Science, Society, and the Biosphere

Defining environmental science and sustainability

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Office Hours

- Biology Conference Room, 210 Ford Life Sciences
- MWF, 12:00–4:00 PM
- Contact me if you would like to meet at an alternate time

Course Web Site

- Lecture Notes
- Non-textbook Reading Assignments (tentatively)
- Discussion Reading Assignments (tentatively)
- Online Resources

`http://napoletano.net/envsci/`

Tentative Discussion Schedule

Date	Discussion
16 Sep	Pricing Ecosystem Services
23 Sep	Freshwater Supplies & Quality
7 Oct	World Hunger, Food Supplies, & Production
14 Oct	Urban Growth & Sprawl
21 Oct	Overpopulation & Overconsumption
4 Nov	Climate Change & Energy Use
11 Nov	Air Quality & Pollution
18 Nov	Land Use & Tropical Deforestation
2 Dec	Biodiversity Conservation in Public Parks
9 Dec	Environmental Governance in a Global Economy

Discussion Selection

Please sign up for the discussions you plan to attend. You can always change your mind later.

Humanity and Global Change

Types of global change

- Pervasive local change (Smil, 2002)
  - Change at one location does not directly affect another
  - Benefits of mitigation primarily local
  - e.g. aquifer depletion and pollution, invasive-alien species, photochemical smog
- Inherently global change (Smil, 2002)
  - Planetary effects regardless of locus of origin
  - Benefits of mitigation primarily global
  - e.g. climate forcing, ozone depletion

Environmental change goes global

- With globalization, humanity has become the dominant ecological *and* evolutionary force on the planet (Ehrlich and Ehrlich, 2004; Speth, 2004)
- During the twentieth century humanity increased its. . .
  - population fourfold,
  - economic output increased twenty-fold,
  - energy use sixteen-fold, and
  - pesticide output tenfold.

Tabulating the cost

Findings of the *Millennium Ecosystem Assessment* (MEA, 2005c):

- 60% (15 of 24) of ecosystem services being degraded or used unsustainably
- Cultivated systems cover 25% of Earth's terrestrial surface
- 20% of coral reefs lost and additional 20% degraded
- 35% of mangrove area lost
- 10–20% of drylands degraded (MEA, 2005b)
- More than 50% of wetlands destroyed, and an even larger proportion degraded (MEA, 2005d)

Tabulating the cost

- Water impoundment quadrupled since 1960,
- Withdrawals from rivers and lakes doubled (70% used for agriculture)
- Reactive nitrogen has doubled since 1960, and phosphorus has tripled
- Atmospheric concentration of carbon dioxide has increased by 32% since 1750, with 60% of this increase after 1959
- 10–30% of mammal, bird, and amphibian species face extinction
- 20–30 percent of assessed plants and animals face extinction if temperatures increase by more than 1.5–2.5 degrees C (MEA, 2005a)

