

Economics 251
Natural Resource and Energy Economics

Course Description: This course examines issues in the provision and management of renewable natural resources (e.g., fish stocks and forests), non-renewable natural resources (e.g., oil, natural gas, and coal), and energy products and services (e.g, electricity and gasoline). It offers both theory and empirical methods related to: (1) market structure, pricing, and performance of important energy and resource industries; (2) sources of market failure in these industries; and (3) alternative regulatory approaches. Students are encouraged to take this course as part of a two-course sequence that includes Economics 250. Prerequisites: Economics 202, 203, 204, and a course in econometrics; or equivalent with consent of the instructor.

Contact Information:

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| Office Hours | Wed. 3:30-5:00 | By appointment |

Readings: Course readings are listed below. There is no textbook.

Prerequisite: Economics 202, 203, 204, and a course in econometrics; or equivalent with consent of the instructor.

Course Format and Grading:

Some key goals of the course are to acquaint students with key issues in natural resource and energy economics, to convey important theoretical and empirical findings, and to provide tools for continued research in these areas. Toward these ends, classes will involve lectures by the instructors, student presentations of specified readings, and class discussion. More specifically, parts of many of the class meetings will focus on a pre-assigned paper. We will ask all students to prepare and turn in at the beginning of class a “referee report” on the paper. In addition, one student will be assigned to present and lead a class discussion of the paper. This approach facilitates close reading and analysis of key papers and a good grasp of the important theoretical and empirical issues.

Grading:

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| Presentation: | 20% |
| Referee reports and class discussion: | 40% |
| Final exam: | 40% |

Note re Special Accommodation:

Students who have a physical, psychological, or learning disability that may necessitate an academic accommodation or the use of auxiliary aids and services in a class must initiate the request with the Disability Resource Center (DRC), not with the instructor. The DRC will evaluate the request along with the required documentation, recommend appropriate accommodations, and prepare a verification letter dated in the current academic term in which the request is being made. Students should contact the DRC as soon as possible as timely notice is needed to arrange for appropriate accommodations. The DRC is located at 563 Salvatierra Walk.

TOPICS AND READINGS

Note: The asterisk (*) identifies required readings, and the double-asterisk (**) identifies readings for referee reports and student presentations.

GENERAL THEMES AND PRINCIPLES

1. Introduction to Natural Resource and Energy Economics

(*) Perman, Roger, Yue Ma, James McGilvray, and Michael Common, *Natural Resource & Environmental Economics*. Ch. 6: "Market Failure and Public Policy," pp. 126-143. Essex: Pearson Education Limited, second edition.

Koopmans, Tjalling C., 1957. *Three Essays on the State of Economic Science*. Chapter I: "Allocation of Resources and the Price System." New York: McGraw-Hill.

2. Efficiency, Distribution, and Potential Roles for Government

(*) Goulder, Lawrence H., and Ian W. H. Parry, 2008. "Instrument Choice in Environmental Policy." *Review of Environmental Economics and Policy* 2(2).

(*) Goulder, Lawrence H., 2006. "Emissions Taxes, Tradable Emissions Allowances, and Technology Mandates: Comparing the Efficiency and Distributional Impacts." Course notes.

(*) Holland, S.P., J.E. Hughes, and C. Knittel, C., 2008. "Greenhouse Gas Reductions under Low Carbon Fuel Standards?," *The American Economic Journal, - Economic Policy* 1(1), February 2009.

Jaffe, Adam, and Robert N. Stavins, 1994. "The Energy Efficiency Gap: What Does It Mean?" *Energy Policy* 22:804-

ENERGY ECONOMICS

3. Introduction to Energy Markets: Market Power, Regulation and Deregulation

Borenstein Severin, James Bushnell, and Steven Stoft. "The Competitive Effects of Transmission Capacity in a Deregulated Electricity Industry." *Rand Journal of Economics*, Vol 31, No. 2, Summer 2000.

(*) Borenstein, Severin. 2002. "The Trouble with Electricity Markets: Understanding California's Restructuring Disaster," *Journal of Economic Perspectives*, 16(Winter).

(*) Borenstein, Severin, James Bushnell, and Frank Wolak. 2002. "Measuring Market Inefficiencies in California's Restructured Wholesale Electricity Market," *American Economic Review*, 92(5): 1376-1405.

