BIO 691, SOS 691, AML 691, ECN 691

Mathematical Natural Resource Economics

Fall 2014

Meeting times:	Tuesday, Thursday 10.30-11.45, TBA
Student credit hours:	3
Course instructors:	Charles Perrings (LSA 127) Charles.Perrings@asu.edu Joshua Abbott (GIOS 366) Joshua.k.abbott@asu.edu
Office hours:	Perrings: Tuesdays 1.00pm-3.00pm or by appointment Abbott: Thursdays 3:00-4:15 or by appointment
Prerequisites:	One of the following courses – or approved alternatives: BIO/AML 424/524 Mathematical Models in Ecology SOS 512 Sustainable Resource Allocation ECN 712 Microeconomics SOS 591 Dynamic modeling for sustainability sciences
Aims:	To introduce students to the principles and methods required to formulate and solve problems in the management of individual natural resources and natural resource systems.
Objectives:	(a) to develop students' understanding of the theory of economically efficient management of resource and resource systems, and command of the techniques required to formulate and solve problems in the field; (b) to develop students' understanding of the practice of resource management, and the way that it is affected by strategic behavior, property rights, institutions and market structures.
General description:	The course offers an advanced training in the economics of natural resources and natural resource systems, and in the application of the theory of optimal resource management to real socio-economic systems. Students will be expected to master the techniques of optimal control and stochastic dynamic programming, and to be able to apply these techniques to the management of real systems. They will also be expected to understand how the structure of property rights, institutions, and the strategic behavior of resource users affects the allocation and sustainability of resources. Finally, it examines the positive and normative economic literature on the management of spatially heterogeneous resources, focusing on the issue of the economic justification for terrestrial or marine reserves (under conditions of certainty or uncertainty) and

how the nature of this justification is highly dependent on the overarching institutions (property rights) of management.

The course comprises lectures and seminars. The first part of the course will be largely composed of lectures, supported four problem sets/clinics. The second part of the course will combine discussion of a number of extensions with student presentations of the ideas they are developing for their term papers.

Assessment: Problem sets: 20%

Mid term exam:40%
Term paper (and review): 40%

Readings: Some readings will be posted online; others you will given the citation and expect to retrieve the reading through the library website. For most of the basic theory we will draw on

Conrad, J. M., and C. W. Clark. 1987. Natural Resource Economics Notes and Problems. Cambridge University Press, New York.

It is highly recommend that you acquire a copy of this book (chapters will *not* be posted online).

Outline and readings Note: The starred references are required reading. Other references are there to help those who are interested in exploring a topic in greater depth to begin their literature search.

Introduction: The characteristics of environmental assets and the services deriving from those assets; differences between 'draw down' problems involving the extraction of single resources or harvested species, and 'sustainable use' problems involving multiple ecosystem services delivered at varying spatial and temporal scales.

Optimal resource use: (Abbott)

Optimal resource use in state-space bioeconomic models using discrete time Lagrangian methods; their relation to the Hamiltonian (discrete and continuous time); illustrations using logistic population dynamics; steady state and equilibrium conditions; numerical examples (simple fishery and mineral depletion) using Excel Solver and Mathematica.

*Conrad J.M. and Clark C.W. 1987. Natural Resource Economics, Cambridge, Cambridge University Press, Chs 1, 2.

*Conrad J. 1999. Resource Economics, Cambridge, Cambridge University Press: Chs 1,2.

Clark, C. 1990. Mathematical Bioeconomics. New York, John Wiley.

The Hotelling rule, extraction and conservation of natural resources (Perrings)

The Hotelling 'draw down' problem: optimal extraction of renewable and non-renewable resources with and without extraction costs; effects of uncertainty.

*Hotelling H. 1931. The Economics of Exhaustible Resources, Journal of Political Economy 39(2): 137-175.

*Dasgupta P.S. and Heal G.M. 1979. Economic Theory and Exhaustible Resources, Cambridge, Cambridge University Press: Ch 13-14.

