Syllabus

ECOLOGY AND ECOSYSTEMS (YID2203)

Academic year 2016-2017, 1st Semester

Contents

1. General information

Instructor: Michiel van Breugel
Email: michiel.vanbreugel@yale-nus.edu.sg
Office: Elm College, RC2 – 02 – 01F
Telephone: 660 13705 / 98621006

Office hours: use https://vanbreugel.youcanbook.me/ to make an appointment
More info: Changes to the syllabus; announcements; detailed descriptions of assignments; course materials and links to online resources can be found on this course's Canvas site.

2. Course description and objectives

What we will study | Ecology investigates the complex interactions of organisms with one another and their environment at different levels of organization, from populations up to ecosystems. This course does not try to cover as many topics within the broad field of Ecology as possible, but rather focuses on three broad ecological questions:

1. What limits and regulates the growth of populations?
2. What drives the coexistence of species in natural communities (biodiversity)?
3. How are trophic interactions, diversity and the dynamics and resilience of ecosystems related?

We will study ecological theory related to each question, after which you will use this newly gained knowledge to explore the role of ecology in a range of applied topics. The questions go from the level of populations, to the level of communities and subsequently that of ecosystems. Each question will introduce new concepts while explicitly building on what we learned previously.

Learning goals | At the end of the course, you should have mastered several important ecological principles and concepts and a *conceptual* understanding of a several mathematical, verbal and graphical models of important ecological processes. More generally, we will explores how the structure, dynamics and behavior of complex natural systems emerge from ecological interactions within and across different levels of organization.

A central theme of this course is, furthermore, to develop an appreciation of how ecology and ecological models can help us in a wide range of applications, including management of our natural resources, the conservation of our biological diversity, city planning, economics and public health. Specifically, this course will provide for the basic ecological literacy that is needed to critically evaluate information and distinguish credible scientific ideas and evidence from opinions and misinformation.

Broader contribution to ES and LS majors | Many of the concepts we will discuss in this course – such as feedback effects, tradeoffs, dynamic equilibrium, resilience or stochasticity – are fundamental to the analysis and understanding of the dynamics of complex systems, whether social, natural or combined. This course will give you a better understanding of how simple interactions lead to complex system dynamics and how we can study and understand drivers of systems resilience and resistance, *two core issues in the fields of Environmental Studies and life Sciences*.

3. Course Outline

The semester will be divided in three blocks of roughly 4 weeks, each of which will focus on one of the three broader questions. Each block will have a similar set up with seminar classes, lab and field work on a series of related experiments. We will have three big assignments. Two are oral presentations on an applied topic based on a literature review and the third assignment is a report based on the experiments.

3.1 Seminar classes

We discuss ecological principles, concepts and theoretical models that relate to the main question, based on text book readings and discussion of scientific papers. In these discussion we will explore ecological theory in the context of different study systems and how hypotheses are tested in field studies and experiments.

One objective of this course is to get a sense of the role, usefulness and limits of ecological concepts and models in addressing applied problems in agriculture, fisheries, forestry, wildlife management, public health and other fields. Therefore we will discuss, *from an ecological point of view*, a variety of case studies. Examples of possible topics are industrialized agriculture versus organic farming systems; collapsing fish stocks; the bee colony collapse disorder; forest restoration; historical domestication of our major crops; and links between land-use change, poaching and outbreaks of infectious diseases. The idea is that these discussions, including choice of topics, will be to a large extent student driven.

Some of the case studies may be revisited in 2 or 3 blocks. One example is the case of reintroduction of a keystone predator (wolves) in the Yellowstone National park. We can use this case study to look at the population dynamics of different species in the food web, trophic structure and the cascading effects of the removal of a top predator, and how disturbances can lead to alternative stable states of ecosystems. Another case might well be about how to manage the pond on our campus such that it won't be a breeding ground for mosquitos!

