BIOL 4590B
RESEARCH PROJECT LAB

Instructor:
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Lecture: Cherry Emerson building room 322; Monday 12:05 pm - 12:55pm.
Lab: Cherry Emerson building room A105; Monday: 1:05 pm - 3:55 pm, Wednesday: 12:05 pm - 2:55 pm.

Course description: Students will gain experience in designing, implementing, and communicating a biology research project, and practical training in modern approaches for biological research. This section will have a scientific theme of ***Causes and Consequences of Biodiversity***. Students will design and run projects to explore how various ecological factors influence one or multiple dimensions of biodiversity (e.g., genetic diversity, species diversity, functional diversity, phylogenetic diversity) and/or how changes in biodiversity influences ecological properties at the species, community, or ecosystem levels.

BIOL 4590 is a 3-credit lab-based course. BIOL 4450 (Senior Seminar) is a co-requisite for BIOL 4590 because students will present their research from BIOL 4590 in Senior Seminar. Students enrolled in BIOL 4590 can sign up for any section of BIOL 4450 as long as it occurs during the same semester.

Because this is a lab-based course, attendance and active participation are required. We expect absences to be rare, and each unexcused lab absence will lower your final grade by 5%. Examples of excusable absences include documented illness, death in the family, accident, and sanctioned Institute events. If you know that you are going to be absent from a lab, you must let the instructor know ahead of time. Unexcused absences from lecture sessions will lower the course participation grade.

Office hours: By appointment. Please email or consult with instructor or TA during class to set up a meeting. Students are also welcome to visit the instructor to talk about issues other than course material (e.g., career plans, research interests).

Optional text: "Writing papers in the Biological Sciences" by Victoria E. McMillan, publisher: Bedford/St. Martin's, fifth edition (2011).

Lab essentials: You will need to wear lab coats, safety glasses and closed-toe shoes whenever we're working in the lab, and you'll need a new lab notebook (*not a spiral notebook or 3-ring binder*).

Lab safety: Georgia Tech has a strict policy regarding appropriate clothing in laboratories where chemicals and organisms are used or manipulated. Students not conforming with the following requirements will be asked to leave the lab to acquire appropriate clothing. In the laboratory, students must wear

1) **Long pants**.
2) **Close-toed shoes** that cover the sides and top of the foot.
3) **Lab coats,** when working at the bench. Lab coats must be 100% cotton and cover the wearer to the knees. Students are responsible for keeping their lab coats in good condition and reasonably clean so as to not create a hazard.
4) **Safety glasses**, when working at the bench. Safety glasses must have side shields for splash protection and conform to the wearer's face. Glasses must be worn over prescription glasses and contact lenses. Georgia Tech Biology provides safety glasses for student use in the lab. Safety glasses prevent eye

exposure to liquid reagents and breakables, as well as dangerous substances such as bacteria, toxins, acids or UV light.

Evaluation:

Reading assignments, quizzes and lab notebook checks	**20%**
Written reports on planned experiments	**20%**
Independent research project:	
Proposal	**10%**
Preliminary manuscript	**10%**
Final manuscript	**20%**
Course participation	**20%**

Quizzes will serve solely as a means of ensuring that students read the assignment. Each quiz will be one or two questions.

Lab notebooks should be handwritten (not typed) in pen and should include original notes you take during the experiment, as well as any preparatory notes you wish to include. Notebooks are graded individually (each student is required to present his/her own notebook). Every page should be numbered (by you if the book doesn't come with numbers). Your notebooks should contain description of the procedures you have performed, and actual/original data. You have to outline experimental steps so that an experienced person (including yourself) should be able to trace your experiments without frequent references to the original detailed procedures or cited references. In addition, it is required that you include all the changes made from the planned procedure, as well as all calculations, measurements/observations, etc.

Written reports on the planned experiment should each be no more than 2 pages of text (single-spaced, 12-point font) plus additional page(s) for figures and references. They should be written in manuscript-style (see recent articles in the journal "Ecology" and instructions for authors for this journal http://esapubs.org/esapubs/AuthorInstructions.htm for appropriate style). Each student writes their own report, even if they worked in teams for gathering data.

Independent research projects will run from weeks 5-16, in groups of 2-3 people. Groups of students will choose their own project, in consultation with the instructor and TA. Recommended readings and the class discussions are designed to help students come up with an original, manageable project. Although the research will be conducted in groups, each student will write his/her own manuscript, although it is expected that students in each group to work together in analyzing and interpreting their data.

