Theoretical Ecology

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OCN750 ~ Special Topics in Biological Oceanography ~ Spring 2009

Description

A graduate-level introduction to theoretical ecology and population dynamics. A background in biology is not a pre-requisite, but undergraduate mathematics (basic differential equations) is essential.

Justification

Pressing global problems mean that ecology, the interaction of organisms with their environment, is now a fundamental discipline—every scientist should know it. This course will give students an overview of theoretical ecology, including marine and terrestrial systems. It will broaden the horizons of students already working in biology, by introducing them to new quantitative techniques, and it will broaden the horizons of students in other sciences by introducing them to ecological concepts that will help them see their own research in a larger context. This is an opportune time for such a course, because a suitable new review of the subject has just been published (May and McClean 2007). Each chapter of the book was written for non-experts by an expert in that area.

The photo shows farm fish parasitized by sea lice. Sea lice are naturally occurring, and rarely harm fish under natural conditions, but crowding of fish in sea-cage farms creates pathogen culture facilities. Farmers and regulators knew that they had to protect their fish from macropredators such as sharks, but they failed to note that nature has an inexhaustible variety of marine micropredators, from which a cage affords no protection. Basic ecology suggests that keeping a shark or two in the cage, for disease control, might save them money!

The course will provide a methodological overview that would be difficult for a student to obtain without taking most of following the existing courses: ZOOL467 (Ecology of Fishes), ZOOL480 (Animal Evolution), BOT652 (Population Biology), BOT654 (Advances in Plant Ecology), ZOOL620 (Marine Ecology), ZOOL652 (Population Biology), and ZOOL690 (Conservation Biology).

Pre-requisites

Math 302 (Differential Equations) or equivalent such as OCN/GG312.

Format
Three one-hour meetings per week: two lecture meetings and one discussion meeting. Three credits.

Grading
Course can be taken CR/NC, or for grade. This is a survey course, so grades will be based mainly on frequent short assignments that require understanding of terms and concepts rather than difficult mathematical details. However, students who wish to focus on a particular aspect will be given credit for additional work on their focus.

Syllabus
Based on the research monograph *Theoretical Ecology* edited by Robert May and Angela McClean, Oxford University Press (2007). That book will be the textbook for the course, with supplementary readings (see below) and journal articles as needed.

1. Introduction
- Ecological principles
- Application to practical problems

2. How Populations cohere: rules for cooperation
- Kin selection
- Direct reciprocity
- Indirect reciprocity
- Graph selection
- Group selection

3. Single population dynamics
- Growth rate
- Structured populations
- Density dependence
- Chaos
- Randomness
- Density-independent populations
- Density-dependent populations

4. Metapopulations and their spatial dynamics
- Levins metapopulations
- Role of empty habitat
- Eradication threshold
- Source-sink metapopulations
- Two-species Levins metapopulations
- Competing species
- Predator-prey metapopulations
- Mutualism

5. Predator-prey interactions

Behavior and patch dynamics
Population dynamics
Space and noise

6. Plant population dynamics

Example: diatoms with a single limiting resource
Two or more plant species with a single limiting resource
Two or more plant species with two resources
Example: diatoms in systems with multiple limiting resources
Population dynamics of annual vascular plants
Microsite limitation
Density-dependent fecundity resulting from size plasticity
Density-dependent mortality
Modeling density dependence in annual plants
Annual plants with a seed bank
Herbaceous perennials
Biomass mixtures
Trees
Herbivores and plant population dynamics
Herbivory and plant productivity

7. Interspecific competition and multispecies coexistence

Lotka-Volterra models
Resource competition for a single limiting resource
Multiple limiting resources
Non-equilibrium co-existence
Competition/colonization trade-offs
Competition and predation—trophic level trade-offs

8. Diversity and stability in ecological communities

History of stability
Effects of diversity

9. Communities: patterns

Flows of energy and material
Food-web structure
Food-webs as networks
How many species?
Neutral community ecology
Relative abundance of species
Lognormal distributions
Other SRA distributions
Succession
Species-area relations
Scaling laws

10. Dynamics of infectious disease

Microparasite models: the single epidemic
Host vital dynamics
Seasonal forcing
Impact of parasites on host dynamics and population regulation

Heterogeneity and regulation
Macroparasites and host population cycles
Model complexity

11. Fisheries

Basic assessment of single-species fisheries
Managing single-species fisheries
Multispecies fisheries and ecosystem considerations
Economic considerations

12. Green revolutions: ecology and food production

Agroecosystems
Home gardens
Swidden
Ecology and agriculture
Integrated pest management
Integrated nutrient management
Tissue culture
Marker aided selection
Genetic engineering
Participation

13. Conservation biology

Example: The grizzly bear
Population viability analysis
Simple models and confusing data
Building a reserve network
Systematic reserve design
Site-selection algorithms and real-world complexity
Models for land use change
Habitat loss, extinctions and extinction debt
Economic goods and services provided by ecosystems
Models of ecosystem services and land-use change
Habitat conversion and ecosystem change

14. Climate change and conservation

Climate effects on species distributions
Climate change effects in mountainous regions
Past responses as a guide to climate change effects
Evolutionary responses to climate change
Land use and climate change interactions
Autoecological characteristics
Protected areas

15. Unanswered questions and their importance

The growth of human populations
Scale of human impacts
Numbers of species
Extinction rates
Why we should care about extinction rates
Narrowly utilitarian considerations

Broadly utilitarian considerations
Ethical considerations.

Supplementary Reading

Hilborn, R. and M. Mangel (1997). *The Ecological Detective*, Princeton University Press.
Nowak, M. A. (2006). *Evolutionary dynamics*, Harvard University Press.
Turchin, P. (2003). *Complex Population Dynamics*, Princeton University Press.
Hudson et al. (2002). *The Ecology of Wildlife Diseases*, Oxford University Press.