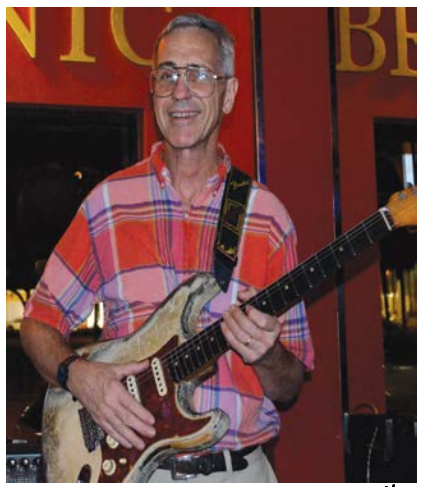
Everything Disperses to Miami: The Role of Movement and Dispersal in Spatial Ecology, Epidemiology and Environmental Science

University of Miami, Coral Gables, Florida
December 14-16, 2012



On the Occasion of Chris Cosner's 60th Birthday

Organizing Committee:
Stephen Cantrell (University of Miami)
Suzanne Lenhart (University of Tennessee and NIMBioS)
Yuan Lou (Ohio State University and MBI)
Shigui Ruan (University of Miami)

Purpose. The movement and dispersal of organisms have long been recognized as key components of ecological interactions and have figured prominently in mathematical models in ecology. More recently, dispersal has been recognized as an equally important consideration in mathematical epidemiology. The University of Miami has become a world leader in employing mathematics to understand the role of movement and dispersal in ecology, epidemiology and environmental science, with major contributions to the study of such important issues as the evolution and ecological effects of dispersal in spatial ecology, the impact of human movement on vector-borne diseases, the effect of global movement in communicable diseases, the cost of movement in ecological applications, and accounting for spatial effects in environmental management. "Everything Disperses to Miami: The Role of Movement and Dispersal in Ecology, Epidemiology and Environmental Science" (EDM) offers a unique opportunity to promote further synthesis between mathematical ecology and mathematical epidemiology and to influence future research directions. EDM is a natural outgrowth of several previous events: the 2005 "Workshop on Spatial Ecology" at the University of Miami that kicked off the University of Miami Institute for Theoretical and Mathematical Ecology (ITME) and lead to the influential 2009 Chapman Hall/CRC volume of essays Spatial Ecology , the MBI 2005-2006 Emphasis year on Evolution and Ecology (specifically Workshop 4: Spatial Ecology March 13-17, 2006) and most especially the just completed July 2011 Banff International Research Station (BIRS) workshop on "Emerging Challenges at the Interface of Mathematics, Environmental Science and Spatial Ecology".

The workshop will also give us a very opportune way to celebrate the 60th birthday of Chris Cosner. Chris will turn 60 on June 3, 2012. We will conclude the workshop with a panel discussion on new directions of research at the interface of mathematics and biology on the role of dispersal in ecology, epidemiology and environmental science, and Chris has agreed to lead this discussion. We will also hold a workshop banquet in honor of this milestone.

Acknowledgments. The workshop is generously supported by the National Science Foundation, the Office of Research, the College of Arts and Sciences, and the Department of Mathematics at the University of Miami, and the Mathematical Biosciences Institute at Ohio State University. The staff in the Department of Mathematics has provided professional assistance in organizing the workshop.

Internet Access. The University of Miami provides free internet access on campus. Just connect as a guest. Computer terminals are also available in Ungar 302.

Breakfast and Lunch. Complimentary breakfast and lunch will be provided at the conference site (Cox Science Building Foyer).

Parking. Please make sure you park in the visitor's parking spot and purchase your parking ticket from the nearby machine.

Restaurants. There are plenty of restaurants in downtown South Miami, which is a few blocks from the Holiday Inn (along US1 in the southwest direction), and in Coral Gables (both downtown and the Village of Merrick Park), which is a little further away but readily accessible.

Contact information.

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December 14, 2012

Dear colleagues,

On behalf of all of us here at the College of Arts and Sciences and the University of Miami, welcome to the "Everything Disperses to Miami" workshop.

Since 2005, the college's mathematicians, biologists, and computer scientists as well as faculty in the Rosenstiel School of Marine and Atmospheric Sciences have been working together under the University of Miami Institute for Theoretical and Mathematical Ecology (ITME) to better understand nature using quantitative methods. As you well know, these innovative interdisciplinary partnerships have advanced knowledge of our ecosphere beyond the temporal, spatial and structural limitations of empirical studies, revealing our natural world in previously unimaginable arrays of wholeness and complexity.

As you discuss analyses, models, and theories of how organisms disperse, move, interact and impact our world during this workshop, I urge you to remember that your work itself spreads far beyond our academic community. Your scholarship has broad implications for the future of our planet, helping all of us to anticipate, identify and address emerging issues of sustainability, biodiversity, human development, and disease. The ideas you discern and debate today will spawn incredible mathematic, scientific and technological discoveries tomorrow.

I am pleased that our college will serve as a hub for such critical exchanges and collaborations in mathematical ecology, epidemiology, and environmental science. I applaud organizers, attendees, distinguished panelists, and all of you who have helped to make this event possible. In the college and across the university, our commitment to your research is stronger than ever, and it is my great hope that what you accomplish here will spur further innovation for years to come.

Sincerely,

Leonidas G. Bachas
Dean
College of Arts & Sciences

UNIVERSITY OF MIAMI
COLLEGE of
ARTS & SCIENCES

Gregory J. Galloway, Professor and Chair

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December 2, 2012

Dear Conference Participants:

It is a great pleasure for me to welcome you all to the University of Miami for the conference "Everything Disperses to Miami: The Role of Movement and Dispersal in Ecology, Epidemiology and Environmental Science." The Department of Mathematics is delighted to be hosting this important scientific event. Steve Cantrell, together with the other organizers Suzanne Lenhart, Yaun Lou, and Shigui Ruan, has worked tirelessly to put together an outstanding program, and, as leading researchers in this highly interdisciplinary arena, your participation will make the conference a great success. I would also like to extend my congratulations to my departmental colleague Chris Cosner who is being honored at the conference on the occasion of his 60th birthday.

I wish you all a very enjoyable and productive stay. If the department can be of help in any way, please let us know.

Sincerely,

Gregory J. Galloway
Professor and Chair of Mathematics

Schedule

FRIDAY DECEMBER 14, 2012

08:00AM – 09:00AM	Breakfast and Registration	Cox Science Building Foyer
09:00AM – 09:15AM	Welcome	Cox 126
09:15AM – 10:15AM	*Plenary Talk 1* (Chair: Steve Cantrell)	**Cox 126**
	Yuan Lou, Evolution of Dispersal in Heterogeneous Landscapes	

Special Session Talks 1

1A. Epidemiology (Conveners: Michel Langlais and Matthew Potts) Cox 126

10:15AM – 10:45PM **Arnaud Ducrot**, Uniform Boundedness and Spreading Speed for some Reaction-diffusion SI Systems
10:45AM – 11:15AM **Rebecca Tyson**, Post-Harvest Diseases of Apples: From Spore Dispersal to Epidemiology
11:15AM – 11:45AM **John Beier**, Sugar Sources that Influence Local Mosquito Movement Patterns Offer Valuable Insights for Novel Vector Control: Attractive Toxic Sugar Baits
11:45AM – 12:15PM **Wayne Getz**, T-LoCoH: A Space-Time Characterization of Movement Over Real Landscapes

1B. Nonlinear Analysis and PDE (Conveners: Hal Smith and Patrick DeLeenheer) Ungar 301

10:15AM – 10:45PM **Thomas Hillen**, Mathematical Modelling with Fully Anisotropic Diffusion
10:45AM – 11:15AM **Adrian Lam**, Evolution of Conditional Dispersal: ESS in Spatial Models
11:15AM – 11:45AM **Junping Shi**, Hopf Bifurcations in Models with Chemotaxis or Advection
11:45AM – 12:15PM

1C. Global Change (Conveners: Huaiping Zhu and Jorge Velasco-Hernandez) Ungar 311

10:15AM – 10:45PM **Mark Lewis**, Impact of Global Change on Predator-prey Relationships in Complex Environments
10:45AM – 11:15AM **Rongsong Liu**, Modeling the Dynamics of Woody Plant-Herbivore Interactions with Age-Dependent Toxicity
11:15AM – 11:45AM **Guihong Fan**, Oscillation and Driving Mechanism in a General Model for Vector-borne Diseases with Time Delay
11:45AM – 12:15PM **Huaiping Zhu**, Modeling of Mosquito Abundance and West Nile Virus Risk Using Weather and Environment Conditions

1D. Biological Synergies (Conveners: Carol Horvitz and Eelke Jongejans) Cox 145

10:15AM – 10:45PM **Hal Caswell**, Invasion Speed and Sensitivity Analysis in Periodic and Stochastic Environments
10:45AM – 11:15AM **Ran Nathan**, A Movement Ecology Approach for Studying Dispersal Processes in Changing Environments
11:15AM – 11:45AM **Christopher Klausmeier**, The Vertical Distribution of Phytoplankton
11:45AM – 12:15PM **Carol Horvitz**, Spread of Fleshy-fruited Exotic Shrubs when Dispersal is Structured by Dispersers that Vary over Time

12:15PM – 01:15PM Lunch — Cox Science Building Foyer

Special Session Talks 2

2A. Epidemiology (Conveners: Michel Langlais and Matthew Potts) Cox 126

01:15PM – 01:45PM **Matthew Potts**, Interactive Dynamics of Wildlife Populations, Human Health and Household Wealth
01:45PM – 02:15PM **Pierre Magal**, Some Mathematical Epidemic Models for Bacterial Hospital Infections
02:15PM – 02:45PM **Hideki Murakawa**, Spatial Patterns in a Population Model Structured by Cell Size, Quiescence and Sensing Radius
02:45PM – 03:15PM **Marisa Eisenberg**, Cholera Dynamics, Multiple Transmission Pathways, and Disease Spread in Haiti

2B. Nonlinear Analysis and PDE (Conveners: Hal Smith and Patrick De Leenheer) Ungar 301

01:15PM – 01:45PM **Liang Kong**, Positive Stationary Solutions and Spreading Speeds of KPP Equations in Locally Spatially Inhomogeneous Media
01:45PM – 02:15PM **Yu Jin**, Metrics for Population Persistence in Rivers

02:15PM – 02:45PM **Dung Le**, Holder Continuity of BMO Weak Solutions to Strongly Coupled Elliptic Systems
02:45PM – 03:15PM **Horst Thieme**, Persistence in Structured Populations with Short Reproductive Season

2C. Global Change (Conveners: Huaiping Zhu and Jorge Velasco-Hernandez) Ungar 311

01:15PM – 01:45PM **Donald Olson**, Population Ranges in Changing Climates
01:45PM – 02:15PM **Brian Coburn**, Targeting Discordant Couples to Mitigate HIV Epidemics in Africa: Modeling the Incidence, Impact, and Feasibility
02:15PM – 02:45PM **Jorge Alfaro-Murillo**, A Time Since Last Infection-Dependent Epidemiological Model
02:45PM – 03:15PM **Chunhua Shan**, The Dynamics of Growing Islets and Transmission of Schistosomiasis Japonica in the Yangtze River

2D. Biological Synergies (Conveners: Carol Horvitz and Eelke Jongejans) Cox 145

01:15PM – 01:45PM **Helene Mueller-Landau**, How the Spatial Scales of Seed Dispersal and Natural Enemy Attack Influence the Strength of Population Regulation, Invasion Growth Rates, and Ultimately Plant Diversity
01:45PM – 02:15PM **Marco Visser**, The Fitness Consequences of Dispersal for a Tropical Palm; the Role of Dispersers, Natural Enemies and Negative Density Dependence
02:15PM – 02:45PM **James Bullock**, Using Analytical Models in Applied Ecology: When is it Good to Simplify?