3.2 Study of model organism (whole semester)

We will do field sampling exercises and lab experiments with a well-studied model organisms: nematodes. I am very excited that we have this year Dr. Jan Gruber and Dr. Ng Li Fang, who use nematodes to study aging, on our teaching team. They helped in the design and set up of the nematode experiments, will teach you the skills you need to work on these experiments, and will participate in the discussions of these experiments.

The experiments will help you to develop a more in depth and intuitive understanding of how we study (i) population dynamics of a specific species; (ii) how the population dynamics of species are shaped by environmental variables and biotic interactions; and (iii) how life history tradeoffs interact with environmental conditions to shape population fitness. During the course, we will read about and discuss ecological concepts and models. This series of field work and lab experiments - including data collection, analysis, presentation and interpretation – will help you to develop a much better sense of different aspects of the ecological research behind these textbook stories, and how challenging, tedious and fun this research can be.

During the semester, each student will individually maintain a log book. At the end of each experiment, Students will write in groups of 2-3 an interim reports with methods, data (of the whole class), analyses and a very brief interpretation of the results. I will have meetings with the groups to discuss their reports.

At the end of the semester the groups will assemble all data and write a final report in which they analyze, interpret and discuss the collective research of the whole class. The more effort you put in the interim reports, the easier and faster will be the writing of the final report in the last week / reading week!

3.3 Presentations

You will choose an issue that (i) is related to the use and management of our natural environment, (ii) can be related to the concepts and models of the first two (presentation 1) or the last two (presentation 2) blocks, and (iii) has been discussed in newspapers, popular science publications, internet discussions or other non-academic sources. Use the principles and concepts you learned in the current and previous blocks to analyze the ecological dynamics of the system and critically evaluate arguments used in the ongoing debate. Use primary literature! In principle, each students will chose a different topic from a list of topics, but let me know if you would want to work on something that is not in the list. These fairly open assignments; take this as an opportunity to explore or get deeper into a topic that really interests you, using what you will have learned so far.

3.4 Developing skills

The course includes activities that will help you (further) develop skills that are important in the field of Environmental Studies. Field and lab work will help you to develop a better understanding of the challenges related to empirical research and get you some practice in experimental design and the collection, analysis and interpretation of scientific data, and writing it all up. We will be doing some simple calculation and simulation exercises to help you understand, at a conceptual level, some of the mathematical models that are fundamental to the scientific field of ecology. This course is light on the math, but I do expect that you are, by the end of the course, able to understand and explain some important conceptual models, fairly complicated graphs, and the significance of a few key equations. Finally, by working as class together on experiments, you will further develop the skills needed to work in collaborative projects, something that is increasingly important within and outside the Sciences.

4. Class dynamics

4.1 Class

- *Days and time*: Mondays and Thursdays, 9:00-10:30am
- *Venue*: Classroom 22, RC3-02-03
- In class, we have lectures, exercises and discussions. Electronic devices (laptops, tablets, telephones etc.) are only allowed when needed for exercises or activities.
- Discussions of readings is an essential part of all classes, so it is mandatory to attend class and you are expected to come well prepared with books, questions and discussion points. When a question is asked, I will always ask the other students to take a shot first before I (try to) give an answer. Frequent absences or bad preparation for class will not only affect your own learning, but also class dynamics and learning of others, so will have a negative effect on your participation grades.
- To get a better *conceptual* understanding of some of the important mathematical models, we will (i) go through the most essential equations so that you see where they come from and (ii) work in-class on some simple calculations and simulation modelling exercises.

- We will have lab and field exercises distributed across the semester, in which we will work with one model organism (nematodes). This includes work on / maintenance of the experiments outside class hours.
- If lecture slides were presented during class, they will be posted afterwards. However, generally these will be short and not cover all that was discussed in class, so please take notes.

