Lecture 9, 22 Sept 2009
Biodiversity V

Conservation Biology
ECOL 406R/506R
University of Arizona
Fall 2009

Kevin Bonine
Mary Jane Epps

506 meet in BSE129
9am Wed (23 Sept)

Biodiversity Readings
- Primack Ch4
- Suzuki Link
- Biocontrol Link

Thank Don Swann

Exam I on Thursday

3rd Lab SATURDAY 26 Sept 7am northwest corner BSE

Nonrival goods
(air to breathe)

or

Nonexclusive goods
(UV protection from ozone)

Science, Vol 162, Issue 3859, 1243-1248 , 13 December 1968

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.

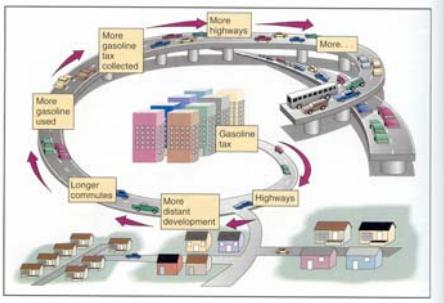


FIGURE 24–5 The development cycle spawned by the Highway Trust Fund.

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?

Product itself

Shift Burden of Proof/Responsibility (precautionary principle)

SMS (safe minimum standard)

	~Developers	~Conservationists
1 Instrumental		B of P
2 Intrinsic also	B of P	
3 BCA		B of P
4 SMS	B of P	

EARTH WATCH

THE CLEAN AIR ACT BRINGS A WINDFALL

The Clean Air Act (1970, 1977, and 1990) has been the subject of open political warfare between those who think its cost has been too high for industry, taxpayers, labor, and consumers and those who think the health and environmental benefits were justified. Compliance has affected patterns of industrial production, employment, and capital investment. Although these expenditures must be viewed as investments that have generated benefits and opportunities, the dislocation in some industries was severe and included reductions in high-sulfur coal mining and cutbacks in polluting industries such as steel. A need developed for a real cost-benefit analysis.

In 1990, Congress requested the EPA to answer the question, How do the overall health, welfare, ecological, and economic benefits of Clean Air Act programs compare with the costs of these programs? In response, the EPA performed the most extensive cost-benefit analysis of public policy ever attempted. Here is what the EPA reported in a 1996 study.

- The total direct cost of implementing the Clean Air Act for all federal, state, and local rules from 1970 to 1990 was $436 billion (in 1990 dollars). This cost was borne by businesses, consumers, and government entities in the form of higher prices for many goods and services and for some utilities.
- The mean estimate of direct benefits from the Clean Air Act from 1970 to 1990 was $6.8 trillion.
- Therefore, the net benefit of the Clean Air Act has been $6.4 trillion!

"The finding is overwhelming. The benefits far exceed the costs of the Clean Air Act in the first 20 years," said Richard Morgenstern, associate administrator for policy planning and evaluation at the EPA. Further, the report states that "all benefits may be significantly underestimated due to the exclusion of large numbers of benefits from the monetized benefit estimate."

The benefits to society, directly and indirectly, have been widespread across the entire population. The clean Air Act has

- reduced air pollution (described in this chapter);
- improved human health: Each year, 79,000 lives were saved, and there were 18,000 fewer heart attacks, 10,000 fewer strokes, 13,000 fewer cases of hypertension, and 15 million fewer cases of respiratory illness.
- "avoided cost": Improved health has meant less debilitating disease, less hospitalization, less need for special care, and less need for medicines.
- lowered levels of lead, which is particularly harmful to children. In 1990, 220,000 tons of lead were not buried in gasoline, because of Clean Air Act measures. Because exposure to lead impairs the cognitive development of children, the huge reductions in lead levels produced a benefit of retained IQ and the possibility of a more productive, less dependent life.
- lowered cancer rates.
- resulted in less acid deposition.

The EPA study result should encourage us in our hopes for a more sustainable future. Society knows what to do, took action despite disruptive efforts by special-interest and political partisans, and reaped about $16 in benefits for every $1 invested to control air pollution.

