Banff International Research Station

for Mathematical Innovation and Discovery

Emerging Challenges at the Interface of Mathematics, Environmental Science and Spatial Ecology

July 3-8, 2011

MEALS

*Breakfast (Buffet): 7:00 – 9:30 am, Sally Borden Building, Monday – Friday
*Lunch (Buffet): 11:30 am – 1:30 pm, Sally Borden Building, Monday – Friday
*Dinner (Buffet): 5:30 – 7:30 pm, Sally Borden Building, Sunday – Thursday
Coffee Breaks: As per daily schedule, 2nd floor lounge, Corbett Hall
***Please remember to scan your meal card at the host/hostess station in the dining room for each meal.**

MEETING ROOMS

All lectures will be held in Max Bell 159 (Max Bell Building accessible by walkway on 2nd floor of Corbett Hall). LCD projector, overhead projectors and blackboards are available for presentations. *Note that the meeting space designated for BIRS is the lower level of Max Bell, Rooms 155-159. Please respect that all other space has been contracted to other Banff Centre guests, including any Food and Beverages in those areas.*

SCHEDULE

Sunday, July 3

16:00 Check-in begins (Front Desk – Professional Development Centre - open 24 hours)
Lecture rooms available after 16:00 (if desired)
17:30-19:30 Buffet Dinner
20:00 Informal gathering in 2nd floor lounge, Corbett Hall
Beverages and small assortment of snacks are available on a cash honor system.

Monday, July 4 **Theme of the Day: Dispersal**

7:00-8:45 Breakfast
8:45-9:00 Introduction and Welcome by BIRS Station Manager, Max Bell 159
9:00-9:15 Workshop Overview
9:15-10:00 **Chris Cosner**, University of Miami
Models for the Evolution of Conditional Dispersal in Spatially Heterogeneous Environments
10:05-10:50 **Wenxian Shen**, Auburn University
Nonlocal Dispersal in Spatially Periodic Media
10:50-11:00 Coffee Break, 2nd floor lounge, Corbett Hall
11:00-11:30 Discussion
Moderator: **Steve Cantrell**
11:30-12:45 Lunch
13:00-14:00 Guided Tour of The Banff Centre; meet in the 2nd floor lounge, Corbett Hall
14:00-14:15 Group Photo; meet on the front steps of Corbett Hall
14:15-15:20 **Breakout Sessions and Open Collaboration**
15:20-15:30 Coffee Break, 2nd floor lounge, Corbett Hall

15:30-17:30 **Breakout Sessions and Open Collaboration**
17:30-18:30 Dinner
18:45-19:30 **Wei-Ming Ni**, University of Minnesota and East China Normal University
Some Recent Progress in Spatially Inhomogeneous Lotka-Volterra Competition-Diffusion Systems
19:35-20:20 **Vlastimil Krivan,** Czech Academy of Sciences
The Ideal Free Distribution
20:25-20:55 Discussion
Moderator: **Yuan Lou**
21:00-22:00 Social

Tuesday, July 5 Theme of the Day: Impact of Spatial Heterogeneity

7:00-9:00 Breakfast
9:15-10:00 **Robert Holt**, University of Florida
Predation and the Evolutionary Dynamics of Species Ranges
10:05-10:50 **Henri Berestycki**, EHESS-Paris and University of Chicago
Reaction-Diffusion Equations in Heterogeneous Media
10:50-11:00 Coffee Break, 2nd floor lounge, Corbett Hall
11:00-11:30 Discussion
Moderator: **Peter Abrams**
11:30-12:45 Lunch
13:00-15:20 **Breakout Sessions and Open Collaboration**
15:20-15:30 Coffee Break, 2nd floor lounge, Corbett Hall
15:30-17:30 **Breakout Sessions and Open Collaboration**
17:30-18:30 Dinner
18:45-19:30 **Karl Hadeler,** University of Tuebingen and Arizona State University
Coupled Dynamics, Quiescent Phases, and Distributed Sojourn Times
19:35-20:20 **Julian Lopez-Gomez,** Complutense University of Madrid
Biodiversity through High Intensity Competition
20:25-20:55 Discussion
Moderator: **Junping Shi**
21:00-22:00 Social

