ENV 829
Natural Resource Economics
Fall 2015
Times: Tuesdays and Thursdays 1:25-2:40
Location: Environment Hall 1111

Instructor

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Office Hours: Tuesdays 10:00-11:00, Fridays 11:00-noon, and by appointment. I also am generally available for a few minutes after class to answer short questions. We have TREE Seminars shortly after on Thursdays some weeks, so for longer conversations please make an appointment or come to regular office hours.

Course Overview

Are we running out of natural resources? How much should we leave to future generations? Under what circumstances do markets optimally allocate the use of natural resources over time? How can we depict the bio-physical characteristics of natural resources in economic models, and how do these characteristics affect optimal management? What institutions are necessary to manage natural resources efficiently? These are central questions in the field of natural resource economics. Specific policy issues have evolved considerably over time: from the status of the coal resource in 19th century England to scarcity of metals in the wake of World War II, fisheries collapses in the 1950s and 1960s, the oil crisis in the early 1970s, and contemporary concerns such as global climate change and threats to ecosystems around the world. Nevertheless, these fundamental questions persist.

This course addresses questions about natural resource scarcity using modern capital theory and optimal control theory to derive the core results. There are two main objectives: 1) to provide students a solid foundation in the theory of natural resource economics and 2) to highlight some contemporary themes in resource economics, both theoretical and empirical. The first objective emphasizes tools and theoretical breadth such that students will be able to pursue research on a wide range of topics and, for those pursuing academic employment, teach a course like this one in the future. For the second objective, I have selected topics that I think will be particularly important in the near future and have emphasized issues in my sub-field of marine resource economics.

Prerequisites

This course is designed for PhD students in economics, finance, agricultural and resource economics, forest economics, or public policy (with an economic concentration) after they have completed a year of PhD-level microeconomic theory and econometrics. I also recommend brushing up on differential equations before taking this course. Other graduate students are welcome to take the course if they consult with the instructor to determine if they have sufficient background.

Assignments and Grading

Problem Sets

There will be roughly five homework assignments in which students set up and solve dynamic optimization problems that pertain to natural resource use and management. Some problems have analytical solutions, while others will require numerical simulation in Matlab (or an equivalent mathematical software). Students may work in groups and submit a single homework for the group. The preferred group size is three students, but I will allow groups of four to make the numbers even out and to prevent students from having to work alone or in a group of just two.

Take-home Midterm

Most dynamic problems cannot be analyzed in just one or two hours. As such, there will be a take-home midterm and a take-home final to allow students sufficient time to explore dynamic analysis in depth. Students must work independently on take-home exams.

Literature Review and Class Presentation

Each student will prepare a brief literature review (4-5 pages) that summarizes at least four papers that are not on the syllabus on a specific topic within a sub-field. In addition to summarizing the articles, students will identify important researchable questions. At the end of the semester, students will give 25-minute presentations to the rest of the class on their chosen topics. The presentation will briefly describe the four papers but focus on the details of just one paper.

Participation in TREE Seminars

The Triangle Resource and Environmental Economics (TREE) Seminar meets five Thursdays during the semester (usually 3:15-4:45). I expect students to read the papers and attend at least three out of the five seminars but encourage everyone to attend all of them. We will organize carpooling in class. If you have a conflict with TREE Seminar participation, see me and we can find alternative seminar participation.

Final Project

Here I would like you to attempt some original dynamic resource economics modeling of a particular resource system. You could use optimal control or numerical modeling, depending on your application and what has been done before. Ideally, you will select a topic that builds on your literature review. Your written project need only be 10-15 pages (double spaced). In it, you

should motivate the assumptions of your model (and parameterization if that is relevant), explain your nomenclature, attempt to derive some results (analytically or numerically), and discuss next steps for the research.

The grading breakdown is as follows:
25% Problem Sets
25% Take-home Midterm
10% Literature Review
10% Class Presentation
10% Participation in TREE Seminars
20% Final Project

Books

All of the books that I list below are useful in this course. Everyone should have at least one good reference on dynamic optimization. For this, I recommend either Caputo's book (available in the bookstore) or Kamien and Schwartz. Caputo's book is a bit more up-to-date. If you plan to work in fisheries economics, I strongly recommend purchasing Clark's book. If you are more interested in non-renewables, then getting a copy of Dasgupta and Heal would be useful (it's out of print, but some copies are available online). For those interested in theoretical issues in green accounting and sustainability, I recommend both Heal's book and Weitzman's book.

