



Biophysical Limits to Growth

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Co-Editor-in-Chief, *Current Research in Environmental Sustainability*



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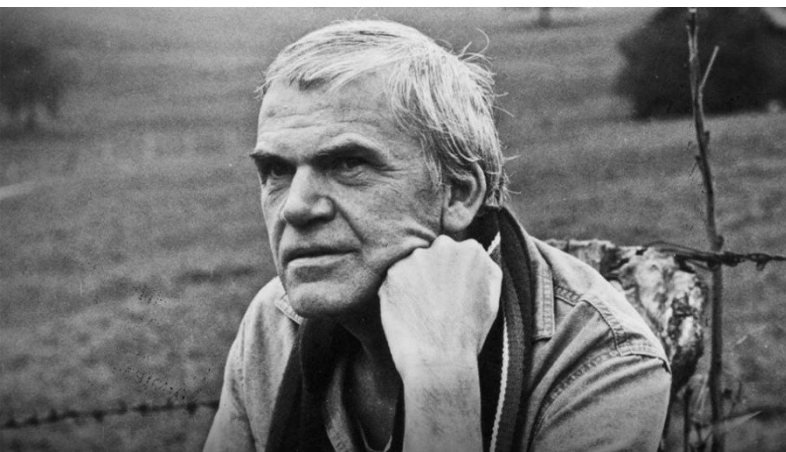
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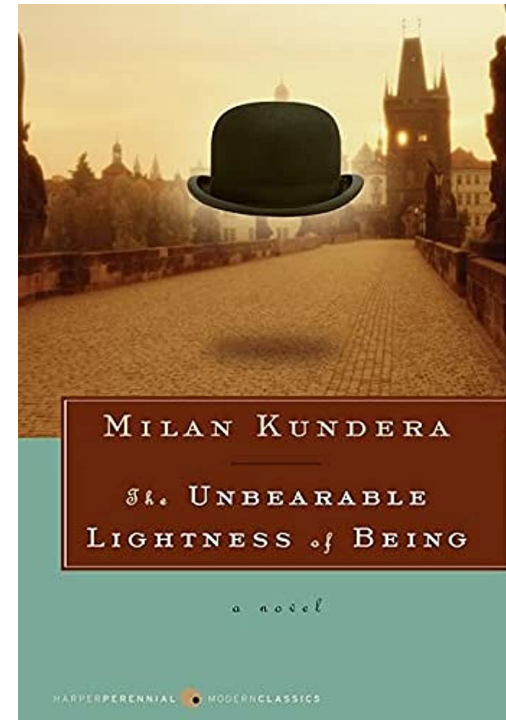
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Lightness

- “With fewer things, we obtain a certain lightness that contributes to overall well-being”
 - Paraphrased from H. Kromp-Kolb July 17 AEMS opening address



Milan Kundera 1929–2023 RIP

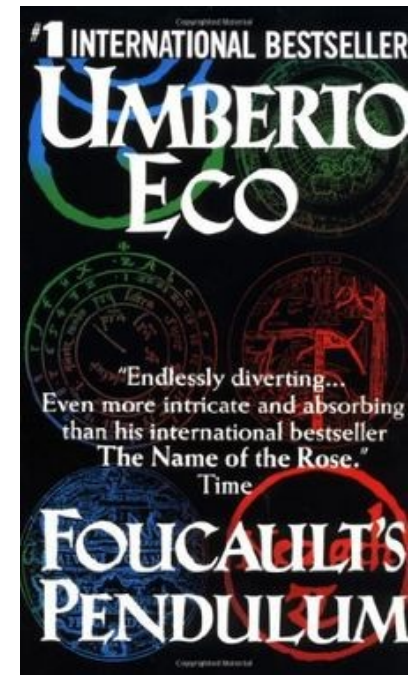


Abundance



We have too much surplus:
Learn to say “Enough”

- “How can life be so bountiful, providing such sublime rewards for mediocrity?” p. 42



The energy crisis we have is not one of shortage but one of surplus





Imagine the destruction we will cause with a cheap, plentiful energy source, regardless if it is renewable or not.

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?



Why environmental resources have been poorly conserved in the past?

1. *Nature's rate of return of ecosystem services leads us to over exploitation*
 - Living off the flow is too slow, for how we want to grow
 - Poor understanding of growth, exponential growth
2. *Externalities*
 - Indirect cost not paid for by producer and consumer as part of a transaction
 - When a decision (for example, to pollute the atmosphere) causes costs or benefits to individuals or groups other than the person making the decision
3. *Pressure for resource consumption*
 - Economic and institutional growth paradigm
 - Victor Lebow (1955): our enormously productive economy demands that we make consumption our way of life, that we convert the buying and use of goods into rituals, that we seek our spiritual satisfactions, our ego satisfactions, in consumption
 - Marketing

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

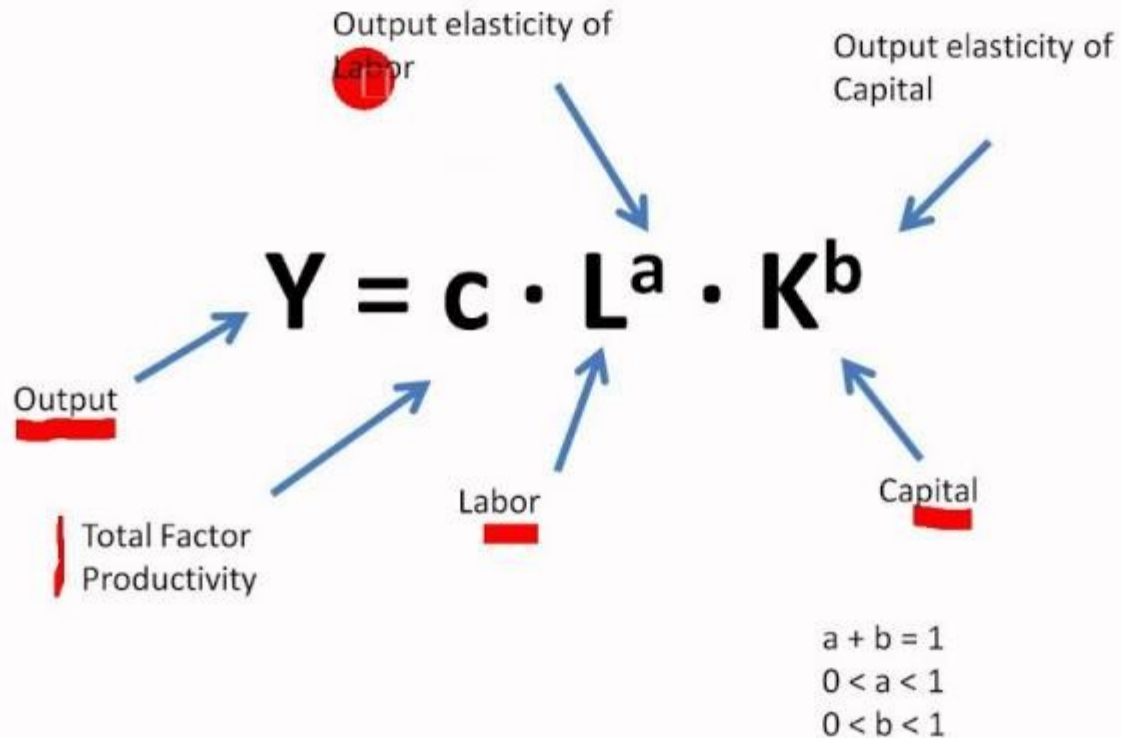


Economics



- 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

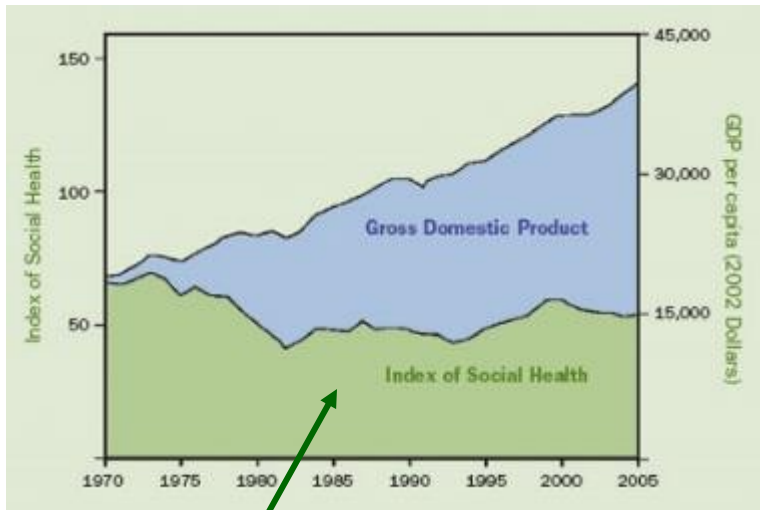
Cobb-Douglas Production Function



WHERE IS ENVIRONMENT?

What is the purpose of growth?

