

# Environmental Economics

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# Topic 1

- Introductory materials
- Course overview
- What is environmental economics?
- Review a few economics principles

# Introductory Materials

- Introduction
- Review Syllabus
- Course overview

# Introductions

- You
  - ▷ Name
  - ▷ Major(s), Minor(s)
  - ▷ Econ courses taken
  - ▷ Math courses taken
  - ▷ Stat courses taken
  - ▷ Home town
  - ▷ Optional extras: hobbies, activities, family, etc.

# Introductions

- Me: Professor A. Ronald Gallant
- Colleges:
  - ▷ San Diego State University, AB, Mathematics, Psychology, Business
  - ▷ University of California, Los Angeles, MBA, Marketing
  - ▷ Iowa State University, Ph.D., Statistics
- Home town: San Diego, California
  - ▷ Family came to CA from Mexico during the Gold Rush.
- Job experience:
  - ▷ More than five years: NCSU, UNC, Duke, PSU
  - ▷ Less: Lockheed, SEC, l'Ecole Polytechnique, INSEE, Colegio de Postgraduados, EMBRAPA, Chicago, Northwestern, UCSD, Board of Governors, Tilburg, ITAM, ANU, Montreal, Uppsala, Stanford, NYU, NCAR.
- Research
  - ▷ <http://www.aronaldg.org>

# Syllabus

- Review syllabus
- <http://www.aronaldg.org>
  - ▷ Click on “Courses”
  - ▷ Click on “Environmental Economics”
  - ▷ For iPhone, iPad, etc.  
<http://www.aronaldg.org/courses/econ428>
- Note in particular the section on extra credit

# Course Mechanics

- Course website: <http://www.aronaldg.org>
  - ▷ Click on "Courses"
  - ▷ Then click on "Environmental Economics"
  - ▷ For iPhone, iPad, etc.  
<http://www.aronaldg.org/courses/econ428>
- Lectures consist of slides and blackboard presentations of illustrative examples
  - ▷ Blackboard presentations will be posted at the course website after lecture.

# Grades

- 10% Class participation
- 25% Homework
- 25% Midterm
- 40% Final



## Where Do Illustrations, Homework Problems, Exam Questions Come From?

- Nathaniel O. Keohane and Sheila M. Olmstead (2007), *Markets and the Environment*, Island Press.
- Field, Barry C., and Martha K. Field (2013) *Environmental Economics, 6th edition*, McGraw-Hill.
- Kolstad, Charles (2010), *Environmental Economics, Second Edition*, Oxford University Press.

# Purpose of the Course

- Examine the implications of economics for business practice relating to environmental issues.
  - ▷ Discover business practices that protect the environment without destroying shareholder value
- Examine the implications of economics for government regulation relating to environmental issues.
  - ▷ What criteria should govern regulation.
  - ▷ What types of regulation are most effective.

# Scope of the Course

- Why do markets fail?
- What are some solutions?
- How does this affect incentives for firms?

# Why Do Markets Fail?

- Competitive markets fail for five reasons:
  1. Market power
  2. Incomplete information
  3. Externalities
  4. Public goods
  5. Tragedy of the commons

# What Are Some Solutions?

- Direct regulation
- Taxation
- Cap and trade
- Allocate property rights
- Voluntary actions of firms

