Nonrival goods  
   (air to breathe)

or

Nonexclusive goods  
   (UV protection from ozone)
The Tragedy of the Commons
Garrett Hardin

The tragedy of the commons develops in this way. Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. Such an arrangement may work reasonably satisfactorily for centuries because tribal wars, poaching, and disease keep the numbers of both man and beast well below the carrying capacity of the land. Finally, however, comes the day of reckoning, that is, the day when the long-desired goal of social stability becomes a reality. At this point, the inherent logic of the commons remorselessly generates tragedy. As a rational being, each herdsman seeks to maximize his gain. Explicitly or implicitly, more or less consciously, he asks, “What is the utility to me of adding one more animal to my herd?” This utility has one negative and one positive component.

1) The positive component is a function of the increment of one animal. Since the herdsman receives all the proceeds from the sale of the additional animal, the positive utility is nearly +1.
2) The negative component is a function of the additional overgrazing created by one more animal. Since, however, the effects of overgrazing are shared by all the herdsmen, the negative utility for any particular decision-making herdsman is only a fraction of -1.

Adding together the component partial utilities, the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. And another; and another . . . . But this is the conclusion reached by each and every rational herdsman sharing a commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit—in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all.

FIGURE 24-5  The development cycle spawned by the Highway Trust Fund.

Wright and Nebel 2002
How to Change Economic Behavior?

- Producer Pays/Polluter Pays
  - Dramatically less waste (packaging, scrubber sludge)
- Taxation/Subsidies

- Government strategies and regulation
  - Stable, democratic government required?

Shift Burden of Proof/Responsibility (precautionary principle)

SMS (safe minimum standard)
**Table 28.1 Water use by people in different sorts of communities in Arabia**

People in indigenous desert settlements use one-tenth the water of people in modern towns. The figures are for all domestic water use, including drinking, washing, bathing, and other water demands.

<table>
<thead>
<tr>
<th>Type of community</th>
<th>Domestic water use per person (L/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modern Arabian town without major industry</td>
<td>745</td>
</tr>
<tr>
<td>Traditional agricultural village</td>
<td>120</td>
</tr>
<tr>
<td>Small desert settlement with supply by government water truck</td>
<td>80</td>
</tr>
<tr>
<td>Small desert settlement with traditional water supply</td>
<td>28</td>
</tr>
</tbody>
</table>

Source: After Goodie and Willkinson 1977. *New York City has a similar usage rate.* (Hill et al. 2004)
Energy (one way)

waste heat = entropy

Everything else cycles
Herman Daly  
Former Environmental Economist with Worldbank  
Professor at U. Maryland

Utility vs. Throughput  
Utility not measurable; it is an experience

Circulatory system vs. digestive system  
(perpetual motion machine)

Wealth vs. Ith (accumulation of goods vs. bads)

Micro vs. Macro economics  
(MR=MC vs. endless)

If resources infinite then price = 0,  
but if pay for resources then can redistribute wealth
Warren Buffett: Tax Inherited Estates

By LAURIE KELLMAN - 14 Nov 2007

Billionaire Warren Buffett told the Senate Finance Committee on Wednesday that Congress should keep the estate tax rather than repeal it and help a few rich Americans like him.

"I think we need to ... take a little more out of the hides of guys like me," Buffett told the panel.

One of the world's richest men and biggest philanthropists, Buffett has been outspoken against efforts, mostly by Republicans, to repeal or reduce the federal tax on inheritances. Democrats argue that a repeal would amount to a huge windfall for the nation's wealthiest families.

Estates worth up to $2 million this year and next will be exempt from the federal estate tax. Portions of estates above that threshold will be taxed at 45 percent.

In 2009, the exemption level rises to $3.5 million, and by 2010 the estate tax will be repealed — but only for a year.

Unless Congress changes the law, it comes roaring back in 2011 with an exemption threshold of only $1 million and a top tax rate of 55 percent.

Buffett said inheritance taxes preserve a measure of meritocracy, and with it opportunity, by recycling portions of great wealth through public coffers.

"The resources of society I don't think should pass along in terms of an aristocratic dynasty of wealth," Buffett told the panel. "I believe in keeping equality of opportunity as much as you can in this country."

