

# ***ESM 201: ECOLOGICAL PRINCIPLES FOR MANAGED ECOSYSTEMS***

## **Course Syllabus, Winter 2019**

**Lectures:** 8:00 – 9:15 AM, Monday/Wednesday, 1414 Bren Hall

Course materials at <https://gauchospace.ucsb.edu>

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Office Hours: Monday and Wednesday 12:00-1:00, or by appointment

Discussion Sections Led By

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The goals of this course are to help you understand

- the scientific principles, concepts and theories that are the foundation of ecology and
- how these are applied to major societal and scientific issues, including those related to human impacts on the functioning, productivity and sustainability of ecosystems at local to global scales

The course is presented as a series of lectures and discussion sections. The subjects of lectures are listed in this syllabus. Unless you have already learned about the mathematics of basic ecological theory (population growth, competition, predation, mutualism, foodwebs), you will find it important to purchase and read our textbook, *A Primer of Ecology* by Nicholas J. Gotelli (called simply “Gotelli” below). Page numbers in this syllabus are based on the 4<sup>th</sup> edition of Gotelli, but other versions are sufficiently similar. Required readings will be available on GauchoSpace. Read assigned papers before each lecture.

The recitation is designed to clarify and amplify points raised in lecture, to discuss all readings, and to help you learn how to analyze and interpret environmental data using statistics. Note: all “Related Readings” are required readings.

### **Jan. 7 Introduction to Ecology and the Grand Challenge of Human Domination of Global Ecosystems**

What is ecology? How we study ecology. Seeking simplicity in complex systems. Wolves and Yellowstone. The scientific method, hypothesis testing and scientific “proof.” How humans impact species and ecosystems. Human domination of ecosystems. Inadvertent management or informed management?

**Related readings:** McLaren, B.E. and R.O. Peterson. 1994. Wolves, moose and tree rings on Isle Royale. *Science* 266:1555-155.

Vitousek, P.M., H.A. Mooney, J. Lubchenco and J.M. Melillo. 1997. Human domination of the Earth’s ecosystems. *Science* 277:494-499.

### **Jan. 9 Density Independent and Dependent Growth and Maximum Yields**

Birth and death rates affect population size. Growth in an unlimited habitat. The power of exponential growth and ecological explosions. The continuous logistic growth model. Density-dependent versus density-independent regulation of population size. The controversy and resolution. Maximum Sustainable Harvest of Fish and Other Renewable Natural Resources

**Related readings:** Gotelli, p. 2-11; 20-31; and 32-48.

**Jan. 14**      **The Ecology of Humans: Human Population Dynamics and Consumption**  
Human population now exceeds 7,000,000,000. When will global population stop increasing? What is the earth's carrying capacity for humans? Why will population stop increasing? The roles of demographic transitions, education of females, per capita consumption, and disease. Trends in per capita incomes and the implications.

**Related reading:** Lutz, W., W. Sanderson and S. Scherbov. 2001. The end of world population growth. *Nature* 412:543-545

**Jan. 16**      **Population Oscillations, Population Regulation and Chaos: Takens' Theorem and the Conceptual Foundations of Simplification**

**Related readings:** May, R. M. 1974. Biological populations with nonoverlapping generations: stable points, stable cycles and chaos. *Science* 186:645-647;

**Jan. 21**      **Martin Luther King Day – No Classes**

**Jan. 23**      **The Ecology of Human Diseases: Measles, Mumps, Polio and Small Pox**  
 $R_0$ , the minimum level Related to sustain pathogen populations. What are the biological attributes that govern disease dynamics? The dynamics of vaccination.

**Related Reading:** R. M. Anderson and R. M. May. 1982. Directly Transmitted Infectious Diseases: Control by Vaccination. *Science* 215: 1053-1060. (The mathematics is complex; you may skim it, and read the paper for its major findings and implications).

**Jan. 28**      **Diseases Ecology (continued) and Diseases of Plants and Animals**  
Herd immunity. Most human diseases were originally diseases of other animal species. Crop diseases. Animal diseases also are transmitted from one species to another, especially after animals are moved to a new geographic realm via the pet trade. Large-scale livestock production is especially susceptible to new diseases, and to devastating outbreaks of established diseases.

**Related Reading:** K. F. Smith. 2009. Reducing the Risks of the Wildlife Trade. *Science* 324: 594-595.

**Jan. 30**      **Humans as the Worlds Greatest Evolutionary Force: Malthus, the Power of Exponential Growth, and Darwin's Logic**  
Population doublings and the "Rule of 70." The power of differential reproductive success. Evolutionary time. Natural selection. "Survival of the fittest" vs. "differential reproductive success." Pesticides, antibiotics, and the evolution of resistance.