Davis, Lucas W. and Catherine D. Wolfram. 2011. "Deregulation, Consolidation and Efficiency: Evidence from U.S. Nuclear Power," *Energy Institute at Haas Working Paper 217*.

(**) Referee report due January 18. Fabrizio, Kira R., Nancy L. Rose, and Catherine D. Wolfram. 2007. "Do Markets Reduce Costs? Assessing the Impact of Regulatory Restructuring on U.S. Electric Generation Efficiency." *American Economic Review*, 97(4), 1250-1277.

Joskow, Paul L. 1973. "Pricing Decisions of Regulated Firms: A Behavioral Approach." *Bell Journal of Economics* 4(1): 118-140.

Joskow, Paul L. 1997. "Restructuring, Competition and Regulatory Reform in the U.S. Electricity Sector." *Journal of Economic Perspectives* 11: 119-138.

Joskow, Paul L. and Nancy L. Rose. 1989. "The Effects of Economic Regulation." In *Handbook of Industrial Organization*, North Holland.

Rose, Nancy L. 1987. "Labor Rent-Sharing & Regulation: Evidence from the Trucking Industry," *Journal of Political Economy*, 95 (December): 1146-1178.

Wolfram, Catherine. 1999. "Measuring Duopoly Power in the British Electricity Spot Market." *American Economic Review*, 89(4): 805-826.

4. Electricity Markets: Supply

Bohn, R.E., Caramanis, M.C., and Schweppe, F.C., (1984) "Optimal Price Electrical Networks Over Space and Time," *Rand Journal of Economics*, volume 15, pp. 360-376.

Bulow, J. and Roberts, J. (1989) "Simple Economics of Optimal Auctions," *Journal of Political Economy*, volume 97, number 5, pp. 1060-1090.

(*) Bushnell, James, Erin Mansur and Celeste Saravia. 2008. "Vertical Arrangements, Market Structure, and Competition: An Analysis of Restructured U.S. Electricity Markets," *American Economic Review*, 98(1): 237-266.

Hortacsu, A. and Puller, S. L. (2008). Understanding Strategic Bidding in Multi-Unit Auctions: A Case Study of the Texas Electricity Spot Market. *The RAND Journal of Economics*, 39(1):86-114.

(*) Reguant, Mar. 2011. "The Welfare Effects of Complementary Bidding Mechanisms: An Empirical Analysis of the Spanish Wholesale Electricity Market"

Wolak, F. A. (2000). An Empirical Analysis of the Impact of Hedge Contracts on Bidding Behavior in a Competitive Electricity Market. *International Economic Journal*, 14(2):1-39.

Wolak, F. A. (2003). Identification and Estimation of Cost Functions Using Observed Bid Data: An Application to Competitive Electricity Markets, chapter 4, pages 133-169. Cambridge University Press.

Wolak, F. A. (2007). Quantifying the Supply-Side Benefits from Forward Contracting in Wholesale Electricity Markets. *Journal of Applied Econometrics*, 22:1179-1209.

5. Electricity Markets: Demand

Allcott, H. (2010). Rethinking Real-Time Electricity Pricing.

Borenstein, S. and Holland, S. (2005). On the Efficiency of Competitive Electricity Markets with Time-Invariant Retail Prices. *The RAND Journal of Economics*, 36(3):469-493.

Borenstein, S (2012) "The Redistributive Impact of Non-Linear Electricity Pricing", forthcoming in *American Economic Journal: Economic Policy*.

(*) Holland, S. P. and Mansur, E. T. (2008). Is Real-Time Pricing Green? The Environmental Impacts of Electricity Demand Variance. *The Review of Economics and Statistics*, 90(3):550-561.

(**) Referee report due January 25. Hortacsu, Ali, Seyed Ali Madanizadeh and Steve Puller. 2011. "Power to Choose: An Analysis of Consumer Behavior in the Texas Retail Electricity Market." *Working paper*.

Ito, Koichiro. 2011. Do Consumers Respond to Marginal or Average Price? Evidence from Nonlinear Electricity Pricing

Ito, Koichiro. 2011. The Effect of Financial Incentive on Energy Conservation: Evidence from Regression Discontinuity Design

Kahn, Matthew and Erin Mansur. "Do Local Energy Prices and Regulation Affect the Geographic Concentration of Employment? A Border Pairs Approach". Working Paper.