03:15PM – 03:30PM Break — Cox Science Foyer

03:30PM – 04:30PM *Plenary Talk 2* (Chair: Suzanne Lenhart) **Cox 126**
Don DeAngelis, Keep Moving: Evolutionarily Stable Strategy for Movement among Patches When There Are Travel Losses

Special Session Talks 3

3A. Epidemiology (Conveners: Michel Langlais and Matthew Potts) Cox 126

04:30PM – 05:00PM **Juan Gutierrez**, Multi-scale Modeling of Malaria: From Endemicity to Elimination
05:00PM – 05:30PM **Daozhou Gao**, Modeling the Spatial Spread of Rift Valley Fever in Egypt
05:30PM – 06:00PM **Suzanne Robertson**, Habitat Selection under the Risk of Infectious Disease
06:00PM – 06:30PM **Michel Langlais**, A Plant-pathogen Multiscale Model System

3B. Nonlinear Analysis and PDE (Conveners: Hal Smith and Patrick De Leenheer) Ungar 301

04:30PM – 05:00PM **Wei-Ming Ni**, Complete Dynamics of a Heterogeneous Competition-Diffusion System
05:00PM – 05:30PM **Dan Ryan**, A Cross-diffusion Model for Avoidance Behavior in an Intraguild Predation Community
05:30PM – 06:00PM **Chuan Xue**, How Do Swimming Bacteria Disperse in Response to Chemical Signals
06:00PM – 06:30PM **Sebastian Schreiber**, Persistence of Structured, Interacting Populations in Stochastic Environments

3C. Global Change (Conveners: Huaiping Zhu and Jorge Velasco-Hernandez) Ungar 311

04:30PM – 05:00PM **Juping Zhang**, Two-patch Model for the Spread of West Nile Virus
05:00PM – 05:30PM **Xiaotian Wu**, Calculating Basic Reproductive Ratio of a Stage-structured Population System with Periodic Delay
05:30PM – 06:00PM **Folashade B. Agusto**, Malaria Drug Resistance: The impact of Human Movement and Spatial Heterogeneity
06:00PM – 06:30PM **Jorge X. Velasco Hernandez**, Spatiotemporal Dynamics of Telegraph Reaction-Diffusion Predator-Prey Models

SATURDAY DECEMBER 15, 2012

08:00AM – 09:00AM Breakfast — Cox Science Building Foyer

Special Session Talks 4

4A. Evolution of Dispersal (Conveners: Priyanga Amarasekare and Vlastimil Krivan) Cox 126

09:00AM – 09:30AM **Ross Cressman**, Game-theoretic Methods for Functional Response and Optimal Foraging Behavior

09:30AM – 10:00AM **Dan Munther**, The Ideal Free Strategy with Weak Allee Effect
10:00AM – 10:30AM **Vlastimil Krivan**, The Ideal Free Distribution: From Hypothesis to Tests
10:30AM – 11:00PM **Andrew Nevai**, Resource Theft and Spatial Population Dynamics

4B. Nonlinear Analysis and PDE (Conveners: Hal Smith and Patrick DeLeenheer) Ungar 301

09:00AM – 09:30AM
09:30AM – 10:00AM **Bingtuan Li**, Traveling Wave Solutions in Partially Degenerate Cooperative Reaction-Diffusion Systems
10:00AM – 10:30AM **Patrick De Leenheer**, Optimal placement of Marine Protected Areas
10:30AM – 11:00PM **Xiaoqiang Zhao**, Principal Eigenvalues and Basic Reproduction Numbers for Reaction-Diffusion Models

4C. Biological Synergies (Conveners: Carol Horvitz and Eelke Jongejans) Ungar 311

09:00AM – 09:30AM **Luca Giuggioli**, Sigmergy: Collective Action and Animal Social Spacing
09:30AM – 10:00AM **Denise Hardesty**, Applying Biogeochemical and Genetic Markers to Understand Movement in Complex Systems
10:00AM – 10:30AM **Patrick Jansen**, Extensive Secondary Seed Dispersal Revealed by Telemetric Seed Tags

4D. Nonlocal Dispersal (Conveners: Salomé Martínez and Frithjof Lutscher) Cox 145

09:00AM – 09:30AM **Jon Jacobsen**, Integrodifference Models for Persistence in Temporally Varying Habitats
09:30AM – 10:00AM **Jeffrey Musgrave**, How Dispersal in Patchy Landscapes Affects Population Spread
10:00AM – 10:30AM **Mike Neubert**, Invasion Speeds of Sex- and Age-structured Populations
10:30AM – 11:00PM **Ying Zhou**, Non-local Dispersal Models for a Population under Global Change

11:00AM – 12:00PM ***Plenary Talk 3*** **Cox 126**
Wei-Ming Ni, Competition-Diffusion in Heterogeneous Environments

12:00PM – 01:00PM Lunch Cox Science Building Foyer

Special Session Talks 5

5A. Evolution of Dispersal (Conveners: Priyanga Amarasekare and Vlastimil Krivan) Cox 126

01:00PM – 01:30PM **Peter Abrams**, A Defense of Fitness-based Movement
01:30PM – 02:00PM **Greta Bocedi**, Uncertainty, Information and Evolution of Context Dependent Emigration
02:00PM – 02:30PM **John Fryxell**, Evolution of Migration in a Changing World
02:30PM – 03:00PM **Justin Travis**, The Evolution of Dispersal (Emigration, Movement and Settlement Rules) During Range Expansion

5B. Biological Synergies (Conveners: Carol Horvitz and Eelke Jongejans) Ungar 302

01:00PM – 01:30PM **Eelke Jongejans**, Geographic Coupling of Juvenile and Adult Habitat Shapes Spatial Population Dynamics of a Coral Reef Fish
01:30PM – 02:00PM **Ellen Damschen**, Seed Dispersal by Wind in Fragmented Landscapes with Corridors
02:00PM – 02:30PM **Pedro Jordano**, Frugivores, Pollinators, Seeds, and Genes: Tracking Long-distance Dispersal and its Consequences
02:30PM – 03:00PM **Bette Loiselle**, Predicting Effective Seed Dispersal Kernels Based on Animal Movement and Habitat Use

5C. Nonlocal Dispersal (Conveners: Salomé Martínez and Frithjof Lutscher) Cox 145

01:00PM – 01:30PM **Jimmy Garnier**, Long Distance Dispersal Accelerates Range Expansions
01:30PM – 02:00PM **Frithjof Lutscher**, Global and Local Averaging for Integrodifferential Equations
02:00PM – 02:30PM **Salomé Martínez**, Asymptotic Behavior of a Nonlocal Equation
02:30PM – 03:00PM **Jorge Ramirez**, Population Persistence under Advection-diffusion in River Networks

03:00PM – 03:15PM Break Cox Science Building Foyer

Special Session Talks 6

6A. Evolution of Dispersal (Conveners: Priyanga Amarasekare and Vlastimil Krivan) Cox 126

03:15PM – 03:45PM **Bob Holt**, Theoretical Studies of the Coevolution of Dispersal, Plasticity, and Local Adaptation in Heterogeneous Landscapes
03:45PM – 04:15PM **Fei Xu**, Strategic Effects of Mobility in Predator-prey Systems
04:15PM – 04:45PM **Pradeep Pillai**, Counterintuitive Patterns of Dispersal Evolution in a Trophic Metacommunity
04:45PM – 05:15PM **Douglas Morris**, Some Causes and Consequences of Dispersal in Real and Model Systems

6B. Nonlinear Analysis and PDE (Conveners: Hal Smith and Patrick DeLeenheer) Ungar 301

03:15PM – 03:45PM
03:45PM – 04:15PM **Julián López-Gómez**, Complex Dynamics Caused by Facilitation in Competitive Environments within Polluted Habitat Patches
04:15PM – 04:45PM **Zhi-Cheng Wang**, Lotka-Volterra Diffusion Systems with Strong Competition
04:45PM – 05:15PM **Hal Smith**, Spread of Viral Infection of Immobilized Bacteria

6C. Global Change (Conveners: Huaiping Zhu and Jorge Velasco-Hernandez) Ungar 311

03:15PM – 03:45PM **Ahmed Abdelrazec**, Optimal Control of West Nile Virus in Mosquitoes, Birds and Humans with Seasonality
03:45PM – 04:15PM **Mayra Núñez-López**, Pattern Formation in a Predator-prey System Characterized by a Spatial Scale of Interaction
04:15PM – 04:45PM **Tim Reluga**, Dynamical-systems Insights into Migration
04:45PM – 05:15PM **Lydia Bourouiba**, Environmental Dispersal of Pathogens: A Fluid Dynamics Perspective

6D. Nonlocal Dispersal (Conveners: Salomé Martínez and Frithjof Lutscher) Cox 145

03:15PM – 03:45PM **Jerome Coville**, Convergence to the Equilibria in Some Mutation-Selection Model
03:45PM – 04:15PM **Thomas Mueller**, Linking Individual Movements and Population Patterns in Dynamic Landscapes
04:15PM – 04:45PM **Grégoire Nadin**, Effect of Habitat Fragmentation on Persistence and Spreading of Populations
04:45PM – 05:15PM **Andrew Noble**, Spatiotemporal Complexity in Metapopulations, no Chaos Required

08:00PM Banquet Hyatt Coral Gables

SUNDAY DECEMBER 16, 2012

08:00AM – 09:00AM Breakfast Cox Science Building Foyer

09:00AM - 10:00AM *Plenary Talk 4* (Chair: Shigui Ruan) **Cox 126**
Suzanne Lenhart, Using Optimal Control of Parabolic PDEs to Investigate Population Questions

10:00AM – 11:00AM *Plenary Talk 5* (Chair: Shigui Ruan) **Cox 126**
Jianhong Wu, Disperse to the North: Climate Impact on Tick Expansion and Lyme Disease Spread

11:00AM – 12:00PM *Plenary Talk 6* (Chair: Steve Cantrell) **Cox 126**
Bill Fagan, Riverine Landscapes: Exploring Connectivity, Extinction Risk, and Biogeography in an Alternative Geometry

12:00PM – 01:00PM Lunch Cox Science Building Foyer

01:00PM – 02:00PM **Panel Discussion** (Chris Cosner) **Cox 126**

02:00PM EDM Disperses

Abstracts

Plenary Lectures

Evolution of Dispersal in Heterogeneous Landscapes

Yuan Lou
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From habitat degradation and climate change to spatial spread of invasive species, dispersal plays a central role in determining how organisms cope with a changing environment. How should organisms disperse "optimally" in heterogeneous environment? The dispersal of many organisms depends upon local biotic and abiotic factors and as such are often biased. This talk will discuss some recent developments on the evolution of biased dispersal in spatially varying but temporally constant environments via reaction-diffusion-advection models.

Keep Moving: Evolutionarily Stable Strategy for Movement among Patches When There Are Travel Losses

Donald L. DeAngelis
U. S. Geological Survey, Florida Integrated Science Centers
and
Department of Biology, University of Miami, Coral Gables, FL 33124
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The distribution of animals among habitat patches has often been described by the ideal free distribution (IFD), which assumes the population would tends towards a distribution in which no individual could gain or lose fitness by being someplace else; that is, the spatial distribution is an evolutionarily stable strategy (ESS). But the IFD assumes that there are no losses of fitness (through mortality, energetic costs, etc.) in the process of moving from one patch to another, which in general is not the case. When movement costs are high, it has often been assumed that animal movement will cease after some time when the cost of movement exceeds the gain in fitness of moving from the current patch to a more profitable one. However, it can be shown that if some rate of movement from one patch to others is forced, then the evolutionarily stable strategy (ESS) for a species is to have some rate of movement back to the original patch. This is true no matter how high the cost of movement is. The ESS has generality to a large system of patches, but is discussed here for a simple two-patch system (Based on joint work with Yuan Lou (Ohio State University) and Gail Wolkowicz (McMaster University)).

Competition-Diffusion in Heterogeneous Environments

Wei-Ming Ni
School of Mathematics, University of Minnesota, 206 Church St. SE, Minneapolis, MN 55455
and
Center for PDE, East China Normal University, Minhang 200241, Shanghai, China
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In this lecture, using the classical Lotka-Volterra competition-diffusion system as a basic example, I will illustrate how the interaction of diffusion and spatial heterogeneity could create interesting phenomena. Simple open problems and conjectures will be discussed throughout this lecture.

Using Optimal Control of Parabolic PDEs to Investigate Population Questions

Suzanne Lenhart
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We investigate optimal control in a class of parabolic partial differential equations, modeling populations with nonlinear growth. One example will address a question about resource management in a fishery model: Are no-take marine reserves a part of optimal harvest strategy designed to maximize yield? A second example is motivated by the question: Does movement toward a better resource environment benefit a population?

