Lecture 1:
Economic Efficiency and Environmental Protection

Reading:

- Keohane & Olmstead, Chs. 1-3
- Haab & Whitehead, Introduction

1. The Model

- Lays out fundamentals of the policy situation
- Basic trade off we face when developing pollution control policy
- Define an efficient level of environmental quality (or control)
  - Discuss in terms of Pareto Criterion w/ Potential Compensation
  - Discuss for any type of environmental protection

- Example: air pollution in a city

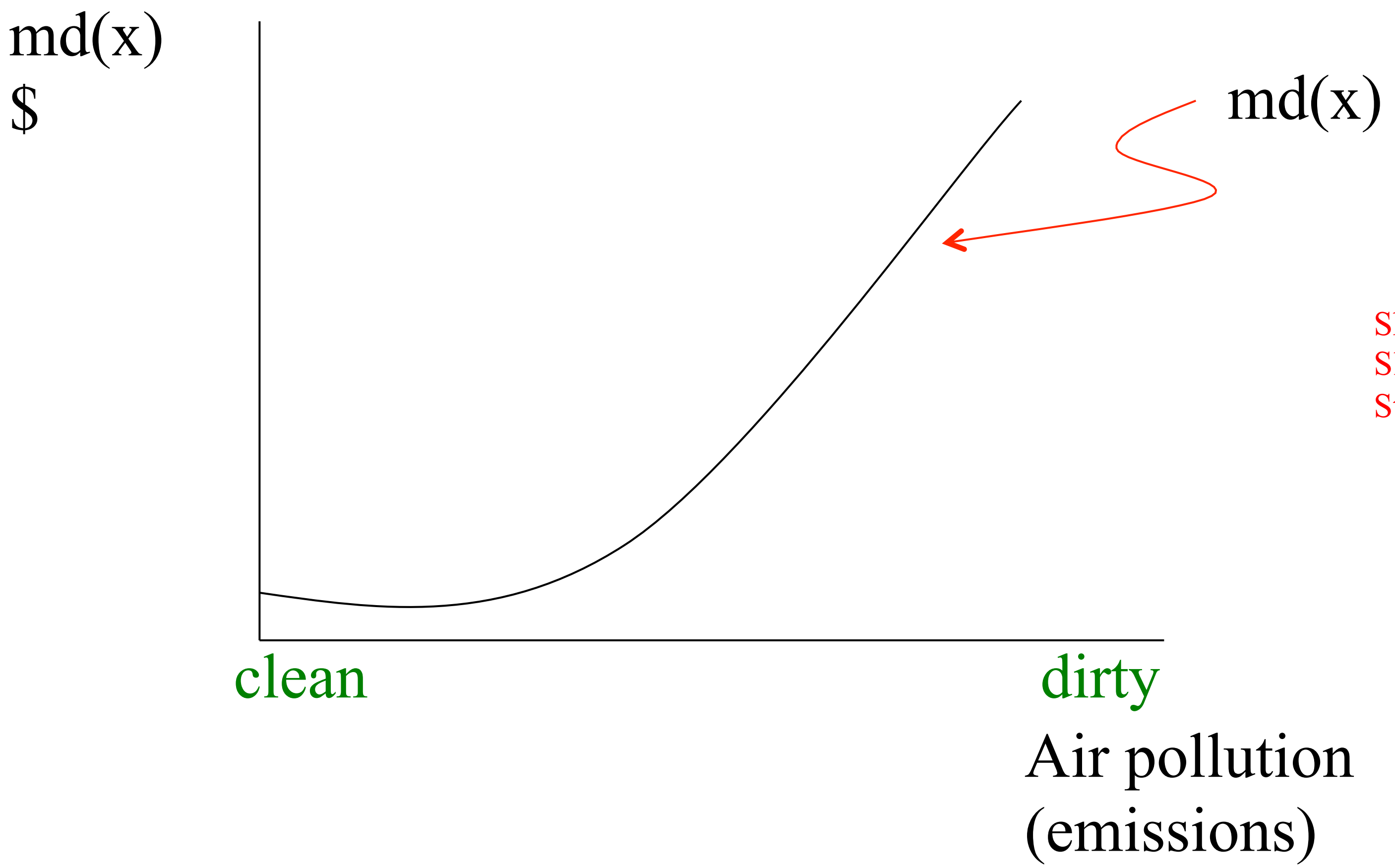
$$x = \text{level of air pollution (emissions)}$$

