Flourishing within Limits to Growth: Revising Economic Systems by Using Nature as a Model

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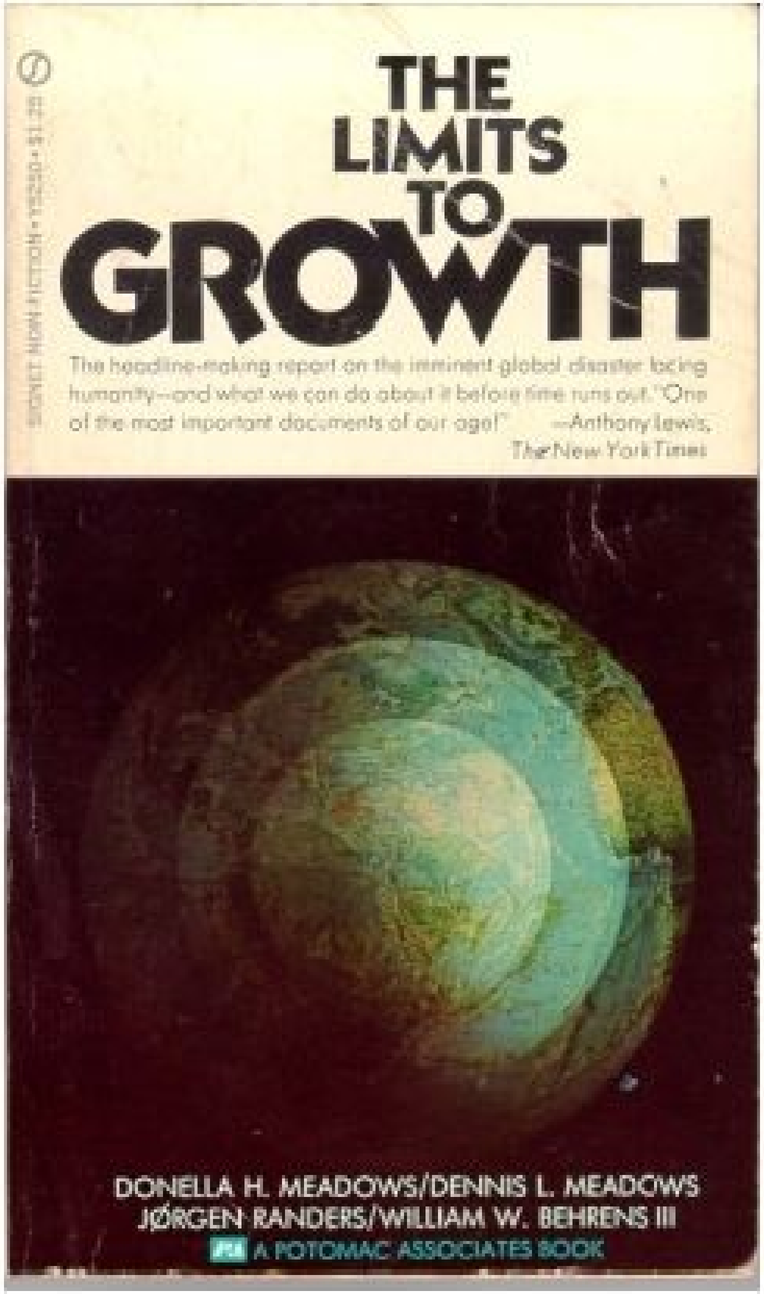
THE LIMITS TO GROWTH
The headline-making report on the imminent global disaster facing humanity—and what we can do about it before time runs out. "One of the most important documents of our age!" —Anthony Lewis, The New York Times
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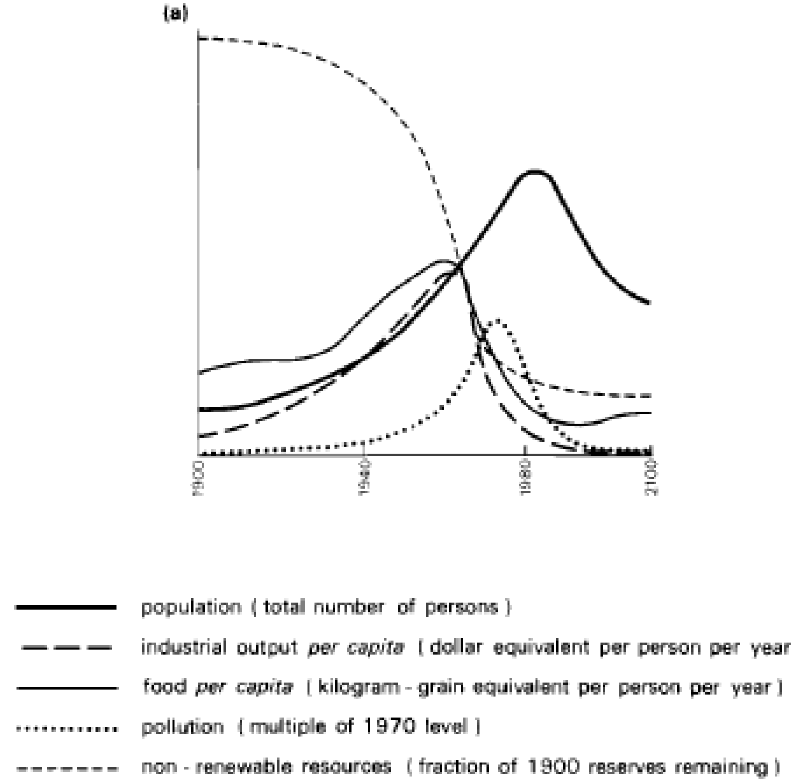
A POTOMAC ASSOCIATES BOOK


(a)
1900
1940
1980
2100
population (total number of persons)
industrial output per capita (dollar equivalent per person per year)
food per capita (kilogram - grain equivalent per person per year)
pollution (multiple of 1970 level)
non - renewable resources (fraction of 1900 reserves remaining)

