



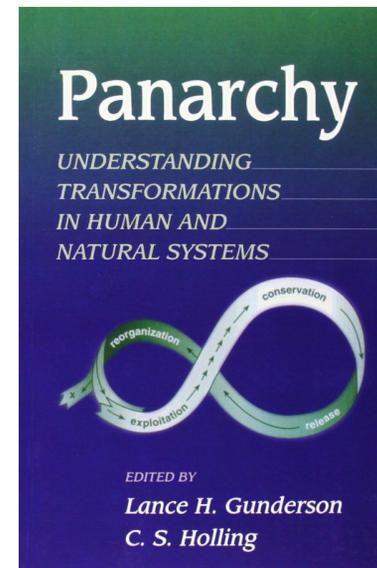
# Ecosystems, collapse & resilience

Karoliina Hovi | Jutta Menestrina | Ekaterina Perfilyeva | Yuchen Yao  
9.2.2016

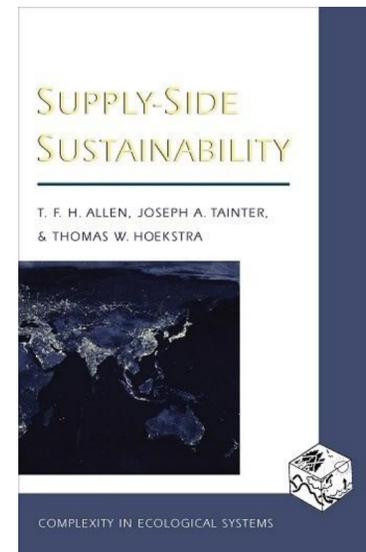


How can we appreciate  
**resilience,**  
as an alternative to the  
possibility of  
**a system collapse?**

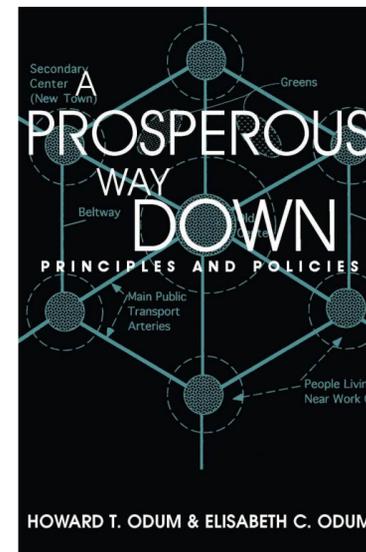




Holling, C. S. and Gunderson, Lance H. 2001



Allen, Timothy F. H., Joseph A. Tainter, and Thomas W. Hoekstra. 1999/2003



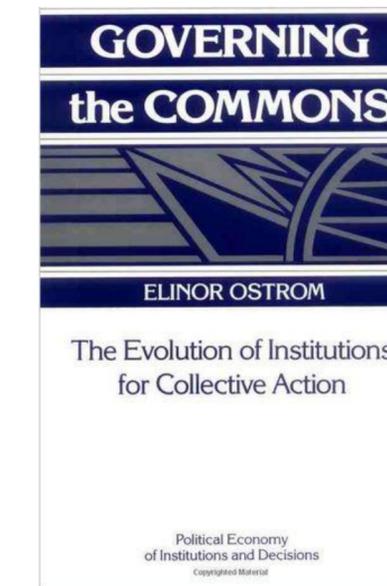
Odum, Howard T., and Elisabeth C. Odum. 2006

## Content

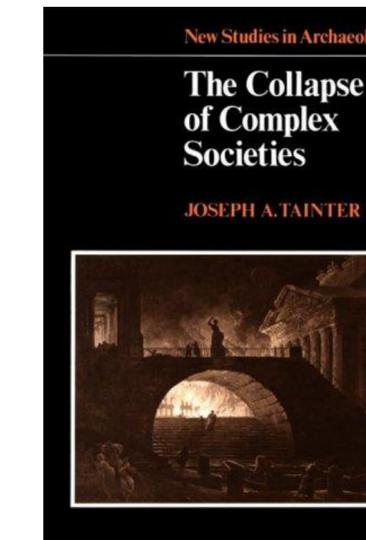
1. Ecosystems
2. Collapse
3. Complexity vs complicatedness
4. Supply side sustainability
5. Resilience

## Bibliography & Systems Thinkers

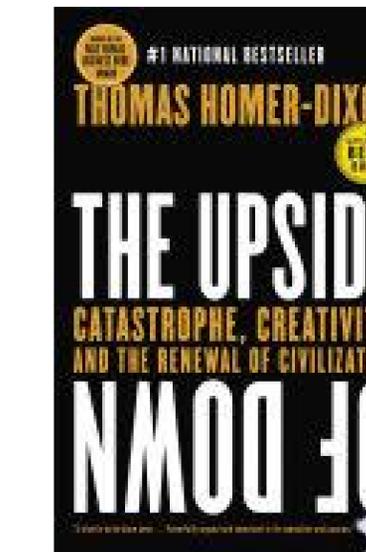
1. Joseph Tainter
2. Holling
3. Allen, Tainter & Hoekstra
4. Ostrom
5. Odum
6. Resilience
7. Socio-ecological systems



Ostrom, Elinor



Tainter, Joseph A. 1990



# ECOSYSTEMS



## ECO (Greek: οἶκος) = HOUSE

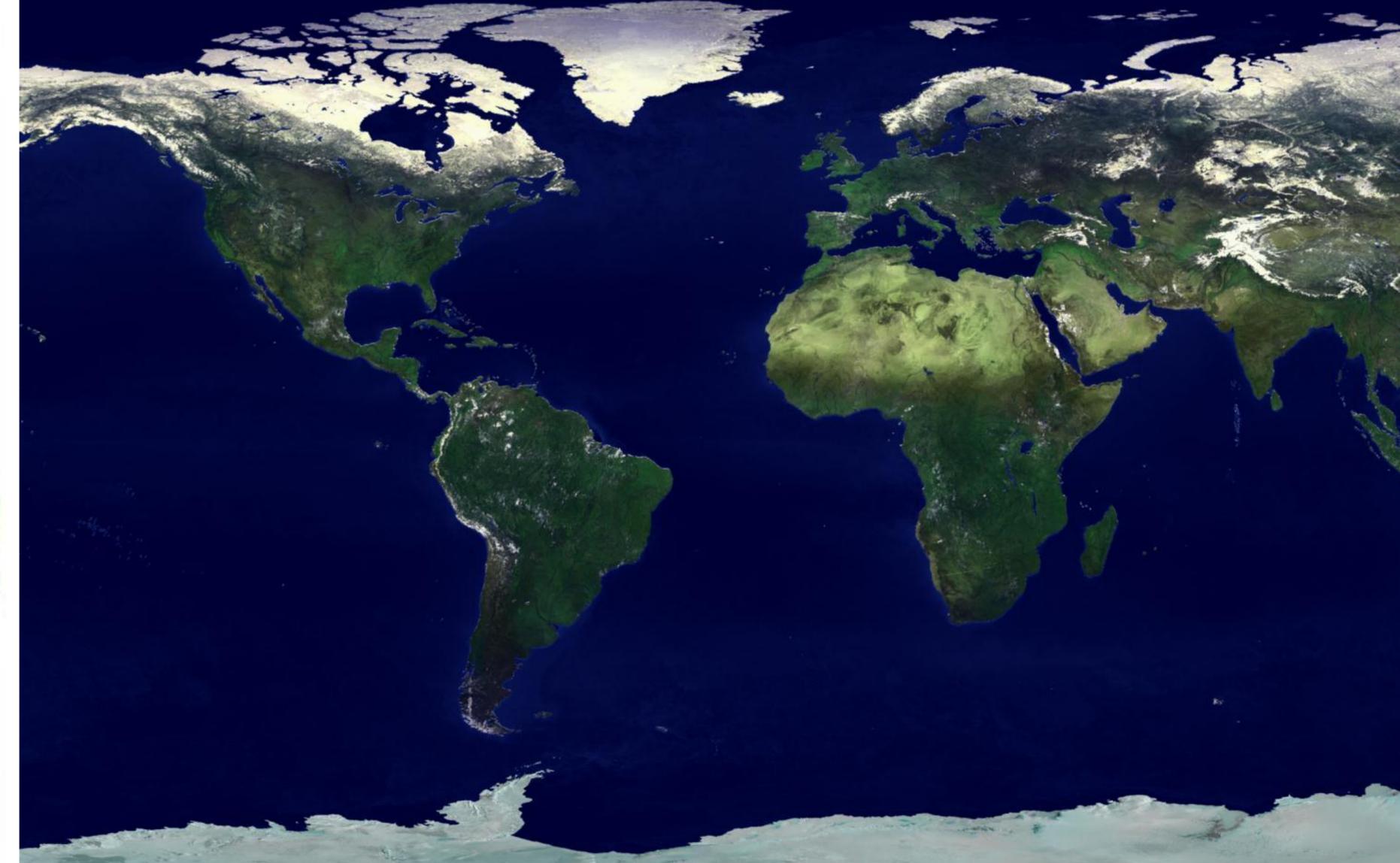
### ECOLOGY

(from Greek: οἶκος, "house"; -λογία, "study of")

