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Sustainable practices to increase the resilience of Italian agriculture under global change dynamics in local places

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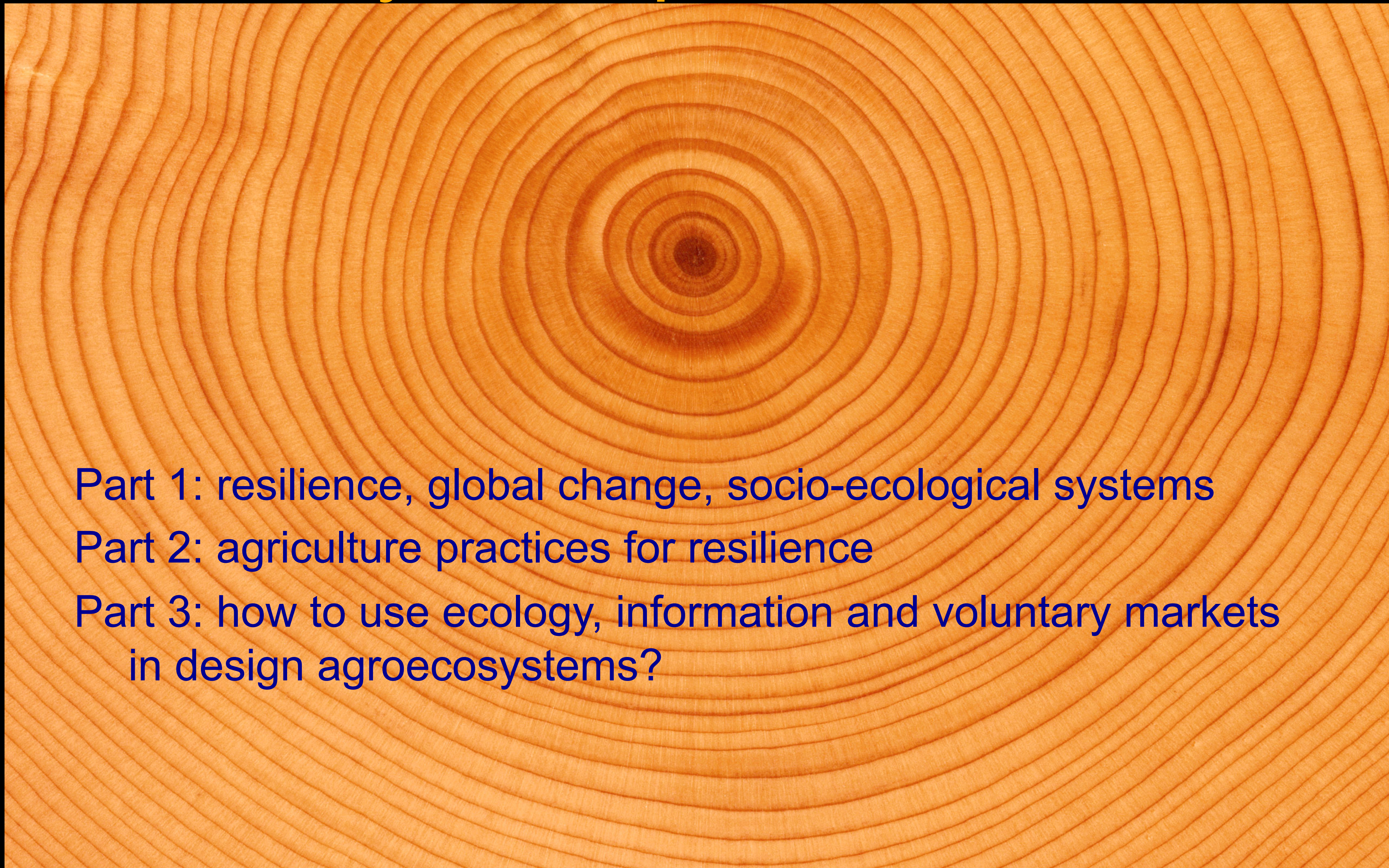
Layout of presentation



Part 1: resilience, global change, socio-ecological systems

Part 2: agriculture practices for resilience

Part 3: how to use ecology, information and voluntary markets in design agroecosystems?

Systems

Systems Perspective...

Definitions…

System - a set of entities comprising a whole where each component interacts with or is related to at least one other component and they all serve a common objective.

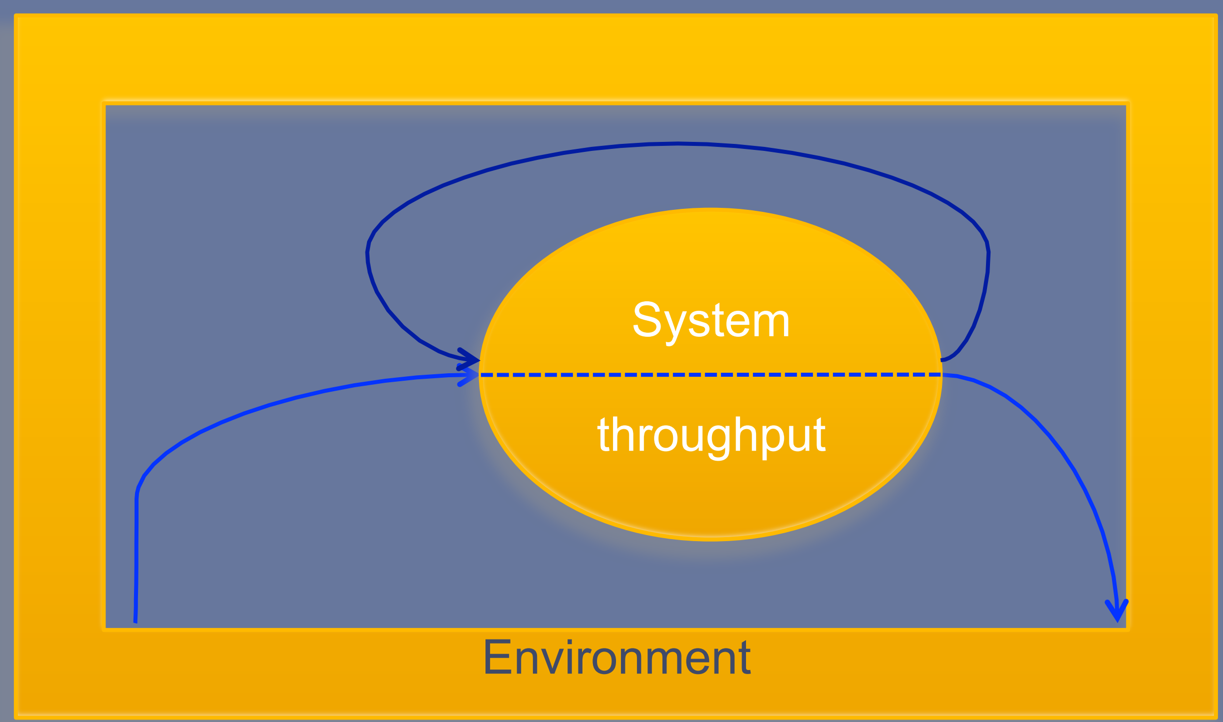
An open system is a system which continuously interacts with its environment or surroundings. The flux can be information, energy, or material. A closed system exachenge energy, an isolated system not exchanges energy, neither matter, nor information with its environment.

from: Brown, M., 2013. Emergy Course

Systems

Systems Approach...