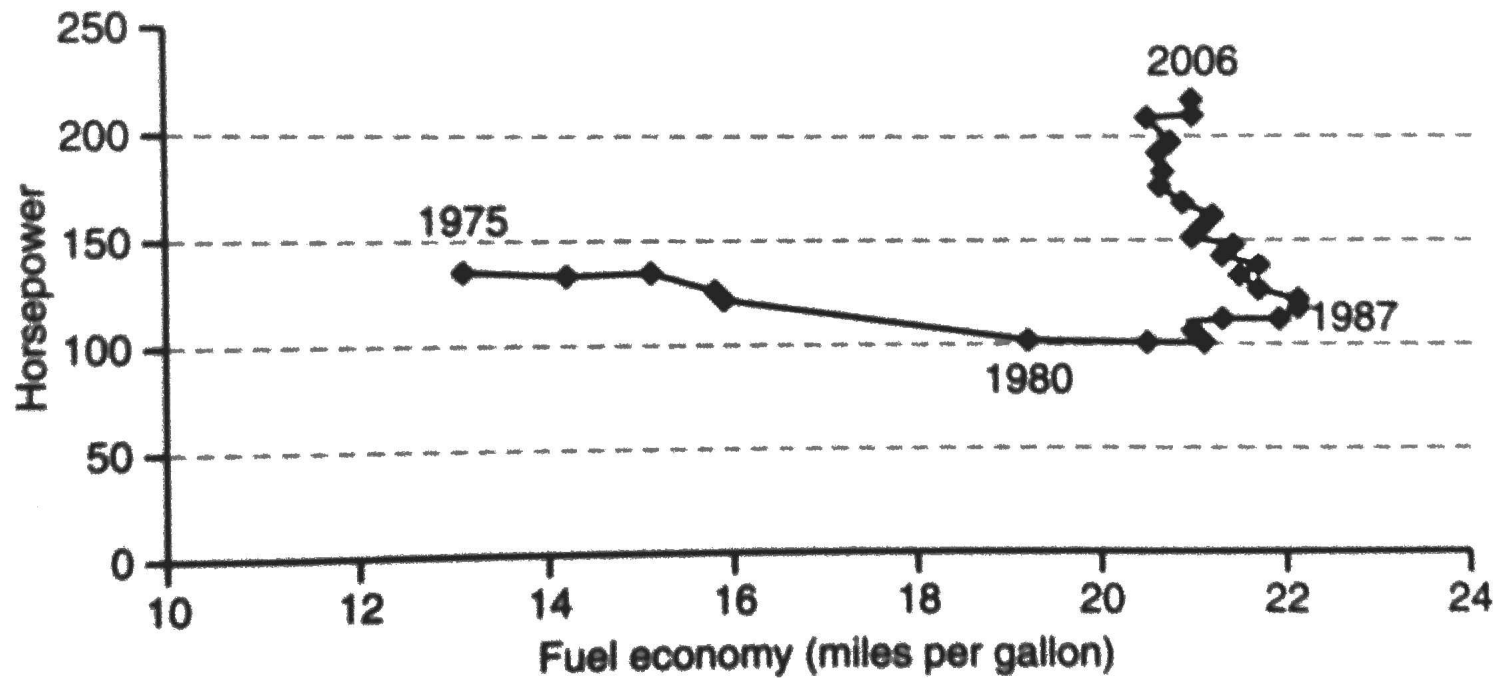
## How Does This Affect Firm Incentives?

- Product differentiation
- Industry level cooperation
- Improved production processes

# Incentives Example, Fort Worth Texas

- Adopted the following trash payment policy
  - ▷ Residents buy carts of sizes 32, 64, and 96 gallons for \$8, \$13, and \$18, respectively.
  - ▷ Free recycling pickup and yard waste pickup.
- City trash costs declined by about 1/3, counting recycling sales.
- Recycling increased from 6% to 20% of total solid waste.
- Landfill usage declined by about 14%.

# Perverse Incentives from Regulation, CAFE



Source: Field and Field



# Definition of Environmental Economics

Environmental economics is concerned with the impact of the economy on the environment, ..., and the appropriate way of regulating economic activity so that balance is achieved among environmental, economic, and other social goals.

Kolstad, Charles, *Environmental Economics*, 2000, p.1

# Environmental Economics

- Is “environmental economics” a paradox?
- There are always tradeoffs
- Economics is the science that studies “the allocation of scarce resources among competing ends”
- To those who suggest it is inappropriate to study and try to quantify environmental costs and benefits associated with production, James V. DeLong (Stavins 2005, p.272) states:

I find it hard to believe, looking around the modern world, that its major problem is that it suffers from an excess of rationality. The world’s stock of ignorance is and will remain quite large enough without adding to it as a matter of deliberate policy.

# Resource Economics

- How to use our natural resources over time
- Renewables
  - ▷ Fish resources
  - ▷ Forests
- Nonrenewables
  - ▷ Fossil Fuels – Nonrenewable in the near future
  - ▷ Minerals
- Some resources have both characteristics
  - ▷ Water – aquifers can be depleted in the short run but replenished the following year
  - ▷ Land – Soil loss and soil regeneration

# History of Environmental Economics

- Pre-history – Welfare economics of Pareto
- Developments in externality theory – Pigou (1920s)
- Coase in 1960
- Environmental movement of the 1960s and environmental policy in early 1970s
- Applications of Pigou's insights and development of marketable permits as an alternative to taxation – 1970s and 1980s
- Valuation of non-market goods
  - ▷ Essentially a new field in economics beginning in the late 1960s
  - ▷ Lots of work in the 1980s
  - ▷ Exxon Valdez spill in 1989 was an catalyst for new developments in 1990s
- Large-scale implementation of marketable permits – 1990s and 2000s

# Fundamental Questions in Environmental Economics

- Why do firms pollute?
- How much pollution should we have?
- How do we design policies to reduce pollution?
- What is the value of the natural environment?
- How do we define and measure sustainable development?