### ECONOMY

(Greek οἶκος-household and νέμωμαι - manage)

Both eternally linked within their respective systems



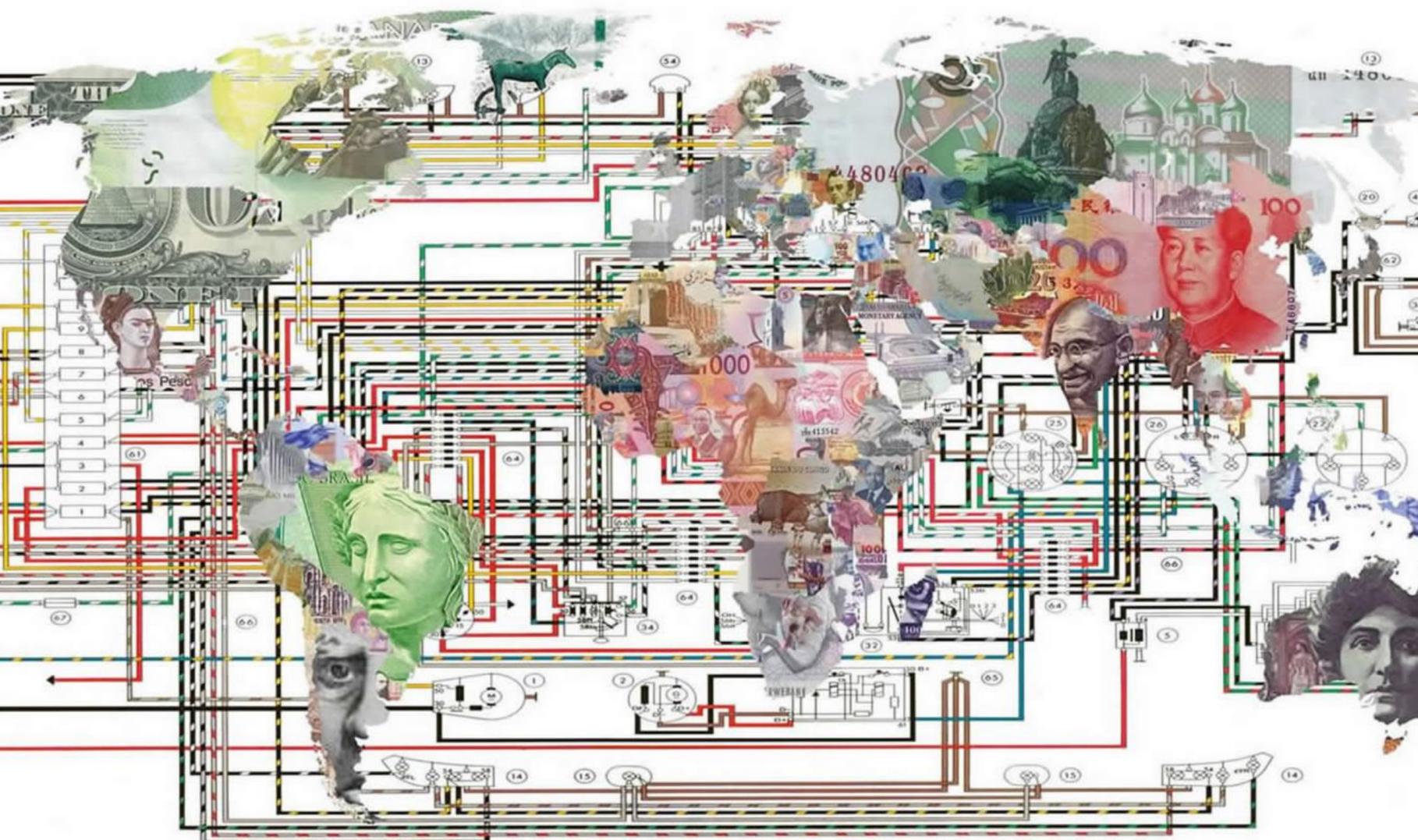


## Ecosystems

- "An ecosystem is a community of living organisms in conjunction with the nonliving components of their environment (things like air, water and mineral soil), interacting as a system."
- Arthur Tansley: 'a particular category of physical systems, consisting of organisms and inorganic components in a relatively stable equilibrium, open and of various sizes and kinds' (1935)
- Complex network or interconnected systems
- With six billion people, critical problem is the use of natural resources while maintaining ecosystems functioning and renewable.

**"In ecosystem management must build and maintain ecological resilience as well as the social flexibility needed to cope, innovate, and adapt (Holling)".**





## Human ecosystems

- Humans are part of a larger system
- Society is part of a bigger global system
- Humans are not isolated from environment
- Systems in nature follow patterns
- Humanity's 3 unique features: foresight, technology & communication
- "Humanity is a virus, -> planet will save itself without humans"

"Hierarchies and adaptive cycles are the basis of ecosystems and social-ecological systems" (Holling).





## Societies

- A **society** is a group of people that interact or share the same geographical or social territory.
- Often societies are subjected to the same political authority and dominant cultural expectations.
- Societies are problem-solving systems that become more complex to solve increasingly difficult problems.
- Complexity vrs complicated
- When we speak of society we tend to disconnect the environment
- Just like societies grow and decline, resource dependent patterns characterise all living species on earth.



