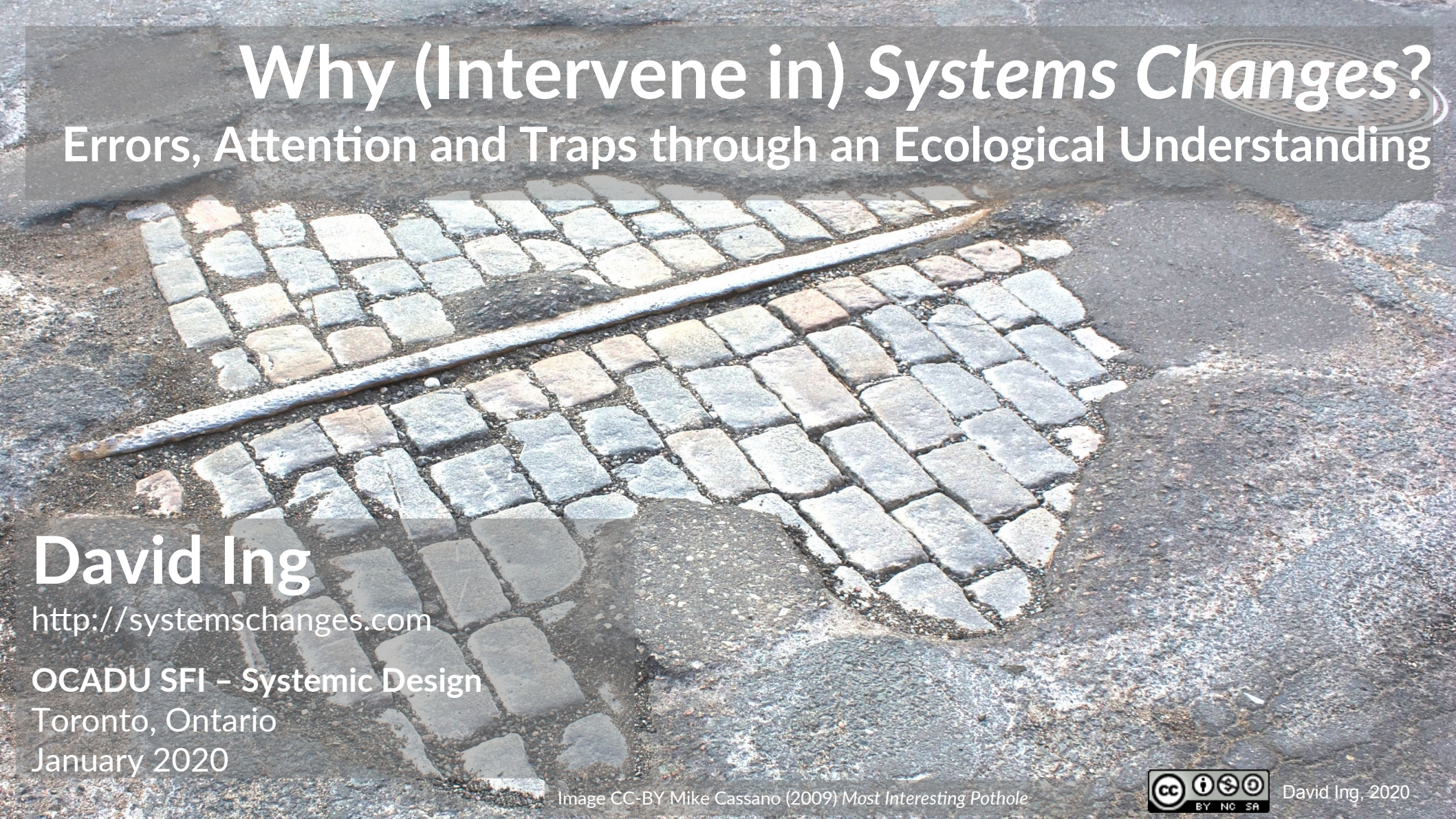
Why (Intervene in) *Systems Changes*?