In 1999, the EPA published a second analysis of costs and benefits that looked at the impacts of the CAAA of 1990 and extended expected costs and benefits to 2010. The findings are consistent with the EPA's previous analysis. According to the late analysis, the new regulations will cost an estimated $27 billion, but will generate health and ecological benefits of about $110 billion. Estimates indicate that the associated benefits will prevent 23,000 Americans from an early death, more than 1.7 million asthma episodes, 67,000 incidences of acute and chronic bronchitis, and 22,000 respiratory-related hospital visits. Many of the benefits, such as those to crops and ecosystems, are difficult to put in dollar terms. Thus, the benefits exceed the costs by a margin of four to one or better; this still sounds like a good bargain!

(Source: Adapted from R. Christopherson, Geosystems: an Introduction to Physical Geography, 3d ed. Copyright © 1997 by the author. Reprinted by permission of Prentice-Hall, Inc., Upper Saddle River, NJ 07458.)

C: ~$436 billion

B: >$6.8 trillion

1:16 -> C:B

Wright and Nebel 2002

nomadic Maasai

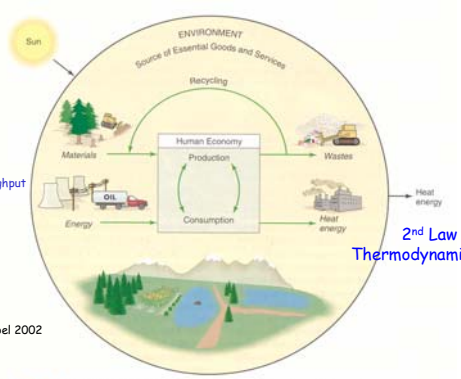
Private Property?

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.

Type of community	Domestic water use per person (L/day)
Modern Arabian town without major industry[a]	240
Traditional agricultural village	120
Small desert settlement with supply by government water truck	80
Small desert settlement with traditional water supply	28

Source: After Goudie and Wilkinson 1977.
[a] New York City has a similar usage rate.

(Hill et al. 2004)



Throughput

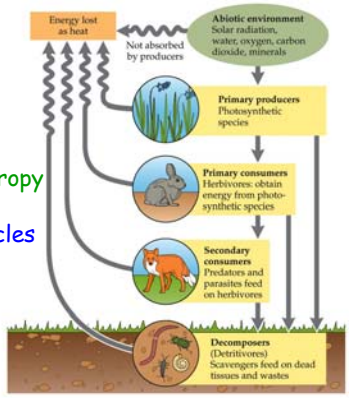
2nd Law of Thermodynamics

Wright and Nebel 2002

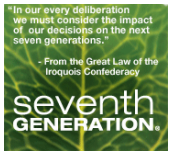
FIGURE 23-3 *Environmental economic view of economic activity.* The natural environment encompasses the economy, which is constrained by the resources found within the environment.

Energy (one way)
waste heat = entropy

Everything else cycles



PRIMER OF CONSERVATION BIOLOGY 4e, Figure 2.5



Vs.

Positive DISCOUNT RATE

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. Ilth (accumulation of goods vs. bads)

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

"SATISFICING"
Development vs. Growth

If resources infinite then price = 0,
but if pay for resources then can redistribute wealth

Center for the Advancement of the

Steady State Economy

http://www.steadystate.org/Index.html

13

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.

14

What are the major threats to biodiversity?