**COLLAPSE**

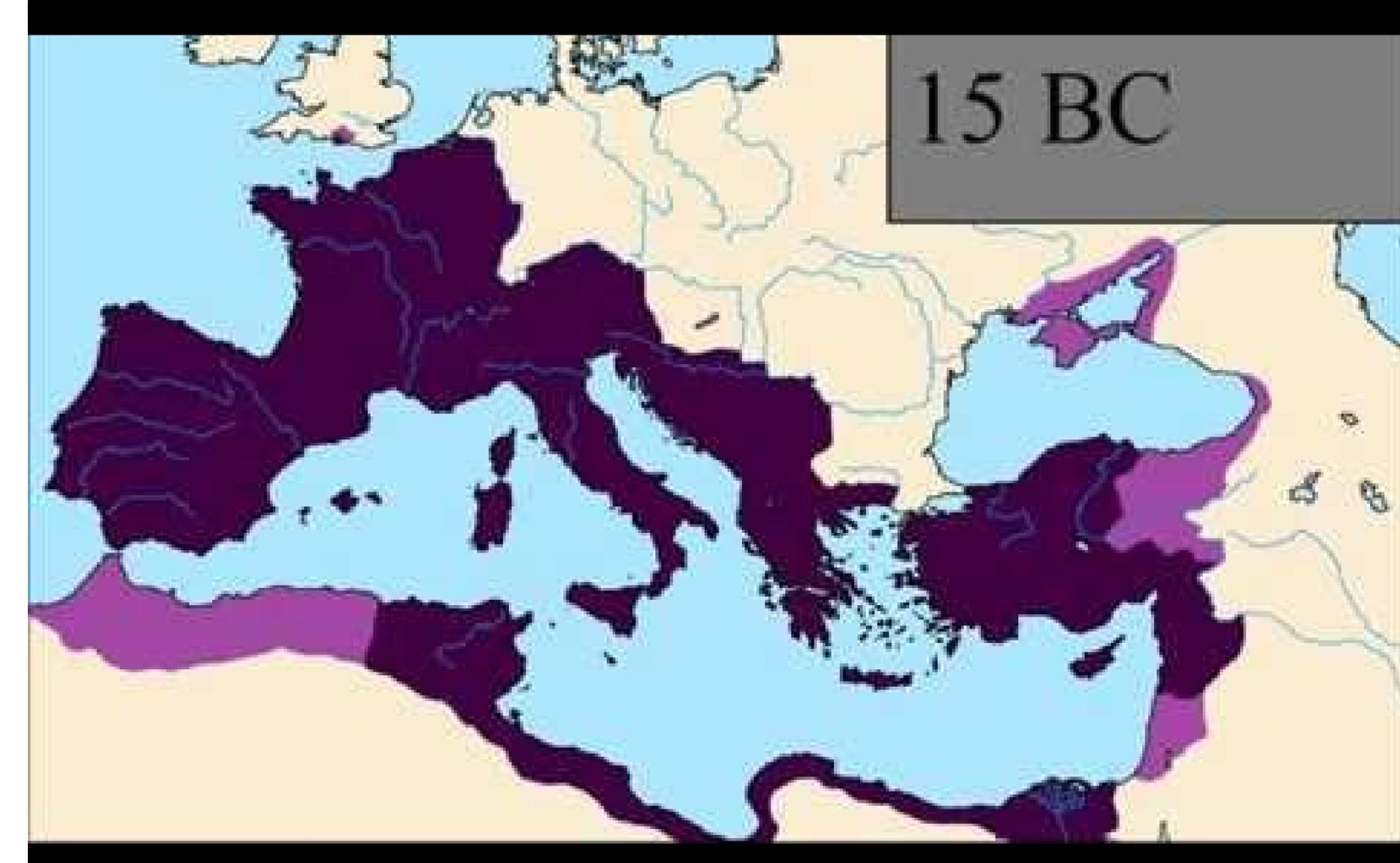


## COLLAPSE of COMPLEX societies

- Joseph Tainter: *Collapse of complex societies* 1990
- Tainter a study in the historical examples of collapse
- What are the occurrences? What can be identified?
- Established level, how long it took to get there, collapse is fast
- Complex society:

“Human history as a whole has been characterized by a seemingly inexorable trend toward higher levels of complexity, specialization, and sociopolitical control, processing of greater quantities of energy and information, formation of ever larger settlements, and development of more complex and capable technologies”

- Fall of the Roman empire a familiar example



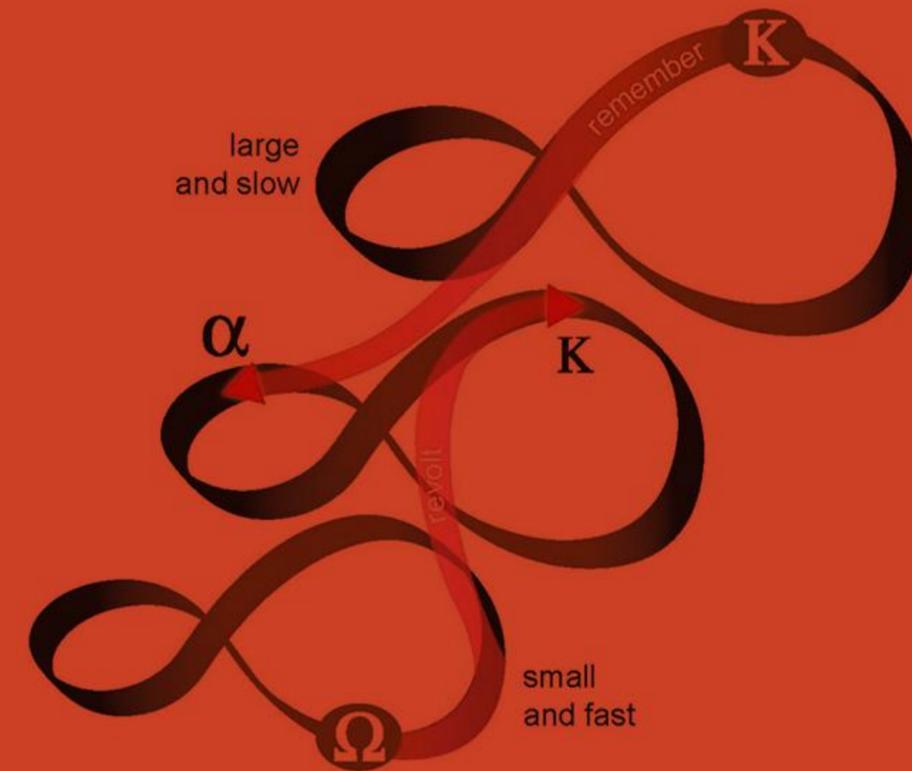


## COLLAPSE

“a situation or occurrence in which something suddenly fails”

- System
  - Ecosystem
  - Ecological
- collapse
- Abrupt events
  - External forces
  - Stochastic events
  - Misuse





## Collapse Panarchy Holling, C. S. and Gunderson, Lance H. 2001

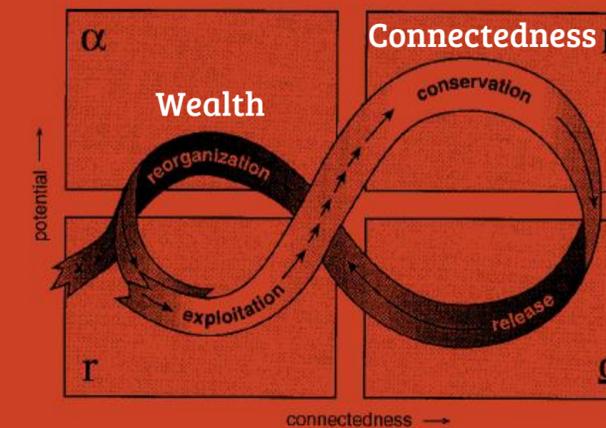
### - PANARCHY:

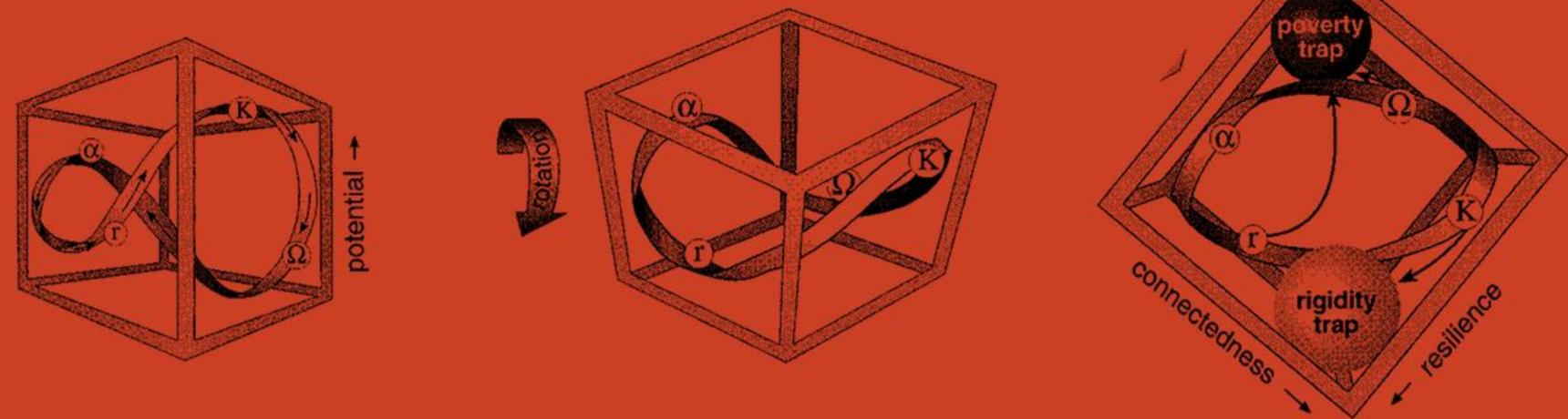
“The panarchy is a representation of the ways in which a healthy social-ecological system can invent and experiment, benefiting from inventions that create opportunity while it is kept safe from those that destabilize the system”