4.2 Assignments

- **Reading assignments**. I expect you to come well prepared to class. This means that you have read indicated chapters from the course text books and additional materials and have prepared written questions and discussion points. Send me before each seminar class these question / discussion points (at least three).
- You are responsible for maintaining a **weekly blog** in which you summarize – briefly! – how the topics of the week relate and build on concepts, ideas and theoretical models that we discussed in previous classes. In your blog, you attempt to integrate (concepts and models of) ecological processes and interactions in a general framework. If you think that this is not possible, be explicit about why not. Sometimes homework includes the use of simulation models (e.g., in Netlogo) to explore theoretical models and behavior of systems under specific assumptions. You are expected to include your observations, notes and interpretations in your blogs. Objective is to help you to develop a system view, rather than seeing ecological processes and interactions in isolation.
- **Presentations**. It is essential that you start working early on these assignments. Be sure you make an appointment with me at least two weeks before the deadline to discuss your ideas and progress with me, to ask questions and to get help. You are expected to upload your extensively annotated PowerPoint presentation at the end of the week (Friday) the presentations were given. Annotations need to be detailed enough for someone to understand the presentation on its own. More details about requirements and format of presentations and reports will be discussed in class.
- **Experiments**. A broad overview of the experiments and when they are scheduled is provide in section 9. More detailed descriptions of the experiments will be provided in a separate document later during the semester. Groups hand in interim reports at the end of each experiment, specific deadlines will be announced during the semester. A rubric for the final report will be uploaded on Canvas later this semester.

4.3 general course schedule

The semester will be divided in three blocks of ~4 weeks, each of which will focus on one central question. We will broadly address the topics listed below. See for a detailed course schedule section 9.

Question 1 | What limits and regulates the growth of populations?

- Simple models of population growth
- Population dynamics, time-lags and stochasticity
- Population regulation: environmental conditions and resources, competition and enemies
- Scaling up: Landscapes and meta-populations

Question 2 | What drives the coexistence of species in natural communities?

- A general framework: Stabilizing forces versus fitness differences
- The fundamental and realized ecological niche

- Temporal variation and stochasticity
- life history strategies and trade-offs
- Ecological interactions and feedback effects

Question 3 | Do interactions and complexity drive ecosystems productivity and resilience?

- Food webs and trophic cascades and keystone species
- Ecosystem complexity, productivity and resilience
- Dynamic equilibrium and alternative stable states
- From ecosystem functioning to ecosystem services.

5. Evaluation

Your final grade will be determined by your performance on the following assignments:

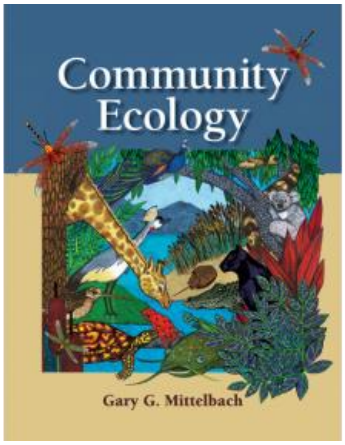
Activity / assignment	points
Presentations. Your grade will be based on the oral presentation and the annotated PowerPoint. Your work should reflect a good understanding of the theoretical concepts and models discussed so far and their proper use in the analysis of your case study; explain clearly the usefulness and limitations of ecological theory in addressing applied questions; and critically evaluate arguments used in the debate on policy / management issues related to your topic.	**2 × 20**
Experiments - report. This is a group assignment and the grade will be determined based on the interim reports and final report (a more detailed rubric will be given later during the semester). Exceptionally good or bad individual contributions to the field and lab work and/or the report may lead to individual adjustments of this grade	**20**
Blog. Weekly blogs are due on Fridays. Grades are based on (i) proper and interesting use of readings, class discussions, homework exercises, and lab- and field work; and (ii) demonstrated progress in your understanding of the concepts and models discussed during this course and how they relate and build upon each other.	**10**
Participation in lab and field work. Points are given for active, independent and diligent participation in lab and field work, in and outside class; quality of your notes and observations in your logbook; quality of your work and data. Absences will negatively affect this participation grade.	**10**
Participation in seminar classes. You get full points when (i) you come well-prepared to class, either with interesting discussion points that demonstrate your understanding of the materials, or with questions that demonstrate your effort to understand the materials and clearly point out what you do not understand; (ii) participates actively in class discussions; and (iii) contribute to the class discussion with interesting questions, ideas and viewpoints that go beyond the assigned reading materials. Frequent absences obviously effect your ability to participate, and will result in a depressed participation grade for this course.	**20**
total	**100**

