Scientific Program

Conference on "Advances in Mathematical Ecology"
June 1 - 2, 2023 at the University of Pittsburgh (Benedum Hall, 157)

Program Overview

Thursday, June 1

8:45am - 9:00am	*Welcoming attendees*
9:00am-10:00am	**Plenary Talk: Karen Abbott**
10:00am - 10:15am	*Coffee/Tea Break*
10:15am - 11:45am	**Invited Talks**
11:45am - 1:30pm	*Lunch Break*
1:30pm - 2:30pm	**Plenary Talk: Sebastian Schreiber**
2:30pm - 2:45pm	*Coffee/Tea Break*
2:45pm - 4:45pm	**Invited Talks**
4:45pm - 5:00pm	*Break*
5:00pm - 7:00pm	**Poster Presentations**

Friday, June 2

9:00am - 10:00am	**Plenary Talk: Frithjof Lutscher**
10:00am - 10:15am	*Coffee/Tea Break*
10:15am - 11:45am	**Invited Talks**
11:45am - 1:30pm	*Lunch Break*
1:30pm - 2:30pm	**Plenary Talk: Yun Kang**
2:30pm - 2:45pm	*Coffee/Tea Break*
2:45pm - 4:15pm	**Invited Talks**
4:15pm - 4:30pm	*Closing*

Detailed Program

Thursday, June 1

Morning Session

8:45am – 9:00am

8:45am – 9:00am
Conference Opening: Welcoming of participants and attendees

9:00am – 10:00am

9:00am – 9:50am
Karen Abbott: *Stability and tipping points in noisy environments*

9:50am – 10:00am: Q&A

10:15am – 11:45am

Each 25minute talk is followed by a 5minute Q&A. The time frames below include the Q&A session.

10:15am – 10:45am
Michael Cortez: *How the mode of adaptation for prey defense influences responses to environmental change*

10:45am – 11:15am
William Wetzel: *Macroecological and macroevolutionary patterns of variability in plant-herbivore interactions*

11:15am – 11:45am
Jonathan Rubin: *A mechanism for inducing irregular timing in population cycles*

Thursday, June 1

Afternoon Session

1:30pm – 2:30pm

1:30pm – 2:20pm
Sebastian Schreiber: *Coexistence in an autocorrelated world*

2:20am – 2:30am: Q&A

2:45pm – 4:45pm

Each 25minute talk is followed by a 5minute Q&A. The time frames below include the Q&A session.

2:45pm – 3:15pm
Alexandru Hening:*Population dynamics under random switching*

3:15pm – 3:45pm
Nicholas Kortessis: *Adaptation and coevolution of competitors in fluctuating environments: challenges and opportunities*

3:45pm – 4:15pm
Swati Patel:*A pulsed eco-evo model for anthelmintic resistance*

4:15pm – 4:45pm
Xingfu Zou: *Role of white-tailed deer in geographic spread of the black-legged tick Ixodes scapularis: analysis of a spatially nonlocal model*

Friday, June 2

Morning Session

9:00am – 10:00am

9:00am – 9:50am
Frithjof Lutscher: *Modelling seasonal population dynamics and exploring the effects of global change*

9:50am – 10:00am: Q&A

10:15am – 11:45am

Each 25minute talk is followed by a 5minute Q&A. The time frames below include the Q&A session.

10:15am – 10:45am
Erol Akçay: *The joint dynamics of epidemics and norm-driven disease avoidance behaviors*

10:45am – 11:15am
Mark Wilber: *Towards a theory of host recovery dynamics following disease-induced declines: an epi-eco-evo perspective*

11:15am – 11:45am
Cameron Browne: *Environmental adaptation and seasonality in multi-strain cholera dynamics*

Friday, June 2

Afternoon Session

1:30pm – 2:30pm

1:30pm – 2:20pm
Yun Kang: *Ecological and Evolutionary Modeling of Complex Adaptive Systems*

2:20am – 2:30am: Q&A

2:45pm – 4:15pm

Each 25minute talk is followed by a 5minute Q&A. The time frames below include the Q&A session.