Clark, C.W., *Mathematical Bioeconomics: The Optimal Management of Renewable Resources*, 2nd Edition, Wiley, 1990.

Caputo, M.R., *Foundations of Dynamic Economic Analysis: Optimal Control Theory and Applications*, Cambridge University Press, 2005.

Dasgupta, P. and G.M. Heal, *Economic Theory and Exhaustible Resources*, Cambridge University Press, 1980.

Heal, G.M., *Valuing the Future: Economic Theory and Sustainability*, Columbia University Press, 1998.

Kamien, M.I. and N.L. Schwartz, *Dynamic Optimization*, Elsevier Science, 1990.

Weitzman, M.L, *Income, Wealth, and the Maximum Principle*, Harvard University Press, 2003.

Course Outline and Rough Schedule – I will update readings and exact dates as we go

I. Overview and Tools

August 25, 27

A. Introduction: A Brief History of Natural Resource Economics

Barnett, H.J. and C. Morse, *Scarcity and Growth: The Economics of Natural Resource Availability*, Baltimore: The Johns Hopkins Press, 1963., pp. 1-71, 252-266.
Kolstad, C.D. (2000), "Energy and Depletable Resources: Economics and Policy, 1973-1998,"*Journal of Environmental Economics and Management* 39(3): 282-305.
Wilen, James E. (2000), "Renewable Resource Economists and Policy: What Differences Have We Made?" *Journal of Environmental Economics and Management* 39(3): 306-327.

B. What makes a problem dynamic?

C. Dynamic Optimization and the Maximum Principle

Caputo, pp. 1-121 (just skim 52-76)
Clark, pp. 88-118

September 1, 3

D. Natural Resources and Capital Theory

Dasgupta and Heal, pp. 1-10.
Clark, pp. 68-87
Weitzman, pp. 1-110 (especially discussion on 99-110)

E. Current Values and Dynamic Consistency
Caputo, pp. 312-336

F. Problems in the Phase Space
Caputo, pp. 337-379

September 8, 10

Brief Introduction to Dynamic Simulation in MATLAB

Before class, review:

Getting Started With MATLAB,
http://www.mathworks.com/access/helpdesk/help/pdf_doc/matlab/getstart.pdf

You can find more materials on the MATLAB documentation website,
http://www.mathworks.com/access/helpdesk/help/techdoc/matlab.html

II. Non-renewable resources

A. Optimal Extraction and Hotelling's Rule

Dasgupta and Heal, pp. 153-175.
Farzin, Y.H. (1992), "The Time Path of Scarcity Rent in the Theory of Exhaustible Resources," *The Economic Journal* 102:813-830.
Weitzman, pp. 157-170

B. Backstop Technology and Production with Depletable Resources

Dasgupta and Heal, pp. 175-226.

D. Exploration

Pindyck, R.S. (1978), "The Optimal Exploration and Production of Nonrenewable Resources," *Journal of Political Economy* 86:841-861.
Pindyck, R.S. (1980), "Uncertainty and Natural Resource Markets,"*Journal of Political Economy* 88:1203-1225.

Additional Readings TBD

September 15, 17, 22

III. Renewable Resources

A. Models of Population Dynamics

Clark, pp. 1-67

B. Bioeconomics of the Fishery and the Problem of Open Access

Clark, pp. 88-121.
Gordon, H. S. (1954), "The Economic Theory of a Common-Property Resource: The Fishery," *Journal of Political Economy* 62, 124-142.
Smith, V.L. (1969), "On Models of Commercial Fishing," *Journal of Political Economy* 77, 181-198.

C. The relevance of open access for other resource systems

Smith, V. L. (1975). The primitive hunter culture, Pleistocene extinction, and the rise of agriculture. *The Journal of Political Economy*, 727-755.

D. Empirical Bioeconomics of Open Access

Wilen, J.E. (1976), "Common Property Resources and the Dynamics of Overexploitation: The Case of the North Pacific Fur Seal," University of British Columbia, Resources Paper No. 3, September 1976.

