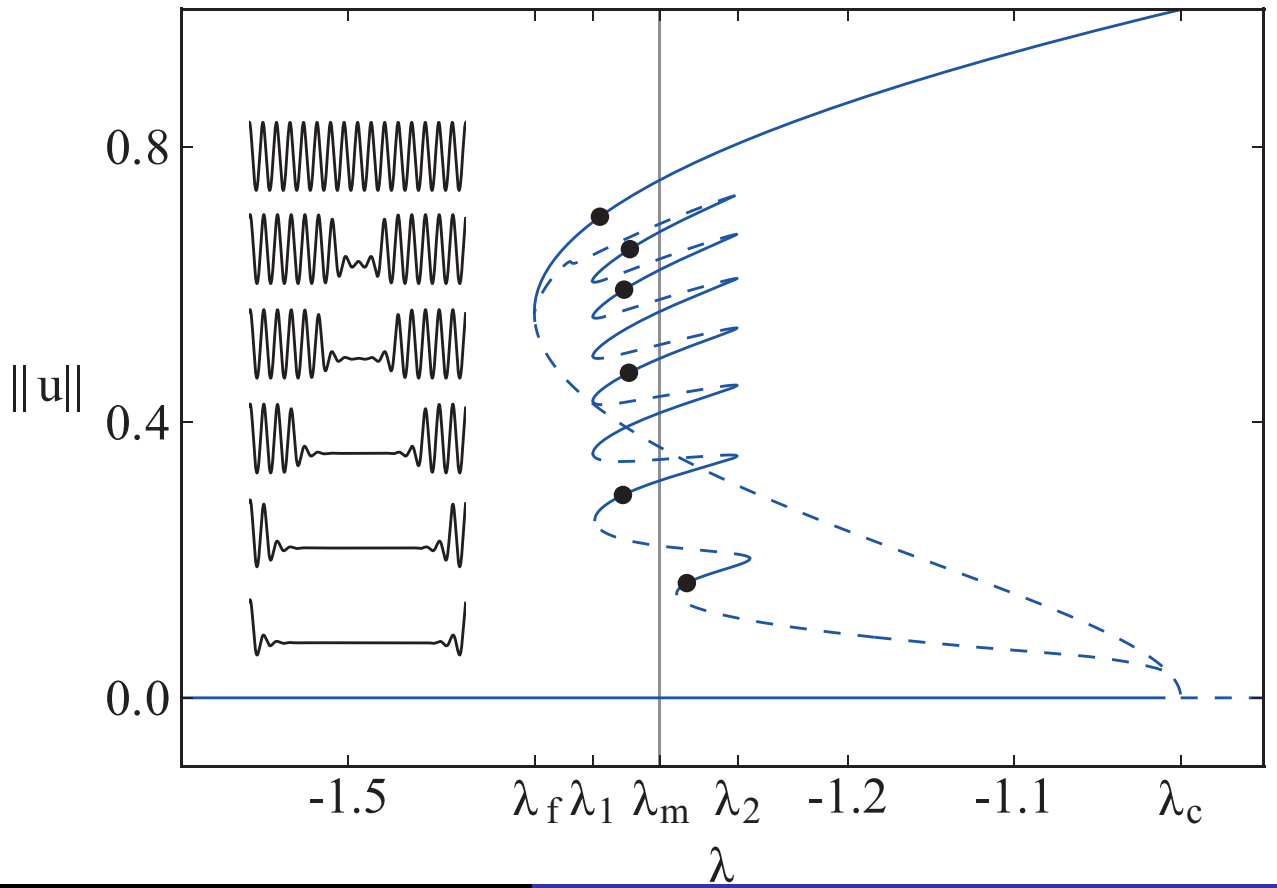


(Deblauwe et al. 2008)

Homo-clinic Snaking

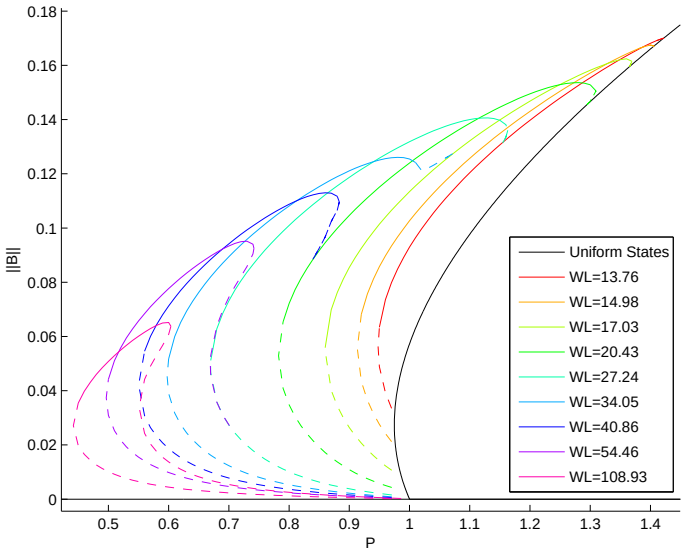
Pattern forming system - the Swift-Hohenberg equation

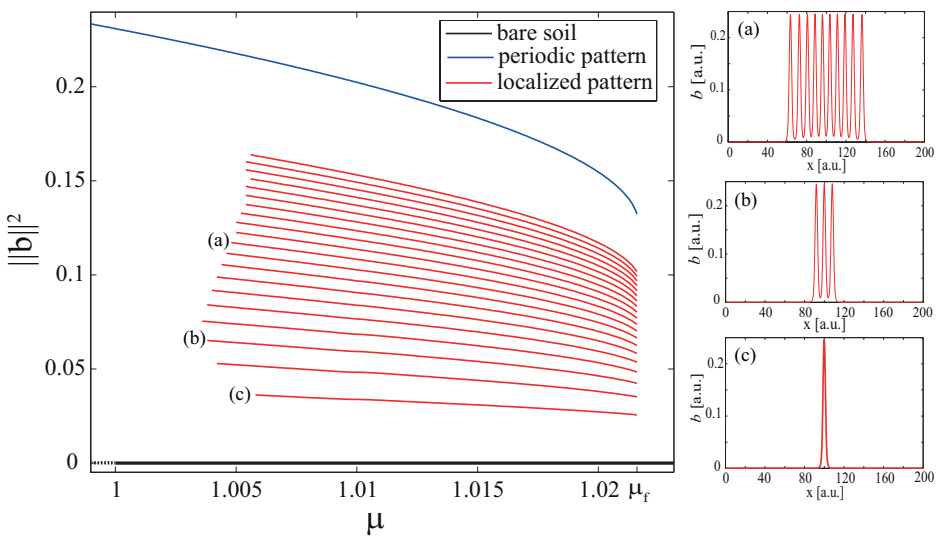
$$\partial_t u = au + bu^2 - u^3 + D\nabla^2 u - \nabla^4 u\,. \tag{3}$$



Results

Results from the simplified Gilad and Lefever-Lejeune models:





Multiplicity of patterned states

Many localized states

Open Questions

- Can bare-soil invade a vegetation state (desertification by front-dynamics)?
- What kind of regime shifts to spatial system undergo?
- Can we see dynamics of vegetation localized states in nature?

Questions

Questions?