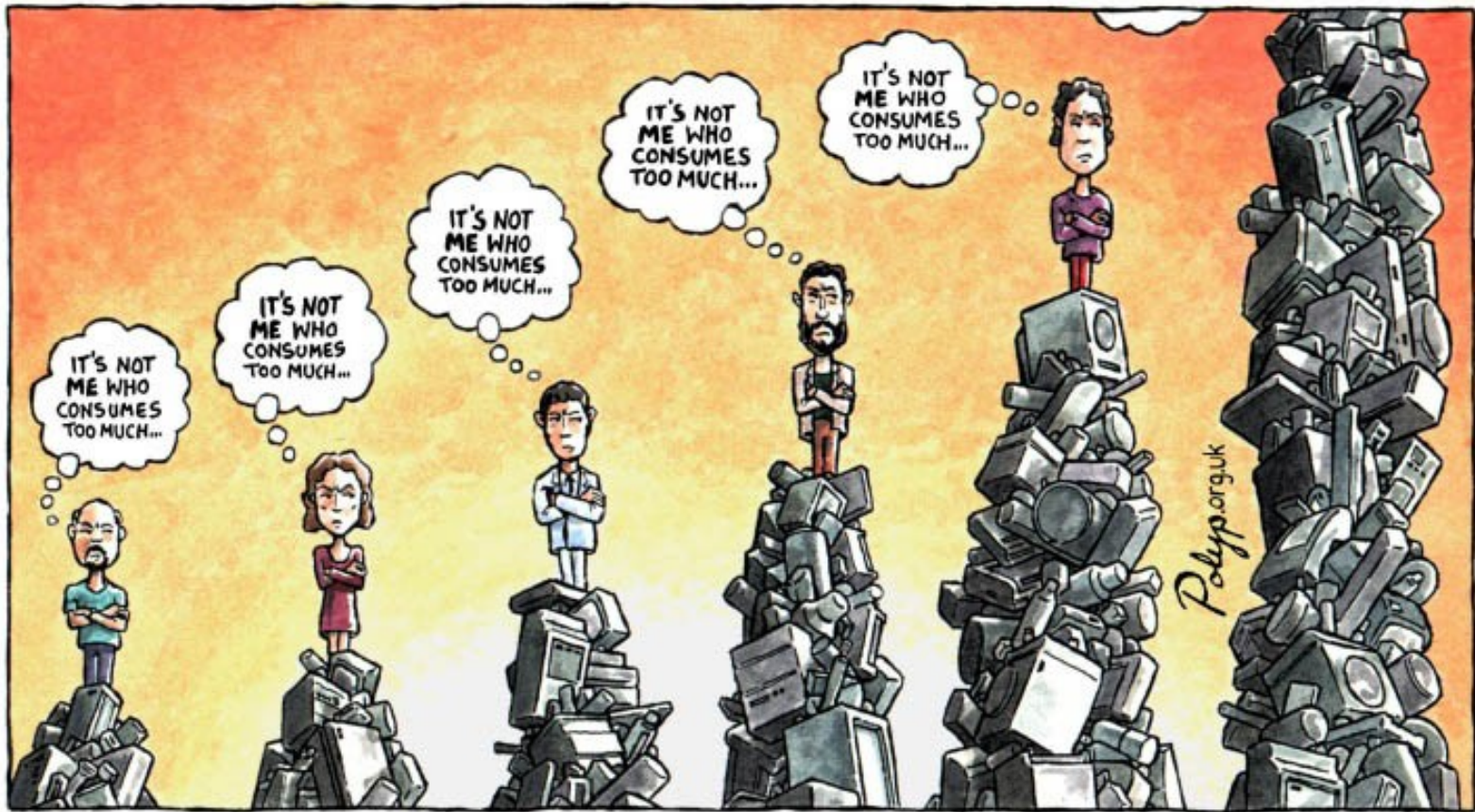
Does bigger always mean better?



Alternative well-being indicators tell a different story

Memetic rivalries: Rene Girard

Our wants are socially constructed in competition (for status) with others.
We measure 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.

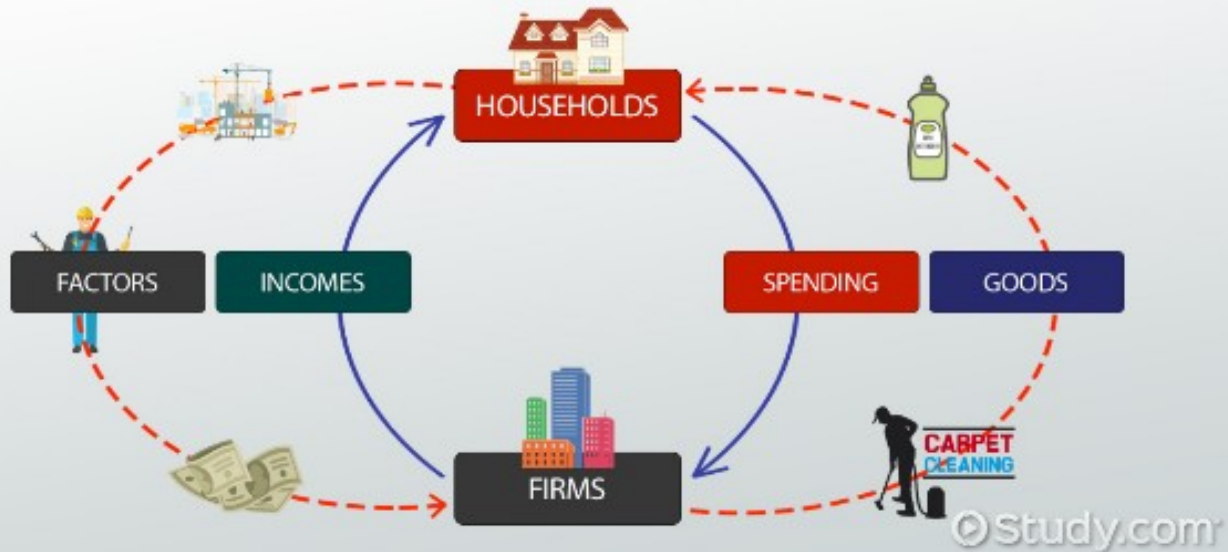
No mention of natural resources or environment

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

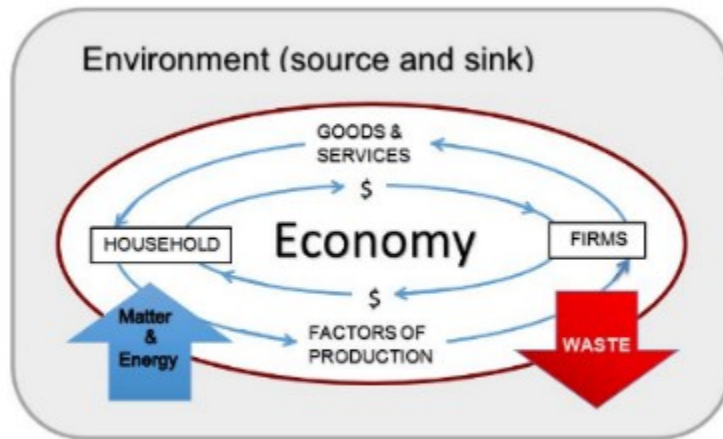
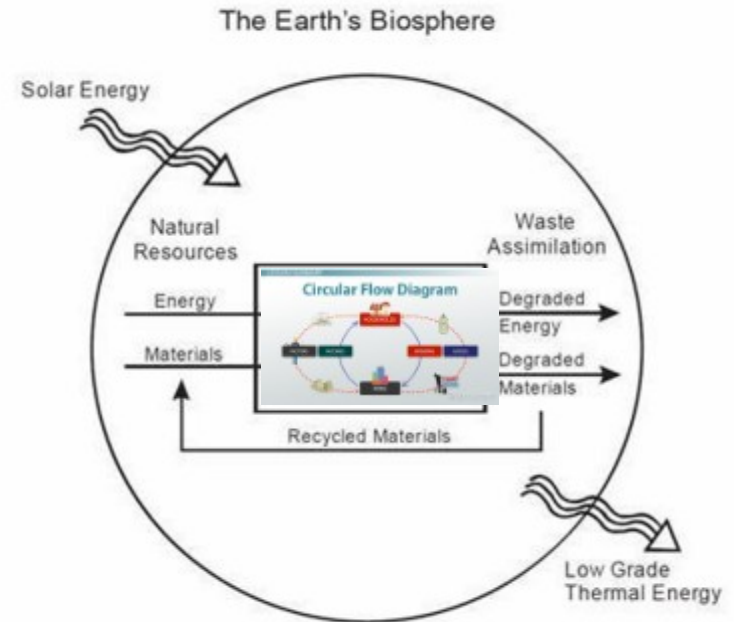



Fig. 2. Thermodynamic throughput model. Note the addition



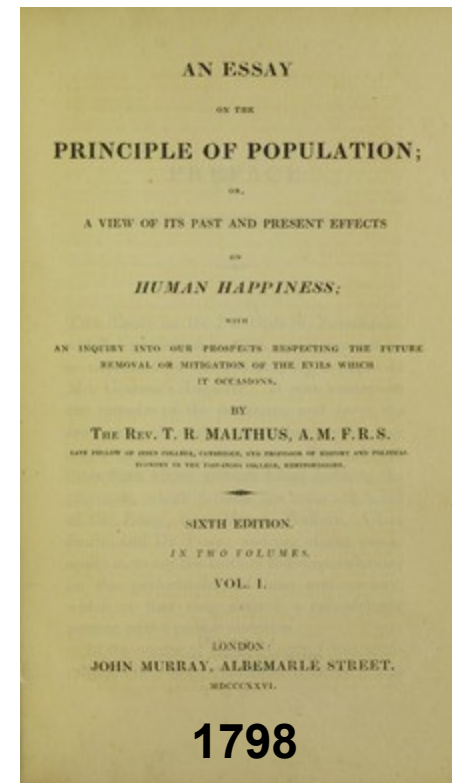
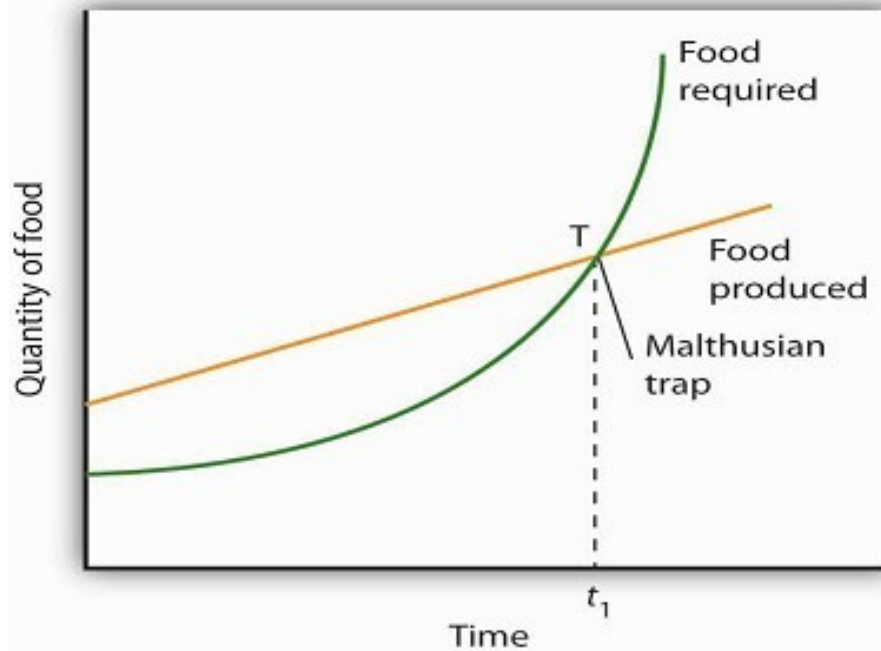


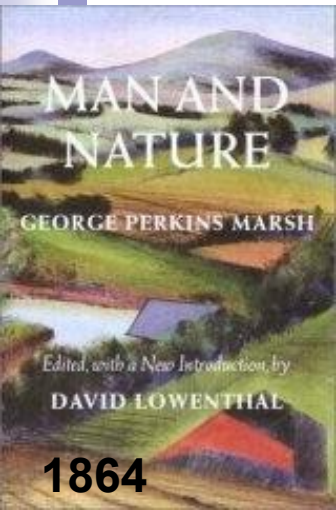
A look back at the history
recognizing limits

Thomas Malthus



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



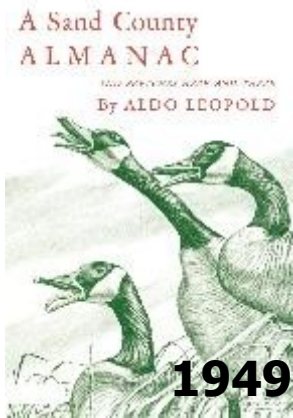


George Perkins Marsh



- “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.