$$md(x) = \text{marginal damage of x}$$

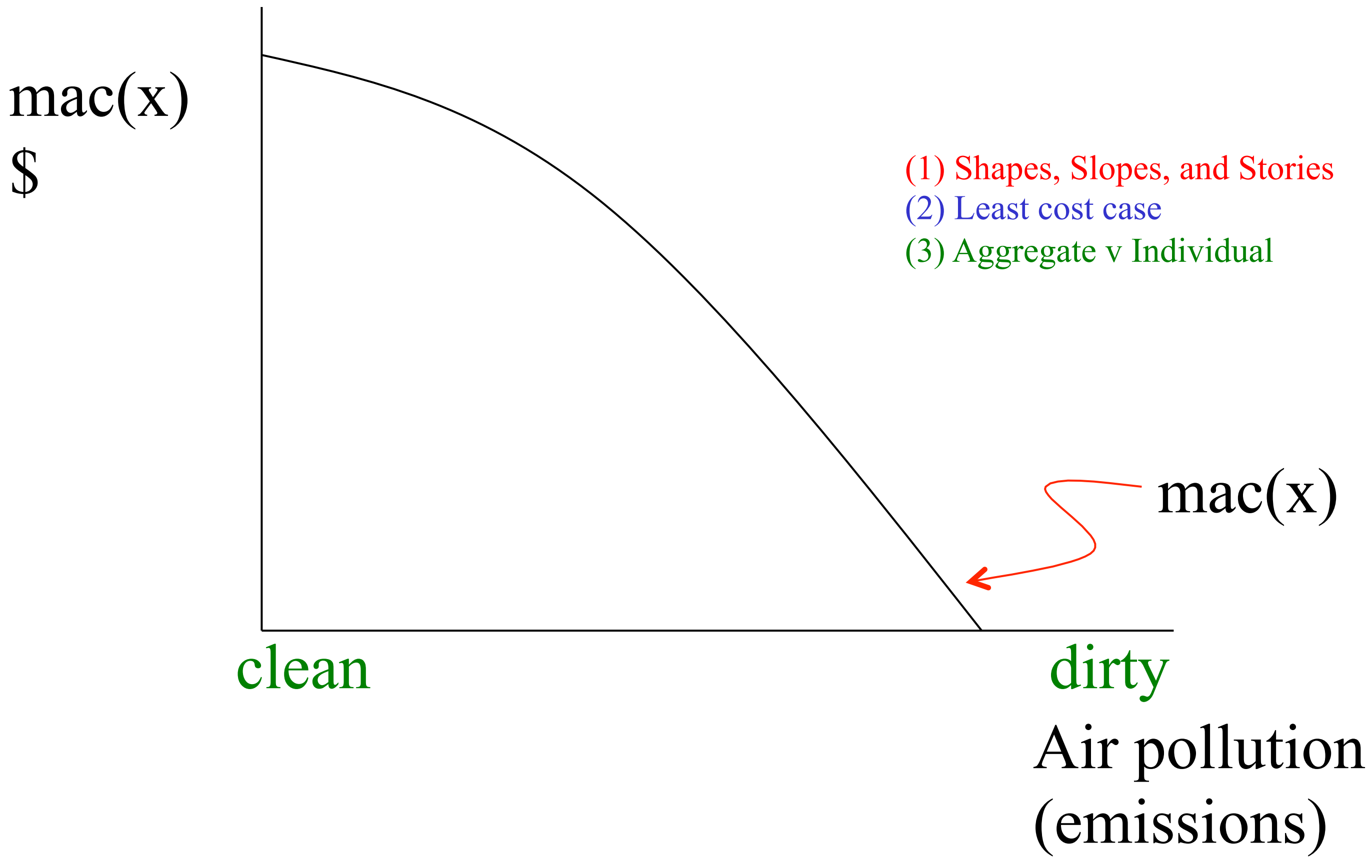
$$mac(x) = \text{marginal abatement cost}$$

- Damage
  - Adverse health effects
  - Poorer visibility
  - Material damages

- Abatement Cost
  - Pollution control equipment
  - Input substitutes (switching)
  - Reduced output (could be shut down)
  - Treatment
  - Recycling