2:45pm – 3:15pm
Corinne Richards-Zawacki:*Modeling resilience to global change: Amphibians and their emerging fungal disease as a case study*

3:15pm – 3:45pm
Amanda Laubmeier: *Modelling the effect of temperature-dependent activity on pest consumption*

3:45pm – 4:15pm
Susmita Sadhu:*Novel methods of analyzing long transients preceding regime shifts in a two timescale predator-prey model*

4:15pm – 4:30pm

4:15pm – 4:30pm
Conference Closing: Thanking the participants and attendees

Abstracts

Karen Abbott

Department of Biology
Case Western Reserve University
Cleveland, Ohio, USA

Stability and tipping points in noisy environments

Abstract:

Sudden, persistent changes in ecosystem state or configuration, known in ecology as regime shifts, are difficult to predict and a cause of great concern. A large, stable prey population may suddenly collapse to an alternative low-density state in response to a stochastic perturbation, for example, or stochasticity may trigger outbreaks in pest populations that were previously stably suppressed. To explain phenomena like these, ecologists have drawn heavily on deterministic theory that emphasizes the nonlinearities that give rise to bifurcation-induced tipping points, while marginalizing the complex role of stochasticity in driving transitions between states.

In this talk, I will discuss how different types of tipping points arise, and how we can use potential functions (including their extensions, such as the quasi-potential) to derive stronger stability concepts that allow us to move beyond classical deterministic theory. Given the pervasive influence of large perturbations in nature, this view promises to yield improved insights into the factors that stabilize or destabilize ecological systems.

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Erol Akçay

Department of Biology
University of Pennsylvania
Philadelphia, Pennsylvania, USA

The joint dynamics of epidemics and norm-driven disease avoidance behaviors

Abstract:

Infectious diseases are fundamentally social phenomena: how diseases get transmitted depends on host social behaviors and contact structure. Moreover, host behaviors affecting transmission are rarely constant, but respond to disease spread. Humans as usual present an even more complicated picture where many of the behaviors that can mitigate the spread of a disease, such as wearing masks, are driven by prevailing social norms. This means behavioral dynamics are not just responsive to the disease but also to what others do. I will present a simple model of an epidemic with norm-driven behaviors that reduce transmission rate of a disease. This model creates endogenous waves of disease and behavioral dynamics and unexpected patterns in the final outcome of the epidemic, such as non-monotonic attack rates in important model parameters. It highlights the complexity that coupled social-infectious disease dynamics pose for prediction and management of epidemics.

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Cameron J. Browne

Mathematics Department
University of Louisiana at Lafayette
Lafayette, Louisiana, USA

Environmental adaptation and seasonality in multi-strain cholera dynamics

Abstract:

Cholera epidemics are largely driven by direct transmission from person to person or indirectly through environment, although Vibrio cholerae is also capable of growth and long-term survival in aquatic ecosystems. Furthermore, environmental fluctuations and strain evolution can drive seasonal cholera outbreaks. In this talk, I will discuss recent mathematical modeling works motivated by the cholera outbreak in Haiti beginning in 2010. First, we calibrate a stochastic multi-strain mixed-transmission dynamic model of V. cholerae to phylogenetic, case and rainfall data from Haiti. We connect genetic diversity and a coalescence process in model simulations to the effective population size computed from serially sampled cholera genomes. The results suggest that environmental replication actively contributes to genetic diversification and environmental adaptation, which can impact the success of different control measures. Mathematical analysis of the underlying deterministic model is challenging, however competitive exclusion is proved in the absence of environmental replication and seasonality. Assuming only partial cross-immunity in this case does induce coexistence of two strains (called serotypes), and we numerically explore the impact of seasonal forcing on cycling or switching of serotype dominance.

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Michael Cortez

Department of Biological Science
Florida State University
Tallahassee, Florida, USA

How the mode of adaptation for prey defense influences responses to environmental change

Abstract:

Adaptive responses in species have the potential to alter community responses to environmental change. In this talk, I use predator-prey models to explore how the mode of adaptation for prey defenses influences trophic cascades in response to eutrophication or increased mortality. I compare responses in communities with an evolving prey defense to communities with an inducible prey defense, where induction can be driven by different cues or have different thresholds for induction and loss of induction. My results show that variation in the induction thresholds only has a quantitative effect on responses. In contrast, differences in the mode of adaptation (evolution vs. plasticity) and the cues driving inducible defenses can lead to different trophic cascades, ranging from responses that are qualitatively identical to those in the absence to adaptation to those where responses in some species are reversed. This work shows that understanding the mode and drivers of adaptive responses in species can be crucial to making predictions about responses to environmental change.