Errors, Attention and Traps through an Ecological Understanding



David Ing

http://systemschanges.com

OCADU SFI – Systemic Design

Toronto, Ontario

January 2020

Agenda

[preamble] Errors, Attention, and Traps (Ecological Understanding)
- Systems Changes Learning Circle (Bateson, Gibson, Ingold)
- (Resistances to) Changing as primary system of interest

A. Socio-Ecological Systems Perspective
- Tavistock Institute (Emery, Trist)
- Organization as primary system of interest

B. (Social-) Ecological Systems + Panarchy
- Stockholm Resilience Centre (Holling, Walker, Peterson)
- Ecology as primary system of interest

C. The Ecosystem Approach
- Resilience Alliance (Waltner-Toews, Kay)
- Sustainable development project as primary system of interest

Are (interventions to) systems changes based on the Hypocratic Oath, or a Bias for Action?

Physicians have vowed to a Hippocratic Oath since 1508 in Germany, becoming standard in France by 1804

… our mantra of “First, do no harm” (a phrase translated into Latin as “ *Primum non nocere* ”) is often mistakenly ascribed to the oath, although it appears nowhere in that venerable pledge.

Hippocrates came closest to issuing this directive in his treatise *Epidemics*, in an axiom that reads, “As to diseases, make a habit of two things — to help, or at least, to do no harm.”

[1] Markel, Howard. 2004. “‘I Swear by Apollo’--on Taking the Hippocratic Oath.” *The New England Journal of Medicine* 350 (20): 2026–29. https://doi.org/10.1056/NEJMp048092 .

Bias for Action was the first chapter of eight, in 1982

5. A Bias for Action

There is no more important trait among the excellent companies than an action orientation. It seems almost trivial: experiments, ad hoc, task forces, small groups, temporary structures. [….] They don’t give in and create permanent committees or task forces that last for years. Nor do the install formal matrixes. They live in accord with the basic human limitations we described earlier: people can only handle a bit of information at one time, and they thrive if they perceive themselves as even somewhat autonomously (e.g. experimenting modestly). [2]

6. Close to the Customer
7. Autonomy and Entrepreneurship
8. Productivity Through People
9. Hand-On, Value-Driven
10. Stick to the Knitting
11. Simple Form, Lean Staff
12. Simultaneous Loose-Tight Properties

[2] Peters, Thomas J., and Robert H. Waterman. 1982. *In Search of Excellence: Lessons from America’s Best-Run Companies*. Harper & Row.

[3] Peters, Thomas. 2001. *In Search of Excellence: A Three-Generation Report Card* . Tom Peters’ Manifesto 2002. Tom Peters Company Press. https://tompeters.com/wp-content/uploads/2014/02/ISOE.pdf .

Doing, not-doing; errors of commission, errors of omission

February 28, 2019 daviding 0 Comments

Should we do, or not-do? Russell Ackoff, over many years, wrote about (negative) potential consequences:

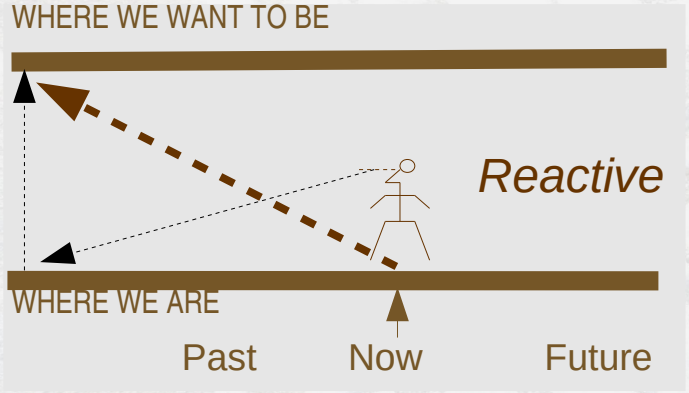
> There are two possible types of decision-making mistakes, which are not equally easy to identify.
>
> - (1) *Errors of commission*: doing something that should not have been done.
> - (2) *Errors of omission*: not doing something that should have been done.
>
> For example, acquiring a company that reduces a corporation's overall performance is an error of commission, as is coming out with a product that fails to break even. Failure to acquire a company

