ACE Network Subject Information Guide

MXN423 – Mathematical Modelling in Ecology

Semester 1, 2025

Administration and contact details

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Host institution	Queensland University of Technology
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Subject details

Handbook entry URL	https://qutvirtual4.qut.edu.au/web/qut/unit?unitCode=MXN423&year=2021&studyPeriodCode=SEM-1
Subject homepage URL	See above
Honours student hand-out URL	Not applicable.
Start date:	24/02/2025
End date:	21/06/2025
Contact hours per week:	3 hours per week (1 hour lecture; 2 hours workshop)
Lecture day(s) and time(s):	Tuesdays 0900-1200
Last day to enrol:	21/03/2025
Description of electronic	Electronic access will be via Zoom (for lectures and workshops).

access arrangements for students (for example, WebCT)	Dropbox folders will be used to host lecture materials, workshop sheets, and project information. Lectures and workshops will be recorded, and videos will be circulated.

Subject content

1. Subject content description

This course focuses on the use of models as scientific instruments in understanding, predicting, and managing ecological systems. The content and examinations will include both theoretical aspects (from both a mathematical and ecological perspective), practical tasks (analysis of models, numerical simulations, and statistical comparisons with data), and scientific contribution (publishing peer-reviewed research, collaborating with real-world actors).

During the unit, we will examine major classes of applied ecological models, from among the following:
1. Single species models and multispecies coexistence theory;
2. Spatial population and metapopulation models;
3. Probabilistic models of detection for rare or invasive species;
4. Game-theoretical models of species and human interactions;
5. Sex and age-structured population modelling;
6. Statistical and mechanistic models of biogeography.

Students will learn to create their own mathematical models to address ecological management questions, to analyse these models, and to confront and parameterise them with realistic data. The course will consider mathematical models primarily from an applied perspective. That is, on understanding how these models can help us make good decisions in natural resource management (e.g., fisheries) and conservation (e.g., threatened species management).

The core of the mathematical content is structured around a major project that exemplifies one or more common challenges in mathematical ecology. A goal is for the students to co-author a collaborative scientific research article describing their solution to this challenge, and to submit this article to an international peer-reviewed journal. In doing, the unit will discuss the process of scientific publication, including writing a manuscript, creating figures, writing a cover letter, choosing between journals, the peer-review process, etc. Assessment will therefore be group and project-based.

The unit will rely heavily on numerical analyses, implemented in **Matlab**. Alternative programming languages are acceptable, but will not receive the same level of support (basically, I can't write in R or Python, so I can't debug your code).

2. Week-by-week topic overview

Week	Topics covered *This outline is only a guide to the topics that may be covered. Because the subject will be focused on applying research tools to generate published research, lectures may focus on a particular subset of this syllabus.*
1	Introduction & outline of the course
2-3	Deterministic single- and multi-species models. - Modelling single species populations - Multispecies Lotka-Volterra models - Finding equilibrial ecosystems - Fitting timeseries of abundance data using MCMC
4-5	Stochastic population models; stochastic coexistence mechanisms; Markov chain population models. - Modelling single species populations with SDEs and MC models - Stochastic lottery model of multispecies coexistence
6-7	Control of deterministic populations: eradication through time using calculus of variations and the Pontryagin maximum principle.
8	Control of stochastic populations: optimal fishery harvest using Dynamic Programming. - Optimal escapement model for stochastic fisheries.
9	Conservation planning via constrained combinatorial optimisation.
10	Dynamic conservation planning – spatiotemporal decision-making using Stochastic Dynamic Programming
11	Choosing between peer-reviewed journals. A comparative review of aims and articles from different journals. The fundamentals of individual and journal bibliometrics. Quality assessment procedures in Australian academia and overseas. How to avoid predatory journals.
12	The principles and processes of scientific publishing. Formatting and initial submission of articles; the fundamentals of editoral oversight and peer-review; review, rejection, resubmission, and acceptance.

3. Assumed prerequisite knowledge and capabilities

Linear algebra (ideally 2nd year)
Calculus and ordinary differential equations
Exposure to MATLAB or equivalent (e.g., simple loops, matrix algebra)

4. Learning outcomes and objectives

Students will acquire advanced knowledge and skills in formulating ecological management and conservation problems as mathematical optimisation models, and then calculating optimal and robust solutions to these problems.
There will be a focus on applied problem solving – that is, the use of critical thinking to understand the key elements of an ecological management problem, and to identify which known mathematical techniques will best describe the system dynamics, and best identify good management decisions.
The unit links to studies in applied and computational mathematics previously undertaken in an undergraduate mathematics degree, and to the types of mathematical modelling employed in industry and in academic research.
The unit will focus at all times on how mathematical solutions to ecological management problems can be communicated to a broader audience – specifically via peer-reviewed journal articles. Throughout the unit, the students will frame their research findings as scientific articles that are destined for peer-review. This will involve a strong introduction to the scientific publication process: understanding journal quality, journal aims, IMRAD writing styles, the expectations of collaborative publishing and co-authorship, and the peer-review and editorial process.

AQF specific Program Learning Outcomes and Learning Outcome Descriptors (if available):

AQF Program Learning Outcomes addressed in this subject	Associated AQF Learning Outcome Descriptors for this subject
Insert Program Learning Outcome here	Choose from list below

Learning Outcome Descriptors at AQF Level 8
Knowledge
K1: coherent and advanced knowledge of the underlying principles and concepts in one or more disciplines
K2: knowledge of research principles and methods
Skills
S1: cognitive skills to review, analyse, consolidate and synthesise knowledge to identify and provide solutions to complex problem with intellectual independence
S2: cognitive and technical skills to demonstrate a broad understanding of a body of knowledge and theoretical concepts with advanced understanding in some areas
S3: cognitive skills to exercise critical thinking and judgement in developing new understanding
S4: technical skills to design and use in a research project
S5: communication skills to present clear and coherent exposition of knowledge and ideas to a variety of audiences
Application of Knowledge and Skills

5. Learning resources

The lecture format will be guided analysis of models (analytic and computer simulations), which are taken from the published literature (i.e., peer-reviewed journal articles). Coursework will also involve the analysis of real-world datasets from applied ecology and conservation biology. All lecture content, datasets, computer code, and necessary material will be provided during the unit.

Access to **Matlab** on a personal computer is important for understanding the lecture material, undertaking the assessment.

6. Assessment

Exam/assignment/classwork breakdown					
Exam	**0%**	**Assignment**	**75%**	**Class work**	**25%**
Assignment due dates		**Presentation on literature** **Project work** **Writing assignments**			**25/03/2025** **08/04/2025** **29/04/2025** **13/05/2025** **20/05/2025** **27/05/2025**
Approximate exam date				**Not applicable.**	

Institution honours program details

Weight of subject in total honours assessment at host department	12.5%
Thesis/subject split at host department	37.5% thesis 50% coursework 12.5% research training

Honours grade ranges at host department	
High Distinction	85-100%
Distinction	75-84%
Credit	65-74%
Pass	50-64%

Institution masters program details

Weight of subject in total masters assessment at host department	N/A (pass/fail)
Thesis/subject split at host department	
Masters grade ranges at host department	
High Distinction	85-100%
Distinction	75-84%
Credit	65-74%
Pass	50-64%