Natural Resource Use

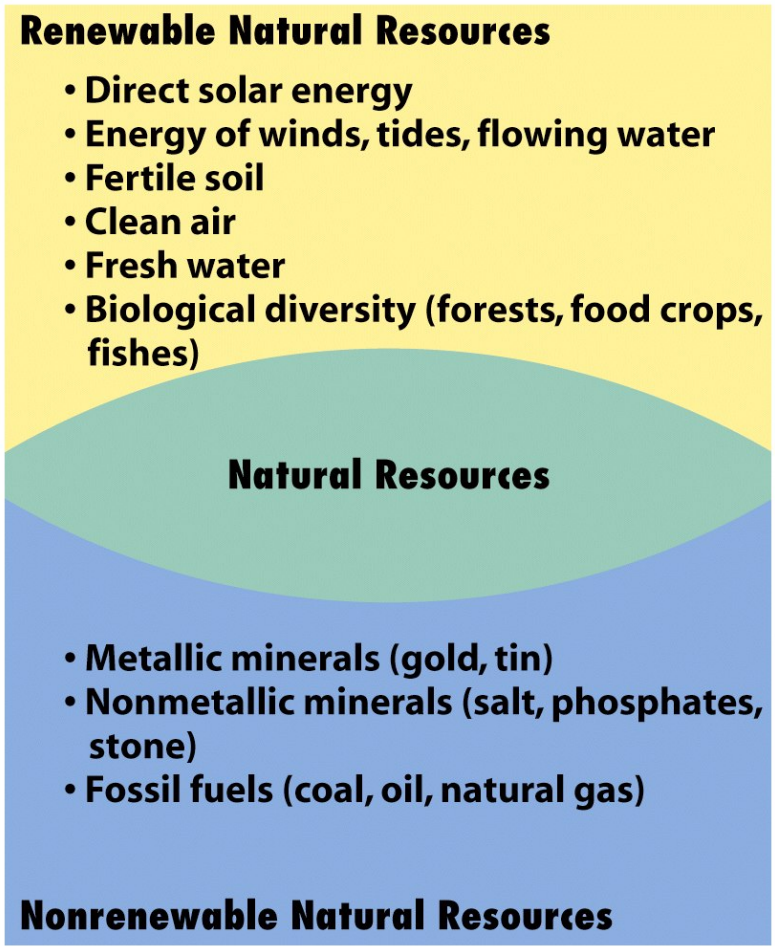


Figure 1-7 Environment, 5/e

A planet-wide experiment

"The fundamental problem is that Homo sapiens is moving ecological systems outside the envelope of conditions that have existed over evolutionary history. This is terra incognita and the assumption that ecological systems will respond stably is unjustified."

–Robert O'Neill (2001)

The role of environmental science in society

- Attempt to identify general patterns in natural and human systems and their interactions
- Systems and synthetic approach, deals with "complex adaptive systems" (Levin, 2000)
- Highly interdisciplinary
- Forecasting and sustainability scenario development
- Minimize, or at least quantify, uncertainty

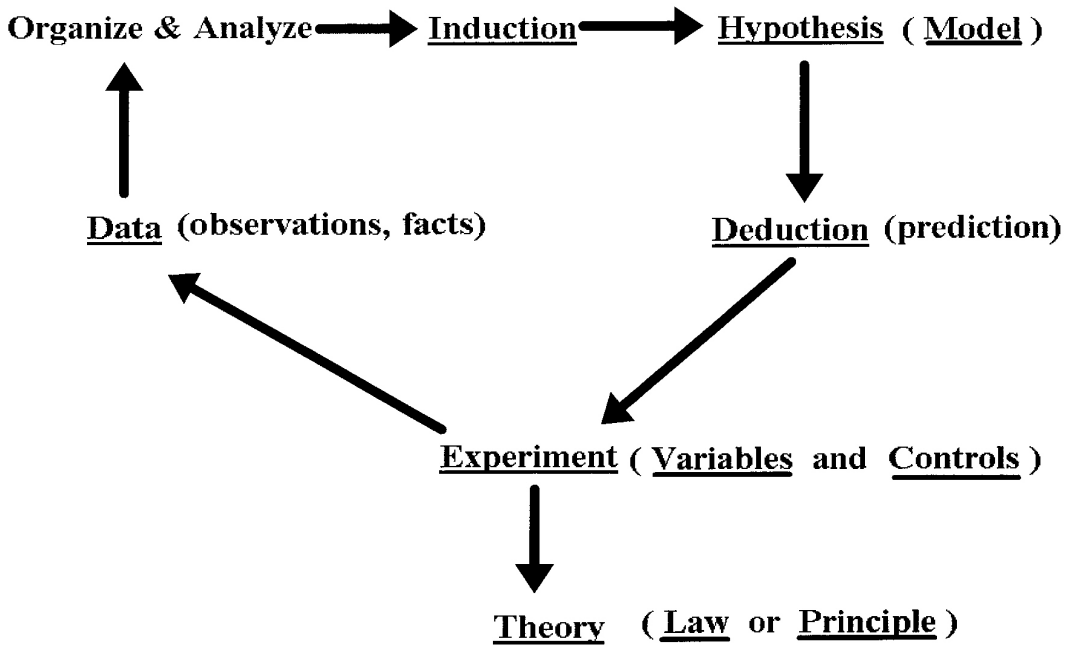
Objectives of the scientific approach

- Explain observed world in terms of generalized principles
- Maximize predictive power (i.e. "If we do x, y will probably result")
- Hypothesis are disproved or not disproved, not proved or not proved