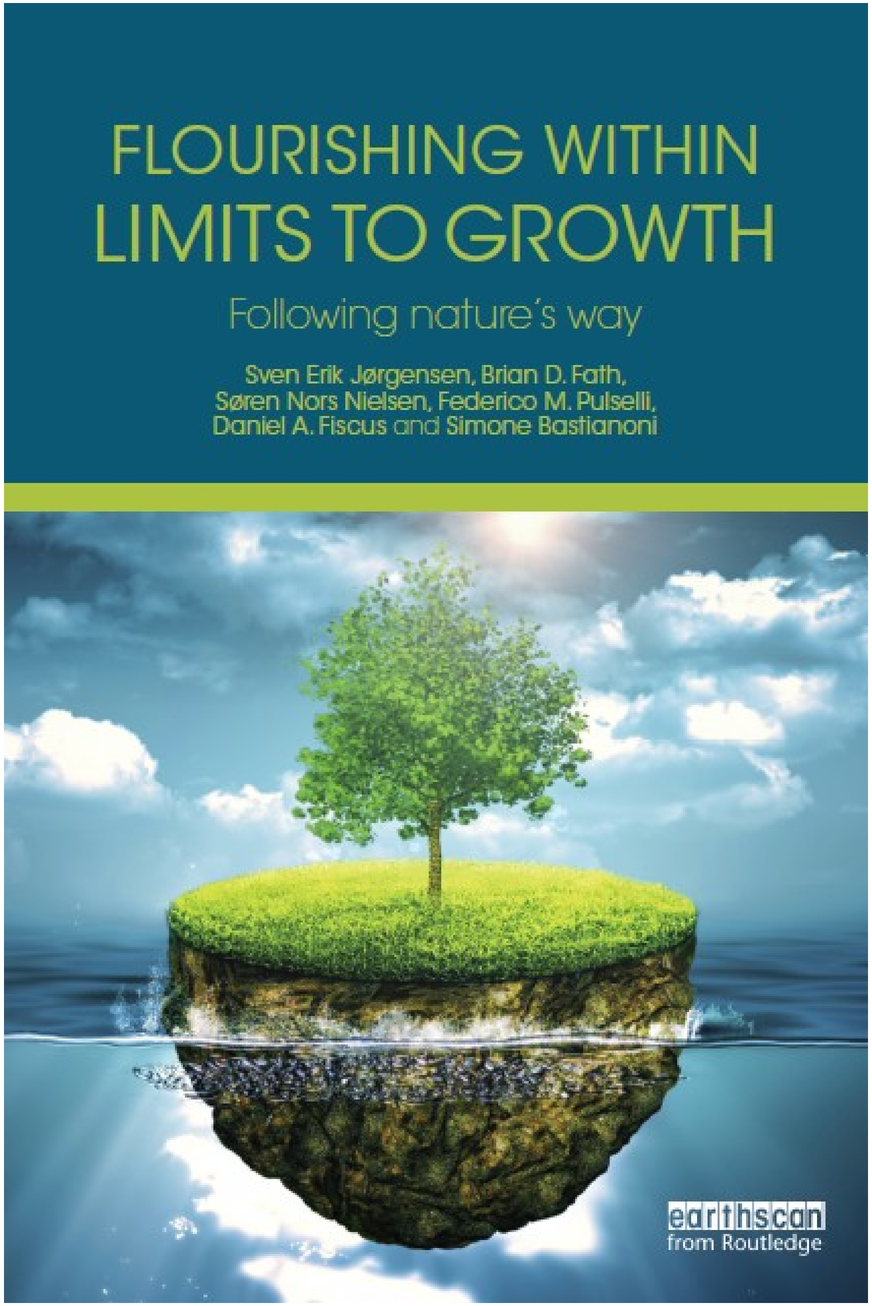
Limits to Growth

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

Jane Jacobs, 2000, p. 12

The Nature of Economies

Club of Siena
SE Jørgensen, BD Fath,
SN Nielsen, FM Pulselli,
DA Fiscus, S Bastianoni



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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 con[illegible]sses

Ontological properties

4) An ecosystem uses surplus ene[illegible]om thermodynamic equilibrium (physically d[illegible]entripetality
5) An ecosystem co[illegible] modifying its environment (biologica[illegible])

Phen[illegible]

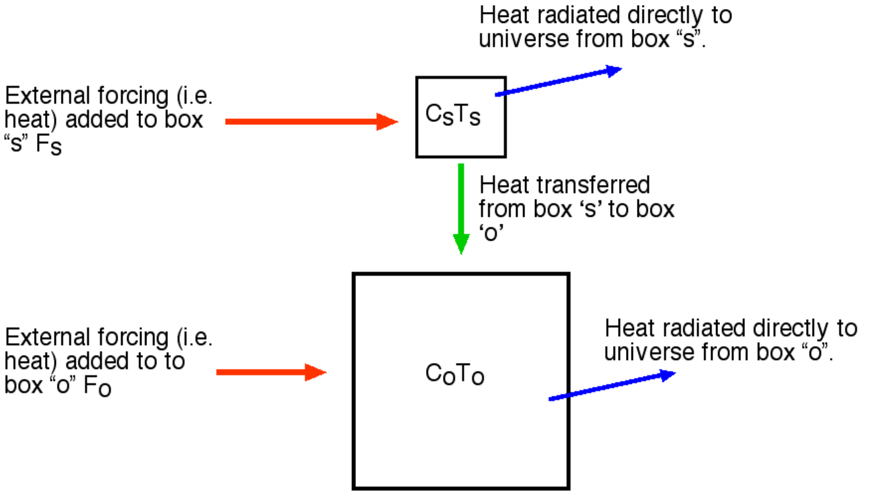
6) Ec[illegible]rsity of structure and function
7) Ecos[illegible]ork together in networks that improve the resource flow utilization
8) Ecosystems are emergent hierarchically
9) Ecosystems have an enormous amount of genetic, biochemical, and process information

Understand these and apply to socio-economic systems

1. Ecosystems conserve *matter and energy*

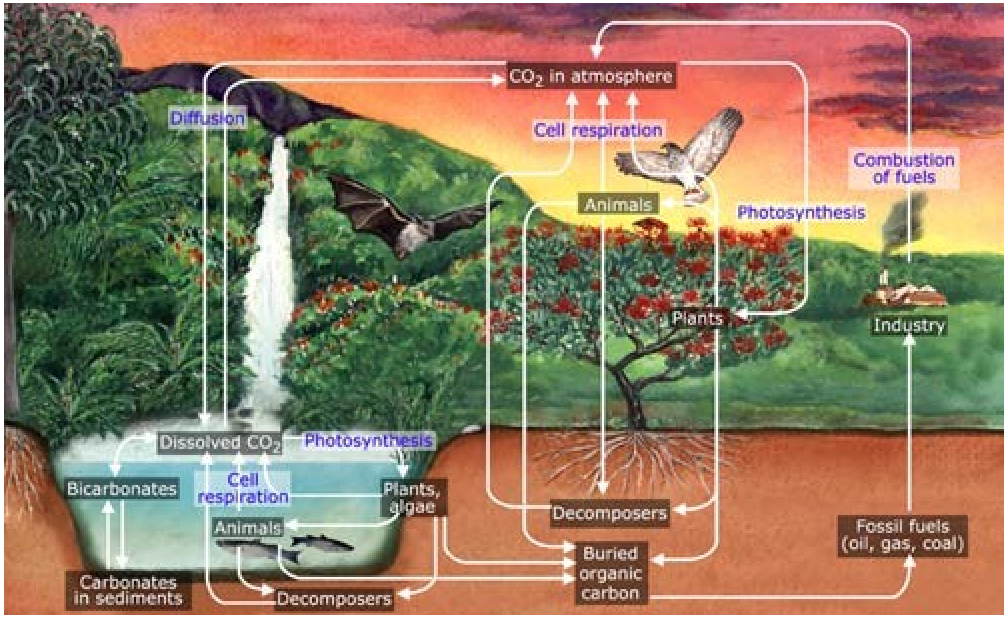
This principle allows one to write balance equations, such as: accumulation = input – output.

General Two Box Energy Balance Model.



