Fundamentals of Ecology
Bi7370
Jeff Nekola

Tuesday 12-13:50; D32-329
http://www.sci.muni.cz/botany/nekola/foe
Autumn 2023

SYLLABUS

The aim of the course is to overview the foundational concepts and ideas underlying the discipline of ecology. Over this semester you will be introduced to most of the major ecological subdisciplines (population ecology and demography; species interactions; community ecology; macroecology). This material will be presented in English through lectures and classroom assignments.

<u>Objectives:</u> (what I want you to take away from this course.)

First and foremost, I want you to be able to think like an ecologist. While I expect you to learn some basic facts, I also realize that unless you decide to follow an ecological career, you will likely forget most of this within a few years. However, if successful, this course should permanently change how you look at biological and ecological problems.

In particular, I expect that by the end of the term you should be able to:

* Appreciate the natural world around you including the great diversity of species and the multiplicity of adaptations from local to global scales;
* Understand population and community dynamics so to be better able to predict the likely impacts of human activity; and
* Understand the interplay between observation and theory critical to the advancement of ecological science so that you can evaluate the validity of published research.

<u>Instructor:</u>

I will be available to answer any of your questions regarding during each week's in-person meeting. I will also always be available to discuss the lecture material with you. Just contact me to set up a meeting.

Office Phone: 549-49-3711
email: nekola@sci.muni.cz

I will be assisted throughout the term by my graduate student, Barbora Winterová. She will be primarily responsible for giving the weekly quizzes and reviewing the answers with you. For those of you who are Czech speakers, she can help answer your questions in Czech IF NECESSARY (remember that learning the content in English is one of the goals of the course). You can contact her at:

email: 423852@mail.muni.cz

<u>Expectations:</u>

I assume that each of you has had the equivalent of a semester course in biology wherein you learned simple Hardy-Weinberg genetics and enough basic botany and zoology to know the major groups of organisms and the terms used for describing them. I will also assume you have a solid background in high school algebra. A semester course in each of chemistry, calculus, and statistics would also be helpful, but if you have not had any or all of these, fear not -- I will teach you what you need to know as we go along.

All lectures have been recorded and are available for streaming. Because the majority of exam material will come from these lectures, watching these videos is essential if you are to do well in this course. While you can binge-watch all of the lectures it really is not a good idea. After two hours the content will stop seeping into your brain. It will work best if you reliably watch both of each week's lectures during the scheduled week.

The text for this course is: Krebs, Charles J. *Ecology: The Experimental Analysis of Distribution and Abundance, 6th Edition*. Pearson. 672 pp. ISBN: 978-0321507433. A digital copy has been made available on the course's IS page.

The specific reading assignments are listed below for each class. Be sure you read the material <u>before</u> viewing each lecture, as I will often lecture on materials not covered in the textbook, but which require understanding of the basic material covered. These readings should be considered only a start; you should be able to find additional readings for topics I bring up in lectures in the textbook index. Use these extra readings when you are studying for exams.

<u>Class Organization:</u>

This course will be taught in a hybrid distance / in-person format: The syllabus, lectures, and supplementary materials are found at http://sci.muni.cz/nekola/foe and are to be accessed remotely. It is your assignment to watch a given weeks lectures BEFORE our weekly in-person meeting. During each weekly in-person meeting Bára will first give an open-book quiz and review the answers with you. I will finish each weekly in-person meeting by answering questions you have from the lectures.

<u>Evaluation:</u>

Course grades will be based on two exams (100 points each): a midterm and a final. These will be done in person and are closed-book / computer: I want to know what information you have retained in your brain. I will combine a variety of question types on the exams. Typically these will include identification / short answer (a few sentences), graph or figure interpretations, and short essays. You might note that it is common for questions to require you to use in new ways the facts, principles, or approaches presented in lecture. To do well on the tests you should not just memorize the content, but should also take time to think about what it means, why it is significant, and how it might be generalized. While each exam must be taken during a single sitting, you will have as much time as needed to complete it.

Retaking of exams are possible for those who fail (e.g. score with <60% of possible points) but will need to be individually rescheduled. An unexcused absence from an examination will result in a score of 0.