# Questions that Relate to the Firm

- To what extent should environmental concerns figure into a firm's managerial decision making?
- How can firms simultaneously deliver environmental quality and shareholder value?
  - ▷ Can firms add value or lower costs while simultaneously reducing the impact of products?
- How can environmental issues generate strategic advantage for a firm?
- To the extent a firm can influence regulation, what regulations would be most valuable both to the firm and the environment?
- Can a firm lower costs and risks by eliminating waste and emission streams?
- How much should a firm invest in environmental preservation?
- To what extent should a firm promote environmental efforts (recycling, hybrid fleets)?

# Review of Relevant Economic Principles

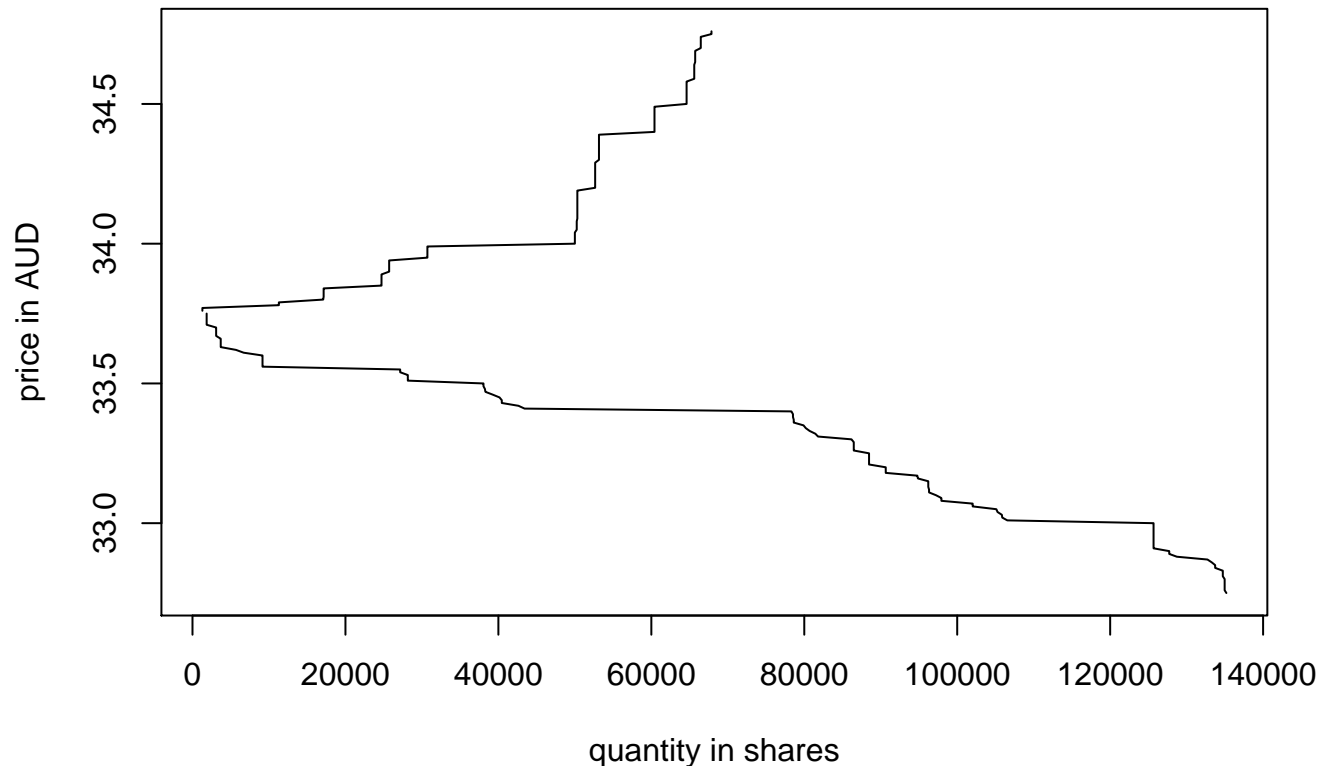
- Mixed blackboard and slide presentation.
- Blackboard presentations will be posted at the course website after lecture.