16

Threats to Biodiversity

(Primack Ch4)

17

Threats to Biodiversity

Habitat Loss

destruction, fragmentation, degradation

Global Climate Change

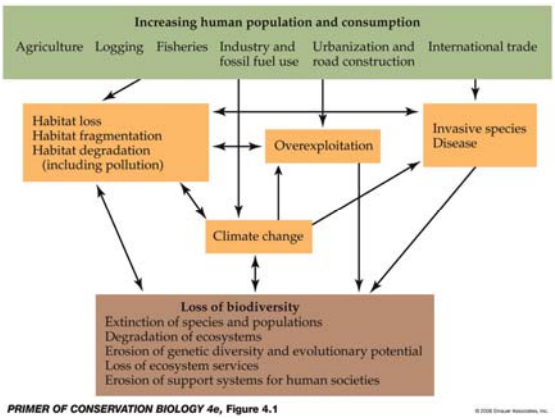
Overexploitation

Invasives

Disease

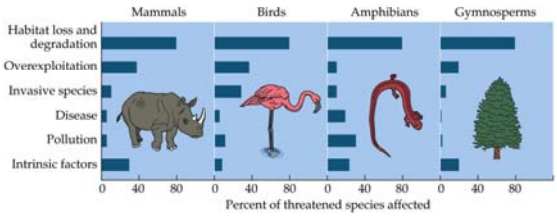
SYNERGY

19



Habitat Loss

destruction, fragmentation, degradation



21

Habitat Loss

destruction, fragmentation, degradation

<u>In the US:</u>

Agriculture
Commercial Developments
Outdoor Recreation
Livestock Grazing
Pollution
Infrastructure and Roads
Change in Fire Ecology
Logging

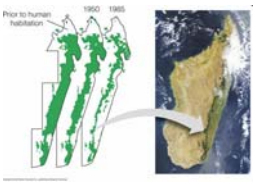
22

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?



23

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

24

Species-Area Relationship

$S = cA^Z$

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

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

25

3 step loss of biodiversity (Rosenzweig)

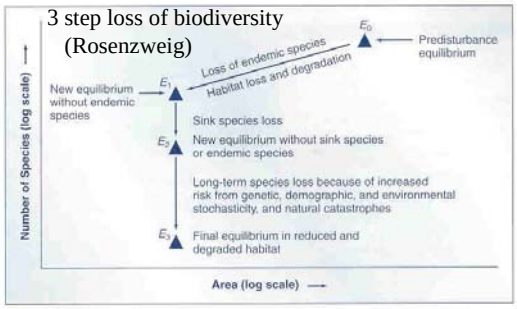


Figure 4.6
When the size of a natural area is decreased, the first species lost are endemics. Next, sink species (those that are not reproducing fast enough to replace themselves) go extinct locally. Finally, failure to replace accidental losses fast enough brings the province to a still lower steady state of biodiversity.
After Rosenzweig (1999).

Van Dyke 2003

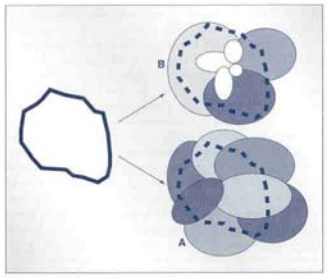


Figure 4.7
The "cookie cutter" model of the effects of habitat loss on endemic species. If the cookie cutter strikes at subarea A, seven species lose habitat but none is exterminated. In contrast, if the cookie cutter strikes subarea B, an area containing species with more restricted ranges, seven species lose habitat, and four species are exterminated. Thus, random habitat loss produces a disproportionately high rate of extinction in endemic species.
After Pimm (1998).