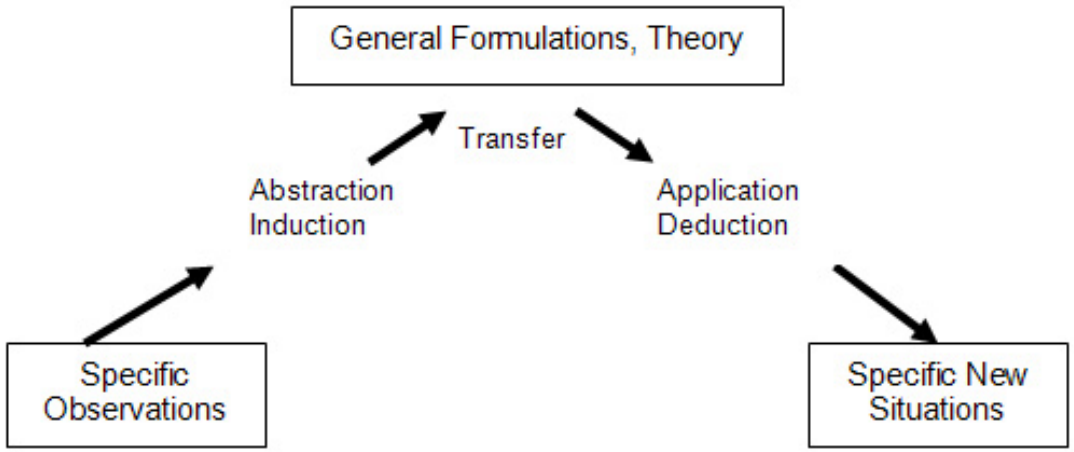
Approaches to scientific knowledge

- Hypothesis formulation and testing (Popper, 1972)
- Empirical generalization (Vernadsky, 1926; Mayring, 2007)
- Systems modeling (Laszlo, 1996)
- Dialectical analysis (Levins, 1998)
- Historical materialism (Hughes, 2000)

