Ecology Transition Workshop
May 4-6, 2015

SPEAKER TITLES/ABSTRACTS

Bijan Seyednasrollah
Duke University

"Applications of Joint Species Distribution Modeling with Case Studies"

Independent species distribution models have been frequently employed in ecology to predict community dynamics in response to climate change. However, co-occurrence and competition between species have usually been ignored. In this study, we utilized a Unified Joint Species Distribution Model (UJSDM) to estimate the distribution of common tree species and their patterns of co-existence across a large mountain climate gradient in the Pacific Northwest. We used three different data types including presence/absence, basal area and stem counts as well as an extensive geo-environmental field data to predict distributions of these species across Mount Rainier National Park, WA. The data was originally collected to develop an old-growth forest community classification for Mt. Rainier between1976 to 1980, and additional sites were later surveyed in 1993 to develop a remote-sensing based land-cover classification. We use both datasets to inform our joint models. This study helps us understand which combinations of climatic variables best describe species distributions and how plot-scale topographic characteristics interact with these factors in contributing to species distributions. Preliminary analysis showed that the three different models (data types) suggest slightly different results, however the abundance models express a stronger consistency with each other than with the presence/absence model. Larger scale climatic factors as well as local topographic factors strongly influenced species distributions, suggesting local site factors can influence species composition. Once taking into account climate, negative covariances between species emerged, suggesting competitive interactions may be common and need to be taken into account to accurately model species distributions. The results will considerably increase our insight into the factors influencing forest composition across climate space as well as the taxonomic and spatial distribution of residual correlations in abundance between species.

Edward Boone
Virginia Commonwealth University

"Data Assimilation using Bayesian Methods for Traditional Ecological Models"

Ecologists are very interested in making inferences from data collected during field studies. As they study more and more complex systems they would like to be able to use more appropriate and complex models. Mathematicians have been studying complex systems such as the Lotka-Volterra for both competition and predator-prey dynamics. Bringing together data with these deterministic models has unexpected challenges. In this talk we present an overview of these models and using Bayesian estimation techniques for data assimilation. The motivating dataset and system arises from the LTER site in Mo'orea.

Louis Gross
University of Tennessee

"Educating Ecologists about Statistics"

SAMSI and NIMBios co-sponsored with the SEEDS program of the Ecological Society of America a Graduate Workshop on Statistics in Ecological Research. I will report on the need that led to this Workshop, some background information on education in quantitative methods for biologists and a preliminary evaluation of the Workshop.

Ephraim Hanks
Pennsylvania State University

"Movement Models for Space use and Contact Networks in Social Insect Colonies"

Contact networks are an important tool in the study of the spread of infectious disease. Most often, observed contact networks are modeled using semiparametric network models such as ERGMs. In contrast, we propose parametric (or semiparametric) modeling of the underlying movement patterns that give rise to contact networks. We take an ant colony as an example, and show that individual-based models for animal movement can capture space use within the nest with high accuracy, but that models that do not account for between-animal interactions or synchronicity in movement do not accurately represent the observed contact network. This highlights the need for increased emphasis on movement models with group interactions.

Leah Johnson
University of South Florida

"How Hot is Malaria? - open challenges in evaluating the impact of climate on the transmission of vector-borne disease"

Malaria is a vector borne disease that is an major source of illness and mortality in humans, especially in developing countries. The dynamics of malaria are greatly influenced by extrinsic environmental factors, such as temperature and rainfall. Much research has gone into improving out understanding of how the dynamics of malaria depend on these environmental factors, and how this translates to spatiotemporal distributions of disease. Here I discuss a process-based model that explicitly links vector and parasite thermal biology to transmission. This model uses laboratory data to understand at which temperatures transmission will be prevented vs promoted. We can use this model to make predictions of the spatial areas with suitable temperatures for transmission now and as climate changes. However, there is uncertainty in the relationship between temperature and transmission as the laboratory data are often limited. I use a Bayesian approach to explore the uncertainty and sensitivity of the prevention and promotion of transmission to mosquito and parasite traits. By better understanding all of the sources of uncertainty, we can prioritize laboratory studies more efficiently and design effective intervention strategies.

Kimberly Kaufeld
SAMSI

"Network Models in Ecology: An overview"

Network models are used to explore and describe the effects of a network structure on properties such as ecosystem stability. Network analysis is an interdisciplinary approach to modeling the modular units (genes, species, ecosystem components) through their connectivity. Diverse areas in ecology use network models, including dispersal, habitat connectivity, landscape genetics, food webs, and streams and rivers. We provide an overview of common network models in ecology linking them through network topology and describing their basic properties and objectives.

Christof Meile
University of Georgia

"Tiny but Mighty: Microbes in Biogeochemical Models"

Many environmentally relevant problems require insight into how chemical substances are moved around and transformed, and how a system responds to perturbations. With microbes being crucial in elemental cycling at the Earth surface, this often necessitates the description of their activity in mathematical models.

Using examples from the marine environment and reactive transport modeling of porous media, I will discuss approaches to model microbially-driven biogeochemical dynamics, touch on the associated challenges of scale and complexity, and highlight potentially fruitful areas for collaborations between geoscientists and applied mathematicians.