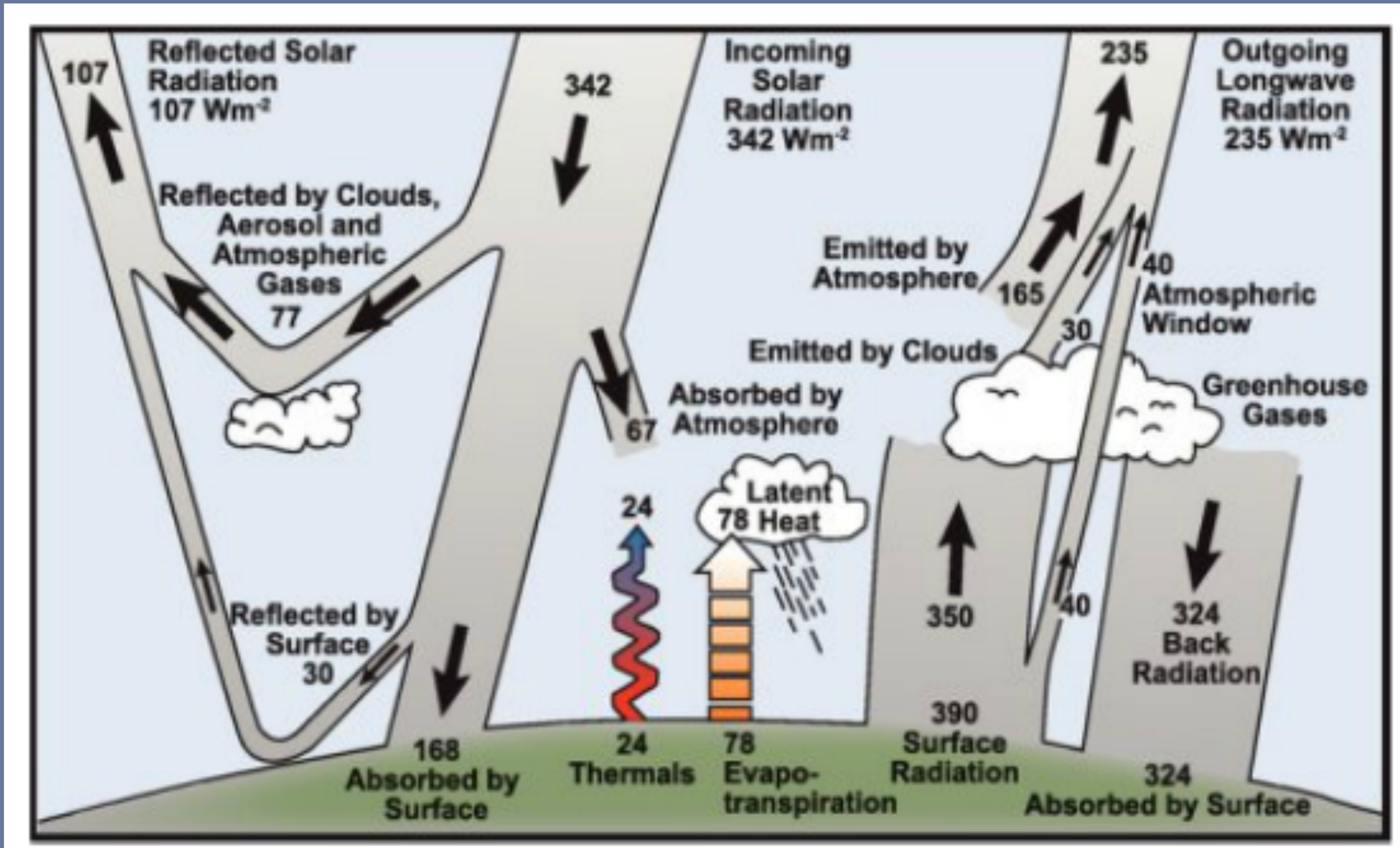
Ludwig von Bertalanffy's concept of a system and its environment and Norbert Wiener feedback



1968, *General System theory: Foundations, Development, Applications, George Braziller, New York.*