Olson L.J. and Knapp K.C. 1997. Exhaustible resource allocation in an overlapping generations economy, Journal of Environmental Economics and Management 32: 277-292.

*Conrad, J. M., and C. W. Clark. 1987. Natural Resource Economics Notes and Problems. Cambridge University Press, New York.

Sustainable use of resources: (Perrings and Abbott)

The 'sustainability problem': sustainability with resource depletion; maintaining the value of assets where produced and natural assets are substitute or complements; the Solow-Hartwick rule; wealth and income measures;

*Hartwick, J.M. 1977. Intergenerational Equity and the Investing of Rents from Exhaustible Resources. American Economic Review, 66, 972-974.

Hartwick, J.M. 1978. Substitution Among Exhaustible Resources and Intergenerational Equity. Review of Economic Studies, 45, 2, 347-354.

*Solow, R.M. 1974. Intergenerational Equity and Exhaustible Resources. Review of Economic Studies, Symposium, 29-46.

*Dasgupta P. 2009. The Welfare Economic Theory of Green National Accounts, Environmental and Resource Economics 42: 3-38.

Hamilton K. and Clemens M. 1999. Genuine savings rates in developing countries. World Bank Econ Rev 13(2): 333–356.

Hartwick J.M. 2000 National accounting and capital. Edward Elgar, Cheltenham.

*Fenichel, E.P. and J.K. Abbott. 2014. Natural Capital: From Metaphor to Measurement. Journal of the Association of Environmental and Resource Economists. In press

Institutions and depletion: (Abbott)

Institutional and behavioral determinants of depletion: property rights, resource management under open access, common property & regulated open access, noncooperative extraction of shared resources.

Gordon, H. S. "The Economic Theory of a Common-Property Resource: The Fishery." The Journal of Political Economy 62, no. 2(1954): 124-142.

*Smith, V. L. "Economics of Production from Natural Resources." American Economic Review 58: 409-431.

*Weitzman, M. L. "Free Access Vs Private Ownership as Alternative Systems for Managing Common Property." Journal of Economic Theory 8, no. 2(1974): 225-234.

*Homans, F. R., and J. E. Wilen. "A Model of Regulated Open Access Resource Use." Journal of Environmental Economics and Management 32, no. 1(1997): 1-21.

Abbott, J. K. and J. E. Wilen. "Rent Dissipation and Efficient Rationalization in For-Hire Recreational Fishing." Journal of Environmental Economics and Management 58 (2009): 300-314.

Gisser, M. "Groundwater - Focusing on the Real Issue." Journal of Political Economy 91, no. 6(1983): 1001-1027.

*Boyce, J. "Individual Transferable Quotas and Production Externalities in a Fishery." Natural Resource Modeling 6, no. 4(1992): 385-408.

Strategic behavior: (Abbott)

The fundamental principles of non-cooperative and cooperative game theory applied to the problem of cooperation in the commons.

Levhari, D., and L. J. Mirman. "The Great Fish War – an Example Using a Dynamic Cournot-Nash Solution." Bell Journal of Economics 11, no. 1(1980): 322-334.

*Provencher, B., and O. Burt. "The Externalities Associated with the Common Property Exploitation of Groundwater." Journal of Environmental Economics and Management 24, no. 2(1993): 139-158.

Baland, J. M., and J. P. Platteau (2003) “Economics of Common Property Management Regimes” In, K. G. Maler, and J. R. Vincent, eds. Handbook of Environmental Economics, vol. 1. Amsterdam, Elsevier, pp. 127-190.

Polasky, S., et al. “Cooperation in the Commons.” Economic Theory 29, no. 1(2006): 71-88.

*Tarui, N., et al. “Cooperation in the Commons with Unobservable Actions.” Journal of Environmental Economics and Management 55, no. 1(2008): 37-51.

*McCarthy, N., E. Sadoulet, and A. de Janvry. “Common Pool Resource Appropriation under Costly Cooperation.” Journal of Environmental Economics and Management 42, no. 3(2001): 297-309.