Proposals will be one-page (single-spaced, 12-point font) plans of the project that will be conducted. The proposal should include background and justification (why would anyone want to do this project and why should anyone want to hear about it), a description of hypotheses to be tested (these can be in the form of questions or falsifiable statements), how the hypotheses will be tested (i.e., what experiments will be conducted), and how data will be interpreted. It is also a good idea to include a statement of expected results, and how the results relate to the goals of the project. The proposal can include a few citations, not included in the page limit. If working in a group, each group of students will submit a single proposal for their project that is approved by all members of the group.

Preliminary manuscripts will consist of the introduction section of the manuscript related to the research of the independent project, written in the style of the journal "Ecology". The introduction should be no more than 4 pages (double-spaced, 12-point font) and should include the background to the research project, why the project is being undertaken (why anyone should care…), and the overall goals of the project. However, it should NOT be written in the future tense as the proposal is written; instead, the introduction should be written as if the project has already been undertaken. Citations should be included at the end of the preliminary manuscript and are not included in the 4-page limit. Feedback from the instructor and TAs on this preliminary manuscript can then be used to improve the introduction for re-submission as part of the final manuscript. If students are working in groups, each student will write his or her own preliminary manuscript.

Final manuscripts will be in the style of the journal "Ecology" and will be no more than 15 pages (double-spaced, 12-point font), plus figures, tables, and citations. The final manuscript must include an abstract, introduction (based upon the preliminary manuscript, with any changes the student wants to make), materials & methods, results, discussion (results & discussion can be combined into one section if desired). Data should be

provided in tables and/or figures as appropriate and appropriate legends for tables and figures should be used. There is no limit on the number of citations used; however, students should NOT cite papers that they have not read. Each student will write his or her own final manuscript.

Academic Integrity: Academic dishonesty will not be tolerated. This includes cheating, lying about course matters, plagiarism, stealing classroom materials, or helping others commit a violation of the Honor Code. Students are reminded of the obligations and expectations associated with the Georgia Tech Academic Honor Code and Student Code of Conduct, available online at www.honor.gatech.edu. While students will collaborate in performing the experiments and collecting the data, each student is expected to write his or her own notebooks and manuscripts, including creating his or her own tables and figures. Plagiarism includes reprinting the words or ideas of others without citation. As direct quotes are seldom used in scientific writing, you are expected to rephrase the words of others and provide the citation. If this is unclear, please ask your instructor or TAs for help as your write before turning in your assignment.

Learning Accommodations: If needed, we will make classroom accommodations for students with disabilities. These accommodations must be arranged in advance and in accordance with the ADAPTS office (http://www.adapts.gatech.edu).

Class calendar (subject to change):

Week	**Date**	**Topic**
1	Jan 5	Introduction to course, biodiversity, and laboratory protist microcosms
	Jan 7	Protist microcosm experiment protocols
2	Jan 12	Discussion to prepare for the two planned experiments Start planned experiment #1: Competition involving two competing species
	Jan 14	Planned experiment #1: Competition involving two competing species
3	Jan 19	No class (MLK Day)
	Jan 21	Planned experiment #1: Competition involving two competing species
4	Jan 26	Discussion on issues related to your proposal; Discussion on experimental design Finish planned experiment #1: Competition involving two competing species
	Jan 28	Planned experiment #2: predation involving one predator and one prey species--functional response measurement ***proposals due in class***
5	Feb 2	Overview of what's expected for independent projects; Discussion to prepare for start of independent projects Start your independent project
	Feb 4	Independent projects ***written report for planned experiment #1 due in class***
6	Feb 9	Discussion of issues related to independent projects; independent projects
	Feb 11	Independent projects ***written report for planned experiment #2 due in class***
7	Feb 16	Discussion of issues related to independent projects; independent projects
	Feb 18	Independent projects
8	Feb 23	Discussion of issues related to independent projects; independent projects
	Feb 25	Independent projects
9	Mar 2	Discussion of issues related to independent projects; independent projects
	Mar 4	Independent projects ***preliminary manuscripts due in class***
10	Mar 9	Discussion of issues related to independent projects; independent projects
	Mar 11	Independent projects
11	Mar 16	No class (spring break)
	Mar 18	No class (spring break)
12	Mar 23	Discussion of issues related to independent projects; independent projects

	Mar 25	Independent projects
13	Mar 30	Discussion of issues related to independent projects; independent projects
	Apr 1	Independent projects
14	Apr 6	Discussion of issues related to independent projects; independent projects
	Apr 8	Independent projects
15	Apr 13	Discussion of issues related to independent projects; independent projects
	Apr 15	Independent projects
16	Apr 20	***Discussion of issues for manuscript***
	Apr 22	Clean up lab Joint poster session for all sections of BIOL 4450 *4-6pm* ***Final manuscripts due in class***

An initial reading list on the ecological causes and consequences of biodiversity

Ecological causes of biodiversity

Adler, P. B., J. HilleRisLambers, and J. M. Levine. 2007. A niche for neutrality. Ecology Letters **10**:95-104.