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Alexandru Hening

Department of Mathematics
Texas A&M University
College Station, Texas, USA

Population dynamics under random switching

Abstract:

An important question in ecology is the relationship between the coexistence of species and environmental fluctuations. A natural way to model environmental fluctuations is to use stochastic differential equations (SDE) or piecewise deterministic Markov processes (PDMP). In a PDMP, the environment switches between a fixed finite number of states to each of which we associate an ordinary differential equation (ODE). In each state the dynamics is given by the flow of its associated ODE. After a random time, the environment switches to a different state, and the dynamics is governed by the ODE associated with the new state. I will look at two and three species examples of SDE and PDMP and explain how randomness can lead to some very interesting and counterintuitive behavior.

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Yun Kang

Sciences and Mathematics Faculty
College of Integrative Sciences and Arts
Arizona State University
Mesa, Arizona, USA

Ecological and Evolutionary Modeling of Complex Adaptive Systems

Abstract:

A complex adaptive system (CAS) is a system that is complex in that it is a dynamic network of interactions, but the behavior of the ensemble may not be predictable according to the behavior of the components. Social insect colonies are excellent examples of complex adaptive. Mathematical models are powerful tools that can provide us quantitative approaches to elucidate complicated ecological and evolutionary processes on the numerous spatial, temporal and hierarchical scales at which CAS such as social insect colonies operate. In this talk, I will review some of our collaborative work with biologists regarding important and interesting questions of social insect colonies such as:

1. What are the mechanisms that can generate multiple evolutionary stable strategies (ESS) for single species model with cooperative effects?
2. How may demographic and environmental stochasticity impact population dynamics with cooperative effects?
3. How may egg cannibalism and parasitism promote survival under harsh environments?
4. How may climate and parasite impact honeybee population dynamics?

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Nicholas Kortessis

Department of Biology
Wake Forest University
Winston-Salem, North Carolina, USA

Adaptation and coevolution of competitors in fluctuating environments: challenges and opportunities

Abstract:

Mathematical modeling of biological systems now shows definitively that there are unique opportunities and challenges for species when faced with conditions that fluctuate over time. For example, species may coexist in fluctuating environments when they cannot in a constant environment, demonstrating that there are ecological opportunities for species in time (i.e., temporal niches). Analogies to habitat and resource specialization suggest that natural selection may favor specialization on these opportunities that arise temporarily in time as well. However, there are biological justifications for why this might be challenging. Life history strategies that are adaptive in fluctuating environments (e.g., bet-hedging or adaptive plasticity) may be incompatible with the ability to specialize on particular times. In addition, there are challenges to modeling and analyzing models of adaptation in fluctuation environments.

In this talk, I will highlight these challenges and use examples from my work on how to make headway on modeling adaptive evolution of competing species in fluctuating environments. I will show how a combination of adaptive dynamics modeling and the theory of diversity maintenance in fluctuating environments work well together in illuminating the conditions that favor adaptive specialization of temporal niches. I will also illustrate some limitations of this work. These limitations are generally shared with other efforts to model coevolution; however, they are exacerbated by an explicit consideration of environmental fluctuations.

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Amanda Laubmeier

Department of Mathematics & Statistics
Texas Tech University
Lubbock, Texas, USA

Modelling the effect of temperature-dependent activity on pest consumption

Abstract:

In agricultural ecosystems, pest control services arise from natural communities of spider and beetle predators. However, many of these predators are generalist consumers, which form dense feeding networks with high levels of intraguild predation. These intraguild interactions are further shaped by environmental factors, since spiders and beetles are strongly influenced by temperature. Understanding the potential interplay between temperature and intraguild interactions is therefore important in the context of pest control services under changing global temperatures. In this work, we describe predator-prey interactions with intraguild interference using a system of ordinary differential equations. Interactions in this model are parameterized by species body mass, and encounter rates depend on ideal temperature ranges for species activity. Using an optimization approach to maximize the expected level of pest control, we determine the "best" balance of species in the predator community. We repeat this under current field conditions and under temperatures with increased average values and daily variability, to assess how climate change might affect expected biological control by natural predator communities.

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Frithjof Lutscher

Department of Mathematics and Statistics
University of Ottawa
Ottawa, Ontario, Canada

Modelling seasonal population dynamics and exploring the effects of global change

Abstract:

Global change is expected to affect ecosystems in many ways, such as increased average temperatures, changes in season length, or increased variation. In order to explore how some of these changes may affect populations and communities, we need to build models that contain the level of detail that we are interested in. Here, I will start with a consumer resource model with two seasons: a summer season where the resource grows and a winter season where it does not. The consumer has a single birth pulse per year, at the beginning of the summer season. I will present results on how several consumer species can coexist on a single resource and how a change in season length may affect their number. I will then consider the very specific forest insect – host tree system of spruce budworm and balsam fir to study the occurrence and effects of mismatch. Mismatch occurs when the growing seasons of the two species do not start at the same time. Using different climate projections, the model predicts certain spatial patterns in terms of where mismatch is expected to increase and decrease. Accordingly, the model predicts a spatial signature of the change in the cyclic outbreak patterns of the budworm.

