



Biophysical Limits to Growth

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Senior Research Scholar, IIASA, Austria

Editor-in-Chief, *Ecological Modelling*

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We witness unsustainable human-ecosystem interactions

- How could people make such serious mistakes in the past and why does society continue to repeat such mistakes today?
- Is it inevitable that the environment must be degraded to satisfy human needs?

Drivers of Unsustainability

■ HUMAN POPULATION INCREASE

- Agriculture
- Shelter
- Mobility
- Stuff

Use Energy and
Material Resources
causes

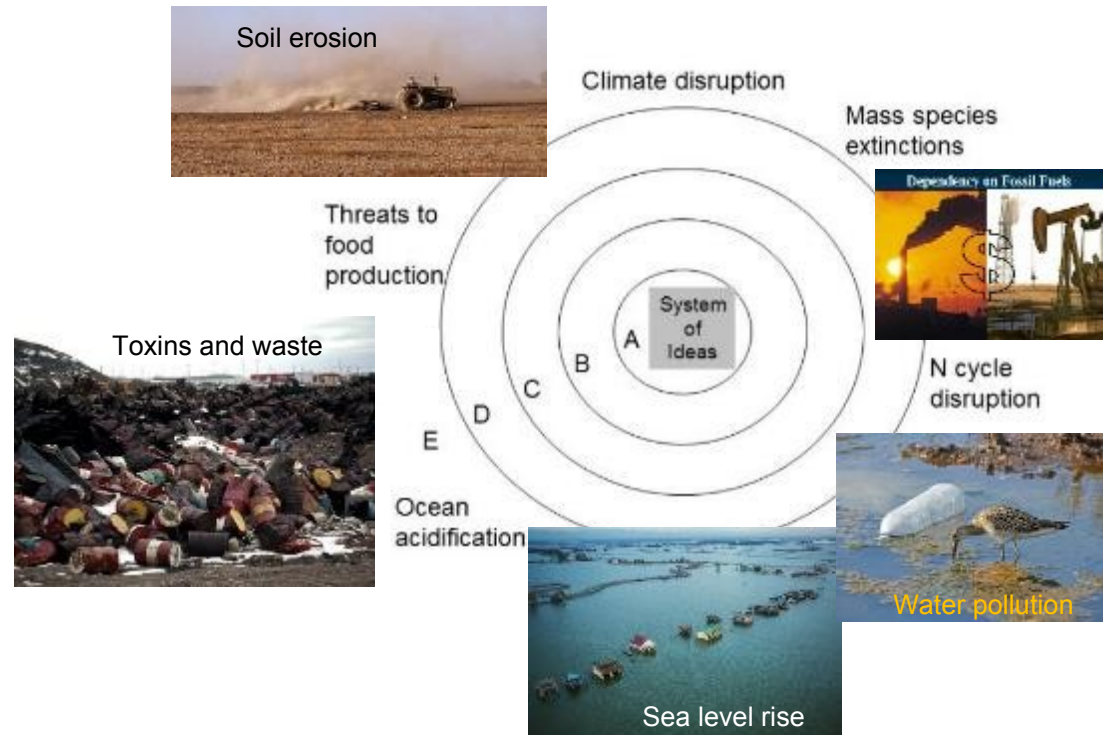
- Land use change
- Habitat loss
- Deforestation
- Alter biogeochemical cycles

Climate Change
Eutrophication
Acid precipitation
Ozone Depletion
Smog
...

Leads to



Environmental (and Social) problems are symptoms of deeper failures

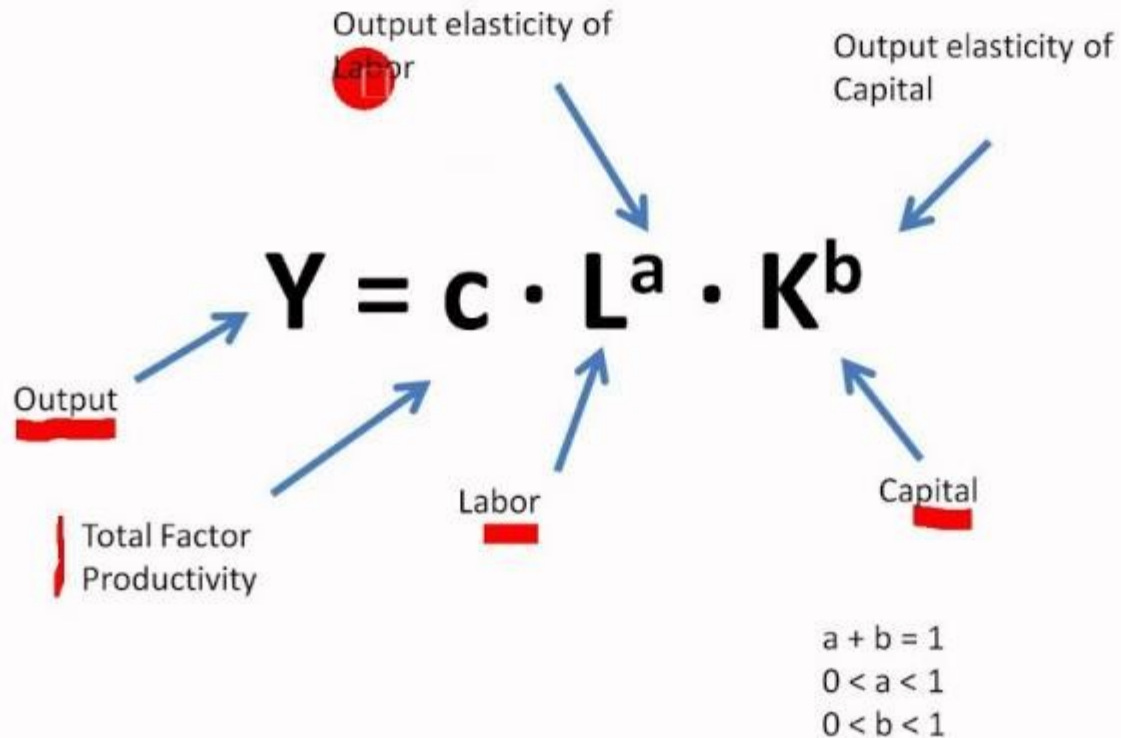


Economics



- Economics is one the main organizing forces in society
- Many decisions are made based on cost-benefit analysis but true costs (direct + indirect) to individual, society, or environment are often not known

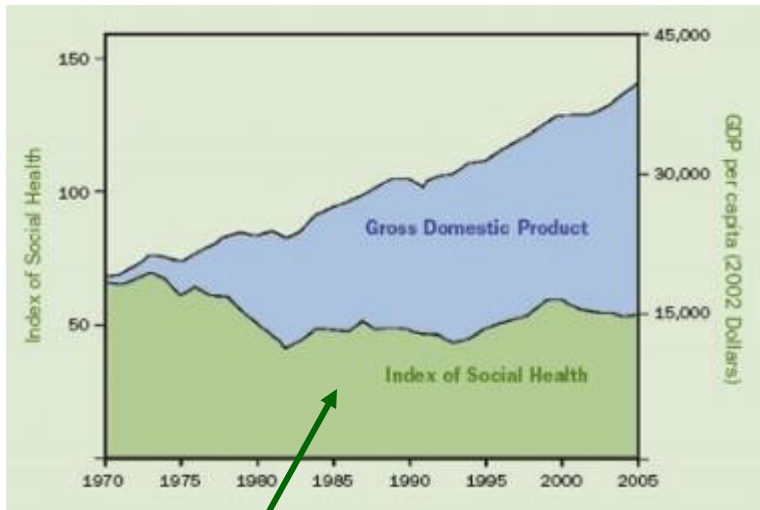
Cobb-Douglas Production Function



WHERE IS ENVIRONMENT?