Systems

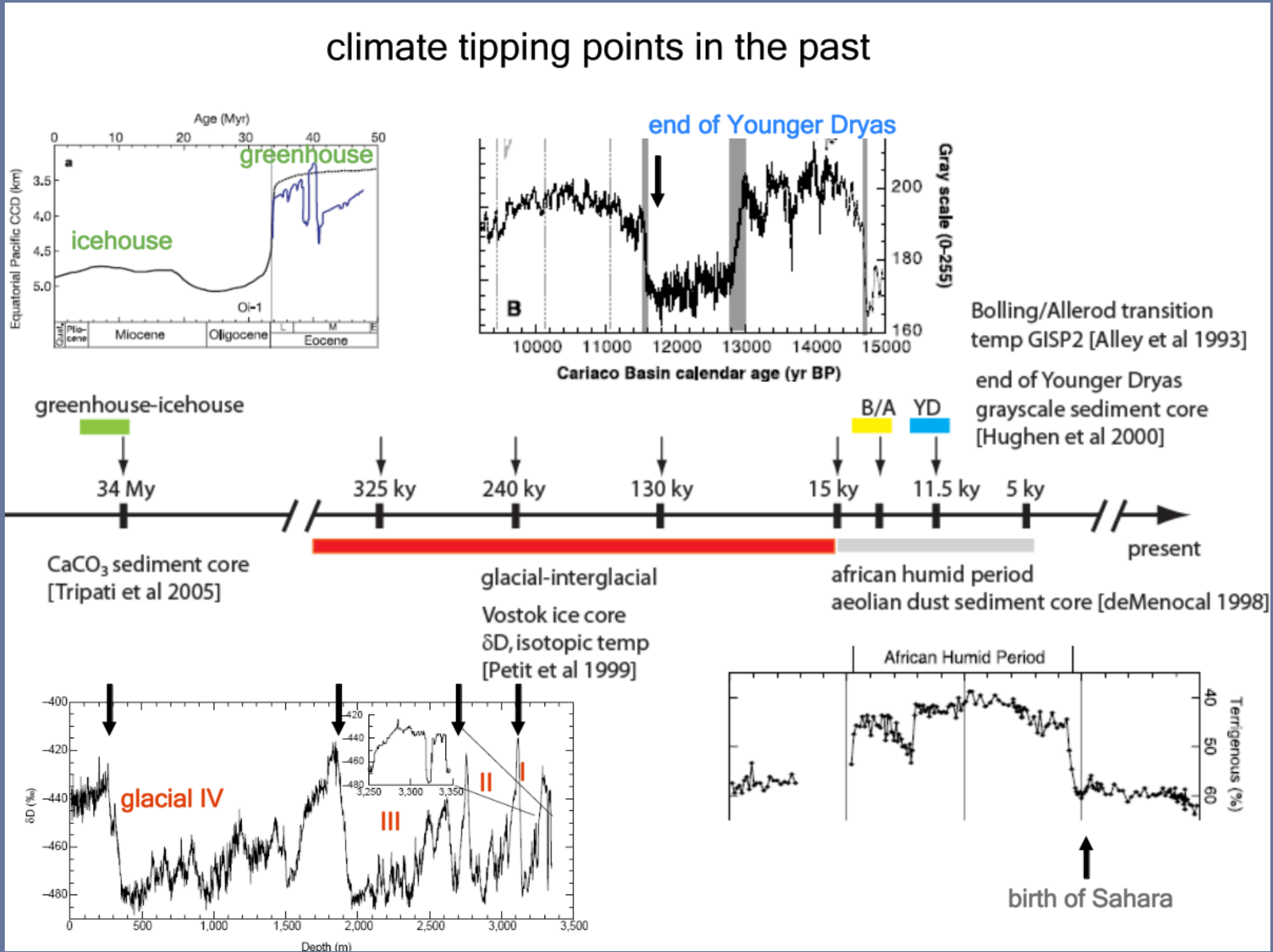
Climate



IPPC, IV Assessment, 2007

Systems

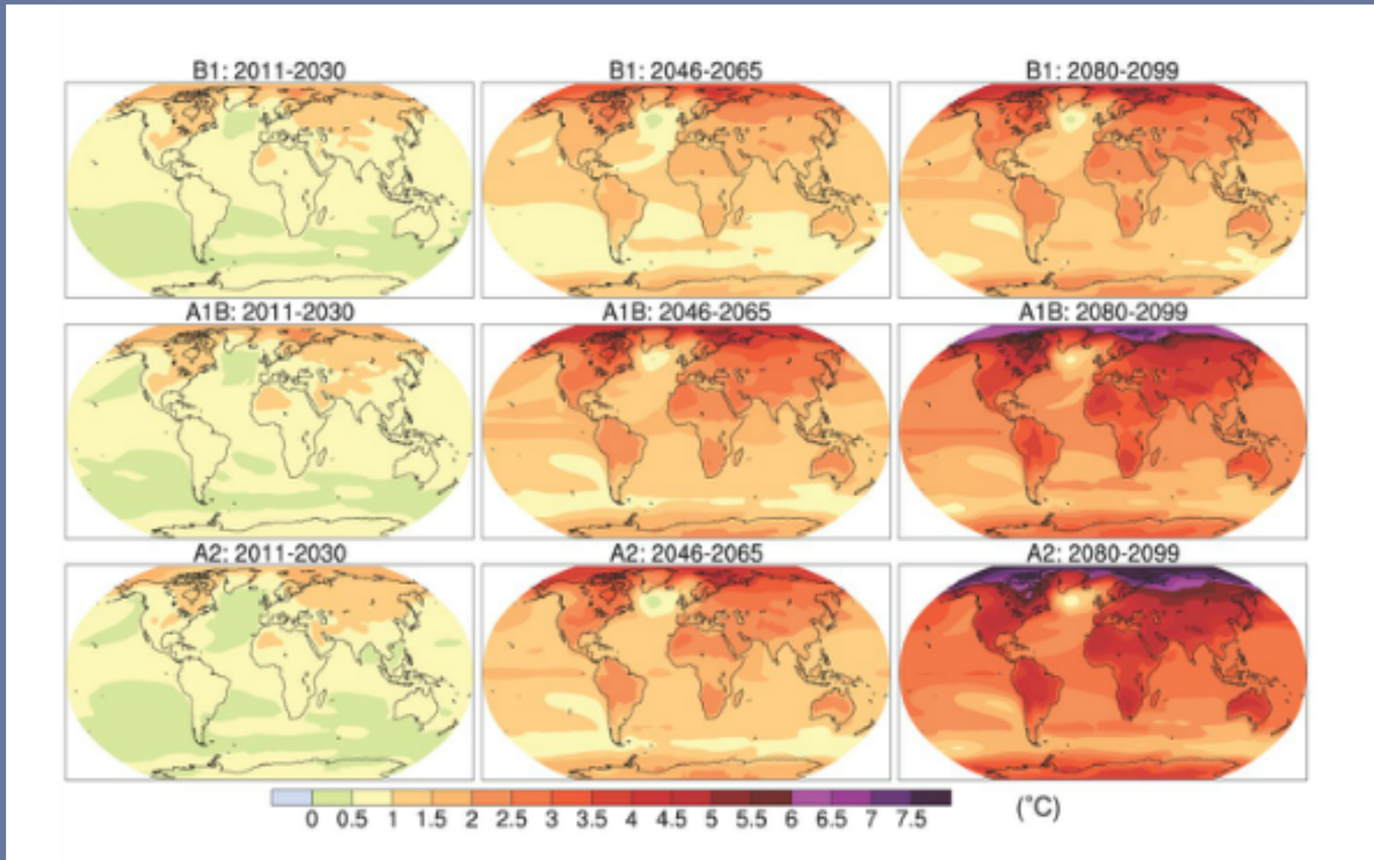
Climate dynamics



w.early-warning-signals.org/wp-content/uploads/2012/09/climate_shifts1.png

Systems

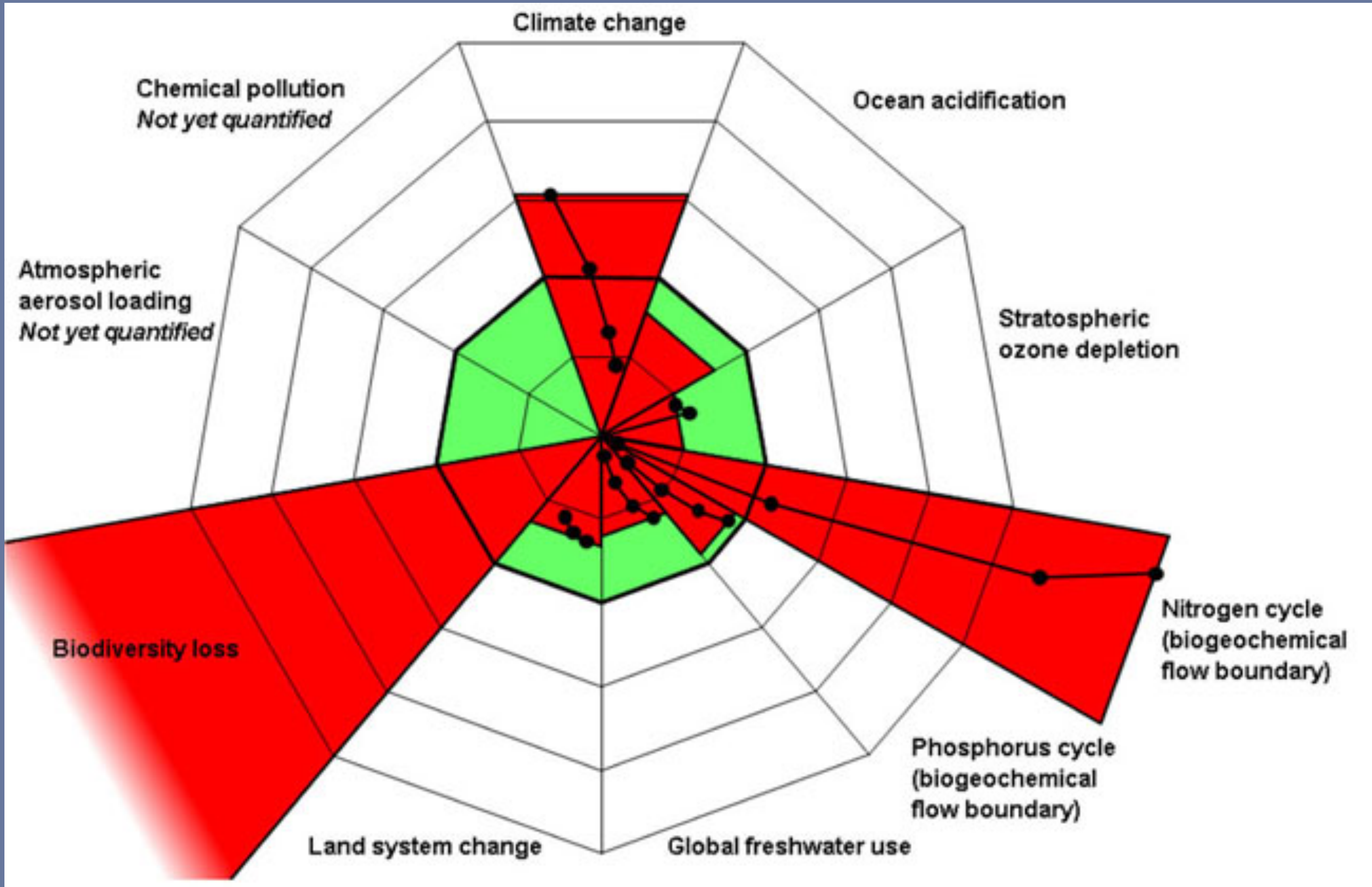
Climate Scenarios Futures



IPPC, IV Assessment, 2007

Systems

Anthropic driven changes: loose of functions as well ecosystem services



Estimates of how the different control variables for seven planetary boundaries have changed from 1950 to present. The green shaded polygon represents the safe operating space.