Reiss, P. and White, M. (2005). Household Electricity Demand, Revisited. *Review of Economic Studies*, 72(3):853-883.

Reiss, Peter and Matthew W. White, 2008. "What changes energy consumption? Prices and public pressures," *RAND Journal of Economics*, RAND Corporation, vol. 39(3), pages 636-663.

Wolak, F. A. (2006). Residential Customer Response to Real-Time Pricing: The Anaheim Critical-Peak Pricing Experiment.

(*) Wolak, F. A. (2010). An Experimental Comparison of Critical Peak and Hourly Pricing: The PowerCentsDC Program.

6. Economics of Renewable Energy

Borenstein, Severin. 2008. "The market value and cost of solar photovoltaic electricity production." Center for the Study of Energy Markets Working Paper

(*) Borenstein, Severin. 2011. "The Private and Public Economics of Renewable Energy." To be published in *Journal of Economic Perspectives* sometime in 2012.

Callaway, Duncan and Meredith Fowle. 2009. "Greenhouse Gas Emissions Reductions from Wind Energy: Location, Location, Location?" <http://nature.berkeley.edu/~fowle/papers.html>.

Callaway, Duncan S. 2009. "Tapping the energy storage potential in electric loads to deliver load following and regulation, with application to wind energy." *Energy Conversion and Management*, 50(5):1389--1400.

Cory, Karlynn and Paul Schwabe. 2009. "Wind Levelized Cost of Energy: A Comparison of Technical and Financing Input Variables." National Renewable Energy Laboratory Technical Report NREL/TP--6A2--46671. <http://www.nrel.gov/docs/fy10osti/46671.pdf>.

Cullen, J. A. (2010). Measuring the Environmental Benefits of Wind Generated Electricity

Energy Information Administration. 2011. "Levelized Costs in the Annual Energy Outlook 2011." http://205.254.135.24/oiaf/aeo/electricity_generation.html

Intergovernmental Panel on Climate Change Working Group III. 2011. *Special Report on Renewable Energy Sources and Climate Change Mitigation*. <http://srren.ipcc-wg3.de/>

(*) Joskow, Paul. 2011. "Comparing the Costs of Intermittent and Dispatchable Electricity Generation Technologies." Center for Energy and Environmental Research Working Paper 2010--013, Revised February 2011.

National Renewable Energy Laboratory. 2010. "Windpowering America: Estimates of Windy Land Area and Wind Energy Potential, by State, for areas $\geq 30\%$ Capacity Factor at 80m." http://www.windpoweringamerica.gov/docs/wind_potential_80m_30percent.xlsx.

(*) Novan, Kevin. "Valuing the Wind: Renewable Energy Policies and Air Pollution Avoided" (Job Market Paper). http://econ.ucsd.edu/~knovan/pdfs/Valuing_the_Wind.pdf

Schmalensee, Richard. Forthcoming. "Evaluating Policies to Increase the Generation of Electricity from Renewable Energy." *Review of Environmental Economics and Policy*.

Wiser, Ryan, Galen Barbose, Carla Peterman, and Naim Darghouth. 2009. "Tracking the Sun II: The Installed Cost of Photovoltaics in the U.S. from 1998 - 2008." Lawrence Berkeley National Laboratory Paper LBNL---2674E. <http://eetd.lbl.gov/ea/emp/reports/lbnl--2674e.pdf>

7. Oil and Gasoline Markets

Anderson, Soren T., Ryan Kellogg, and James M. Sallee, "What Do Consumers Believe About Future Gasoline Prices?" working paper (2010).

(*) Borenstein, S., Cameron, C., and Gilbert, R. (1997) "Do Gasoline Prices Respond Asymmetrically to Crude Oil Price Changes?" *Quarterly Journal of Economics*, vol.112, 305-339.

Borenstein, S. and Shepard, A, (1996) "Dynamic Pricing in Retail Gasoline Markets," *RAND Journal of Economics*, vol. 27, No. 3, 429-451.

Borenstein, S. and Shepard, A, (1996) "Sticky prices, inventories, and market power in wholesale gasoline markets," *RAND Journal of Economics*, vol. 33, No. 1, 116-139.