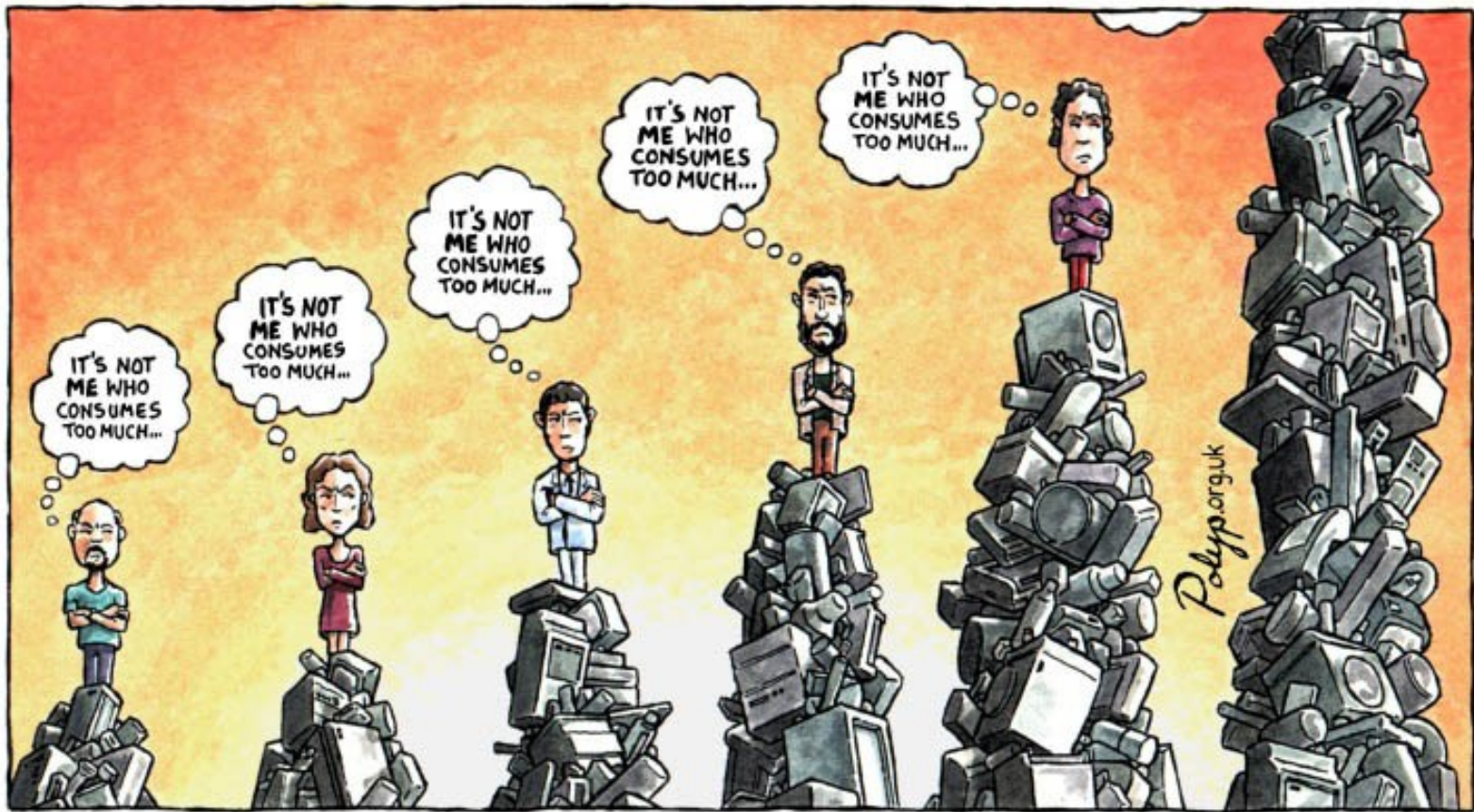
What is the purpose of growth?

Does bigger always mean better?



Alternative well-being indicators tell a different story

Humans are social animals, measuring in terms of others, not absolutes



'IT'S NOT ME'

TheUpshot

ECONOMIC TRENDS

We're in a Low-Growth World. How Did We Get Here?



Neil Irwin @Neil_Irwin AUG. 6, 2016

One central fact about the global economy in the past year's remarkable headlines: Economic growth in advanced nations has been weaker for longer than at any point in the lifetime of most people on earth.

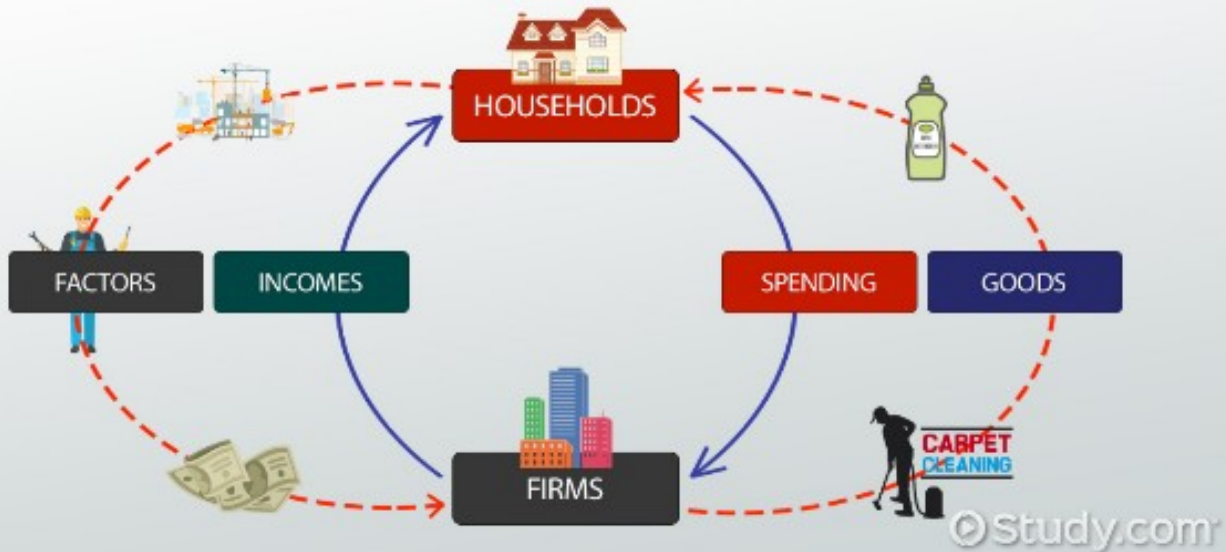
No mention of natural resources or environment

It increasingly looks as if something fundamental is broken in the global growth machine — and that the usual menu of policies, like interest rate cuts and modest fiscal stimulus, aren't up to the task of fixing it (though some well-devised policies could help).

Assumption error:
Economy as an isolated system

LESSON SUMMARY

Circular Flow Diagram



A better model: Economy as an open system

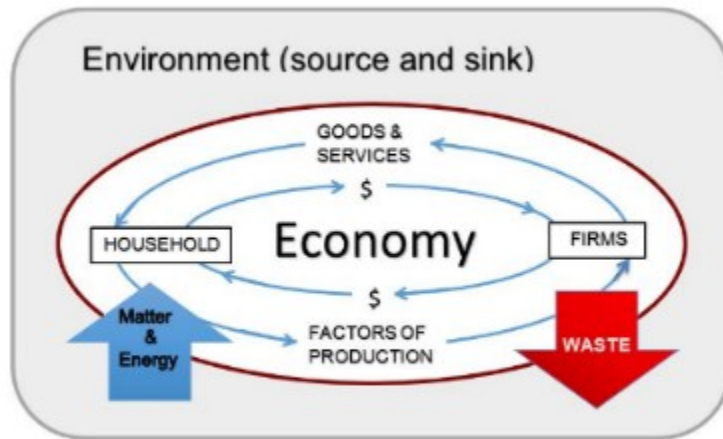
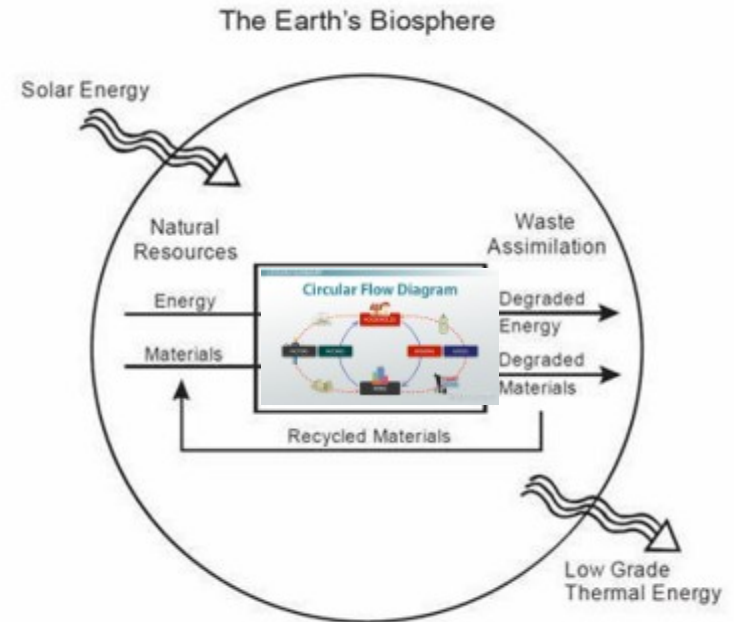