In addition up to 30 points will be added to your exam scores based on your participation in the compulsory weekly in-person meetings. These points will be based on: (1) 24 points from the sum of your weekly quiz scores (standardized with 100% correct = 24 points); and (2) 6 points for two assignments that will be presented in Bára's part of our weekly meeting. These are designed to illustrate how well you can apply ideas covered in the class to examples from your life. For each assignment you will create a short presentation (5 minutes) or an online poster. Each will be graded as follows:

- 3 points - the student applied principles taught during the class to a novel example not showed during the class and was able to answer questions from the audience / lecturer
- 2 points - the student applied principles taught during the class to a novel example not showed during the class
- 1 point - the student applied principles taught during the class, but not in a novel way, or applied them incorrectly,

I will award you the next highest grade at the end of the class if you: (1) significantly improve your score from Exam 1 to Exam 2, and (2) are within 2 percentage points of the next grade break.

<u>Lecture Organization:</u>

One of the challenges of ecology is that everything is interrelated. As a consequence, there is no "correct" or "natural" order in which to present the material. I have chosen to present the material based on levels of organization and complexity. We will start with population dynamics of single species (Section 1). We will then relax the assumption of one species and discuss the interactions of populations of different species (Section 2). We next move on to the dynamics of natural species assemblages – aka "communities" (Section 3). Finally, we examine macroecological pattern and process (Section 4). You will note that this ordering differs from that of the Krebs textbook.

<u>Lecture Outline:</u>

Date (and my goals for each class) — Topic — Readings

September 19: Course Introduction

Visit the course website and watch Course Introduction video to find out about class schedule and expectations.

History of ecology — Chapter 1

(How the term 'ecology' has changed over time, as well as the cultures in which it is embedded. Definition of ecological subdisciplines.)

1. POPULATION DYNAMICS

Population Growth Models — Chapter 9

(Understand how and why geometric, exponential and logistic growth models are used to predict changes in population size. Know the assumptions behind these models and how they can be expanded by relaxing the assumptions. Understand why absolute prediction of future population size is impossible for some organisms.)

September 26:

Life Tables — Chapter 8

(Know the difference between latitudinal and longitudinal demographic data. Be able to construct a life table, calculate age-specific life expectancies and estimate a population's doubling time. Know how to construct population pyramid diagrams and be able to use them to interpret events which have influenced population structure and be able to roughly predict its future trajectory.)

Regulation of individual size **Chapter 15**

(Know three major groups of mortality curves. Understand the difference between species expressing determinant vs. indeterminate adult body size. Define how population biomass is controlled for species with indeterminate growth using the law of constant final yield, and use thinning laws to predict maximum body size of these organisms over time. Understand how mathematical concepts such as dimensional and/or metabolic scaling provide an explanation for these patterns.)

October 3:

Fertility Tables **Chapter 8**

(Know the data needed to construct a fertility table, and how to calculate mean generation time, intrinsic rate of increase and net reproductive rate from such a table. Learn how to calculate half-life for shrinking populations and how to estimate the intrinsic rate of change using either life table or fertility table data. Consider why these estimates often differ.)

Life history traits **Chapters 8, 10**

(Understand the necessity of tradeoffs in the evolution of life history traits. Explain the relative advantages of semelparous vs. itreroparous reproduction though a consideration of Cole's Paradox. Overview the concepts of *r* and *K* selection, and the major traits associated with each. Relate these to Grime's C-S-R Triangle model, and why *r* vs. *K* may not function in stressful environments.)

October 10:

Regulation of Species Range – I **Chapter 4**

(Be able to list the principle factors that limit species ranges, and understand how transplant experiments can be used to determine the importance of these mechanisms. Understand how 'false positive' and 'false negative' results can complicate interpretation of such experiments. Understand the main types of dispersal, Beijerinck's Law, and what is meant by 'dispersal limitation'.)

Regulation of Species Range - II **Chapters 5, 6**

(Know how moisture, light, and temperature often limit species distribution. Be able to explain the main ways in which natural selection has modified organism body plans and physiology to better adapt to the environment. Be able to identify and explain the function of xeromorphic adaptations, what is meant by C3 vs. C4 vs. CAM photosynthesis pathways, and how/why these influence species range.)

October 17:

2. POPULATION INTERACTIONS

Lotka-Volterra Competition Models **Chapter 10**

(Understand the mathematics underlying the graphical Lotka-Volterra competition model. Be able to construct and interpret them and understand the conditions which lead to species exclusion and coexistence.)