(Image courtesy of Courtesy of Stockholm Resilience Centre)© Copyright Arizona Board of Regents.
https://asunews.asu.edu/files/images/spider%20image%20for%20web.jpg

Resilience in ecology

* Resilience is the magnitude of disturbance a system can tolerate before it shifts into a different state.
* adaptive capacity: The degree to which the system is capable of self- organization. When managers control certain variables in a system, they create inter-variable feedbacks that would not be there without their intervention. The more "self-organizing" the system, the fewer feedbacks need to be introduced by managers.

heffer, M., Carpenter, S. & Foley, J. A. Folke, C. & Walker, B. 2011. Catastrophic shifts in ecosystems. Nature 413, 591–596.
://www.early-warning-signals.org/wp-content/uploads/2012/09/climate_shifts1.png

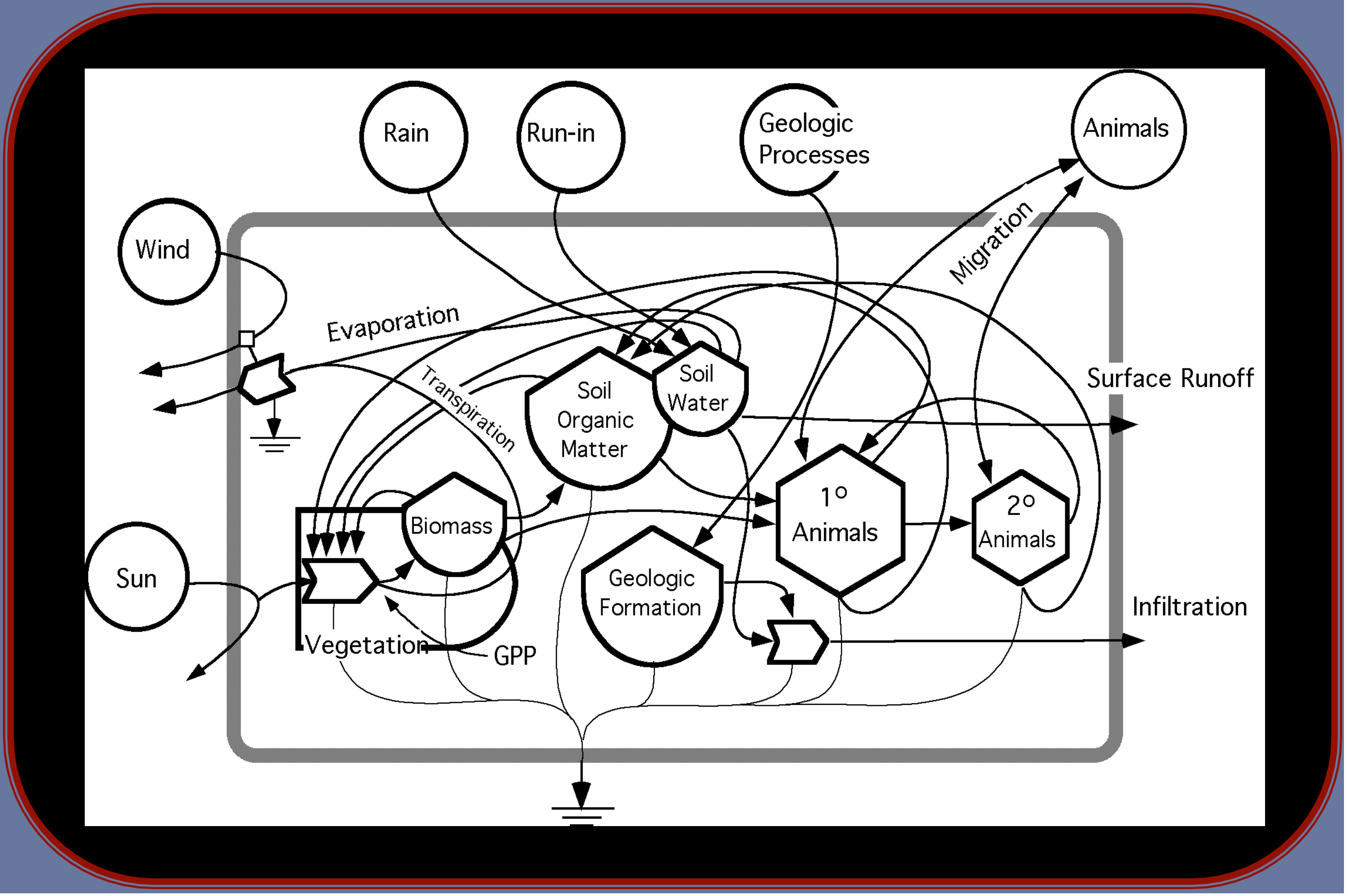
Socio-ecological system

* A socio-ecological system is a complex ecosystem in which humans controls some fluxes of energy and biogeochemical cycles.

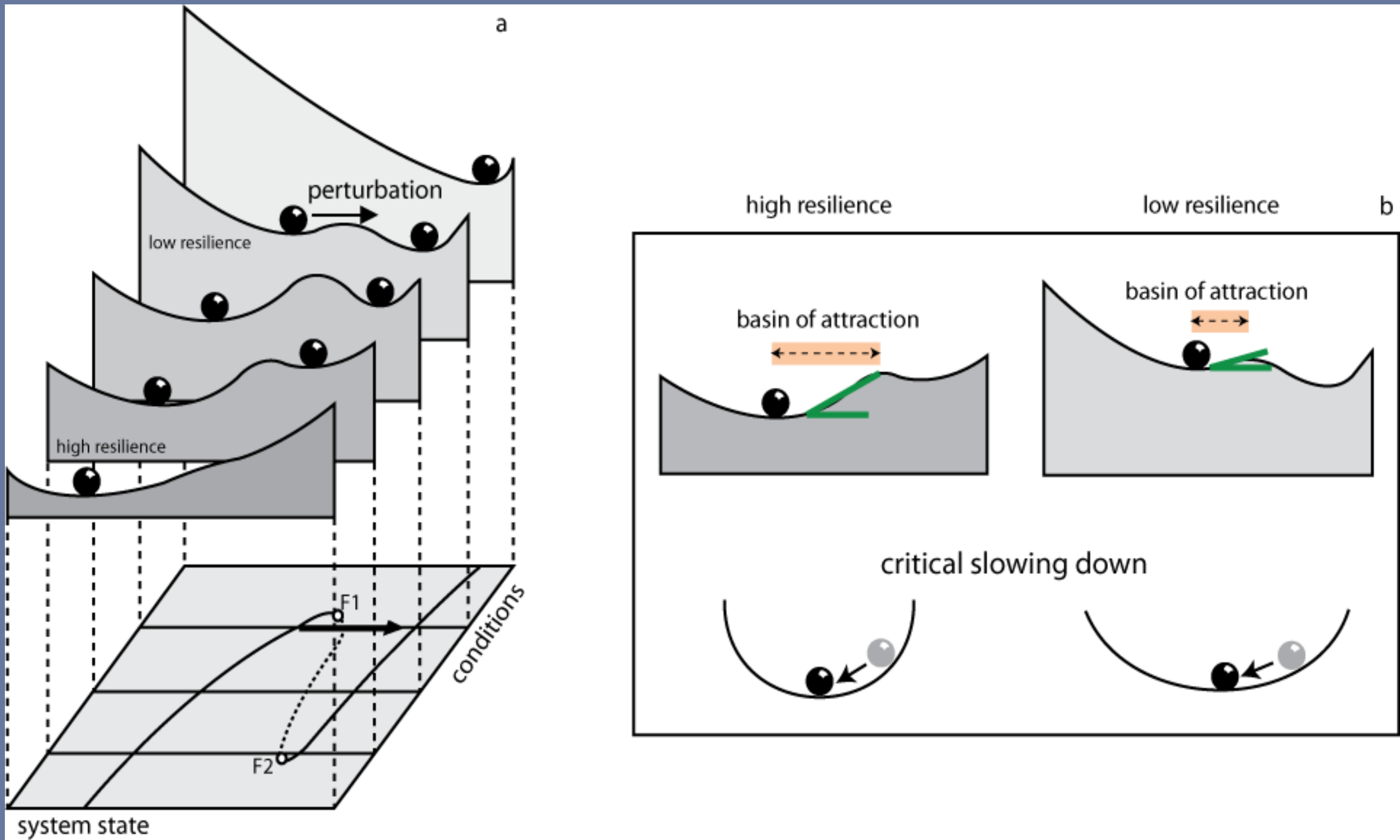
* Social ecology is an appeal not only for moral regeneration but also, and above all, for social reconstruction along ecological lines (Murray Bookchin, 1964)

A socio-ecological system is an ecosystem

Energy and matter are:
Sunlight, wind, rain, nutrients, CO_2, etc...