Disperse to the North: Climate Impact on Tick Expansion and Lyme Disease Spread

Jianhong Wu
MITACS Centre for Disease Modeling and
Department of Mathematics and Statistics, York University, Toronto, ON M3J 1P3, Canada
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To better understand the effects of seasonal temperature variation and host community composition on the Lyme disease pathogen transmission and spread, we develop and analyze a stage-structured periodic deterministic model parametrized by the Canadian geographical landscape and observed/predicted degree days. The model integrates seasonal tick development and activity, multiple host species and complex transmission routes between ticks and hosts. We derive two basic reproductive ratios, one for ticks and another for disease pathogen, and use these ratios to identify the northward expansion fronts of tick populations and Lyme disease pathogen. We also investigate the effect of climate warming and host diversity on the pathogen transmission. We confirm that climate warming will promote the establishment of pathogen-infected focus, and we illustrate how increasing the level of host diversity will dilute or amplify the Lyme disease risk to public health.

Riverine Landscapes: Exploring Connectivity, Extinction Risk, and Biogeography in an Alternative Geometry

Bill Fagan
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Riverine landscapes differ in fundamental ways from terrestrial ones. In particular, the branching hierarchical geometry and downstream flow of river systems lead to a suite of network properties rarely considered in the 1- and 2-dimensional systems that have long been the mainstay of spatial ecology. Intrinsic effects of configuration, directional biases, transient connectivity, and opportunities for 'out of network' movement may all lead to inherently asymmetrical opportunities for dispersal among parts of a riverine landscape thereby influencing ecological processes and biogeographic patterns. This 'alternative geometry' of riverine networks provides excellent opportunities for scientists to explore how network connectivity shapes habitat occupancy, metacommunity dynamics, and biogeographic patterns. Using examples involving fish communities that inhabit the river networks of North America and India, I will discuss here how human modifications to the spatial characteristics of river systems, such as habitat fragmentation and interbasin water transfer projects, influence ecological dynamics and biogeographic patterns. Taken together these research projects illustrate the important contributions that riverine geometry makes to our understanding of interspecific variation in extinction risks and the potentially broad relevance of the neutral theory of biodiversity.

Invited Session Talks

Optimal Control of West Nile Virus in Mosquitoes, Birds and Humans with Seasonality

Ahmed Abdelrazec
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In this study, we use compartment models to investigate the behavior of the transmission of West Nile virus in the mosquito-bird cycle and humans. Firstly, we study the model without season and prove existence the backward bifurcation of the model. Secondly, we consider the model with seasonal variations and prove the existence of periodic solutions under specific condition. Furthermore, we examine the dynamics of the model when the seasonal variation becomes stronger. Then, we extend the first and second models by adding three control functions: adulticide, larvicide and human protection. We simulate a set of possible control strategies in two models referred to above, and reached the following: (1) Larvicide is the most effective strategy to control an ongoing epidemic in reducing disease cost. (2) The results emphasize the importance of using the information about quantity of other animals that could be infected and the percentage of the non-corvids bird at any region before applying the control strategies. (3) Identifying the ultimate time of applying the control to achieve the best control strategy. Our findings further highlight the importance of carefully taking into account the impact of the seasonal variation when applying the control.

A Defense of Fitness-based Movement

Peter A. Abrams
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A variety of works in recent years have argued that animals should NOT use estimates of relative instantaneous fitness in deciding how to move between patches. Several other quantities have been proposed as alternative bases for movement, including the population density of a single species and patch 'carrying capacity' among others. Cases where such 'alternative' criteria have been shown to displace fitness based movement in general fall into two categories; (1) special (and unlikely) circumstances where the 'alternative' criterion correlates perfectly with instantaneous fitness; (2) cases where synchronized movements of different species remove information about the conditions that will apply in the patch when the movement is completed; (3) cases with movement costs, where comparison of current fitness between patches produces a biased estimate of the change in expected future fitness following a move between those patches. There are systems in which one or more species cannot assess some components of fitness, even in the currently occupied patch. These may lead to random movement or complex forms of dependence on those components of fitness that can be estimated.

Malaria Drug Resistance: The impact of Human Movement and Spatial Heterogeneity

Folashade B. Agusto
Department of Mathematics and Statistics, Austin Peay State University, Clarksville TN 37044
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Human habitat connectivity, movement rates and spatial heterogeneity have tremendous impact on the effectiveness of malaria control and eradication. In this paper, a deterministic system of differential equations for malaria transmission in a two patch system that incorporates human movements and the development of drug resistance malaria is presented. The impact of movement between the patches is determined by qualitative analysis of the model basic reproduction number. Sensitivity analysis is perform on the key parameters that drive the disease dynamics of the model in order to determine their relative importance to disease transmission and control within and between patch.

A Time Since Last Infection-Dependent Epidemiological Model

Jorge A. Alfaro-Murillo
Department of Mathematics, Purdue University, West Lafayette, IN 47907-2067
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The aim of this work is to provide a model for infectious agents with a transmission rate that varies during the infectious period, and/or that have the ability to reinfect a host. Influenza is an example of a disease that satisfies both characteristics. The probability that an individual transmits influenza is directly related to the amount of virus shedding, which is linked to the time that has elapsed since the individual became infected. The infectivity reaches its peak after 2-3 days then decreases until the person recovers. In addition to that, being once infected with influenza completely protects the individual against reinfection by the same strain. But the virus mutates via the process known as drift, and new strains, against which the individual only has partial protection, appear in the population. Without the introduction of a completely new strain in the population (a shift process occurring) the immunity of a host to reinfection depends mainly on the amount of time that has elapsed since the last infection of the individual. A nonlinear time since last infection-dependent epidemiological model is proposed. Conditions for the existence, positivity, regularity and continuity of the solutions will be addressed. The analysis of the existence and stability of equilibrium solutions will be conducted using the theory of strongly continuous nonlinear semigroups. The model exhibits interesting outcomes, including the existence of multiple endemic equilibria, a backward bifurcation (i.e., the existence of an endemic equilibrium with $R_0<1$), and the existence of an endemic equilibrium even in the absence of vital dynamics.

Sugar Sources that Influence Local Mosquito Movement Patterns Offer Valuable Insights for Novel Vector Control: Attractive Toxic Sugar Baits (ATSB)

John C. Beier
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Newly developed attractive toxic sugar bait (ATSB) methods represent a new form of mosquito control based on an "attract and kill" principle. The ATSB approach uses fruit or flower scent as an attractant, sugar solution as a feeding stimulant, and oral toxin to kill the mosquitoes. The ATSB solutions are either sprayed on vegetation or suspended in simple bait stations, and the mosquitoes ingesting the toxic solutions are killed. As such, this method targets sugar-feeding female and male mosquitoes outdoors. Plant sugars or "sugar meals" represent an important source of energy for female mosquitoes and are the only food source for males. In nature, mosquitoes are attracted to plant volatiles. Highly attractive flowering plants can attract mosquitoes at distances up to about 50 meters. Mosquito orientation and local dispersal is highly influenced by locations of sugar feeding centers. Over a range of arid environments, field trials of ATSB methods have proven highly effective in decimating local populations of diverse mosquito species. In addition to being highly effective, technologically simple, and low-cost, the ATSB methods are based on the use of oral toxins as opposed to contact insecticides. Recent modeling studies show the utility of ATSB when used in conjunction with current vector control tools.

Uncertainty, Information and Evolution of Context Dependent Emigration

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There is increasing empirical evidence that individuals utilize social and environmental cues in making decisions as to whether or not to disperse. However, we lack theory exploring the influence of information acquisition and use on the evolution of dispersal strategies and metapopulation dynamics. We used an individual-based, spatially explicit simulation model to explore the evolution of emigration strategies under varying precision of information about the natal patch, cost of information acquisition, and environmental predictability. Our findings show an interesting interplay between information use and the evolved emigration propensity. Lack of information led to higher emigration probabilities in more unpredictable environments but to lower emigration probabilities in constant or highly predictable scenarios. Somewhat informed dispersal strategies were selected for in most cases, even when the acquisition of information was associated with a moderate reproductive cost. Notably, selection rarely favored investment in acquisition of high-precision information, and the tendency to invest in information acquisition was greatest in predictable environments when the associated cost was low. Our results highlight that information use can affect dispersal in a complex manner and also emphasize

that information-acquisition behaviors can themselves come under strong selection, resulting in evolutionary dynamics that are tightly coupled to those of context-dependent behaviors.

Environmental Dispersal of Pathogens: A Fluid Dynamics Perspective

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The fundamental mechanisms of contact and transmission remain poorly understood even for the most common infectious diseases. For numerous diseases, contact and transmission from host to host represent important phases of pathogen dispersal in the environmental. The detailed mechanisms of transmission can be critical in determining the outcome of an epidemic. I will discuss recent work in which the role of fluid fragmentation and dispersal outside the host are examined.

Using Analytical Models in Applied Ecology: When is it Good to Simplify?

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Applied ecologists deal with specific problems, such as how to control a certain invasive or how to help a particular species cope with climate change. Complex models, often involving spatially explicit simulations, are generally used to answer these questions, and they often require detailed data. So, why should applied ecologists be interested in analytical models, which are usually highly simplified representations of reality? For example, wavespeed models usually assume spatial homogeneity, constant and isotropic dispersal and no change in parameter values over time. Using wavespeed models I show how such simplifications can be of great use in addressing general applied questions. I make use of the limited data available for a majority of species, and other information such as the projected rates of climate change, to ask general questions about the ability of plants to respond to climate change. I argue that such general projections are of much greater utility in planning responses than detailed predictions about individual species. As Thoreau said: “When the mathematician would solve a difficult problem, he first frees the equation of all incumbrances, and reduces it to its simplest terms. So simplify the problem of life, distinguish the necessary and the real”.

Invasion Speed and Sensitivity Analysis in Periodic and Stochastic Environments

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Temporally variable environments will, in general, affect both demography (i.e., the stage-specific rates of mortality, fertility, and stage transition) and dispersal (i.e., the stage-specific distributions of dispersal distances). The variation may be periodic, as in seasonal intra-annual variation, or stochastic. We show how to compute the asymptotic average invasion speed in both these cases, and the sensitivity of this invasion speed to both demographic and dispersal parameters. The results complete a set of invasion models that now include both unstructured and structured populations, in constant, periodic, and stochastic environments.

Targeting Discordant Couples to Mitigate HIV Epidemics in Africa: Modeling the Incidence, Impact, and Feasibility

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The World Health Organization (WHO) has recently placed a high priority on public health interventions targeted to discordant couples (i.e., couples where one partner is HIV-positive). The extent to which discordant couples drive incidence in Africa is controversial. We used data-based modeling analysis to determine the proportion of country-level incidence attributed to transmission within discordant couples. We parameterized the model with data on the level of discordancy and HIV prevalence in 14 African countries. Our results show discordant couples can be important in driving incidence, but their importance is country-specific. Two recent large-scale Phase III clinical trials have shown interventions targeted to discordant couples can be extremely effective in reducing transmission. Transmission was reduced by 96% in HPTN 052 (by using treatment as prevention) and by 67-75% in the Partners Study (by using pre-exposure prophylaxis). There is much debate on the extent to which an intervention for discordant couples could mitigate the HIV epidemic. To address this issue, we used modeling to predict the epidemic impact of treating discordant couples in Ghana, Lesotho, Malawi and Rwanda. We found interventions targeting discordant couples could prevent a number of infections; however, the effectiveness would vary between countries due to differences in epidemiology and the level of discordancy. Currently, it is not known whether interventions based on discordant couples would be feasible. We addressed this topic using a data-based model to predict the level of discordancy given HIV prevalence. We found interventions targeting discordant couples may not be feasible in countries where HIV prevalence is less than 5%, because only 3-19/1000 individuals are HIV-positive/negative and in discordant couples. Interventions may be feasible in countries where prevalence is greater than 10%, because 34-48/1000 individuals are HIV-positive/negative and in discordant couples. We calculated that 20-27% of all HIV-positive individuals, but less than 6% of all HIV-negative individuals, are in discordant couples. Consequently, targeting HIV-positive partners could significantly reduce transmission, whereas targeting HIV-negative partners may have little impact. Our results have significant implications for the policy developed by the WHO.

Convergence to the Equilibria in Some Mutation-Selection Model

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I will present some recent results on the convergence to the unique equilibrium in some mutation selection model. I will first start by exposing some results concerning a Lotka-Volterra competition system with mutation. Then I will present some extension to a PDE version of the Lotka-Volterra competition system with mutation and point some consequence on the dynamics.