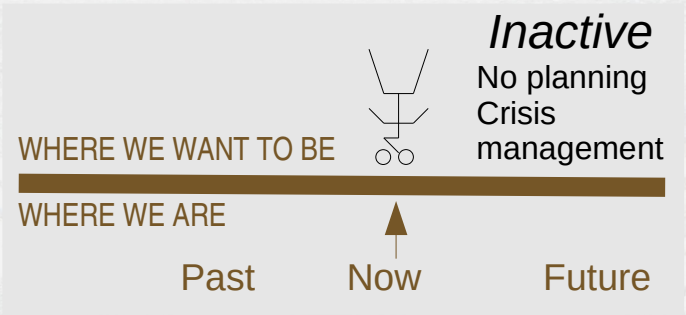
Appendix. Doing or not-doing in management can be placed philosophically in American pragmatism

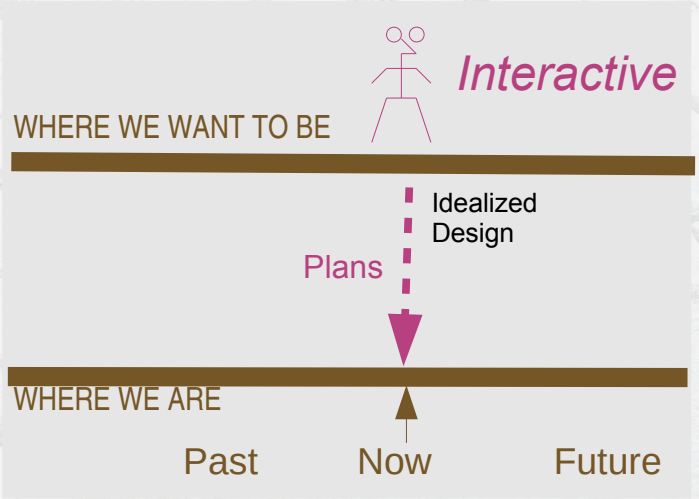
From Ackoff, commission/omission and doing/not-doing derives from a school of American pragmatism. Ackoff was only 6 years younger than his Ph.D. supervisor, West Churchman, who guided him on this path.

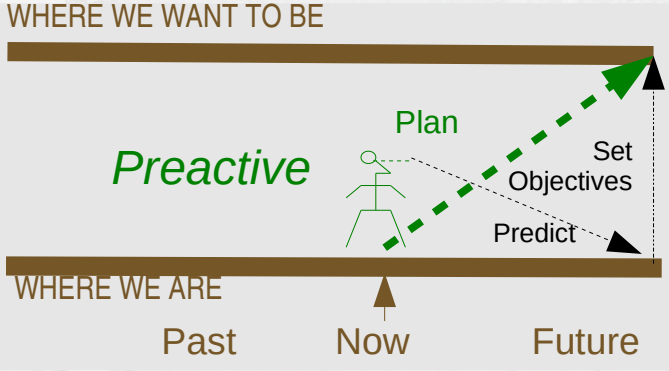
> Ackoff was more successful than Churchman in turning his action-orientated philosophizing based on Singerian pragmatism into practical methods that could be applied by practitioners. He argued that objectivity through modelling was impossible; objectivity can only be approached by groups of individuals with diverse values. His approach 'interactive planning' involves gaining the participation of stakeholders in the design of desirable futures and bringing them about. His work has had a major impact on the OR and systems communities, particularly in the UK.
>
> Jackson (2000) observes that Ackoff's approach has also been criticized for its 'subjectivism' and its 'idealism'. Further, he says that Ackoff is accused of not giving serious attention to deep-seated conflict and coercion and of relying too much on participation as a remedy for organizational problems. He is also accused of artificially limiting the scope of his projects so as not to challenge his client's or sponsors fundamental interests. Ackoff believes his critics are obsessed with the notion of irresolvable conflicts. He points out that he has not encountered such conflicts in more than 300 projects (pp 243–246). [Ormerod 2006, p. 905]

What are your orientations on systems changes over time?









