Research Statement

My research interests are mainly focused on the effects of spatial heterogeneity on biological systems with particular interests in epidemiology. I study these effects using mathematical models and computer simulations. Most mathematical models previously developed for biological applications have largely ignored spatial components. While these models can be used successfully for certain questions, they are limited in answering many more. Also, an investigation using these simpler models excludes insights into localized areas of concern. For example, if the question being investigated is how best to control a tick-borne disease, non-spatial models offer no insights into the best location for the application of control measures. Whereas with a spatially-explicit model, the location and timing of control can be explored to find the most effective solution. Ecological conservation and restoration studies also benefit from the use of localized controls or inclusion of a fragmented and heterogeneous environment. Mathematical models and computer simulations of biology systems can be extended in a variety of ways to include spatial heterogeneity. Each extension allows the potential for new understanding of the biological questions being asked.

My current postdoctoral position involves a group project investigating optimal control of integro-difference equations. The techniques of optimal control have never been developed for these types of equations prior to this project. The focus of my role is to solve the problem numerically to help verify the analytical solutions we are developing. Once we have established the mathematical justification and verified the numerical results, I will develop tools to help visualize the model outputs, and we will then begin to pursue biological applications for these types of models.

Prior to my current position, I worked as a management consultant providing professional services for Blue Pumpkin software. Blue Pumpkin is a software package for contact center managers. It is based on the modified Erlang equations and queuing theory. My role was to provide feedback for further research and development of the software. In addition, I would travel to the client sites where I would install the software, train the clients and provide advanced consulting and technical support.

As part of my graduate work, I developed a spatially-explicit, patch model for the spread and control of a tick-borne disease. This is a differential equation model with a number of assumptions about tick life history. The motivation for the model was an outbreak of human ehrlichiosis at a retirement golf community in Cumberland County, Tennessee. Human ehrlichiosis is a tick-borne disease caused by *Ehrlichia chaffeensis* and spread by the lone star tick, *Amblyomma americanum*. The results of the model found that location as well as duration were significant factors to consider for controlling spread of a tick-borne disease. I am continuing work to further analyze the results of this model.

Throughout graduate school and as part of my postdoctoral work at the University of Tennessee, I have been a member of a multi-model project called Across Trophic Level System Simulation (ATLSS). ATLSS is part of the Central and Southern Florida Comprehensive Study Review (Restudy) with the goal of aiding plans for major changes to the hydrologic control systems over the next 30 years. My specific role in the ATLSS project is to develop the fish model (ALFISH). ALFISH is a spatially-explicit, age/size structured model and is evaluated over the entire South Florida study area. I was responsible for writing and running the C++ software code for the model and for developing tools to visualize the output such as time series graphs and difference maps. I wrote many reports to summarize the model findings as part of the Restudy and for periodic reviews. We continue to analyze and update both parameters and functional forms to gain better understanding of the fish ecology and generate more accurate model results. To this end, I am working with fish ecologists from the Everglades area using their data to improve the model and developing field studies to gather additional data that could further improve the model.

I have also worked as a postdoctoral fellow on a number of other modeling projects on a variety of subjects. At the University of California, San Francisco, I worked on developing a model to explore the control of HIV by controlling the spread of herpes simplex virus, type 2. Then, I worked at the University of California, Berkeley, modeling and evaluating a data set to determine the influence of hydrology on nutrient dynamics. The data set includes the nutrient concentrations and the hydrologic conductivity for a number of different habitat types along a riparian zone in the Lake Tahoe area.

My future goals for research include further explorations into the impacts of spatial heterogeneity on the spread and control of disease. I would like to continue with my focus on the spread of vector-borne diseases. I have just started exploring the results of my simple model. Many other hypotheses could be tested including adding more habitat types or more complex migration structures. Additionally, the simple model that I used could easily be expanded to include more of the details of the life history of the vector. An improved model would allow for testing of more complex hypotheses. For example, different life stages of ticks are active at different times of the year, and control measures may be more effective for certain life stages. So a model that included this information would allow a more detailed answer to the question of when and where to apply the control measures. Additionally, with the growing concerns about bioterrorist threats, mathematical models need to be developed to help create early warning detections as well as to help explore possible scenarios for response to bioterrorist attacks. Potential funding for this research could come from the Centers for Disease Control, the National Institutes of Health or other health organizations.

I would also like to become involved in restoration and conservation programs similar to the ATLSS project. There is a great need for models to evaluate restoration and conservation plans for almost every ecosystem. Many federal, state and local government agencies are funding restoration and conservation projects across the United States. Whether the system being restored is large or small, mathematical models can provide a mechanism for testing various scenarios prior to implementation.

With any research I work on I would collaborate with field biologists, medical personnel or other experts in the area of investigation. I have successfully collaborated with many other scientists and consultants for every project on which I have worked. The type of research projects I am interested in working on would also provide a many opportunities for student research. The interdisciplinary nature of this type of work creates links between various departments within the university as well as with other universities and scientific agencies.