Wednesday, July 6 Theme of the Day: Invasion and Spread

7:00-9:00 Breakfast
9:00-9:45 **Linda Allen**, Texas Tech University
Spread of Disease from Reservoir to Spillover Populations
9:50-10:35 **Hal Smith**, Arizona State University
Spread of Viruses in a Growing Plaque
10:35-10:45 Coffee Break, 2nd floor lounge, Corbett Hall
10:45-11:30 **Xiao-Qiang Zhao**, Memorial University
Global Dynamics for a Reaction and Diffusion Model for Lyme Disease
11:30-12:00 Discussion
Moderator: **Shigui Ruan**
12:00-13:00 Lunch
13:00-17:30 Hike and Other Recreation
17:30-18:30 Dinner
18:45-19:30 **Sergei Petrovskii**, University of Leicester
A Tale of Two Tails: The Impact of Statistical Structure
19:35-20:20 **Bill Fagan**, University of Maryland
Migration, Nomadism, and Range-Residency: How Landscape Dynamics Link Individual

Movements to Population-Level Patterns
20:25-20:55 Discussion
Moderator: **Salome Martinez**
21:00-22:00 Social

Thursday, July 7 Theme of the Day: Scale, Stochasticity and Determinism

7:00-9:00 Breakfast
9:15-10:00 **Roger Nisbet**, UC Santa Barbara
A Salmon's Perspective on Spatial Ecology
10:05-10:50 **Thomas Hillen**, University of Alberta
Kinetic Models for Movement in Oriented Habitats and Scaling Limits
10:50-11:00 Coffee Break, 2nd floor lounge, Corbett Hall
11:00-11:30 Discussion
Moderator: **Frithjof Lutscher**
11:30-12:45 Lunch
13:00-15:20 **Breakout Sessions and Open Collaboration**
15:20-15:30 Coffee Break, 2nd floor lounge, Corbett Hall
15:30-17:30 **Breakout Sessions and Open Collaboration**
17:30-18:30 Dinner
18:45-19:30 **Otso Ovaskainen**, University of Helsinki
Environmental Heterogeneity in Continuous-Space Continuous-Time Models
19:35-20:20 **Alan Hastings**, UC Davis
Spatial Population Dynamics and Control of Spatial Populations
20:25-20:55 Discussion
Moderator: **Odo Diekmann**
21:00-22:00 Social

Friday, July 8 Theme of the Day: Real World Applications

7:00-8:45 Breakfast
9:00-9:45 **Don DeAngelis**, USGS and University of Miami
Plant Herbivore Defense: Modeling Optimal Defense Allocation as a Function of Light and Nutrient Availabilities and Intensity of Herbivory
9:50-10:35 **Mark Lewis**, University of Alberta
Analysis of Spatiotemporal Models for Stream Populations
10:40-11:10 Discussion
Moderator: **Jim Powell**

Checkout by 12 noon.

** 5-day workshop participants are welcome to use BIRS facilities (2nd Floor Lounge, Max Bell Meeting Rooms, Reading Room) until 3 pm on Friday, although participants are still required to checkout of the guest rooms by 12 noon. **

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ABSTRACTS

Linda J. S. Allen
Texas Tech University
Spread of Disease from Reservoir to Spillover Populations

Interspecies pathogen transmission is a primary route for emergence of new infectious diseases. Spatial overlap of habitats leads to greater numbers of interspecies encounters which in turn may lead to pathogen transmission in a naïve host or adaptation of the pathogen to create a new reservoir. Deterministic and stochastic patch models for spread of disease among reservoir and spillover populations are used to investigate the dynamics of interspecies pathogen transmission when habitats overlap.

Henri Berestycki
EHESS-Paris and University of Chicago
Reaction-Diffusion Equations in Heterogeneous Media

I will review several recent developments regarding the mathematical theory of reaction-diffusion equations in general non-homogeneous framework. Issues such as non-uniform stationary states, generalized transition waves and what determines the speed of propagation will be discussed. These topics are relevant for ecology modeling in heterogeneous environment.

Chris Cosner
University of Miami
Models for the Evolution of Conditional Dispersal in Spatially Heterogeneous Environments

Mathematical models predict that in environments that are heterogeneous in space but constant in time, there will be selection for slower rates of unconditional dispersal, including specifically random dispersal by diffusion. However, some types of unconditional dispersal may be unavoidable for some organisms, and some organisms may disperse in ways that depend on environmental conditions. In some cases, models predict that certain types of conditional dispersal strategies may be evolutionarily stable within a given class of strategies. For environments that vary in space but not in time those strategies are often the ones that lead to an ideal free distribution of the population using them, provided that such strategies are available within the class of feasible strategies.