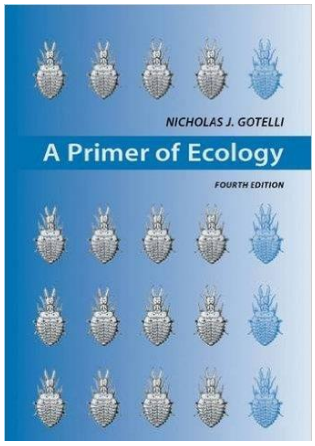
Assignments have to be uploaded on Canvas. When deadlines are different from what was indicated in this syllabus, they will be announced in class and subsequently on Canvas. Assignments and blogs are always due **6pm on the indicated day**, unless explicitly stated otherwise. Ten percent will be deducted each 24 hours that your assignment or blog is too late. If something is unclear to you (deadline, assignment, required format, etc.), ask me in advance, not when it is almost due or afterwards!

Your grade is in principle based on demonstration of learning, not on time or effort. However, I do reserve the right to take improvement and specific circumstances into account in adjusting the weight of specific scores and in determining your final grade. Whether I do this or not is not open for discussion. Letter grades will be determined as in the table below. This scale is subject to change based on overall course performance.

Letter grade	**A**	**A-**	**B+**	**B**	**B-**	**C+**	**C**	**C-**	**D+**	**D**	**F**
Lower limit	94	90	87	83	80	77	73	70	67	60	<60
Upper limit	100	93	89	86	83	79	76	72	69	66	

6. Course materials





We use the following textbook: G.G. Mittelbach (2012) Community Ecology. Sinauer Associates. 400 p. ISBN: 978-0-87893-509-3, as well as chapters from N.J. Gotelli (2008) A Primer of Ecology, 4th Edition. Sinauer Associates, 280 p. ISBN-13: 978-0878933181. 'Community Ecology' is available in the Yale-NUS library and gives a good impression of the kind of topics we will cover.

During the course we will use chapters from other books, reports, scientific articles, websites and other resources as well. These materials or links to these materials will be provided in class or posted on the Canvas site.

7. Some final points

Prerequisites – There are no prerequisites. I aim to make this course accessible to non-science majors while keeping it academically rigorous.

7.1 Out-of-class work –You should plan on spending at least 9 hours weekly on assignments and preparing for classes (12 hours / week for a 5 MS course, including 3 hours class time). That time includes lab and field work, reading of assigned textbook sections and supplementary materials; reviewing your own lecture notes and writing your blog; preparing questions about things you do not yet understand; and preparing discussion points for in-class discussions. Make sure you reserve enough time ahead the deadlines for presentations and reports to work on independent literature research, analyses and writing.

7.2 Conduct – This course has a policy of non-discriminatory language and conduct. Students should not use racist, sexist or other discriminatory language in class discussions or written work.

7.3 Learning Disabilities – Students with learning disabilities should contact the Vice Rector's office for support and guidance.

8. Academic Integrity

All of your work has to be your own and all sources, quotations, and paraphrasing have to be noted and cited appropriately. As a reminder, here is what you have been told earlier about how to reduce risks of a lapse of academic integrity.