Game-theoretic Methods for Functional Response and Optimal Foraging Behavior

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The number of prey of a given type consumed by a predator per unit time (i.e. the functional response) depends on the spatial distribution of the prey as well as on the decisions taken by the predator (e.g. where to search for prey, which type of prey to pursue, whether to attack, etc.) and on the times taken for these activities relative to their expected nutritional value. I will discuss (i) how this information can be conveniently represented in a tree diagram similar to an extensive form game; (ii) how standard functional responses such as Holling II emerge naturally from this setting; (iii) how game-theoretic methods can be used to analyze the optimal foraging strategy of the predator. The methods will be illustrated for classical diet choice and patch choice models, including those that involve the effects of simultaneously encountering different types of prey and of prey recognition effects. They will also be applied to predict equilibrium foraging behavior of a predator population with intraspecific strategies taken from a Hawk-Dove game that includes interaction times.

Seed Dispersal by Wind in Fragmented Landscapes with Corridors

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Widespread human-induced habitat loss and fragmentation can alter movement and dispersal of organisms, impacting populations, communities and ecosystems. Key challenges for understanding the many ecological and evolutionary processes involving wind-dispersed organisms are to extract the basic principles of dispersal in fragmented environments and test them empirically in real landscapes. By combining spatially-explicit fluid-dynamics dispersal models, wind measurements, and seed releases in a large landscape experiment, we elucidate how habitat corridors and fragmentation alter wind dynamics and seed dispersal, with consequences for the plant community. Corridors of open habitat can enhance wind dispersal by redirecting and bellowing airflow, and by intensifying seed uplift, increasing dispersal distances. This novel approach will help understand and predict wind dispersal, and thus population and community dynamics, in fragmented landscapes.

Optimal placement of Marine Protected Areas

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Overfishing can lead to the reduction or elimination of fish populations and the degradation or destruction of their habitats. This can be prevented by introducing Marine Protected Areas (MPA's), regions in the ocean or along coastlines where fishing is prohibited. MPA's can also lead to larger fish densities outside the protected area through spill-over, which in turn may increase the fishing yield. A natural question in this context, is when and where exactly to establish an MPA, in order to maximize these benefits. We address this problem along a one-dimensional coast-line, by first proposing a model for the fish dynamics. Fish are assumed to move diffusively, and are subject to recruitment, natural death and harvesting through fishing. Our problem is then cast as an optimal control problem for the steady state equation corresponding to the PDE which models the fish dynamics. The functional being maximized is a weighted sum of the average fish density and the average fishing yield. We show that optimal controls exist, and will see that the form of an optimal control -and hence the location of the MPA- is determined by two key model parameters, namely the length of the coastline, and the weight of the average fish density appearing in the cost. If these parameters are large enough -and precisely how large, can be calculated- our results indicate when and where an MPA should be established.

Uniform Boundedness and Spreading Speed for some Reaction-diffusion SI Systems

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In this work a two components epidemic reaction-diffusion system posed on the whole space R^N is considered. Uniform boundedness of the solutions is proved using suitable local L^p–estimates. The spatial invasion of a localized introduced amount of infective is studied yielding to the derivation of the asymptotic speed of spread for the infection. This part is achieved using uniform persistence ideas. The state of the population after the epidemic is further investigated using different Lyapunov like arguments.

Cholera Dynamics, Multiple Transmission Pathways, and Disease Spread in Haiti

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Cholera is a waterborne intestinal infection which causes profuse, watery diarrhea, vomiting and dehydration. Haiti has been in the grip of a cholera epidemic since October 2010, which has so far caused over 600,000 cases and over 7000 deaths. In this talk I will discuss some of our work modeling cholera in Haiti, examining multiple transmission pathways, and the roles of environment and human movement in the spread of cholera. I will also discuss some work examining potential intervention strategies, such as vaccination, provision of clean water, and improved sanitation.

Oscillation and Driving Mechanism in a General Model for Vector-borne Diseases with Time Delay

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Vector-borne diseases cause severe illness in humans or animals. Vectors population plays a critical rule in the transmission and spread of the disease. We first use a differential equation with delay to study the population dynamics of vector population under the impact of temperature. Then we extend to formulate a model of delay differential equations for the transmission of vector-borne diseases between vectors and hosts. Analytical analysis show that vectors alone can force the system to oscillate and may be responsible for the repeated outbreaks of the disease. The interaction between vector and amplification host is unlikely responsible for oscillatory behaviors of the system. We will then show some applications of malaria and West Nile virus. This is a joint work with Huaiping Zhu.

Evolution of Migration in a Changing World

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Just as behavioral ecologists begin to understand the myriad ways that environmental constraints shape the evolution of migration, those constraints are changing at a rapid pace. I will use game theory to evaluate the effect of demographic constraints on the evolution of migration as well as considering the implications of rapid change in climate, ecological interactions, and human disturbance patterns. Seasonal migration in montane and boreal zone herbivores will be used to illustrate clear examples of how such processes might play out in the real world.

Modeling the Spatial Spread of Rift Valley Fever in Egypt

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Rift Valley fever (RVF) is a severe viral zoonosis in Africa and the Middle East that harms both human health and livestock production. It is believed that RVF in Egypt has been repeatedly introduced by the importation of infected animals from Sudan. We develop a three-patch model for the process that animals enter Egypt from Sudan are moved up the Nile, and then consumed at those population centres. The basic reproduction number for each patch is introduced and then the threshold dynamics of the model are established. We simulate an interesting scenario showing possible explanation to the observed phenomenon of the geographic spread of RVF in Egypt. This is a joint work with Drs. Chris Cosner, Stephen Cantrell, John Beier and Shigui Ruan.

Long Distance Dispersal Accelerates Range Expansions

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I present the spreading properties of the solutions of an integro-differential equation of the form $u_t = J*u-u+f(u)$. I focus on equations with slowly decaying dispersal kernels $J(x)$ which correspond to models of population dynamics with long-distance dispersal events. I show that for kernels J which decrease to 0 slower than any exponentially decaying function, the level sets of the solution u propagate with an infinite asymptotic speed. Moreover, I obtain lower and upper bounds for the position of any level set of u. These bounds allow me to estimate how the solution accelerates, depending on the kernel J: the slower the kernel decays, the faster the level sets propagate. My results are in sharp contrast with most results on this type of equation, where the dispersal kernels are generally assumed to decrease exponentially fast, leading to finite propagation speeds.

T-LoCoH: A Space-Time Characterization of Movement Over Real Landscapes

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Advances in GPS technology have created both opportunities in ecology as well as a need for analytical tools that can deal with the growing array of ancillary variables associated with each location. We present T-LoCoH, a home range construction algorithm that incorporates time into the construction and

aggregation of local kernels, thereby enabling the construction of utilization distributions that capture temporal partitions of space as well as internal contours based on movement phase and time-use metrics. We test T-LoCoH against a simulated dataset and provide illustrative examples from a GPS dataset from springbok in Namibia. The incorporation of time into home range construction expands the concept of utilization distributions beyond the traditional density gradient to spatial models of movement phase and time-use, opening the door to new applications in behavioral ecology (Coauthors: Andy Lyons and Wendy Turner).

Sigmergy: Collective Action and Animal Social Spacing

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Spacing patterns in mobile animals occur to a large extent as a result of how individuals react to each other's presence. As animals respond to both current and past positions of their neighbors, the assumption that the relative location of the individuals is statistically and history-independent is not tenable. Here we move beyond that assumption, by constructing a framework to study spatial segregation of mobile animals when neighbor proximity elicits a retreat. This enables us to link conspecific encounter rate to memory-dependent avoidance behavior. Our approach rests on the knowledge that animals communicate by modifying the environment in which they live, providing a method to analyse the social cohesion emerging from the degree of stigmergy of the population. The rate of animal encounters indicates that individuals are better off either sharing the available space and forming social groups, or defending exclusive areas and being territorial, rather than partially excluding conspecifics. Practical application of these ideas to empirical data will also be discussed.

Complex Dynamics Caused by Facilitation in Competitive Environments within Polluted Habitat Patches

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This talk discusses a class of one-dimensional superlinear indefinite boundary value problems of great interest in population dynamics, under non-homogeneous boundary conditions, the main bifurcation parameter being the amplitude of the superlinear term. From the point of view of the applications in population dynamics, the results of this talk establish that, under facilitative effects in competitive media, the harsher the environmental conditions, the richer the dynamics of the species.

Multi-scale Modeling of Malaria: From Endemicity to Elimination

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Malaria is the fifth leading cause of death worldwide. It produces several hundred million clinical infections in about 100 countries, and an unknown, probably ten-fold, number of asymptomatic cases per year. The malaria parasites in circulation are not uniform, but instead are comprised of sub-groups that can have different diversity, antigenic variation, and virulence. Together these are fundamental drivers in the transmission of malaria, and their correct characterization requires a change in the current dominant paradigm for mathematical modeling of this disease.

Instead of compartmentalizing individuals within a population, as traditionally done, into susceptible, exposed, infected, recovered (SEIR), I propose to study the formulation of the transmission of malaria as a multi-scale ecological problem in which the parasite lives in "islands" (humans and anopheline mosquitoes) with a rate of connectivity (i.e. rate of infection). Using this framework, it will be possible to estimate the population density of the parasite within both symptomatic and asymptomatic individuals in a geographic area (as opposed to estimating risk of human infection or number of infected patients), which in turn could inform the optimal use of public health resources towards the elimination of the parasite. The number of infected humans can be easily calculated indirectly with this approach.

Applying Biogeochemical and Genetic Markers to Understand Movement in Complex Systems

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An emerging issue in understanding movement for species of interest is the ability to identify the natal site or region of origin for individuals encountered away from their native, natal or breeding grounds. For instance, linking activities such as hunting, fishing or harvesting, planting or human-mediated dispersal with changes in population size to understand demographic or large-scale impacts of human activities has largely been an intractable problem. Applying a geographic assignment approach which uses a combination of stable isotope, trace element, morphometric and/or genetic data, we can assign individuals to their site or region of origin. This in turn can allow allows researchers and managers to prioritize conservation approaches and establish appropriate mitigation or offset measures for impacted populations, as well as to identify appropriate management strategies focused on desired outcomes.

We applied a novel geographic assignment approach to identify origins for unknown provenance Flesh-footed shearwaters (Puffinus caneipes) using eighteen stable isotopes and trace elements and eleven microsatellite markers. Our aim was to compare birds from five breeding sites across their geographic range with birds of unknown provenance killed via fishing activities at multiple locations to identify their likely colonies of origin. To test the quality of our assignments we used a re-sampling procedure and limited the data set to birds whose breeding site was known. We discuss biases in sampling and marker selection, utility of the approach and application across systems and taxa.

Mathematical Modelling with Fully Anisotropic Diffusion

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With "fully anisotropic" I describe diffusion models of the form $u_t = \nabla\nabla(\mathrm{D(x)u})$, where the diffusion tensor appears inside both derivatives. This model arises naturally in the modeling of brain tumor spread and wolf movement and other applications. Since this model does not satisfy a maximum principle, it can lead to interesting spatial pattern formation, even in the linear case. I will present a detailed derivation of this model and discuss its application to brain tumors and wolf movement. Furthermore, I will present an example where, in the linear case, the solution blows-up in infinite time; a quite surprising result for a linear parabolic equation. (joint work with K.J. Painter and M. Winkler).

Theoretical Studies of the Coevolution of Dispersal, Plasticity, and Local Adaptation in Heterogeneous Landscapes

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In a spatially heterogeneous environment, the rate at which individuals move among habitats affects whether selection favors phenotypic plasticity or genetic differentiation, with high dispersal rates favoring trait plasticity. Until now, in theoretical explorations of plasticity evolution, dispersal rate has always been treated as a fixed, albeit probabilistic, characteristic of a population, raising the question of what happens when the propensity to disperse and trait plasticity are allowed to evolve jointly. We examined the effects of their joint evolution on selection for plasticity using an individual-based computer simulation model. In the model, the environment consisted of a linear gradient of 50 demes with dispersal occurring either before or after selection. Individuals consisted of loci whose phenotypic expression either are affected (plastic) or are not affected (non-plastic) by the environment, plus loci determining the propensity to disperse. When dispersal rate and trait plasticity evolve jointly the, system tends to dichotomous outcomes of either high trait plasticity and high dispersal, or low trait plasticity and low dispersal. The outcome strongly depended on starting conditions, with high trait plasticity and dispersal favored when the system started at high values for one either trait plasticity or dispersal rate (or both). Adding a cost of plasticity tended to drive the system to genetic differentiation, although this effect also depended on initial conditions. Genetic linkage between trait plasticity loci and dispersal loci further enhanced this strong dichotomy. All of these effects depended on organismal life history pattern, and in particular: whether selection occurred before or after dispersal. These results can explain why adaptive trait plasticity is less common than might be expected (Joint work with Mike Barfield and Sam Scheiner).