Resource-Ratio Competition Models **Chapter 10**

(Understand the mathematics and general processes underlying competition models based upon the supply ratios for limiting resources. Understand the conditions which lead to species exclusion and coexistence.)

October 24:

Predator-Prey Models – Classic **Chapter 11**

(Understand the mathematics underlying the graphical Lotka-Volterra predator-prey model. Be able to construct, interpret, and predict predator-prey dynamics based upon them.)

Predator-Prey Models -- Modern **Chapter 11**

(Know the major limitations of the Lotka-Volterra approach and be able to explain how relaxation of limiting and/or false assumptions can lead to more realistic models. Know the conditions necessary for stable co-existence in a predator-prey system.)

October 31: ***Mid-Term Exam***

November 7:

Allelopathy and Herbivory **Chapter 12**

(Define allelopathy and provide classic examples of this type of interaction. Be able to explain alternative mechanisms to explain these patterns. Characterize the major defensive strategies used by plants to combat herbivory, and how these differ between apparent and inconspicuous species. Detail the responses of herbivores to these strategies.)

Coevolution and Mutualisms **Chapter 12**

(Describe and provide examples of the major forms of mimicry. Know the major classes of mutualisms which exist within and between different species, and be able to describe examples of each.)

November 14:

3. COMMUNITY ECOLOGY

Community structure and niche theory **Chapter 18**

(Understand the various definitions for the term 'niche'. Define and describe several types of guilds. Distinguish between the oganismic and individualistic views of niche distribution. Explain how these approaches lead to different views of community assembly. Define neutral community assembly.)

Species diversity: Measurement **Chapter 18**

(Discuss the differences between richness and evenness in the measurement of biodiversity. Show how the Species Abundance Relationship can be displayed and mathematical artifacts that alter its apparent shape. Differentiate between evenness indices based on probability and information theory and know how sensitive each is to changes in the evenness of rare and common species. Illustrate the various types of Species Accumulation Functions, and show how they differ across various ecological settings.)

November 21:

Species diversity: Mechanisms **Chapters 18, 21**

(Understand the difference between equilibrium and non-equilibrium models of species diversity. Be able to use the theory of island biogeography to illustrate how area and isolation influence site richness. Discuss how disturbance, mass effect, and competitive equivalency can affect species diversity. Describe how the supply ratios of resources can affect species diversity.)

Disturbance ecology **Chapter 21**

(Characterize the major types of disturbances affecting natural habitats by their intensity, scale, and return interval. Know the differences between exogenous and endogenous disturbance regimes. Understand the importance of spatial and temporal scale in characterizing disturbance regimes.)

November 28:

Succession **Chapter 19**

(Be able to define and give examples of primary and secondary succession. Identify the major mechanisms underlying successional change. Know the major successional trends in diversity, niche width, and compositional predictability, and be able to provide specific examples from the natural world.)

6. MACROECOLOGY

Macroecology Origins; Latitudinal Richness / Evenness Patterns **Chapters 18, 21**

(Understand the origins of macroecology. Describe global latitudinal patterns in species richness and evenness. Detail the major theories that have been proposed to account for them, and how well they actually explain patterns. Be able to identify the major logical flaw in Dominance Diversity curves and how this can be fixed by using Cumulative Rank Frequency plots.)

December 5:

Range Size, Turnover, Body Size and Allometric Scaling

(Understand what is meant by the Age-Area Hypothesis and Rappaport's Rule, and how the limitation of these concepts in explaining real world range patterns. Be able to relate what is meant by Distance Decay, and know how analysis of its two main functional forms (power law and exponential decay) and rates of change can illuminate ecological process. Understand the main shapes found in body size distributions for species and individuals, and relate how incongruence between them is related to sample latitude. Describe what is meant by Allometric Scaling.)

Universality

(Understand what is meant by a 'universal pattern' and provide common examples within ecology and macroecology. Consider the ultimate mechanisms which can give rise to them, including poor choice of data presentation, complexity science / MaxEnt, central limit theorem, extreme value statistics, dimensional scaling, and quantum ecology. Know how identify those patterns most likely generated by purely ecological processes.)

December 12: ***Final Examination***