

ENVIRONMENTAL AND RESOURCE ECONOMICS

Requirements and Schedule

1. **Time and Location:** TuTh 930-11A in 201 Giannini (Thursday, Nov 28 is a holiday)
2. **Prerequisites:** Econ 201AB or ARE 201 and 202 or equivalent preparation. Minimal preparation is completion of a calculus-based course in microeconomics (e.g., EEP 100 or Econ 101A) and a corresponding background in mathematics (e.g., Math 53 and 54).
3. A 20 minute (and no longer) **presentation** of a paper that is or should be on the reading list, but is not a paper we are planning on covering in depth in lecture. The topic must be cleared with an instructor. The presentation will be **20 %** of the final grade. The presentations must be distributed across the term. Everybody will have to pick a topic and a slot within the first two weeks of the semester.
4. There will be a **problem set approximately every other week**. The problem sets will count for **30%** of the grade.
5. A **final exam** will be given at the end of the semester. The exam will count **50%** of the final grade. The exam will be held during the last class, **Dec 5th at 9:30am** and will be due back to us by noon.
6. **Optional:** You can write a term paper. The term paper will count **25%** of your grade and other items rescale accordingly. The term paper is either a thorough literature review of a topic in the field (and should get you started to find your own research question), or it outlines a research idea, putting it into context and sketching model and methods. The paper is approximately 10 pages long, 12pt, double spaced. If you want to write this optional term paper you have to declare it and find a topic of consent within the first 2-3 weeks of class. This shifts your grading scale irreversibly.
7. **Office hours:**
 - Karp, 330 Giannini Hall (karp@berkeley.edu), Tuesday, 2 – 3.30 and by appointment.
 - Traeger, 322 Giannini Hall (510/642-9781; traeger@berkeley.edu), Wednesday, 11:00-12:00 pm, and by appointment.

Course Outline

1. Taxes versus Quantities in a Static Setting & some Application
2. The Maximum Principle & Stock Pollution
3. Fishery & some Numerics (collocation method & ODE's)
4. Non-Renewable Resources & some Numerics (Discrete Time Dynamic Programming)
5. Integrated Assessment of Climate Change (IAM)
6. Uncertainty (incl. IAM, Taxes versus Quantities in a Dynamic Setting)
7. Social Discounting
8. Imperfect Property Rights
9. International Trade and the Environment

Books on Reserve

N. Hanley, J.F. Shogren, and B. White, Environmental Economics in Theory and Practice. Palgrave Macmillan, 2nd edition 2007.

J.M. Conrad and C.W. Clark. Natural Resource Economics. Cambridge: Cambridge University Press, 1987.

R. Perman, Y. Ma, J. Mc Gilvray, M. Common. Natural Resource and Environmental Economics. Pearson, 3rd edition 2003.

M. Kamien and N. Schwartz, Dynamic Optimization, 2nd ed, North Holland.

C. Clark, Mathematical Bioeconomics, 2nd ed, Wiley.

M. Miranda and P. Fackler, Applied Computational Economics and Finance, MIT Press, 2002

A. Chiang, Elements of Dynamic Optimization, McGraw Hill.

J. Stachurski, Economic Dynamics: Theory and Computation, MIT Press, 2009.

Topics and Readings:

1. Taxes versus Quantities in a Static Setting & some Application:

M. Weitzman (1974), Prices vs. Quantities, *Review of Economic Studies* 41: 477-491.

Lecture notes* (bSpace). Linear Quadratic, pages 1 – 11.

Some political economy considerations (climate change policy):

<http://are.berkeley.edu/~karp/SuggestionsCopenhagenJune09.pdf>

Chapter 4

R. Perman, Y. Ma, J. Mc Gilvray, M. Common. *Natural Resource and Environmental Economics*. Pearson, 3rd edition 2003. Chapters 7 and 8.

2. The Maximum Principle and Stock Pollution: This section is an introduction to optimal control theory (Pontryagin's maximum principle). We will apply the theory to a simple stock pollutant problem, explaining phase space diagrams.

*Lecture Notes

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

M. Kamien and N. Schwartz, *Dynamic Optimization*, North Holland, 1991, part II, sections 1 – 9.

Seierstad and Sydsæter. *Optimal Control Theory With Economic Applications*, North-Holland, 1987.

A.C. Chiang, *Elements of Dynamic Optimization*, McGraw Hill, 1999, chapters 7 – 9.

