Mathematical Ecology: Theory and Applications (META)

Joint Research Group in the UK - LMS Scheme 3

META WORKSHOP

`Mathematical methods for complex ecological systems'

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ABSTRACTS

Dmitri Finkelshtein
Swansea University

Mean-field description of individual-based models: how to reduce the losses

We present a unified approach to the study of statistical multi-scale description for spatiotemporal marked point processes which correspond to stochastic evolutions of complex systems. We consider how to derive rigorously spatially inhomogeneous mean-field equations which describe approximate densities of populations of considered entities. We explain effects which may appear for solutions to these equations. We show how to include the next order of approximation, and illustrate its benefit by the study of an extinction threshold in a spatial logistic model.

Nick Isaac
Centre for Ecology & Hydrology

Modelling biodiversity change from messy and biased data

We have entered a new geological epoch, the Anthropocene, reflecting the pervasive impact of humans on our planet. One feature the Anthropocene is what ecologists refer to as the biodiversity crisis, or the “Sixth Mass Extinction.” Monitoring and understanding biodiversity change is critical in order to enact effective mitigation strategies, but there is a dearth of high quality data for this purpose. Occurrence records, such as those collected by Citizen Science projects, are a rich source of information: the Global Biodiversity Information Facility (GBIF) database now contains over 600 million records. However, occurrence records were not gathered in a systematic manner, leading to numerous biases. I will describe the application of hierarchical Bayesian occupancy-detection models to unstructured occurrence records, and show using computer simulation that the resultant trends are robust to known biases in the data. I will illustrate the use of these models using a suite of examples, including biodiversity indicators and measuring the impact of pesticides on beneficial insects.

Irene Moroz
Oxford University

Chaos in an NPPZ model for plankton

The dynamics of plankton ecosystems have long been of interest to ecologists and mathematicians, with some of the earliest examples of chaotic dynamics being provided by ecological models. Mortality terms were initially identified as determinants of chaos in simple ecosystem models, but relatively little attention has been given to the role of grazing terms. The behaviour of omnivores has arisen as a particularly interesting case. Recent experiments have revealed that plankton omnivores may change their feeding behaviour in response to changes in temperature, and is therefore of interest to plankton modellers contributing models of biogeochemical cycling in the ocean to climate models. In this talk we consider the role of an omnivorous zooplankton's foraging strategy, and the choice of functional forms on the dynamics of a simple two prey-one predator plankton model, within a Conservative-Normal framework. We find that assumptions about the way the predator forages for food, the specific form for grazing and mortality terms, all qualitatively affect the predictions that the model will produce.
In particular, specialist foraging leads to chaotic dynamics while Holling Type III grazing and quadratic mortality terms suppress chaotic dynamics.

Andrew Morozov
University of Leicester

Imperfect prey selectivity of generalist predators promotes biodiversity and irregularity in food webs

Ecological communities are often characterised by many species occupying the same trophic level and competing over a small number of vital resources, and planktonic communities including hundreds of different phytoplankton and zooplankton species is a particularly important study case. The mechanisms maintaining high biodiversity in such systems are still poorly understood. For example, a good understanding of the ‘paradox of plankton’ – the coexistence of many phytoplankton species competing over a few vital nutrient resources in an apparently homogeneous environment- is still lacking. In this talk, I revisit the role of prey selectivity by generalist predators in promoting biodiversity in food webs. Mathematically, I

consider a generic tri-trophic food web, consisting of a single limiting nutrient resource, a large number of primary producers (phytoplankton) and a generalist predator (mesozooplankton). Firstly, I suggest a novel framework to describe the predator functional response, combining food selectivity for distinctly different functional prey groups with proportion-based consumption of similar prey species. Model simulation reveals that intermediate levels of prey selectivity can explain high species richness, functional biodiversity, and variability among prey species observed in plankton communities. In contrast, perfect food selectivity or purely proportion-based food consumption (largely implemented in the current literature) would lead to a collapse of prey functional biodiversity. The model results are in agreement with empirical phytoplankton rank-abundance curves in lakes.

Jonathan Pitchford
University of York

Simple mathematical models in a world of Big Data

TBA

Kam W. Tang
Swansea University

Microbial dynamics on marine particles: experimental and modelling study of a complex microcosm

Globally, carbon burial to the deep ocean by marine snow fluxes is of comparable magnitude as anthropogenic carbon emission. Large-scale commercial fertilization of the ocean has been proposed as a way to enhance marine snow fluxes and thereby sequester atmospheric carbon and lessen the greenhouse effect. The hidden danger of such a proposal, however, is that very little is known about the ecological impacts marine snow may have on the surrounding environment. Far from being inert sinking particles, marine snow constantly interacts with the ambient microbial communities. Intensive bacterial and protist activities on and around marine snow transform and degrade marine snow materials, with significant ramifications for carbon fluxes. We formulated and tested simple mathematical models that adequately describe the initial colonization, growth and mortality of bacteria on marine snow particles. Subsequent laboratory and mesocosm studies, however, showed that the succession and inter-specific interactions of the microbial community on marine snow is more complex than previously thought.

Stuart Townley
University of Exeter

Adaptive control and robust management of natural populations

Pests epitomize natural populations in that they require management and yet admit dynamics that are often highly uncertain and poorly understood. We argue that adaptive control approaches are well suited to the management of pests, and natural populations more generally, and propose simple adaptive tuning mechanism so that nonlinear feedback controls achieve exponential stabilization. In developing our control strategies we appeal to comparison and monotonicity arguments. Interestingly, componentwise nonnegativity of the model, combined with irreducibility, circumvents several issues typically associated with adaptive controllers.