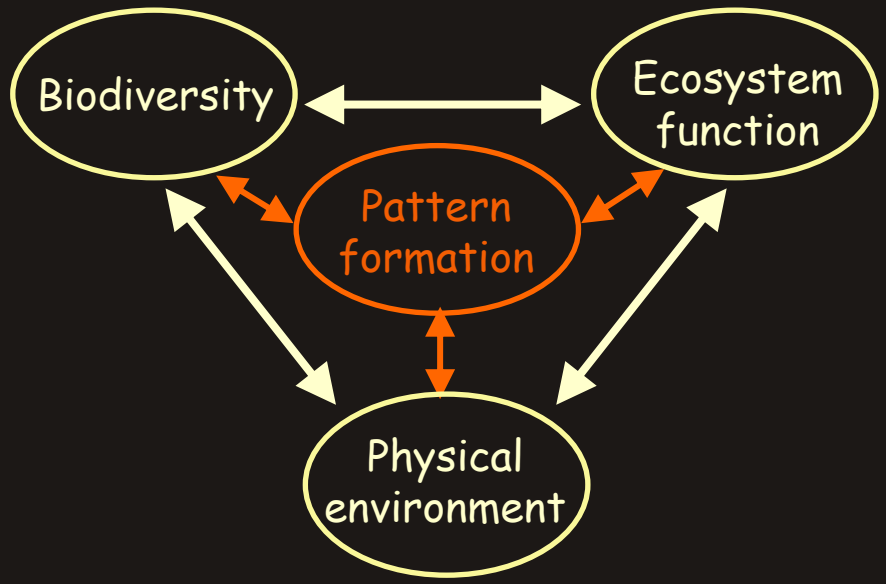
Research group of Ehud Meron

Physics-SEEP meeting, April 6, 2016

Research topics:

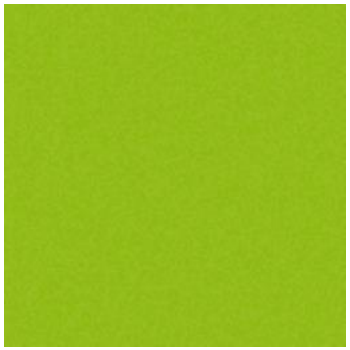
- Pattern formation in general
- Pattern formation in drylands
- Implications for ecosystem function



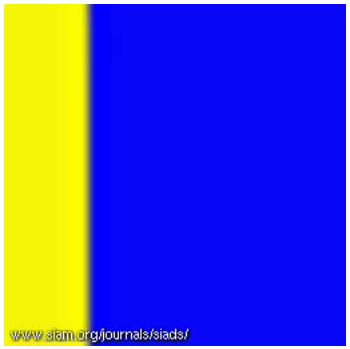
Pattern formation in general

Mathematical aspects of pattern formation:

- Non-uniform instabilities of uniform states: studies of pattern dynamics using normal form equations



- Uniform instabilities resulting in multiple stable states: studies of front dynamics using singular perturbation theory



- Pattern control by periodic forcing in space and time

Spatial forcing of a stripe pattern

Temporal forcing of spiral waves

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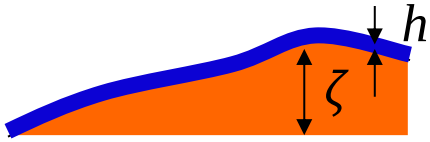
Pattern formation in drylands

Scaling up local processes and organism-level traits to landscape patterns and species assemblage properties by mathematical modeling:

$$\partial_t b = G_b[w]b(1 - b/\kappa) - b + \nabla^2 b$$ Areal biomass density

$$\partial_t w = Ih - Lw - G_w[b]w + \delta_w \nabla^2 w$$ Soil-water content per unit ground area