Russell L. Ackoff. 1999.
Re-creating the Corporation: A Design of Organizations for the 21st Century.
Oxford University Press.

Willful action and *non-intrusive action* are central in Chinese thinking

為
wèi

無為
wú wèi

wéi: p. 517
I (verb)
1. **do; act**: 敢做敢 ~ gǎn zuò gǎn ~ bold in action
2. **act as; serve as**: 以此 ~ 凭 yí cǐ ~ píng This will serve as proof.
3. **become**: ~ 良田 biàn shā mó ~ liáng tiān turn the desert into arable land.
4. **be; mean**: 一公里 ~ 二里 yī gōng lǐ ~ èr huā lǐ One kilometer is equivalent to two li.

wu2: p. 526
I (noun) **nothing; nil**: 从 ~ 到有 cóng ~ dào yǒu start from scratch
II (verb) **not have; there is not; without**: ~ 一定 ~ yī dìng jì huà have no definite plan
III (adverb) **not**: ~ ~ xǔ duō tǎn need not go into details

Concise English-Chinese Chinese-English Dictionary (2004), 3ed, Commercial Press and Oxford University Press

Wei meant application of **the force of will-power**, the **determination** that things, animals, or even other men, should do what they were ordered to do, but
wu wei was the opposite of this, **leaving things alone**, letting **Nature** take her course, profiting by **going with the grain** of things instead of going against it, and **knowing how not to interfere**.

Needham, Joseph. 2004. "General Conclusions and Reflections." In The Social Background, edited by Kenneth Girdwood Robinson. Vol. VII:2. *Science and Civilisation in China*. Cambridge University Press. p. 16

Some scholars have argued that the interpretation of ***wuwei*** as "**non-intrusive action**" or "**non-interfering action**" is more philosophically profound and interesting.
These latter translations support a meaningful rendition of the concept *wuwei* **both at the sociopolitical level** (arguing against the imposition of artificial, conformist and universally binding norms) **and at the metaphysical level** (acknowledging the inappropriateness and fatality of imposing egocentric or anthropocentric norms upon other individuals or species).

Lai, Karyn. 2003. "Conceptual Foundations for Environmental Ethics: A Daoist Perspective." *Environmental Ethics* 25 (3): 247–66. https://doi.org/10.5840/enviroethics200325317 .

What is the way of *castor canadensis* (beaver) in habitats?

Image: CC-BY D.W. Ross (2010) “North American Beaver”

Image: CC-BY Steve Hersey (2007) “Happy Beaver”

Image: BY Jens Teichmann, "Biberfrass"

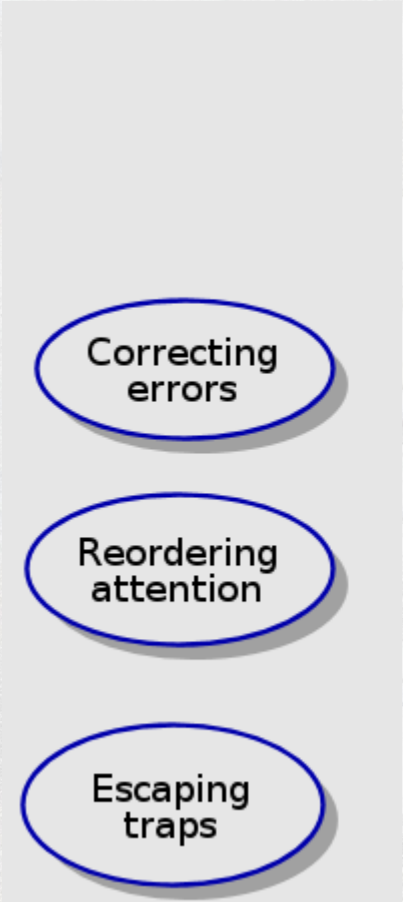
Image: CC-BY Jay Cross (2012), "Other End of the Beaver Dam"

Attenborough, David. 2008. *How Do Beavers Build A Damn*. Web Video. BBC Studios. https://www.youtube.com/watch?v=VuMRDZbrdXc .