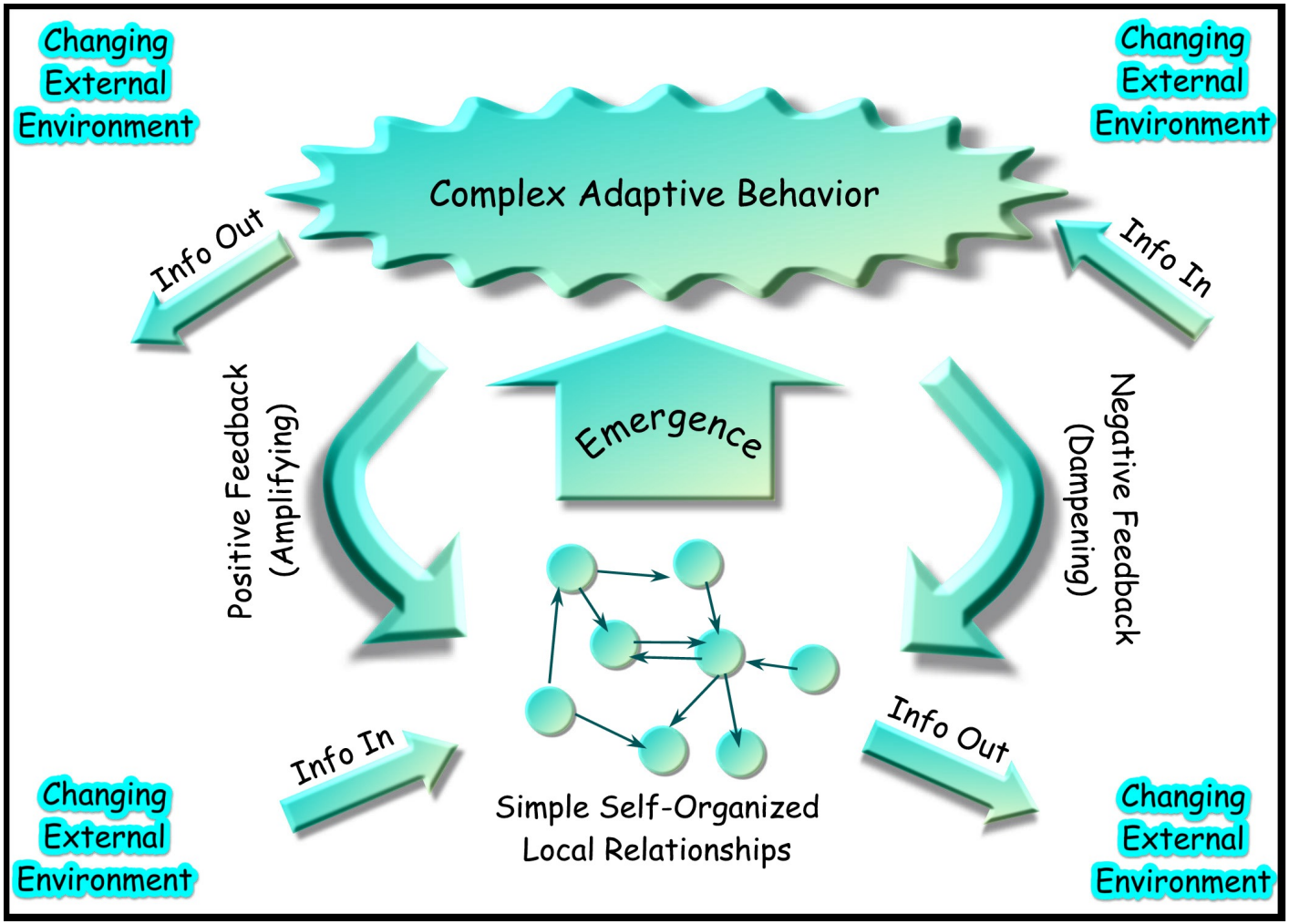
Hypothesis testing



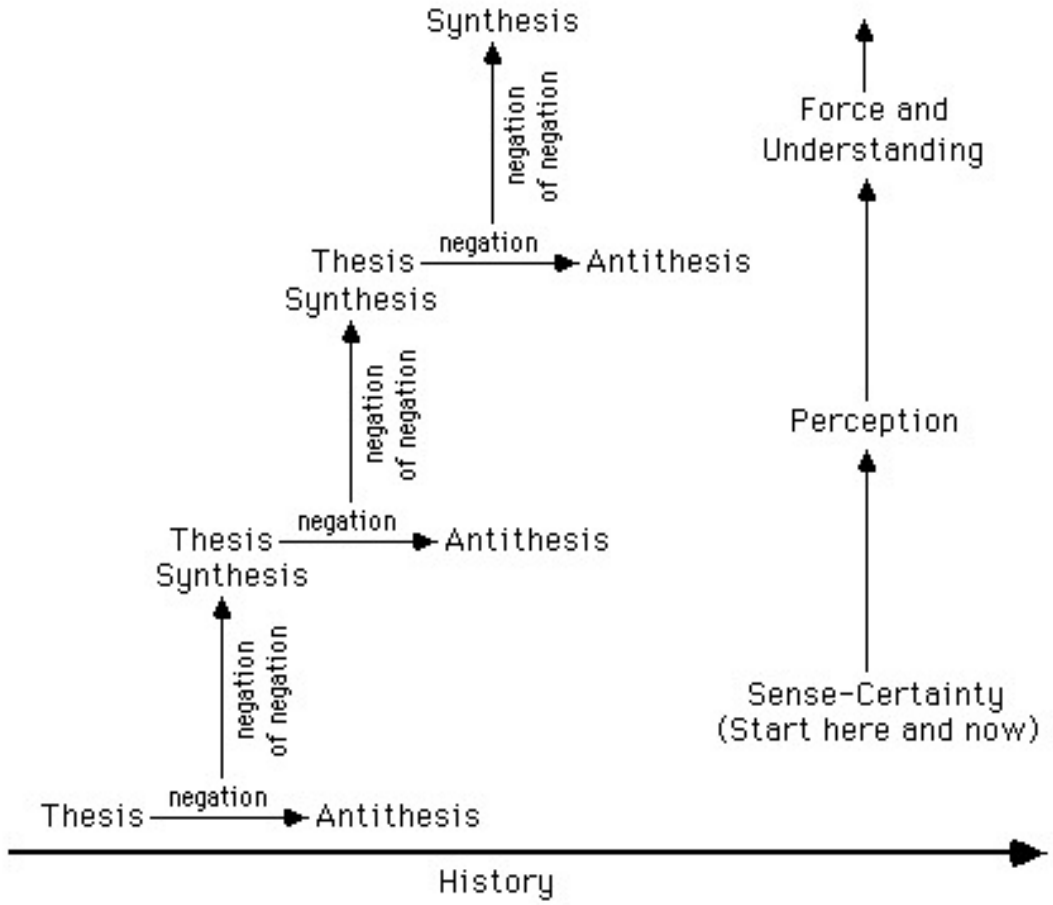
Empirical generalization



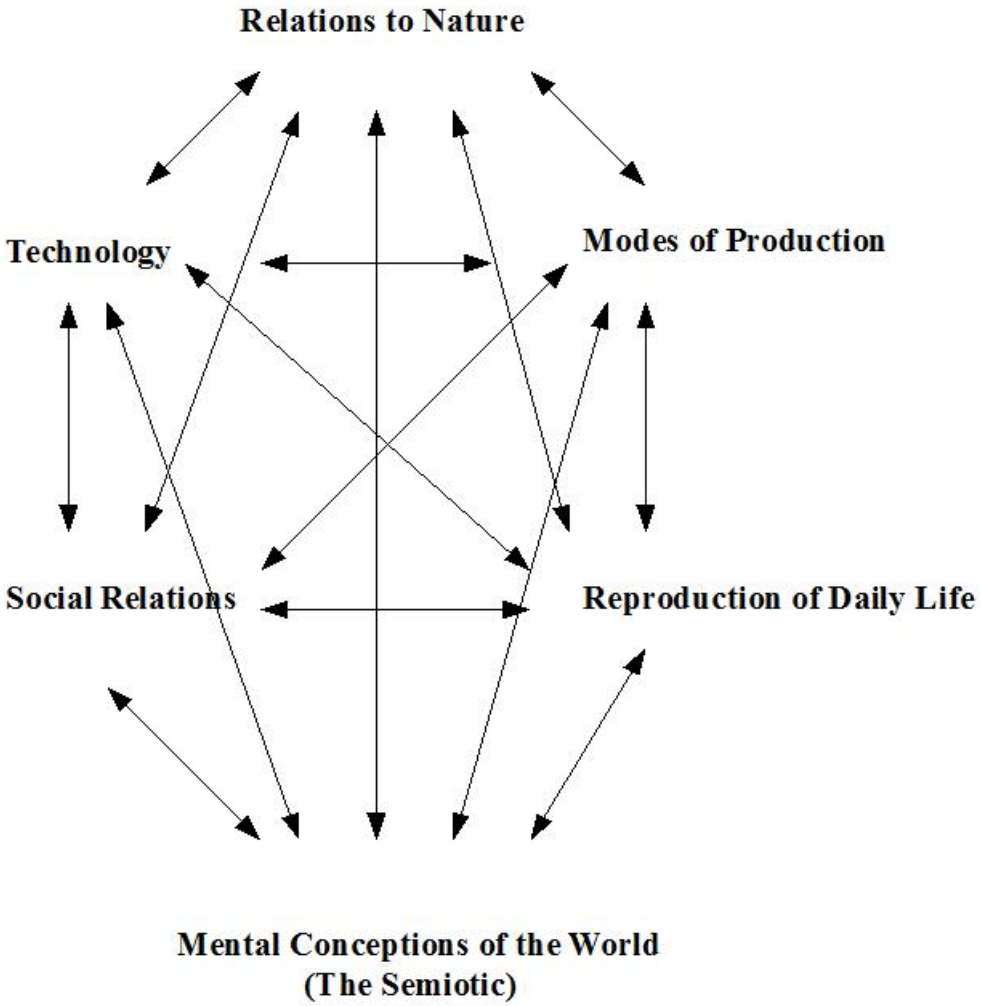
Modeling complex adaptive systems



Dialectical analysis



Historical materialism



The Earth System

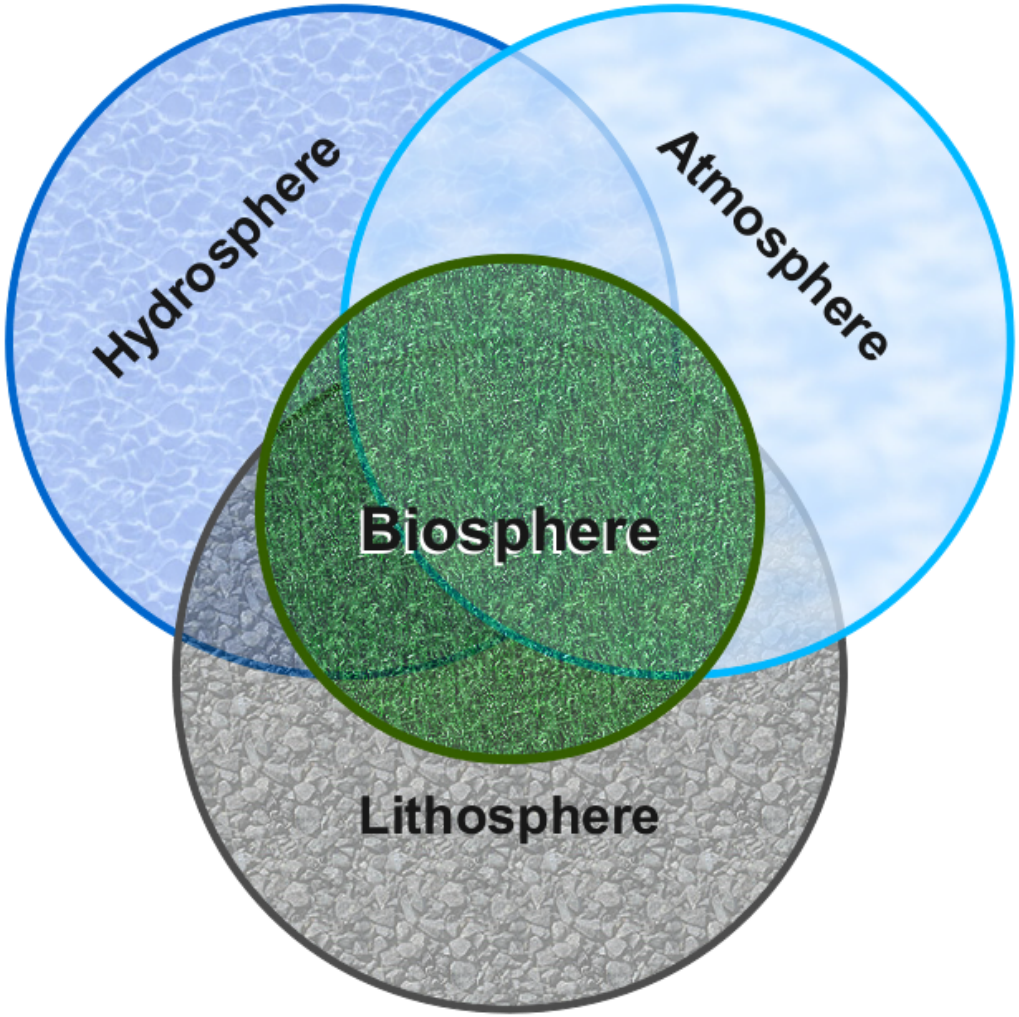
Lineage of the Concept

- Eduard Suess (1831–1914), Austrian geologist, introduced "biosphere"