Fig. 2. Thermodynamic throughput model. Note the addition



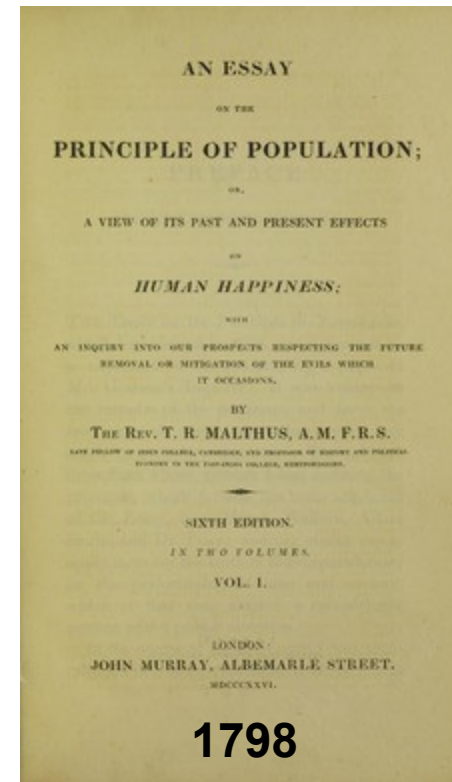
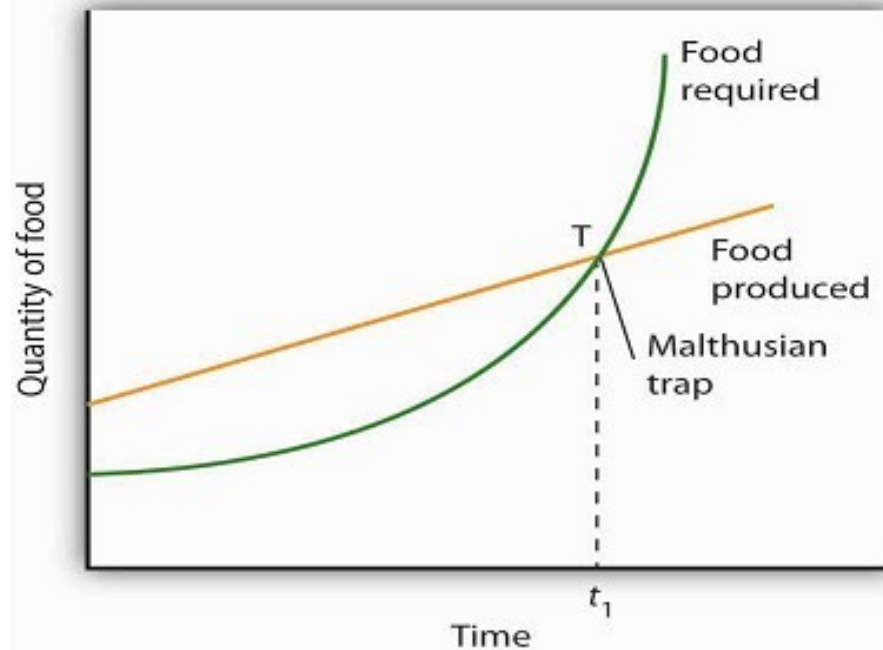


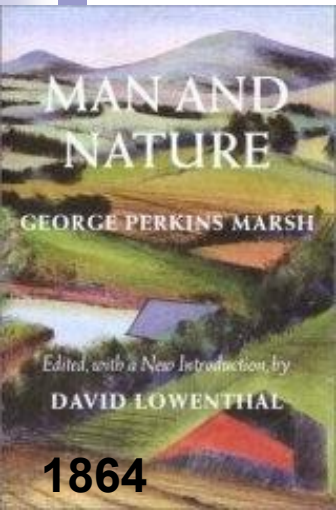
A look back at the history
recognizing limits

Thomas Malthus



- Predicts eventually food and resources will run out as populations explode



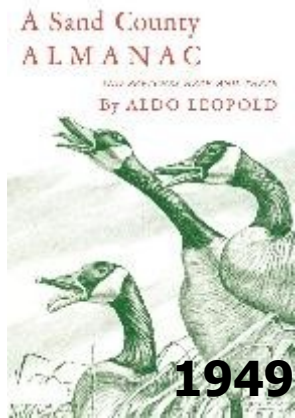


George Perkins Marsh



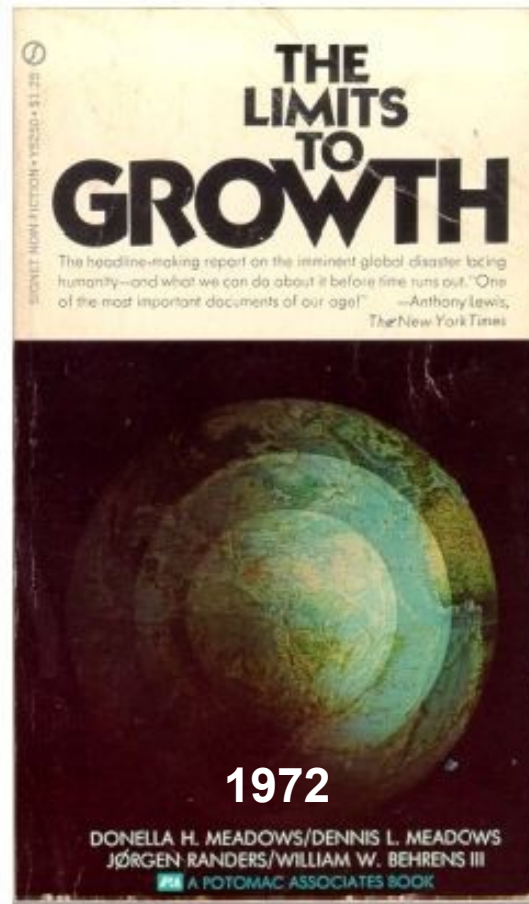
- “A certain measure of transformation of terrestrial surface, of suppression of natural, and stimulation of artificially modified productivity becomes necessary. This measure man has unfortunately exceeded.”
- “The ravages committed by man subvert the relations and destroy the balance which nature has established...; and she avenges herself upon the intruder by letting loose her destructive energies...”

Aldo Leopold



- A Sand County Almanac – regarded as the most influential book on conservation ever written.
- The land ethic:
- "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise."
- Enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: the land.

