Aims

The course aims to teach the application of ordinary differential equations and difference equations to problems in ecology. It will provide an understanding of the mathematical modelling methods that describe population dynamics, epidemiological processes and evolutionary processes in ecological systems. It will provide training in a wide variety of mathematical techniques which are used to describe ecological systems and provide instruction in the biological interpretation of mathematical results.

Syllabus

Single species population models: Continuous and discrete time model formulations and analysis; exponential growth, self-limited growth, period-doubling bifurcations, chaos; graphical stability analysis and cobweb diagrams; harvesting problems, insect population dynamics, insect outbreak models. (8 lectures)

Multi species population models: Continuous and discrete time model formulations and analysis; nondimensionalisation, linear stability analysis, phase plane methods; Models for interacting species, symbiotic, competitive, predator-prey and host-parasite ecological interactions; Age-structured models. (8 lectures)

Mathematical models of ecological systems: Develop mathematical models from descriptive information of ecological systems; model analysis and biological interpretation of results. (3 lectures)

Epidemiological models: Models of infectious disease; threshold conditions for epidemic outbreaks, the basic reproductive rate of a disease; vaccination strategies to control infection, pulse vaccination strategies. (5 lectures)

Evolution and evolutionary game theory: Modelling the evolution of life history parameters; the evolution of reproduction and carrying capacity, the evolution of infection, trade-offs between parameters; Game theoretical approaches to evolution; 2-strategy games (Hawk-Dove). (6 lectures)

Revision and problem solving: (3 lectures)

Teaching and Assessment

Contact Hours: 3 lectures and 1 tutorial per week
Assessment: 0% by class tests or other continuous assessment
100% by end of course 2-hour exam
Resit Type: none
By the end of the course, students should be able to:

- Give biological interpretations for the terms in ordinary differential equation and discrete time models for ecological systems.
- Provide a biological interpretation of mathematical results.
- Determine steady states and their stability for single species models.
- Use graphical methods to understand the dynamics of single species models.
- Understand the mechanisms which determine species interactions.
- Determine steady states and stability of ecological models consisting of two coupled ODEs or discrete equation.
- Produce phase plane portraits.
- Nondimensionalise mathematical models.
- Write down mathematical models for simple biological situations.
- Understand simple infectious disease models and the concepts of epidemic, endemic and disease-free states.
- Derive $R_0$, the basic reproduction rate for a disease and relate it to vaccination strategies.
- Determine the stability of periodic solutions in the context of pulse vaccination strategies.
- Understand how mutation and invasion can lead to the evolution of life history parameters.
- Understand the concept of a trade-off between parameters and the effect of trade-off shape on evolution.
- Understand the concept of evolutionary game theory and an evolutionarily stable strategy (ESS).
- Determine ESSs in 2-strategy games.