# Basics of Demand and Supply

- Demand as “Marginal Willingness to Pay” (MWTP)
- Supply as “Marginal Cost” (MC)
- Market demand – add up across individual consumer MWTPs
  - ▷ Horizontal sum
- Market supply – add up across individual firm MCs
  - ▷ Horizontal sum

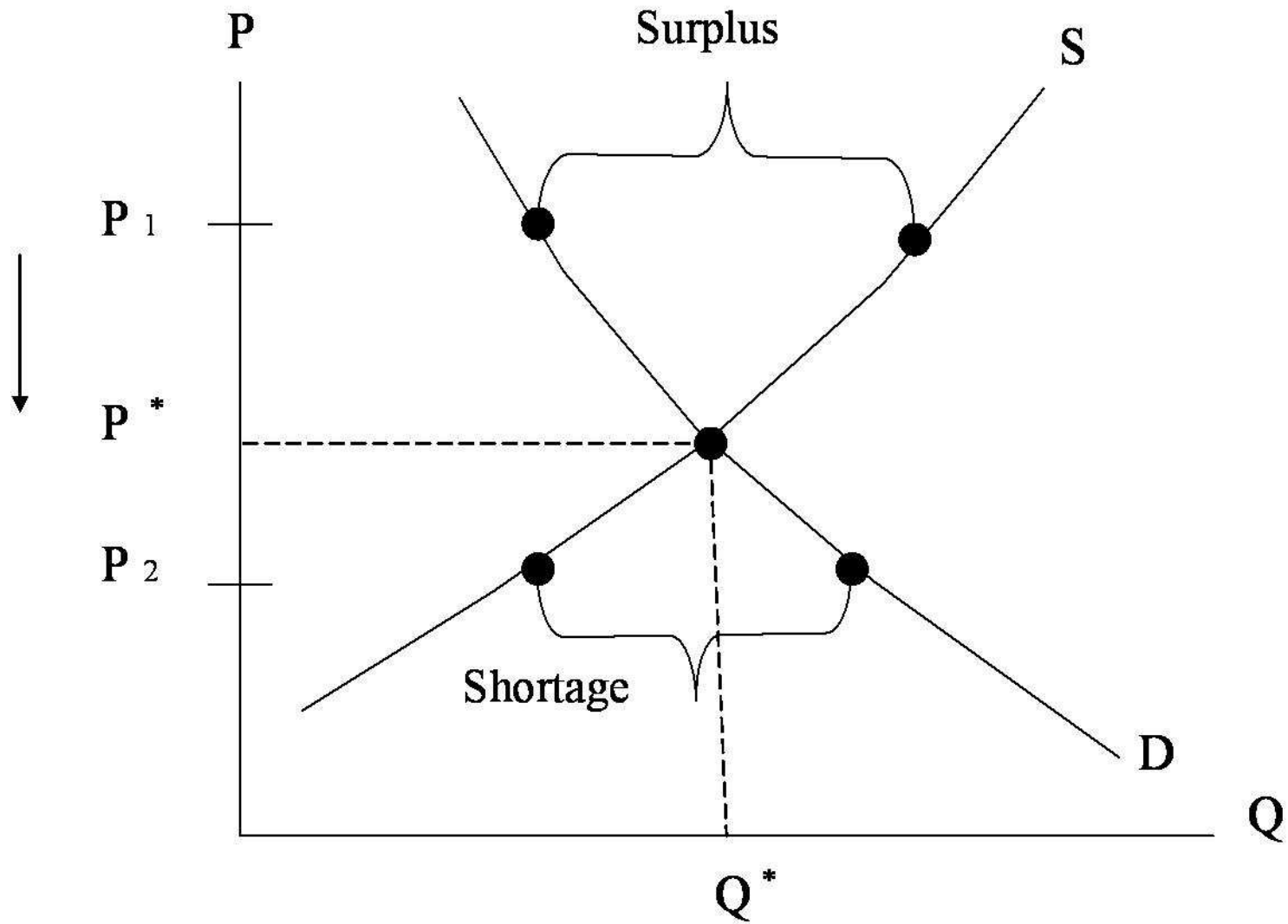


# A Limit Order Book on July 8, 2002



- Shown is the quantity that remains after the market clears.
- Gains to trade (surplus) have eliminated quantities to the left.
- Source: Nikolaus Hautsch, Humboldt University, Berlin
- Stock information withheld due to a confidentiality agreement.
- July 8, 2002, predates the emergence of "dark pools".