Laura Miller
University of North Carolina

"Fluid Physics of Long Distance Dispersal"

While numerous studies have considered dispersal mechanisms and modeling in specific taxonomic groups and ecosystems, there remains little understanding of their unifying physical principles. Furthermore, the trade-off between simplifying assumptions and robustness of the mathematical models and associated data used to develop them has been given limited consideration. The broad goal of this working group is to address this limitation by linking long distance dispersal across air- and water-dwelling organisms and pathogens to their shared mechanical and mathematical frameworks. We are working towards making these mathematical connections that include fluid dynamics, stochastic processes, dispersal kernels, dynamical networks, and Bayesian approaches to model development and parameterization. Future challenges in understanding long distance dispersal influenced by fluid physics include: (i) modeling techniques to connect dynamics at various spatial and temporal scales; (ii) data collection protocols and data accessibility; (iii) dynamic networks and network parameterization; and (iv) code generation that is well-documented and generally applicable.

Brian Reich
North Carolina State University

"Data Fusion for Ecological Studies"

Ecological surveys used to construct species distribution maps are typically expensive to collect and have many sources of error including imperfect detection. Therefore, combining multiple surveys in a joint analysis is potentially quite valuable. Of particular interest is combining data collected by a formal survey with citizen-science data. These two data sources complement each other; survey data are sparse but reliable, whereas citizen science data are abundant but may be biased. Combining surveys requires careful modeling because different surveys many have different biases and errors. Our group will present a literature review of this area, some initial results of Bayesian hierarchical modelling of these data, and plans for future work.

James Russell
Pennsylvania State University

"Dynamic Models of Animal Movement with Spatial Point Process Interactions"

When analyzing animal movement, it is important to account for interactions between individuals. However, statistical models for incorporating interaction behavior in movement models are limited. We propose an approach that models dependent movement by augmenting a dynamic marginal movement model with a spatial point process interaction function. The model is flexible, as different movement models and interaction functions can be selected according to species behavior. Inference for model parameters is complicated by intractable normalizing constants. We develop a double Metropolis-Hastings algorithm to perform Bayesian inference. We illustrate our approach through the analysis of movement tracks of guppies (Poecilia reticulata).

Arvind Santhanakrishnan
Oklahoma State University

"Wing-Wing Interaction in Tiny Insect Flight"

Though hard to notice even when they hop, walk, or fly, the smallest flying insects reported in the literature have body lengths less than 1 mm and are of considerable ecological and agricultural importance. Examples of these insects include thrips and parasitoid wasps. These insects serve important ecological roles such as transmitting pollen during feeding, invasive pests of agriculturally important plants, and biological vectors of microbial plant pathogens. In contrast to the aerodynamics of flapping flight in insects ranging from the scale of the hawk moth down to the scale of the fruit fly, the aerodynamics of flight in these small flying insects remains relatively unexplored. Understanding single insect aerodynamics is imperative for the development of mathematical models of their collective dispersal. The aerodynamics of flapping flight for the smallest insects such as thrips is often characterized by a 'clap and fling' wing-wing interaction, where the wings clap at the end of the upstroke and fling apart at the beginning of the downstroke. Furthermore, these insects have been observed to use bristled wings as opposed to rigid wings. Given the challenges associated with acquiring real-time recordings of freely flying tiny insects at length scales of under a millimeter while resolving fast wing beats on the order of 100 Hz, we use experiments on dynamically scaled physical models and 2D numerical simulations for investigation. In this talk, I will discuss the importance of bristled wing morphology and wing-wing interaction in the aerodynamics of tiny insect flight.

Henry Scharf
Colorado State University

"Spatio-temporal Models for Animal Social Structure"

Network modeling techniques provide a means for quantifying social characteristics of populations of animals. However, data used to estimate the social associativity within a group are typically in the form of counts of interactions between individuals based on ad hoc thresholds of physical proximity. In most applications, collecting these data is expensive, time consuming, and potentially invasive. Telemetry data offer an alternative way of estimating the pairwise associativity among individuals in a group. We investigate a Bayesian hierarchical model for animal movement for which attraction to group centroids is a primary driver. We find this model has good sensitivity and specificity with regard to it's ability to estimate the latent network in simulated movement data.

Daniel Taylor-Rodriguez
SAMSI

"Dimension Reduction for Joint Species Distribution Modeling"

In Joint Species Distribution Modeling (JSDM) a key issue emerges. This is the need to accommodate a large number of species (>1,000), which entails modeling joint dependence over this many species. In this setting, an enormous amount of sparsity arises across locations/plots. To take advantage of this fact, we formulate a dimension reduction strategy that makes this problem computationally feasible.

Yuan Zhang
Duke University

"Weak Convergence of a Seasonally Forced Stochastic Epidemic Model"

In this study we extend the results of Kurtz (1970,1971) to show the weak convergence of epidemic processes that include explicit time dependence, specifically where the transmission parameter, $\beta(t)$, carries a time dependency. We first show that when population size goes to infinity, the time inhomogeneous process converges weakly to the solution of the mean-field ODE. Our second result is that, under proper scaling, the central limit type fluctuations converge to a diffusion process.

Wen Zhou
Colorado State University

"Modeling and Analysis of Diurnal Patterns in Maize Leaf with RNA-Sequencing Data"

To study the diurnal patterns of gene expression profiles along maize leaf development, a set of RNA-sequencing experiments were done over 24 hours with samples taken every two hours from four different sections of maize leaves. We explore the diurnal patterns using a semi-parametric method through smoothing splines and a flexible mathematical model. Interesting features of the diurnal patterns are described through geometric properties of the mathematical model. In this talk, we will provide some preliminary results of our analysis.