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

U. Moslener and T. Requate (2007), “Optimal abatement in dynamic multi-pollutant problems when pollutants can be complements or substitutes”. *Journal of Economic Dynamics and Control*: 31(7), Pages 2293-2316.

T. Goeschl and G. Perino (2007), “Innovation without magic bullets: Stock pollution and R&D sequences.” *Journal of Environmental Economics and Management*, Vol. 54(2), Pages 146-161

P. Dasgupta, P. Hammond and E. Maskin (1980), On imperfect information and optimal pollution control, *Review of Economics Studies* 47, 857-860.

P. Dasgupta and K.G. Maler (2003), The Economics of Non-Convex Ecosystems: Introduction, *Environmental and Resource Economics* 26: 499–525.

3. Fishery & some Numerics: This section introduces optimal extraction of renewable resources, in particular, fishery. We introduce the collocation method to numerically solve boundary value problems that derive from the maximum principle.

C. Clark, *Mathematical Bioeconomics*, 2nd ed, Wiley. Chapters 1,2, and 4

N. Hanley, J. Shogren, and B. White. *Environmental Economics in Theory and Practice*, 2nd Edition. Palgrave/Macmillan, 2007, Chapter 9..

R. Perman, Y. Ma, J. Mc Gilvray, M. Common. *Natural Resource and Environmental*. Chapter 17.

R. Arnason (1990). Minimum information management in fisheries. *Canadian Journal of Economics*, 23(3):630-653.

J. R. Boyce (1992). Individual transferable quotas and production externalities in a fishery. *Natural Resource Modeling*, 6(4):385-408.

C. W. Clark (1973). Profit Maximization and the Extinction of Animal Species. *The Journal of Political Economy*, (4), 950–961.

P. Copes (1972). Factor Rents, Sole Ownership and the Optimum Level of Fisheries Exploitation. *The Manchester School of Economic & Social Studies*, 40(2), 145–163.

C. Costello, Gaines, S. D., and Lynham, J. (2008). Can catch shares prevent fisheries collapse? *Science*, 321(5896):1678-1681.

R.G. Felthoven, and Morrison Paul, C. J. (2004). Directions for productivity measurement in fisheries. *Marine Policy*, 28(2):161-169.

H. S. Gordon (1954). The Economic Theory of a Common-Property Resource: The Fishery. *The Journal of Political Economy*, 62, 124–142.

R. Hannesson (1984). Bioeconomic production function in fisheries: Theoretical and empirical analysis. *Canadian Journal of Fisheries and Aquatic Sciences*, 40, 969–982.

- F. R. Homans, and Wilen, J. E. (1997). A model of regulated open access resource use. *Journal of Environmental Economics and Management*, 32(1):1-21.
- S. Polasky, de Zeeuw, A., and Wagener, F. (2011). Optimal management with potential regime shifts. *Journal of Environmental Economics and Management*, 62(2):229-240.
- M.F. Quaas & Requate, T. (2013). Sushi or Fish Fingers? Seafood Diversity, Collapsing Fish Stocks, and Multispecies Fishery Management. *The Scandinavian Journal of Economics*, 115(2), 381–422.
- W. J. Reed (1979). Optimal escapement levels in stochastic and deterministic harvesting models. *Journal of Environmental Economics and Management*, 6, 350–363.
- J.N. Sanchirico and J.E. Wilen (2001). A bioeconomic model of marine reserve creation. *Journal of Environmental Economics and Management*, 42, 257–276.
- G. Sethi, Costello, C., Fisher, A., Hanemann, M., and Karp, L. (2005). Fishery management under multiple uncertainty. *Journal of Environmental Economics and Management*, 50(2):300-318.
- A. Scott, (1955). The Fishery: The Objectives of Sole Ownership. *The Journal of Political Economy*, 63(2):116{124.
- O. Tahvonen (2009). Economics of harvesting age-structured fish populations. *Journal Of Environmental Economics And Management*, 58(3), 281–299.
- J. E. Wilen (2000). Renewable resource economists and policy: What differences have we made? *Journal of Environmental Economics and Management*, 39(3), 306–327.

Collocation and ODE solving:

M. Miranda and P. Fackler, *Applied Computational Economics and Finance*, MIT Press, 2002

4. Nonrenewable Resources & some Numerics: This section treats socially optimal resource extraction as well as extraction under different market structures. It briefly discusses the green paradox. One of the lectures introduces discrete time dynamic programming as well as a numeric solution approach (function iteration).