Borenstein, S., Bushnell J. and Lewis, M. (2005), "Market Power in California's Gasoline Market, CSEM Working Paper No. 132 (available at <http://www.ucei.berkeley.edu/PDF/csemwp132.pdf>)

Cuddington, J.T. and Moss, D.L. (2001) "Technological Change, Depletion, and the U.S. Petroleum Industry," *American Economic Review*, 1135-1148 ([cuddington_and_moss.pdf](http://www.aeaweb.org/articles.php?doi=10.1257/aer.91.5.1135))

Griffin, J.M. and Xiong, W. (1997) "The Incentive to Cheat: An Empirical Analysis of OPEC," *Journal of Law and Economics*, 40(2), 289-316.

Hamilton, J. (2008) "Understanding Crude Oil Prices," Department of Economics, UC-San Diego. ([understand_oil.pdf](http://www.econ.ucsd.edu/~jhamilton/understand_oil.pdf)).

(*) Hastings, Justine, "Vertical Relationships and Competition in Retail Gasoline Markets: Empirical Evidence from Contract Changes in Southern California." *American Economic Review*, March 2004.

Hastings, Justine and Jesse Shapiro, "Wholesale Price Discrimination and regulation: Implications for Retail Gasoline Prices." Working Paper. April (2008).

Hastings, Justine and Jesse Shapiro, "Mental Accounting and Consumer Choice: Evidence from Commodity Price Shocks." Working Paper. April (2011).

Hughes, Jonathan E., Christopher R. Knittel, and Daniel Sperling, "Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand," *Energy Journal* 29 (2008).

Kellogg, Ryan, "Learning by Drilling: Inter-Firm Learning and Relationship Persistence in the Texas Oilpatch," *Quarterly Journal of Economics* 126 (Nov., 2011), 1961-2004.

(**) Referee report due Feb 1. Kellogg, Ryan, "The Effect of Uncertainty on Investment: Evidence from Texas Oil Drilling," NBER working paper #16541 (2010).

Lewis, M., (2004) "Asymmetric Price Adjustment and Consumer Search: An Examination of the Retail Gasoline Market, May 2004 (available at <http://economics.sbs.ohio-state.edu/mlewis/APACS 9-1-04.pdf>)

Lewis, Matthew and Howard P. Marvel, "When Do Consumers Search?," *Journal of Industrial Economics*, 59 (3), September 2011: 457-483.

Lewis, Matthew and Michael Noel, "The Speed of Gasoline Price Response in Markets with and without Edgeworth Cycles," *Review of Economics and Statistics*, 93 (2), May 2011: 672-682.

8. Fuel Economy Standards and Automobile Markets

Allcott, Hunt and Nathan Wozny, "Gasoline Prices, Fuel Economy, and the Energy Paradox," working paper (2010).

Anderson, Michael and Max Auffhammer, "Pounds that Kill: The External Costs of Vehicle Weight", NBER Working Paper 17170

(*) Anderson, Soren T. and James M. Sallee, "Using Loopholes to Reveal the Marginal Cost of Regulation: The Case of Fuel Economy Standards," *American Economic Review*, forthcoming (2011).

Bento, Antonio M., Lawrence H. Goulder, Mark R. Jacobsen, and Roger H. von Haefen, "Distributional and Efficiency Impacts of Increased US Gasoline Taxes," *American Economic Review* 99 (2009), 667-699.

Berry, Steven, James Levinsohn, and Ariel Pakes, "Automobile Prices in Market Equilibrium," *Econometrica* 63 (1995), 841-890.

(**) Referee report due Feb 8 Busse, Meghan R., Christopher R. Knittel, and Florian Zettelmeyer, "Pain at the Pump: The Differential Effect of Gasoline Prices on New and Used Automobile Markets," NBER working paper 15590 (2009).

Davis, Lucas W. and Matthew E. Kahn, "International Trade in Used Vehicles: The Environmental Consequences of NAFTA," working paper (2010).

Goldberg, Pinelopi Koujianou, "The Effects of the Corporate Average Fuel Efficiency Standards in the US," *Journal of Industrial Economics* 46 (Mar., 1998), 1-33.