Rachel Carson

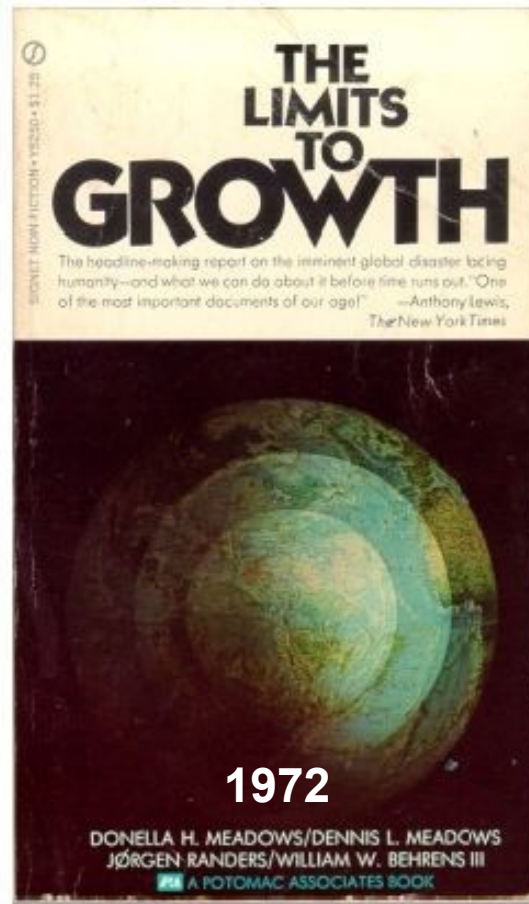


- 1960s – The modern environmental movement is
- 1962 *Silent Spring*
- Carson, writer and marine biologist, told how chemical use on farms, forests, and gardens, poison the environment. Insects were dying (not just the pest species) which meant no food for the birds. No birds, no bird song – a silent spring
- Public awareness that humans are damaging environment

1st Earth Day 1970



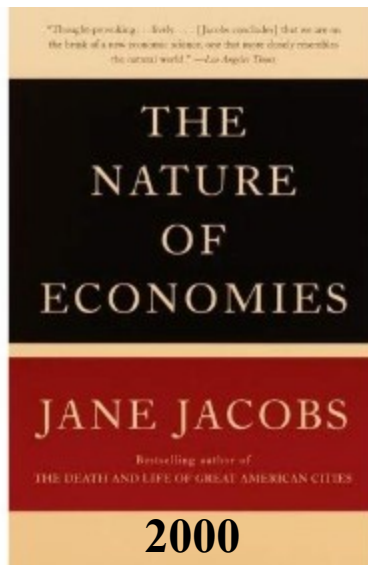
Donella Meadows and Club of Rome





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

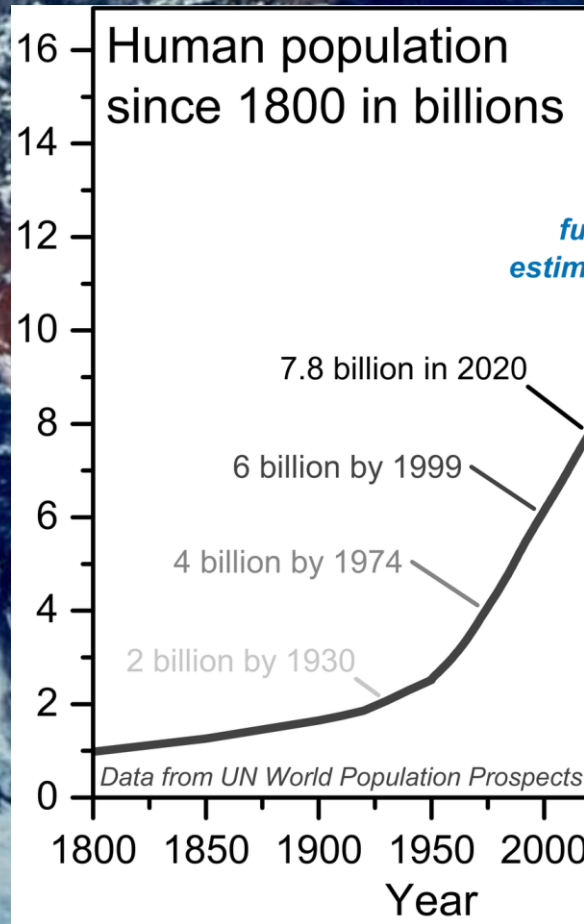
Following nature's way

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

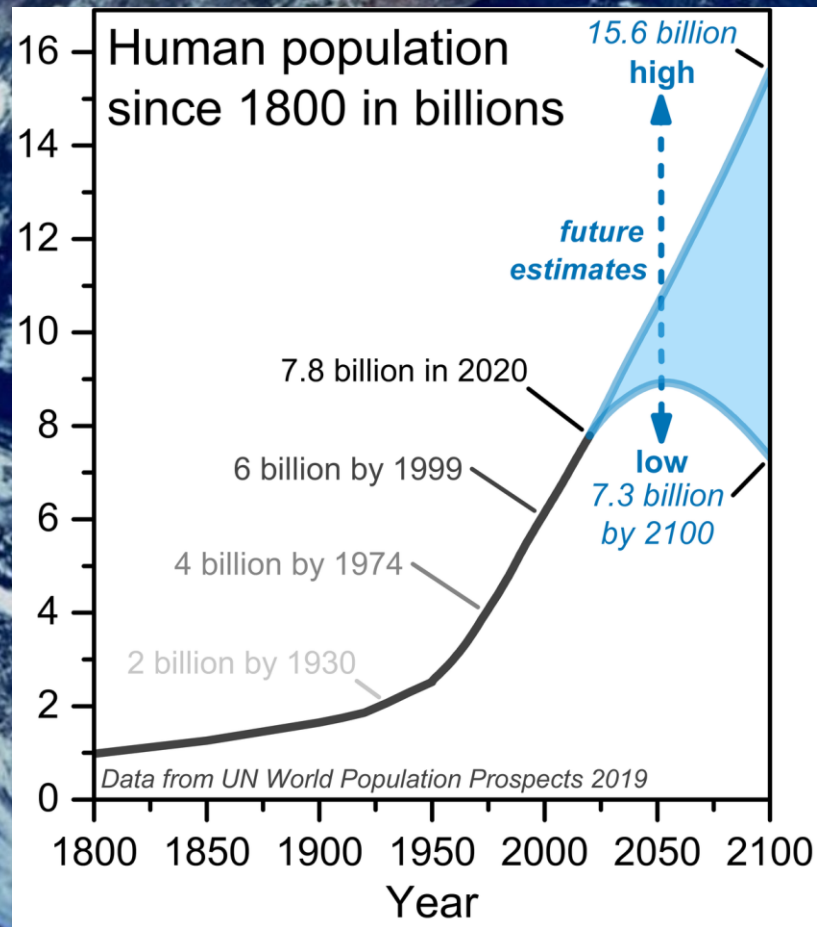


clubofsiena.eco-soft.dk

Importance of scale



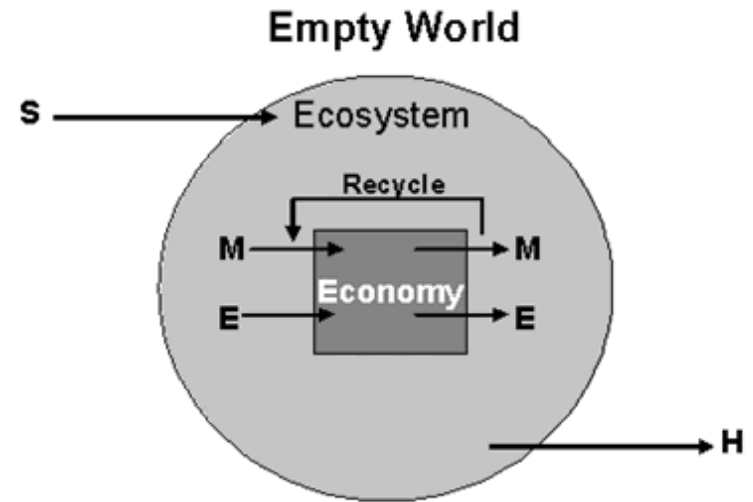
Importance of scale



Emergence of humans, from a minor component of natural system to predominant occupant