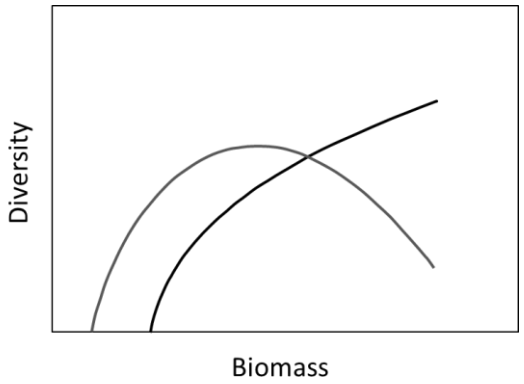
$$\partial_t h = p - I(b)h - \boldsymbol{\nabla} \cdot \boldsymbol{J} \qquad \boldsymbol{J} = -2\delta_h h\, \boldsymbol{\nabla}(h + \zeta)$$ Surface-water height

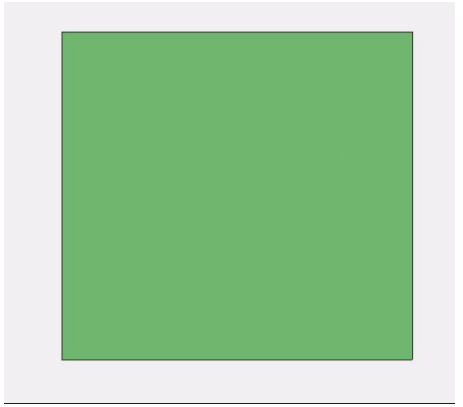


Extension to community:

$$b = b(\boldsymbol{r}, t) \rightarrow \; b = b(\boldsymbol{r}, \boldsymbol{\chi}, t)$$

Derive community-level properties:





Implications of pattern formation for ecosystem function

A population-level mechanism to survive water stress

Can mitigate adverse effects of desertification and biodiversity loss

Human intervention keeping ecological integrity high

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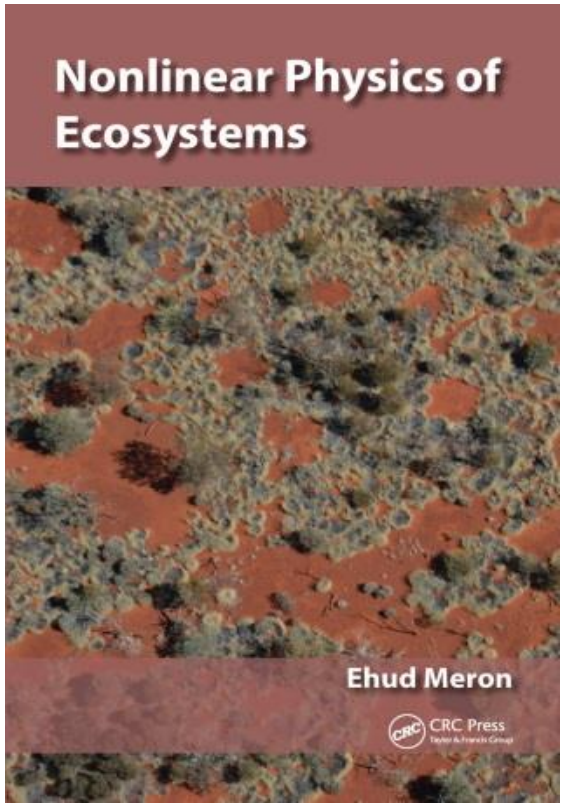
New book



Introduction

I Overview

II Pattern formation theory

III Applications to Ecology

Introduces the concepts and tools of pattern formation theory and demonstrates their utility in ecological research using problems from spatial ecology …

Reviews:

Physics Today, Hugo Fort (2015)

Contemporary Physics, K. Alan Shore (2015)

Key papers relevant to this talk:

PRL 2004: Gilad et al., Ecosystem Engineers: From Pattern Formation to Habitat Creation

PRL 2012: Mau et al., Spatial periodic forcing can displace patterns it is intended to control

PRL 2014: Kinast et al., Interplay between Turing Mechanisms can Increase Pattern Diversity

PRE 2015: Mau et al., Reversing desertification as a spatial resonance problem

PNAS 2015: Zelnik et al., Gradual Regime Shifts in Fairy Circles

PNAS 2016: Getzin et al., Discovery of fairy circles in Australia supports self-organization theory

Mathematical Biosciences 2016: Meron, Pattern formation – a missing link in the study of ecosystem …