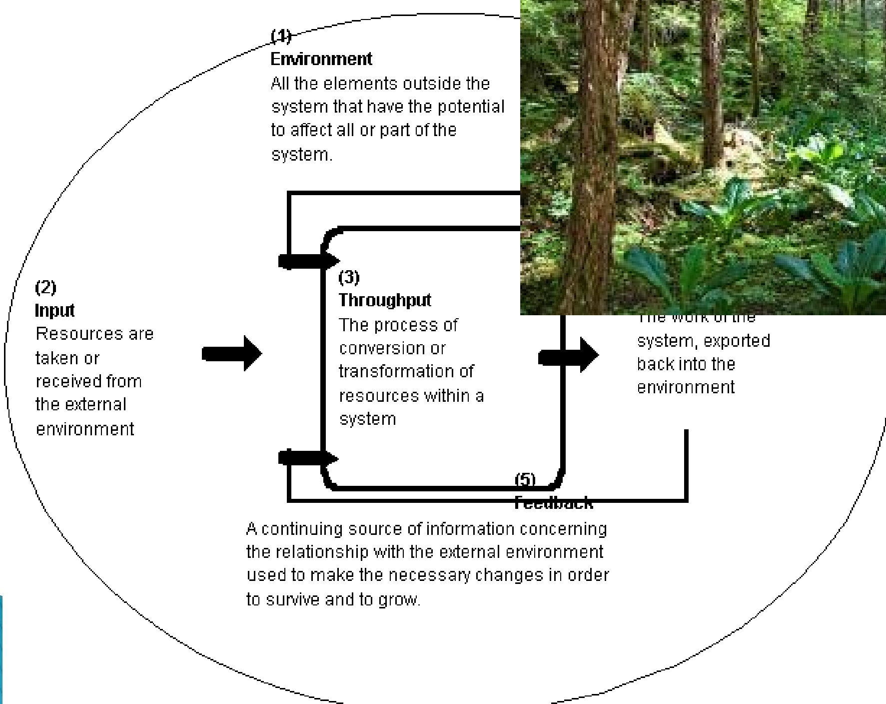
1.1. *There are no trash cans in nature*

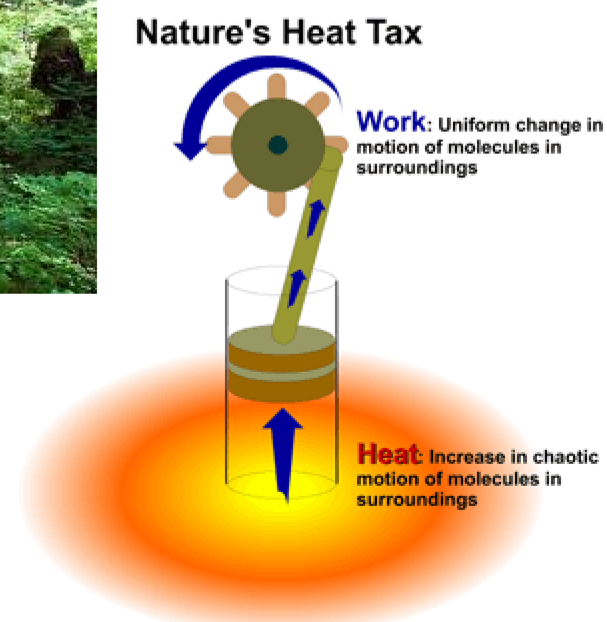
Material is reused again and again through functional couplings



2. *All ecosystem processes are dissipative and irreversible* (useful way to express the 2nd Law in ecology).

Evolution is a step-wise development that is based on previous configurations for survival in a changeable and very dynamic world.





3. *All life uses largely the same biochemical constituents and processes*

Many biochemical compounds can be found in all living organisms. They have therefore almost the same elemental composition derived from about 25 elements.

The Periodic Table of the Elements

1 H Hydrogen 1.00794																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012182											5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
11 Na Sodium 22.989770	12 Mg Magnesium 24.3050											13 Al Aluminum 26.981538	14 Si Silicon 28.0855	15 P Phosphorus 30.973761	16 S Sulfur 32.066	17 Cl Chlorine 35.4527	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955910	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938049	26 Fe Iron 55.845	27 Co Cobalt 58.933200	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.61	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.29
55 Cs Cesium 132.90545	56 Ba Barium 137.327	57 La Lanthanum 138.9055	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.078	79 Au Gold 196.96655	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98038	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93032	68 Er Erbium 167.26	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
90 Th Thorium 232.0381	91 Pa Protactinium 231.03588	92 U Uranium 238.0289	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

Yellow Boxes = **Top 5 Elements** present in the human body

Green Boxes = **Second 5 Top Elements** present in the human body

Blue Boxes = **Trace elements that are required** by the human body

Violet Boxes = **Elements that are deleterious** to the human body.

4. *An ecosystem uses surplus energy to move further from thermodynamic equilibrium (physically driven biological aspect).*

Another way of expressing that ecosystems can grow – progressive, directional change