Spread of Fleshy-fruited Exotic Shrubs when Dispersal is Structured by Dispersers that Vary over Time

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Here we describe a novel application of a structured population model for wavespeed that incorporates disperser-taxon and we evaluate how the relative proportion of mammalian and avian dispersers affect the rate of spread of an invasive shrub in southern Florida, *Ardisia elliptica* and we propose an application to another invasive shrub in our region, *Schinus terebinthifolius*. We make use of a disperser-structured dispersal model that would include dispersal kernels estimated separately for gravity-, catbird-, robin- and raccoon-dispersed seeds. For the *Ardisia* example, an inverse modeling method was used to parameterize the dispersal kernels from mapped seedlings and adults. The disperser-structured dispersal model estimated invasion speeds of 11.4 m yr^{-1}. Infrequent long-distance dispersal by raccoons was important in determining invasion speed in the disperser-structured model. We propose a similar effect of robins for *Schinus*, although a different field technique will be needed, and discuss application of a new framework that includes temporally varying dispersal kernels along with temporally varying demography. Comparing model projections with the (historically) known rate of spread, we show how a model that stratifies seeds by dispersal agents does better than one that ignores them, even though some longer distance vectors may still be missing from our observations (coauthors: A. KOOP & K. ERICKSON).

Integrodifference Models for Persistence in Temporally Varying Habitats

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We consider integrodifference models of growth and dispersal on finite domains to investigate population dynamics in the context of local growth dynamics with temporally varying dispersal kernels. We consider persistence in the context of single, periodic, and random kernel parameters.

Extensive Secondary Seed Dispersal Revealed by Telemetric Seed Tags

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Most studies of seed dispersal assume that seeds reach the site where they either germinate or die in a single step, often referred to as primary dispersal. The importance of secondary dispersal tends to be downplayed. We used miniature radio transmitters to track the 'secondary' dispersal of palm seeds by agoutis, which scatter-hoard seeds in shallow caches in the soil throughout the forest, on Barro Colorado Island, Panama. We found that rodents removed seeds at high rates but that seeds were initially cached at mostly short distances and then quickly dug up again, suggesting poor dispersal and low survival. However, rather than eating the recovered seeds, agoutis continued to move and re-cache the seeds, up to 36 times. An estimated 35% of seeds travelled >100 m from the source. Serial video-monitoring of cached seeds revealed that the stepwise dispersal was caused by agoutis repeatedly stealing and re-caching each other's buried seeds. Agoutis directed dispersal towards locations that had fewer palms and palm seeds than did the origin, supposedly to reduce the risk of cache theft. Thus, telemetry revealed that secondary dispersal by agoutis was highly effective, facilitating movement away from adults and siblings to a degree never before anticipated.

Metrics for Population Persistence in Rivers

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Water resources worldwide require management to meet industrial, agricultural, and urban consumption needs. Water managers are tasked with meeting water needs while mitigating ecosystem impacts. We develop process-oriented advection-diffusion-reaction equations that couple hydraulic flow to population growth, and analyze them to assess the effect of water flow on population persistence. We present a new mathematical framework, based on the net reproductive rate R_0 for advection-diffusion-reaction equations and on related measures. We apply the measures to population persistence in rivers under various flow regimes.

Geographic Coupling of Juvenile and Adult Habitat Shapes Spatial Population Dynamics of a Coral Reef Fish

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Marine spatial population dynamics are often addressed with a focus on larval dispersal, without taking into account movement behavior of individuals in later life stages. Processes occurring during demersal life stages may also drive spatial population dynamics if habitat quality is perceived differently by animals belonging to different life stages. In this study, we used a dual approach to understand how stage-structured habitat use, and dispersal ability of adults shape the population of a marine fish species. Our study area and focal species provided us with the unique opportunity to study a closed island-population. A spatial simulation model was used to estimate dispersal distances along a coral reef that surrounds the island, while contributions of different nursery bays were determined based on otolith stable isotope signatures of adult reef fish. The model showed that adult dispersal away from reef areas near nursery bays is limited. The results further show that different bays contributed unequally to the

adult population on the coral reef, with productivity of juveniles in bay nursery habitat determining the degree of mixing among local populations on the reef and with one highly productive area contributing most to the island's reef fish population. The contribution of the coral reef as a nursery habitat was minimal, even though it had a much larger surface area. These findings indicate that the geographic distribution of nursery areas and their productivity are important drivers for the spatial distribution patterns of adults on coral reefs. We suggest that limited dispersal of adults on reefs can lead to a source-sink structure in the adult stage, where reefs close to nurseries replenish more isolated reef areas. Understanding these spatial population dynamics of the demersal phase of marine animals is of major importance for the design and placement of marine reserves, as nursery areas contribute differently to maintain adult populations (Coauthors: Chantal M. Huijbers, Ivan Nagelkerken, and Adolphe O. Debrot).

Frugivores, Pollinators, Seeds, and Genes: Tracking Long-distance Dispersal and its Consequences

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Mutualistic interactions among plants and animals take a tremendous variety of forms in nature and have pervasive consequences for the population dynamics and evolution of partner species. Pollen and seed movement are the primary outcomes these interactions, yet we know very little of how key ecological functions such as long-distance dispersal events (LDD) or outcrossing map onto these highly complex webs of mutualism and what are the consequences of these diversified mutualisms. A persistent challenge in dispersal ecology has been the robust characterization of dispersal functions (kernels), a fundamental tool to predict how dispersal processes respond under global change scenarios. In this talk I discuss two fundamental questions faced by researchers seeking empirical data about the frequency and extent of dispersal events, in the specific case of animal-mediated dispersal of plant propagules (seeds and pollen). Given a sampled propagule (i.e., a dispersed seed on the forest floor, an established seedling, an embryo within a fruit): 1) which is the source tree where the propagule comes from, taken by the animal disperser?; and 2) which is the animal vector that dispersed the propagule to that specific target location? Most seed dispersal and pollination mutualisms involve the interaction of plants with tens of animal species that widely differ in the amount of propagules dispersed and in their contribution to different sectors of the dispersal kernel (i.e., contributions to different portions of the tail). I explore the consequences of these variable contributions when embedded in the complex web of diversified mutualisms. For example, what are the consequences of large-bodied frugivore extinctions in fragmented areas? How will dispersal kernels be modified (i.e., truncated) as a consequence of differential extinctions of animal mutualists performing distinct ecological services, such as contribution to LDD events? What consequences will have the resulting collapse of connectivity among fragmented populations? Recent applications of hypervariable (SSR) DNA markers together with new approaches bridging landscape ecology, advanced biotelemetry, and ecological genomics are ground-breaking advances in the study of dispersal ecology. Together with new modeling tools they define a promising research avenue to understand how highly dynamic dispersal systems respond to contemporary global change scenarios.

The Vertical Distribution of Phytoplankton

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Phytoplankton face a dilemma: light comes from above, nutrients come from below, and they need both. Although the name "plankton" comes from the Greek word for "wanderer", many phytoplankton taxa have adaptations to choose their position within the water column and solve this dilemma. Under uniformly poorly mixed conditions, this adaptive movement results in a thin layer of phytoplankton at a depth where it is colimited by nutrients and light. Complications from interspecific competition, more realistic mixing patterns (stratification), and higher trophic levels will be discussed, as will experimental results.

Positive Stationary Solutions and Spreading Speeds of KPP Equations in Locally Spatially Inhomogeneous Media

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This paper mainly explores spatial spread and front propagation dynamics of KPP evolution equations with random or nonlocal or discrete dispersal in unbounded inhomogeneous and random media and reveals such an important biological scenario: the localized spatial in-homogeneity of the media does not prevent the population to persist and to spread, moreover, it neither slows down nor speeds up the spatial spread of the population. This is joint work with Dr. Wenxian Shen.

The Ideal Free Distribution: From Hypothesis to Tests

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The Ideal Free Distribution predicts that a single population will distribute among multiple habitat patches so that patch payoffs in occupied patches will be the same and maximal. Tests with vertebrate species show fairly good agreement between the theory and observations. Recent work shows that the IFD is also an evolutionarily stable strategy of the Habitat selection game, a general game theoretical concept that allows to consider multiple species undergoing population dynamics. I my talk I will focus on extensions of the single species IFD to situation of two competing species and a single species that undergoes population dynamics. Besides theoretical hypothesis I will also show some empirical tests of the theory.

Evolution of Conditional Dispersal: ESS in Spatial Models

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We consider a two-species reaction-diffusion-advection competition model in which the species have the same population dynamics but different dispersal strategies. Regarding the advection coefficients as movement strategies of species, we investigate their course of evolution in the game-theoretical setting. By applying invasion analysis we find that if the spatial environmental variation is less than a critical value, there is a unique evolutionarily singular strategy, which is also evolutionarily stable. If the spatial environmental variation exceeds the critical value, there can be at least three evolutionarily singular strategies, one of which is not evolutionarily stable. Our results suggest that the evolution of directed movement of organisms depends upon the spatial heterogeneity of the environment in a subtle way.

A Plant-pathogen Multiscale Model System

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The spatial spread of an airborne pathogen within an anthropized crop plot depends on many factors acting at contrasted spatio-temporal scales: plant, plot or landscape scales. This is of paramount importance for vine and powdery mildew, one of its airborne pathogen. We shall first review a preliminary complex discrete model at the plant scale and an aggregated ODE system capturing the flavor of the local dynamics of the discrete one, with respect to available data. Then we aimed at developing a coupled PDEs-ODEs model for plant-pathogen interactions at the plot scale level in order to assess the effects of various host heterogeneities on the epidemic spread. Taking into account natural spatial periodicity of rows generated by anthropized cultural practices allows to use homogenization techniques to derive a further simplified model.

Holder Continuity of BMO Weak Solutions to Strongly Coupled Elliptic Systems

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In this talk we will discuss the regularity of weak solutions to a class of strongly coupled systems which consist of more than two equations. The main assumption is that the systems possess some maximum principles concerning the BMO norms of their weak solutions. Such BMO maximum principles will also be presented.

Impact of Global Change on Predator-prey Relationships in Complex Environments

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In this talk I will analyze the effects of environmental change on predator prey interactions. My focus will be on predator searching efficiency relative to man-made landscape features. I will use the theory of first passage time to analyze complex movement patterns of predators searching for prey. I will extend the analysis to complex heterogeneous environments to assess the effects of man-made linear landscape features on functional responses in wolves searching for elk. (This work is joint with Hannah McKenzie, Evelyn Merrill and Ray Spiteri).

Traveling Wave Solutions in Partially Degenerate Cooperative Reaction-Diffusion Systems

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We will discuss the existence of traveling wave solutions for partially degenerate cooperative reaction-diffusion systems that can have three or more equilibria. We show via integral systems that there exist traveling wave solutions in such a system with speeds above two well-defined extended real numbers. We prove that the two numbers are the same and may be characterized as the spreading speed as well as the slowest speed of a class of traveling wave solutions provided that the linear determinacy conditions are satisfied. We demonstrate the theoretical results by examining a partially degenerate Lotka-Voltarra competition model with advection terms.

Modeling the Dynamics of Woody Plant-Herbivore Interactions with Age-Dependent Toxicity

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In this paper we study the effects that woody plant chemical defenses may have on interactions between boreal hares that in winter feed almost entirely on twigs. We focus particularly on the fact that toxin concentration often varies with the age of twig segments. The model incorporates the fact that early in the growth of twigs, segments are often highly defended by toxins and are, therefore, highly unpalatable to hares. But, in the second year of twig growth, the toxin concentration of older twig segments begins to decline increasing the palatability of their biomass. This age-dependent toxicity of twig segments is modeled using age-structured model equations which are reduced to a system of delay differential equations involving multiple delays in the woody plant - hare dynamics. A novel aspect of the modeling was that it had to account for mortality of non-consumed younger twig segment biomass when older twig biomass was bitten off and consumed. Basic mathematical properties of the model are established together with upper and lower bounds on the solutions. Necessary and sufficient conditions are found for the linear stability of the equilibrium in which the hare is extinct, and sufficient conditions are found for the global stability of this equilibrium. Numerical simulations confirmed the analytical results and demonstrated the existence of limit cycles over ranges of parameters reasonable for hares browsing on woody vegetation in boreal ecosystems. This showed that age dependence in plant chemical defenses has the capacity to cause hare - plant population cycles, a new result.