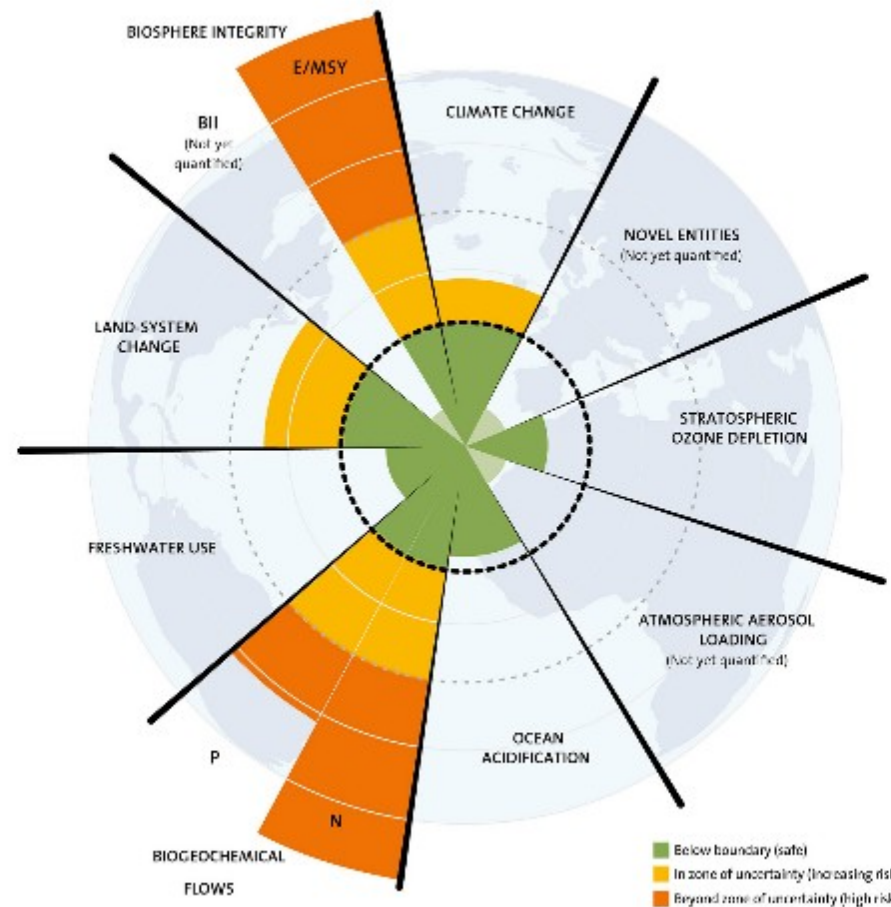
Scale of humanity has increased greatly putting pressure on all natural resources

The changes have come so fast our customs ethics, and religious patterns may not have adapted to them.



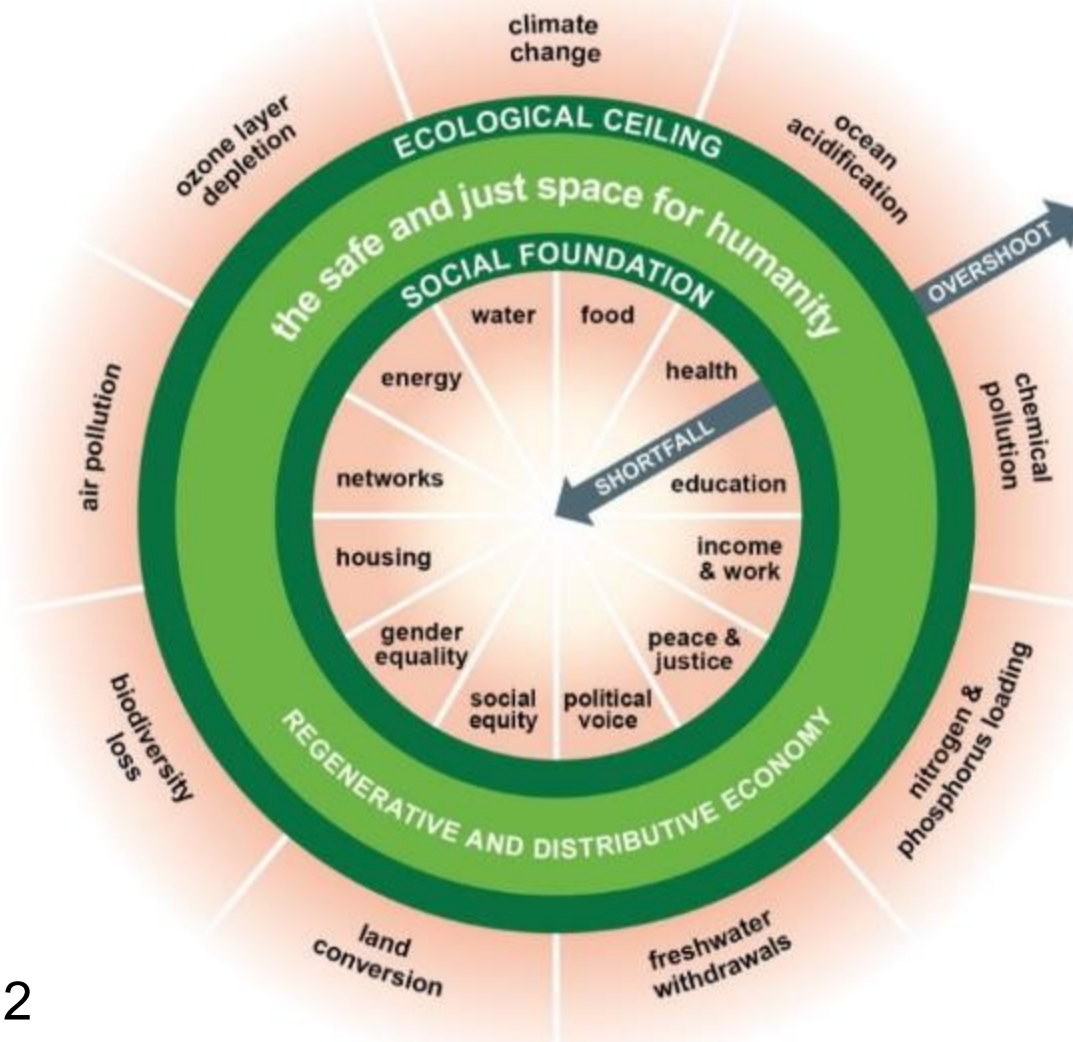
Man-made Capital Natural Capital
S = Solar Energy H = Heat M = Matter E = Energy