Bell, G. 2001. Ecology - Neutral macroecology. Science **293**:2413-2418.

Borer, E. T., E. W. Seabloom, D. S. Gruner, W. S. Harpole, H. Hillebrand, E. M. Lind, P. B. Adler, J. Alberti, T. M. Anderson, J. D. Bakker, L. Biederman, D. Blumenthal, C. S. Brown, L. A. Brudvig, Y. M. Buckley, M. Cadotte, C. Chu, E. E. Cleland, M. J. Crawley, P. Daleo, E. I. Damschen, K. F. Davies, N. M. DeCrappeo, G. Du, J. Firn, Y. Hautier, R. W. Heckman, A. Hector, J. HilleRisLambers, O. Iribarne, J. A. Klein, J. M. H. Knops, K. J. La Pierre, A. D. B. Leakey, W. Li, A. S. MacDougall, R. L. McCulley, B. A. Melbourne, C. E. Mitchell, J. L. Moore, B. Mortensen, L. R. O'Halloran, J. L. Orrock, J. Pascual, S. M. Prober, D. A. Pyke, A. C. Risch, M. Schuetz, M. D. Smith, C. J. Stevens, L. L. Sullivan, R. J. Williams, P. D. Wragg, J. P. Wright, and L. H. Yang. 2014. Herbivores and nutrients control grassland plant diversity via light limitation. Nature **508**:517-520.

Chesson, P. 2000. Mechanisms of maintenance of species diversity. Annual Review of Ecology and Systematics 31:343-366.

Clark, C. M. and D. Tilman. 2008. Loss of plant species after chronic low-level nitrogen deposition to prairie grasslands. Nature **451**:712-715.5

Connell, J. H. 1978. Diversity in tropical rain forests and coral reefs - High diversity of trees and corals is maintained only in a non-equilibrium state. Science **199**:1302-1310.

Descamps-Julien, B. and A. Gonzalez. 2005. Stable coexistence in a fluctuating environment: An experimental demonstration. Ecology **86**:2815-2824.

Haddad, N. M., D. Tilman, J. Haarstad, M. Ritchie, and J. M. H. Knops. 2001. Contrasting effects of plant richness and composition on insect communities: A field experiment. American Naturalist **158**:17-35.

Harpole, W. S. and D. Tilman. 2007. Grassland species loss resulting from reduced niche dimension. Nature **446**:791-793.

Hautier, Y., P. A. Niklaus, and A. Hector. 2009. Competition for light causes plant biodiversity loss after eutrophication. Science **324**:636-638.

Hubbell, S. P. 1997. A unified theory of biogeography and relative species abundance and its application to tropical rain forests and coral reefs. Coral Reefs **16**:S9-S21.

Jiang, L. and P. J. Morin. 2005. Predator diet breadth influences the relative importance of bottom-up and top-down control of prey biomass and diversity. American Naturalist **165**:350-363.

Levine, J. M. and J. HilleRisLambers. 2009. The importance of niches for the maintenance of species diversity. Nature **461**:254-U130.

Lubchenco, J. 1978. Plant species diversity in a marine intertidal community: importance of herbivore food preferences and algal competitive abilities. American Naturalist **112**:23-39.

Paine, R. T. 1966. Food web complexity and species diversity. American Naturalist **100**:65-75.

Stevens, C. J., N. B. Dise, J. O. Mountford, and D. J. Gowing. 2004. Impact of nitrogen deposition on the species richness of grasslands. Science **303**:1876-1879.

Violle, C., D. R. Nemergut, Z. C. Pu, and L. Jiang. 2011. Phylogenetic limiting similarity and competitive exclusion. Ecology Letters **14**:782-787.

Ecological consequences of biodiversity

Cadotte, M. W., B. J. Cardinale, and T. H. Oakley. 2008. Evolutionary history and the effect of biodiversity on plant productivity. Proceedings of the National Academy of Sciences of the United States of America **105**:17012-17017.