### - ADAPTIVE CYCLE:

#### - Three properties that shape the adaptive cycle

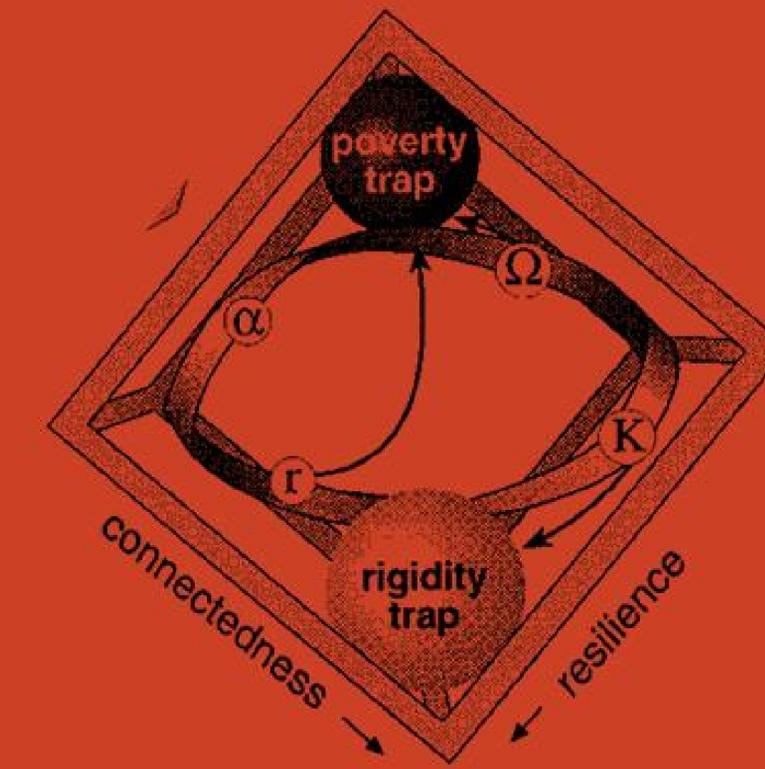
- Potential: “wealth” \_\_\_\_\_
- Controllability: connectedness \_\_\_\_\_ of a SYSTEM
- Resilience: opposite of vulnerability \_\_\_\_\_





## Collapse Adaptive cycle Holling, C. S. and Gunderson, Lance H. 2001

- **COLLAPSE:**
- **LARGE STOCHASTIC EVENTS:**
  - Can trigger spasmodic collapses
- **VULNERABILITY:**
  - Aligning vulnerabilities: cascading effect in the panarchy
- **MALADAPTIVE CYCLE:**
  - **Rigidity trap:** High connectedness + great potential + resilience high
  - **Poverty trap:** Low connectedness + low potential + low resilience



- Poverty trap:**
- loss of potential
  - loss of diversity
  - destroying cycle

- Poverty trap:**
- self-reinforcing
  - prevents flexibility
  - a seed for destruction



**COLLAPSE JENGA**

Collapse Jenga





## COLLAPSE JENGA

### 1. Historical examples of collapsed societies

1min

as many examples as possible





## COLLAPSE JENGA

2. Large uncontrollable unforeseen natural events causing collapse to society or ecology

4 examples

as soon as you have written the 4

stand up!





## COLLAPSE JENGA

3. List causes or threats of ecological collapse  
(for example overfishing)

1min

as many examples as possible





## COLLAPSE JENGA

4. List causes for collapse of society

1min

as many examples as possible





## COLLAPSE JENGA

5. Traps in adaptive cycles that may cause collapse

2 examples

as soon as you have written the 2

stand up!





## COLLAPSE JENGA

6. Proposed alternative for a system collapse

1 answer

as soon as you have written the answer

stand up!





**COLLAPSE JENGA:**

**congrats to the winners!**

**NOW**

**let's look into how to avoid**

**COLLAPSE**

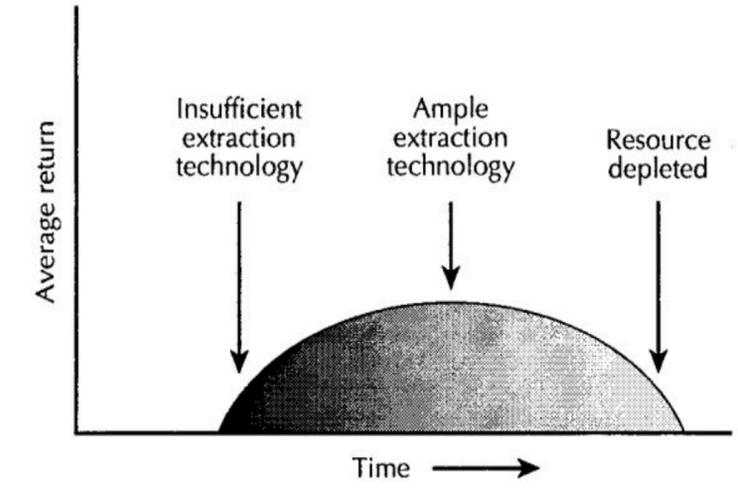


**COMPLEXITY  
VS  
COMPLICATEDNESS**



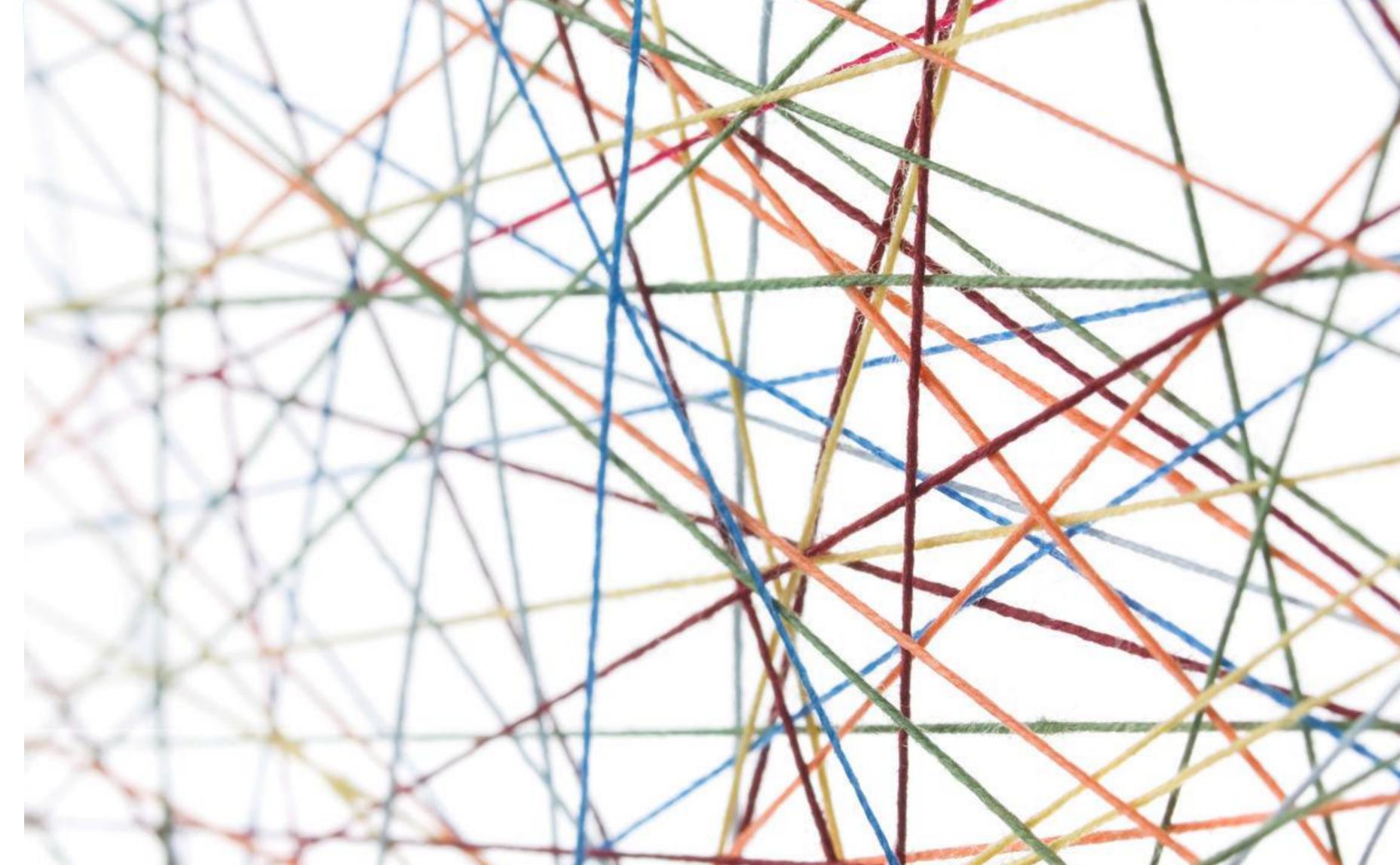
CLOUDED  
WITH IDEAS?  
LOST, WITH  
NO VISION?