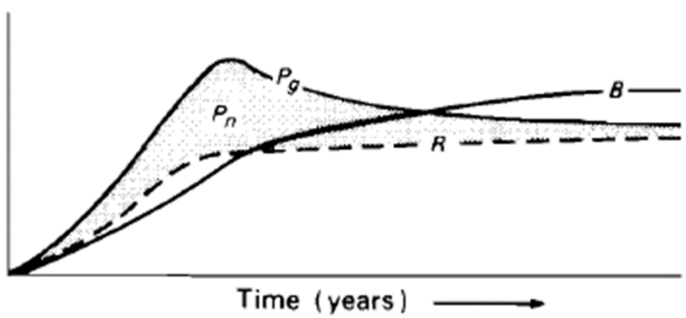
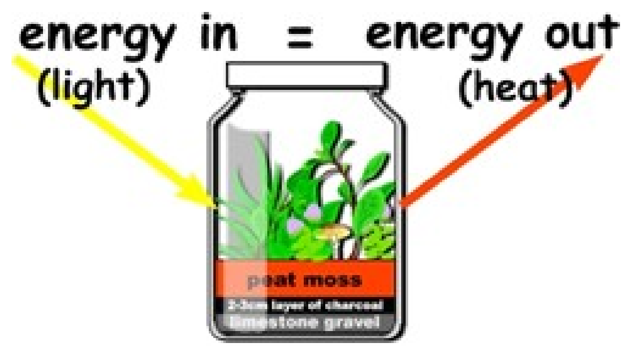
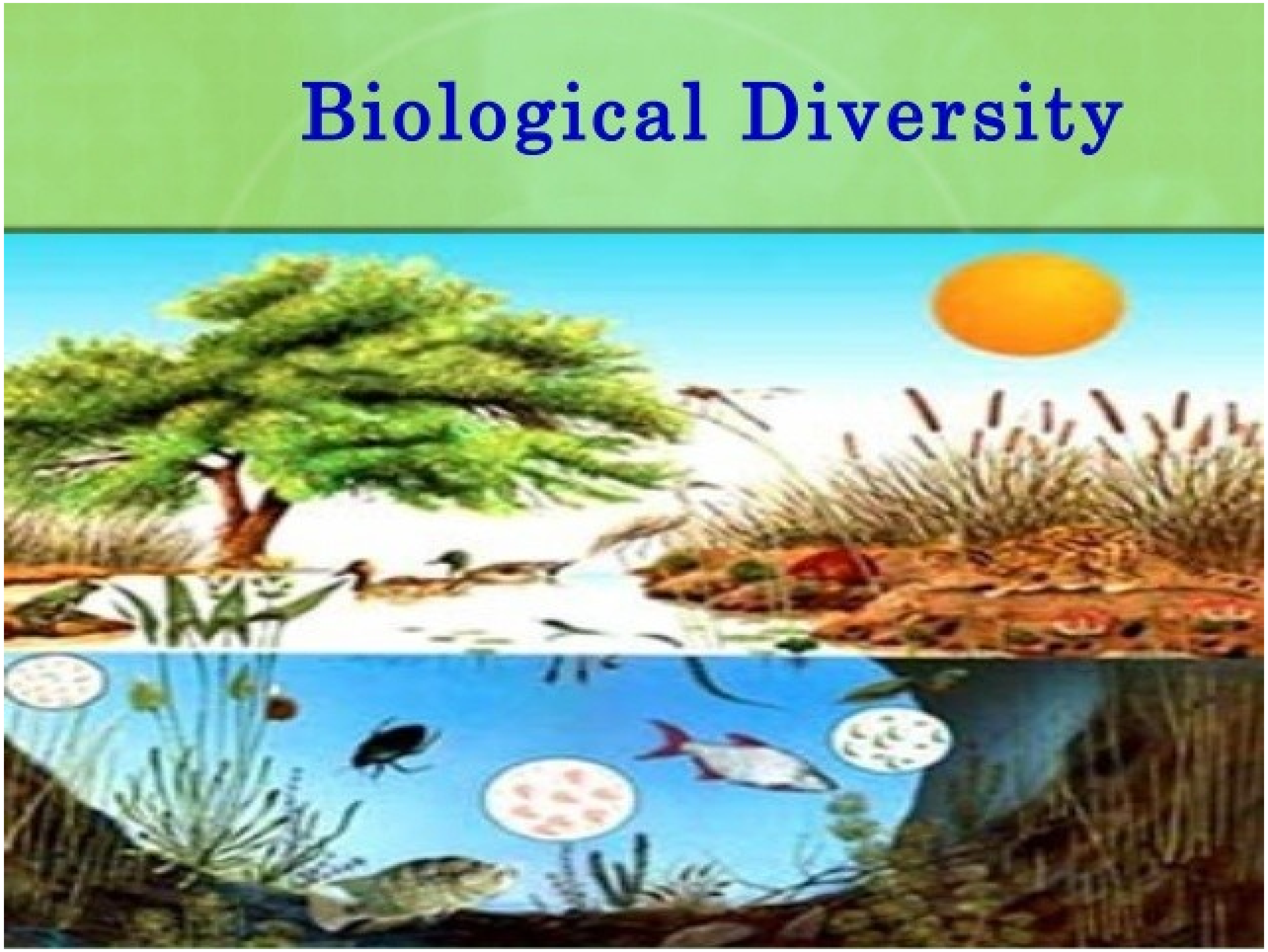


Fig. 25.17 Changes in gross (P_g) and net (P_n) production, respiration (R) and biomass (B) through succession.



5. *An ecosystem co-evolves by adapting to and modifying its environment (biologically driven biological aspect).*

6. *Ecosystems have diversity of structure and function.*



7. Ecosystems work together in networks that improve the resource flow utilization

Connectivity is a basic property that, through transactions and relations, binds ecosystem parts together as an interacting system.

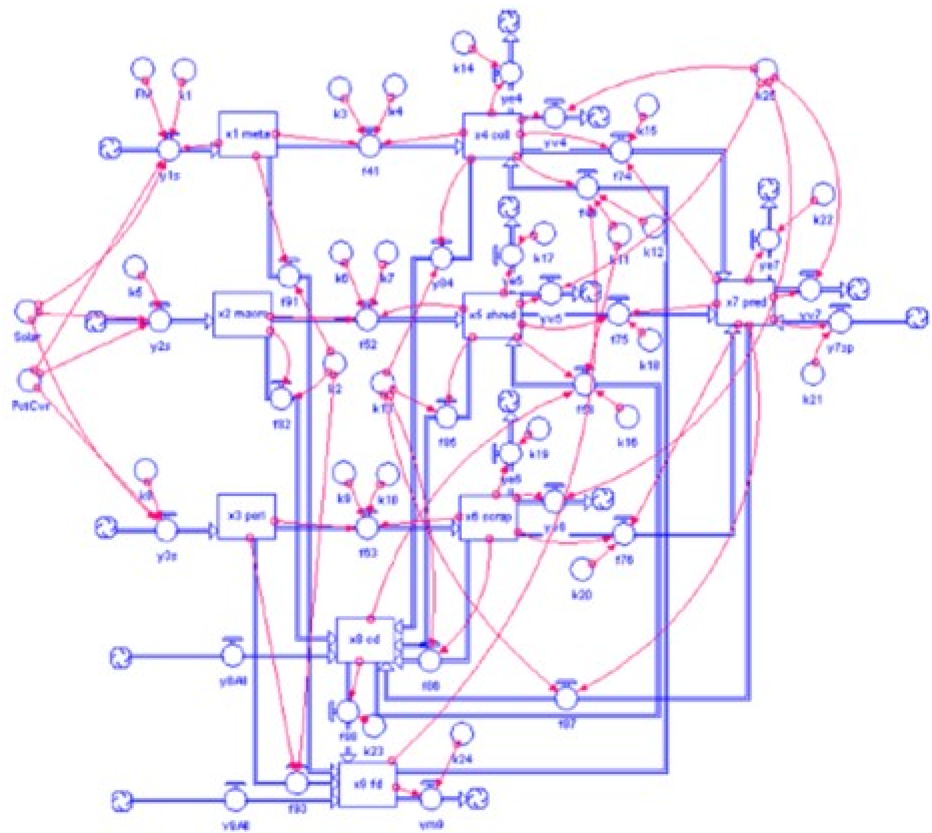
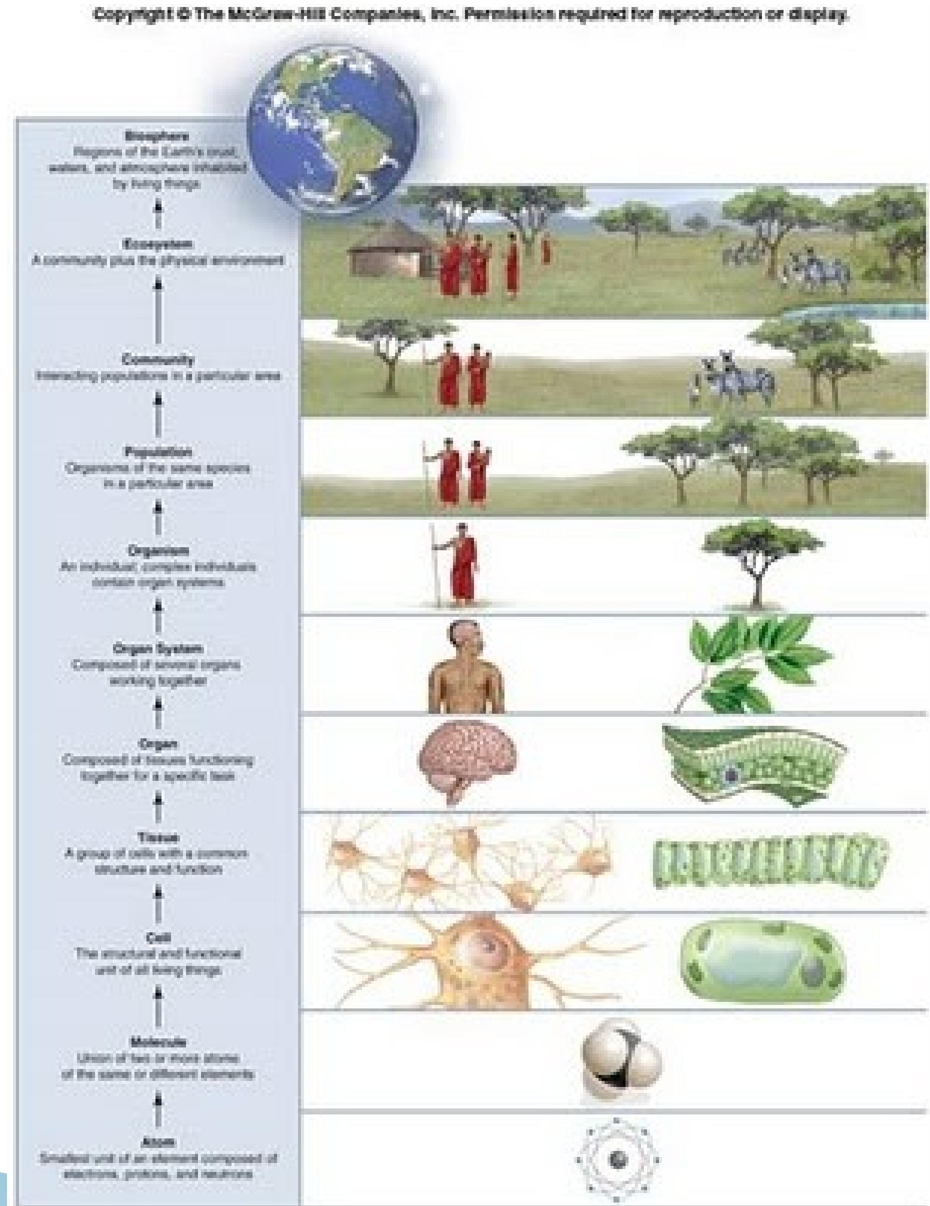