Bjorndal, T., and J.M. Conrad (1987), "The Dynamics of an Open Access Fishery," *Canadian Journal of Economics* 20:74-85.

Homans, F.R. and J.E. Wilen (1997), "A Model of Regulated Open Access Resource Use," *Journal of Environmental Economics and Management* 32:1-21.

Smith, M.D. (2008), "Bioeconometrics: Empirical Modeling of Bioeconomic Systems," *Marine Resource Economics*, 23:1-23, 2008

E. Stochastic Renewable Resource Models

Clark, pp. 343-349

Reed, W.J. (1979), "Optimal Escapement Levels in Stochastic and Deterministic Harvesting Models," *Journal of Environmental Economics and Management* 6:350-63.

Sethi, G. C. Costello, A. Fisher, M. Hanemann, L. Karp (2005), "Fishery Management Under Multiple Uncertainty," *Journal of Environmental Economics and Management* 50: 300-318.

September 24, 29, and October 1

D. Forest Economics and Rotational Harvesting

Clark, pp. 267-274

Samuelson, P.A. (1976), "Economics of Forestry in an Evolving Society," *Economic Inquiry* 14, 466-492.

Hartman, R. (1976), "The Harvesting Decision When a Standing Forest Has Value," *Economic Inquiry* 14:52-58.

Swallow, S.K. and D. Wear (1993), "Spatial Interactions in Multiple-Use Forestry and Substitution and Wealth Effects for the Single Stand," *Journal of Environmental Economics and Management* 25:103-120.

Provencher, B. (1995), "Structural Estimation of the Stochastic Dynamic Decision Problems of Resource Users: An Application to the Timber Harvest Decision," *Journal of Environmental Economics and Management* 29(3): 321-38.

Tahvonen, O. and S. Salo (1999), "Optimal forest rotation with in situ preferences," *Journal of Environmental Economics and Management* 37:106-128.

Clark, pp. 349-352

E. Rotational Beach Management

Smith, M.D., J.M. Slott, D. McNamara, and A.B. Murray (2009), "Beach Nourishment as a Dynamic Capital Accumulation Problem," *Journal of Environmental Economics and Management*

October 6, 8

E. Predator-Prey Models in Renewable Resource Economics

Clark, pp. 310-342

Ragozin, D.L. and G. Brown (1985), "Harvest Policies and Nonmarket Valuation in a Predator-Prey System," *Journal of Environmental Economics and Management* 12, 155-168.

Brander, J.A. and M. Scott Taylor (1998), "The Simple Economics of Easter Island: A Ricardo-Malthus Model of Renewable Resource Use," *American Economic Review* 88:1, 119-139.

Smith, M. D. (2007). Generating value in habitat-dependent fisheries: the importance of fishery management institutions. *Land Economics*, *83*(1), 59-73.

F. Cohort Models in Fisheries

Clark, pp. 275-309

Smith, M. D., Zhang, J., & Coleman, F. C. (2008). Econometric modeling of fisheries with complex life histories: Avoiding biological management failures. *Journal of Environmental Economics and Management*, *55*(3), 265-280.

October 13 – No Class for Fall Break

October 15, 20, 22, 27

H. Spatial Models in Renewable Resource Economics

Holland, Daniel S. and Richard J. Brazee (1996), "Marine Reserves for Fisheries Management," *Marine Resource Economics* 11, 157-171.

Sanchirico, J.N., and J.E. Wilen (1999), "Bioeconomics of Spatial Exploitation in a Patchy Environment," *Journal of Environmental Economics and Management* 37:129-50.

Smith, M.D. and J.E. Wilen (2003), "Economic Impacts of Marine Reserves: The Importance of Spatial Behavior," *Journal of Environmental Economics and Management* 46(2), 183-206.

Smith, M.D. (2005), "State Dependence and Heterogeneity in Fishing Location Choice," *Journal of Environmental Economics and Management* 50:319-340.

Smith, M. D., Sanchirico, J. N., & Wilen, J. E. (2009). The economics of spatial-dynamic processes: applications to renewable resources. *Journal of Environmental Economics and Management*, *57*(1), 104-121.

Costello,C. and S. Polasky (2008), "Optimal Harvesting of Stochastic Spatial Resources." *Journal of Environmental Economics and Management* 56.