Resilience



Scheffer, M., Carpenter, S. & Foley, J. A. Folke, C. & Walker, B. 2011. Catastrophic shifts in ecosystems. Nature 413, 591–596.
http://www.early-warning-signals.org/wp-content/uploads/2012/09/climate_shifts1.png

Definitions

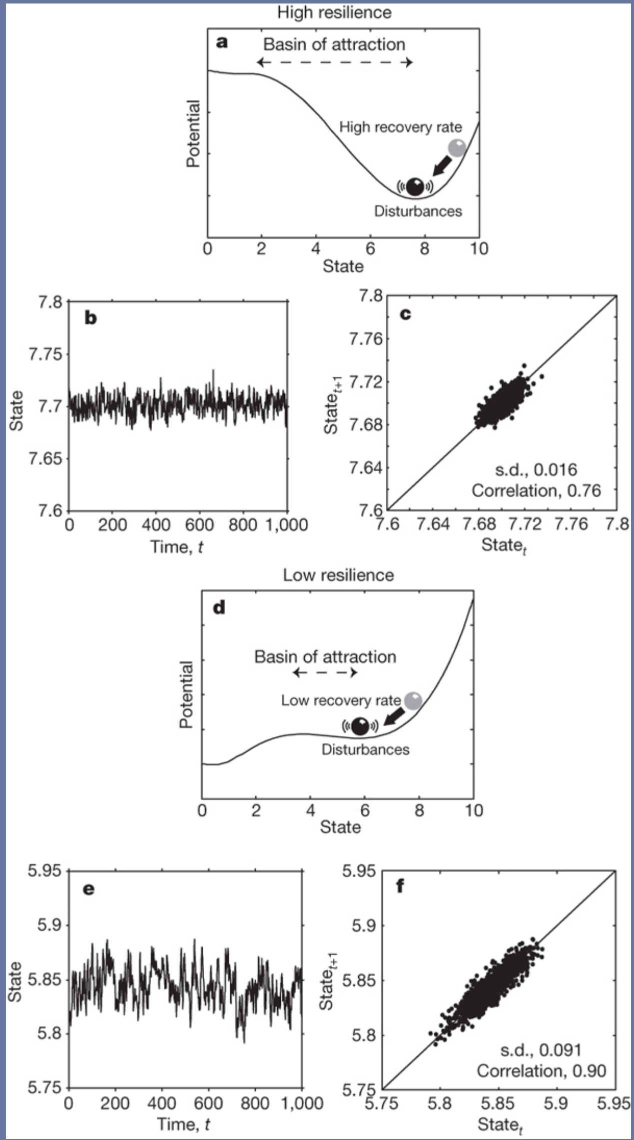
Self-organized patterns: Patterns in space that emerge from the interaction between many units.

Transition: *Discontinuous (first-order): Abrupt change in the qualitative behaviour of a system. Continuous (second-order): Smooth change in the qualitative behaviour of a system. Noise-induced: Change in the qualitative behaviour of a system in the presence of high noise intensity.*

Threshold: A point where the system is very sensitive to changing conditions.

Tipping point: A point where the system may flip to another state.

Systems

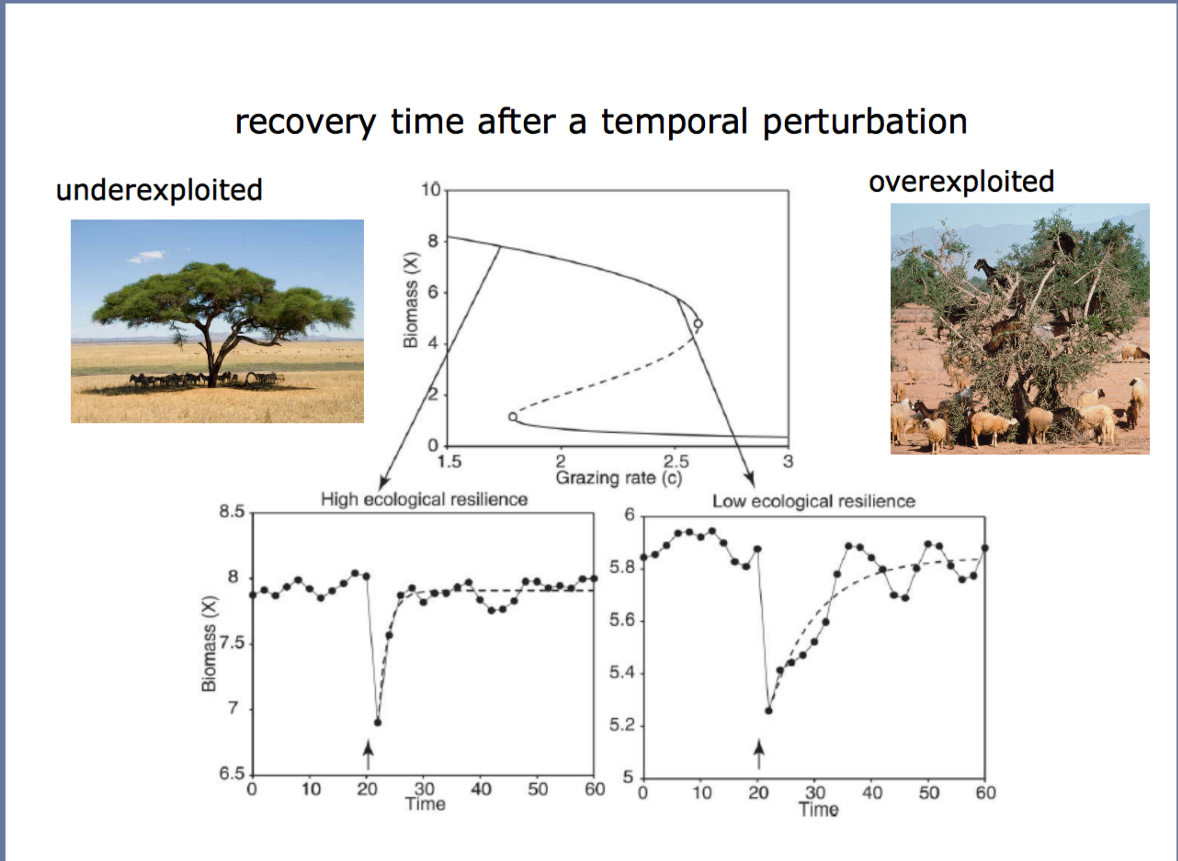


Some characteristic changes in non-equilibrium dynamics as a system approaches a catastrophic bifurcation (such as F_1 or F_2, Box 1).