- Vladimir Ivanovich Vernadsky (Vernadskii, 1863–1945), Russian mineralogist, introduced and described modern concept
- Evelyn Hutchinson (1903–1991), US ecologist, introduced Vernadsky to the English-speaking world (Smil, 2002)

Modern concept of the biosphere

- Physical domain of life
- Geological force
- Irreducible whole, complex adaptive system

Meet the Biosphere



"Laws of ecology"

1. Everything is connected to everything else
2. Everything must go somewhere
3. Nature (usually) knows best
4. There is no such thing as a free lunch (TANSTAFL)

From Commoner (1971)

Overpopulation, overconsumption, & technology

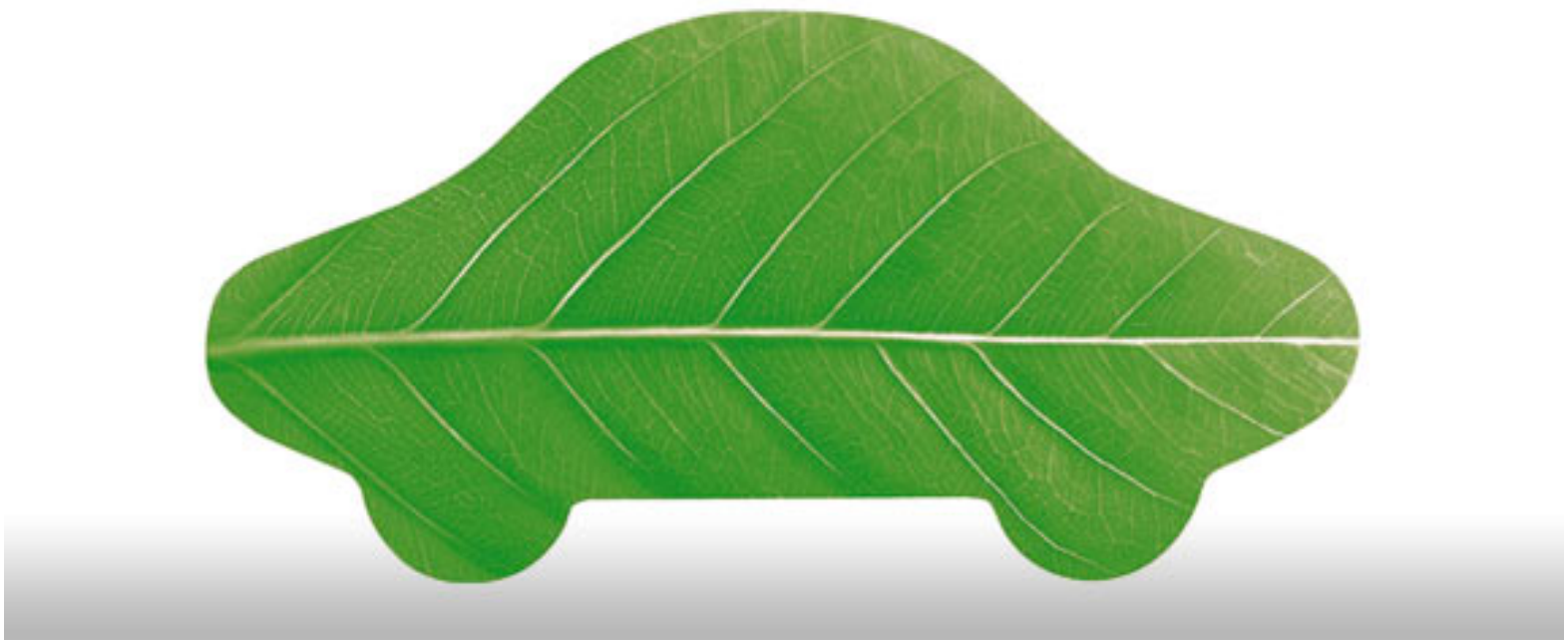
$$I = P \times A \times T \tag{1}$$

After Ehrlich and Holdren (1971)