Holland, Hughes and Knittel. 2009. "Greenhouse Gas Reductions under Low Carbon Fuel Standards?," *The American Economic Journal: Economic Policy*, 1(1), February 2009, pp. 106-146.

Knittel, Christopher R., "Automobiles on Steroids: Product Attribute Trade-Offs and Technological Progress in the Automobile Sector," NBER working paper 15162 (2009).

(*) Knittel, Christopher R., "Reducing Petroleum Consumption from Transportation," forthcoming *Journal of Economic Perspectives*.

Langer, Ashely and Nathan Miller, "Automakers' Short-Run Responses to Changing Gasoline Prices and the Implications for Energy Policy," working paper (2009).

Li, Shanjun, Christopher Timmins, and Roger H. von Haefen, "How Do Gasoline Prices Affect Fleet Fuel Economy?" *American Economic Journal: Economic Policy* 1 (2009), 113-137.

Sallee, James M., "The Surprising Incidence of Tax Credits for the Toyota Prius," *American Economic Journal: Economic Policy*, forthcoming (2011).

9. Energy Efficiency

Baughman, M., and P. Joskow. "The Effects of Fuel Prices on Residential Appliance Choice in the United States." *Land Economics* 51, no. 1 (1975): 41-49.

Eichholtz Piet, Nils Kok and John M. Quigley "The Economics of Green Building" *Review of Economics and Statistics*, forthcoming

Gillingham, Kenneth, Richard G. Newell and Karen Palmer. 2006. Energy Efficiency Policies: A Retrospective Examination. *Annual Review of Environment and Resources*. 31: pp.161-92.

(*) Gillingham, Kenneth, Richard G. Newell and Karen Palmer. 2009. Energy Efficiency Economics and Policy. *Annual Review of Resource Economics*, In Press.

Jaffe, Adam B., and Robert N. Stavins. 1994. "The energy-efficiency gap: What does it mean?" *Energy Policy* 22 (10): 804-811.

(*) Davis, Lucas. 2008. Durable Goods and Residential Demand for Energy and Water: Evidence from a Field Trial, *RAND Journal of Economics*, 39(2), 530-546.

Davis, Lucas (2012) Evaluating the Slow Adoption of Energy Efficient Investments: Are Renters Less Likely to Have Energy Efficient Appliances? in "The Design and Implementation of U.S. Climate Policy," Fullerton, D. and C. Wolfram (eds.), University of Chicago Press, forthcoming

Hausman, Jerry. 1979. Individual Discount Rates and the Purchase and Utilization of Energy Using Durables," *Bell Journal of Economics*, vol. 10(1), 33-54.

Joskow, Paul L., and Donald B. Marron. 1993. "What does a negawatt really cost? Evidence from Utility Conservation Programs." *The Energy Journal* 13 (4): 41-74.

(*) Kok Nils, Marquise McGraw and John M. Quigley. "The Diffusion of Energy Efficiency in Building." *American Economic Review*, 101(2), 2011

Metcalf, G., and K. Hassett (1999). "Measuring the Energy Savings From Home Improvement Investments: Evidence From Monthly Billing Data." *The Review of Economics and Statistics* 81(3): 516-528.

Newell, Richard, Adam Jaffe and Robert Stavins. 1999. The Induced Innovation Hypothesis and Energy-Saving Technological Change. *Quarterly Journal of Economics*, volume 114, issue 3, August 1999, pp. 941-975.

Train, Kenneth. 1985. "Discount Rates in Consumers' Energy-Related Decisions: A Review of the Literature." *Energy* 10 (12): 1243-1253

Jacobsen Grant and M. J. Kotchen. 2010. Are Building Codes Effective at Saving Energy? Evidence from Residential Billing Data in Florida, NBER Working Paper No. 16194, July 2010.

10. R&D and Innovation in Energy Markets

(**) Referee report due Feb 15. Fowlie, Meredith 2010. "Emissions Trading, Electricity Restructuring, and Investment in Pollution Abatement", *American Economic Review* 100 (June 2010): 837-869

Goulder, Lawrence H. and Stephen H. Schneider, 1999. "Induced technological change and the attractiveness of CO2 abatement policies," *Resource and Energy Economics* 21 pp. 211-253.

Goulder, L.H., Mathai, K. (2000). "Optimal CO₂ abatement in the presence of induced technological change". *Journal of Environmental Economics and Management* 39, 1-38.