Donella Meadows and Club of Rome

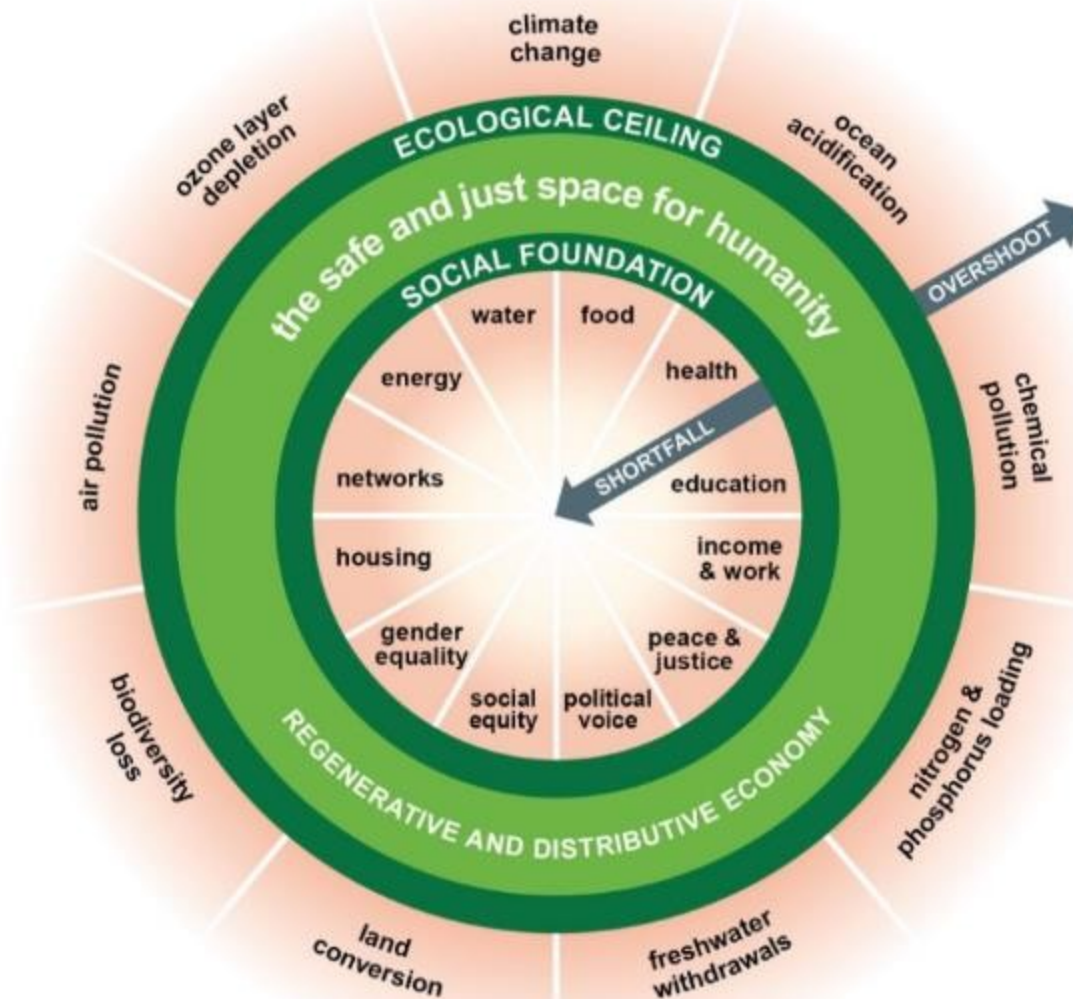




Planetary Boundaries – Stockholm Resilience Centre



Donut Economics – Kate Raworth

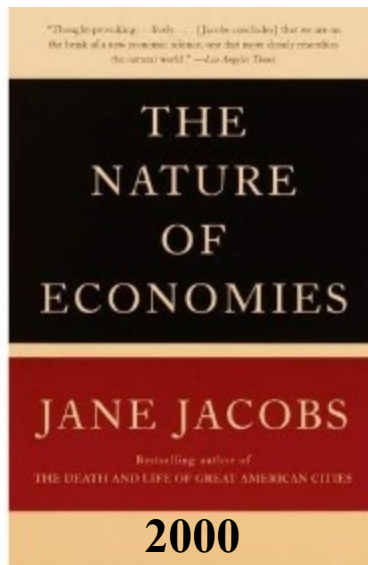


Overshooting the limits



Limits to Growth

- *“Natural principles of chemistry, mechanics and biology are not merely limits. They’re invitations to work along with them.”*



Jane Jacobs



- *“There are limits. Let’s celebrate the limits, because we can reinvent a different future.”*



Sunita Narain
This Changes Everything 2015



Ecosystems do quite well under constraints, let's learn from them

FLOURISHING WITHIN LIMITS TO GROWTH

Following nature's way

Sven Erik Jørgensen, Brian D. Fath,
Søren Nors Nielsen, Federico M. Pulselli,
Daniel A. Fiscus and Simone Bastianoni

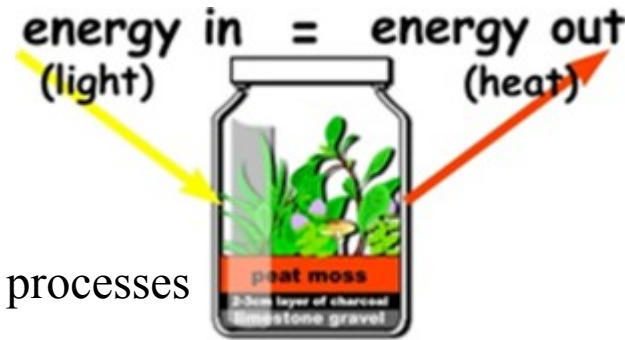


clubofsiena.eco-soft.dk

9 properties of ecosystems

Material constraints

- 1) Ecosystems conserve matter and energy – 1st law
- 2) All processes are dissipative – 2nd law
- 3) All life uses largely the same biochemical elements and processes



Ontological properties

- 4) An ecosystem uses surplus energy to move away from thermodynamic equilibrium (even biological aspect) – centripetality
- 5) Ecosystems are adapted to prevailing conditions (biologically)

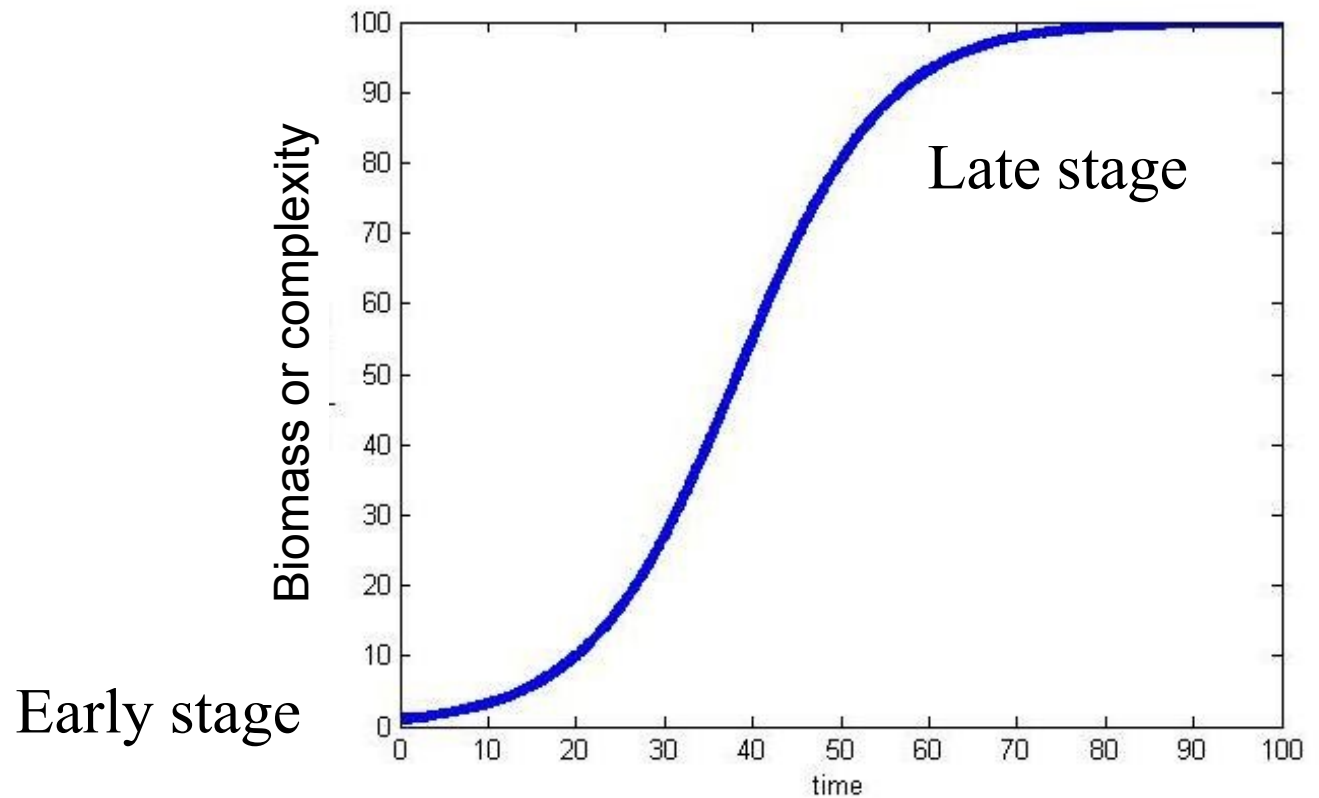
Phenomenological properties

- 6) Ecosystems have diversity of structure and function
- 7) Ecosystems work together in networks that improve the resource flow utilization
- 8) Ecosystems are emergent hierarchically
- 9) Ecosystems have an enormous amount of genetic, biochemical, and process information



Understand these and apply to socio-economic systems

Ecosystem growth and development follows a logistic curve from early to late successional stages



Bioenergetic model of succession

In early stages of succession, $P > R$ and excess is channeled into growth and accumulation of biomass.
In late stages of succession, $P = R$ as maintenance costs increase respiration.