Planetary Boundaries – Stockholm Resilience Centre

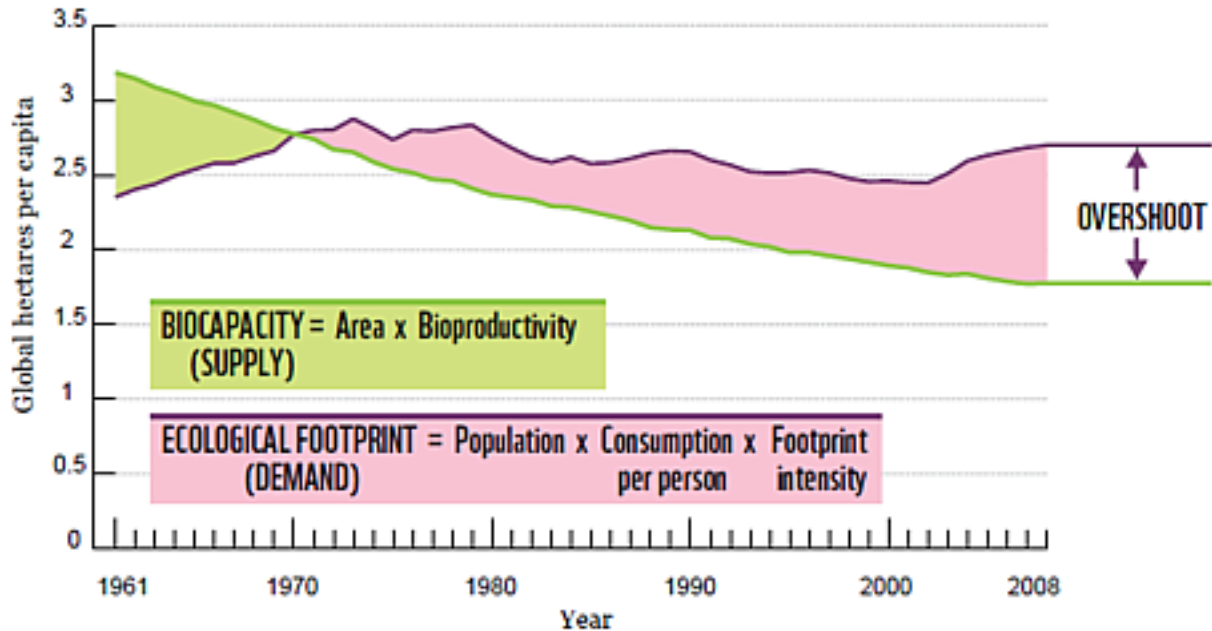


2009

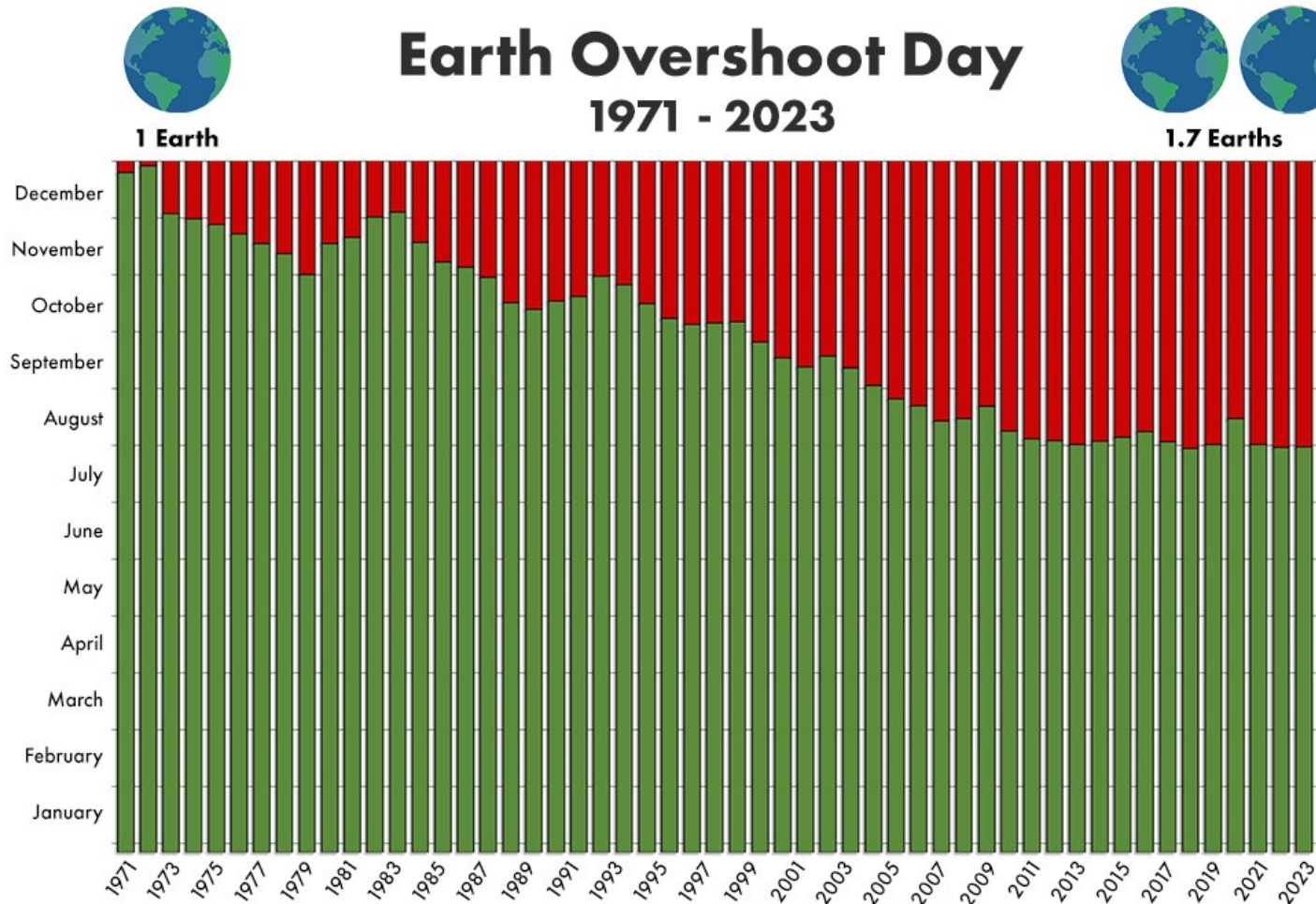
Donut Economics – Kate Raworth



Overshooting the limits

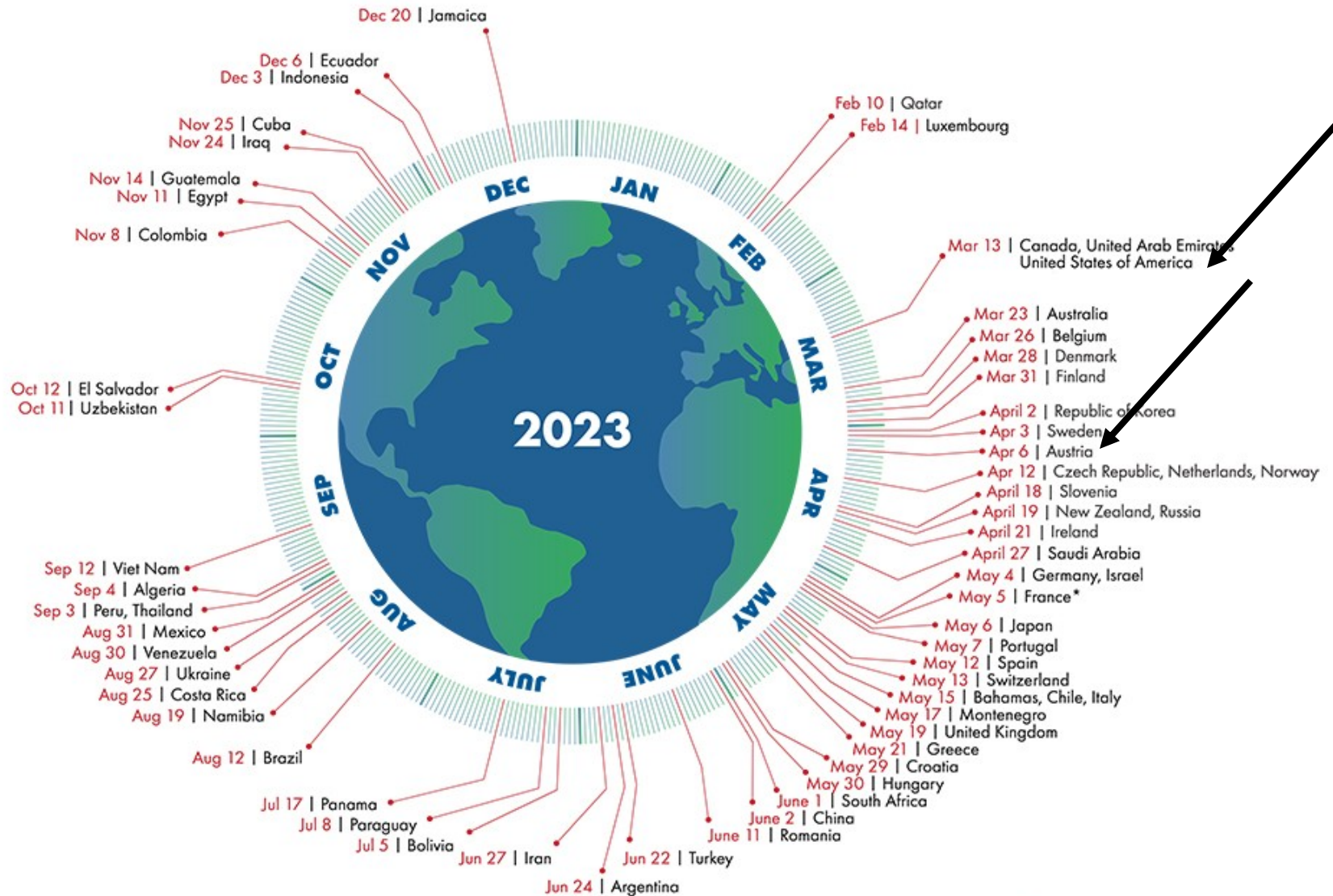


Overshooting the limits – August 2, 2023



Country Overshoot Days 2023

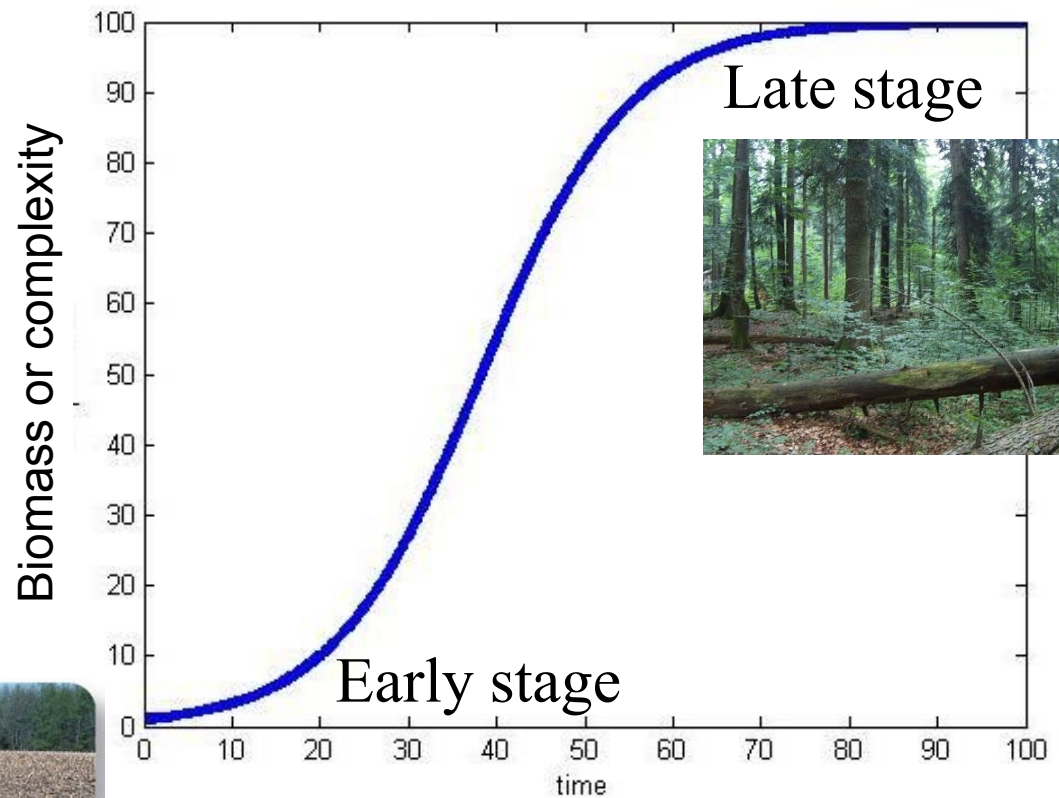
When would Earth Overshoot Day land if the world's population lived like...



For a full list of countries, visit overshootday.org/country-overshoot-days.
*French Overshoot Day based on nowcasted data. See overshootday.org/france.

Source: National Footprint and Biocapacity Accounts, 2022 Edition
data.footprintnetwork.org

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).

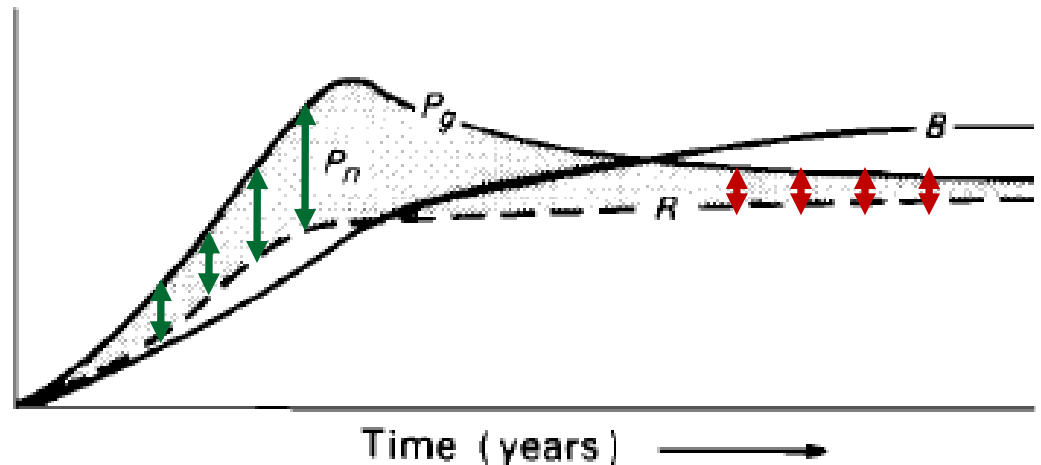


Fig. 25.17 Changes in gross (P_g) and net (P_n) production, respiration (R) and biomass (B) through succession.



Growth → *Quantitative* increase

Development → *Qualitative* increase

"We must realize that growth and development are two very different things. You can develop without growing and vice versa."