Predicting Effective Seed Dispersal Kernels Based on Animal Movement and Habitat Use

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In tropical wet forests, animals are essential to plant regeneration as they remove seeds away from the parent plant where seed and seedling mortality is disproportionately high. Understanding how animals contribute to seed dispersal kernels of plants is difficult due to the scale at which animals move and the relative rarity at which fruits are removed. The use of molecular genetic techniques have provided new avenues to directly measure seed dispersal kernels by connecting seeds or seedlings back to parent plants. These molecular genetic methods, however, do not provide details regarding the functional roles of the various animal species that consume fruits and disperse seeds. A potential solution is to model disperser-specific seed dispersal kernels using information about fruit removal, habitat use, passage time and distance moved. Disperser-specific seed dispersal kernels are developed in this study to predict the distribution of seedlings of Miconia nervosa (Melastomataceae), a relatively common understory shrub that produces bird-dispersed berries. Spatially-explicit models of seed kernels take into account the differential behavior and ecology of males and females from a suite of disperser species and the distribution of adult plants. These seed kernels are then compared to known distribution patterns of M. nervosa seedlings. The match between disperser-specific seed kernels and seedling distributions are compared using an information-theoretic approach (Coauthors: G. Rivas, K. M. Holbrook, R. Durães and J. G. Blake).

Complex Dynamics Caused by Facilitation in Competitive Environments within Polluted Habitat Patches

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This talk discusses a class of one-dimensional superlinear indefinite boundary value problems of great interest in population dynamics, under non-homogeneous boundary conditions, the main bifurcation parameter being the amplitude of the superlinear term. From the point of view of the applications in population dynamics, the results of this talk establish that, under facilitative effects in competitive media, the harsher the environmental conditions, the richer the dynamics of the species.

Global and Local Averaging for Integrodifferential Equations

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Homogenization techniques for partial differential equations with different spatial scales are well understood. They allow us to derive approximate equations on larger spatial scales by appropriate averaging over smaller scales. In this talk, I present similar averaging methods for integrodifferential equations that describe the growth and movement of a species in a heterogeneous landscape. In these equations, movement of individuals is described by an integral operator. I use global averaging to explore persistence conditions and spreading speeds for invasive species. I compare the results of different model formulations and I make some comparison with homogenization techniques for corresponding reaction-diffusion equations. In addition, I then introduce a local averaging technique that retains more information about the movement process and consequently gives a better approximation to the persistence condition for the invasive species.

Some Mathematical Epidemic Models for Bacterial Hospital Infections

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The development of drug-resistant strains of bacteria is an increasing threat to society, especially in hospital settings. Many antibiotics that were formerly effective in combating bacterial infections in hospital patients are no longer effective due to the evolution of resistant strains. The evolution of these resistant strains compromises medical care worldwide. In this talk, we will first present a comparison between the classical SIR problems and Individual Based Model (IMB) (i.e. Monte-Carlo computer simulations). The idea of this first part is to reconsider the classical SIR problem starting from a description of the interaction at the individual level. In hospital this is useful to model one Intensive Care Unit. In the context of hospital infection, age of infection turns to be very useful to describe the history of the infection at the patient level. Here we will present some recent result about the global dynamical properties an SIR epidemic model with age of infection. We will conclude this talk with an application of a two group infection age model to nosocomial infection.

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Asymptotic Behavior of a Nonlocal Equation

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In this talk we will study the asymptotic behavior of the solutions of

$$u_t = \int_R J(\frac{x-y}{g(y)})\frac{u(y,t)}{g(y)}dy - u(x,t),$$

with $J: R \to R$ is a nonnegative even function with compact support such that $\int_R J(y)dy = 1$. In this equation the dispersal is inhomogeneous in space since the step size *g(y)* depends on the position *y*. We assume that *g(y) > 0* in *R*, and of particular interest will be the case in which the dispersal $g(y) \to 1$ as $|y| \to \infty$. We will study the asymptotic behavior of the initial value problem depending on the step size behavior.

Some Causes and Consequences of Dispersal in Real and Model Systems

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Spatial-temporal heterogeneity coupled with the struggle for existence suggests that dispersal should not only be adaptive but that it should be contingent on both habitat and density. We provide an example with lemmings and use the ideal-free solution to forecast future habitat selection strategies. We then use computer simulations to evaluate the stability of two alternative 'territorial' strategies. Although probabilities of successful invasion vary between the strategies, most simulations yield coexistence that may explain within-habitat differences in territorial behaviour. The likelihood of such density-dependent fitness maximizing strategies of habitat selection (and dispersal) should vary with a species' cognitive ability, sensory awareness, and mobility. Laboratory experiments with motile phototactic algae support the assumption. Dispersal appears independent of density but contingent on habitat. Thus it seems that even the simplest of organisms possess remarkable skills at dispersal that validate the importance of adaptive habitat selection to our understanding of population biology (based on joint work with Jody MacEachern, MaryJane Moses, and Angélique Dupuch).

Linking Individual Movements and Population Patterns in Dynamic Landscapes

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The interplay of individual-level movement behaviors (e.g., non-oriented movements, oriented movements, and movements based on memory), with spatiotemporal resource dynamics leads to population-level movement patterns. Resources with little spatial variability should facilitate sedentary ranges, whereas resources with predictable seasonal variation in spatial distributions should generate migratory patterns. A third pattern, nomadism, should emerge when resource distributions are unpredictable in both space and time.

We used relocation data from four ungulate species to examine individual movements and the interrelation of movements among individuals. We applied and developed a suite of spatial metrics (e.g., population dispersion, movement coordination and realized mobility) that measure variation in movement among individuals. Taken together, these metrics allowed us to quantify and distinguish among different large-scale population-level movement patterns such as migration, range residency and nomadism. We then related the population level movement patterns to the underlying landscape vegetation dynamics via long-term remote sensing measurements of the temporal variability, spatial variability and unpredictability of vegetation productivity.

We show how broad-scale landscape unpredictability may lead to nomadism, an understudied type of long-distance movement. In contrast to classical migration where landscapes may vary at broad scales but in a predictable manner, long-distance movements of nomadic individuals are uncoordinated and independent from other such individuals. Landscapes with little broad-scale variability in vegetation productivity feature smaller-scale movements and allow for range residency. Nomadism requires distinct integrative conservation strategies that facilitate long-distance movements across the entire landscape and are not limited to certain migration corridors.

How the Spatial Scales of Seed Dispersal and Natural Enemy Attack Influence the Strength of Population Regulation, Invasion Growth Rates, and Ultimately Plant Diversity

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Over 35 years ago, Janzen and Connell suggested that specialized natural enemies concentrate around adult trees, that these enemies elevate seed and seedling mortality near conspecific adults, and that this contributes to the maintenance of tree species diversity in tropical forests by preventing any one species from becoming very common. While we now have extensive empirical evidence for elevated mortality near conspecific adults and theoretical demonstration that such mortality contributes to diversity maintenance, we lack tools for extrapolating from quantities measured in the field to community-level effects on population and community dynamics, and ultimately diversity. Here, we use spatially explicit models and moment approximations to them to analyze how changes in seed dispersal kernels and natural enemy attack kernels affect spatial structure and the strength of stabilization (aka population regulation). We further use simulations to examine effects on invasion growth rates, extinction times, and species diversity maintenance. We find that stabilization is weakest when natural enemy dispersal distances are short relative to seed dispersal distances, exactly the conditions under which spatial patterns show the overdispersion classically associated with Janzen-Connell. In contrast, long enemy attack scales relative to seed dispersal results in stronger stabilization, and ultimately greater contributions to diversity maintenance (Talk coauthors: Matteo Detto and Fred Adler).

The Ideal Free Strategy with Weak Allee Effect

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This talk examines the interplay between optimal movement strategies and the weak Allee effect within the context of two competing species in a spatially heterogenous environment. When both species have the same populations dynamics, previous studies identified an `ideal free' strategy which is able to exclude any other competitor playing a `non-ideal free' strategy. We find that if the ideal free disperser is subject to a `weak' Allee effect, a competing species utilizing very weak or very strong advection will still be excluded despite having superior population dynamics. However, for intermediate advection rates, such a competitor can invade the ideal free disperser and even drive it to extinction. Not only do these results enhance ecological understanding of competing species, but they provide insight into the non-linear theory of reaction-advection-diffusion models when the usual linearization techniques offer no information.

Spatial Patterns in a Population Model Structured by Cell Size, Quiescence and Sensing Radius

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In this talk, we develop a mathematical model to describe spatial movement of an in vitro cell population. First, we present a two-compartment space and size structured model taking account of cell size, cell division, mortality, motility, contact inhibition, supply and demand for nutrition or oxygen, proliferative/quiescent states. Then we reduce the complicated two-compartment model to a single equation. The resulting simplified model consists of a nonlinear diffusion of porous medium type and a nonlocal reaction term. This model contains the complex phenomena present in the cell biology, but are simple enough to be theoretically analyzed. Numerical experiments are carried out to demonstrate the formation of cell colonies. This is a joint work with Arnaud Ducrot (Universite Victor Segalen Bordeaux 2, France), Frank Le Foll (University of Le Havre, France), Pierre Magal (Universite Victor Segalen Bordeaux 2, France), Jennifer Pasquier (University of Le Havre, France) and Glenn F. Webb (Vanderbilt University, USA).

How Dispersal in Patchy Landscapes Affects Population Spread

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Formulating mathematical models for population dynamics and spread of invasive insects has garnered much attention in recent years. In particular, these models have been developed on fragmented landscapes, since fragmentation may lead to extinction, and poor conditions between habitats may slow the spread of a population. Inherent to this problem is the assumption of how a population disperses across an interface. It was widely accepted that the density and flux of a population density must be continuous across an interface. Recent work has shown that, under certain conditions, the density may not be continuous. To study these phenomena, we formulate an integrodifference equation (IDE) on a periodic (patchy) landscape. To investigate the effect of different movement assumptions on persistence and spread, we first derive dispersal kernels to implement into the IDE. We then derive implicit formulae for the minimal spreading speed, and compare how the different assumptions about behavior at an interface affect persistence.

Effect of Habitat Fragmentation on Persistence and Spreading of Populations

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This talk will use reaction-diffusion equations in order to discuss the effect of habitat fragmentation on persistence and spreading of populations. Cantrell and Cosner where the first ones to address such a question, in dimension 1, when only two types of habitat are considered. An appropriate mathematical tool in order to quantify the fragmentation in a general framework is the Steiner symmetrization of the habitat function. Our main result is that fragmentation decreases the speed of propagation of the population in dimension 1. In higher dimensions, several related question are open, involving deep mathematical problems.

A Movement Ecology Approach for Studying Dispersal Processes in Changing Environments

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Understanding and predicting the dynamics of complex ecological systems are best accomplished through the synthesis and integration of information across relevant spatial, temporal and thematic scales. Recent advances in mechanistic modeling and tracking technology have enriched our capacity to disentangle the key parameters affecting dispersal and other movement processes and to accurately quantify movement patterns. In lieu of this favorable background, movement ecology has recently emerged to facilitate the unification of movement research. Movement ecology aims at investigating the explicit links between the internal state, the motion and the navigation capacities of the individual and the external environmental factors affecting its movement. Therefore, it provides a natural platform for examining the mechanisms underlying dispersal processes and patterns and consequences of dispersal in changing environments. In this talk I present the basic principles of the movement ecology approach, and will illustrate its application to the study of dispersal of plant seeds by wind and by animals.

Resource Theft and Spatial Population Dynamics

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We describe the dynamics of a producer-scrounger system in a spatial habitat using a partial differential equation model. Both species are assumed to increase logistically and to move randomly in their environment. Producers can obtain the resource directly from the environment, whereas scroungers must steal it from nearby producers. When possible, parameter combinations which allow producers and/or scroungers to persist either alone or together are distinguished from those in which they cannot. This work is in collaboration with C. Cosner (Miami).

Invasion Speeds of Sex- and Age-structured Populations

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A key descriptive statistic of an ecological invasion is the speed that it spreads across the landscape, the invasion speed. In general, the invasion speed will depend upon the vital rates (growth, survival, fecundity, etc.) and dispersal rates of individuals. These rates typically vary from individual to individual and much of that difference can be attributed to the individual's life-history stage. Mathematical ecologists have incorporated these stage-specific differences into integrodifference matrix population models from which they can compute the invasion speed, and the sensitivity of the speed to changes in the vital and dispersal rates. These models consider only one sex. In this talk, I will present a model that accounts for both population age- and sex-structure. I will conjecture a formula for the invasion speed, and show how it depends upon the model parameters and the nature of the pair-formation process that governs mating.