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Swati Patel

Department of Mathematics
Oregon State University
Corvallis, Oregon, USA

A pulsed eco-evo model for anthelmintic resistance

Abstract:

As the world's most prevalent human pathogen, parasitic helminths infect approximately one billion people around the world, typically in impoverished communities. To combat the inflicted disease, the World Health Organization outlined a strategy of massive drug administration to preemptively treat whole subsets of populations where the disease is thought to be endemic. However, with such widespread treatment, there is a risk of the development of drug resistance. Here, we present and analyze a simple baseline model that couples the ecology of the parasite with its underlying evolution in response to the pulsed treatments, which act as selection and disturbance events.

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Corinne Richards-Zawacki

Department of Biological Sciences
University of Pittsburgh
Pittsburgh, Pennsylvania, USA

Modeling resilience to global change: Amphibians and their emerging fungal disease as a case study

Abstract:

The Resilience Institute Bridging Biological Training and Research (RIBBiTR) is a Pitt-led, NSF funded Biology Integration Institute, whose focus is on understanding how living systems achieve resilience to emerging infectious diseases and other global change associated threats. Our team is bringing together datasets, tool kits, and expertise from across biological disciplines and beyond to develop a new framework for quantifying resilience and applying that framework to understand and predict amphibian resilience to the emerging fungal disease chytridiomycosis. My talk will highlight the diverse study systems, types of data, and tools our team is using to study the mechanisms by which frog species are managing to bounce back after epizootics had decimated their numbers and diversity in many parts of the world.

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Jonathan Rubin

Department of Mathematics
University of Pittsburgh
Pittsburgh, Pennsylvania, USA

A mechanism for inducing irregular timing in population cycles

Abstract:

Mathematical models of cyclic population dynamics have historically exhibited much greater regularity in cycle periods than many real populations, even when they incorporate stochasticity. In this talk, I will present computational and mathematical analysis of a mechanism by which environmental stochasticity can cause or contribute to the irregular timing of population cycles. Specifically, consumer–resource cycles that bring the populations close to a saddle point may be subject to a slow passage effect that has been dubbed a 'saddle crawlby'. Stochasticity that generates variability in how close predator and prey populations come to saddles can result in substantial variability in the durations of crawlbys and, as a result, in the periods of population cycles. Overall, this analysis can be used to predict when environmental stochasticity is, and is not, expected to generate cyclic dynamics with variability across periods.

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Susmita Sadhu

Department of Mathematics
Georgia College & State University
Milledgeville, Georgia, USA

Novel methods of analyzing long transients preceding regime shifts in a two timescale predator-prey model

Abstract:

In many ecosystems, prior to a regime shift, the dynamics can be viewed to be in a long transient phase in a seemingly constant environment. Hence, developing methods to analyze transient dynamics in mathematical models can be useful to understand regime shifts. In this talk, I will consider a three-dimensional predator-prey model featuring two-timescales that governs the interaction between two species of predators competing for their common prey with explicit interference competition, which exhibits long transient dynamics before it reaches its asymptotic state. I will consider two different scenarios in a parameter regime near singular Hopf bifurcation of the coexistence equilibrium point. In one case, the system exhibits bistability between a periodic attractor and a boundary equilibrium state with long transients characterized by rapid small-amplitude oscillations and slow variation in amplitudes, while in the other, the system exhibits chaotic mixed-mode oscillations, featuring concatenation of small and large-amplitude oscillations as long transients before approaching a stable limit cycle. To analyze the transients, the system is reduced to a suitable normal form near the singular Hopf point. Exploiting the separation of timescales and the underlying geometry of the normal form, the transient dynamics are analyzed. The analyses are then used to devise methods for identifying early warning signals of a large population transition leading to an outbreak or resulting in an extinction of one of the species.