**Related reading:** Palumbi, S. 2001. Humans as the World's greatest evolutionary force. *Science* 293:1786-1790.

- Feb. 4 Interspecific Competition, Tradeoffs and Coexistence**  
 Many species compete with other species in natural and managed ecosystems. The classical Lotka-Volterra model of competition. The qualitative processes that lead to competitive dominance or stable coexistence. Competition for a single limiting resource. The  $R^*$  concept. Theory and experimental studies.
- Related reading:** Gotelli, p. 100-124;  
 Tilman, D. Chapter 3 from *Resource competition and community structure*. Princeton University Press. Related
- Optional Reading:** Ricklefs, R. 2010. Evolutionary diversification, coevolution between populations and their antagonists, and the filling of niche space.
- Feb. 6 Competition for two or more resources, interspecific tradeoffs, and multispecies coexistence.**  
 Theory of competition for two essential versus two switching resources. How resource type can limit coexistence and diversity. The Universal Tradeoff Hypothesis for the diversity of life on earth.
- Related Reading:** Tilman, D. 2010. Diversification, Biotic Interchange, and the Universal Trade-Off Hypothesis. *The American Naturalist* 178: 355-371
- Feb. 11 Predator-Prey Interactions and Top-Down versus Bottom-Up Management of Food Webs**  
 Density-density dependent prey growth and predator-prey stability. Isocline models of predator-prey interactions.  
 What is a more important control of plant community biomass – nutrient supply or herbivores/predators?
- Related readings:** Gotelli, p. 126-143;  
 Pace et al. 1999. Trophic cascades revealed in diverse ecosystems. *TREE* 14: 483-488.
- Feb. 13 The Ecology of Humans: Food, Dietary Choices and Escalating Global Food Demand**  
 Are the next 50 years the final period of rapid expansion of global human impacts? Per capita income and culture are two major drivers of dietary choices – choices that have major global environmental implications. Current food demand and its likely trajectory. How could food choices be modified? Cost, health or the environment – will any of these cause dietary choices to change?
- Related readings:**  
 S. Bonhommeau et al. 2013. Eating up the world's food web and the human trophic level. *PNAS* 110: 20617-20620.  
 Tilman, Balzer, Hill and Befort. 2011. Global food demand and the sustainable intensification of agriculture. *PNAS* 108: 20260-20264. (Note: Focus on the first two pages. Read the rest if you are interested)

P Grassini, K Eskridge & K Cassman. 2013 Distinguishing between yield advances and yield plateaus in historical crop production trends. *NATURE COMMUNICATIONS* 4:2918|DOI:10.1038/ncomms3918.

**Feb. 18**      **Presidents' Day – No Classes**

**Feb. 20**      **The Environmental Impacts of Agriculture**

Global magnitudes of agriculturally-driven land clearing, greenhouse gas emissions, nitrogen and phosphorus use and movement, water use, and pesticides, and their environmental impacts.

**Related readings:** Vitousek et al. 1997. Human alteration of the global nitrogen cycle: sources and consequences. *Ecological Applications* 7:737-750.

Tilman et al. 2001. Forecasting Agriculturally-Driven Global Environmental Change. *Science* 292: 281-284.

**Feb. 25**      **First Examination (covers all material through Feb. 11 lecture)**

**Feb. 27**      **Agricultural Sustainability and Healthy Diets**

What will be needed to greatly increase the environmental sustainability of global agriculture? How can the diet and human health dilemma be solved? Is local food a solution? Can we be rescued by higher yields or GMO crops? Does each crop have a maximum potential yield, and are yields close to such maxima? How can the yield gap be closed, or diets changed, and what would be the environmental benefits of such actions?

**Related readings:**

J Foley et al. 2011. Solutions for a cultivated planet. *Nature*, doi:10.1038/nature10452.

Tilman, D. and M. Clark. 2014. Global diets link environmental sustainability and human health. *Nature* 515: 518-522.

(Optional) For a markedly different perspective: J. Ausubel et al. 2012. Peak farmland and the prospect for land sparing. *Population & Development Review* 38: 221-242.

**Mar. 4**      **The Ecology of Humans: Land Clearing, Habitat Destruction, the Extinction Debt**

The species-area curve illustrates the effect of habitat size on biodiversity and the effects of habitat destruction on species extinctions. Habitat destruction and the biased, time-delayed extinction of many species.