Complete Dynamics of a Heterogeneous Competition-Diffusion System

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In this joint work with Adrian King-Yeung Lam we will discuss the interaction of diffusion and spatial heterogeneity and its effect in a Lotka-Volterra competition system. In the case when one of the inter-specific competition is very weak, we are able to obtain the complete dynamics of the system, following Yuan Lou's approach.

Spatiotemporal Complexity in Metapopulations, no Chaos Required

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I will discuss the spatiotemporal complexity that emerges from metapopulation dynamics in the absence of the high local growth rates required for chaos. In particular, I will focus on stochastic coupled map lattices in which local growth rates would yield a simple two-cycle for an isolated, deterministic patch. Coupling these two-cycles together at intermediate levels of migration, with either local or non-local dispersal kernels, generates a large number of metastable states for a noisy, multi-patch metapopulation. Threshold behaviors and ecological implications will be highlighted.

Pattern Formation in a Predator-prey System Characterized by a Spatial Scale of Interaction

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We describe pattern formation in ecological systems using a version of the classical Lotka-Volterra model characterized by a spatial scale which controls the predator-prey interaction range. Analytical and simulational results show that patterns can emerge in some regions of the parameters space showing how spatial patterns can emerge for some values of the interaction range and of the diffusion parameter.

Population Ranges in Changing Climates

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Determinates of population ranges are explored in terms of a formulation that includes the probabilities of reproduction, spatial dispersion through an environment, and successful settlement in widely distributed ecological suitable patches (niches). A model framework that includes nonlinear dynamics in reproduction and successful occupation of territory introduces the possibility of Allee effects in successful populations across such an ecosystem. Connections between these local population limitations and restrictions placed by the dispersal of populations across land- or seascapes are considered in terms of advection-diffusion models. Of particular interest are disconnected areas and the concepts behind island biogeography in the McArthur/Wilson sense. These ideas are explored in terms of a set of canonical migration or flow regimes with diffusion. These include closed systems with return and dispersive systems that lead to population losses for an area. The result allows explicit calculation of meta-population connectivity and a discussion of the influence of variations in ecosystems via climate or trophic changes on biogeography. Examples involving marine and terrestrial populations are given (Joint work with Chris Cosner and Steve Cantrell).

Counterintuitive Patterns of Dispersal Evolution in a Trophic Metacommunity

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Theoretical studies have repeatedly demonstrated that species exhibiting a regional metapopulation structure while being subject to increasing rates of local patch extinctions should experience strong selective pressures to disperse more rapidly despite the costs such increased dispersal would entail in terms of decreased local fitness. We have extended these studies to consider how extinctions arising from trophic interactions will affect the evolution of dispersal for species inhabiting a metacommunity. Specifically we investigated how increasing a strong extinction-prone interaction between a predator and prey within local patches will affect the evolution of each species' dispersal rate at the metacommunity scale. As per previous studies, the evolutionarily stable strategy (ESS) dispersal rate of the predator was found to increase monotonically in response to increasing local extinctions induced by strong predator top-down effects. However for the prey, ESS dispersal rates were unexpectedly found to display a nonmonotonic response to increasing predator-induced extinction rates-actually decreasing for a significant range of values. These counterintuitive results can be shown to arise from how extinctions resulting from trophic interactions are likely to play out at different spatial scales: interactions that increase extinction rates of both species locally can, at the same time, decrease the frequency of interaction between the prey and predator at the metacommunity scale.

Interactive Dynamics of Wildlife Populations, Human Health and Household Wealth

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Daily decisions of rural households concerning the use of natural resources for food, fuel and other products interact with ecosystem dynamics to determine social well-being and ecological sustainability. In this talk, we present an integrated ecological, socioeconomic and health model to illuminate and predict how varying reliance on and preferences for wildlife harvesting impact household wealth, health and the sustainability of wildlife populations (Coauthors: R. M. Marsh and E. Marshalek).

Population Persistence under Advection-diffusion in River Networks

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We consider the spatio-temporal evolution of the density *u(t, x)* of individuals on a directed tree graph *Γ*, as a model for a population of organisms in a river network. Each stream of the network is modelled as an edge in the graph. The model is an extension to graphs of the work of Lutscher, Pachepsky and Lewis (2005). It assumes a constant reproductive rate r, a rate µ at which individuals get dispersed by the water column, and a dispersion kernel *K(y, x)*. The results are given in terms of the critical reproductive rate r_{crit}, defined as the minimum rate at which the extinction state is stable, and therefore the population cannot recover from very low density values. The dispersion kernel is constructed assuming that while an organism is mobile, it undergoes an advection-diffusion process on *Γ* for an exponential random time. The values of the advection *v* and the diffusion coefficient *D* are allowed to vary between stream, and are constrained by the continuity of the population density, the flux of individuals, and water discharge at nodes connecting streams. The results include upper and lower bounds for the critical reproductive rate in terms of the physical and biological variables of the model.

Dynamical-systems Insights into Migration

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Long-distance migrations form some of the most astonishing phenomena in animal life on planet earth, and also some of the clearest examples of oscillations in populations. There are many different examples of long-distance migration for very different animals, including monarchs annual migration to Mexico, wildebeest migration in Africa, and salmon migrations between oceans and fresh-water rivers. It's clear that these species gain advantages in survival based on their migration patterns. But it's less clear how species without human capacities for reasoning, evolved to exhibit these long-distance migrations. In this talk, I'll review some classical dynamical-systems results and re-apply them to explore how migratory behavior can evolve and how different migration patterns can co-exist in a common landscape.

Habitat Selection under the Risk of Infectious Disease

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How does the risk of infectious disease transmission affect individual habitat selection decisions and the resulting spatial distributions of populations? To answer this question, we use a differential equation model to describe disease dynamics in two habitats coupled by natal dispersal and use an evolutionary game theoretical approach to calculate the evolutionarily stable strategy for habitat choice. In the absence of disease, our model predicts input matching (i.e. the distribution of individuals matches the distribution of resource inputs). We find the negative fitness consequences of infection can result in undermatching (underuse of the high-quality habitat compared with input matching), but stable overmatching (overuse of the high-quality habitat) is never predicted. We look at the effects of increasing the risk of transmission or the cost of infection when both habitats present a risk of disease as well as when only the high-quality habitat is infected (Coauthor: Ian Hamilton).

A Cross-diffusion Model for Avoidance Behavior in an Intraguild Predation Community

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Intraguild predation (IGP) refers to a community module that blends competitive and predator-prey dynamics. Although IGP is widespread in nature, spatially homogeneous models for IGP communities predict that stable coexistence is only possible if restrictive conditions on resource productivity, competitive ability and predation susceptibility are satisfied. This talk will consider the population dynamics of an IGP module in a spatially heterogeneous landscape and examine how avoidance strategies deployed by the intraguild prey can lead to more robust coexistence states

Persistence of Structured, Interacting Populations in Stochastic Environments

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Individuals within any species exhibit differences in size, developmental state, or spatial location. These differences coupled with environmental fluctuations can have subtle effects on population persistence and species coexistence. To understand these effects, I describe a general theory for coexistence for nonlinear, multi species matrix models with stochastically varying parameters. The coexistence criterion requires that there is a weighted combination of the stochastic growth rates which is positive at all stationary distributions supporting a subset of species. When this coexistence condition holds, the community is stochastically persistent: the fraction of time that a species density goes below $\delta>0$ approaches zero as δ approaches zero. To illustrate the use of this theory, I will provide applications to spatially explicit lottery models with transitive competition and intransitive competition. This work is joint with Gregory Roth from UC Davis.

The Dynamics of Growing Islets and Transmission of *Schistosomiasis Japonica* in the Yangtze River

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In this talk we formulate and analyze a system of ordinary differential equations for the transmission of *schistosomiasis japonica* on the islets in the Yangtze River, China. The impact of growing islets on the disease spread is investigated by the bifurcation analysis of the model. Using projection technique, the normal form of cusp bifurcation of codimension 2 is derived to overcome the technical difficulties in studying the existence, stability and bifurcation of multiple endemic equilibria in high dimensional phase spaces. We prove that the model can also undergo transcritical bifurcation, saddle-node bifurcation, pitchfork bifurcation, and Hopf bifurcation. The bifurcation diagram and epidemiological interpretations are given. We conclude that when the islet reaches a critical size, the transmission cycle of *schistosomiasis japonica* between the wild rat *Rattus norvegicus* and the intermediate host snail *Oncomelania hupensis* could be established, which serves as a possible source of schistosomiasis transmission along the Yangtze River.

Hopf Bifurcations in Models with Chemotaxis or Advection

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In an evolution model, a constant equilibrium is often stable if the perturbation is also constant one, hence it is dynamically stable with respect to an ODE dynamics. More realistic models often include the effect of spatial dispersal. In classical Turing reaction-diffusion model, an instability is caused by diffusion with different diffusion coefficients, and it generates non-constant equilibria via bifurcation. In a model with attractive and repulsive chemotaxis, and another model with advection, we show that instability of a constant equilibrium can be caused by advection or chemotaxis. In both cases, Hopf bifurcations occur so oscillatory states emerge as the result of instability.

Spread of Viral Infection of Immobilized Bacteria

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A reaction diffusion system with a distributed time delay is proposed for virus spread on bacteria immobilized on an agar-coated plate. A distributed delay explicitly accounts for a virus latent period of

variable duration. The model allows the number of virus progeny released when an infected cell lyses to depend on the duration of the latent period. A unique spreading speed for virus infection is established and traveling wave solutions are shown to exist. This is joint work with D. Jones and H. Thieme.

Persistence in Structured Populations with Short Reproductive Season

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Persistence results will be presented for discrete semiflows arising from models for populations with infinite dimensional structure. They will be applied to diffusing two-sex populations with short reproductive seasons. A threshold separating persistence from local stability of the extinction equilibrium is provided by the spectral radius of a homogeneous order preserving map that is not additive (joint work with Wen Jin).

The Evolution of Dispersal (Emigration, Movement and Settlement Rules) During Range Expansion

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Individual-based simulation models have provided important insights into how we might expect dispersal to evolve during invasion processes. Here I will highlight some key results and emphasise some key remaining knowledge gaps. As is the case in other theory on dispersal evolution, the focus has been on emigration, the first phase of dispersal. Greater emigration propensity is generally anticipated to evolve during range expansion although this can be reduced under a strong Allee effect or, when there is inter-specific competition, due to trade-offs between dispersal and other life-histories. Dispersal distance is also expected to be selected upwards at expanding fronts relative to that in a core population even when there is substantial increase in dispersal mortality. Very recently, evolutionary models have begun to include greater details in the movement phase and in addition to exhibiting some interesting behaviours, these new approaches offer a promising direction for developing increasingly tactical eco-evolutionary models of invasions that can ultimately be used to inform management.

Post-Harvest Diseases of Apples: From Spore Dispersal to Epidemiology

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Postharvest diseases, especially those caused by fungi, can cause considerable damage to harvested apples in controlled atmosphere storage. Fungicides are used to control the disease, but resistance to fungicides is increasing and there is pressure by consumers and ecologists to reduce reliance on chemical controls. There is some evidence that physical conditions related to orchard management are predictive of postharvest disease incidence, and so the first line of defense against postharvest disease should involve best practices in orchards. In this work, we develop and analyse mathematical models to understand the dispersal of spores in the orchard, the initial infection level of fruit entering storage, and the epidemiology of the disease once the apples are in storage. We focus on conditions in the Okanagan Valley, where summers are dry and fungal spore presence is generally low. This leads to a mathematical problem where we are attempting to quantitatively and deterministically evaluate conditions surrounding rare events, that is, infection of fruit, and the fundamental stochasticity of the problem is crucial (Coauthors: L. Nelson, K.A. Williams, and M. Dutot).

Spatiotemporal Dynamics of Telegraph Reaction-Diffusion Predator-Prey Models

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Reaction-diffusion (RD) equations are commonly used to model the propagation of population. RD systems are described by parabolic partial differential equations (PDE), based on Fickian diffusion, hence arbitrarily large population speeds are involved. To avoid this situation, we introduce the Cattaneo's diffusion in a spatiotemporal models of prey-predator interactions. The resulting model is the so-called telegraph RD model. Numerical simulations on predator-prey models with Holling type II functional response and cross-diffusion show the effects of the relaxation time in the dynamic of population interactions (This is a joint work in collaboration with Eliseo Hernandez-Martinez, Hector Puebla, Teresa Perez-Munoz and Margarita Gonzalez-Brambila).