N. Hanley, J. Shogren, and B. White. *Environmental Economics in Theory and Practice*, 2nd Edition. Palgrave/Macmillan, 2007, Chapter 7, Chapter 8.

J.M. Conrad and C.W. Clark. *Natural Resource Economics*. Cambridge: Cambridge University Press, 1987, Chapter 3.

- G. Gaudet (2007). "Natural resource economics under the rule of Hotelling". *Canadian Journal of Economics* 40: 1033-1059.
- G. Gaudet and A.M. Khadr (1991). "The Evolution of Natural Resource Prices under Stochastic Investment Opportunities - An Intertemporal Asset-Pricing Approach." *International Economic Review* 32(2): 441-455.
- R. Gerlagh (2011), "Too much oil", *CESifo Economic Studies* 57: 79-102.
- R. Gerlagh and M. Liski (2011), "Strategic Resource Dependence." *Journal of Economic Theory* 146(2): 699-727.
- M. Hoel (2009), "Bush meets Hotelling: Effects of improved renewable energy technology on greenhouse gas emissions." *CESifo Working Paper* 2492.
- HW Sinn (2008), "Public policies against global warming: a supply side approach", *International tax and public finance* 15: 360-394.
- R.M. Solow (1974), "Richard T. Ely Lecture: The Economics of Resources or the Resources of Economics." *American Economic Review*, No. 64, pp. 1-14.
- X R. M. Solow (1974), "Intergenerational Equity and Exhaustible Resources." *Review of Economic Studies*, 41: 29-46.
- R.M. Solow and F.Y. Wan. 1976. Extraction costs in the theory of exhaustible resources. *Bell Journal of Economics* 7, 359-370.
- P. Berck and M. Roberts (1996), "Natural Resource Prices: Will They Ever Turn Up?" *Journal of Environmental Economics and Management*, Vol. 30, pp. 65-78.
- M.H. Miller and C.W. Upton (1985), "A Test of the Hotelling Valuation Principle." *Journal of Political Economy*, No. 93, pp. 1-25.
- R. Halvorsen and T.R. Smith (1991), "A Test of the Theory of Exhaustible Resources." *The Quarterly Journal of Economics*, pp. 123-140.
- C. Withagen (1998), "Untested Hypotheses in Non-Renewable Resource Economics." *Environmental and Resource Economics*, Vol. 11, pp. 623-634.

Dynamic Programming & Function Iteration:

- M. Miranda and P. Fackler, *Applied Computational Economics and Finance*, MIT Press, 2002
- J. Stachurski, *Economic Dynamics: Theory and Computation*, MIT Press, 2009.
- N. Stokey and R. Lucas, *Recursive Methods in Economic Dynamics*, Harvard University Press, 1989

5. Integrated Assessment of Climate Change (IAM): This section discusses models of economic growth that integrate climate and analyze climatic change. We start with a brief overview of climate change. Then, first, we discuss the analytic IAM of Golosov et al. and, second, we discuss the numeric IAM DICE by Nordhaus.

*IPCC. "Climate Change 2007: The Physical Science Basis," Summary for Policymakers. *Fourth Assessment Report of the United Nations Intergovernmental Panel on Climate Change*, Working Group I, 2007a.

*M. Golosov, J. Hassler, P. Krusell, and A. Tryvinki (2011). "Optimal Taxes on Fossil Fuel in General Equilibrium. NBER Working Paper No 17348.

(*)W.D. Nordhaus. *A Question of Balance: Weighing the Options on Global Warming Policies*, Yale University Press, New Haven, CT, 2008.

R. Gerlagh and M. Liski (2012), "Carbon Prices for the Next Thousand Years", CESifo Working Paper Series No. 3855

J. Hassler and P. Krusell (2012), Economics and Climate Change - Integrated assessment in a multi-region world, NBER Working Paper 17757.

IPCC. "Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability," Summary for Policymakers. *Fourth Assessment Report of the United Nations Intergovernmental Panel on Climate Change*, Working Group II, 2007b.

C.D. Kolstad and M. Toman. "The Economics of Climate Policy." In Mäler and Vincent (eds.) *Handbook of Environmental Economics*, Vol. 3, Elsevier, 2005, Chapter 30, Section 2: Overview of the Climate Change Issue.

D. Lemoine and C. Traeger (2010). "Tipping Points and Ambiguity in the Integrated Assessment of Climate Change". CUDARE Working Paper 1111.