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Sebastian Schreiber

Department of Evolution and Ecology
University of California, Davis
Davis, California, USA

Coexistence in an autocorrelated world

Abstract:

All species experience temporal fluctuations in environmental conditions e.g. temperature or mortality risk. These fluctuations often are autocorrelated e.g. warmer years tending to be followed by warmer years. How these autocorrelations influence population persistence and species coexistence remains, largely, an open problem. In this talk, I review recent mathematical techniques and applications of these techniques to understand how autocorrelated fluctuations impact persistence of metapopulations and species sharing a common predator. The mathematical theory provides sufficient conditions for coexistence and extinction for stochastic, multispecies models with auxiliary variables. These conditions rely on non-zero Lyapunov exponents (invasion growth rates) at stationary distributions of the models. Using diffusion style approximations of these exponents, I illustrate how autocorrelated fluctuations (i) can promote metapopulation persistence in landscapes of sink habitats, and (ii) can generate stochastic priority effects or mediate coexistence for species sharing a common predator. Collectively, this talk highlights the use of auxiliary variables in stochastic models and the importance of temporal autocorrelations in structuring ecological communities.

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William Wetzel

Department of Integrative Biology
Michigan State University
East Lansing, Michigan, USA

Macroecological and macroevolutionary patterns of variability in plant-herbivore interactions

Abstract:

Macroecological and macroevolutionary studies of biotic interactions have focused on differences in mean interaction rates across systems. Theory, however, indicates that differences in variability in interaction rates also influence ecology and evolution. Using standardized surveys of plant–herbivore interactions for 503 plant species at 790 sites across 116° of latitude, we show that variability in herbivory within plant populations increases with latitude, decreases with plant size, and is phylogenetically structured. Moreover, these relationships were stronger than the ones for mean herbivory. Our results indicate that differences in the variability of herbivory are central to how plant–herbivore ecology and evolution varies across macroscale gradients.

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Mark Wilber

Department of Forestry, Wildlife, and Fisheries
University of Tennessee Institute of Agriculture
Knoxville, Tennessee, USA

Towards a theory of host recovery dynamics following disease-induced declines: an epi-eco-evo perspective

Abstract:

Recoveries of populations that have suffered severe disease-induced declines are being observed across disparate taxa. Yet, we lack theoretical understanding of the drivers and dynamics of recovery in host populations and communities impacted by infectious disease. In particular, many amphibian populations and communities have been devastated by infectious disease and we are only recently beginning to see recoveries. However, the mechanisms of these recoveries remain obscure. We developed an epidemiological-ecological-evolutionary (E3) model to dissect the anatomy of host recovery trajectories following disease-induced declines and asked three questions: 1) how does host life history, pathogen life history, and initial variability in host defense affect population recovery trajectories? 2) how do recovery trajectories differ between host populations evolving different defense strategies? and 3) how do community interactions alter recovery trajectories and reorganize communities following disease-induced declines? We found that host life history is a major driver of recovery trajectories, with faster hosts declining less and recovering more quickly than slower hosts. Host defense strategy also affected trajectories, with hosts using resistance strategies generally recovering more quickly than hosts using tolerance strategies. However, recovery dynamics were highly dependent on community structure. In multi-species host communities where different species were evolving different defense strategies, the recovery rate of hosts evolving resistance strategies could be significantly reduced compared to hosts evolving tolerance strategies, leading to transient community reorganization. By identifying predictable characteristics of host recoveries, the E3 model provides a foundation to link observed patterns of host recovery to underlying processes.

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Xingfu Zou

Department of Mathematics
University of Western Ontario
London, Ontario, Canada

Role of white-tailed deer in geographic spread of the black-legged tick Ixodes scapularis: analysis of a spatially nonlocal model

Abstract[1]*:*

Lyme disease is transmitted via blacklegged ticks, the spatial spread of which is believed to be primarily via transport on white-tailed deer. In this talk, I will present a mathematical model to describe the spatial spread of blacklegged ticks by the deer's dispersal. The model turns out to be a system of differential equations with a spatially non-local term accounting for the phenomenon that a questing female adult tick that attaches to a deer at one location may later drop to the ground, fully fed, at another location having been transported by the deer. I will report the analytic results of this model, including well-posedness, stability of its steady states, existence of traveling wave fronts connecting the extinction equilibrium with the positive equilibrium for the system, minimal wave speed and asymptotic spreading speed (both coincide). I will also present some some numerical simulations to confirm and demonstrate the role of spreading speed described above, and numerically explore the dependence of minimal wave speed on the dispersion rate of the white tailed deer, by which one may evaluate the role of the deer's dispersion in the geographical spread of the ticks.

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[1]Title and abstract changed per request by speaker on May 16.