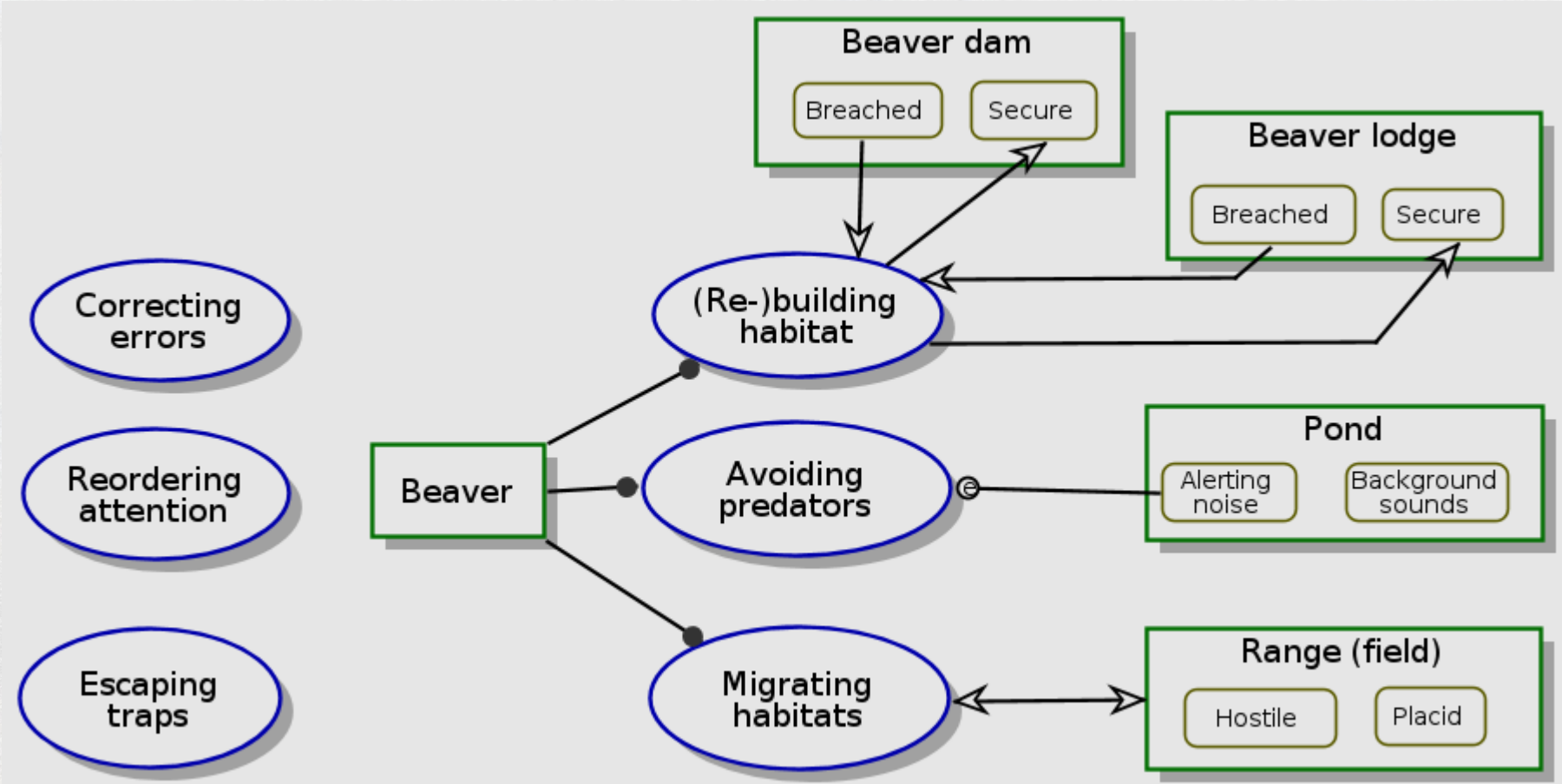
Image: CC-BY Bob Smith (bobistraveling) (2017) “Broken Beaver Dam”

