ESM 201: ECOLOGICAL PRINCIPLES FOR HUMAN DOMINATED ECOSYSTEMS.

Course Syllabus, Winter 2024
Syllabus may be modified as the class progresses

Lectures: 9:30 – 10:45 AM PDT, Tuesday and Thursday
Course materials at https://gauchospace.ucsb.edu

Dr. David Tilman – email: tilman@ucsb.edu

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OFFICE HOURS

Dr. Tilman - 12:00 - 1:00 Tuesday and Thursday in Bren 4414 or by appointment (tilman@ucsb.edu)

Leonardo Feitosa - TBD

Zoe Sims – TBD

The goals of this course are to have you learn

- The principles, concepts and theories that are the scientific basis for conservation policy and for the preservation of biodiversity and ecosystem services.
- How this scientific knowledge is applied to major societal and scientific issues, especially those related to human impacts on the functioning, productivity and sustainability of ecosystems at local to global scales.
- How and why humans impact and manage all of Earth's ecosystems, and how this can be done in more sustainable ways.

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 the mathematics of ecological concepts theory (population growth, competition, predation, mutualism, foodwebs, biodiversity, and ecosystem functioning), it is **highly important for you to read our textbook, A Primer of Ecology** by Nicholas J. Gotelli (called simply "Gotelli" below). Page numbers in this syllabus are based on the 4th edition of Gotelli, but other versions are sufficiently similar. All other 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, and to discuss readings.

Class Grading: The Midterm Exam and the Final Exam are each worth 100 points. Homework and other recitation activities are worth 50 Points. Total is 250 points.

Jan. 9 **Human Environmental Impacts**

From Foodwebs to Endangered Species. What is known? What must be known to make wise conservation decisions? The central role of population ecology. Birth and death rates and extinction risks. Growth in an unlimited habitat -- exponential growth and ecological explosions.

Required reading: Gotelli, p. 2-11
Vitousek_1997_Human domination of the Earth's ecosystems. Science

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

Jan. 11 **Population Growth: Density Independent and Dependent Growth**

The math of exponential growth. Density-dependent growth and the continuous logistic growth model. Density-dependent versus density-independent regulation of population size.

Required reading: Gotelli, p. 26-32.

Jan. 16 **Population Growth Continued; Extinction Risk for Rare Species; Time Lags and Population Dynamics**

Maximum Sustainable Harvest of Fish and Other Renewable Natural Resources. The logic, and math, of extinction risks. A different model of population growth.

Required reading: Gotelli, p. 14-23

Jan. 18 **Population Regulation, Population Oscillations and Chaos; Takens' Theorem and the Conceptual Foundations of Simplification**

Required reading: Gotelli, p. 11-13; and 31-48.
Optional reading: May, R. M. 1974. Biological populations with nonoverlapping generations: stable points, stable cycles and chaos. Science 186:645-647.

Jan. 23 **The Ecology of Humans: Human Population Dynamics**

Human population now exceeds 8,000,000,000. 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.

Required reading:
Bongaarts, J. 2009. Human population growth and the demographic transition. Pro. Roy. Soc. B 364: 2985–2990

Jan. 25 **The Ecology of Humans: What controls how much a person consumes?**

Are the next 50 years the final period of rapid expansion of global human impacts? People purchase and use – and thus consume – thousands of products, including metals, rare earth elements, wood, cement, fossil fuels, and food. How can we forecast future demand? Income, culture, religion? Ethics of food and food as a basic human right.

Required reading: S. Bonhommeaua et al. 2013. Eating up the world's food web and the human trophic level. PNAS 110: 20617-20620.

Jan. 30 **Humans as the World's 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. The evolution of COVID.

Required reading:

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

Feb. 1 **The Ecology of Human Diseases**

R_0, the minimum level Required to sustain pathogen populations. What are the biological attributes that govern disease dynamics? The dynamics of vaccination. Herd Immunity. Age and disease dynamics. Most human diseases were originally diseases of other animal species, especially those animals that we eat.

Required Reading:

R. M. May. 1982. Vaccination programs and herd immunity. Nature 300: 481-483.

Optional – for those who love math: R. Anderson and R. M. May. 1982. Directly Transmitted Infectious Diseases: Control by Vaccination. Science 215: 1053-1060.

Feb. 6 **Interspecific Competition and Causes of 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.

Required reading: Gotelli, p. 100-124;

Kartzinel et al. 2015. DNA metabarcoding illuminates dietary niche partitioning by African large herbivores. PNAS 112: 8019–8024.

Feb. 8 **Competition for Limiting Resources, Tradeoffs and Multispecies Coexistence**

The R* concept. Theory and experimental studies.