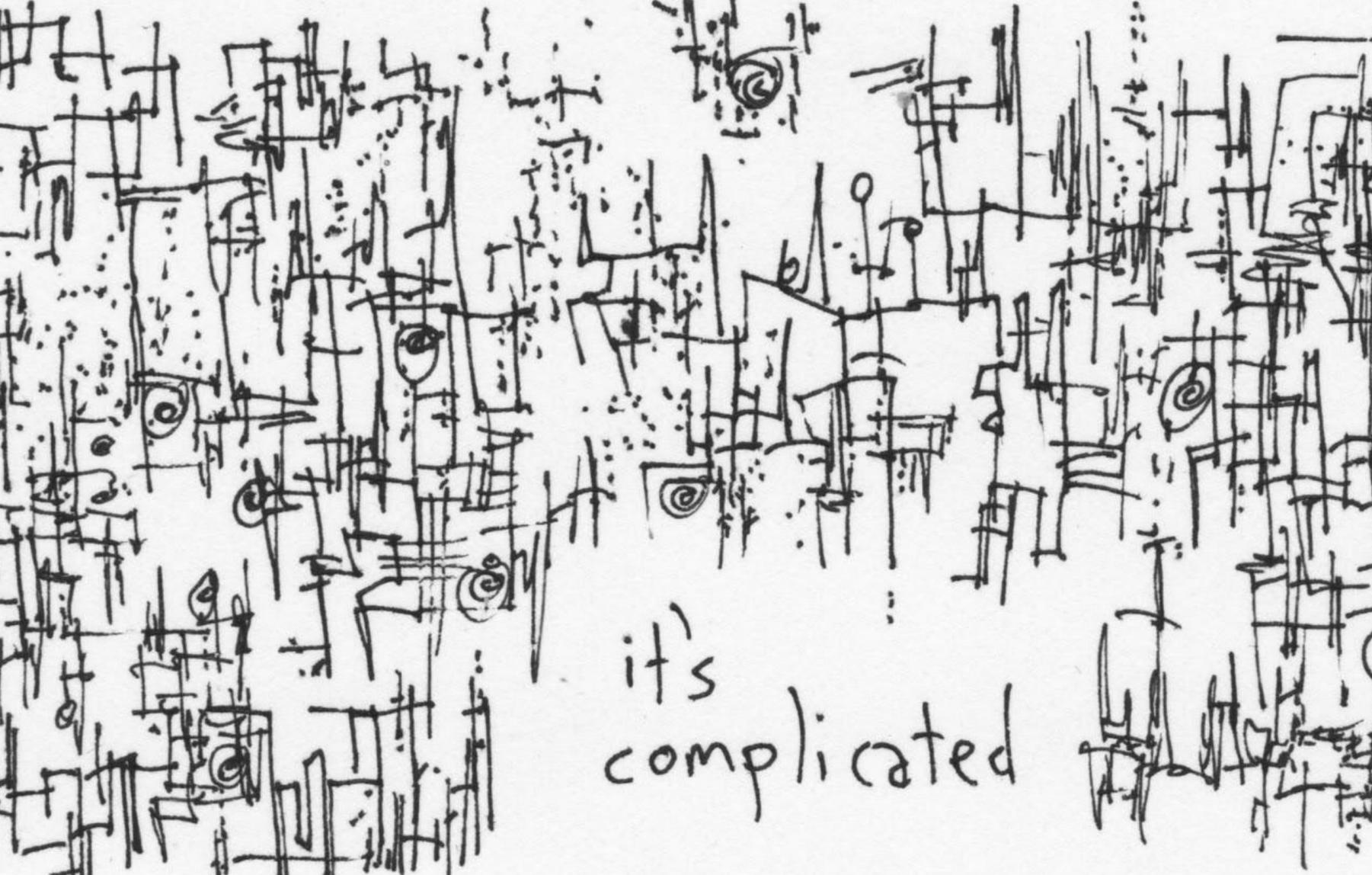
## Diminishing returns on problem solving (Allen, Tainter, Hoekstra, 1999)



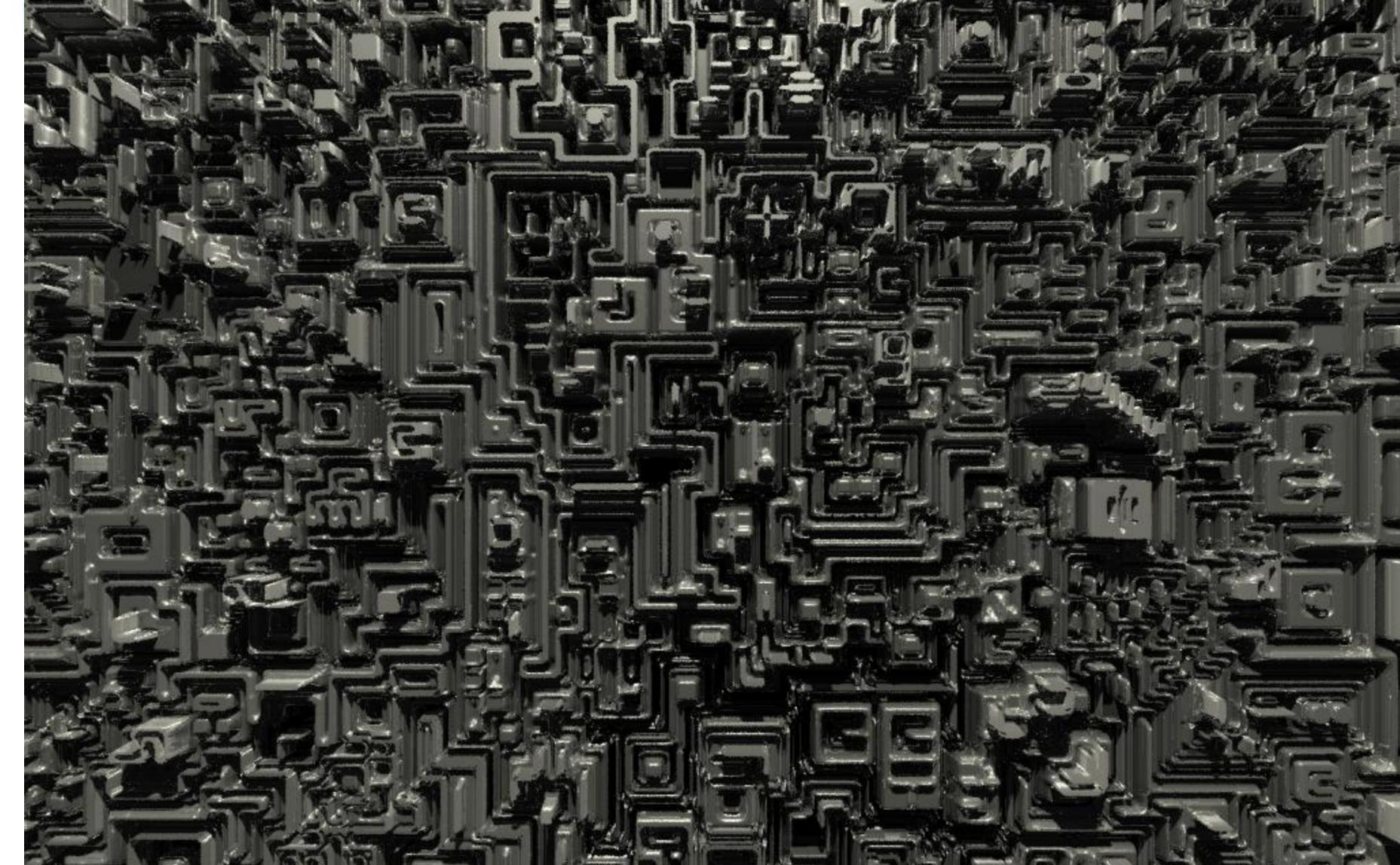
Tainter (1988) - the root of collapses of many complex societies: diminishing returns on efforts to solve problems of resource supply