N. Stern et al. "Stern Review on the Economics of Climate Change." HM Treasury, 2007.

Online Sources on Different Integrated Assessment Models:

DICE: <http://www.econ.yale.edu/~nordhaus/homepage/index.html>

FUND: <http://www.fund-model.org/>

WITCH: <http://www.witchmodel.org/pag/model.html>

Model survey: <http://www.metasd.com/ModelSurvey.xml>

6. Uncertainty. We discuss the effects of uncertainty and learning on optimal policies. We start with a simple two period stock pollution/extraction model, discussing the implications of Jensen's inequality and prudence for optimal decisions. Then, we examine taxes versus quantities under uncertainty in the dynamic setting. Finally, we discuss various applications of uncertainty analysis to the integrated assessment of climate change.

Lecture Notes

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

L. Eeckhoudt and H. Schlesinger. "Putting Risk in Its Proper Place." *American Economic Review*, Vol. 96 (2006), pp. 280-289.

L. Epstein. "Decision Making and the Temporal Resolution of Uncertainty." *International Economic Review*, Vol. 21 (1980), pp. 269-283.

B. Crost, and C. Traeger (2013f), Optimal Climate Policy: Uncertainty versus Monte-Carlo, *Forthcoming in Economic Letters*.

A.K. Dixit and R.S. Pindyck. *Investment Under Uncertainty*. Princeton University Press, 1994, Chapters 1-2.

C. Gollier, B. Julien, and N. Treich. "Scientific Progress and Irreversibility: An Economic Interpretation of the Precautionary Principle." *Journal of Public Economics*, Vol. 75 (2000), pp. 229-253.

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

M. Hoel and L. Karp (2001), "Taxes and quotas for a stock pollutant with multiplicative uncertainty", *Journal of Public Economics* 82: 91-114.

M. Hoel and L. Karp (2002), Taxes versus quotas for a stock pollutant, *Resource and Energy Economics* 24: 367-384.

S. Jensen and C. Traeger (2012), "Mitigation under Long-Term Growth Uncertainty: Growing Emissions but Outgrowing its Consequences?", see homepage Traeger.

S. Jensen and C. Traeger (2012), "Optimally Climate Sensitive Policy under Uncertainty and Learning", see homepage Traeger.

W.M. Hanemann. "Information and the Concept of Option Value." *Journal of Environmental Economics and Management*, Vol. 16 (1989), pp. 23-37.

- L. Karp and J. Zhang (2005), Regulation with Anticipated Learning about Environmental Damages, *Journal of Environmental Economics and Management* 51: 259–279.
- D. Kelly and C. Kolstad (1999), Bayesian learning, growth, and pollution, *Journal of Economic Dynamics and Control*, 23: 491-518.
- Lange and Treich (2008), Uncertainty, learning and ambiguity in economic models on climate policy: some classical results and new directions, *Climatic Change* 89:7–21.
- D. Lemoine and C. Traeger (2013f), “Watch Your Step: Optimal Policy in a Tipping Climate”, *Forthcoming in American Economic Journal: Economic Policy*.
- R. Newell and W. Pizer (2003), Regulating stock externalities under uncertainty, *Journal of Environmental Economics and Management* 45: 416-432.
- R.S. Pindyck. “Optimal Timing Problems in Environmental Economics.” *Journal of Economic Dynamics & Control*, Vol. 26 (2002), pp. 1677-1697.
- R.S. Pindyck. “Uncertainty in Environmental Economics.” *Review of Environmental Economics and Policy*, Vol. 1 (2007), pp. 45-65.
- F. Salanie and N. Treich, “Option Value and Flexibility: A General Theorem with Applications”. Working Paper (2007)
- C. Traeger (2009): Recent Developments in the Intertemporal Modeling of Uncertainty. *Annu. Rev. Resour. Econ.* 2009. 1:261-85.
- C. Traeger (2012), “A 4-stated DICE: Quantitatively Addressing Uncertainty Effects in Climate Change”, *CUDARE Working Papers*, No. 1130.
- A. Vercelli. “Hard Uncertainty and Environmental Policy.” In Chichilnisky, Heal, and Vercelli (eds.) *Sustainability: Dynamics and Uncertainty*. Springer, 1998.

7. Social Discounting: The section introduces to the debate on the 'right' social discount rate in the context of climate change evaluation. It thereby relates to questions of intergenerational justice, and evaluation under uncertainty.