Negative feedback maintains steady state, with little or no change in biomass. Increase capacity and complexity of the energy storage compartments (total biomass of all species and trophic levels) as well as the complexity of energy transfer pathways (network, feedback, cycling).

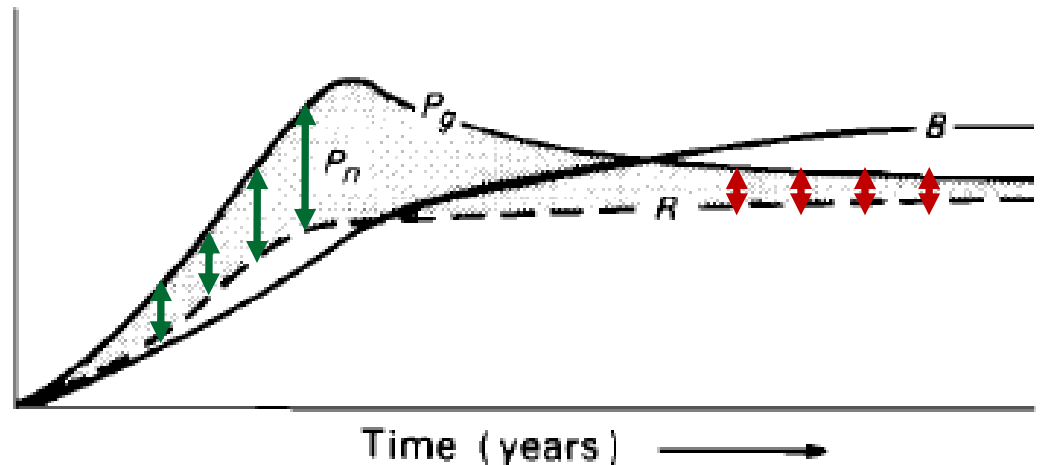


Fig. 25.17 Changes in gross (P_g) and net (P_n) production, respiration (R) and biomass (B) through succession.

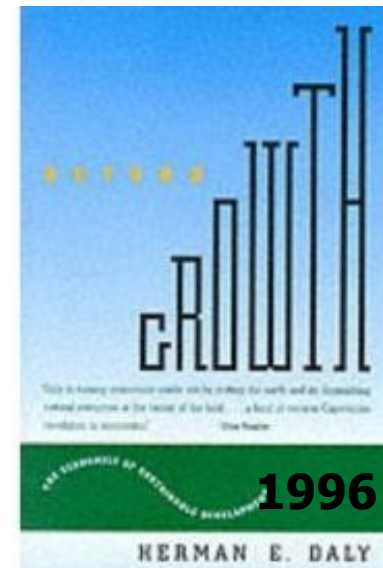


Alternative Economic Systems...

Herman Daly



- **Beyond Growth: the economics of sustainable development**
 - The first and second laws of thermodynamics must be the starting point of economics
 - Neither the sources of useful inputs nor the sinks for polluting waste outputs are infinite.

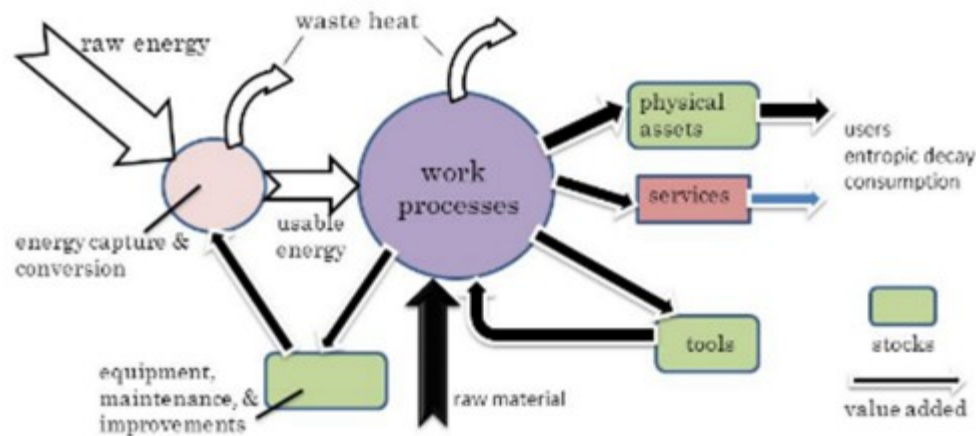


Nicolas Georgescu-Roegen



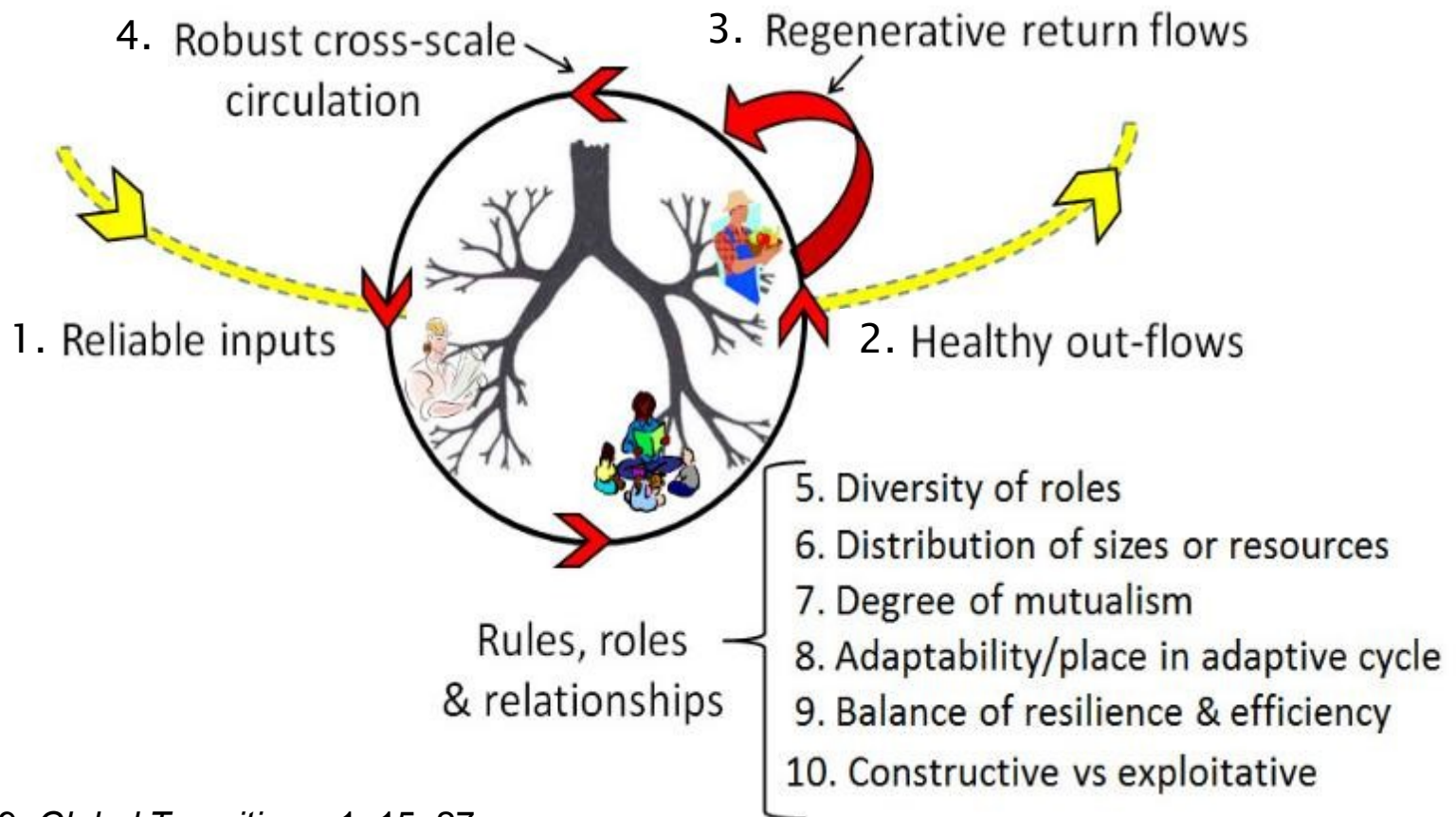
- *The Entropy Laws and the Economic Process* (1971)
 - Wealth is an open system, a structure maintained in the midst of throughput
 - It begins with the depletion of useful matter/energy and ends with the return of an equal quantity of spent matter/energy back to the environment.