Overpopulation

Overconsumption

Technology



Problems with IPAT

- "Implicitly neo-Malthusian" (de Sherbinin et al., 2007)
- Industrial production (Commoner et al., 1971; Commoner, 1997)
- Global trade & material flows (Fischer-Kowalski and Amann, 2001)
- Policy & institutional factors (Geist and Lambin, 2001)
- Scale & spatial factors (de Sherbinin et al., 2007)
- Interactions between the terms (Dietz and Rosa, 1994)
  - Population & consumption growth cause collapse
  - Population & consumption growth stimulate technology
  - Technology subsumes population & consumption
  - Multiple factors

Tragedy of the Commons

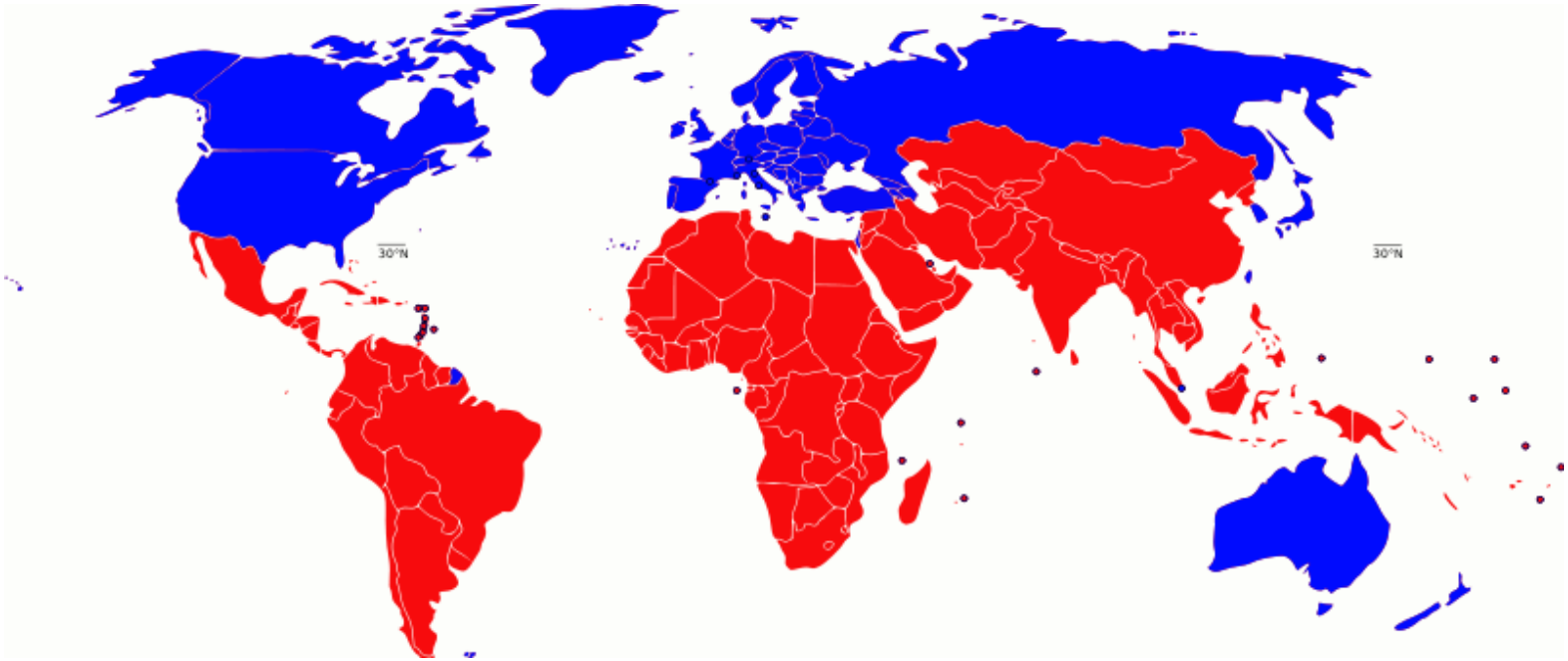
- Used by Hardin (1968) to advocate
  - Eliminating foreign aid
  - Eliminating welfare and social services
  - Privatization of natural resources and public parks
  - "Lifeboat ethic"
- Difference between "common-pool" and "open-access" resources (Berkes et al., 1989)
- Policy recommendations called unrealistic, untenable, and ethically dubious (Callahan, 1974)
- Privatization & destruction of communal property exacerbated environmental degradation (McGranahan, 1991; Monbiot, 2002; Reddy, 2002)

How is globalization affecting the biosphere?