Problems in the evolution of dispersal have been addressed from two complementary mathematical viewpoints, namely game theory and mathematical population dynamics. This talk will describe some results and open problems from the viewpoint of spatially explicit models in population dynamics, including reaction-diffusion-advection models and models for nonlocal dispersal. Some of the results and problems are related to the evolutionary stability of dispersal strategies leading to an ideal free distribution and the mechanisms that might allow organisms to realize such strategies.

Donald L. DeAngelis
U. S. Geological Survey and University of Miami
Plant Herbivore Defense: Modeling Optimal Defense Allocation as a Function of Light and Nutrient Availabilities and Intensity of Herbivory

Woody plants allocate their acquired resources, energy (or carbon) and nutrients, to meet their several essential functions. In order to grow and reproduce, plants allocate resources to acquire solar radiation (grow leaf biomass) and to acquire nutrients (grow fine root biomass). Investment in stem wood, beyond what is needed structurally by the foliage and roots, is provided to obtain a competitive advantage through height for capturing light. In addition to the allocation of resources to these essential functions, resources are usually allocated to chemical antiherbivore defense, or other types of defense, such as spines or thickening of leaf surfaces, because herbivory can significantly reduce growth and increase mortality, thereby reducing plant fitness. Optimization of physiological trade-offs between growth and defense has been termed a "central dilemma of plants." However, despite extensive research on chemically mediated plant herbivore interactions over the past three decades, an improved synthesis of plant defenses as a part of plant resource allocation strategies is lacking. Although such a synthesis will ultimately depend upon on empirical examination of patterns of chemical defense over a broad variety of environments, the efficiency of this empirical research can be greatly increased by appropriate use of modeling. The purpose of this study is to interpret theory using a quantitative framework for determining optimization of trade-offs between growth and chemical (or other) defense in terms of phenotypic responses of a plant as a function of spatial and temporal variation, external conditions, including available solar radiation (influenced by the degree of shadiness), external nutrient input, and intensity of herbivory. The model treats plant components and the herbivore compartment as variables. The herbivory is currently assumed to be purely folivory. Three alternative functional responses are used for herbivory, two of which are variations on donor dependent herbivory and one of which is a Lotka-Volterra type interaction. All three are modified to include the negative effects of chemical defenses on the herbivore. In preliminary results, optimal strategies of carbon allocation are found and shown to vary with most changes in environmental conditions. Increased intensity of herbivory led to an increase in the optimal allocation of carbon with increasing intensity of herbivory. Decreases in available limiting nutrient generally led to increasing importance of defense. Increases in shading also led, in one of the models, to increases in defense allocation, though not in the other two. Because the plant defense was only in the foliage, increases in allocation to plant defense were usually accompanied by shifts in carbon allocation from foliage to fine roots, because the effects of herbivory on foliage decreased.

William F. Fagan and Thomas Mueller
University of Maryland
Migration, Nomadism, and Range-Residency: How Landscape Dynamics Link Individual Movements to Population-Level Patterns

To help synthesize existing research, I will outline a unifying conceptual framework that uses spatio-temporal resource dynamics to bridge the gap between individual-level behaviors and population-level spatial distributions. This framework distinguishes among (1) non-oriented movements based on diffusion and kinesis in response to proximate stimuli, (2) oriented movements utilizing perceptual cues, and (3) memory mechanisms that assume prior knowledge of movement targets. Species' use of these mechanisms depends on life-history traits and resource dynamics, which together shape population-level patterns. Static and well-dispersed resources should facilitate sedentary ranges, whereas resources with predictable spatial distributions but seasonal variation should generate migratory patterns. A third pattern, 'nomadism', should emerge when resource distributions are unpredictable in both space and time. Extensive empirical datasets detailing animal movements, remote sensing imagery time series, and a variety of mathematical models will all be used to demonstrate the connections among individual movements, landscape dynamics, and population-level patterns.

K.P. Hadeler
University of Tuebingen and Arizona State University
Coupled Dynamics, Quiescent Phases, and Distributed Sojourn Times

Heterogeneity enters dynamical models in different ways. For example, consider a population distributed in space that evolves in time. The whole population can be subject to temporal (e.g. seasonal) changes of the habitat, individuals can move in a heterogeneous habitat, or individuals can switch between phases that may be connected to differential properties of the habitat. These different views of what happens to individuals lead to models that may appear similar but which may greatly differ with respect to stability of stationary states, properties of periodic orbits, and traveling waves. Phases of quiescence (resting phases) or reduced activity provide illuminating examples. In our most recent research (with Frithjof Lutscher) we replace exponentially distributed sojourn times (the usual Poisson assumption) by general distributions that lead to novel types of delay differential (diffusion) equations.

