SIAM Graduate Students Research Day 2024
Time: 3-5 PM, April 9, 2024

**Nathan Holtman**

Applied Mathematics/Economics/Biomathematics

**Title**

A Differential Game Model for Optimal Management of Wolf-Livestock Conflict.

**Abstract**

Since the early 1990s, the reintroduction of gray wolves (Canis lupus) in the Northern Rocky Mountain region has created a discourse between livestock ranchers and wolf conservationists. Wolf predation of livestock is known to increase costs for ranchers, but conservationists maintain the ecological benefits of wolf reintroduction outweigh these adverse costs to ranchers. Given these conflicting objectives, we study the interaction between ranchers and conservationists in a differential game setting to determine an optimal wolf–livestock conflict management policy in the Northern Rocky Mountain region. The use of differential games allows the optimal strategy to take into account (i) the interaction of conservationists and ranchers and (ii) the influence of this interaction on the population of livestock and wolves. To our knowledge, this approach is novel in the study of wolf (and other endangered species) management as other studies do not consider how the give–and–take relationship between ranchers and conservationists influences wolf–livestock conflict management policies.

Utilizing up–to–date data from federal and state agencies, including wolf hunting and predation, and the model is numerically solved. We obtain optimal solutions of the livestock population, wolf population, number of livestock attacked, and number of wolves hunted over time, which closely match the magnitude and trajectories of the data. In particular, we find optimal hunting effort by ranchers consistently increases throughout the differential game while optimal wolf protection measures by conservationists follows a parabolic path by decreasing in the first portion of the game and increasing in the second portion. These results help to provide policy implications to determine an optimal strategy that balances the damages caused by wolf predation of livestock with the environmental benefits of wolves.

**Boluwatife Awoyemi**

Applied Mathematics (Mathematical Biology)

**Title**

Simulation and Latin Hypercube Sampling of Comparable Mixed-Time Models in a Consumer-Resource Relationship.

**Abstract**

Many species have a consumer-resource relationship in which the resource species serve as food to the consumer species, causing death for the resource and growth for the consumer species. This relationship can involve a consumer and a resource like we studied in this work or multiple consumers and a resource. These processes can be continuous (which monitors consumer and resource populations at every time) or discrete (which monitors the populations yearly). Only continuous or discrete models may fail to take on the various workings of the species. Hence, this work combines continuous and discrete approaches in four (4) model formulations that embody linear versus saturating responses to describe consumer-resource interactions. For these models, it is vital to understand what leads to the death of the species, the survival of either, or the coexistence of both. However, identifying and understanding the behaviors possible requires careful analysis and computations due to the approach of the models. We use a numerical approach to create bifurcation-like images that show the possible behaviors these models can exhibit for our parameter space. These are accomplished by testing the models over a wide span of parameters and varying initial conditions using Latin Hypercube Sampling. We identify parameters and initial conditions that produce the persistence of both species in each model, compare the behavior in different regions to existing bifurcation curves within and across models, obtain a better understanding of parameter regions without analytic results, and discuss the biological meaning behind these model formulations and their resulting maps.

**Md Mahmudul Bari Hridoy**

Applied Mathematics

**Title**

Investigating Infectious Disease Dynamics with Seasonal Stochastic Epidemic Models.

**Abstract**

Changes in contacts during the school year or summer months and the effect of temperature or humidity on disease susceptibility are some of the proposed reasons for seasonal occurrence of infectious disease outbreaks. In order to formulate effective strategies for disease prevention and control, it is essential to comprehend the primary factors driving seasonal fluctuations and their interconnected dynamics. We examine how seasonal variation in transmission, recovery, or dispersal rates, their magnitude and seasonal synchrony or asynchrony impact the probability of disease extinction and time to disease extinction in several well-known continuous-time Markov chain (CTMC) SIR, SEIR multipatch, and vector-host epidemic models. An ODE framework which incorporates periodic parameters for transmission, recovery, or dispersal serves as a basis for each stochastic model. The basic reproduction numbers and seasonal reproduction numbers from the ODE and branching process approximations of the CTMC are useful in predicting some of the stochastic behavior of the CTMC epidemic models. In particular, we apply these techniques to estimate a time-periodic probability of disease extinction, or equivalently, the probability of no disease emergence at the initiation of an epidemic. We also test the branching process approximations against simulations of the full CTMC epidemic models. The numerical outcomes show that seasonal variation in transmission, recovery, or dispersal generally increases the probability of disease extinction (reducing disease emergence) and the shape of the seasonal reproduction number provides information about the shape of the periodic probability of disease extinction. However, extrema of seasonal probability of extinction precede those predicted by the instantaneous probability of extinction, a.k.a the "winter is coming" effect. These findings pave the way for the implementation of more effective disease mitigation strategies.