- ***General principle***: might someone reading this imagine that I am claiming (i) as mine an idea due to someone else or (ii) as fact what is not?
- Intellectual property is a form of property: treat others' with respect
- If uncertain, ***ask your instructor***. For example, can students discuss with each other? Remember that your instructor is here to help you learn – including best academic practice in this particular field. So, let me know if you have any questions or concerns about this.
- It is always a good idea to attend sessions at Writers' Centre.

Just to be clear: By a vote of the Faculty at Yale-NUS College, professors must refer any suspected instances of academic dishonesty to the Academic Integrity Committee for assessment and adjudication:

"*Yale-NUS College expects its students to abide by the highest standards of academic integrity as a matter of personal honesty and communal responsibility. Acting with academic integrity requires that (a) students do their own work, (b) students not interfere with the work of others, (c) students accurately and honestly represent the content of their work, and (d) students properly attribute others' work. Violations of the College's academic integrity standards undermine both the community and the individual growth of students. Accordingly, they will be addressed with the utmost seriousness and sanctions ranging from grade penalties to expulsion. Examples of violations of academic integrity include plagiarism, copying or sharing homework answers, submitting work completed for one course as 'new' work for another course, or fabricating or falsifying research data. Professors are obligated to refer suspected lapses in academic integrity to the Academic Integrity Committee, which follows a set of policies and procedures approved by the faculty when investigating and adjudicating cases.*" Source: Yale NUS College Library, "Yale-NUS Policies on Academic Integrity." (2014). In *Avoiding Plagiarism*. Retrieved from http://library.yale-nus.edu.sg/plagiarism/

9. Detailed Program

Colored week numbers and dates indicate the blocks (brown = block 1, blue = block 2, green = block 3, black = not a specific block), each of which is focused on topics within the framework of a specific question (see section 2). Shading in the columns numbered 1-7 indicate the time period over which students will work on the different experiments (mostly outside class). Program is tentative. Changes will be announced in class and on Canvas and be reflected in updated versions of this program on Canvas.

	Experiment 1	2	3	4	5	6	7
Week 1 ***08 August 2016 | Introduction to the course + Exponential population growth*** *Activity:* Seminar class *Readings:* G08, Chapter 1: Exponential Population Growth ***11 August 2016 | Logistic Population Growth*** *Activity:* *Seminar class* *Readings:* • M12, Chapter 4: Population growth and density dependence • G08, Chapter 2: Logistic Population Growth							
Week 2 ***15 August 2016 | Age-structure populations and life history strategies*** *Activity:* Seminar class *Readings:* • G08, Chapter 3: Age-structured population growth *Homework:* Modelling and comparing population growth of different species ***18 August 2016 | Metapopulation dynamics*** *Activity:* Seminar class *Readings:* • M12, Chapter 12: Patchy environments, metapopulations and fugitive species • G08, Chapter 4: Metapopulation dynamics *Homework:* Using Netlogo to explore (meta)population dynamics							
Week 3 ***22 August 2016 | Meet the worm: using nematodes (C. Elegans) as a model systems*** *Activity:* • Mini-lecture on worm handling • Observations on life stages							

- Experiment 1 – resource availability and fecundity
- Start of experiment 2 – Lifespan of *C.elegans*

Readings: To be determined

25 August 2016 | Models of predator-prey dynamics

Activity: *Seminar class*

Readings:

- M12, Chapter 5: The basics of predator-prey relationships
- G08, Chapter 6: Predation

Homework: Using Netlogo to explore predator-prey dynamics

Week 4

29 August 2016 | Population growth of nematodes *(on a petri dish)*

Activity:

- Mini-lecture basics of sampling
- Start of experiment 3 – Growth rate of C. elegans populations

Readings: Ruxton & Colegrave (2011). Experimental design for the life sciences.