Shapes,
Slopes, and
Stories

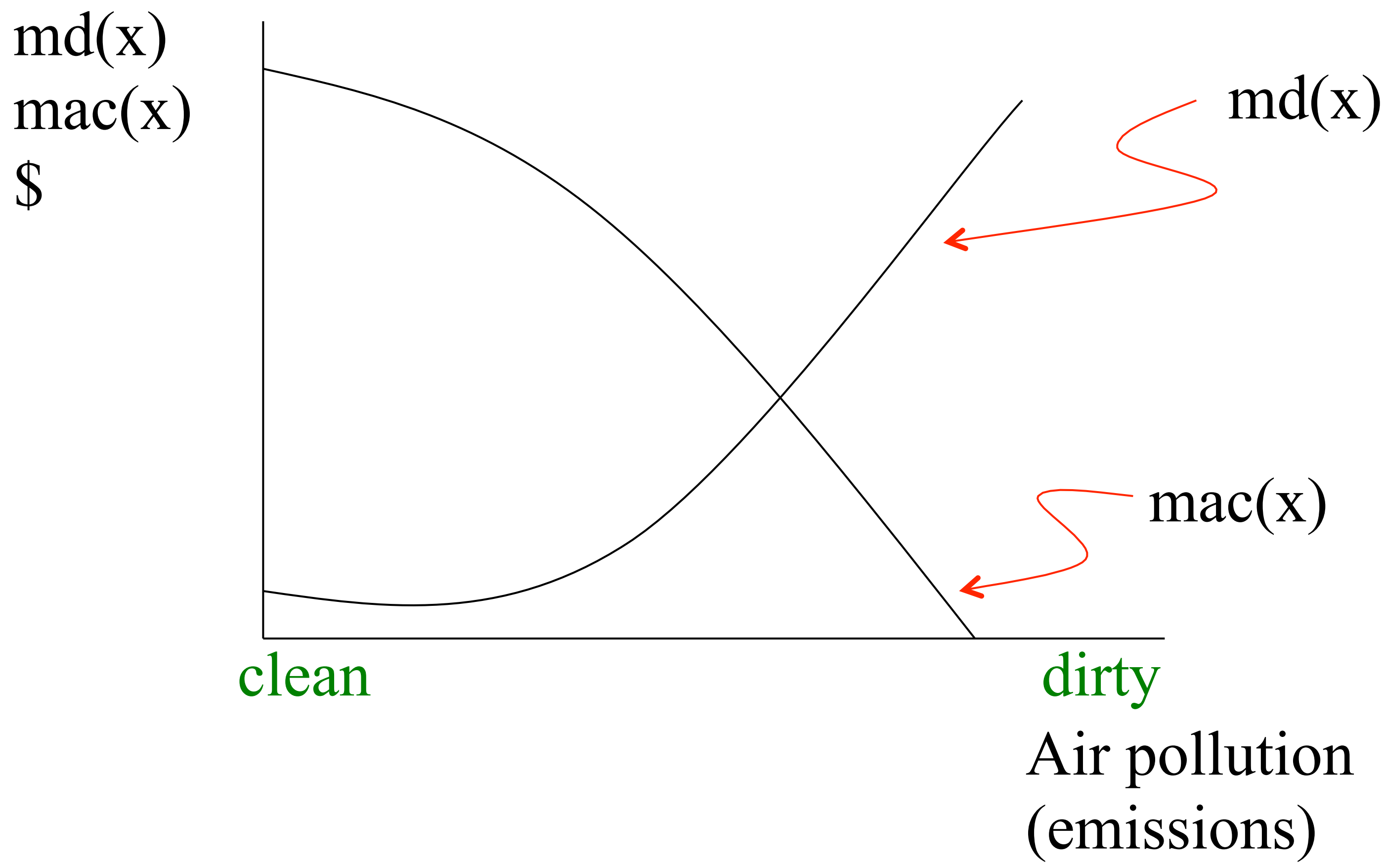


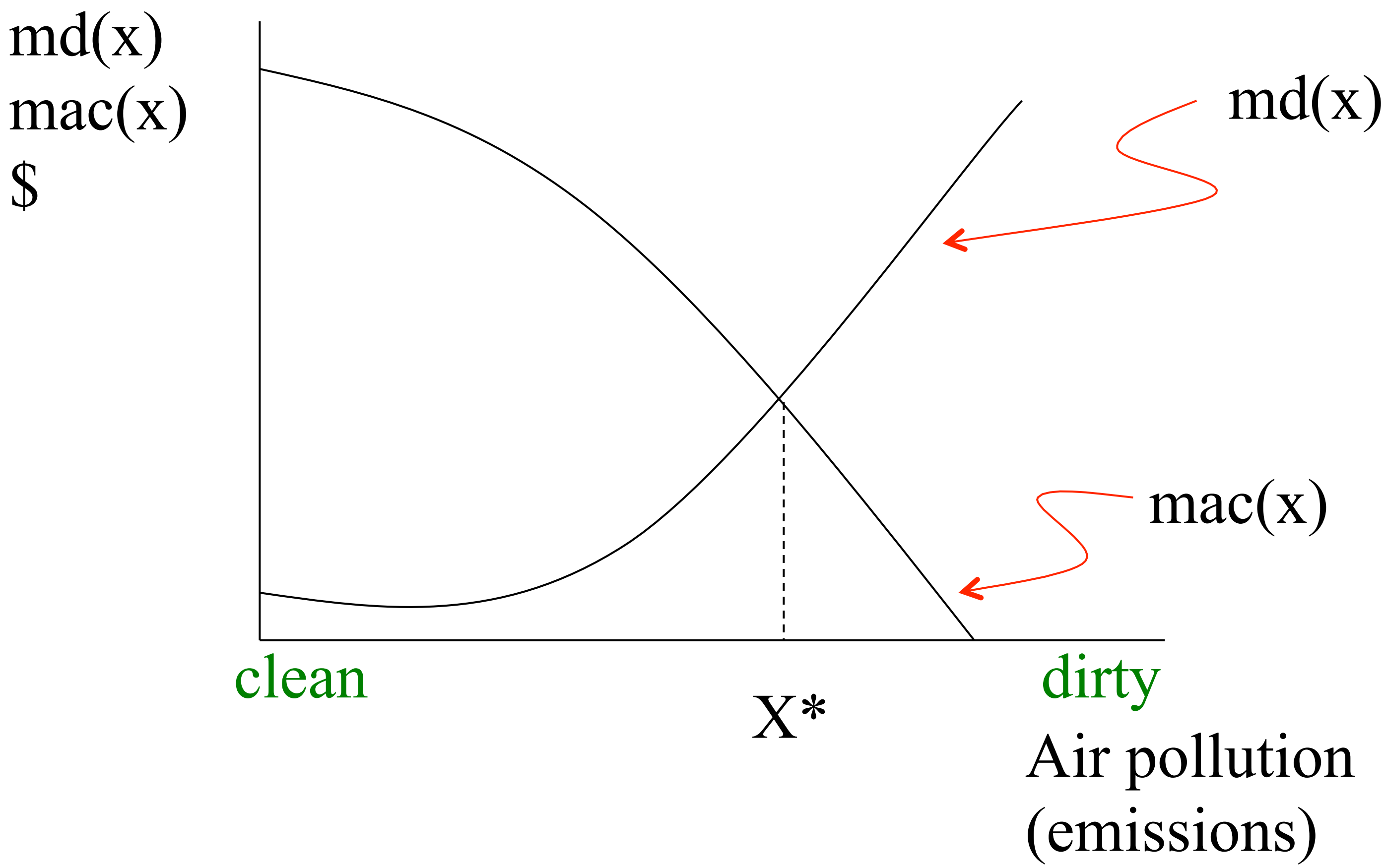
(1) Shapes, Slopes, and Stories
(2) Least cost case
(3) Aggregate v Individual

Thinking on the Margin ***continued***

Alternative	Pollution (AOX, in kg per year)	Incremental abate-ment (kg per year)	Total annual cost	Increase in total annual cost	Marginal cost (per kg of additional abatement)
1. Standard pulp (baseline)	1,000,000	No reduction	$0	$0	$0
2. ECF pulp using chlorine dioxide	250,000	750,000	$28.5 million	$28.5 million	$3.80
3. ECF + oxygen delignification	200,000	50,000	$29.6 million	$1.1 million	$22
4. TCF pulp using ozone	10,000	190,000	$40.4 million	$10.6 million	$56