Tibor Vasko, 2009, www.solon-line.de/interview-with-tibor-vasko.html

Four types of Ecosystem Growth and Development

Bigger

Better



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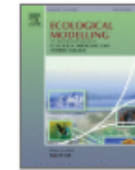
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Ecological Modelling

Volume 426, 15 June 2020, 109075



Letter to the Editor

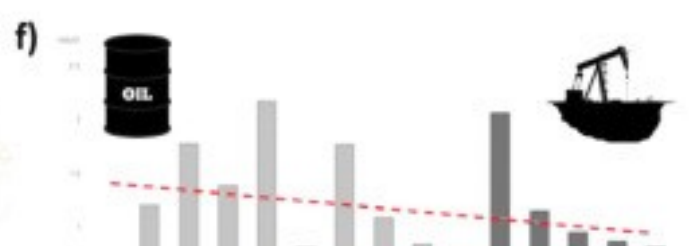
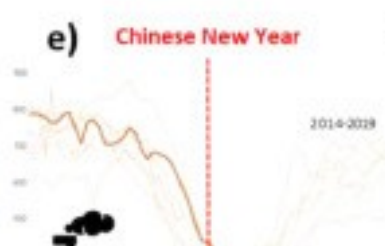
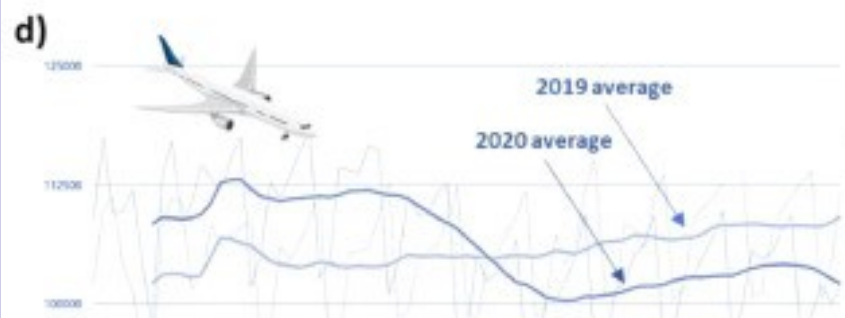
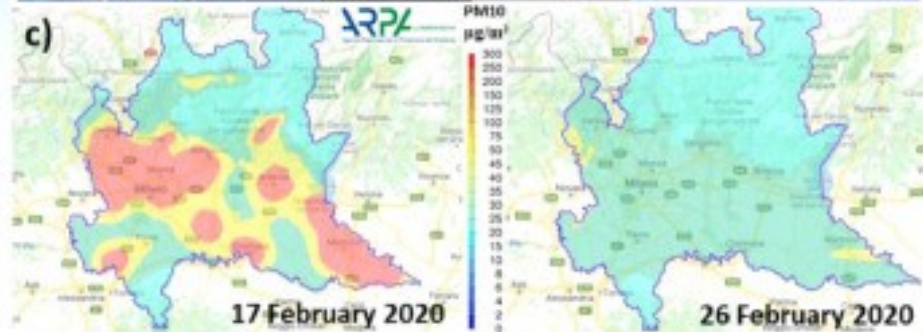
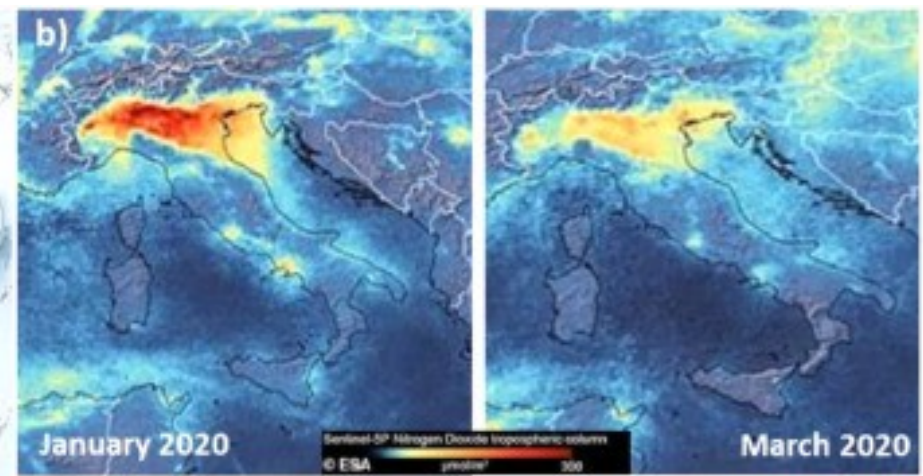
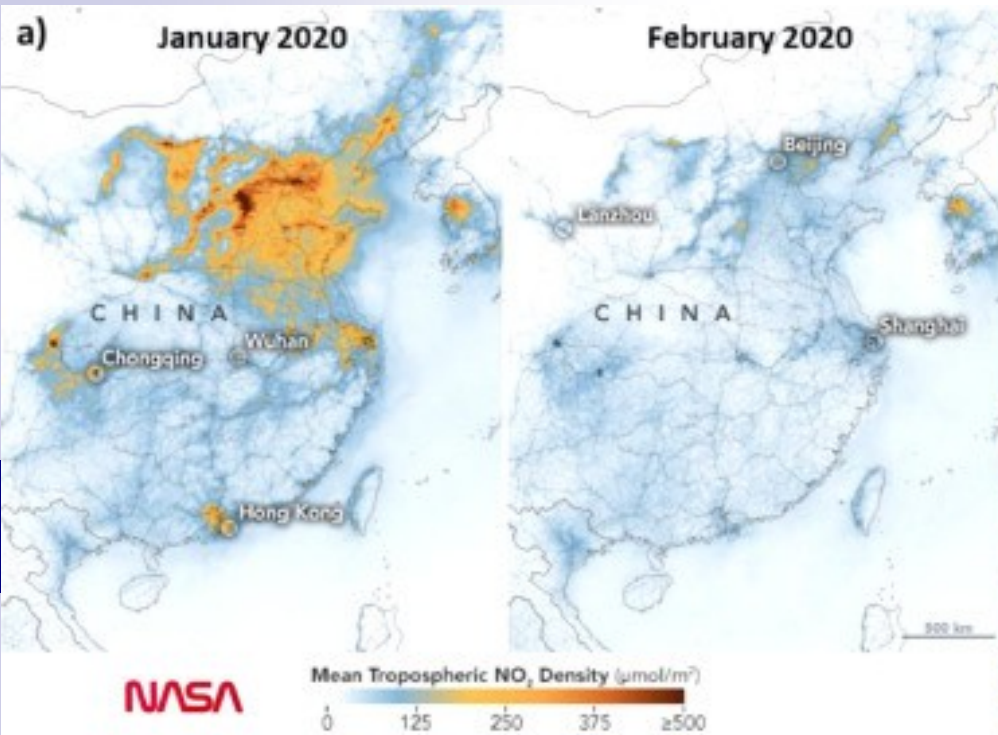
Coronavirus outbreak is a symptom of Gaia's sickness

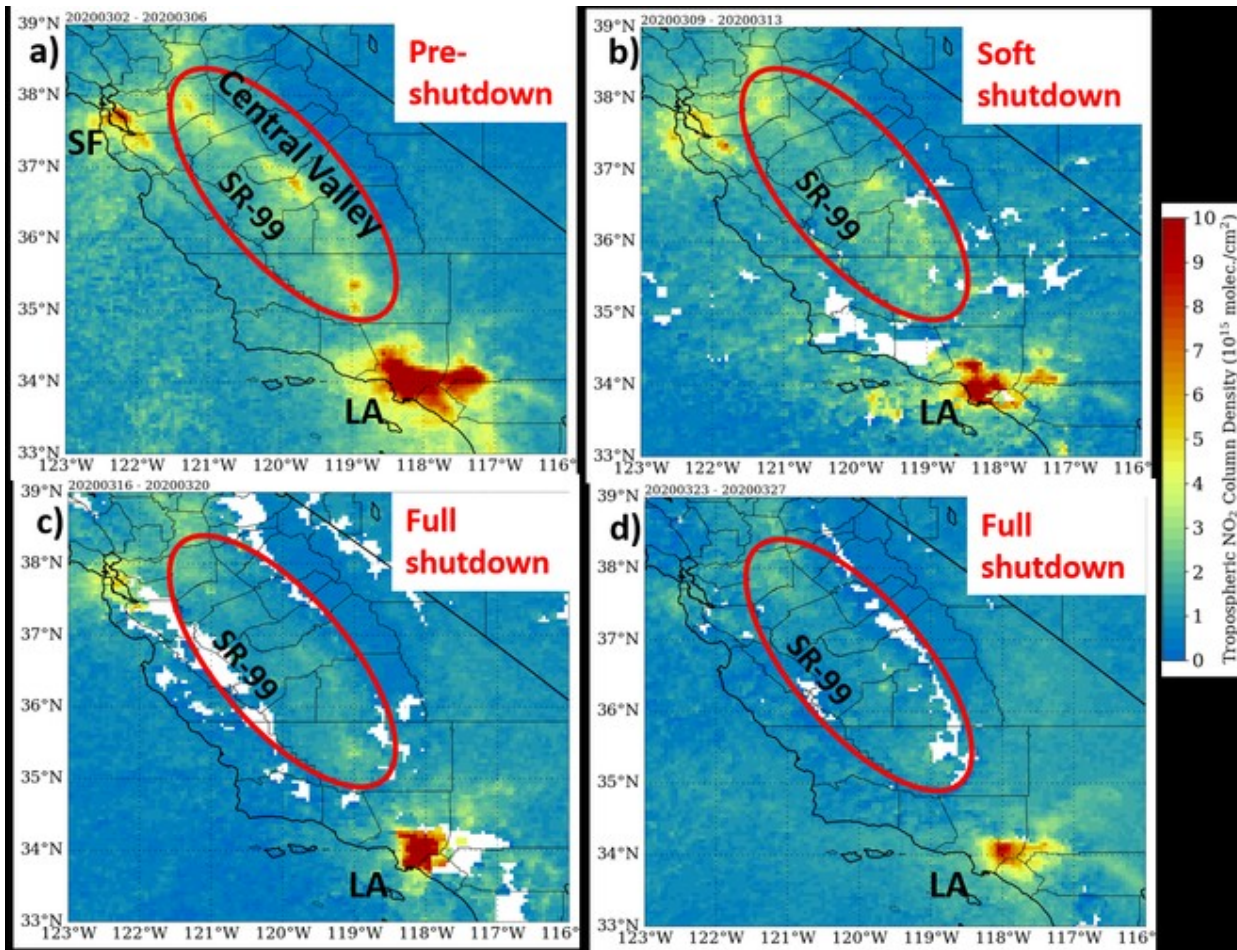
Roberto Cazzolla Gatti ^{a, b}  

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<https://doi.org/10.1016/j.ecolmodel.2020.109075>

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nasaoprt.wordpress.com/2020/04/04/new-generation-satellite-observations-monitor-air-pollution-during-covid-19-lockdown-measures-in-california/

Venice, Italy





Alternative Economic Systems...