# Market Equilibrium



# Elasticity of Demand

- Convenient way to characterize supply and demand relationships that avoids units problems.
- Price elasticity of demand is the percent change in quantity demanded for a one percent change in price

$$\text{elasticity} = \frac{\% \Delta Q}{\% \Delta P} = \frac{dQ}{dP} \frac{P}{Q}$$

- ▷ Large negative value: demand curve is nearly horizontal – easy to substitute away from the good
  - ▷ Small negative value: demand curve is nearly vertical – hard to substitute away from the good
- Usually drop the negative sign when reporting elasticities

# Foundations of Supply

## – Competitive Firms

- Competitive firm
  - ▷ max profits by choosing quantity produced
  - ▷ Profits = Revenues – Costs
  - ▷  $\Pi(Q) = P \cdot Q - C(Q)$
  - ▷ Taking the derivative, we get:

$$P = C'(Q) \Leftrightarrow \text{Price} = \text{Marginal Cost}$$

- The competitive firm's supply curve is its marginal cost curve

# Elasticity of Supply

- Price elasticity of supply is the percent change in quantity supplied for a one percent change in price (same formula)

$$\text{elasticity} = \frac{\% \Delta Q}{\% \Delta P} = \frac{dQ}{dP} \frac{P}{Q}$$

- ▷ Large positive value: supply curve is nearly horizontal – easy to substitute one input for another
- ▷ Small positive value: supply curve is nearly vertical – hard to substitute one input for another

# Foundations of Supply

## – Firms with Market Power

- General firm

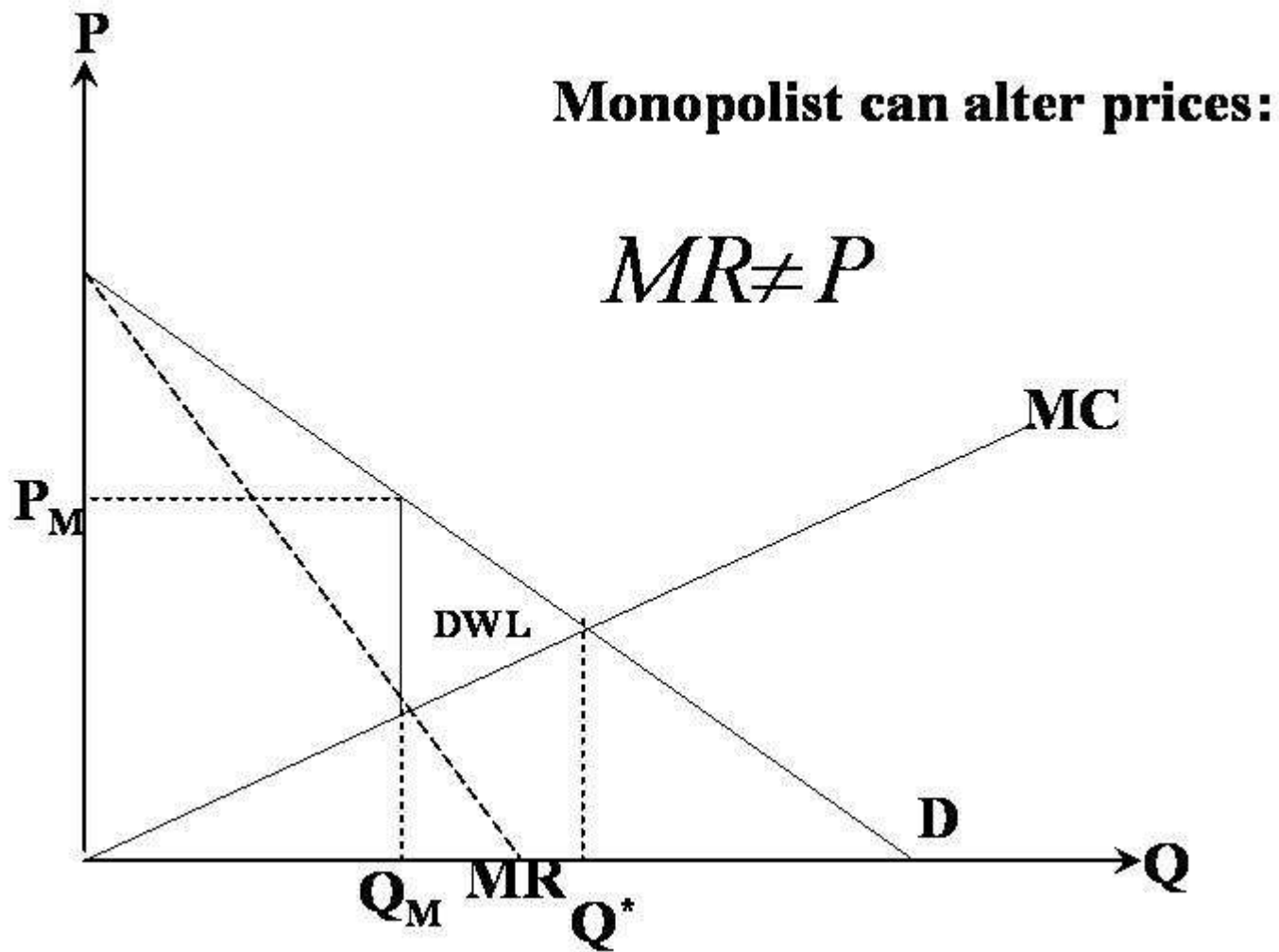
- ▷ Let  $R(Q)$  be the revenue associated with quantity  $Q$