The Fitness Consequences of Dispersal for a Tropical Palm; the Role of Dispersers, Natural Enemies and Negative Density Dependence

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As the only mobile phase in a plant's life-cycle, seeds are a key stage and the movement of seeds is of crucial importance. Seed dispersal not only determines the area in which plants can recruit but also sets the spatial template for ensuing processes such as predation, competition and mating. Theoretically, therefore seed dispersal, has a direct influence on the population dynamics of plants. It may even be a strong determinant structuring communities and species diversity. In this study, we quantify the fitness consequences of seed dispersal for the palm Attalea butyracea. We investigate how seed movement is structured by competition for dispersers, and how trophic interactions influence seed predation and recruitment. We follow the palm from seed to adult, evaluating how the initial movements of seeds affect the subsequent fate of offspring and - eventually – the population growth rate (coauthors: Helene Muller-Landau, Joe Wright, Annieke Borst, Gemma Rutten, Helen Esser, Jasper Ruifrok and Patrick Jansen).

Multi-dimensional Traveling Waves in Lotka-Volterra Diffusion Systems with Strong Competition

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This talk is concerned with multi-dimensional traveling fronts in Lotka-Volterra competition-diffusion system

$$\frac{\partial}{\partial t}u_1(x,t) = \Delta u_1\,(x,t) + u_1(x,t)[1 - u_1(x,t) - cu_2(x,t)].$$
$$\frac{\partial}{\partial t}u_2(x,t) = d\Delta u_2\,(x,t) + u_2(x,t)[a - u_2(x,t) - bu_1(x,t)]$$

for $x \in R^m, t > 0$. Assume that $0 < 1/c < a < b$. In this case (namely, strong competition case) it is showed that the system admits a monotone one-dimensional traveling front $\Phi(x+\rho t) = (\Phi_1(x + \rho t), \Phi_2(x +\rho t))$ connecting two stable equilibria $E_u = (1, 0)$ and $E_v = (0, a)$, where $\rho \in R$ is the unique wave speed. When $\rho>0$, we establish the existence and stability of two-dimensional V-shaped fronts, three-dimensional pyramidal traveling fronts and conical traveling fronts for any $s > \rho > 0$. We further show that conical traveling fronts locally uniformly converge to the planar traveling front when s tends to ρ. When $\rho= 0$, for any $s\neq 0$ we show that the system admits a cylindrically symmetric traveling front

$\Psi(x, y + st) = (\Psi_1(x,y + st), \Psi_2(x, y + st))$

in R^2 connecting $E_u = (1, 0)$ and $E_v = (0, a)$. Moreover, some important qualitative properties of cylindrically symmetric traveling fronts are showed. Finally, we also show the nonexistence of cylindrically symmetric traveling fronts.

Calculating Basic Reproductive Ratio of a Stage-structured Population System with Periodic Delay

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For *Ixodes scapularis* population, the length of time from one life stage to next varies with climate change and hence is approximately time periodic. Motivated by the physiology of the tick population, we develop a stage-structured tick population growth model in seasonally varying environment, which is a periodic system of delay differential equations with periodic delays. Using the method of spectral analysis to follow the ideas of Bacaer et al. in the time-periodic seasonal model, we define and compute the reproductive ratio of the system incorporated two periodicities: periodicity in model coefficients and periodicity in developmental delay.

Strategic Effects of Mobility in Predator-prey Systems

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In this paper we investigate the dynamics of a predator-prey system with the assumption that both prey and predators use game theory-based strategies to maximize their per capita population growth rates. The predators adjust their strategies in order to catch more prey per unit time, while the prey, on the other hand, adjust their reactions to minimize the chances of being caught. Numerical simulation results indicate that, for some parameter values, the system has chaotic behavior. Our investigation reveals the relation-ship between the game theory-based reactions of prey and predators, and their population changes.

How Do Swimming Bacteria Disperse in Response to Chemical Signals

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Bacteria such as E. coli swim using a run-and-tumble random walk. In the presence of a chemoattractant, the random walk is biased towards higher concentrations of the attractant. This process is called chemotaxis, and is orchestrated by an adaptive signal transduction network inside each cell. At the population level, bacterial chemotaxis has been modeled by the Patlak-Keller-Segel (PKS) type equations since 1970's. Recently, experimental results showed that when E. coli cells swim in a spatially and temporally oscillating attractant field, they form aggregates out of phase with the attractant wave,

which cannot be explained by the PKS equations. This poses the question: what macroscopic equations should one use to describe the spatial-temporal dynamics of bacterial chemotaxis? In this talk, I will start from an individual-based model of bacterial chemotaxis, based on detailed biochemistry of cell signalling and movement, and derive its continuum limits given different signal.

Two-patch Model for the Spread of West Nile Virus

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West Nile virus (WNV) has emerged in recent years in temperate regions of Europe and North America, presenting a threat to public and animal health. A patch model for the spread of West Nile virus between two discrete geographic regions is established to incorporate a mobility process which describes how contact transmission occurs between individuals from the two regions. In the mobility process, we assume that the host birds can migrate between regions, but not the mosquitoes. We define the basic reproduction number R_0. The disease-free equilibrium is globally asymptotically stable if $R_0 < 1$. When $R_0 > 1$, there exists a unique endemic equilibrium if $m_1 + m_2 = 1$, which is asymptotically stable on the biological domain minus the disease-free equilibrium. Using the perturbation theory, we obtain that the model has a unique endemic equilibrium and its stability in the neighborhood of $m_1 + m_2 = 1$. Numerical simulations demonstrate that the disease becomes endemic in both patches when birds move back and forth between the two regions.

Principal Eigenvalues and Basic Reproduction Numbers for Reaction-Diffusion Models

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In this talk, I will report our recent research on the basic reproduction number for reaction-diffusion epidemic models with compartmental structure, and its characterization in terms of the principal eigenvalue of an elliptic eigenvalue problem. Due to the lack of diffusion terms in some equations, the solution maps are not compact. This motivated us to study the existence of the principal eigenvalue for the eigenvalue problem associated with such a linear system of parabolic type, which is different from the standard application of the celebrated Krein-Rutman theorem. Our developed theory also applies to non-epidemic spatial population models under appropriate assumptions. As an illustrative example, we analyze the influence of spatial heterogeneity on disease spread for the rabies model. This talk is based on my joint work with Wendi Wang.

Non-local Dispersal Models for a Population under Global Change

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In this talk, I will introduce some integrodifference equation (IDE) models that are inspired by the impact of climate warming on species ranges. In recent warming years, species across the globe have been observed to shift their geographic ranges pole-ward in latitude or upward in elevation. This phenomenon has inspired us to consider a population whose suitable spatial range for reproduction changes over time. In the simplest case, we allow the population to reproduce only on a homogeneous suitable patch that is shifting, in one direction, at a constant speed. The corresponding model can be thought of as a model with moving Dirichlet boundary conditions. It gains insight, in some sense, from two classic problems in IDE models: the critical patch size problem and the invasion speed problem. Population persistence in this model is profoundly affected by the speed of shift. That is, if the suitable patch shifts too fast, the population may fail to persist. Dispersal (as described by an integral kernel), recruitment rate, and patch size jointly determine the speed a population can keep up with. This model can be reformulated in a more universal form by relaxing the harsh Dirichlet boundary conditions and including spatial heterogeneity in recruitment rate. The reformulated model has an analytically tractable example that allows us to consider more complicated scenarios, such as non-constant speeds of shift.

Modeling of Mosquito Abundance and West Nile Virus Risk Using Weather and Environment Conditions

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In this talk, I will present modeling studies (statistical and dynamical) of mosquito abundance and West Nile virus risk considering weather and environmental conditions. The surveillance, weather and environment data from Region of Peel, Ontario will be used to estimate the parameters in both of the statistical and dynamical models. I will then present the tools and practice in collaboration with Region of Peel and Public Health Agency of Canada on forecasting the mosquito abundance and West Nile risk in the region in the last two years. This is a joint work of LAMPS/CDM team.

The 4th International Conference on Computational and Mathematical Population Dynamics (CMPD4)

May 29 – June 2, 2013
Taiyuan, China

This is the fourth joint meeting of the Conference on Mathematical Population Dynamics (MPD) and the Conference on Deterministic and Stochastic Models for Biological Interactions (DeStoBio), with a 26-year history of international meetings. The previous conferences are: MPD1 (University of Mississippi, USA, 1986); MPD2 (Rutgers University, USA, 1989); MPD3 (University of Pau, France, 1992); MPD4 (Rice University, USA, 1995); MPD5 (Zakopane, Poland, 1998); DeStoBio1 (Sofia, Bulgaria, 1997); DeStoBio2 (West Lafayette, USA, 2000); and the past joint conferences are CMPD1 (Trento, Italy, 2004); CMPD2 (Campinas, Brazil, 2007); CMPD3 (Bordeaux, France, 2010).

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Plenary speakers: Odo Diekmann (Universiteit Utrecht,The Netherland), Zhilan Feng (Purdue University, USA), Hisashi Inaba (University of Tokyo, Japan), Zhen Jin (North University of China, China), Hanna Kokko (Australian National University), Frithjof Lutscher (University of Ottawa, Canada), Pierre Magal (University of Bordueax, France), Sebastian Schreiber (University of California at Davis, USA), Jianhong Wu (York University, Canada)

Conference Website: http://202.99.210.182:2013/Home/Index/1

Chair of the Organizing Committee: Professor Shigui Ruan, Department of Mathematics, University of Miami, Coral Gables, FL 33124, USA. Email: CMPD4_2013@yahoo.com

University of Miami

A private research university with more than 15,000 students from around the world, the University of Miami is a vibrant and diverse academic community focused on teaching and learning, the discovery of new knowledge, and service to the South Florida region and beyond.

Led by President Donna E. Shalala, the University comprises 12 schools and colleges serving undergraduate and graduate students in more than 180 majors and programs. In 2012, U.S. News & World Report ranked UM No. 44 in its "Best Colleges" listings, the fourth year in a row it has been among the top 50, and it continued to be the highest ranked school in Florida. U.S. News also cited several of its programs in "America's Best Graduate Schools."

Established in 1925 during the region's famous real estate boom, UM is a major research university engaged in $360 million in research and sponsored program expenditures a year. While the majority of this work is housed at the Miller School of Medicine, investigators conduct dozens of studies in other areas, including marine science, engineering, education, and psychology.

Department of Mathematics at the University of Miami

The Department of Mathematics has about 25 professors pursuing research and providing instruction in mathematics. We are well-represented in many areas of mathematics and many of the faculty hold federally funded grants.

Research Groups

Algebraic Combinatorics
- Drew Armstrong, Algebraic Combinatorics
- Michelle Wachs, Algebraic Combinatorics

Algebraic Geometry
- Bruno de Oliveira, Algebraic Geometry
- Shulim Kaliman, Complex Analysis and Algebraic Geometry
- Ludmil Katzarkov, Algebraic Geometry, Symplectic Geometry, Mathematics of String Theory
- Maxim Kontsevich, Mathematical Physics, Noncommutative Algebra, Algebraic Geometry

Analysis
- Richard Goodman, Numerical Analysis, Computer Science, Computational Mathematics
- Lev Kapitanski, Nonlinear Evolution Equations, Variational Problems with Topological Constraints, Control of Mechanical Systems, Mathematics of Vision, Mathematical Genetics
- Alan Zame, Analysis, Probability

Differential Geometry
- Ming-Liang Cai, Differential Geometry
- Gregory J. Galloway, Differential Geometry, General Relativity
- Pengzi Miao, Differential Geometry, General Relativity

Dynamical Systems
- Brian Coomes, Differential Equations, Dynamical Systems
- Hüseyin Koçak, Dynamical Systems, Scientific Computing

Mathematical Biology
- Robert Stephen Cantrell, Mathematical Ecology, Nonlinear Analysis and Partial Differential Equations
- Chris Cosner, Partial Differential Equations and Mathematical Biology
- Valerie Hower, Genomics, Discrete Mathematical Biology, Probabilistic and Topological Methods in Data Analysis
- Shigui Ruan, Differential Equations, Applied Mathematics, Mathematical Biology

Probability
- Robert Wen-Shaing Chen, Probability, Statistics, Mathematical Finance
- Ilie Grigorescu, Probability, PDE
- Victor C. Pestien, Probability, Optimization
- Subramanian Ramakrishnan, Probability, Statistics

Representation Theory
- Alexander Dvorsky, Representation Theory, Lie Groups

Topology
- Ken Baker, Low Dimensional Topology
- Marvin Mielke, Algebraic and Categorical Topology
- Nikolai Saveliev, Low Dimensional Topology, Gauge Theory

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