Tradeoff Example: Competition for two resources, interspecific tradeoffs, and multispecies coexistence. Indirect Effects of Multi-Species Competition.

Required Reading

Tilman, D. Chapter 3 *from Resource competition and community structure.* Princeton University Press. Required

Tilman, D. 2010. Diversification, Biotic Interchange, and the Universal Trade-Off Hypothesis. The American Naturalist 178: 355-371

Feb. 13 **Predator-Prey Interactions; The Ecological Impacts of Predators and Their Loss**

Density-density dependent prey growth and predator-prey stability. Isocline models of predator-prey interactions.

Required reading: Gotelli, p. 126-143;

Pace et al. 1999. Trophic cascades revealed in diverse ecosystems. TREE 14: 483-488.

Optional: Geremia, C, J Merkle, D Eacker, R Wallen, P White, M Hebblewhite & M Kauffman. 2019. Migrating bison engineer the green wave. Proceeding of the National Academy of Sciences ("PNAS") 116: 25707–25713.

Feb. 15 First Hourly Examination (covers all material through Feb. 6 lecture)

Feb. 20 **Top-Down versus Bottom-Up Management of Food Webs; Direct and Indirect Food Web Effects**

What is a more important control of plant community biomass – nutrient supply or herbivores/predators? Would the presence of herbivore-resistant plant species change these relationships? How can you manage a multi-species ecosystem to make a species more or less abundant?

Feb. 22 **The Ecology of Humans: Habitat Destruction and the Extinction Debt**

Then: The fossil record, how the Earth became so biologically diverse, and the universal tradeoff hypothesis. **Now:** Human-caused habitat destruction and the biased, time-delayed extinction of many species.

Required reading:

N. Haddad et al. 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. Science Advances, DOI:1:e1500052

Tilman, May, Lehman and Nowak. 1994. Habitat Destruction and the Extinction Debt. Nature 371: 65-66.

Optional: Gotelli, p. 82-97;

Feb. 27 **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?

Required reading:

Cardinale B et al. 2012. Biodiversity loss and its impacts on humanity. Nature 486: 59-67.

Optional: Hooper, D et al. 2012. A global synthesis reveals biodiversity loss as a major driver of ecosystem change. Nature 486: 105-108.

Optional: Tilman, D., P. Reich and F Isbell. 2012. Biodiversity impacts ecosystem productivity as much as resources, disturbance, or herbivory. PNAS

Feb. 29 **Impacts of Biodiversity continued; Preventing Extinctions, Protected Areas and the Future of Earth's Species Diversity**

Mar. 5 **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. Agricultural air pollution and mortality. Environmental justice: pesticides; food for rich and malnourished farmers?; food to biofuels when 800 million people are malnourished"

Required readings:

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

Mar. 7 **Health Impacts of Foods and Diets**

What we eat, and why. Nutrition. Taste and health – past and now. Good food, bad food. How to translate food risk estimates into understandable numbers. How can the diet and human health dilemma be solved? Are Taste, Culture, Price and Profit Everything?

Required readings:

M. A. Clark et al. 2019. Multiple health and environmental impacts of foods. PNAS 116: 23357–23362.

Optional: Willet, W. et al. 2019. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. The Lancet http://dx.doi.org/10.1016/S0140-6736(18)31788-4

Mar. 12 **Agricultural Sustainability**

How can the environmental sustainability of global agriculture be greatly increased? Benefits of 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, and what would be the environmental benefits of such actions? Nitrogen use efficiency.

Required readings:

Cui et al. 2018 Pursuing sustainable productivity with millions of smallholder farmers. Nature 555: 363–366.

Optional: Read this paper for its big points: 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.

Required Reading:

Clark, M.A. et al. 2020. Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets. Science 370: 705–708.

Mar. 14 **Achieving Sustainability; Balancing the Needs/Wants of 9 Billion for Energy, Food & Livable Environments**

Efficiency. Increased agricultural biodiversity to improve yields and the stability of the food supply, increase soil fertility, increase soil carbon stores, reduce the incidence of crop diseases, and create biofuels that REDUCE CO2 levels.
The ultimate question: How can the choices of 9 billion consumers be guided to create a livable and equitable planet?

Required readings:

Clark, M.A. et al. 2020. Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets. Science 370: 705–708.

Optional: 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.

Tuesday, Mar. 19 ***FINAL EXAMINATION.*** **8 AM – 10 AM**

This final exam will cover the entire course, but will mainly focus on lecture material from February 8 through March 14.

Class Grading: Each exam is worth 100 points, and an additional 50 points come from recitation, for a total of 250 points for the class.

Student Services – Where to seek 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
- 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) Centerhttp://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