- ▷  $\Pi(Q) = R(Q) - C(Q)$

- ▷ Taking the derivative, we get:

$$R'(Q) = C'(Q) \Leftrightarrow \text{Marginal Revenue} = \text{Marginal Cost}$$

# Monopoly Example

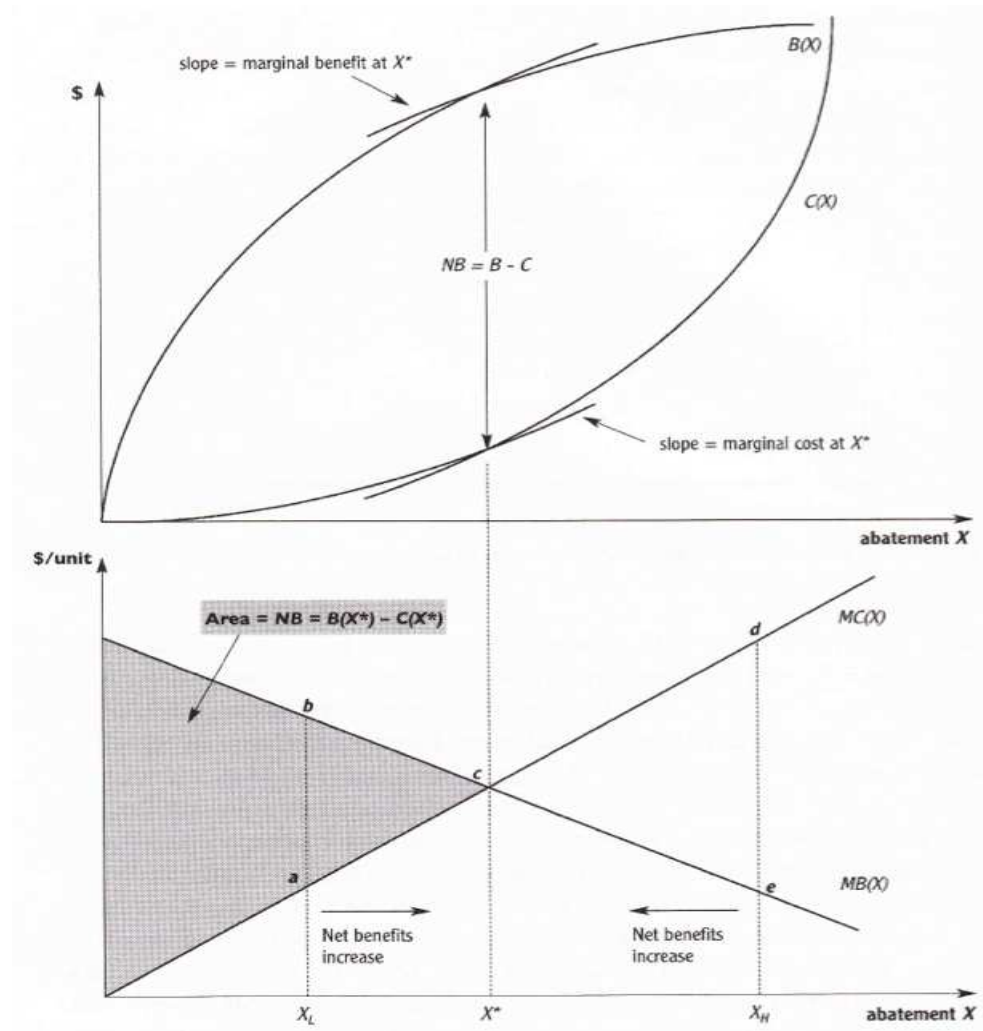


# Monopoly Supply

- A monopolist will supply more or less if the demand curve shifts
  - ▷ Only possibility if  $MC$  doesn't change
  - ▷ To determine a supply curve must tell a story about how demand shifts. E.g. does the slope change when it shifts?
  - ▷ For each shift find  $P$  and  $Q$  where  $MC = MR$ .
  - ▷ That's the supply curve
- The monopolists supply curve will be above the  $MC$  curve
  - ▷ I.e. monopoly prices are higher than competitive prices