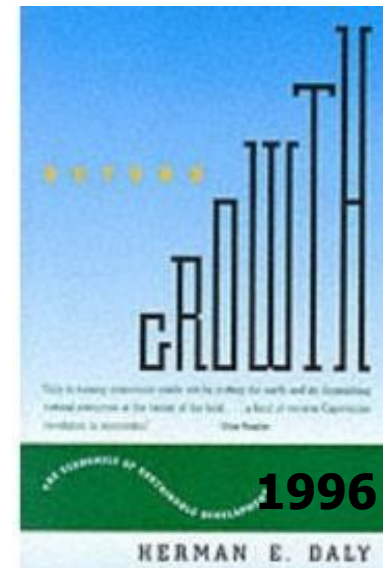
One mistake of the 2007 financial crisis was the rush to put the system back as it was, flaws and all

Use Covid to Build back better

Herman Daly

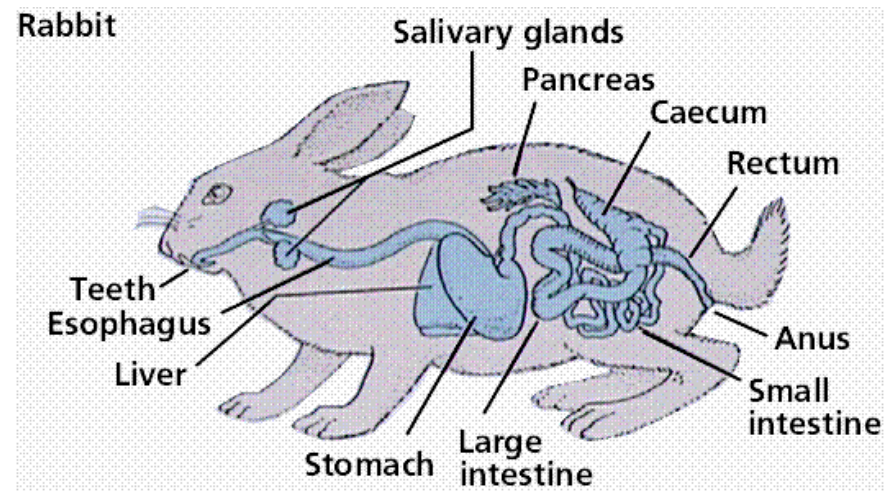


- **Beyond Growth: the economics of sustainable development**
 - The first and second laws of thermodynamics must be the starting point of economics
 - Neither the sources of useful inputs nor the sinks for polluting waste outputs are infinite.

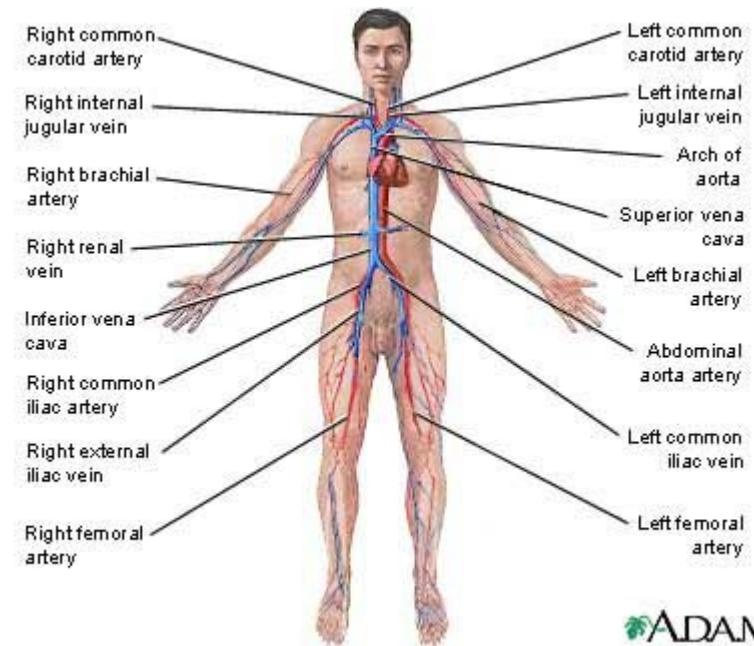
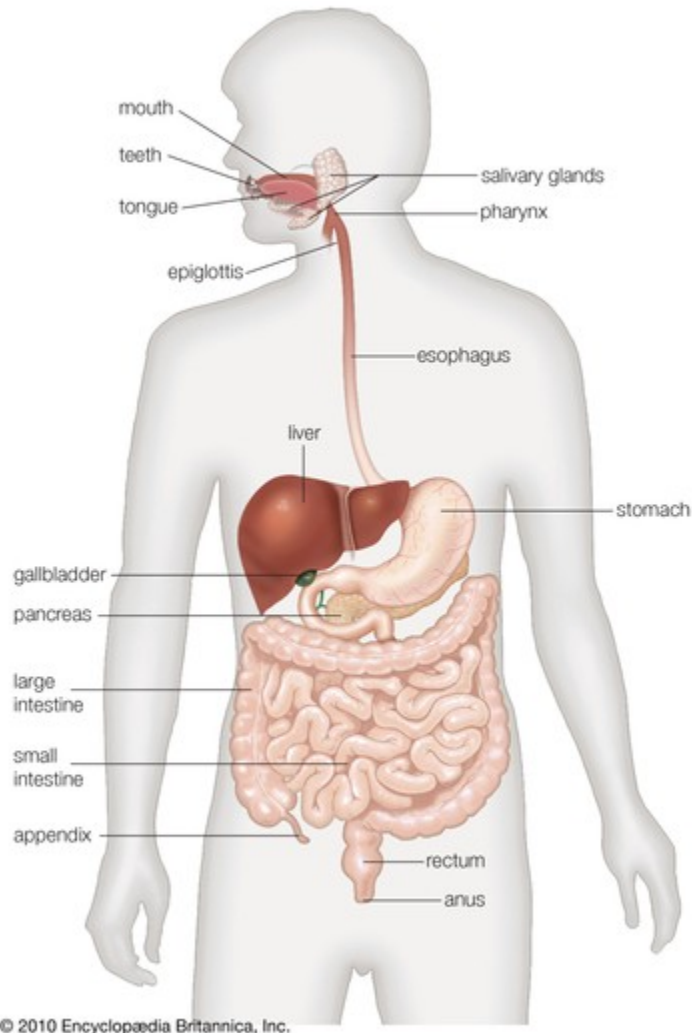


Daly (1996) continued

- The circular flow model of economy is exactly as if a biology textbook proposed to study an animal only in terms of its circulatory system, without ever mentioning its digestive tract!
- An animal with an isolated circulatory system and no digestive tract would be a perpetual motion machine.
- *Unlike this imaginary circular-flow animal, real animals have digestive tracts that **connect them to their environment at both ends.***



Can't have circulation without digestion



Organisms continuously take in useful energy/matter and give back spent energy/matter.

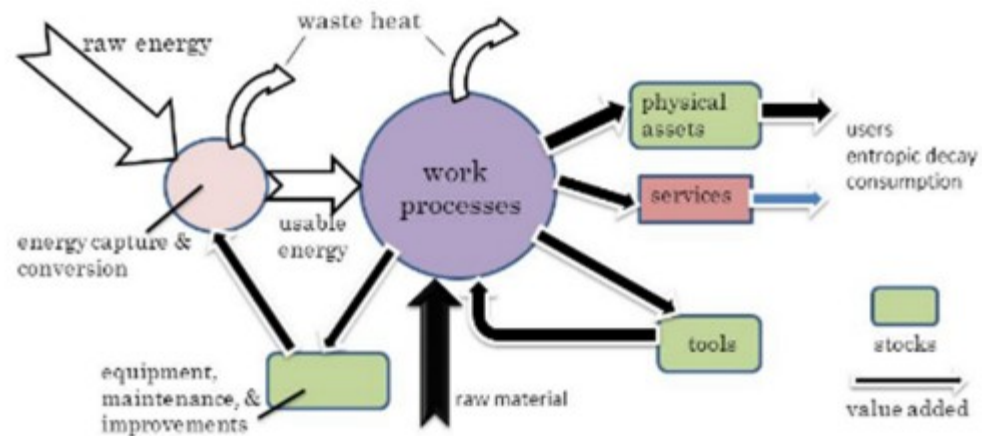
Circulation in a closed system is not a measure of how the organism is connected to its environment.