Ostrom, E. Governing the Commons: The Evolution of Institutions for Collective Action. The Political Economy of Institutions and Decisions. New York: Cambridge University Press, 1990.

*Ostrom, E., J. Walker, and R. Gardner. “Covenants With and Without a Sword – Self-Governance is Possible.” American Political Science Review 86, no. 2(1992): 404-417.

Mason, C. F., and O. R. Phillips. “Mitigating the Tragedy of the Commons Through Cooperation: An Experimental Evaluation.” Journal of Environmental Economics and Management 34, no. 2(1997): 148-172.

Extension 1: (Abbott)

Resource management under spatial heterogeneity: the case for protected areas

*Sanchirico, J. N., and J. E. Wilen. “A Bioeconomic Model of Marine Reserve Creation.” Journal of Environmental Economics and Management 42, no. 3(2001): 257-276.

*Sanchirico, J., and J. E. Wilen. “Optimal Spatial Management of Renewable Resources: Matching Policy Scope to Ecosystem Scale.” Journal of Environmental Economics and Management 50, no. 1(2005): 23-46.

Costello, C., and S. Polasky. “Optimal Harvesting of Stochastic Spatial Resources.” Journal of Environmental Economics and Management 56, no. 1(2008): 1-18.

Grafton, R. Q., T. Kompas, and D. Lindenmayer. “Marine Reserves with Ecological Uncertainty.” Bulletin of Mathematical Biology 67, no. 5(2005): 957-971.

Extension 2: (Perrings)

Modeling disease control decisions; analyzing the contact rate in compartmental epidemiological models; pest surveillance and control.

*Fenichel E.P., Castillo-Chavez C., Ceddia M.G., Chowell G., Gonzalez Parra P.A., Hickling G.J., Holloway G., Horan R., Morin B., Perrings C., Springborn M., Velazquez L. & Villalobos C. (2011). Adaptive human behavior in epidemiological models. Proceedings of the National Academy of Sciences, 108, 6306-6311.

Horan R.D. & Melstrom R.T. (2011). No Sympathy for the Devil. Journal of Environmental Economics and Management, 62, 367-385.

Eisworth M.E. & Johnson W.S. (2002). Managing nonindigenous invasive species: insights from dynamic analysis. Environmental and Resource Economics, 23, 319-342.

Extension 3: (Abbott)

Incorporating greater realism into the economic models of resource management; the nexus between variations in the institutions of management and its behavioral and economic impacts on resource users. (Much of this work is econometric with many studies exploiting developments in microeconometrics and available data to model the (often spatial) behavior of resource users at a fine scale.

*Smith, M. D., and J. E. Wilen. "Economic Impacts of Marine Reserves: The Importance of Spatial Behavior." Journal of Environmental Economics and Management 46, no. 2(2003): 183-206

*Newell, R. G., J. N. Sanchirico, and S. Kerr. "Fishing Quota Markets." Journal of Environmental Economics and Management 49, no. 3(2005): 437-462.

*Alix-Garcia, J. "A Spatial Analysis of Common Property Deforestation." Journal of Environmental Economics and Management 53, no. 2(2007): 141-157.

Stavins, R. N., and A. B. Jaffe. "Unintended Impacts of Public-Investments on Private Decisions - the Depletion of Forested Wetlands." American Economic Review 80, no. 3(1990): 337-352.

Wilen, J. E., and F. R. Homans. "What do Regulators Do? Dynamic Behavior of Resource Managers in the North Pacific Halibut Fishery 1935-1978." Ecological Economics 24, no. 2-3(1998): 289-298.

Extension 4: (Perrings)

Exploiting multiple species systems; taking species interactions into account in optimal resource use decisions; two state variables and more, endogenous nonlinear feedback rules

*Dasgupta, P., and K. G. Maler. 2003. The economics of non-convex ecosystems: Introduction. Environmental and Resource Economics 26:499-525.

*Fenichel, E. P., and R. D. Horan. 2007. Jointly-determined ecological thresholds and economic trade-offs in wildlife disease management. Natural Resource Modeling 20:511-547.