Jaffe, A.B., Palmer, K. (1997). "Environmental regulation and innovation: A panel data study". *Review of Economics and Statistics* 79, 610-619.

Jaffe, A.B., Stavins, R.N. (1994). "The energy paradox and the diffusion of conservation technology". *Resource and Energy Economics* 16, 91-122. □

Jaffe, A.B., Stavins, R.N. (1995). "Dynamic incentives of environmental regulations: The effects of alternative policy instruments on technology diffusion". *Journal of Environmental Economics and Management* 29, S43-S63.

(*) Jaffe, A.B., Newell, R.G., Stavins, R.N. (2003). "Technological change and the environment". In: Maler, K.-G., Vincent, J. (Eds.), *Handbook of Environmental Economics. Handbooks in Economics Series* (Arrow, K.J., Intriligator, M.D., Series Eds.), vol. 1. North-Holland/Elsevier, Amsterdam, pp. 461-516.

Jaffe, A.B., Newell, R.G., Stavins, R.N. (2005). "A tale of two market failures: Technology and environmental policy". *Ecological Economics* 54, 164-174.

Jaffe, A.B. (2011). "Technology Policy and Climate Change". *The Next Round of Climate Economics & Policy Research* Washington, D.C. October 27-28, 2011

Moser, Petra and Tom Nicholas. "Was Electricity a General Purpose Technology? Evidence from Historical Patent Citations", □ *The American Economic Review, Papers and Proceedings*, May 2004, vol.94, no.2, pp.388-394

Newell, R., Jaffe, A., Stavins, R. (1999). "The induced innovation hypothesis and energy-saving technological change". *The Quarterly Journal of Economics* 114 (3), 941-975.

Popp, D. (2002). "Induced innovation and energy prices". *American Economic Review* 92 (1), 160-180.

(*) Popp, David, Richard Newell and Adam Jaffe, 2010. "Energy, the environment, and technological change," in Hall, Bronwyn H. and Nathan Rosenberg, eds., *Handbook of the Economics of Innovation*, North Holland, <http://fds.duke.edu/db/attachment/1682>

Rose, N., Joskow, P. (1990). "The diffusion of new technologies: Evidence from the electric utility industry". *Rand Journal of Economics* 21, 354-373.

MANAGEMENT OF NONRENEWABLE AND RENEWABLE RESOURCES

11. Nonrenewable Resource Management

(**) Referee report due February 20. Fisher, Anthony C., 1981. *Resource and Environmental Economics*. Cambridge: Cambridge University Press. Ch. 2, pp. 10-36.

Dasgupta, Partha S., and Geoffrey M. Heal. 1979. *Economic Theory and Exhaustible Resources*. Cambridge, England: Cambridge University Press. Ch. 6.

Grafton, R. Quenton, Wiktor Adamowicz, Diane Dupont, Harry Nelson, Robert J. Hill, and Steven Renzetti, *The Economics of the Environment and Natural Resources*, chapter 7.

Hotelling, Harold. 1931. "The Economics of Exhaustible Resources." *Journal of Political Economy* 39, pp. 137-175.

(*) Solow, Robert M. 1974. "The Economics of Resources or Resources of Economics." *American Economic Review* 64, pp. 1-14.

(*) Miller, Merton H. and Charles W. Upton. February 1985. "A Test of the Hotelling Valuation Principle," *Journal of Political Economy* 93 (1), pp. 1-25.

(*) Fisher, *op. cit.*, ch. 2, pp. 37-74.

Weinstein, M. C. and R. Zeckhauser, 1975. "Optimal Consumption of Depletable Resources." *Quarterly Journal of Economics* 89, pp. 371-92.

12. Renewable Resource Management: The Fishery

a. Theory

(*) Grafton *et al.*, *op. cit.*, chapter 4.

Clark, Colin W., *Mathematical Bioeconomics: The Optimal Management of Renewable Resources*, (John Wiley and Sons, 1990). Chapters 1 and 2.

Gordon, H.S., "The Economic Theory of a Common Property Resource: The Fishery," *Journal of Political Economy* (1954), pp. 124-142.

Clark, C.W., 1973. "Profit Maximization and the Extinction of Animal Species," *Journal of Political Economy*.

