BI/EV 557: Population Ecology

Semester

Class Sessions

MWF (2-2:50 PM)

Instructor

Dr. Peter Houk

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Office Location

UOG Marine Lab 102

Office Hours

Tuesday or Thursday Afternoons

Course Objectives

This course provides a quantitative background of the processes and principles associated with population dynamics. Applied modeling techniques (lab that accompanies this course) will be used to help students visualize patterns observed in natural systems, and predict their futures. We will start by examining individual populations without any regulation, and build upon a sequential foundation throughout the semester to understand how processes like density dependence, competition, and predation are essential components of stable population cycles. Eventually, we will integrate and apply these principles towards understanding networks of food webs, and their stability criteria. The course is relevant and generalized for all graduate biology and environmental science students, however, examples are mainly focused on marine ecosystems (my expertise), and coral reefs in particular.

Course Materials

Papers and book chapters will be provided, but three text books are required. Population models will be developed using the freely-available R software platform, however no prior knowledge of R is required.

Stevens, MH (2009) A Primer of Ecology with R. Springer, New York.

Gotelli, NJ (2008) A Primer of Ecology. Sinauer Associtès, Inc. Sunderland, Mass, USA.

Aho, K (2013) Foundational and applied statstics for biologist using R. Electronic appendix: Introduction to R. Taylor and Francis, Florida.

Grading

- Attendance and participation (20%)
- Topic Paper Selection and Presentation (20%)
- Exams (60%)

Course Description and Objectives

Part I - Introduction

Week 1 - Introduction to course, expectations, and background on concept of population ecology as a discipline. Introduction to the concepts that will be developed throughout the course with several examples (hypothetical and from published literature)

Reading/Assignment – Complete two exercises on introduction to the R computing platform. Complete Coupled course readings (Chapter 1 – Gotelli).

Part II – Single-species populations

Week 2 - Density independent growth. Practical uses of these simplistic models as well as limitations. Lab – density independent modeling in R, adding stochastic variation to simplistic models to provide realism in predicting if Guam Rail reintroductions will be successful.

Reading/Assignment – Chapter 1 – Gotelli; Chapter 1 – Stevens.

Week 3 - Density dependent growth. Applications towards fisheries models and other relevant situations. Lab – density dependent modeling in R with both stochastic variation and harvesting. Practical uses of models and limitations.

Reading/Assignment – Chapter 2 – Gotelli; Chapter 3 – Stevens.

Week 4 – Stage-structured populations. Considering the role of recruit, juvenile, adult population stages in contributing to overall population viability. Lab - applying linear algebra to forecast life-history models of the rabbitfish *Siganus spinus* and predict which population stages are most critical for survival.

Reading/Assignment – Chapter 2 – Stevens.

Week 5 – Metapopulation dynamics. Understanding populations across space and time. Lab – Understanding the principles that dictate coral species richness patterns across numerous atolls within Chuuk State, Federated States of Micronesia.

Reading/Assignment – Chapter 4 – Gotelli; Chapter 4 – Stevens.

Week 6 – **1st Midterm Exam, single species population dynamics.**

Part III – Two species interactions (begin in second part of week 6)

Interspecific competition introduction using Lotka-Volterra equations and commonly used variants. Introduction to species traits and their applicability towards population stability. Advanced aspects of interspecific competition. Understanding the link between biologically-defined stability criteria and mathematically defined criteria using examples from coral reef and terrestrial environments. Lab – understanding founding principles that drive species coexistence, and life-history assumptions that are required for coexistence. In doing so, the lab introduces how to solve differential equations in R, and how to simulate future populations under user-defined life-history parameters that emulate empirical data.

Reading/Assignment – Chapter 5 – Gotelli; Chapter 5 – Stevens.

Week 7 – Introduction to allometry (body-size and growth), with relevance to how energy flows through ecosystems. Introduction to some founding concepts of food web theory. Highlight practical uses of allometric relationships for fisheries, metabolic theory, and consistencies that exist across ecosystems. Lab – introduction to Jacobian matrices for evaluating conditions and thresholds for competitive species coexistence.

Reading/Assignment – Peer-reviewed papers, TBD.

Week 8 – Ecological niche and species assembly rules. How might competition and environmental gradients structure species assembly? Review of two paramount theories of species distribution patterns: niche and neutral theories. Examine uses of each, critiques, and eventually, reconciliation.