…

Committee Chairman Max Baucus, D-Mont., citing information from the IRS, said that of nearly 2.5 million deaths in 2004, about 19,300 estates paid the estate tax.
What are the major threats to biodiversity?
Threats to Biodiversity

(Primack Ch4)

Habitat Loss
  destruction, fragmentation, degradation

Global Climate Change

Overexploitation

Invasives

Disease
Increasing human population and consumption

Agriculture  Logging  Fisheries  Industry and fossil fuel use  Urbanization and road construction  International trade

Habitat loss
Habitat fragmentation
Habitat degradation (including pollution)

Overexploitation

Invasive species
Disease

Climate change

Loss of biodiversity
Extinction of species and populations
Degradation of ecosystems
Erosion of genetic diversity and evolutionary potential
Loss of ecosystem services
Erosion of support systems for human societies

PRIMER OF CONSERVATION BIOLOGY 4e, Figure 4.1

Habitat Loss

destruction, fragmentation, degradation

In the US:

Agriculture
Commercial Developments
Outdoor Recreation
Livestock Grazing
Pollution
Infrastructure and Roads
Change in Fire Ecology
Logging
Habitat Loss
destruction, fragmentation, degradation

Tropical Forests
7% Area, 50% species
lose 1% of original area/year
poor farmers, including resettlement
poor soils

Madagascar
1.5% in 2020?

Habitat Loss
destruction, fragmentation, degradation

Tropical Deciduous Forests
Where people settle first
Agriculture and Ranching

Temperate Grasslands
Farming & Ranching

Wetlands (just "swamps")
Ecosystem Services, Biodiversity

Coasts (esp. Mangroves)
Human Settlement, Aquaculture, etc.

Coral Reefs
Exploitation, Warmer Waters, Pollution

Desertification
Stress arid areas
Species-Area Relationship

3 step loss of biodiversity (Rosenzweig)

1. Endemics
2. Sink populations
3. Stochasticity

Therefore end up with lower steady state species richness and loss of biodiversity

\[ S = cA^Z \]

\( S \) = species richness
\( c \) = taxon-specific constant
\( A \) = area
\( Z \) = extinction coefficient for taxon

---

**Figure 4.6**

When the size of a natural area is decreased, the first species lost are endemics. Next, sink species (those that are not reproducing fast enough to replace themselves) go extinct locally. Finally, failure to replace accidental losses fast enough brings the province to a still lower steady state of biodiversity.

*After Rosenzweig (1999).*
Habitat FRAGMENTATION

1. Smaller Populations

2. EDGE EFFECT
   increase amount of edge

3. Less remains far from edges
Habitat FRAGMENTATION

Remove 2% area (road, rail line)
BUT lose ~50% interior habitat

ROADS also allow new ACCESS

Invasives ↑
Generalists ↑
Specialists ↓
Environmental DEGRADATION & POLLUTION

Biomagnification especially filter feeders

Water Pollution
Toxins, Eutrophication

Air Pollution
Acid
Ozone
Toxins
CLIMATE

Water Pollution
Eutrophication

↓ Oligotrophic
↓ Mesotrophic
↓ Eutrophic

N, P
Water Pollution

Dead Zones

http://www.gulfhypoxia.net/overview/

http://blog.nola.com/graphics/deadzone_map061007.gif
What is an invasive species?

- a species of plant, animal, or other organism introduced (usually by humans; occasionally invasives are natives) to a new or modified ecosystem, where it becomes harmful to the natural environment (or to human health and welfare).
What is an invasive species?

- TYPICALLY: organism not native to a region
- Introduced accidentally or intentionally
- Out-compete native species for available resources, reproduce prolifically, and dominate regions and ecosystems.
- Difficult to control w/o native predators

*Remember: not all invasive species are exotic, and not all exotic species are invasive!*

Historical context in North America

- Originally viewed as welcome additions to landscape!
- Domesticated plants and animals
- Ornamental plants and animals to remind settlers of home
Current state

- More than 6,500 species of established, self-sustaining populations of non-native species in the U.S.

- Result from: increased movements of people, transportation of products, and reduced travel time between destinations

How serious of a problem?

- Costs due to invasive spp. in U.S. is $125-140 billion / year.
- 25% of US agriculture GNP lost to foreign pests
- Nearly 1/2 of species listed as threatened or endangered under the E.S.A. are at risk due to competition with or predation by non-native species
- Considered by biologists to be the third greatest threat to biodiversity!
Not all introduced species are successful

The “Tens Rule”:
- 10% of non-native species become established
- 10% of those become ecological problems (invasives!!)

Characteristics of invasive species
- Widespread distribution (AND abundance)
- Great dispersal ability or migratory tendencies
- Great reproductive capability; being r-selected
- Early maturation; short generation time
- Small body size
- Edge species
- Affinity with humans (anthrophilic)
- Capacity for clonal/asexual reproduction
Characteristics of invaded habitats

- Disturbance
- Low diversity
- Absence of predators of invading species
- Absence of native species morphologically or ecologically similar to invader
- Absence of predators or grazers in evolutionary history (naive prey)