Systems Ecology and Sustainability

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What is sustainability?
Sustainable Development vs Sustainability

- Sustainable Development: “development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs” – *Our Common Future/ Brundtland Report*, 1987

- Sustainability: “the capacity to endure; how systems remain productive over time”
Sustainababble

The word "sustainable" is unsustainable.

Frequency of use of the word "sustainable" in US English text, as a percentage of all words, by year.

Source: Google Ngrams

2036: "Sustainable" occurs an average of once per page.

2061: "Sustainable" occurs an average of once per sentence.

2109: All sentences are just the word "sustainable" repeated over and over.

Present day

The word "sustainable" is unsustainable.
“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

clubofsiena.eco-soft.dk
Thermodynamically, Open Systems

...build and maintain order and organization by taking in high quality energy, using it, and passing degraded energy outside of the system.
Ecosystem Input Constraints

- Solar radiation
- Global carbon cycle
- Rate of nutrient cycling
- Rate of hydrological cycle

System

Input ?

Output
Ecosystem Output Constraints

- Rate of decomposition
- Rate of accumulation of unwanted byproducts
Ecosystems have evolved and developed within these input-output environmental constraints.

What patterns of organization and complexity arise in ecosystems?
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 constituents and processes

**Ontological properties**
4) An ecosystem uses surplus energy to move further away from thermodynamic equilibrium (physically driven biological aspect) – centripetality
5) Ecosystems co-evolve and adapt to prevailing conditions (biologically driven biological aspect)

**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
Key feature is forming and maintaining self-sustaining cycles and doing so at various scales
Closure

- “Operational closure: The results of systemic operations are at once more systemic operations.” On Luhmann p. 14
- “Function systems are operationally closed and function autopoietically.” On Luhmann p. 101
Structural Coupling

“…is a state in which two systems shape the environment of the other in such a way that both depend on the other for continuing their autopoiesis and increasing their structural complexity.” On Luhmann p. 19

Continuation of this IS SUSTAINABILITY
Centers

“Centers are the fundamental primary entities. A center is any zone of coherence that occurs in space... may arise, initially as a minor non-homogeneity in space, through differentiation. Each center is (recursively) dependent on other coherent centers for its own coherence.” Alexander, p. 428
Some centers share parts of other centers. The elements are ambiguously overlaid together. Each one is seen as combining with this one, or that one. Each one is shaped by its neighbor.

“Structure-preserving transformations - wholeness-extending transformations.”

Alexander, p. 428.
Ecological example of autocatalysis

The 5-species Ladybug system: aphids suck the sap from the plant. Ladybugs prey on aphids. Aphids produce a honeydew for ants. Endosymbiotic relationship between aphids and the bacteria.
Economic example: Regenerative economy

Input, Output, and System Dynamics

1. Reliable inputs
2. Healthy out-flows
3. Regenerative return flows
4. Robust cross-scale circulation

Rules, roles & relationships

5. Diversity of roles
6. Distribution of sizes or resources
7. Degree of mutualism
8. Adaptability/place in adaptive cycle
9. Balance of resilience & efficiency
10. Constructive vs exploitative
Conclusions: Sustainability is a property of interaction networks

- Linking together of processes that are positively reinforcing: autocatalysis
- Closure leads to niche extension and creation: Emergence of diversity and complexity
- Nature provides templates for design of sustainable systems
Take Home

“It may be that all self-sustaining systems are reciprocating.” p. 126.

Jane Jacobs. 1969. *The Economy of Cities*