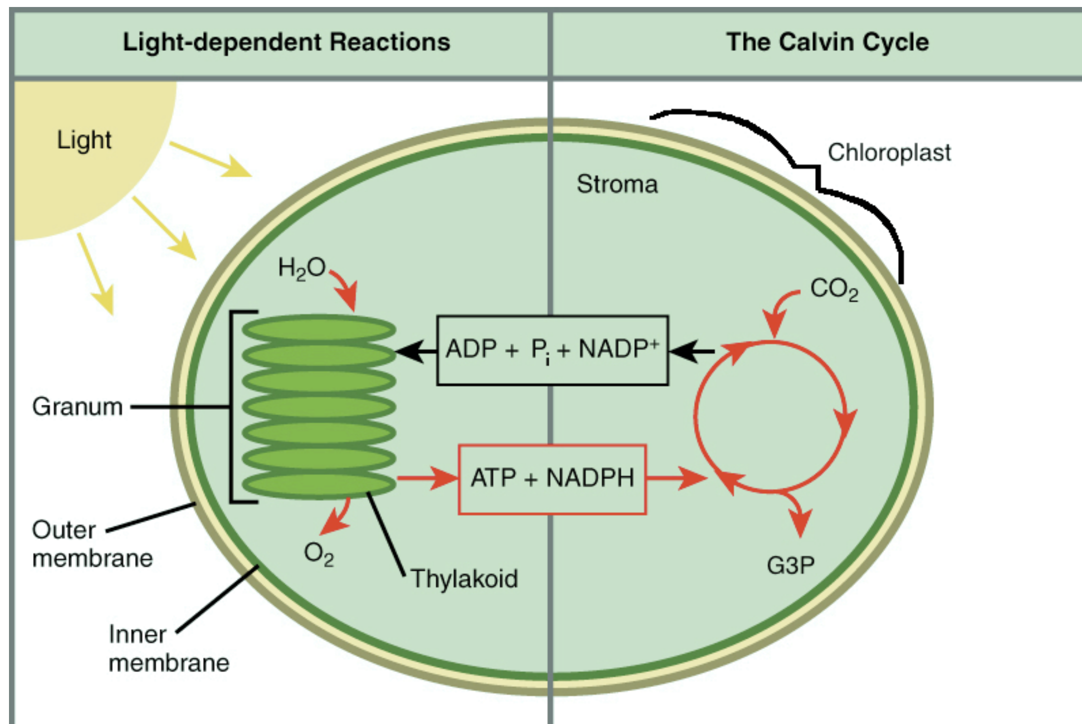
Fig. 1 – Trophic model of Olentangy Wetland in STELLA (recreated from Spieles and Mitsch, 2003).

8. *Ecosystems are emergent hierarchically*

Ecosphere
Ecosystems
Communities
Populations
Organisms
Organ systems
Organs
Tissue
Cells
Molecules
Atoms



9. *Ecosystems have an enormous amount of genetic, biochemical, and process information*