**Law of diminishing returns.** (*in economics*) the fact, often stated as a law or principle, that when any factor of production, as labor, is increased while other factors, as capital and land, are held constant in amount, the output per unit of the variable factor will eventually diminish



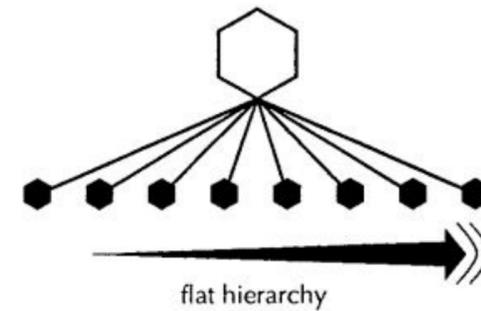


<b>Structure</b>	<b>Organisation</b>
cost of maintaining an ever more elaborate infrastructure continuously increases as successfully harder problems are solved	expenditure of resources, more highly organised societies cost a lot more to run
increase in <b>complicatedness</b>	increase in <b>complexity</b>
complication	complexification
<b>complicated system</b>	<b>complex system</b>
to complicate	to complexify
benefits are first great but then suffer from diminishing returns	benefits are contextual to both the costs and benefits of structural elaboration



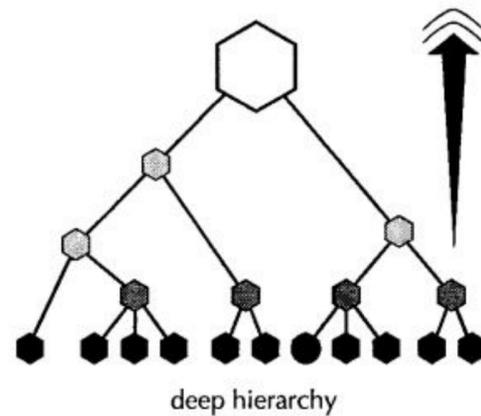
### Horizontal Differentiation

**Elaboration of structure** solves problems and moves on to the next problem, leaving structure behind. Evolution makes COMPLICATED structure that is difficult to control, predict, or mend. It causes horizontal differentiation.



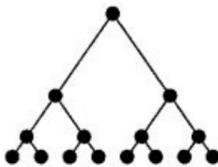
### Vertical Differentiation

**Elaboration of organization** creates energy dissipative far from equilibrium structures. It causes COMPLEX structure with many levels. Behavior becomes simple but energetic cost is high. Emergence causes vertical differentiation.



### Complexity

Elaboration of organization  
Behavior gets simpler  
Hierarchy gets deeper  
• Hierarchical complexity  
• Spectral complexity  
• Elaboration across scales  
• Increased certainty from samples



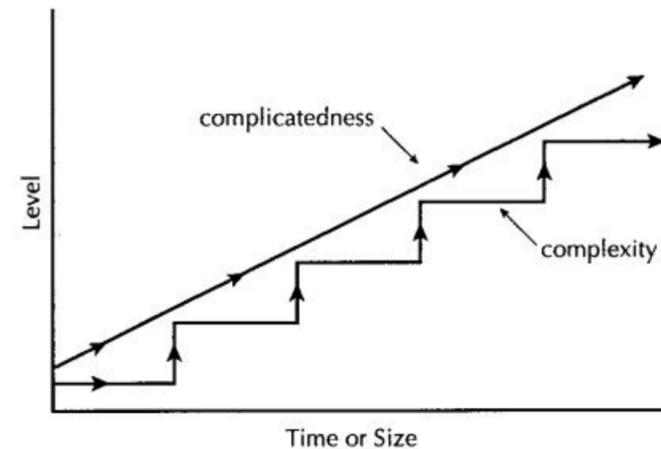
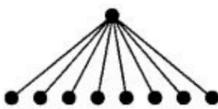
### Behavior

Becomes more elaborate  
e.g. Chaotic or Random  
• Algorithmic complexity

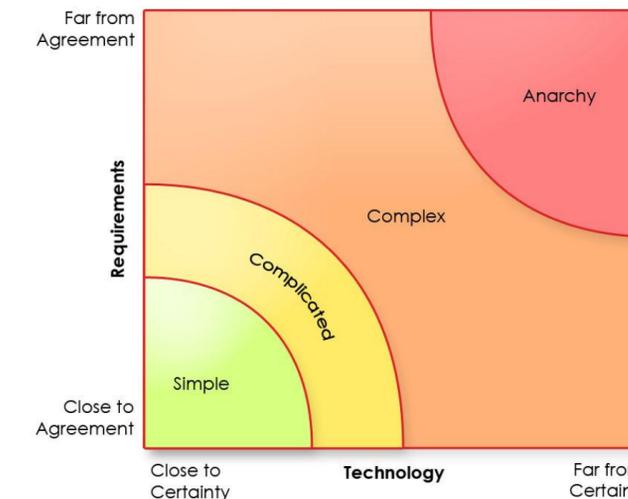


### Complicatedness

Elaboration of structure  
Behavior gets more complicated  
Hierarchy gets flatter  
More degrees of freedom  
• Diversity  
• Graph theoretic connectedness  
• Information theory–Uncertainty



### The Spectrum of Process Complexity



(R.Stacey)

# Exercise

## Complicatedness or complexity?

(in an ecological system):

increase in species diversity vs. appearance of the primary consumer species

(in a transport system):