• The Economy: Energy, work, and goods/services

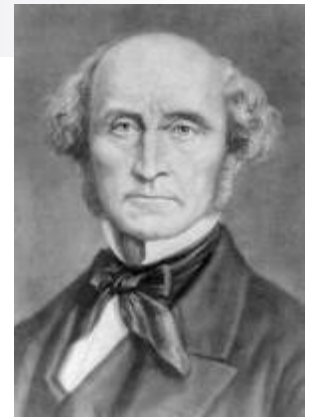


Regenerative economy

Input, Output, and System Dynamics



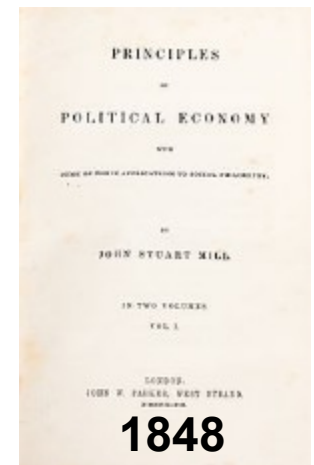
John Stuart Mill



- British philosopher, political economist and civil servant (1806-1873)
- Considered “the most influential English-speaking philosopher of the nineteenth century”

“Perpetual growth in material well-being is not possible or desirable.”

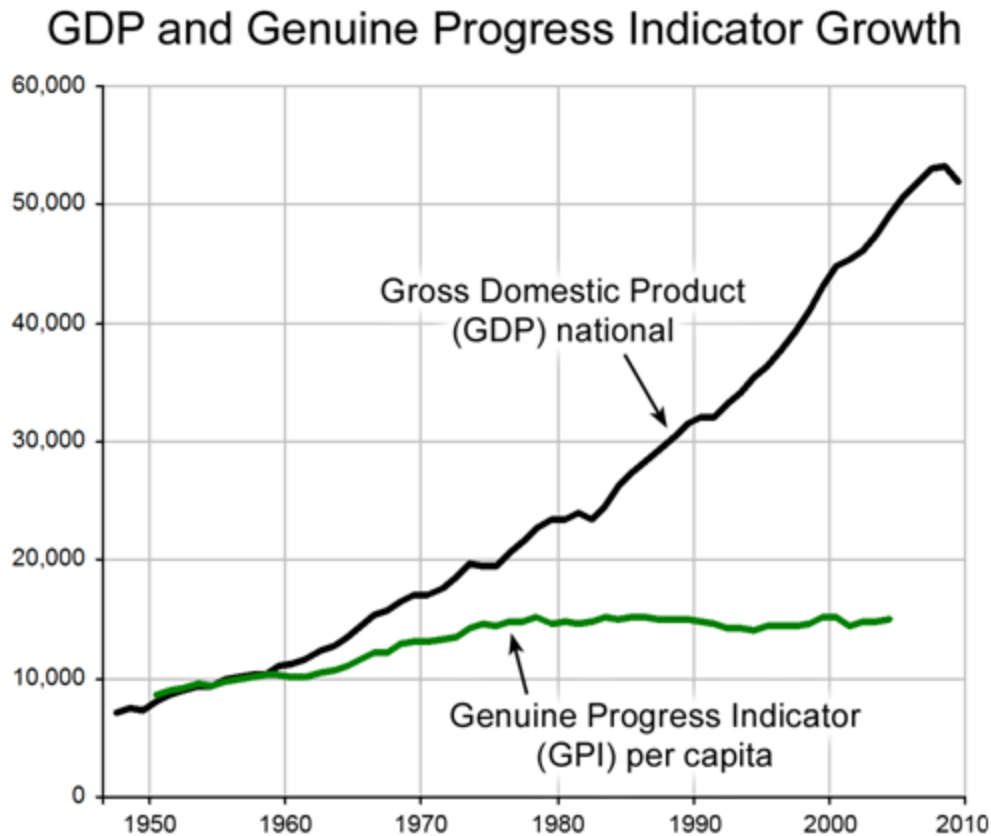
Mill argued that the logical conclusion of unlimited growth was destruction of the environment and a reduced quality of life. He concluded that a stationary state could be preferable to unending economic growth



WHY HAVE WE NOT LEARNED THIS LESSON?



How we measure progress matters

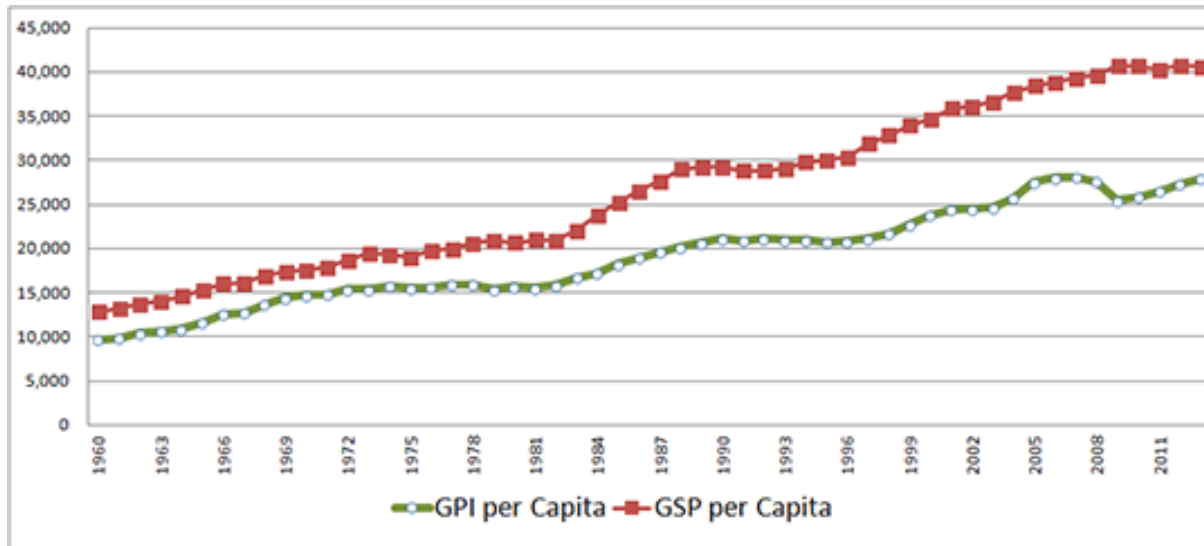


GPI accounts for 26 indicators including economic, environmental, and social factors to determine if we are well off.