Munro, Gordon R. and Anthony Scott. 1985. "The Economics of Fisheries Management." In *Handbook of Natural Resources and Energy Economics*, vol. II, edited by A.V. Kneese and J.L. Sweeney. New York: Elsevier Science Publishers.

Homans, Frances R. and James Wilen, "A Model of Regulated Open Access Resource Use," *JEEM*, vol. 32(1), pp. 1-21, (1997).

Clark, Colin and G Munro, "The Economics of Fishing and Modern Capital Theory: A Simplified Approach," *JEEM*, vol. 2 (1975), pp. 92-106.

b. Policy:

1. Individual Fishing Quotas

(**) Referee report due February 27. Costello, Chris, Robert Gaines, and John Lynham, 2008. "Can Catch Shares Prevent Fisheries Collapse?" *Science* 321(5896):1678-1681.

Newell, Richard G., James N. Sanchirico and Suzi Kerr 'Fishing Quota Markets' *Journal of Environmental Economics and Management* Vol. 49 pp. 437-462, 2005

Grafton, R. Quentin, Tom Kompas, and Ray Hilborn, 2007. "Economics of Overexploitation Revisited." *Science* 318 (5856): 1601.

Hastings and Botsford (1999) "Equivalence in Yield from Marine Reserves and Traditional Fisheries Management", *Science*.

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

Sanchirico, J.N., D. Holland, K. Quigley, and M. Fina. Catch-quota balancing in Multispecies Individual Fishing Quotas. *Marine Policy* 30(6): 767-785, 2006.

Grafton, R.Q., D. Squires, and K. Fox. 2000. "Private Property and Economic Efficiency: A Study of a Common-Pool Resource." *Journal of Law and Economics* 43(2): 679-713.

2. Marine Reserves and Spatial Modeling

(*) "Effectiveness of Marine Reserves for Large-Scale Fisheries Management", *Canadian Journal of Fisheries and Aquatic Sciences*.

Sanchirico, James and James E. Wilen, "Bioeconomics of Spatial Exploitation in a Patchy Environment," *JEEM*, 37(2), March 1999 pp. 129-150.

Sanchirico, James and J. Wilen. "A Bioeconomic Model of Marine Reserve Creation," *JEEM*, 42(3), 2001. pp. 257-76.

Smith, Martin D., James N. Sanchirico, and James E. Wilen (2009) The economics of spatial-dynamic processes: Applications to renewable resources *Journal of Environmental Economics and Management* 57 pp. 104-121

NATURAL RESOURCES, LONG-RUN GROWTH, AND WELFARE

13. Resource Scarcity and Economic Growth

(**) Referee report due March 5: Nordhaus, William. "Lethal Model 2: The Limits to Growth Revisited," *Brookings Papers on Economic Activity* 2:1992.

(*) Fisher, *op. cit.*, ch. 4, sections 4 and 5.

Dasgupta and Heal, *op. cit.*, ch. 7.

Grafton *et al.*, chapter 11.

14. Sustainability: Concepts, Measures, and Policy Implications

Grafton *et al.*, chapter 12.

(*) Solow, Robert M., 2000. "Sustainability: An Economist's Perspective." In *Economics of the Environment: Selected Readings*. (New York: W. W. Norton, Second Edition.)

(*) Arrow, Kenneth, Partha Dasgupta, Gretchen Daily, Paul Ehrlich, Lawrence Goulder, Geoffrey Heal, Simon Levin, Karl-Goran Maler, Stephen Schneider, David Starrett, and Brian Walker, 2004. "Are We Consuming Too Much?" *Journal of Economic Perspectives*, Summer 2004.

Arrow, Kenneth, Partha Dasgupta, Lawrence Goulder, Kevin Mumford, and Kirsten Oleson, "Sustainability and the Measurement of Wealth." Working paper, Stanford University, June 2010.

Brock, H. and M. Scott Taylor, 2003. "The Kindergarten Rule of Sustainable Growth." Working paper, Department of Economics, University of Wisconsin.

Stiglitz, Joseph E., Amartya Sen, and Jean-Paul Fitoussi (2009) Report by the Commission on the Measurement of Economic Performance and Social Progress. Available at <http://www.stiglitz-sen-fitoussi.fr/en/index.htm>.