Alan Hastings
University of California, Davis
Spatial Population Dynamics and Control of Spatial Populations

I will discuss two related issues in spatial ecology. I will consider the dynamics of spatial spread when all appropriate sources of stochasticity are included. This work shows that calculations from typical deterministic models can be very misleading. A key issue is that in natural systems we have only a single realization of a stochastic process. I will then consider how to optimally control the spread of invasive species, using the case of Spartina alterniflora as an example. This work shows the difficulties of drawing on rules of thumb to determine control strategies.

Thomas Hillen and Kevin J. Painter
University of Alberta
Kinetic Models for Movement in Oriented Habitats and Scaling Limits

Kinetic models for movement in oriented habitats are a useful tool if the environment shows some distinct directional features, such as roads, rivers, seismic lines, or row-plantations. Historically, kinetic models were considered for diluted gases (Boltzmann equations), and various scaling limits were developed. In my talk I plan to review the three most common scaling methods (i) parabolic scaling, (ii) hyperbolic scaling, and (iii) moment closure, in the ecological context. I will show how these scalings are related and I will discuss in which case which scaling is more appropriate. I will illustrate the theory on examples of movement in habitats with linear features, on attraction to a food source, and on life in a stream.

Robert D. Holt
University of Florida
Predation and the Evolutionary Dynamics of Species Ranges

Gene flow that hampers local adaptation can constrain species distributions and slow down invasions. Predation as an ecological factor mainly limits prey species ranges, but a richer array of possibilities arise once one accounts for how predation alters the interplay of gene flow and selection. In this talk, I will extend previous single species theory on the interplay of demography, gene flow, and selection, by investigating how predation modifies the coupled demographic-evolutionary dynamics of the range and habitat use of a prey species. I first consider a model for two discrete and heterogeneous patches, coupled by movement, and then a complementary model for species distributed along continuous environmental gradients. The latter involves an extension of familiar reaction-diffusion models, stemming back to Skellam. I show that predation can strongly influence the evolutionary stability of prey habitat specialization and range limits. Predators can permit prey to expand in habitat use or geographical ranges, or conversely cause range collapses. Transient increases in predation can induce shifts in prey ranges that persist even if the predator itself later goes extinct. Whether a predator tightens or loosens evolutionary constraints on the invasion speed and ultimate size of the range of its prey depends on the predator effectiveness, its mobility relative to its prey, and the prey's intraspecific density dependence, as well as the magnitude of environmental heterogeneity. These results potentially provide a novel explanation for lags and reversals in species invasions.

Vlastimil Krivan
Czech Academy of Sciences
The Ideal Free Distribution

The IFD is a game theoretical model that describes a theoretical distribution of a population in a patchy environment consisting of habitat or foraging patches. Under the IFD, payoff in all occupied patches is the same and individuals cannot increase their fitness by changing their strategy. Thus, the IFD is a Nash equilibrium of the underlying habitat selection game. Originally, this concept was defined for a single population that does not undergo population dynamics. In my talk I will discuss some extensions of his concept to situations with more interacting populations (e.g., two competing species), and with populations that undergo population dynamics. I will show that distributional models based on the IFD when combined with population dynamics can lead to new insights on the effect of adaptive animal behaviors on their population dynamics. Some of these simple models that combine population dynamics with distributional dynamics can be analyzed provided we assume time scale separation. In my talk I will focus on the situation where behavioral (distributional) dynamics operate on fast time scale when compared with population dynamics. The resulting models lead to piece-wise continuous differential equations that, in the case of two or three interacting species, are often analyzable.

Mark Lewis
University of Alberta
Analysis of Spatiotemporal Models for Stream Populations

Water resources worldwide require management to meet industrial, agricultural, and urban consumption needs. Management actions change the natural flow regime, which impacts the river ecosystem. 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 dynamics. We present a mathematical framework, based on the net reproductive rate R_0 for advection-diffusion-reaction equations and on related measures. We apply the measures to populations in rivers under various flow regimes. This work lays the groundwork for connecting R_0 to more complex models of spatially structured and interacting populations, as well as more detailed habitat and hydrological data. This is achieved through explicit numerical simulation of two dimensional depth-averaged models for river population dynamics.

This talk is is based on recent collaborative work with Frank Hilker, Jon Jacobsen, Yu Jin, Hannah McKenzie, and Peter Steffler as well as earlier collaborative work with Frithjof Lutscher, Ed McCauley, and Roger Nisbet.