* The cost figures for Aracruz are derived from estimates in Jackie Prince Roberts, "Aracruz Celulose, S.A.," Harvard Business School Case 9-794-049 (January 1995), 28 pp. In particular, the numbers in the table draw on the estimated costs for upgrading Mill A, Line 1. For purposes of illustration we have ignored the possible cost savings due to oxygen delignification and have treated that as an optional additional step. Abatement figures are based on 250,000 tons of pulp output per year and current authors' estimates of 4 kg AOX/ton for standard pulping, 1 kg/ton for ECF, 0.8 kg/ton for ECF + oxygen delignification, and 0.03 kg/ton for TCF. Following Roberts, we have applied a 10% discount rate to capital costs in order to combine them with variable costs.


md(x)
mac(x)
$
md(x)
mac(x)
clean
dirty
Air pollution
(emissions)



X* is an efficient level of pollution

If X < X*, air is too clean

If X > X*, air is too dirty

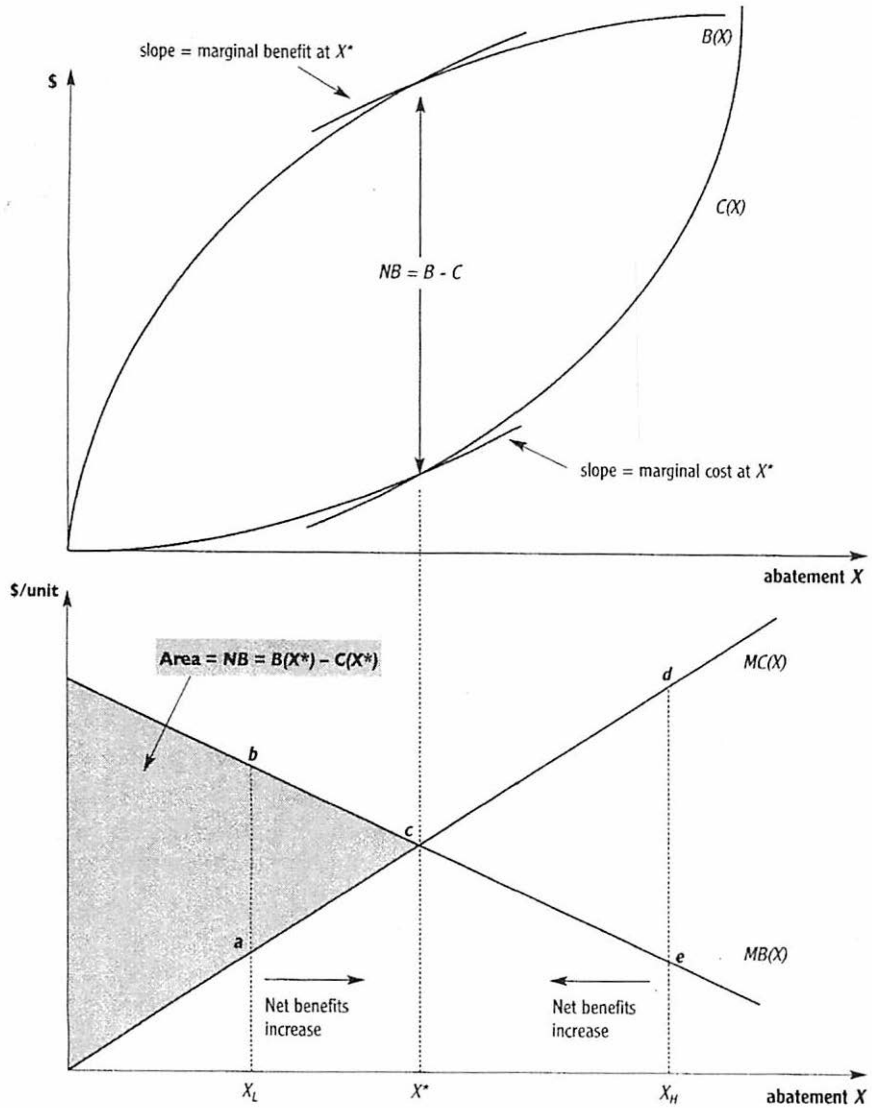
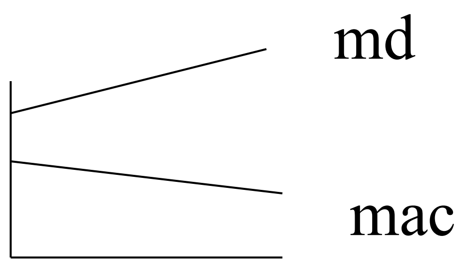


Figure 2.6 The efficient level of abatement, represented in terms of total costs and benefits (top panel) and marginal costs and benefits (bottom panel).