**Related reading:** Gotelli, p. 82-97;

Tilman, May, Lehman and Nowak. 1994. Habitat Destruction and the Extinction Debt. *Nature*.

Optional, but interesting: Barnosky, A. et al. 2004. Assessing the Causes of Late Pleistocene Extinctions on the Continents. *Science* 306, 70-75.

- Mar. 6      Biodiversity, Stability and Productivity**  
The Diversity and Stability Debate. Elton, May and others. Theory and concepts. The debate and its resolution. How and why does biodiversity impact the functioning of ecosystems, including their productivity, disease dynamics, nutrient dynamics, carbon storage capabilities and exotic invasive species?
- Related reading:** Hautier, Y, et al. 2015. Anthropogenic environmental changes affect ecosystem stability via biodiversity. *Science* 348: 336-340.
- Mar. 11      Ecosystem Functioning and the Loss of Biodiversity**  
The universal tradeoff hypothesis and the potential for universal impacts of biodiversity loss. The effects of biodiversity loss compared to other human-driven environmental changes. Loss of biodiversity as an intermediary driver of the effects of human-driven environmental changes.
- Related Reading:** Hooper, D et al. 2012. A global synthesis reveals biodiversity loss as a major driver of ecosystem change. *Nature* 486: 105-108.  
Cardinale B et al. 2012. Biodiversity loss and its impacts on humanity. *Nature* 486: 59-67.  
Optional: Tilman, D., P. Reich and F Isbell. 2012. Biodiversity impacts ecosystem productivity as much as resources, disturbance, or herbivory. *PNAS*
- Mar. 13      Sustainably Balancing the Needs of 9 Billion for Energy, Food and Livable Environments**  
Modern industrial societies have immense demands for energy and food, and require a livable and sustainable global environment. Solutions to one problem, like climate, change, can negatively impacts other human needs. How can multiple linked problems be solved? How can 9 billion people make choices that lead to a livable and equitable planet?
- Related readings:**  
Pacala, S. and R. Socolow. 2004. Stabilization Wedges: Solving the climate problem for the next 50 years with current technologies. *Science* 305:968-972.  
Searchinger et al. 2008. Use of US croplands for biofuels increases greenhouse gas emissions through land use change. *Science*.  
Cohen, J. and D Tilman. Biosphere 2 and Biodiversity – The Lessons So Far. *Science* 274: 1150-1151.

**Monday, Mar. 18    *SECOND EXAMINATION. 5 PM – 8 PM***

**Class Grading:** Each exam is worth 100 points, and an additional 100 points can be earned in recitation, for a total of 300 points for the class.

## ***Student Services – Where to go when you need help***

- Campus Learning Assistance Services (CLAS) <http://clas.sa.ucsb.edu>
- Campus Advocacy Resource and Education (CARE): <http://wgse.sa.ucsb.edu/care/home>
- Counseling & Psychological Services <http://caps.sa.ucsb.edu>
- Disabled Students Program <http://dsp.sa.ucsb.edu/>
- Educational Opportunity Program (EOP) <http://eop.sa.ucsb.edu>
- Health and Wellness <http://wellness.sa.ucsb.edu>
- Little Big Engineer: <https://orgsync.com/129034/chapter>
- MultiCultural Center <http://mcc.sa.ucsb.edu/>
- Non-Traditional Student Resource Center <http://wgse.sa.ucsb.edu/nontrad/>
- Office of International Students and Scholars <http://oiss.sa.ucsb.edu/>
- Office of the Ombuds <https://ombuds.ucsb.edu/>
- Office of Student Life (OSL) <http://osl.sa.ucsb.edu/>
- Opening New Doors to Accelerating Success (ONDAS) Center <http://www.ondas.ucsb.edu/home>
- Resource Center for Sexual and Gender Diversity: <http://wgse.sa.ucsb.edu/RCSGD/home>
- Transfer Student Center (TSC) <http://transfercenter.ucsb.edu>
- UCSB Alcohol and Drug Program: <https://alcohol.sa.ucsb.edu/>
- UCSB Social Work Services: <http://studenthealth.sa.ucsb.edu/behavioral-health/social-work>
- UCSB Student Health Services: <http://studenthealth.sa.ucsb.edu/>
- Undergraduate Mentorship Program <http://duels.ucsb.edu/academics/academic-success/mentor>
- Undocumented Student Services <http://www.sa.ucsb.edu/dreamscholars/home>
- Veterans' Resource Center: <http://www.sa.ucsb.edu/veterans/home>
- Women's Center <http://wgse.sa.ucsb.edu/WomensCenter/home>