Julian Lopez-Gomez
Complutense University of Madrid
Biodiversity through High Intensity Competition

Classical non-spatial competing species models, as introduced by A. J. Lotka and V. Volterra, predict extinction of some of the species when the level of the aggressions between antagonists is sufficiently large. As a byproduct, in non-spatial models the principle of competitive exclusion plays a significant role in describing the dynamics. Rather strikingly, even in the simplest cases when the species disperse through random transport, the spatial heterogeneities might explain the Earth biodiversity through the existence of refuge patches for some of the competing species, where they can segregate when the intensity of the aggression from the antagonists increases. If the refuge patches can support each of the species in the absence of competitors, some further adaptation mechanisms to the inherent territorial specificities might explain the extraordinary biodiversity of Gaia; possibly enhanced by some additional, eventually hidden, facilitative mechanisms between the species which might increment, even dramatically, the productivity and stability of the ecosystem, as it seemingly occurs in the tropical habitats. The importance of mathematical models in designing stable and productive ecosystems will become apparent when scientists can predict, by simply analyzing a prototype model, some hidden unexpected relevant phenomenology, like it was the prediction of the curvature of the light in Physics, by A. Einstein, one century ago. Here relies the great power of mathematics in dealing with real world problems. Besides estimating the relevant parameters of the models, mathematics provides with very simple toys to think about and order the available information in a rather systematic way.

Wei-Ming Ni
University of Minnesota and East China Normal University
Some Recent Progress in Spatially Inhomogeneous Lotka-Volterra Competition-Diffusion Systems

In recent years, lots of extremely interesting research in understanding the interaction among diffusion, directed movements and spatial heterogeneity have been done. In this talk I wish to report some of the recent progress in this direction.

Roger M Nisbet
University of California Santa Barbara
A Salmon's Perspective on Spatial Ecology

The dynamics of a population are determined by the interactions of individual organisms with their "environment". However, different spatial characteristics of the environment are important at each life stage. I shall illustrate this by considering the *full life cycle* (egg/embryo, juvenile adult) of Pacific salmon. Eggs mature in gravel in upland streams, young fish grow in stream and river habitat before migrating to the ocean, and returning fish migrate upstream and spawn. Key physiological rates in *all* life stages can be described by a Dynamic Energy Budget (DEB) model that relates growth, development and reproduction to the fish's environment. The model's qualitative predictions have been tested for five species: pink, chum, sockeye, coho and chinook. Practical application of the model to any particular salmon population requires considering processes at many spatial scales. Embryonic development and survival is influenced by spatial heterogeneity at the scale of 10-2m. Growth of young fish is influenced by the flow mediated dispersal of benthic macro-invertebrates that comprise their major food; food supply in upland streams will vary over 1-10m. Migrating juveniles face challenges of high temperatures and low water quality on a scale of 1-100km. Returning adults do not feed but face energetic challenges in upstream migration with large spatial heterogeneity in currents. I shall review how each is treated when working with the DEB model, and end with some general remarks on integrating multi-scale spatial and physiological heterogeneity into population models.

Otso Ovaskainen
University of Helsinki
Environmental Heterogeneity in Continuous-Space Continuous-Time Models

I discuss models of animal movement, population dynamics and evolutionary dynamics, focusing on the interplay between environmental heterogeneity and a biological process. I consider both theoretical approaches examining the link between the underlying assumptions and the emerging patterns, and statistical approaches aimed at interpreting data. I first discuss how mark-recapture data (e.g. on butterfly movements) can be fitted to diffusion-advection-reaction models. Here environmental heterogeneity is modeled either through a discrete set of habitat types (with habitat selection at boundaries) or through continuously varying habitat quality. Inclusion of linear elements (such as movement corridors or barriers) leads to a mixture of two- and one-dimensional diffusions. I then discuss how diverse ecological and evolutionary phenomena can be modeled by spatio-temporal point processes. In this framework environmental heterogeneity is modeled e.g. through a smoothed point field, allowing one to control parameters such as patch size, patch quality, and patch turnover rate. The spatial and stochastic individual-based models can be analyzed mathematically by constructing a perturbation expansion around the mean-field obtained at the limit of global interactions. As an example I discuss how the evolution of dispersal distance depends on landscape structure, life-history parameters and the approach taken to model evolutionary dynamics (adaptive dynamics vs. mutation-selection-drift balance).