01 September 2016 | Introduction to Community Ecology

Activity: Seminar class

Readings:

- Mittelbach (2012), chapter 1: Introduction to community ecology
- Vellend (2010), page 183 – 193

Week 5

05 September 2016 | Selective predators and responsive prey

Activity: Seminar class (with guest lecturer)

Readings: M12, Chapter 6: Selective predators and responsive prey

08 September 2016 | Beneficial interactions

Activity: Seminar Class

Readings: M12, Chapter 9: beneficial interactions in communities

Week 6

12 September 2016 | Public Holiday

15 September 2016 | Interspecific competition

Activity: Seminar class

Readings:

- M12, Chapter 7: Interspecific competition; simple theory
- G08, Chapter 5: Competition
- M12, chapter 8: Competition in Nature; empirical patterns and tests of theory

Homework: Modelling interspecific competition

Week 7

26 September 2016 | C. elegans, aging, stress, and survival

Activity:

- Guest lecture: 'Nematodes (*C. Elegans*) as a model systems to study aging' + discussion how this relates to ecology
- Start of experiment 4 – Effects of stress (chemical or heat shock) on mortality of *C. elegans* strains age-1 vs. WT

Readings: Some text on experimental design.

29 September 2016 | C. elegans , life history and competition

Activity:

- Discussion on the basics of experimental design
- Start of experiment 5 – Competition between daf-2 and WT strains with and without stress events'

Week 8

03 October 2016 | Applied Ecology

Activity: Student Presentations

06 October 2016 | Applied Ecology

Activity:

- Student presentations
- Discussion of (progress in) experiments 1-5

Week 9

10 October 2016 | Scaling up: Metacommunities

Activity: Seminar class

Readings: M12, Chapter 13: Metacommunities and the neutral theory

Homework: Using Netlogo to explore effects of dispersal and stochasticity on species coexistence

13 October 2016 | Species coexistence in variable environments

Activity: Seminar class

Readings:

- Mittelbach (2012), chapter 14: Species coexistence in variable environments
- Vellend (2010)
- Adler et al. 2007

Week 10

17 October 2016 | Species interactions in ecological networks

Activity:

- Seminar class
- Discussion of experiments 4+5

Readings: M12, chapter 10 Species interactions in ecological networks

20 October 2016 | Food chains and Food webs

Activity: Seminar class

Readings : M12, chapter 11: Food chains and Food webs

Week 11

24 October 2016 | Populations of C. elegans: From petri dish to field

Activity:

- Field work!
- Experiment 6: Distribution and abundance of C. elegans in soils
- Start of experiment 7: Survival of C. elegans in a community of soil organisms

27 October 2016 | Species diversity versus productivity and stability

Activity: Seminar class

Readings: Mittelbach (2012), Chapter 3: Biodiversity and Ecosystem Functioning

Week 12

31 November 2016 | Meta-analyses: Diversity and productivity in agro-ecological systems

Activity:

- Seminar class
- Discussion of experiment 6+7

Readings:

There are many topics related to and studies on agriculture and agroforestry, these articles are just two examples. The first is a meta-analysis of the effects of agroforestry systems on the control of crop-enemy interactions. The second is a large meta-analysis that compares yields of different farming systems (from conventional to agro-ecological) and discusses other issues that sh/could be taken into account. These kind of meta-analyses provide comparisons across many independent studies and thus give an idea how generalizable certain patterns are across systems.

- Pumariño et al. (2015) Effects of agroforestry on pest, disease and weed control: A meta-analysis. Basic and Applied Ecology 16: 573-582 (You do not need to understand the statistical analyses)
- Ponisio et al. (2014) Diversification practices reduce organic to conventional yield gap. Proceedings of the Royal Society. http://dx.doi.org/10.1098/rspb.2014.1396. (You do not need to understand the statistical analyses)

03 November 2016 | The study of complex systems: similarities with economic research

Activity: Guest lecture + discussion

Note: Class needs to be rescheduled because guest lecturer is not available during the time slots of our class.

Week 13

07 November 2016 | Applied Ecology

Activity: Student Presentations

10 November 2016 | Applied Ecology

Activity: Student presentations