building a highway vs. managing urban traffic congestion

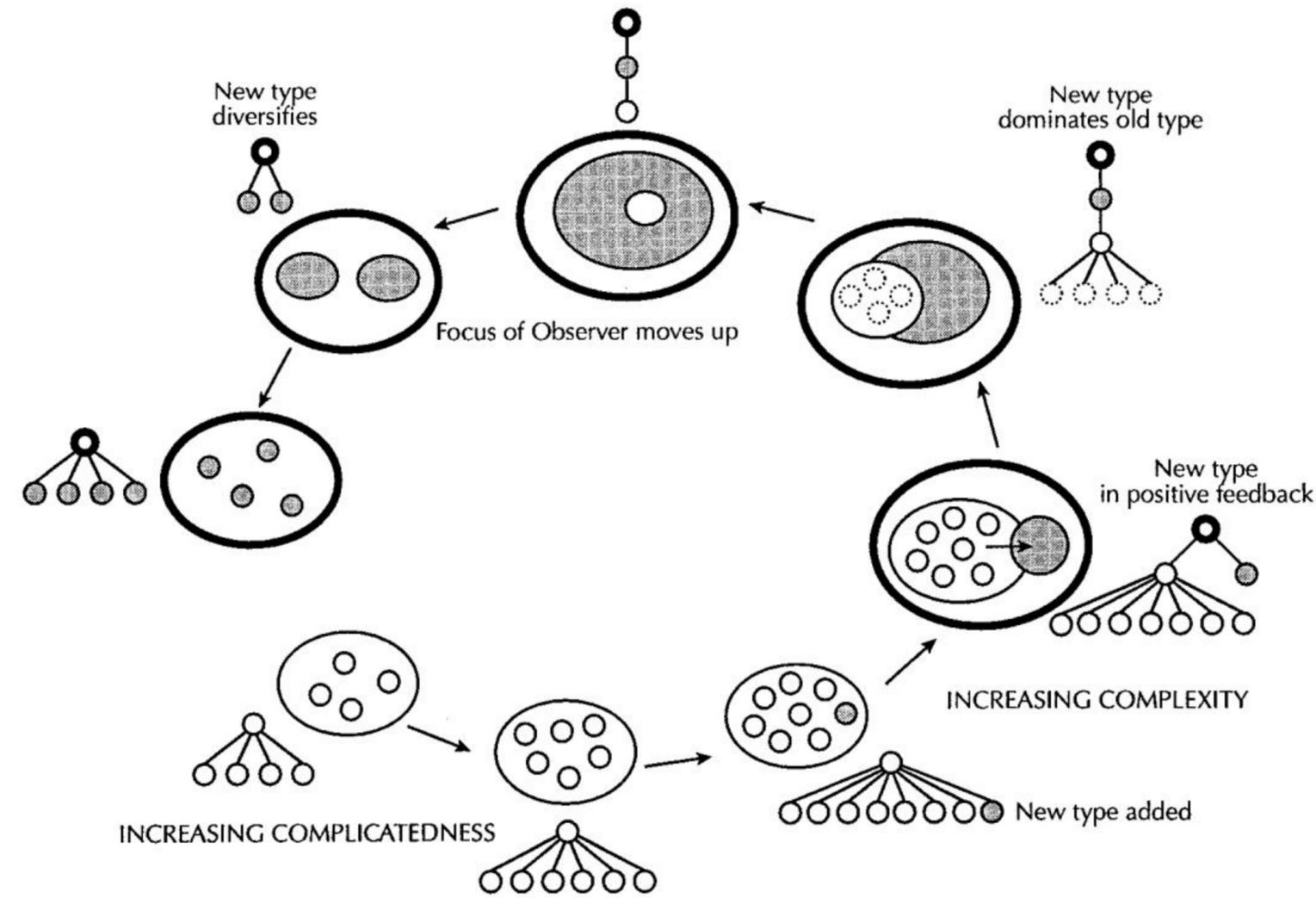
cars vs. traffic

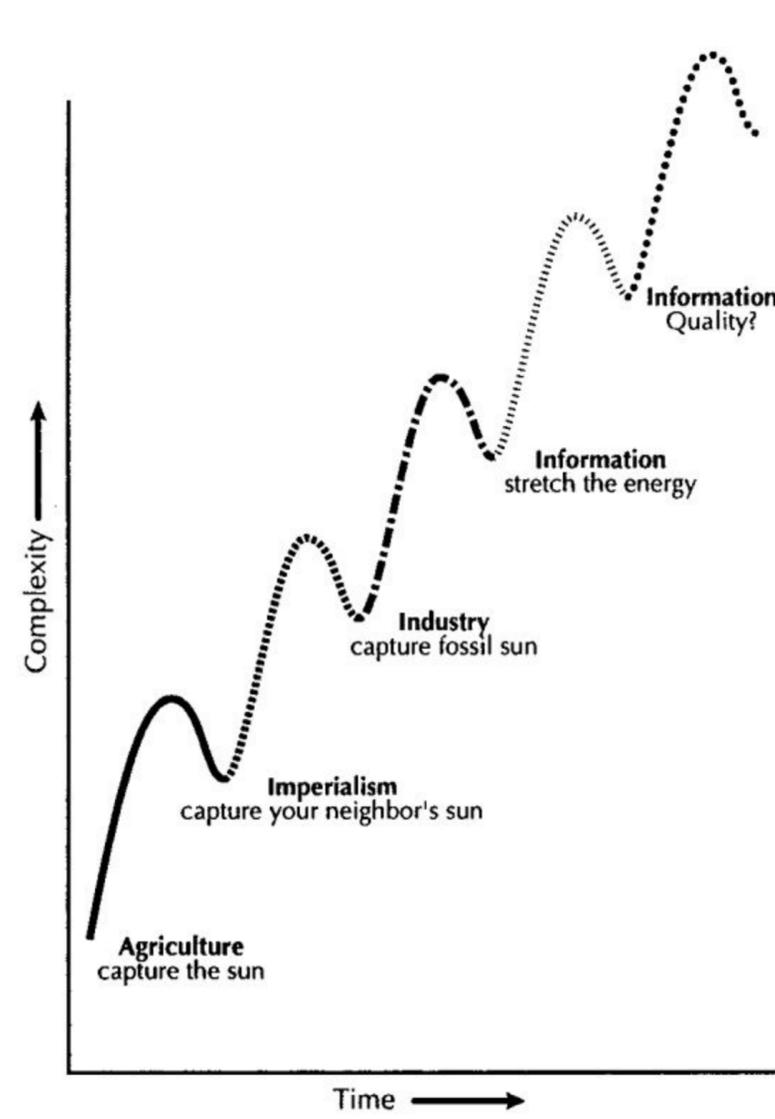
house vs. household

problem: complicated or complex?

sending a rocket to the moon vs raising a child

Can you think of your own example?





# **SUPPLY-SIDE SUSTAINABILITY**



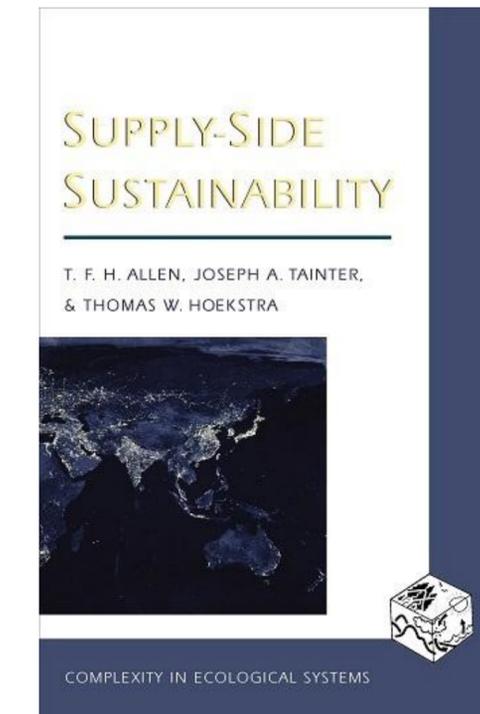
## Supply-Side Sustainability (T.Allen, J.Tainter, T. Hoekstra, 1999/2003)