Sergei Petrovskii
University of Leicester
A Tale of Two Tails: The Impact of Statistical Structure

The rate of decay in the population density at large distances from the species' main range has been an issue of controversy, a subject of heated debate and a focus of intensive research for at least two decades. The traditional random walk/diffusion-based theoretical framework that predicts a thin Gaussian tail was eventually opposed by 'superdiffusion' theories resulting in a fat tail with either exponential or even a slower power law rate of decay. Indeed, field data often show a decay rate slower than Gaussian. This issue is apparently very important for understanding invasion rates as a fatter tail normally results in a faster spread of the invading species. Here we show that the thin tail is, in fact, an artifact of an over-simplified description of the dispersing population and not an immanent property of the random walk diffusion. Specifically, we show that a fat-tailed dispersal curve arises naturally in a population of non-identical individuals, i.e. in a population with some inherent statistical structure. Therefore, contrary to a widely spread opinion, a thick dispersal tail is not necessarily a fingerprint of Levy flights or superdiffusion. A good understanding of population dispersal and biological invasions is hardly possible without knowing what happens on the microscale of the individual movement. Correspondingly, we then proceed to the analysis of animal's individual paths. Movement paths are characterized by the duration of bouts of continuous movements. Studies on different species have revealed that the distribution of bout durations often has a fat tail well described by a power law. The relation between this pattern and the underlying processes remains poorly understood though. Basing on the concept of 'statistically structured population' introduced in the first part of the talk, here we formulate an approach that allows us to describe data on bout duration within a unified framework and show that a truncated fat-tail in the bout distribution of animal movement is an immediate consequence of the inherent statistical variation of individual traits.

Wenxian Shen
Auburn University
Nonlocal Dispersal in Spatially Periodic Media

The current talk is concerned with two separate, but related dynamical aspects associated to nonlocal dispersals in spatially periodic media, that is, the principal eigenvalue of spatially periodic nonlocal dispersal operators and the spatial spread and front propagation dynamics of monostable equations with nonlocal dispersal in spatially periodic habitats. First, a principal eigenvalue theory for nonlocal dispersal operators with space periodic dependence is developed, which plays an important role in the study of spatial spread and front propagation of spatially periodic nonlocal monostable equations and is also of independent interest. It is seen that a nonlocal dispersal operator with space periodic dependence has a principal eigenvalue for following cases: the nonlocal dispersal is nearly local; the periodic dependence is nearly globally homogeneous or it is nearly homogeneous in a region where it is most conducive to the growth of the solutions of the associated evolution equation. It is also seen that in general, a nonlocal dispersal operator may not have a principal eigenvalue, which reveals some essential difference between nonlocal and random dispersal operators. Second, by applying the principal eigenvalue theory mentioned above, it establishes some general theory about spatial spreading speeds and traveling wave solutions of spatially periodic nonlocal monostable equations, including the existence of spatial spreading speeds and the existence, uniqueness, and stability of traveling wave solutions in any given direction with speed greater than the spreading speed in that direction. It is seen that the spatial spreading feature is generic for nonlocal monostable equations in the sense that the existence of spatial spreading speeds is independent of the existence of principal eigenvalue of the linearized nonlocal dispersal operator at the trivial solution. It is also seen that the spatial variation of the underline medium speeds up the spatial spread. The talk will also present some ongoing research on nonlocal monostable equations in locally spatially inhomogeneous habitats.

Hal Smith, Don Jones, Horst Thieme, Gergely Rost
Arizona State University
Spread of Viruses in a Growing Plaque

A reaction diffusion system with time delay is proposed for virus spread on bacteria immobilized on agar-coated plate. The delay explicitly accounts for a virus latent period of fixed duration. The focus is on the speed of spread of the plaque and on the existence of traveling wave solutions of the model equations, which represent a spreading plaque. We give a rigorous proof of upper and lower spreading speeds associated with the system and provide a proof of the existence of traveling wave solutions. Our spreading speeds give better quantitative agreement with experimental results than earlier, non-rigorous, results.

Xiaoqiang Zhao
Memorial University
Global Dynamics of a Reaction and Diffusion Model for Lyme Disease

In this talk, I will report our recent research on a reaction and diffusion model for Lyme disease. In the case of a bounded spatial habitat, we obtain the global stability of either disease-free or endemic steady state in terms of the basic reproduction number R_0. In the case of a unbounded spatial habitat, we establish the existence of the spreading speed of the disease and its coincidence with the minimal wave speed for traveling fronts. Our analytic results show that R_0 is a threshold value for the global dynamics and that the spreading speed is linearly determinate.