* Lecture Notes

* Karp, L. and C. Traeger (2013), Discounting, In: Shogren, J.F., (ed.) *Encyclopedia of Energy, Natural Resource, and Environmental Economics*, volume 2, pp. 286-292 Amsterdam: Elsevier. See homepage Traeger.

*W.D. Nordhaus. “A Review of the Stern Review on the Economics of Climate Change.” *Journal of Economic Literature*, Vol. 45 (2007), pp. 703-724.

- C. Gollier. *Pricing the Future*. Princeton University Press, 2013.
- G. Asheim, “Intergenerational Equity”, *Annual Review of Economics Vol. 2* (2010).
- P. Dasgupta. “Commentary: The Stern Review’s Economics of Climate Change.” *National Institute Economic Review*, Vol. 199, No. 1 (2007), pp. 4-7.
- C. Gollier and M. Weitzman. “How Should the Distant Future be Discounted when Discount Rates are Uncertain”, *Economics Letters 107*(3): 350-353.
- B. Groom, C. Hepburn, P. Koundouri, and D. Pearce. “Declining Discount Rates: The Long and the Short of It.” *Environmental & Resource Economics*, Vol. 32 (2005), pp. 445-493.
- M. Hoel, T. Sterner (2007), “Discounting and relative prices”, *Climatic Change 84* (2007) 265–280.
- L. Karp, and I.H. Lee (2003) “Time Consistent Policies” *Journal of Economic Theory* 112: 353- 64.
- L. Karp (2005), “Global warming and hyperbolic discounting”, *Journal of Public Economics* 89: 261–282.
- L. Karp (2007), “Non-constant discounting in continuous time”, *Journal of Economic Theory* 132: 557 – 568.
- L. Karp (2012), “Provision of public goods with altruistic overlapping generations”, see homepage Karp.
- M. Schneider., C. Traeger, and R. Winkler (2012), *Trading off Generations: Equity, Discounting, and Climate Change*, *European Economic Review* 56: 1621-1644.
- T. Sterner and U.M. Persson. “An Even Sterner Review: Introducing Relative Prices into the Discounting Debate”, *Review of Environmental Economics and Policy*, Vol. 2 (2008), pp. 61–76.
- C. Traeger (2013), “Why Uncertainty Matters - Discounting under Intertemporal Risk Aversion and Ambiguity”, forthcoming in *Economic Theory*.
- C. Traeger, (2013f), “Discounting under Uncertainty: Disentangling the Weitzman and the Gollier Effect”, forthcoming in *Journal of Environmental Economics and Management*.
- C. Traeger, (2011), “Sustainability, Limited Substitutability and Non-constant Social Discount Rates”, *Journal of Environmental Economics and Management* 62: 215–228.

C. Traeger, "Discounting and Confidence." CUDARE Working Paper No. 1117 (2010).

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

M.L. Weitzman. "On Modeling and Interpreting the Economics of Catastrophic Climate Change," *Review of Economics and Statistics*: 91(1) (2009), pp. 1–19.

M.L. Weitzman. "A Review of the Stern Review on the Economics of Climate Change." *Journal of Economic Literature*, Vol. 45 (2007), pp. 703-724.

8. Imperfect Property Rights and Trade:

Chichilnisky, G. "North-South Trade and the Global Environment", *American Economic Review*, 1994, vol 84, pp 851-74.

Copeland, B. and MS Taylor "Trade, Tragedy, and the Commons", *American Economic Review*, 2009, vol 99}, pp 725-49.

Copeland, B, *Policy Endogeneity and the Effects of Trade on the Environment*}, *Agricultural and Resource Economics Review*, 2005, vol 34, no 1

Hotte, L. ns N Long and H Tian "International trade with endogenous enforcement of property rights", *Journal of Development Economics*, 2000, vol 62, pp 25 - 54

Karp, L and A Rezai "Trade and Resource Sustainability with Overlapping Generations", working paper.

9. International Trade and the Environment:

Copeland, B and S Taylor "Trade, Growth and the Environment" *Journal of Economic Literature*, 2004, XLI, pp 7 -- 71.

Karp, L "The Environment and Trade" *Annual Review of Resource Economics*, 2011, pp 397 -- 417

Fullerton, D, D Karney and K Baylis "Negative Leakage" 2013 working paper

Karp, L. "The Income and production effects of leakage", 2013, working paper.