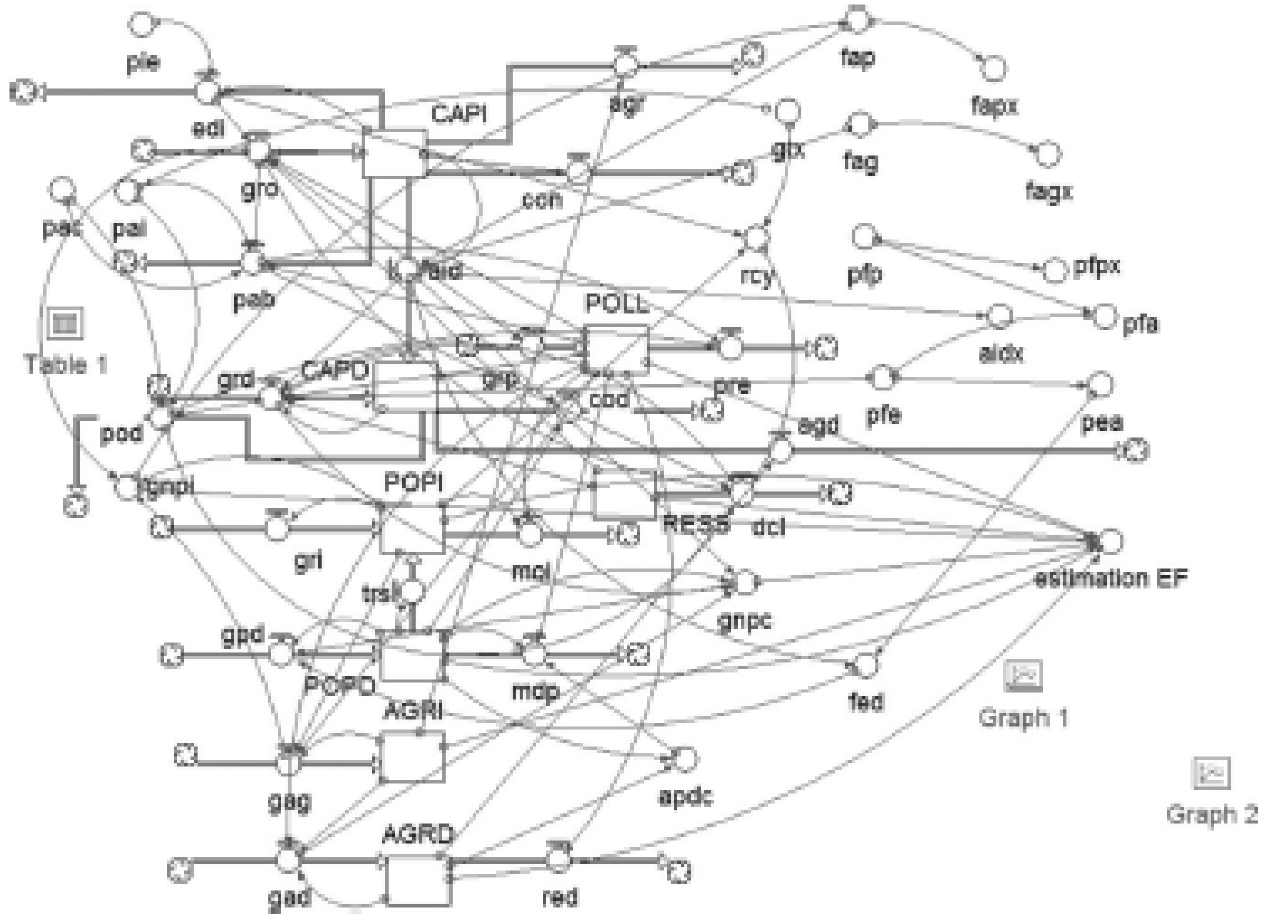
Similarities between human and natural systems

- Have to respect that mass and energy are conserved
- Have only irreversible processes, where work energy is lost as heat energy that cannot do further work
- Are open and need an input of work energy for maintenance
- Are organized hierarchically
- Have high diversity
- Have components working in interactive networks
- Have high information level

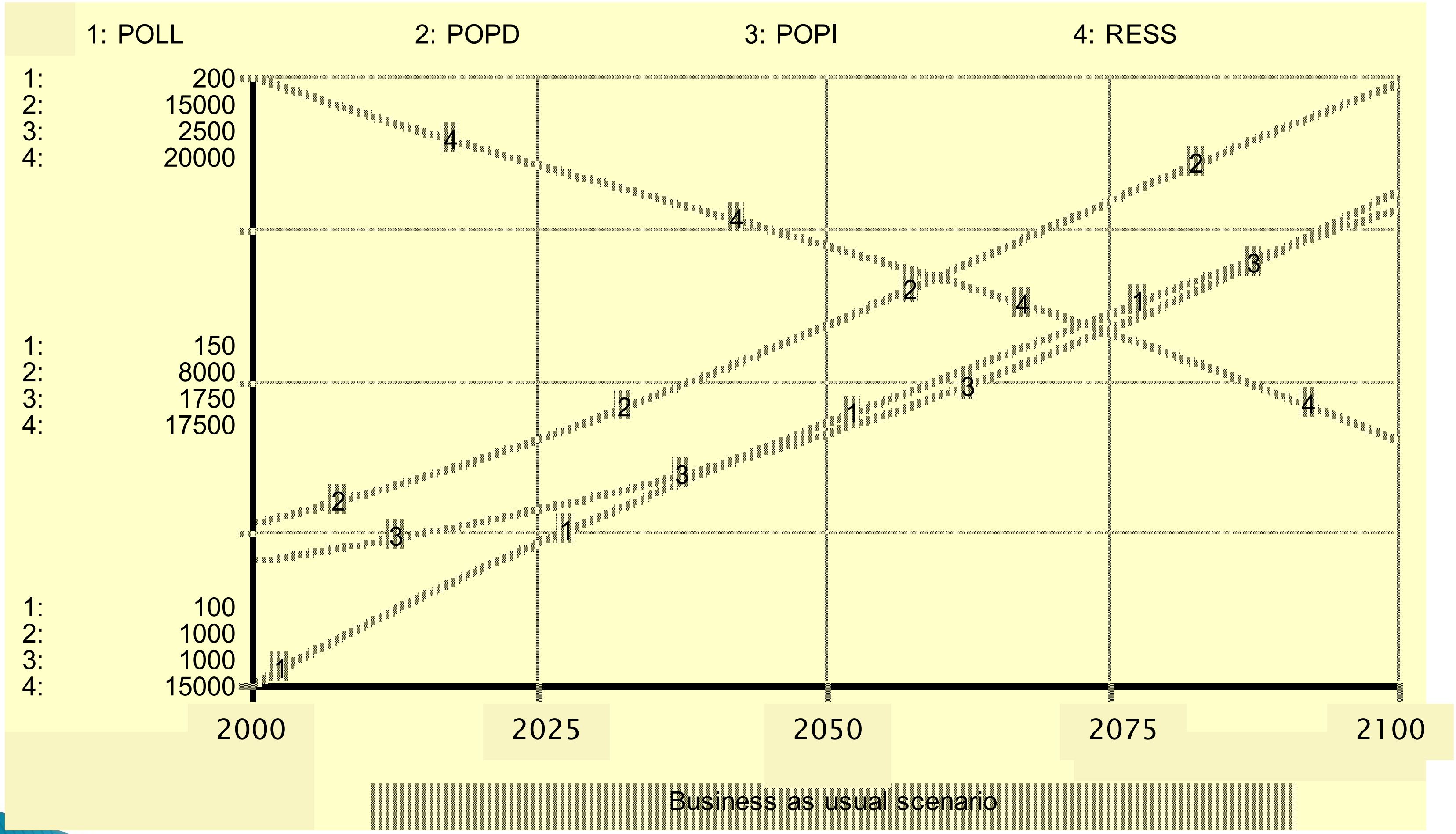
Differences between natural and human systems

- Ecosystems recycle most resources; human systems recycle very modestly compared to the overall potential
- Ecosystems store surplus work energy in biomass and increased organizational complexity. Human societies do the same to a certain extent, but the *primary energy source – fossil fuels – are non-renewable and create pollution problems*
- Ecosystems use growth and development to continue flourishing, while human societies rely largely on growing through increased input of natural resources, underutilizing networks and information
- Economic rewards are given for either *building or exploiting gradients, without differentiation*

Global Model



Business as usual scenario



POLL=pollution; POPD=population (developing countries); POPI=population (industrial countries); RESS=resources

How can we curb population growth?

- In the developing countries, supporting birth control and increase in GNP per capita

- It is also important to raise the education level, particularly for women

How can we curb pollution?

- Invest in pollution abatement through the introduction of a fair accounting framework, such as a Pigovian tax, based on internalizing the externalities.
- The "invoice" to the polluter should include the costs of all the consequences of pollution, including the reduction of ecosystem services

How can we slow down natural resource use?