Reading/Assignment – Peer-reviewed papers, TBD.

Week 9 – Introduction to predator and prey dynamics. Start with classic models of oscillating predator and prey populations, and build upon them to incorporate 'realism' for species rich systems such as coral reefs. Lab – Projecting predator-prey dynamics with both Lotka-Volterra and Rosenzweig-MacArthur models, conceptualizing their differences and the importance of life-history parameters if promoting stability.

Reading/Assignment – Reading/Assignment – Chapter 6 – Gotelli; Chapter 6 – Stevens.

Week 11 – Advances in predator-prey population models for understanding how stable populations originate and persist. Introduction to the paradox of enrichment. Describe how predator-prey interactions form building blocks for understanding ecosystem dynamics. Lab – stability of predator-prey dynamics, and introduction to evaluating thresholds in stability with respect to life-history characteristics.

Reading/Assignment – Research for building your own models, submit outlines.

Part IV – Communities and population assemblages

Week 12 – Measuring and modeling diversity using a variety of common approaches. Review of MacArthur and Wilson Equilibrium Theory of Island Biogeography and its predictions. Build into advanced topics dealing with the distribution of diversity across coral reefs and terrestrial environments, generate useful generalizations and predictions.

Reading/Assignment – Peer-reviewed papers, TBD. Chapter 7 and 9 – Gotelli.

Week 13 – Diversity continued. Disturbances to populations and ecosystems and their impact on diversity. Analytical approaches towards measuring diversity.

Reading/Assignment – Peer-reviewed papers, TBD. Chapter 10 – Stevens.

Week 14 – **Final Exam, cumulative**.

Last topics covered for discussion but not included for exam. Food webs, traditional theory and metrics. Food webs from a connectence and energy-flow perspective. Food web properties, disturbances, human influences, top-down regulation, bottom-up considerations.

Reading/Assignment – Selected chapters from specialized text provided by instructor.

Week 15 - Food webs II. Stability of food webs using simplified models. Discussion of modern papers using food webs and their application.

Reading/Assignment – Work on models and papers.

Week 16 - **Final week, model presentations**.

BI/EV 557L: Population Ecology Lab

Semester

Class Sessions

F (3-4 PM)

Instructor

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Office Location

UOG Marine Lab 102

Office Hours

Tuesday or Thursday Afternoons

Course Objectives

This lab provides the accompanying hand-on experience for the Population Ecology course. Labs will consist of applied modeling techniques to help students visualize patterns observed in natural systems, and predict their futures. We will start by examining individual populations without any regulation, and build upon a sequential foundation throughout the semester to understand how processes like density dependence, competition, and predation are essential components of stable population cycles. The labs will be conducted using R, a freely available software that is extremely useful for statistical analyses and population modeling. No prior experience in R is required. The course is relevant and generalized for graduate biology and environmental science students, however, examples are mainly focused on marine ecosystems (my expertise), and coral reefs in particular.

Course Materials

Papers and book chapters will be provided, but two text books are required. Population models will be developed using the freely-available R software platform, however no prior knowledge of R is required.

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Grading

- Attendance and participation (20%)
- Lab problem sets (30%)
- Midterm (extra credit) and Final Exam (10%) questions
- Final model and presentation (40%)

Course Schedule

Part I. Introduction

Lab #1 Introduction to R and modeling.

Lab#2 Primer to quantitative ecology in R.

Part II. Single-species populations

Lab #3 Density independent growth models and stochastic variation among them.

Lab #4 Density dependent growth models and stochastic variation among them.

Lab #5 Metapopulation models, source-sink dynamics, and stochastic variation among them.

Lab #6 Population stage structures, life-stage contributions towards population stability.

FIRST MIDTERM EXAMINATION (lab question extra credit)

Part III. Two-species interactions

Lab #7 Lotka-Volterra competition models introduction.

Lab #8 Stability and coexistence conditions of two-species interaction models.

Lab #9 Lotka-Volterra predator-prey models introduction.

Lab #10 Rosenzweig-MacArthur predator-prey models, eigenanalyses and stability, linearization of two-species systems.

Part IV. Communities and population assemblages

Lab #11 Develop and share ideas for student derived models with groups.

Lab #12 Discuss progress with model development and supporting peer-reviewed literature.

FINAL EXAMINATION (lab question included)

Part V. Final model development

PRESENTATION OF FINAL MODELS