GDP measures the circulation of money

Maryland was first state to adopt GPI as official indicator

Maryland's Genuine Progress Indicator compared with Gross State Product



Measuring environmental impact

- $I=PAT$
- $\text{Impact} = \text{Population} * \text{Affluence} * \text{Technology}$
- Affluence ~ consumption per person
- Technology ~ impact per consumption

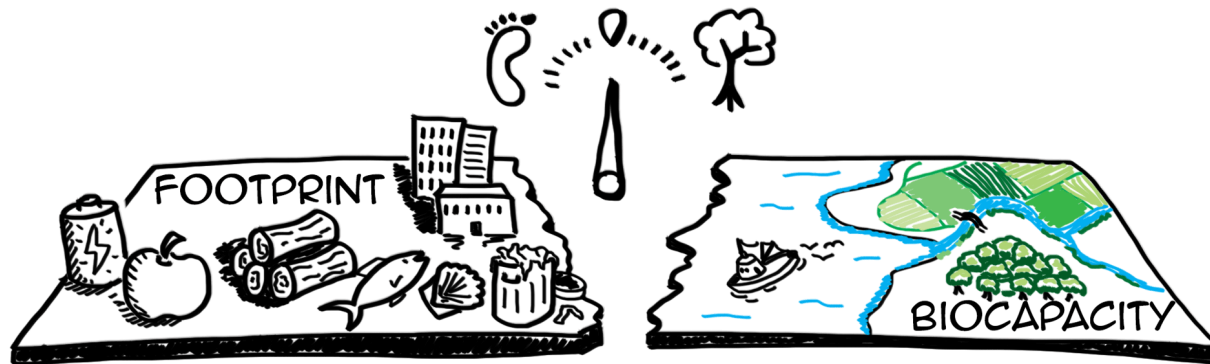


Ecological Footprint

- the impact of human activities measured in terms of the area of biologically productive land and water required to produce the goods consumed and to assimilate the wastes generated.
 - 1) Transportation,
 - 2) Diet,
 - 3) Household/lifestyle choices

Ecological Footprint Calculator

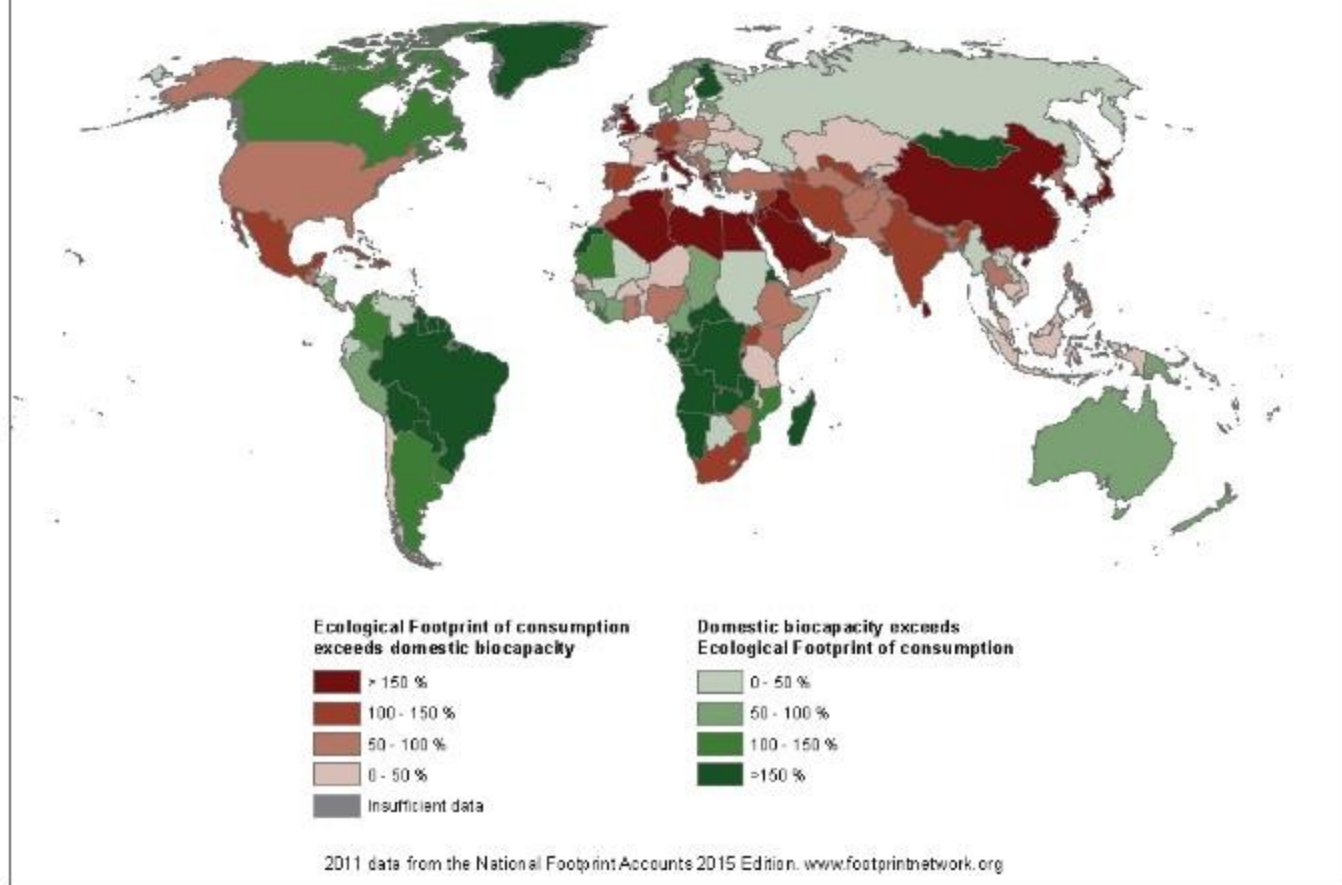
- <https://www.footprintcalculator.org/>



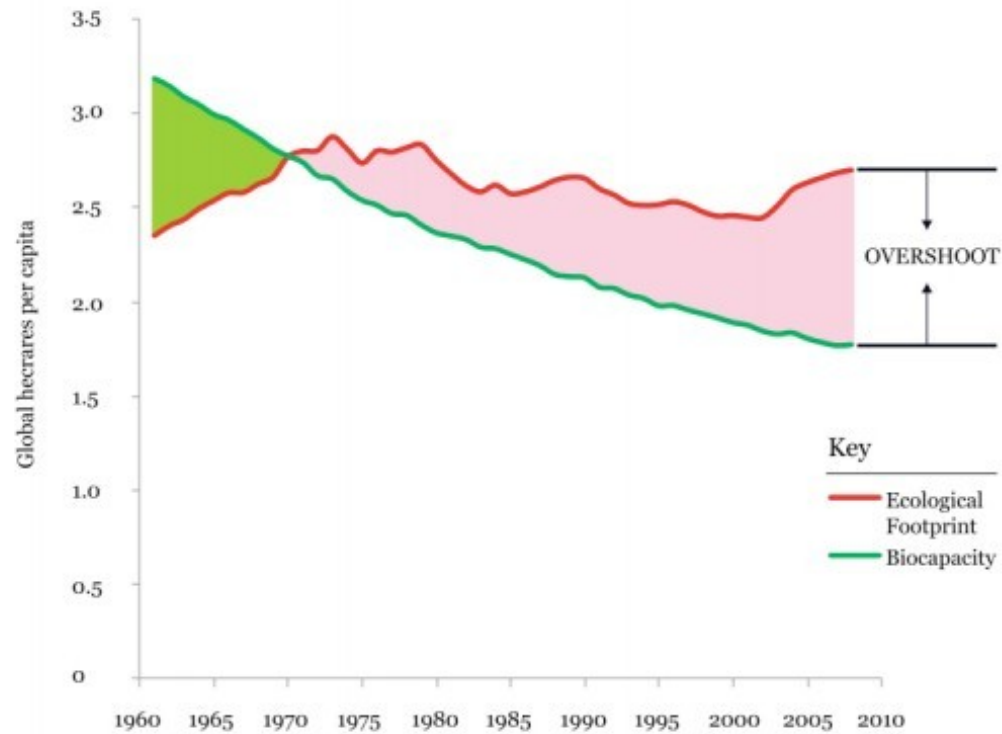
ECOLOGICAL FOOTPRINT

world-average ecological footprint in 2012 was 2.84 global hectares per person. world-average biocapacity of 1.73 global hectares per person

Biocapacity Deficit and Reserve



Overshoot!