- Tradeoffs
- Opportunity costs
- Efficient environmental policies strive for X*
- Pareto, Kaldor-Hicks, and Social Choice Foundation
- Other types of environmental problems
  - Efficient acreage of wetlands
  - Efficient level of recycling
  - Endangered species
  - And so on …..

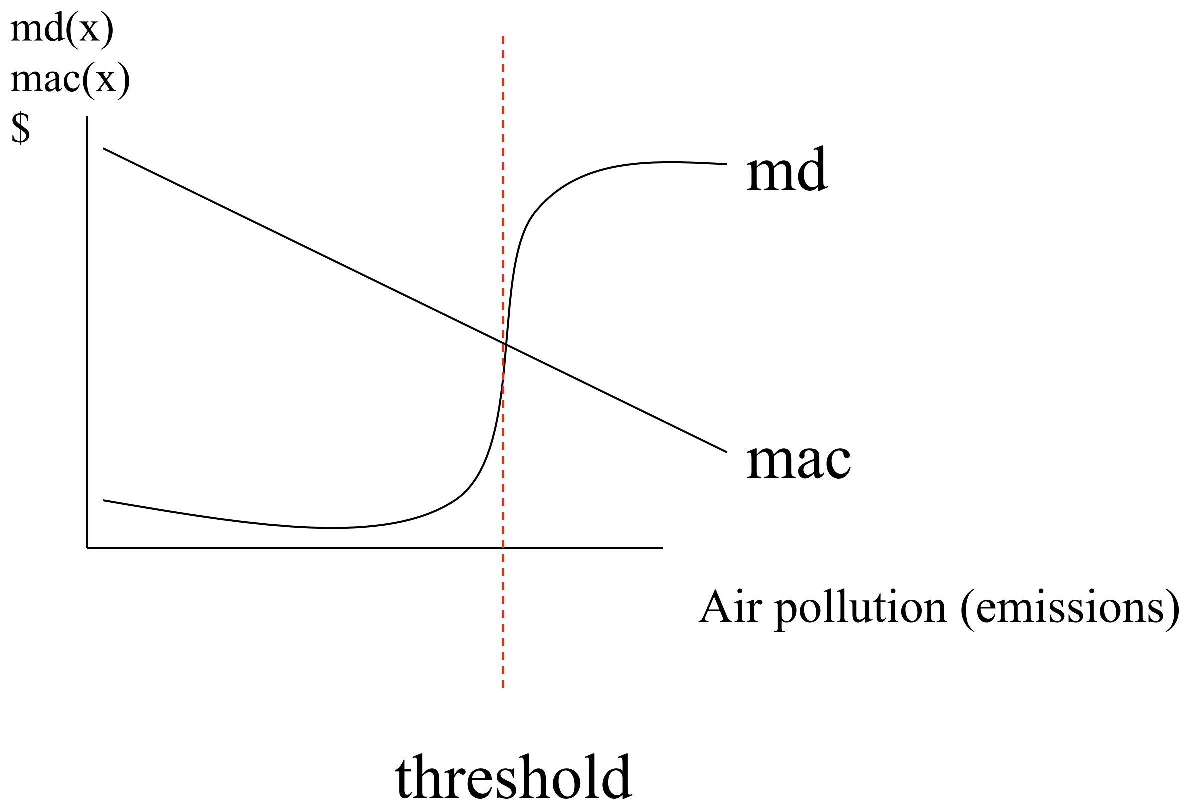
2. Comments

- Efficiency depends on nature, preferences, and technology
- Zero pollution usually is inefficient



- Non-market goods count
- Anthropocentric
- Static or Dynamic

- Shapes and positions of curves can tell interesting stories
  - thresholds in damages