- Creating an economy that minimizes the level of unwanted wastes by coupling flows through by-product synergies
- An accounting framework that internalizes externalities
- Investment in education, innovation, and research
- Production decreases when resources are unavailable

Summary: 6-point action plan

1) All industrialized countries with a GNP/capita > $20,000/yr pay 0.8% of GNP increasing by 0.04% per year
2) 10% of this support is used for family planning
3) 40% of the support is used to improve education in the developing countries; remaining 50% is negotiated between the donor and the receiving country
4) 2.5% of the production value is allocated to pollution control
5) An 8% Pigovian tax encourages resource efficiency
6) Investment, ≥10% of GNP, is made in education, innovation, and research in the industrialized countries

Results of using the 6-point plan

State variable	unit	Initial value (2000)	2054	2100
production capacity of industrial countries	rel.	340	539	814
production capacity of developing countries	rel.	110	158	659
population of industrial countries	10^9	1300	1590	1900
population of developing countries	10^9	4700	6768	3860
Total Pop	10^9	6000	8358	5760
Agricultural output of industrial countries	rel.	100	121	186
Agricultural output of developing countries	rel.	100	172	252
Pollution emissions	rel.	100	122	104
Resource availability	rel.	20	19.4	18.8
GNP/cap (industrial countries)	$1K/cap	29.5	32.4	44.4
GNP/cap (developing countries)	$1K/cap	2.7	3.2	19.5

8 recommendations

1) Use the three R's (reduce, reuse, and recycle) much more extensively.
2) Use solar radiation, directly or indirectly, as sole energy source.
3) Focus on flourishing rather than growing by changing from quantitative growth that requires natural resources to qualitative development which uses network organization and information to remain vigorous and dynamic
4) Changing the objective toward building and maintaining greater work energy capital rather than exploitation of the gradients for short-term economic return. Economic profit should reflect how much work energy is built not how much is extracted.

8 recommendations

5) Improving integration on and between all hierarchical levels.
6) Appreciating diversity and understanding that it gives society a wider array of resistance and buffers to changes.
7) Promoting and valuing opportunities to increase information by investing in education, research, and innovation.
8) Maintain and replenish ecosystem services.

These improvements can be made within the current economic framework through altered pricing and incentives

Is it possible? Is it enough?

More systemic/radical alternative…

A bottom up re-visioning is vital: A new holistic paradigm for life

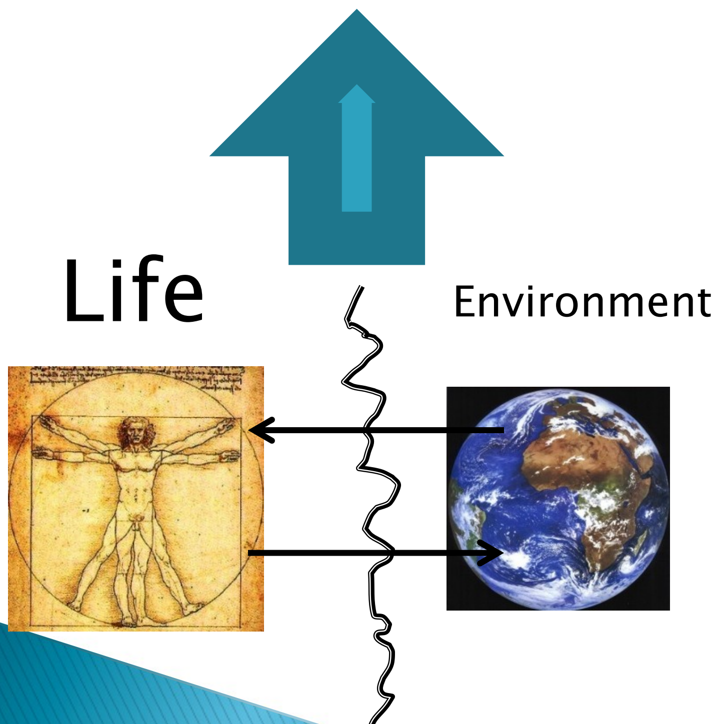
- Contrary to the dominant mainstream view, the basis of all current biology and life science education, it now is becoming clear that ***life is not only (or even primarily) an organismal property.***

- In the view actively emerging, life is not centered on or emanating from organisms, nor is it primarily a localized, objectified or material phenomenon.

- ***Life is inherently relational, distributed, and non-localized***

Mental models and outcomes
Real impacts of choice of system boundaries

Tragedy of the Commons
Humans win, environment degrades

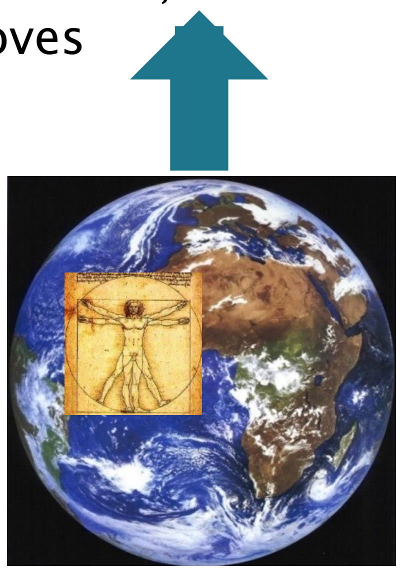


Figures by Dan Fiscus

- Inherent in this paradigm, life is separated from environment in mind and action – severs the unity of life and life support systems
- Once fragmented, it is possible and likely that the value of environment is seen and treated as less than the value of life
- Environment is consumed and degraded as manifest in many symptoms of ecological crisis, and the influence of the citizens' mental fragmentation and devaluation of environment travels upward to larger scales and produces the global crisis

Recursive nature of nature

Bounty of the Commons
Humans win, environment improves



1) Life and environment are best understood and modeled as unified as a single "life–environment" system.
2) A hyperset equation explicitly and formally *prohibits fragmentation of life from environment*