Brock, W. and A. Xepapadeas, Diffusion-Induced Instability and Pattern Formation in Infinite Horizon Recursive Optimal Control. *Journal of Economics Dynamics and Control*, Forthcoming (2008).

IV. Stock Pollutants and Climate Change

Keeler, E., A.M. Spence and R. Zeckhauser (1972), "The Optimal Control of Pollution," *Journal of Economic Theory* 4:19-34.

Falk, I. and R. Mendelsohn (1993), "The Economics of Controlling Stock Pollutants: An Efficient Strategy for Greenhouse Gases," *Journal of Environmental Economics and Management* 25:76-88.

Mendelsohn, Robert, William D. Nordhaus, and Daigee Shaw (1994). "The impact of global warming on agriculture: a Ricardian analysis." *The American Economic Review* 84: 753-771.

Newell, R.G. and W.A. Pizer (2003), "Regulating Stock Externalities under Uncertainty," *Journal of Environmental Economics and Management* 45:416-432.

Chakravorty, U. J. Roumasset, and K. Tse (1997) "Endogenous Substitution among Energy Resources and Global Warming," *Journal of Political Economy* 105, No. 6 pp. 1201-1234.

V. Dynamic Games in Natural Resource Economics

Dockner, E. J., & Van Long, N. (1993). International pollution control: cooperative versus noncooperative strategies. *Journal of Environmental Economics and Management, 25*(1), 13-29.

Sethi, Rajiv, and Eswaran Somanathan. (1996) "The evolution of social norms in common property resource use." *The American Economic Review* 86: 766-788.

Huang, L. and M.D. Smith (2014). The dynamic efficiency costs of common-pool resource exploitation. *The American Economics Review* 104 (12), 4071-4103.

October 29, November 3 and 5

VI. Sustainability

A. Intergenerational Equity and Sustainability Paradigms

Heal, pp. 1-25, 36-93.

Solow, R.M. (1974), "Intergenerational Equity and Exhaustible Resources,"*Review of Economic Studies* 0, Symposium, 29-45.

Hartwick, J.M. (1977), "Intergenerational Equity and the Investing of Rents from Exhaustible Resources," *American Economic Review* 67:972-4.

Howarth, R.B. and R.B. Norgaard (1990), "Intergenerational Resource Rights, Efficiency, and Social Optimality," *Land Economics* 66, 1-11.

Chichilnisky, G., "An Axiomatic Approach to Sustainable Development," *Social Choice and Welfare* 13(2), 219-248, 1996.

Daly, H.E., "Forum: Georgescu-Roegen versus Solow/Stiglitz," *Ecological Economics* 22, 261-266, 1997.

Solow, R.M. "Reply: Georgescu-Roegen versus Solow/Stiglitz," *Ecological Economics* 22, 267-268, 1997.

B. Non-Constant Discounting

Heal, pp. 94-114

Weitzman, M.L. (2001), "Gamma Discounting," *American Economic Review* 91(1):260-271.

Cropper, M. and D. Laibson (1999), "The Implications of Hyperbolic Discounting for Project Evaluation," in P.R. Portney and J.P. and Weyant, eds. *Discounting and intergenerational equity*, Washington, D.C.: Resources for the Future, 163-172

Frederick, S., G. Loewenstein, and T. O'Donoghue(2002), "Time Discounting and Time Preference: A Critical Review," *Journal of Economic Literature* 40(2):351-401.

Karp, L. (2005). Global warming and hyperbolic discounting. *Journal of Public Economics*, 89(2), 261-282.

Karp, Larry (2015). "Provision of a Public Good with Multiple Dynasties." UC Berkeley Working Paper.

C. Empirical Analysis of Resource Scarcity and Measuring Sustainability

Dasgupta and Heal, pp. 439-470.

Weitzman, pp. 185-294

Heal, pp. 155-195

Hall, D.C. and J.V. Hall (1984), "Concepts and Measures of Natural Resource Scarcity with a Summary of Recent Trends," *Journal of Environmental Economics and Management* 11:363-379.

Halvorsen, R. and T.R. Smith (1991), "A test of the theory of exhaustible resources," *Quarterly Journal of Economics* 106:123-140.