Settle, C., T. D. Crocker, and J. F. Shogren. 2002. On the joint determination biological and economic systems. Ecological Economics 42:301-311.

*Finnoff, D., and J. Tschirhart. 2008. Linking dynamic economic and ecological general equilibrium models. Resource and Energy Economics 30:91-114.

Brock, W., and A. Xepapadeas. 2002. Optimal ecosystem management when species compete for limiting resources. Journal of Environmental Economics and Management 44:189-220.

Extension 5: (Perrings)

Spatially explicit models of the exploitation of ecosystems delivering multiple ecosystem services; papers from non-economic journals.

Nelson E., Mendoza G., Regetz J., Polasky S., Tallis H., Cameron D.R., Chan K.M.A., Daily G.C., Goldstein J., Kareiva P.M., Lonsdorf E., Naidoo R., Ricketts T.H. & Shaw M.R. (2009). Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. Front Ecol Environ, 7, 4-11.

Polasky S., Nelson E., Lonsdorf E., Fackler P. & Starfield A. (2003). Conserving species in a working landscape: land use with biological and economic objectives. Ecological Applications, 15, 1387-1401.

Polasky S., Nelson E., Camm J., Csuti B., Fackler P., Lonsdorf E., Montgomery C., White D., Arthur J., Garber-Yonts B., Haight R., Kagan J., Starfield A. & Tobalske C. (2008). Where to put things? Spatial land management to sustain biodiversity and economic returns. Biol Conserv, 141, 1505-1524.

Lecture/seminar schedule

8/21	TH	1	Introduction to the course	Perrings, Abbott
8/26	T	2	Introduction to Optimal Control: derivation of the Hamiltonian and its interpretation, the maximum principle, discounting	Abbott
8/28	TH	2	Introduction to Optimal Control: present and current value Hamiltonian, stability analysis of equilibria and phase plane diagrams	Abbott
9/2	T	3	Introduction to Optimal Control: continued from before AND introduction to numerical software	Abbott
9/4	TH	3	Linear control problems, singular solutions	Abbott
9/9	T	4	Canonical problems: optimal renewable resource use (fisheries and maybe Faustmann), the golden rule	Abbott
9/18	TH	4	The Hotelling rule and the conservation and use of natural resources	Perrings
9/16	T	5	The Hotelling rule extended to renewable resources	Perrings
9/18	TH	5	Canonical problems: forestry	Perrings
9/23	T	6	Uncertainty: expected utility and mean/variance models	Perrings
9/25	TH	6	Uncertainty: stochastic dynamic programming models	Perrings
9/30	T	7	Uncertainty: stochastic dynamic programming models continued	Perrings
10/2	TH	7	Sustainability: the Solow-Hartwick rule	Perrings
10/7	T	8	Sustainability: Measuring natural capital	Abbott
10/9	TH	8	Fall Break - NO CLASS	
10/14	T	9	Institutional determinants of depletion: Open access and regulated open access	Abbott
10/16	TH	9	Institutional determinants of depletion: sole ownership, taxes and quotas	Abbott
10/21	T	10	Institutional determinants of depletion: common property and strategic behavior	Abbott

10/23	TH	10	Institutional determinants of depletion: common property and strategic behavior	Abbott
10/28	T	11	Extension 1: Spatial models 1	Abbott
10/30	TH	11	Student led seminar	Abbott
11/4	T	12	Extension 2: Pests and pathogens	Perrings
11/6	TH	12	Student led seminar	Perrings
11/11	T	13	Extension 3: Behavioral realism & empirical models in resource economics	Abbott
11/13	TH	13	Student led seminar	Abbott
11/18	T	14	Thanksgiving - NO CLASS	
11/20	TH	14	Extension 4: Multiple species models	Perrings
11/25	T	15	Student led seminar	Perrings
11/27	TH	15	Extension 5: Spatial models 2	Perrings
12/2	T	16	Student led seminar	Perrings
12/4	TH	16	Review	Perrings, Abbott