Van Dyke 2003

Endemics
Habitat Size
Habitat Loss

27

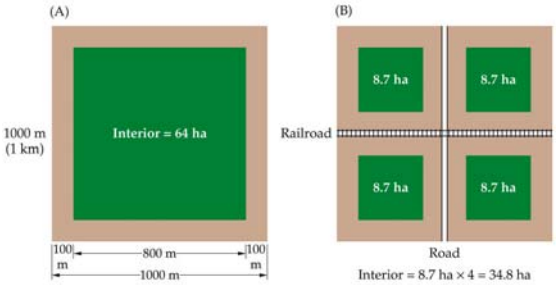
Habitat FRAGMENTATION

1. Smaller Populations
2. EDGE EFFECT
   increase amount of edge
3. Less remains far from edges

28

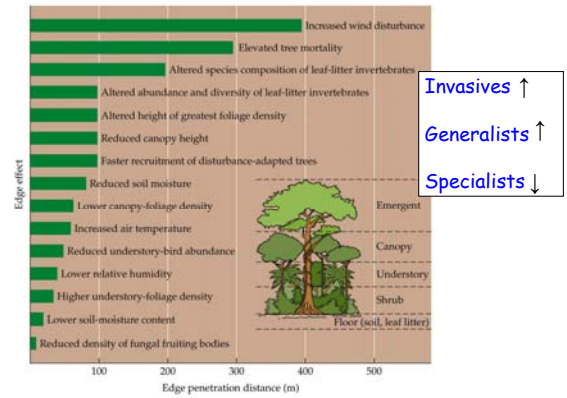
Habitat FRAGMENTATION

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



ROADS also allow new ACCESS

29



F CONSERVATION BIOLOGY 4e, Figure 4.10

30

Environmental
DEGRADATION & POLLUTION

Biomagnification
especially filter feeders

Water Pollution
Toxins, Eutrophication

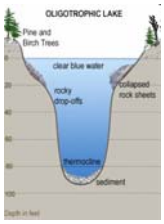
Air Pollution
Acid
Ozone
Toxins
CLIMATE

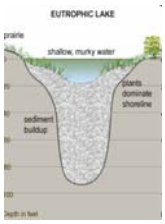
31

Water Pollution
Eutrophication

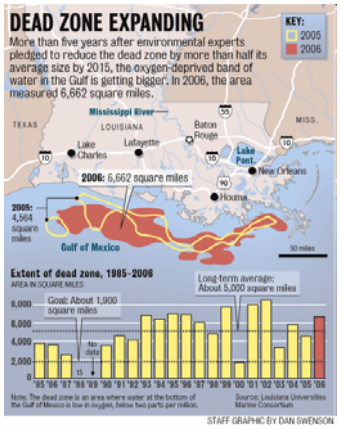
time
↓ Oligotrophic
↓ Mesotrophic
↓ Eutrophic

N, P





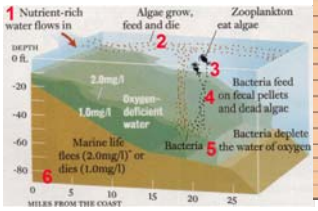
32



http://blog.nola.com/graphics/deadzone_map061007.gif

33

Water Pollution
Dead Zones



Year	Square Kilometers	Square Miles	Comparative Geography
1985	9,774	3,768	Rhode Island + Delaware
1986	9,432	3,636	Rhode Island + Delaware
1987	6,688	2,578	> Delaware
1988	40	15	
1989	8,100 est.	3,122 est.	Rhode Island + Delaware
1990	9,260	3,570	Rhode Island + Delaware
1991	11,920	4,595	~ Connecticut
1992	10,840	4,179	Rhode Island + Delaware
1993	17,600	6,785	> Connecticut
1994	16,600	6,399	> Connecticut
1995	18,200	7,016	~ Lake Ontario
1996	17,920	6,908	~ Lake Ontario
1997	15,840	6,106	> Connecticut
1998	12,480	4,811	~ Connecticut
1999	20,000	7,710	New Jersey
2000	4,400	1,696	>Rhode Island
2001	20,720	7,988	New Jersey
2002	22,000	8,481	Massachusetts
2003	8,560	3,300	Rhode Island + Delaware
2004	15,040	5,798	> Connecticut
2005	11,840	4,564	~ Connecticut
2006	17,280	6,662	10 x Lake Ponchartrain
2007	20,500	7,903	New Jersey
2008	20,720	7,988	New Jersey

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

Biological Invasions

Modified from Kathy Gerst (2008)
Dept. of Ecology and Evolutionary Biology

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).

36

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!*

37

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

38

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

39

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!

40

Not all introduced species are successful

The “Tens Rule”:

- 10% of non-native species become established

- 10% of those become ecological problems (invasives!!)

41

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

42

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)