Sustainable Development

To be considered sustainable, development "meets the needs of the present without compromising the ability of future generations to meet their own needs"
–WCED (1987)

North-South Divide



Uneven national consumption

- The Global North accounts for less than 20% of the world population, yet consumes:
  - 86% of aluminum produced
  - 76% of timber harvested
  - 68% of energy produced
  - 61% of meat consumed
  - 42% of freshwater used
  - and generates 75% of the world's waste and pollution
- 54% of global income goes to 10% of population (UNDP, 2005)
- 5% of global income is shared by 40% of population
- 1.6% of income of top 10% could eliminate extreme poverty

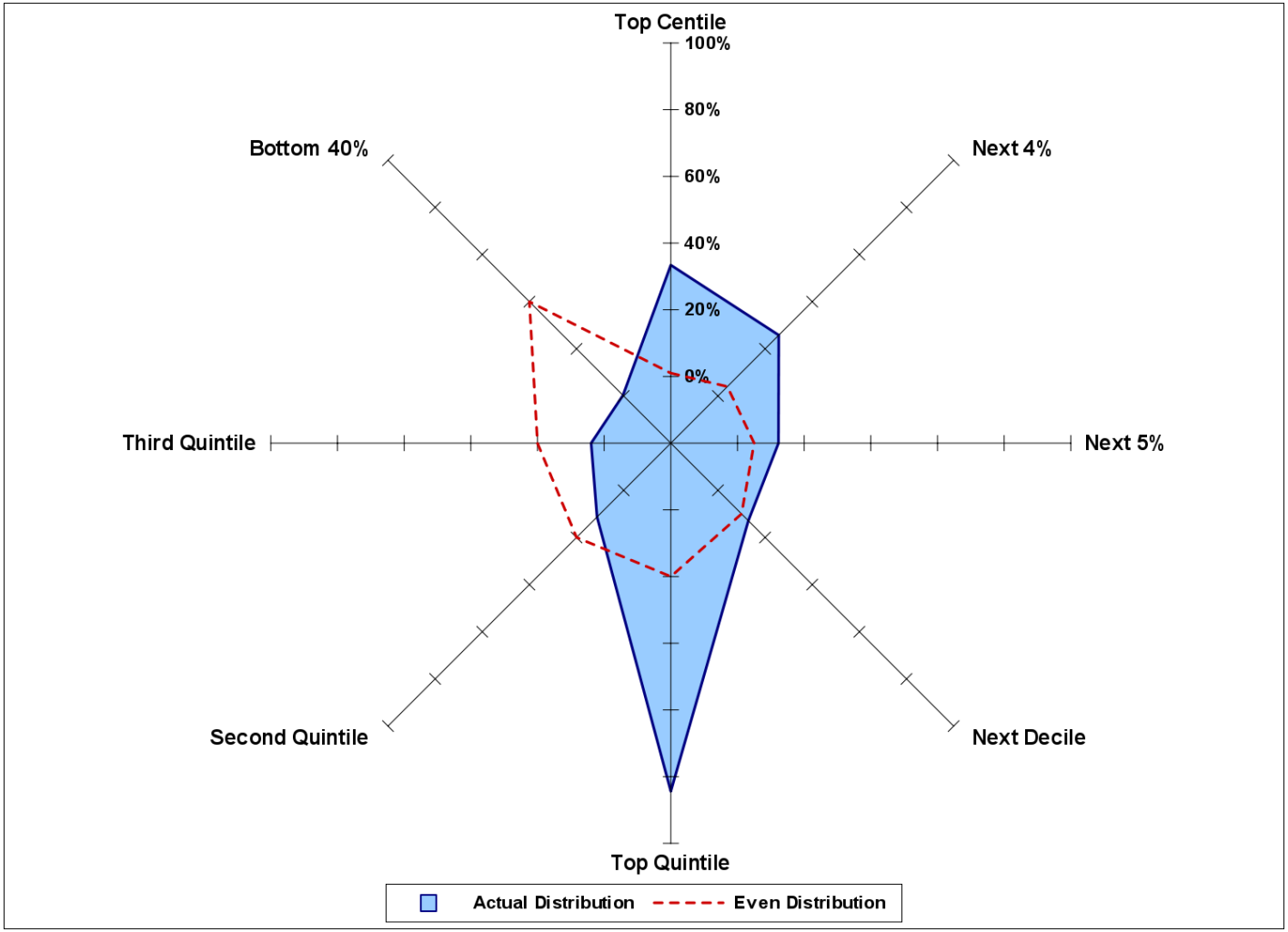
Uneven intranational consumption

Net worth in the United States

Rank	Share	Per-capita GDP
Top 1%	33.4%	$1,155,835
Top 20%	84.4%	$146,037
Second 20%	11.3%	$19,552
Third 20%	3.9%	$6,748
Last 40%	0.3%	$260

After Kapur et al. (2005)

Net worth in the US



Questions of Equity

- Intra-generational equity
- Inter-generational equity
- Inter-specific equity?

The challenge of global sustainability

"At this moment in time, we are all simultaneous and central, complete contemporaries who are entering the new millennium on the same day, walking together. In the globalized world, either we all save each other, or even god will not be saved."

–Armando Bartra (2004)

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