- An Interesting Marginal Cost Curve

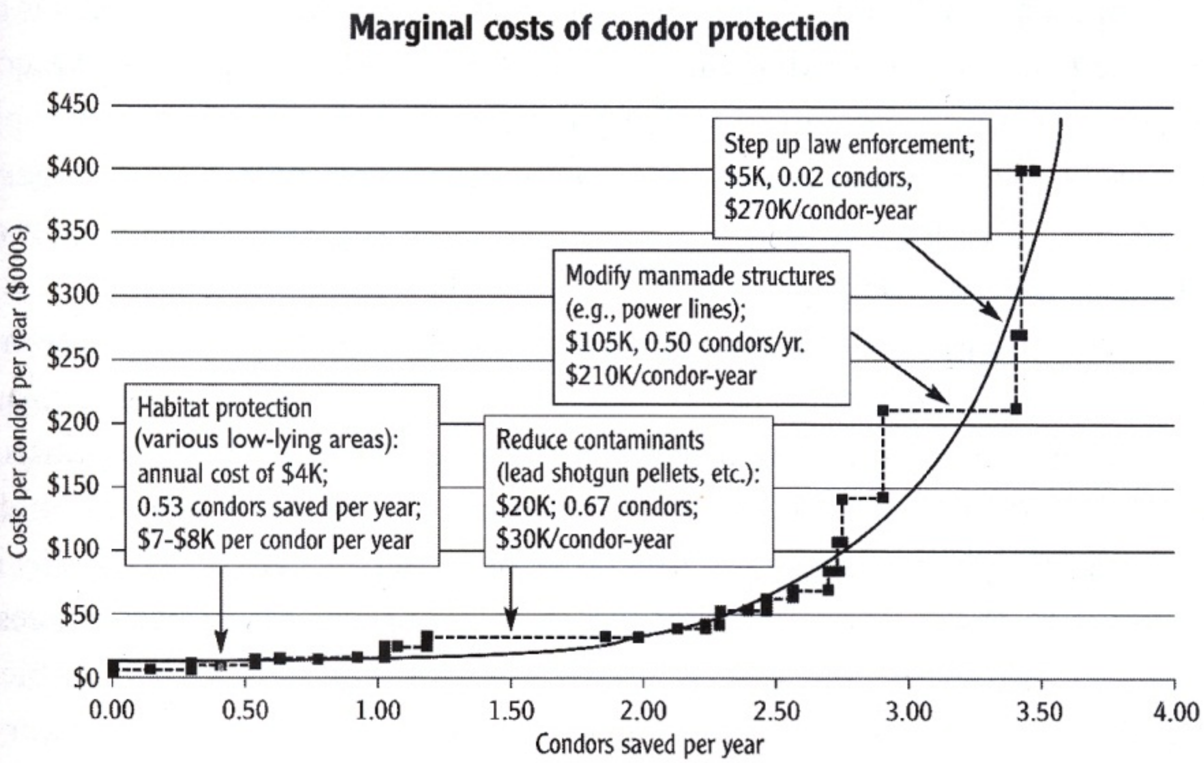
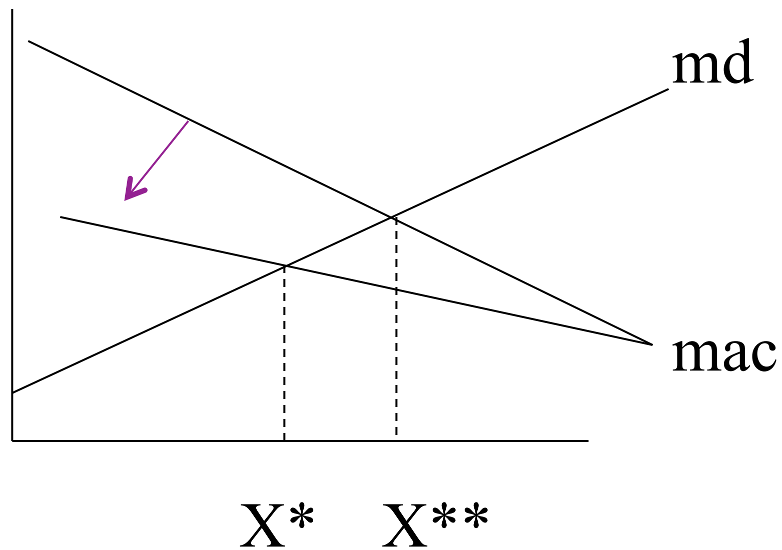


Figure 3.1 Marginal cost graph for condor example. Each "step" on the dashed line corresponds to a specific protection measure, arranged from lowest to highest unit cost. The boxes highlight four specific actions among over two dozen considered. The solid line represents a smooth approximation to the "staircase" function.

- technology changes



*Say cost of removing pollutants gets cheaper. mac(x) shifts inward ⇨ efficient level of emissions goes down

- Why national standards may not make sense