Nicolas Georgescu-Roegen

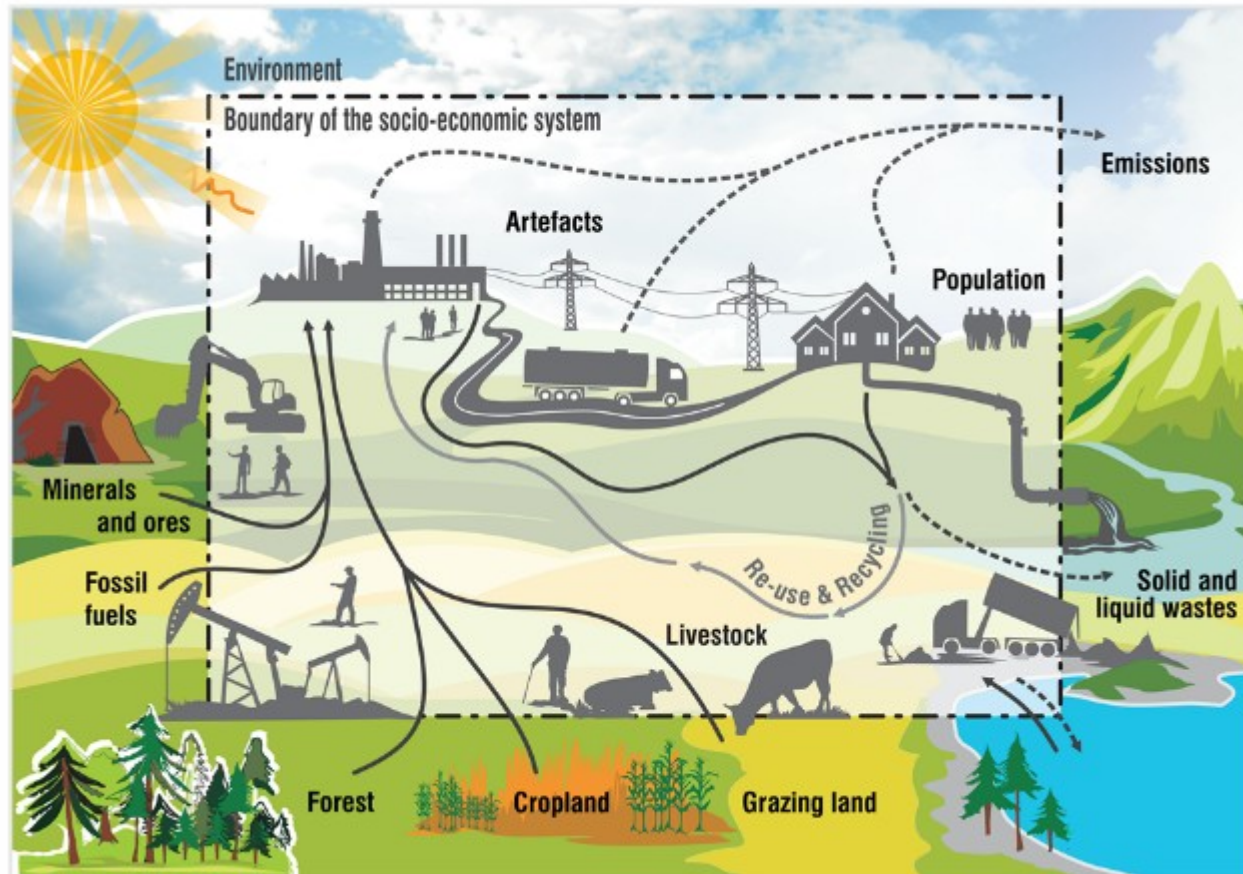


- *The Entropy Laws and the Economic Process* (1971)
 - Wealth is an open system, a structure maintained in the midst of throughput
 - It begins with the depletion of useful matter/energy and ends with the return of an equal quantity of spent matter/energy back to the environment.

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

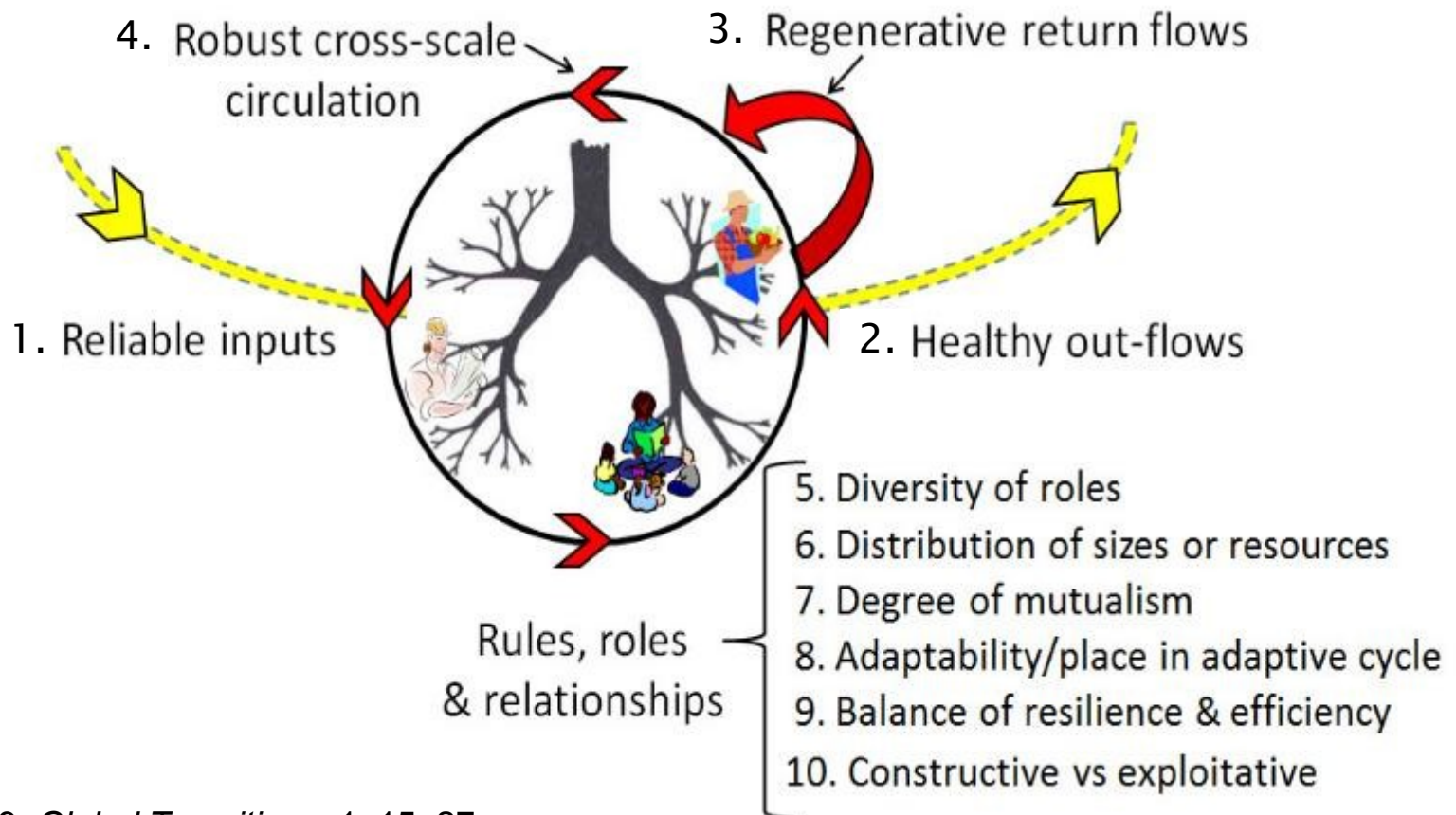


Social/urban Metabolism: society's digestive system

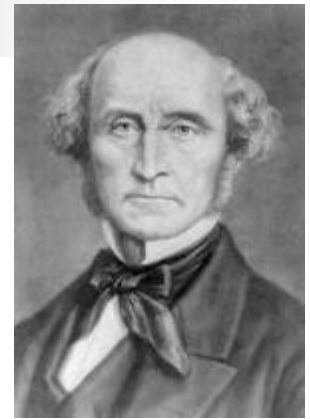


Regenerative economy

Input, Output, and System Dynamics



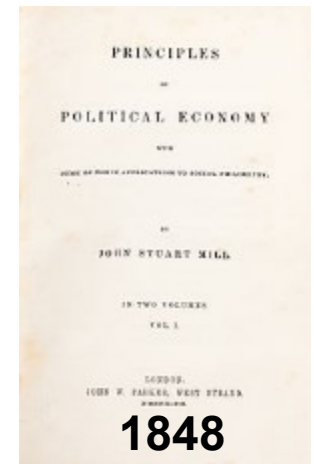
John Stuart Mill



- 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?

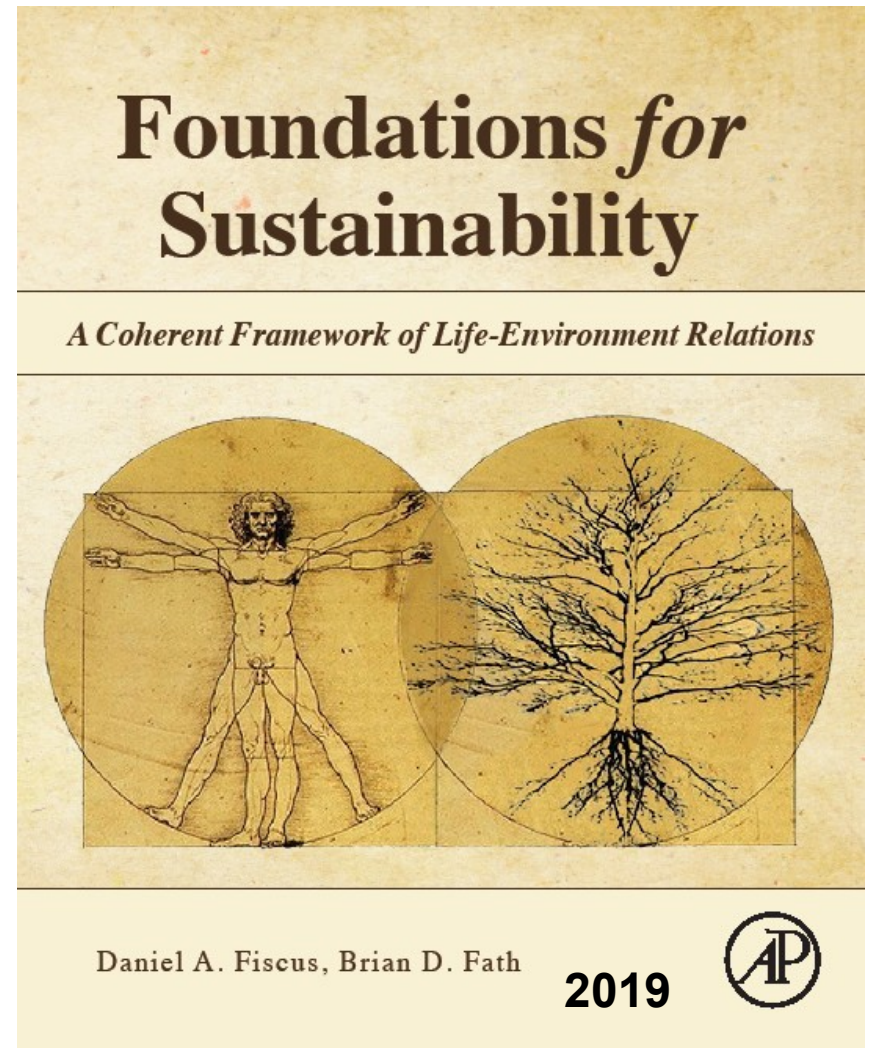


Steps forward

- Identify a shared common vision that respects planetary boundaries
- Enhance built environment by mimicking natural processes
- Systems thinking at all levels of decision-making
- Define sustainability and measure/monitor if current trends are heading toward or away from these trajectories

- Next generation initiates transformative change

There is a right time
to grow, it is just not
always



Thank you for your attention!