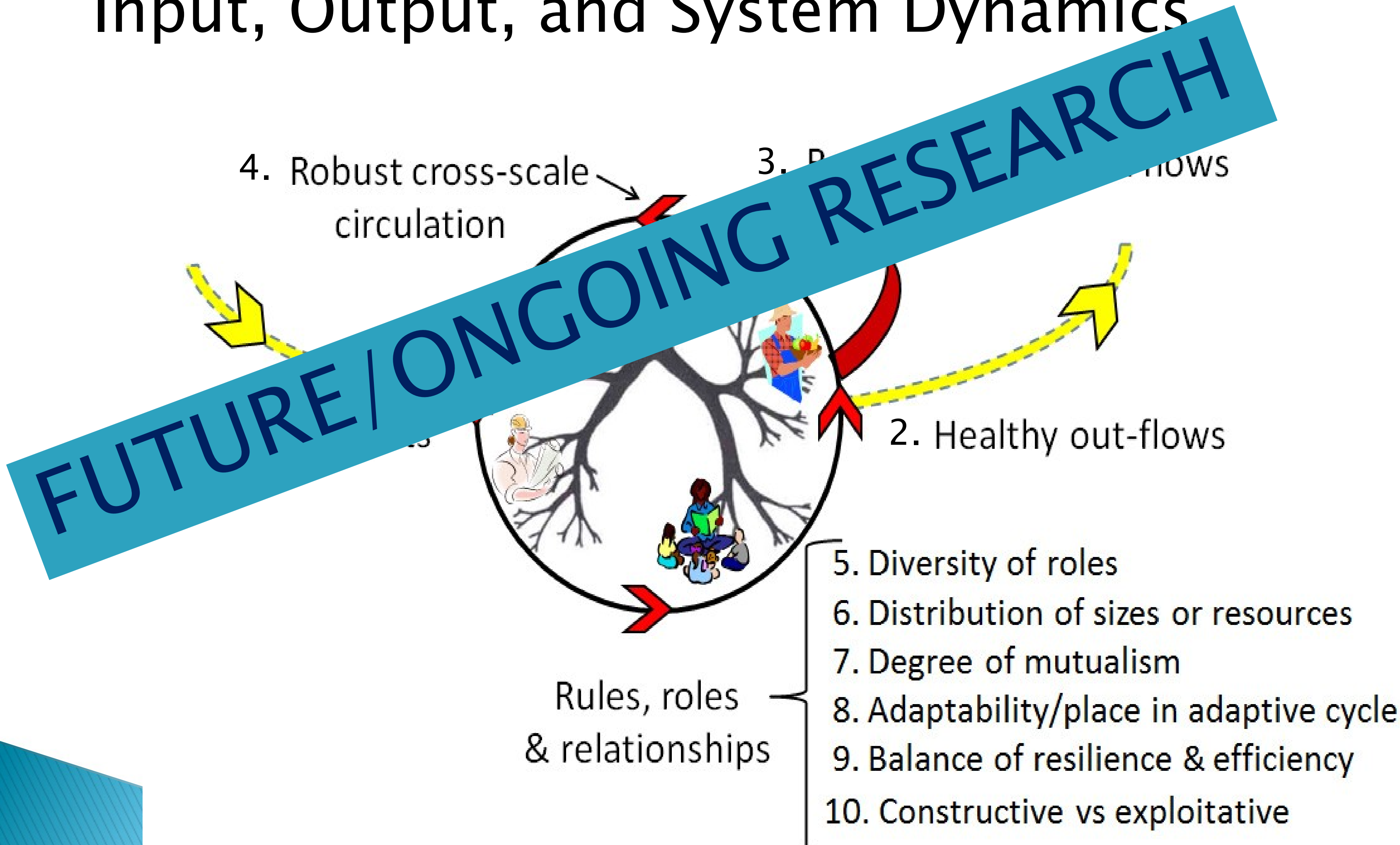
life–environment =

{environment{ecosystems{organisms{environment}}}}

Fiscus D, Fath BD, Goerner S. 2012. E:CO 14(3), 44-88.

Regenerative economy

Input, Output, and System Dynamics



Conclusion

The business-as-usual approach of chasing perpetual economic growth is failing. It is not sustainable on our finite planet and it is not solving the problems of unemployment, poverty, and inequality - in contrast to what economists and politicians claim.

However, actions such as:

- increased investment in education and knowledge creation,
- accounting the contributions of ecosystem services,
- a transition from non-renewable to renewable energy sources,
- focus on development and quality over growth and quantity, and
- building community networks within sustainable places,

can guide human society closer to ecological balance by learning and adopting ***how nature flourishes*** within the imposed biophysical and thermodynamic constraints.

Read all the details here!

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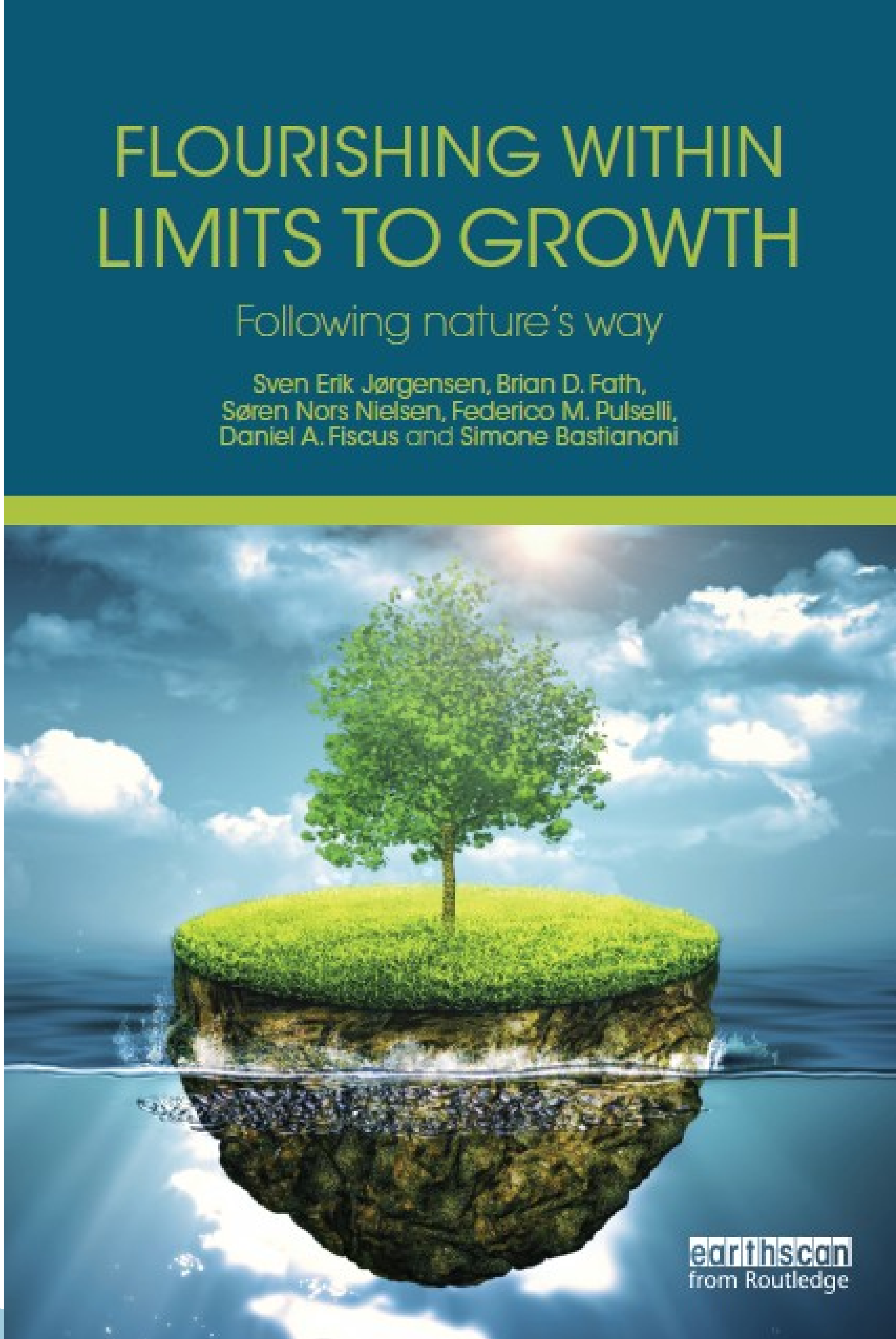

Thank you for your attention!