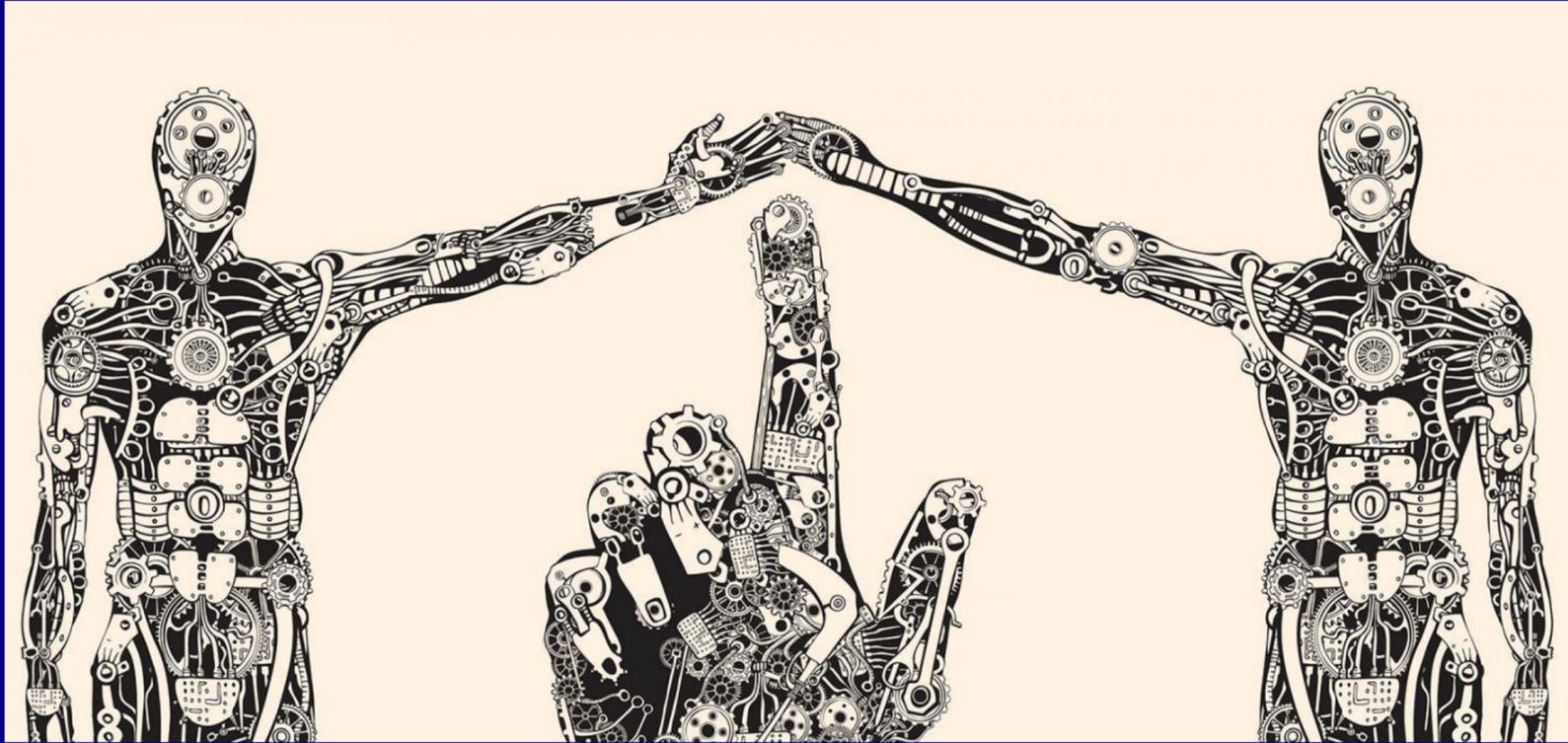
an interdisciplinary perspective - integrates ecological and social sciences

systems-based theory for biophysical and social phenomena seen as a whole

seeks a guide for redefining problem solving capabilities for sustainability instead of facing collapse

context: management / from the context of the whole ecosystem functioning, not the resources





## Supply-Side Sustainability: key idea

sustainability entails management of systems and their contexts that is intensive and knowledge-based

**if we manage from the context for whole ecosystem functions, rather than for resources the cost of problem solving will diminish, the effectiveness of management will greatly increase**

we will achieve sustainability by managing the contexts of consumption and production rather than the consumption itself

*when the manager gets the context right, the ecosystem does the rest /*

*get the context right and nature will do the rest for us*



# RESILIENCE

After the collapse:  
new states  
resilience  
recoveries





## What is resilience?

- Resilience is the long-term capacity of a system, be it an individual, a forest, a city or an economy, to deal with change and continue to develop.
- It is about how humans and nature can use shocks and disturbances like a financial crisis or climate change to spur renewal and innovative thinking.
- It is the capacity of a system to simultaneously be able to **persist** and **change**.



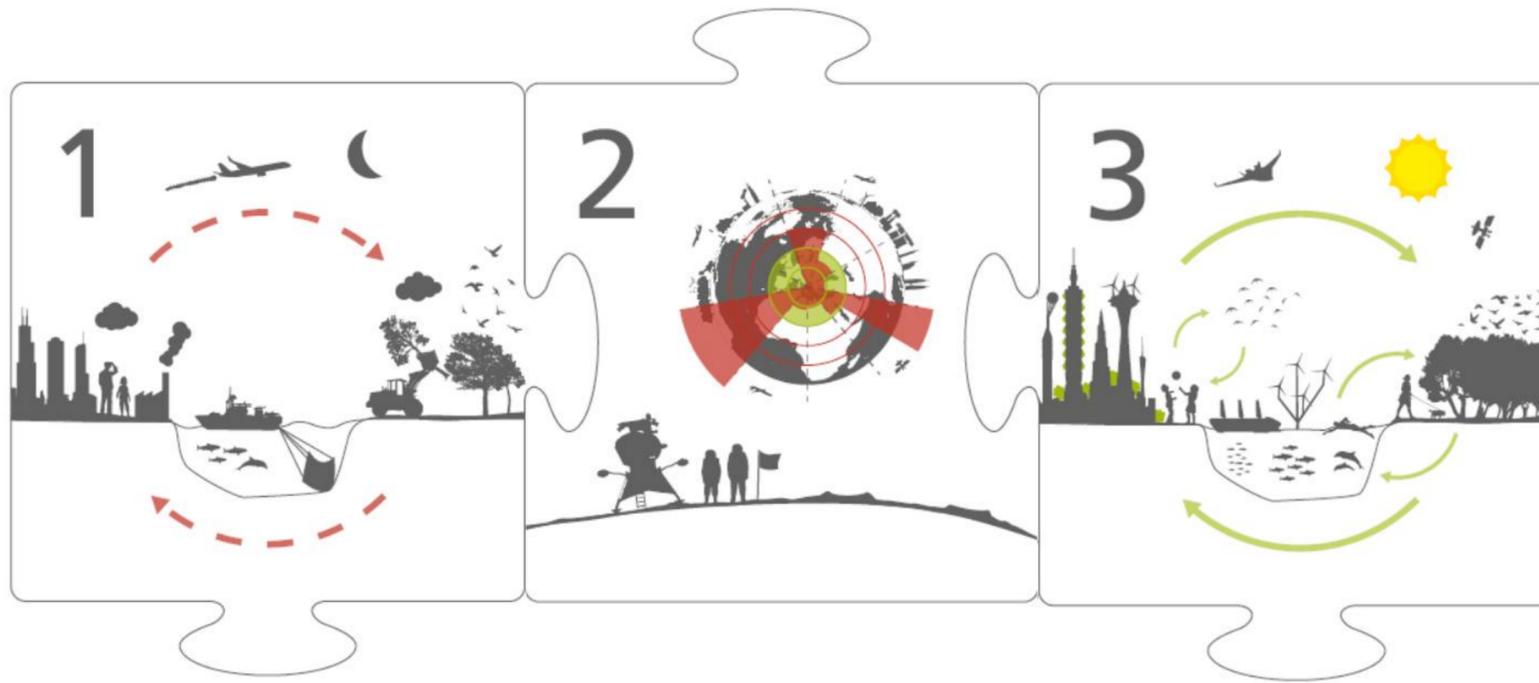


## What do resilient systems need?

- Diversity & Redundancy
- Connectivity
- Slow variables & Feedbacks
- Complex adaptive systems thinking
- Learning
- Participation
- Polycentric Governance

<https://www.youtube.com/watch?v=hIwVqdVJxpI>





## Put resilience into practice

- Reconnecting to Biosphere
- Linking people with ecosystem
- From hunter-gatherers to planetary stewards
- Social-ecological innovations for planetary opportunities
- Creating good anthropocene



## References

- T.F.Allen, Joseph A.Tainter, T.W.Hoekstra, 1999. Supply-Side Sustainability, Research Paper. In: Systems Research and Behavioural Sciences Vol.16, 403-427
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- Reinette Biggs, Maja Schlüter, Michael L. Schoon, Principles for Building Resilience: Sustaining Ecosystem Services in Social-Ecological Systems, Cambridge, 2015
- Allen, W., 2015. Complicated or Complex: Knowing the Difference is Important. Available at: <https://www.linkedin.com/pulse/complicated-complex-knowing-difference-important-will-allen>
- Kamensky, J.M. Managing the Complicated vs. The Complex. IBM Center for The Business of Government



# Discussion



# Thank you!