Attenborough, David. 2009. Beaver Lodge Construction Squad. Web Video. BBC Earth. https://www.youtube.com/watch?v=iyNA62FrKCE .

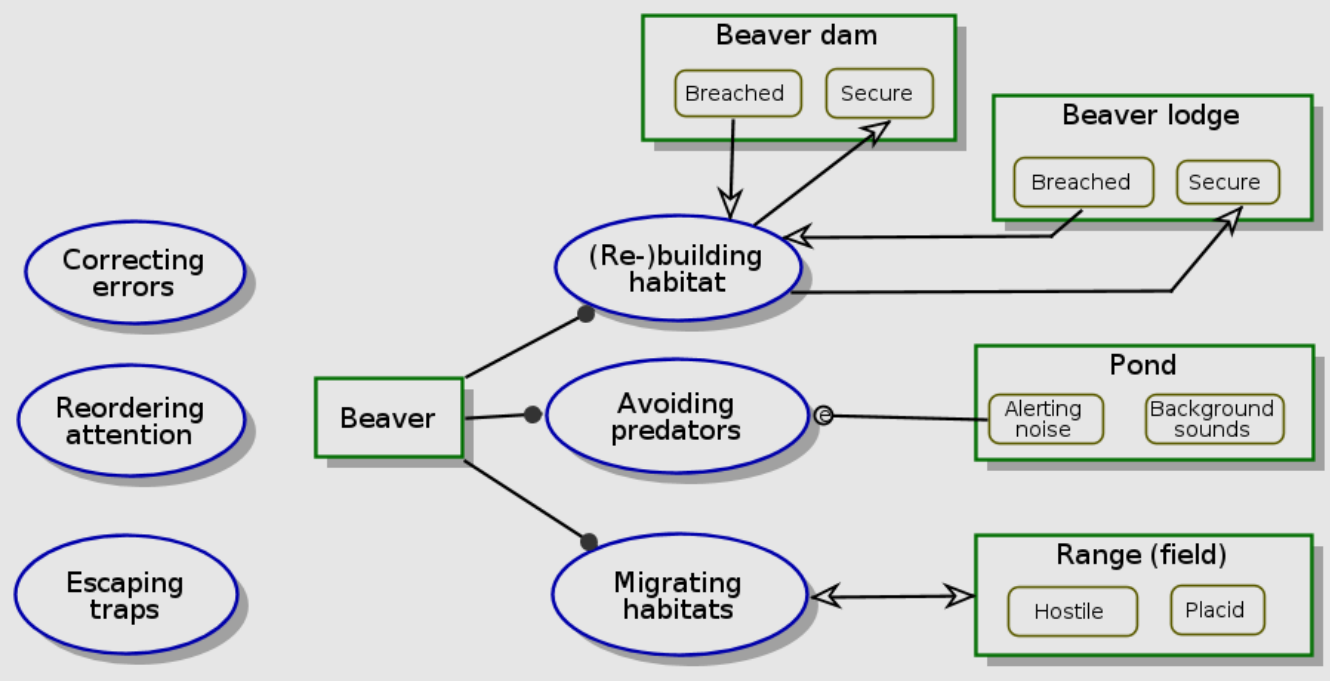
Systems Changes with *Object Process Methodology* start process-first