er *et al. Nature* **461**, 53-59 (2009) doi:10.1038/nature08227

nature

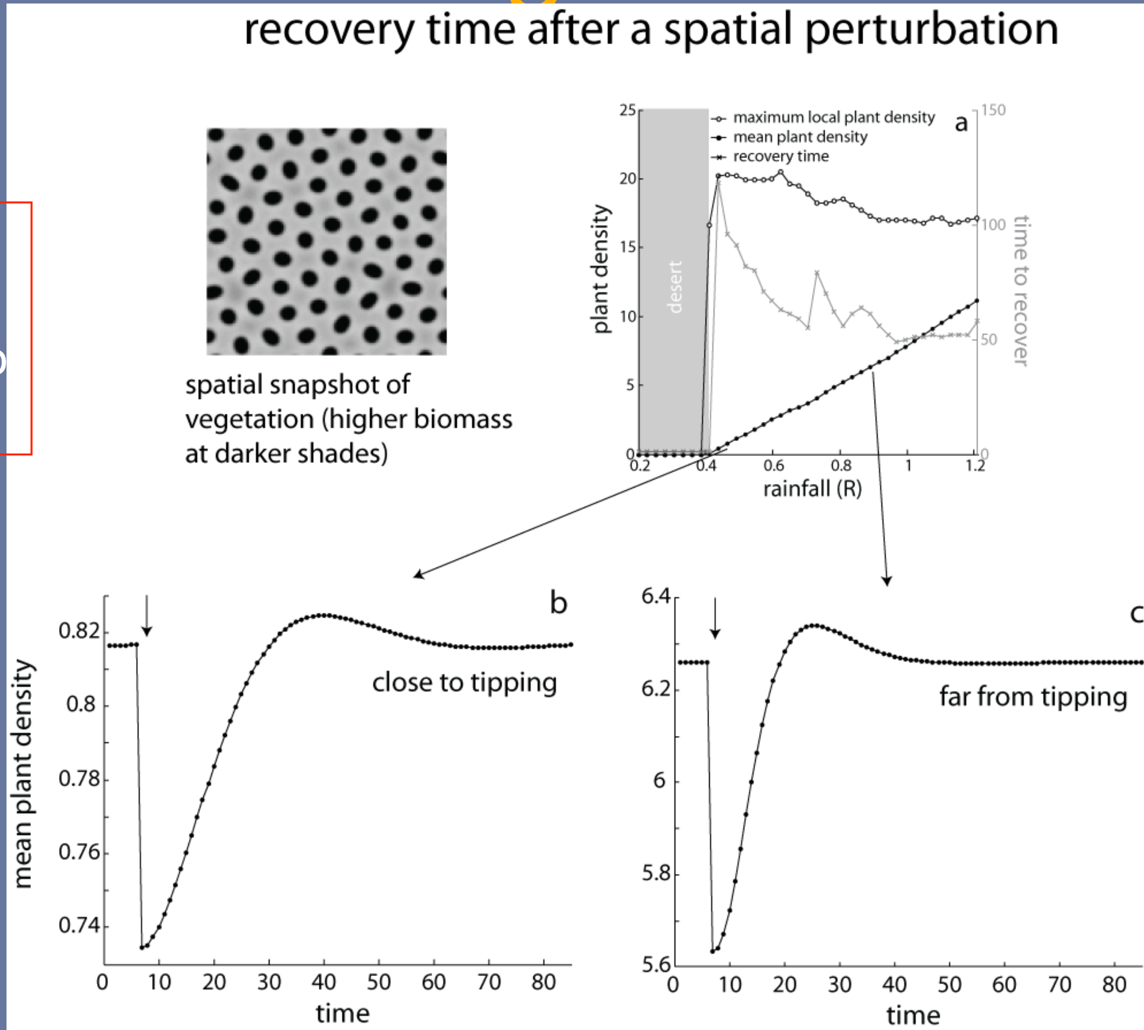
Resilience as recovering



http://www.early-warning-signals.org/?page_id=286

Recovering

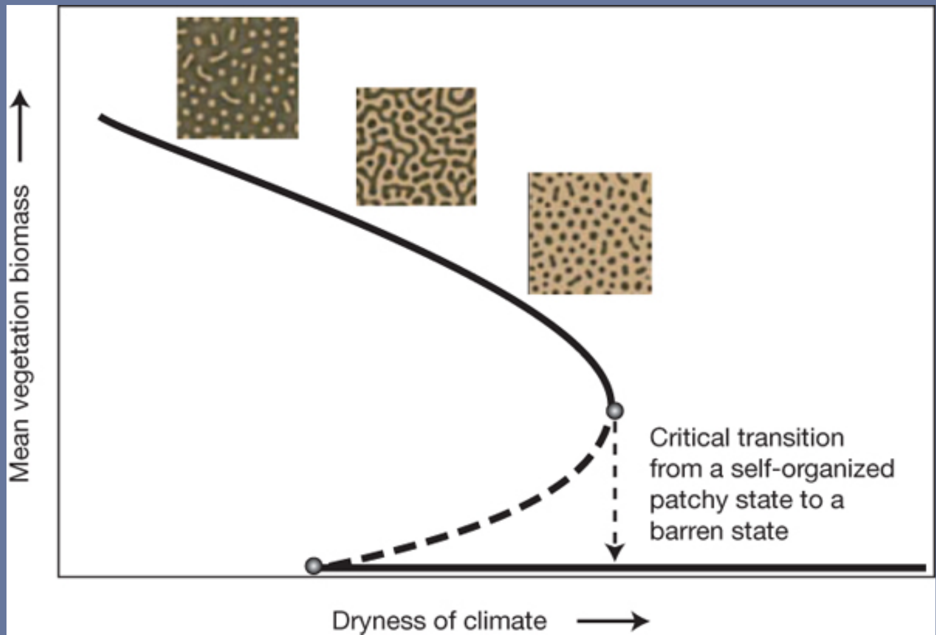
Tipping point:
A point where the system may flip to another state



lis Dakos, Sonia Kéfi, Max Rietkerk, Egbert H. van Nes, and Marten Scheffer, 2011.
ving Down in Spatially Patterned Ecosystems at the Brink of Collapse. *The American Naturalist , Vol. 177, No. 6 (June 2011), E153-E166*

Systems

Ecosystems may undergo a predictable sequence of self-organized spatial patterns as they approach a critical transition.



nature

M Scheffer *et al.* *Nature* **461**, 53-59 (2009) doi:10.1038/nature08227

Landscape: total human ecosystem

Landscape as the total Human Ecosystem

Ecosystems are dynamic, also when in “equilibrium” they are far from the static one.

Ecosystems are self-organizing autopoietic ones.

(Naveh, 2005)

The open space system can give the observer a sense of the more permanent system of which he and the city are only parts. ..... To a sense of the Web of life, …interdependent system of living things, …(Lynch 1972)

Energy, cycles in an ecosystems

All ecosystems have a flux of energy and a few basic underlying cycles. They are continuously and discontinuously subject to flux of matter and energy to and from other systems and to chemical reactions and and are the processes produce entropy.

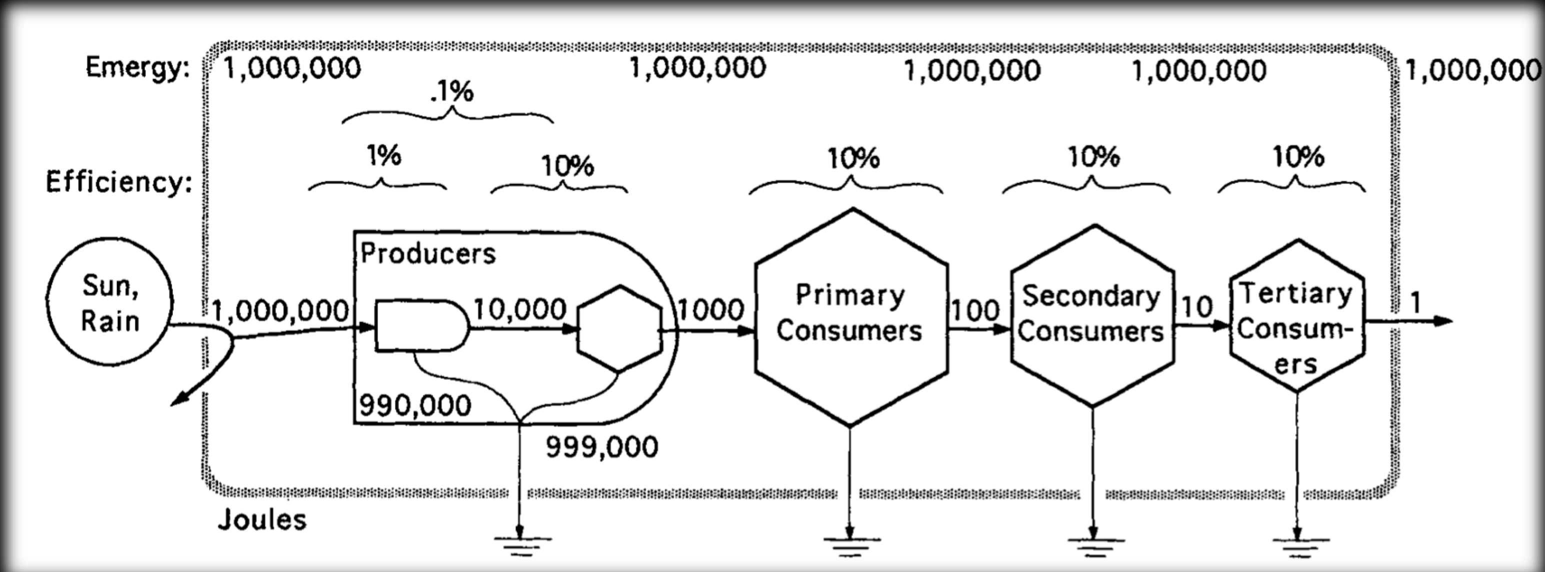
Cycle normally brings to mind physical, chemical, biological, etc. processes that return a system to a previous state: the nitrogen cycle, the rotation/revolution of the earth, crop rotation, the circadian wake/ sleep cycle, the Krebs cycle, $O_2 \rightarrow CO_2 \rightarrow O_2$, …

