Mathematical Models in Environmental Sciences
Modèles mathématiques en sciences environnementales
(Org: **Rick Caron** (Windsor))

GUIHONG FAN, York University
The impact of maturation delay of mosquitoes on the transmission of West Nile Virus

We formulate and analyze a seasonal model of a system of delay differential equations for the transmission of West Nile virus between vector mosquitoes and avian hosts that incorporates maturation delay for mosquitoes. Since the maturation time from eggs to adult mosquitoes is sensitive to weather conditions, in particular the temperature, we investigate the impact of the maturation time on transmission dynamics of the virus among mosquitoes and birds. Numerical results of the model show that a combination of the maturation time delay and the vertical transmission of the virus in mosquitoes have an important impact on the abundance of mosquitoes in a region and the number of peaks of the infection.

MARKUS GUENTHER, University of Vienna, Bruenner Str. 71, A-1210 Vienna, Austria
Modeling the diffusion process of a second generation biofuel: an agent-based simulation approach

Second generation biofuels are widely considered to be a promising alternative to non-renewable fossil energy sources. Although these high-quality fuels will not completely replace conventional fuels (e.g., due to the limited availability of biomass), they can contribute to reducing emissions and strengthening a country's energy autonomy. In Austria, a team of researchers at the Vienna University of Technology is developing a biomass-to-liquid process for the production of corresponding biofuels. Once they have succeeded, the market introduction of the novel fuels will require substantial investments.

Here, our agent-based simulation approach comes into play. It aims at gaining a better understanding of potential market diffusion patterns as well as at supporting entrepreneurs in evaluating different targeting, timing, and pricing strategies. While individual consumers are modeled as agents embedded in a geographically dispersed social network through which they exchange information, we have also considered heterogeneous consumer preferences, word-of-mouth effects, and first-hand personal experiences which are particularly relevant for repurchase decisions. In order to derive parameters for the simulation runs we conducted an empirical study on the Austrian market. In our talk, we motivate our approach, provide an overview of the underlying mathematical model, describe its implementation and parameterization, and discuss simulation results for various scenarios.

RYAN LUKEMAN, St. Francis Xavier University
Inferring interaction rules from empirical data of collective motion in animal groups

Collective motion in animal groups has been studied rather extensively with a variety of models, but real data to test model hypotheses is scarce, owing to difficulty in gathering such data. Here, I discuss our empirical study to capture movements of surf scoters (a type of duck), collectively foraging in groups of a few hundred individuals near Vancouver, BC. We are able to reconstruct individual trajectories for each individual duck, giving a temporal dimension to the data that proves useful for comparing to dynamic models. We then test hypotheses for inter-individual interactions against the data to develop an individual-based zonal model that captures both the angular preference and overall spatial distribution of neighbors observed in the surf scoter data.

SEVERIEN NKURUNZIZA, University of Windsor, 401 Sunset Ave., Windsor, ON N9B 3P4
Statistical Modeling and Testing Concerning the Homogeneity of Some Predator-Prey Populations

In this talk, we consider a testing problem concerning the homogeneity between k pairs of the interaction parameters of k deterministic Lotka–Volterra systems of ordinary differential equations (ODEs), that describe the ecological interaction between

k predator-prey populations. To this end, we consider a measurement-type model for which the trajectories of the ODEs are perturbed with k pairs of correlated Ornstein–Uhlenbeck processes. Accordingly, we extend the stochastic model suggested in Froda and Nkuru-nziza (2007) where $k = 1$. Thanks to certain reparametrization properties of the Lotka–Volterra ODEs, we establish a likelihood ratio test. Further, we study the asymptotic properties of this test and highlight its performance through some simulations studies.

MARIO PINEDA-KRCH, University of Alberta
Evolutionary dynamics of eco-physiological traits in bark beetle-host interactions

Bark beetles have devastated vast areas of western North American pine forest, including around 15 million hectares in British Columbia alone. A remarkably intricate suite of ecological interactions between conspecifics and their host trees characterizes the ecology of bark beetles. A key component in understanding outbreak dynamics of bark beetles is to elucidate the role eco-physiological interactions play in the ecological and evolutionary dynamics of the beetle-host populations.

By meshing a series of well-characterized existing models describing different aspects of the bark beetle-host ecology I will present a qualitative process-based composite model describing the eco-physiological intra- and inter-specific beetle-host interactions. By defining a quantitative genetic basis for traits describing the intra- and inter-specific ecological and physiological interactions the ecological model is then extended to an evolutionary model. Finally, the evolutionary dynamics of different suite of traits is explored and the feedback to ecological dynamics is discussed.

JAMES WATMOUGH, University of New Brunswick
Mechanistic models for the spread of forest alien invasive insects

The Asian longhorned beetle, the Brown spruce longhorn beetle and the Emerald ash borer are the three most recent invasive forest insects to arrive on Canada's doorstep. These insects cause extensive and costly damage to Canada's forests, and their management depends on reliable models for the establishment and spread of populations in a region. In this talk I present some recent results from a mechanistic model for spread of the Emerald ash borer-based suspected dependence of dispersal on the distribution of the host trees.

GAIL WOLKOWICZ, McMaster University
Predator-prey models with time delay in the conversion process

The dynamics of the classical predator-prey model and the predator-prey model based in the chemostat are studied and compared to see whether delay in the conversion process can lead to sustained oscillatory behaviour, when no such behaviour is possible when delay is ignored.

JIANHONG WU, York University
Impact of Environmental Changes on Disease Spread: Case study of Avian Influenza

Virulent outbreaks of Highly Pathogenic Avian Influenza since 2005 have raised the question about the roles of migratory and wild birds in this disease's transmission dynamics. Despite increased monitoring, the role of wild waterfowl as the primary source of the highly pathogenic H5N1 has not been clearly established, and the consequence of outbreaks of HPAI among species of wild birds for the local and non-local ecology where migratory species are established has not been quantified.

Understanding the entangled dynamics of migration and the disease dynamics is key to planning of prevention and control strategies for humans, migratory birds and the poultry industry. The impact of environmental changes on the migration patterns of birds and effect of infection of environment by domestic birds on the migratory bird survival can both be significant. This talk will introduce the various factors involved in the spatial spread of H5N1 and present the results of a few dynamical models of seasonal migration linking the local dynamics during migratory stopovers to the larger-scale migratory routes. The effect of repeated epizootic at specific migratory stopovers for Bar-headed geese (Anser indicus) will be discussed as an illustration of the ecological impact of H5N1 outbreaks. Issues relevant to the co-existence and interaction of low and high pathogenic

strains will be addressed, and some challenging problems in the theory of monotone periodic processes and nonlinear dynamical systems described by delay differential equations with periodic coefficients will be presented.

HUAIPING ZHU, York University
Modeling the Population of Culex Pipiens and Culex Restuans Mosquitoes with Weather Conditions

Mosquito abundance is a significant determinant of outbreaks of mosquito-borne diseases, such as West Nile virus. Mosquito populations are sensitive to long term variations in climate and short term variations in weather. In this talk, the short term impact of weather conditions (temperature and precipitation) on Culex pipiens and Culex restuans mosquito density in Peel Region, Ontario, Canada, was investigated using a generalized linear model. The mosquito count in this region had a clear association with temperature and precipitation changes. This study shows that weather conditions can readily predict WNv vector abundance.