Slade, M.E. and H. Thille (1997), "Hotelling Confronts CAPM, A Test of the Theory of Exhaustible Resources," *Canadian Journal of Economics* 30:685-708.

Asheim, G.B. (1994), "Net National Product as an Indicator of Sustainability," *Scandinavian Journal of Economics* 96:257-265.

Lofgren, K-G, T. Aronsson, and K. Backlund, "Resource Scarcity, National Accounting and Growth," Organized Session Paper, 2nd World Congress of Environmental and Resource Economists, 2002.

November 10, 13, 17

V. Political Economy and Trade

A. Trade and Natural Resources

Chichilnisky, Graciela. "North-south trade and the global environment." *The American Economic Review* (1994): 851-874.

Brander, James A., and M. Scott Taylor. "Open access renewable resources: trade and trade policy in a two-country model." *Journal of International Economics* 44.2 (1998): 181-209.

Karp, Larry, Sandeep Sacheti, and Jinhua Zhao. "Common ground between free-traders and environmentalists." *International Economic Review* (2001): 617-647.

B. Political Economy of Property Rights for Natural Resources

Johnson, Ronald N., and Gary D. Libecap. "Contracting problems and regulation: the case of the fishery." *The American Economic Review* (1982), 72(5): 1005-1022.

Libecap, G. D., & Wiggins, S. N. (1985). The influence of private contractual failure on regulation: the case of oil field unitization. *The Journal of Political Economy*, 690-714.

Bohn, Henning, and Robert T. Deacon. (2000) "Ownership risk, investment, and the use of natural resources." *American Economic Review* 90: 526-549.

Copeland, Brian R. and M. Scott Taylor. "Trade, Tragedy, and the Commons." *American Economic Review* 99, 3 (June 2009): 725-49.

November 19 and 24

Final Presentations

VI. Special Topics – Class Presentations Can be on One of These Topics or Students Can Work with the Instructor to Develop Another One

A. Economics of Biodiversity

Weitzman, M.L. (1998), "The Noah's Ark Problem," *Econometrica* 66(6), 1279-1298.

Polasky, S. J.D. Camm, and B. Garber-Yonts (2001), "Selecting Biological Reserves Cost-Effectively: An Application to Terrestrial Vertebrate Conservation in Oregon," *Land Economics* 77(1) February, 68-78.

Brock, W.A. and A. Xepapadeas (2003), "Valuing Biodiversity from an Economic Perspective: A Unified Economic, Ecological, and Genetic Approach," *American Economic Review* 93(5):1597-1614.

B. Option Value and Precaution

Arrow, K.J. and A.C. Fisher (1974), "Environmental Preservation, Uncertainty, and Irreversibility," *Quarterly Journal of Economics* 88:312-319.

Gollier, C. and N. Treich (2003), "Decision-Making Under Scientific Uncertainty: The Economics of the Precautionary Principle," *The Journal of Risk and Uncertainty* 27:77-103.

C. Renewable Resource Economics and Water

Zilberman, D. and L. Lipper (1999), "The Economies of Water Use," in J.C.J.M. van den Bergh, ed., *Handbook of environmental and resource economics*, Cheltenham, U.K. and Northampton, Mass.: Elgar, 141-158.

Provencher, B. and O. Burt (1993), "The Externalities Associated with Common Property Exploitation of Groundwater," *Journal of Environmental Economics and Management* 24:139-158.

D. Economics of Non-Convex Ecosystems

Dasgupta, P., and K.-G. Maler, "The Economics of Non-convex Ecosystems: Introduction," *Environmental and Resource Economics*, Special Issue Dec. 2003; 26(4): 499-525.

Brock,W.A. and D. Starrett, "Managing Systems with Non-convex Positive Feedback," *Environmental and Resource Economics*, Special Issue Dec. 2003; 26(4): 575-602.

Brock, W.A., K.-G. Maler, and C. Perrings, "Resilience and Sustainability: The Economic Analysis of Nonlinear Dynamic Systems," in L.H. Gunderson and C.S. Holling, editors, *Panarchy: Understanding Transformations in Human and Natural Systems*, Washington: Island Press, 2002.

Maler, K.-G., A. Xepapadeas, and A. de Zeeuw, "The Economics of Shallow Lakes," *Environmental and Resource Economics*, Special Issue Dec. 2003; 26(4): 603-624.