from: Abbott, 2011. Energy and complex systems

agriculture practices for resilience

Energy Chain

The food chain can be thought of as an energy transformation chain. At each transformation step some energy is degraded and some is passed to the next step in the chain.

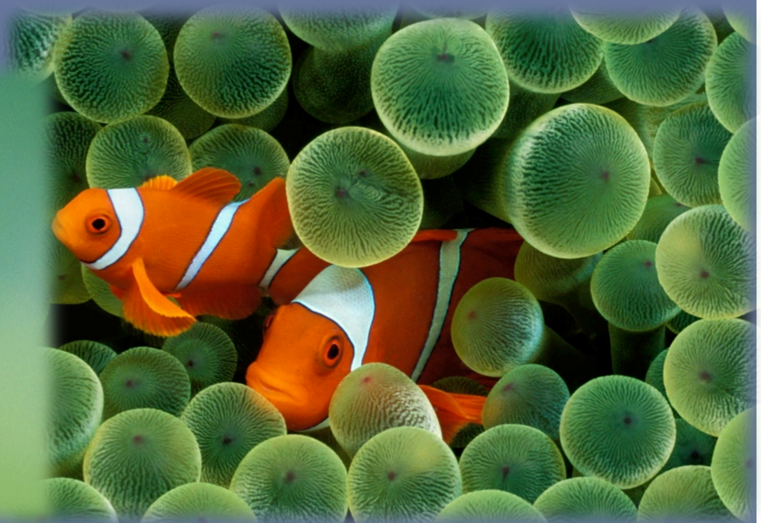


from: Brown, M., 2013. Emergy Course

agriculture practices for resilience

Ecosystem Services – Values of services and Natural Prices

The values we assign to ecosystem assets — goods and services like pollination or water filtration — are an important factor in how we treat ecosystems. Placing a value on an ecosystem's beauty or its cultural importance is far more difficult than valuing the direct goods provided by an ecosystem, like the value of fish as a food source.



agriculture practices for resilience

Ecosystem Services – Values of services and Natural Prices

The global technical mitigation potential of all strategies in the agricultural sector is 5,500–6,000 megatons of carbon dioxide equivalent per year (Mt CO_2-eq/yr) by 2030. Of this estimate, carbon sequestration accounts for nearly 90% of the potential, and CH_4 mitigation and soil N_2O emission reductions account for 9% and 2%, respectively.

Europe could potentially reduce emissions by 90-100 Mt CO_2-eq/yr at a carbon price of US$20 per ton of CO_2-eq, which represents approximately 8-9% of the total global economic potential (including soil carbon sequestration).

Emergy Evaluation of Environment…

One kilometer square of earth's surface:

emergy of agricolture 60-90E15 seJ

Table 10. Emergy evaluation of renewable inputs to 1 kilometer of the Earth's surface

Note	Item	Raw Units		Transformity (seJ/unit)	Solar Emergy (E15 seJ)
RENEWABLE RESOURCES:					
1	Sunlight	7.09E+15	J	1	7.1
2	Wind, kinetic energy	1.51E+12	J	1578	2.4
3	Rain, chemical potential	2.78E+12	J	6360	17.7
4	Runoff, geopotential	6.73E+10	J	10909	0.7
5	Earth Cycle, heat flow	9.52E+10	J	20300	1.9
6	Runoff, chemical potential	1.13E+12	J	18000	20.3
7	Waves, kinetic energy	5.34E+10	J	22167	1.2
8	Tide, kinetic energy	3.67E+10	J	72400	2.7

from: Brown, M., 2013. Emergy Course

Ecosystem Services – Carbon sequestration

There is significant potential for small farmers to sequester soil carbon if appropriate policy reforms are implemented. If the high transaction costs for small-scale projects can be eliminated, carbon markets could be a significant source of financing. Successful implementation of soil carbon trading would generate important co-benefits for soil fertility and long-term agricultural productivity.

20 – 80 C02 tonn per ha per yr

Ecosystem Services – Biofuels

biofuel production has the potential to offer carbon savings compared with the use of conventional fossil fuels. The potential of biofuels to reduce carbon emissions, however, is highly dependent on the nature of the production process. The current generation of crop- based biofuels has had a low or even negative effect on carbon mitigation when land use change for biofuel production is taken into account. Ensuring that biofuel production does not create negative tradeoffs with food and land markets, land use change, biodiversity, and environmental degradation, will require careful policy design, as well as subsequent monitoring.

EROI close to 1

Typical Emergy Evaluation Table: Bioethanol

Table 5
Emergy analysis of ethanol production from sugarbeet in Italy (1984 nationwide average values per hectare per year).