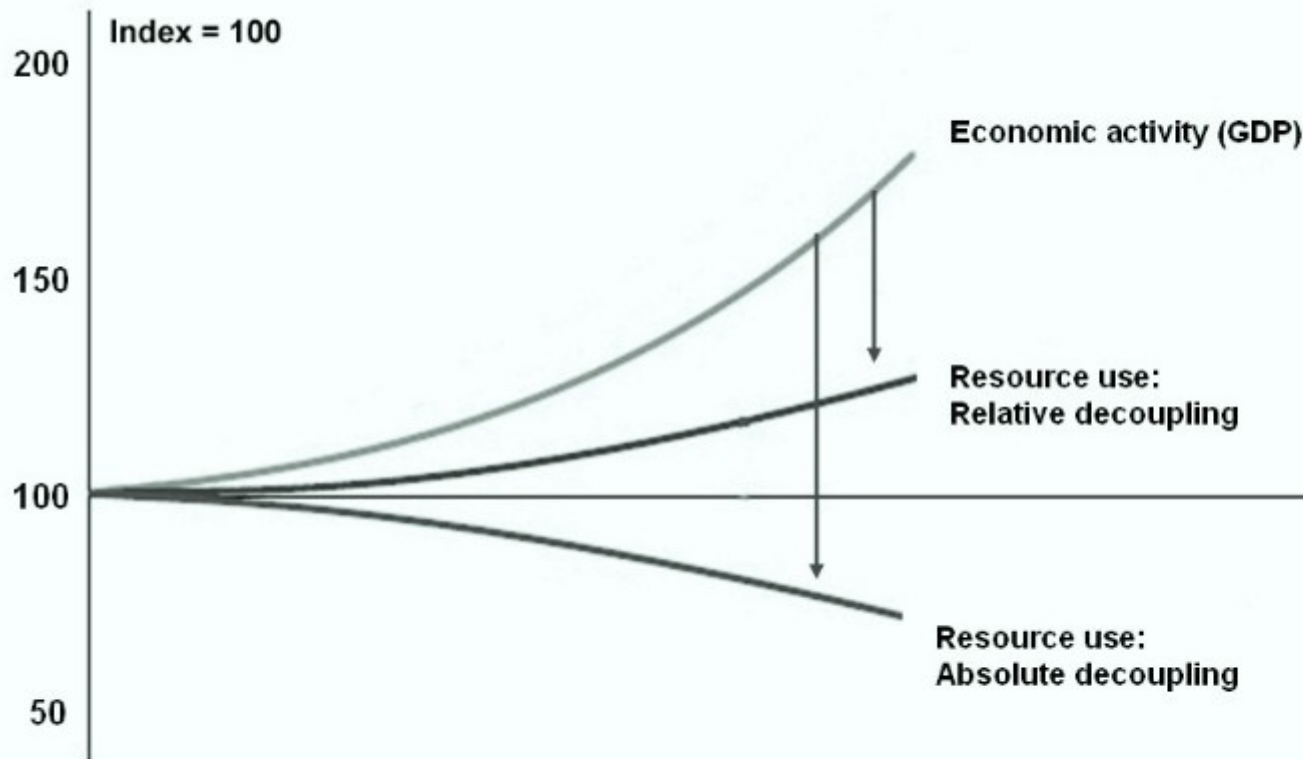




Discussion questions

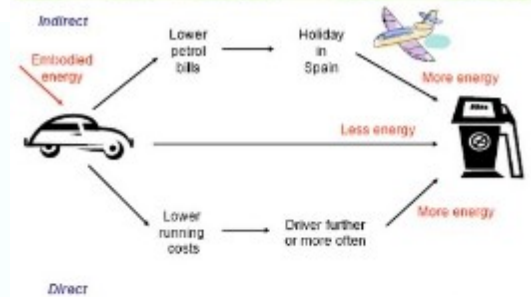
- Should biophysical limits be considered in economics?
 - How?
- Is it mostly a matter of getting the prices right – internalize extranalties?
- How to differentiate between productive work and exploitative work?
- How to move away from growth as a goal function?
- Give an example of increased efficiency leading to increased consumption. How can we account for this in reducing environmental impacts?

Decoupling – greater resource efficiency

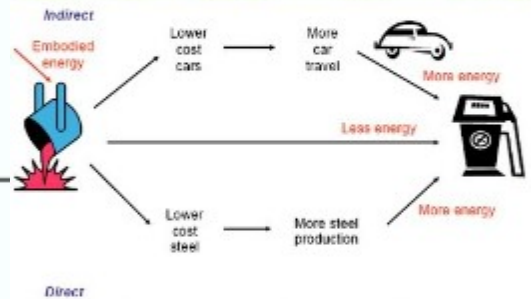


Do more with less

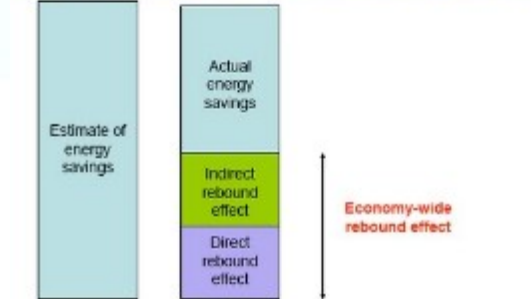
Rebound effects - consumers



Rebound effects - producers



Economy-wide rebound effect



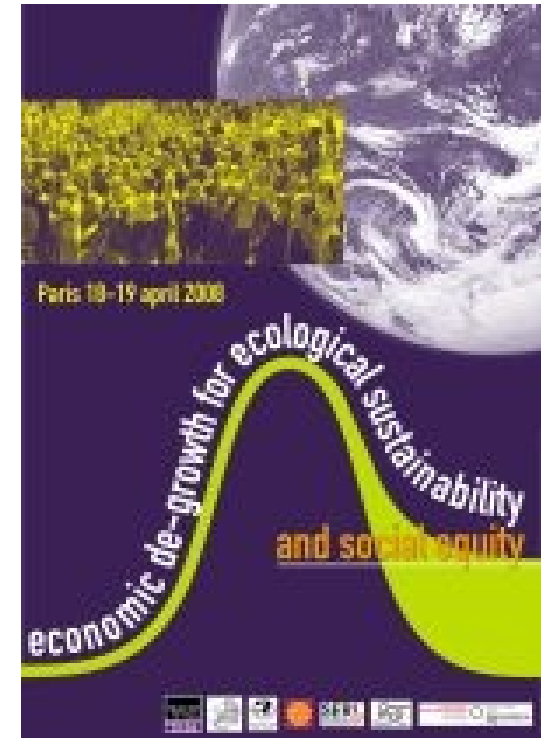
degrowth

- Reduce scale to fit within planetary boundaries



'THE SAME BOAT'

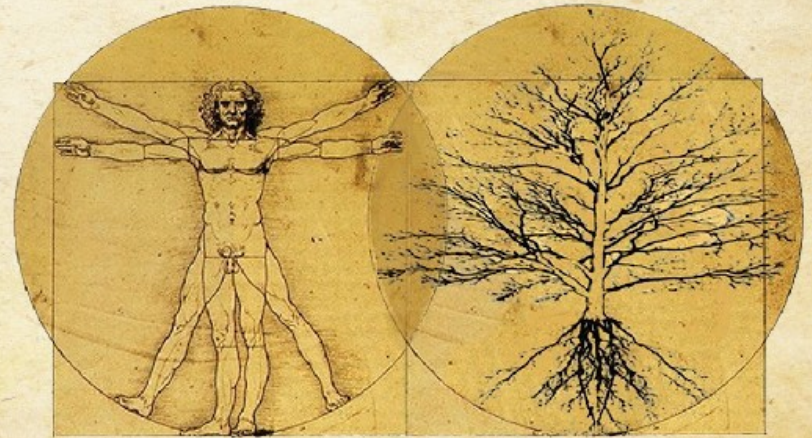
Do less



Thank you for your attention!

Foundations *for* Sustainability

A Coherent Framework of Life-Environment Relations



Daniel A. Fiscus, Brian D. Fath

2019