# Cost-Benefit Analysis, Source: Keohane and Olmstead



# Cost Benefit Analysis

## Relation to Previous Ideas

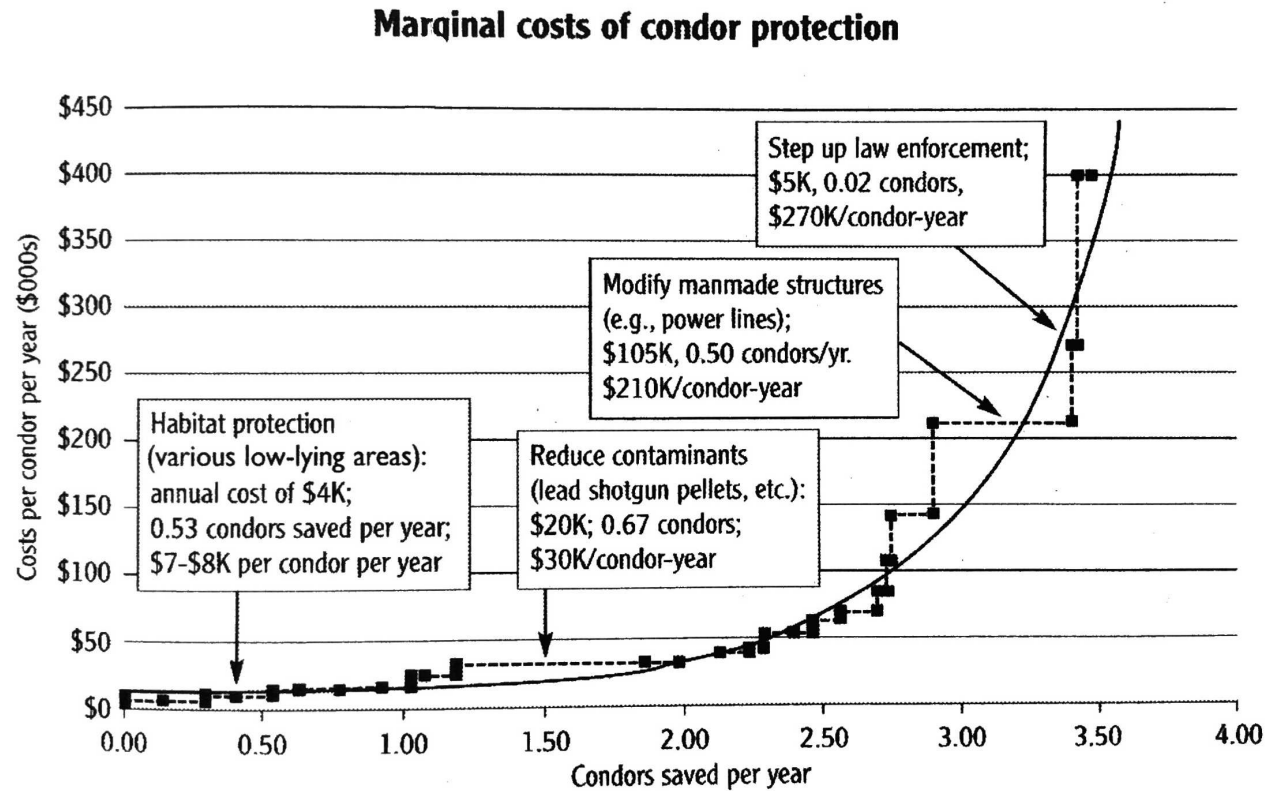
- The marginal benefit curve  $MB(X)$  is similar to willingness to pay for abatement.
  - ▷ As we will see later, it is often determined in practice by measuring willingness to pay statistically.
- The benefit curve  $B(X)$  is cumulative willingness to pay, which is the area under  $MB(X)$  from 0 to  $X$ .
- Cost  $C(X)$  is the industry cost curve for abatement and marginal cost  $MC(X)$  is  $\Delta C/\Delta X$ .
- The area  $NB = B(X^*) - C(X^*)$  is similar to the sum of consumer and producer surplus.