#	Item	Unit	Units/ha/yr	Solar transformity (sej/unit)	Ref. for Transf.	Solar emergy (E14 sej/ha/yr)
(numbers of each item refer to footnotes in the Appendix)						
ENVIRONMENTAL INPUTS						
1	Sunlight	J	4.41E+13	1.00E+00	[2]	0.44
2	Rain chemical potential	J	4.45E+10	1.82E+04	[2]	8.09
3	Wind	J	8.82E+10	1.50E+03	[2]	1.32
4	Earth cycle	J	3.00E+10	3.44E+04	[2]	10.32
AGRICULTURAL PRODUCTION PHASE						
5a	Loss topsoil, resid. in field	J	1.36E+10	7.38E+04	[1]	10.01
5b	Loss topsoil, resid.harvested	J	2.71E+10	7.38E+04	[1]	20.02
Inputs assuming that residues are left in field						
6	Nitrogen fertilizer (N)	g	1.36E+05	3.80E+09	[2]	5.17
7	Phosphate fertilizer (P2O5)	g	1.87E+05	3.90E+09	[2]	7.29
8	Potash (K2O)	g	7.28E+04	1.10E+09	[2]	0.80
9	Insecticides & pesticides	g	4.07E+04	1.48E+10	[1]	6.02
10	Herbicides	g	1.52E+04	1.48E+10	[1]	2.25
11	Diesel	J	1.33E+10	6.60E+04	[1]	8.75
12	Lubricants	J	2.53E+08	6.60E+04	[1]	0.17
13	Gasoline	J	4.42E+08	6.60E+04	[1]	0.29
14	Human labor	J	1.26E+08	7.38E+06	[3]	9.27
15	Agric. machinery	g	8.37E+04	6.70E+09	[1]	5.61
16	Electricity	J	5.86E+08	2.00E+05	[1]	1.17
17	Seeds	J	5.58E+07	8.94E+04	[3]	0.05
18a	Surface water for irrigation	J	6.17E+09	4.10E+04	[1]	2.53
18b	Fuel for irrigation (#)	J		6.60E+04	[1]	
Additional inputs if 70% residues are harvested						
19	Nitrogen loss with erosion	g	4.50E+04	3.80E+09	[2]	1.71
20	Phosph. loss with erosion	g	2.25E+04	3.90E+09	[2]	0.88
21	Potash loss with erosion	g	1.50E+05	1.10E+09	[2]	1.65
22a	Additional water demand	J	2.47E+09	4.10E+04	[1]	1.01
22b	Fuel for additional water demand	J	2.39E+09	6.60E+04	[1]	1.57
23	Nitrogen harv. in residues	g	3.50E+04	3.80E+09	[2]	1.33
24	Phosphorus harv. in resid.	g	2.10E+04	3.90E+09	[2]	0.82
25	Potash harv. in residues.	g	1.40E+05	1.10E+09	[2]	1.54
26	Diesel for residues	J	2.23E+09	6.60E+04	[1]	1.47
27	Labor for residues	J	4.38E+06	7.38E+06	[3]	0.32
28	Machinery for residues	g	2.46E+03	6.70E+09	[1]	0.16
Products of the agricultural phase						
29	Sugarbeet produced	J	1.14E+11	6.14E+04		69.70
30	Sugar available in sugarbeet	J	1.05E+11	6.66E+04		69.70
31	Residues in field as such (°)	J	4.67E+10	1.49E+05		69.70
32	70% harvested agric. resid. (°)	J	n.a.	n.a.		92.19
INDUSTRIAL PRODUCTION PHASE						
33	Plant machinery	g	7.24E+03	6.70E+09	[1]	0.48
34	Diesel for transport	J	1.77E+09	6.60E+04	[1]	1.17
35	Diesel for process heat	J	3.72E+10	6.60E+04	[1]	24.58
36	Electricity	J	1.87E+10	2.00E+05	[1]	37.49
Product of industrial phase						
37a	Ethanol, without residues	J	9.42E+10	1.42E+05		133.42
37b	Ethanol, with residues use	J	9.42E+10	1.65E+05		155.91

from: Brown, M., 2013. Emergy Course

how to use ecosystem approach and information in design agroecological systems?

Closing cycles of humankind

Increasing feedbacks and biodiversity

Economic sustainability within ecosystem approach

Responses

Compensating Greenhouse gases fluxes

shift far from thresholds or tipping points

Recovering ecosystems

work on self organizing patterns

Change local condition

increase resilience

Responses in agriculture

Increasing absorption and stocks in soils and biomass

Change microclimate

Shift from non renewable into renewable primary matters

Increasing biodiversity and landscape diversity

Improving voluntary markets

Responses in agriculture: olive

For olive tree the total woody biomass, the dry weight of the aboveground biomass without the leaves but with the values for the pruning is 65.08 t dry matter. The respective amount of C, using the measured CF is 0.04803 tons (0.04803 tons × 330 trees per hectare = 15.85 t which is equivalent to 58.70 tons of CO_2 sequestered per hectare per year).

Ilarioni, L., L. Nasini, A. Brunori and P. Proietti, 2013. Experimental measurement of the biomass of Olea europaea L., African Journal of Biotechnology Vol. 12(11), pp. 1216-1222.

50 tons of of CO_2 sequestered per hectare per year at carbon price of US$20 per ton of CO_2-eq, gives a flux of more than 100 US$ per Ha per yr

Responses in agriculture: assessment

(Med type Landscape olive + vineyard + orchards)

	traditional	industrial	organic	
Landscape	1.8	1.2	1.9	(BTC) J ha^{-1} yr^{-1}
Ec.footprint	0.9	1.1	0.3	gha yr^{-1}
Biodiversity	0.9	0.2	0.9	
Emergy	3	90	20	10E15 seJ ha^{-1} yr^{-1}
Abs CO_2	50	30	60	ton ha^{-1} yr^{-1}
Emission CO_2	10	30	20	ton ha^{-1} yr^{-1}

Responses in agriculture: assessment

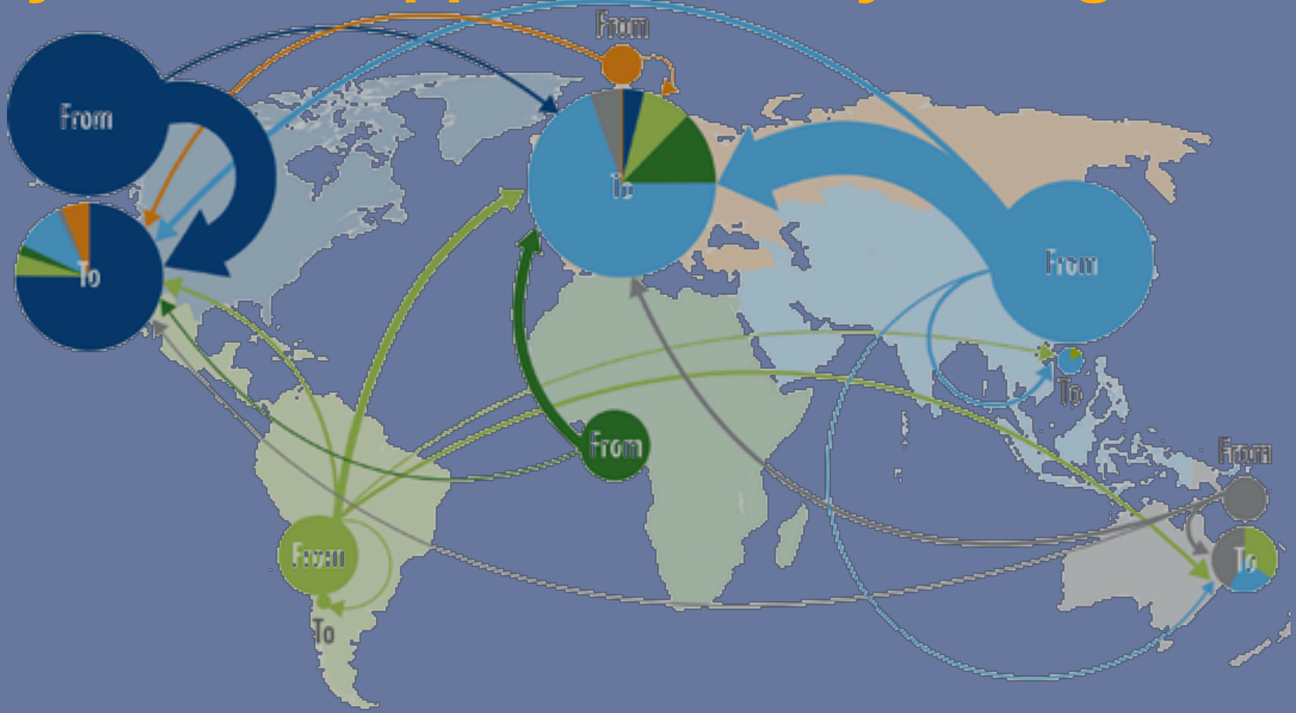
(Med type Landscape olive + vineyard + orchards)

	traditional	industrial	organic
Resilience	1	0.6	1.1
Adaptation	1	0.2	1

Application in agroecosystem planning, management & recovery

Flow of Transacted Volumes

by Offset Supplier and Buyer Region, OTC 2012



From ↓ To →	North America	Latin America	Asia	Oceania	Europe
North America	10.3 M	-	-	-	1.2 M
Latin America	1.1 M	0.2 M	0.3 M	1.5 M	2.0 M
Africa	0.7 M	-	-	0.03 M*	3.9 M
Asia	2.5 M	-	1.9 M	1 M	21.5 M
Oceania	0.3 M	-	-	1.8 M	1.7 M
Europe	1.5 M	-	-	-	0.4 M

*Values smaller than 0.1 Million (M) are not shown on map

http://www.forest-trends.org/images/misc/sovcm2013/map_graph.png

Questions?

Comments?

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