MINISYMPOSIUM

SPATIAL PATTERNS ACROSS ECOLOGY: DIFFERENCES AND SIMILARITIES

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Minisymposium Keywords: pattern formation, ecosystems, multiple scales

In this mini-symposium we bring together research on spatial patterning across ecology. Although spatial patterns sometimes look similar, the ecological processes behind these patterns are often very different. The goal of this mini-symposium is to learn which pattern characteristics are generic and which are ecosystem specific, thereby facilitating the transfer of mathematical techniques and the construction of a pattern-based indicator framework for the assessment of ecosystem resilience.

Tuesday, July 24th, 14:00 **Room: C8.2.13**

Minisymposium: Spatial patterns across ecology: differences and similarities

MULTI-SCALE PATTERNS IN SELF-ORGANIZED ECOSYSTEMS: A NEW HYPE OR SOMETHING REALLY IMPORTANT?

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Keywords: Self-organization, Pattern formation, Resilience.

Natural ecosystems are characterised by a multitude of spatial patterns occurring at a wide range of spatial scales. They can have the origins in different processes: population-dynamical mechanisms such as competition and facilitation, and behavioural mechanisms leading to aggregation of organisms in clumps, herds and schools. Understanding of how different forms of self-organization can interact requires integration of physical, ecological and mathematical concepts of self-organization, and effective communication between scientists from these fields having very different backgrounds. In this session, we highlight how this merger of concepts from different disciplines can provide new insights into shapes that characterise natural ecosystems from small to large spatial scales, and how these patterns in turn shape ecosystem resilience.

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INTERPLAY OF WATER AND TOXICITY IN VEGETATION PATTERN FORMATION

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Keywords: Vegetation paterns, Toxicity, Reaction-diffusion.

Vegetation patterns are largely present in nature. Their formation, however, is still far from being fully understood. A prevailing view is to treat water availability as the main causal factor for the emergence of vegetation patterns, as they are mostly observed in arid and semiarid regions. While successful, this hypothesis fails to explain the presence of vegetation patterns in humid environments. We present here a novel toxicity-mediated model for vegetation pattern formation and investigate its rich structure. This model consists of three PDEs accounting for a dynamic balance between biomass, water, and toxic compounds. Different (ecologically feasible) regions of the model's parameter space give rise to stable spatial vegetation patterns in Turing and non-Turing regimes. Strong negative feedback gives rise to dynamic spatial patterns that continuously move in space while retaining their stable topology.

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HOW DOES LONG-RANGE DISPERSAL AFFECT PATTERN FORMATION IN SEMI-ARID VEGETATION?

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Keywords: Vegetation patterns, Nonlocal diffusion, Reaction-diffusion-advection, Convolution kernel.

Vegetation patterns are a characteristic feature of semi-arid regions. On hillsides these patterns occur as stripes running parallel to the contours. The Klausmeier model, a coupled reaction-advection-diffusion system based on the assumption that plants compete for water, is a deliberately simple model describing the phenomenon. To account for the possibility of long-range dispersal of seeds, we replace the diffusion term describing plant dispersal by a more realistic nonlocal convolution of the plant density with a probability distribution. Our analysis focuses on the rainfall level at which there is a transition between uniform vegetation and pattern formation. We obtain results, valid to leading order in the large parameter comparing the rate of water flow downhill to the rate of plant dispersal, for a negative exponential dispersal kernel. Our results indicate that both a wider dispersal of seeds and an increase in dispersal rate inhibit the formation of patterns. Assuming an evolutionary trade-off between these two quantities, mathematically motivated by the limiting behaviour of the convolution term, allows us to make comparisons to existing results for the original reaction-advection-diffusion system. These comparisons show that the nonlocal model always predicts a larger parameter region supporting pattern formation. We obtain the same parametric trends on the rainfall threshold for other dispersal kernels by investigating the model's solution numerically. By comparing results for these kernels we show that the tendency to form patterns further depends on the type of decay of the kernel.

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VEGETATION PATTERNS AND ECOSYSTEM DEGRADATION: TOWARDS A COMPLETE INDICATOR FRAMEWORK

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Keywords: Ecosystem degradation, Pattern formation, Resilience, Indicator framework.

Models suggest that adaptations in vegetation patterns can serve as indicators for ecosystem degradation. As conditions become harsher, vegetation patterns adapt from a gap pattern, to a labyrinthine pattern and eventually a spot pattern before ecosystems transition towards a bare degraded state. In this talk I will present reasons why this indicator framework is incomplete. First, I will show that Turing patterns are sticky (do not adapt in response to environmental change) and exhibit multistability (different patterns for the same environmental conditions), which limit their use as indicators for degradation. I will continue by discussing a class ecosystems with Turing-like patterns that are continuously adapting, even in absence of environmental change. Finally, I show how in these ecosystems adaptations in patterns and in their dynamics may still provide ways to assess ecosystem resilience to environmental change.