# California Condor Protection



Source: Wikimedia Commons

# California Condor Protection Marginal Cost



Source: Keohane and Olmstead

## California Condor Protection Marginal Benefit

- Class discussion question.
- How would one measure the marginal (or total) benefit of California condor protection?

# Discounting

- To convert present value to future value

$$FV_t = PV(1 + r)^t$$

- ▷  $r$  is the annual interest rate expressed as a decimal, e.g., 0.02 rather than as 2%
  - ▷  $t$  is time in years
  - ▷  $FV_t$  is the value in dollars of year  $t$
  - ▷  $PV_t = FV_t / (1 + r)^t$  is the value of  $FV_t$  in today's dollars
- To convert a stream  $FV_0, FV_1, \dots, FV_T$  of future values to present value use

$$PV = \sum_{t=0}^T \frac{FV_t}{(1 + r)^t} = \sum_{t=0}^T \delta^t FV_t \quad \delta = \frac{1}{1 + r}$$

# Discounting Example

## from Keohane and Olmstead

- The value of \$100 fifty years from now

$$\$100(1 + .05)^{50} = \$1,146.74$$

- The value of an investment that costs \$100 now and pays \$50 for twenty years

$$-\$100 + \frac{\$50}{(1 + .05)^1} + \frac{\$50}{(1 + .05)^2} + \dots + \frac{\$50}{(1 + 0.5)^{20}} = \$523.11$$

- ▷ This value disagrees with the text; see spreadsheet pv.xls at website.

# Discounting

- Present value of marginal cost

$$MC = MC_{t=0} + (1 + r)^{-1}MC_{t=1} + (1 + r)^{-2}MC_{t=2} + \dots$$

where the sum either terminates at some finite time  $T$  or continues indefinitely,  $T = \infty$ .

- Similar formula for the present value of a marginal benefit.
- The rate  $r$  assumed will dramatically influence cost-benefit analysis if the timing of costs and benefits differ.
  - ▷ One definition of sustainability is  $r = 0$ , which causes mathematical problems if  $T = \infty$  Can approximate by small  $r$ .
  - ▷ Congressional Budget Office recommends  $r = 0.02$  for one year time increments, long term T-Bill rate
  - ▷ Office of Management and Budget recommends  $r = 0.07$ , pretax return to capital
  - ▷ Typical business “hurdle rate” is  $r = 0.20$ .



# Decision to Purchase Compact Bulbs

		13W Compact Fluorescent	60W Incandescent
Price (fall 2008)		\$9.98	\$4.98
Number in package		6	8
Watts (per bulb)		13	60
Life (hours per bulb)		12000	1000
Cost per kilowatt hour	\$0.10		
Hours per day of use for bulb	4		
Hours per year of use for bulb	1460		
Electricity cost per year		\$1.90	\$8.76
Life of a bulb (years)		8.2	0.7
Repurchase frequency (years)		49.3	5.5
Period length (fraction of a year)	1		
Time horizon (years)	30		
		13W Compact Fluorescent	60W Incandescent
Interest rate (annual)	0.02		
present value of electricity cost		\$43.36	\$200.12
present value of repurchase cost		\$9.98	\$23.40
present value of costs		\$53.34	\$223.52
Interest rate (annual)	0.2		
present value of electricity cost		\$11.34	\$52.34
present value of repurchase cost		\$9.98	\$9.41
present value of costs		\$21.32	\$61.75

# Decision to Purchase Compact Bulbs

Illustrate with spreadsheet lb.xls at website.