Cardinale, B. J., J. E. Duffy, A. Gonzalez, D. U. Hooper, C. Perrings, P. Venail, A. Narwani, G. M. Mace, D. Tilman, D. A. Wardle, A. P. Kinzig, G. C. Daily, M. Loreau, J. B. Grace, A. Larigauderie, D. S. Srivastava, and S. Naeem. 2012. Biodiversity loss and its impact on humanity. Nature **486**:59-67.

Cottingham, K. L., B. L. Brown, and J. T. Lennon. 2001. Biodiversity may regulate the temporal variability of ecological systems. Ecology Letters **4**:72-85.

Crutsinger, G. M., M. D. Collins, J. A. Fordyce, Z. Gompert, C. C. Nice, and N. J. Sanders. 2006. Plant genotypic diversity predicts community structure and governs an ecosystem process. Science **313**:966-968.

Hector, A., B. Schmid, C. Beierkuhnlein, M. C. Caldeira, M. Diemer, P. G. Dimitrakopoulos, J. A. Finn, H. Freitas, P. S. Giller, J. Good, R. Harris, P. Hogberg, K. Huss-Danell, J. Joshi, A. Jumpponen, C. Korner, P. W. Leadley, M. Loreau, A. Minns, C. P. H. Mulder, G. O'Donovan, S. J. Otway, J. S. Pereira, A. Prinz, D. J. Read, M. Scherer-Lorenzen, E. D. Schulze, A. S. D. Siamantziouras, E. M. Spehn, A. C. Terry, A. Y. Troumbis, F. I. Woodward, S. Yachi, and J. H. Lawton. 1999. Plant diversity and productivity experiments in European grasslands. Science **286**:1123-1127.

Hooper, D. U., E. C. Adair, B. J. Cardinale, J. E. K. Byrnes, B. A. Hungate, K. L. Matulich, A. Gonzalez, J. E. Duffy, L. Gamfeldt, and M. I. O'Connor. 2012. A global synthesis reveals biodiversity loss as a major driver of ecosystem change. Nature **486**:105-U129.

Hughes, A. R., B. D. Inouye, M. T. J. Johnson, N. Underwood, and M. Vellend. 2008. Ecological consequences of genetic diversity. Ecology Letters **11**:609-623.

Isbell, F., V. Calcagno, A. Hector, J. Connolly, W. S. Harpole, P. B. Reich, M. Scherer-Lorenzen, B. Schmid, D. Tilman, J. van Ruijven, A. Weigelt, B. J. Wilsey, E. S. Zavaleta, and M. Loreau. 2011. High plant diversity is needed to maintain ecosystem services. Nature **477**:199-U196.

Kennedy, T. A., S. Naeem, K. M. Howe, J. M. H. Knops, D. Tilman, and P. Reich. 2002. Biodiversity as a barrier to ecological invasion. Nature **417**:636-638.

Levine, J. M. 2000. Species diversity and biological invasions: relating local process to community pattern. Science **288**:852-854.

Levine, J. M. and J. HilleRisLambers. 2009. The importance of niches for the maintenance of species diversity. Nature **461**:254-U130.

Loreau, M. and A. Hector. 2001. Partitioning selection and complementarity in biodiversity experiments. Nature **412**:72-76.

McCann, K. S. 2000. The diversity-stability debate. Nature **405**:228-233.

McGrady-Steed, J., P. M. Harris, and P. J. Morin. 1997. Biodiversity regulates ecosystem predictability. Nature **390**:162-165.

Naeem, S., J. E. Duffy, and E. Zavaleta. 2012. The functions of biological diversity in an age of extinction. Science **336**:1401-1406.

Petchey, O. L. and K. J. Gaston. 2006. Functional diversity: back to basics and looking forward. Ecology Letters **9**:741-758.

Tilman, D. 1999. The ecological consequences of changes in biodiversity: A search for general principles. Ecology 80:1455-1474.

Tilman, D., P. B. Reich, J. Knops, D. Wedin, T. Mielke, and C. Lehman. 2001. Diversity and productivity in a long-term grassland experiment. Science **294**:843-845.

Tilman, D., P. B. Reich, and J. M. H. Knops. 2006. Biodiversity and ecosystem stability in a decade-long grassland experiment. Nature **441**:629-632.

Yachi, S. and M. Loreau. 1999. Biodiversity and ecosystem productivity in a fluctuating environment: The insurance hypothesis. Proceedings of the National Academy of Sciences of the United States of America **96**:1463-1468.