A beaver habitat includes errors, attention and traps



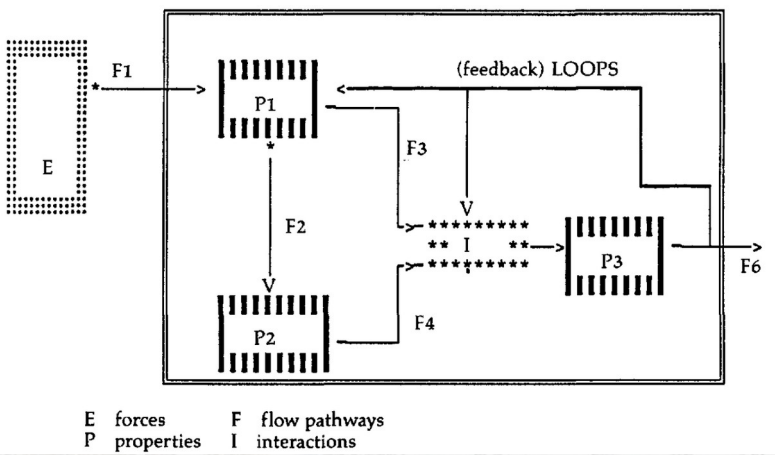
An Object Process Diagram matches its Object Process Language



Beaver is physical.
Beaver handles Migrating habitats, Avoiding predators, and (Re-)building habitat.
Beaver dam is physical.
Beaver dam can be Secure or Breached.
Beaver lodge is physical.
Beaver lodge can be Breached or Secure.
Pond is physical.
Pond can be Alerting noise or Background sounds.
Pond triggers Avoiding predators when it enters Alerting noise.
Range (field) is physical.
Range (field) can be Hostile or Placid.
Correcting errors is physical.
Reordering attention is physical.
Escaping traps is physical.
(Re-)building habitat is physical.
(Re-)building habitat changes Beaver lodge from Breached to Secure and Beaver dam from Breached to Secure.
Avoiding predators is physical.
Avoiding predators requires Alerting noise Pond.
Migrating habitats is physical.
Migrating habitats affects Range (field).

Models of *ecological understanding* may view (i) everything as material, or (ii) as material and information handled differently

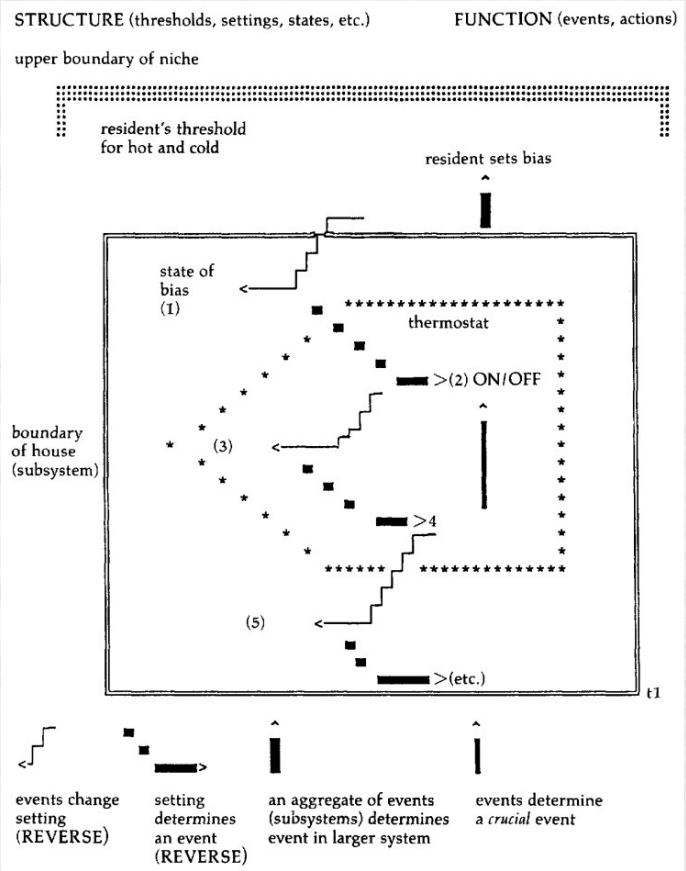
Model 1: Systems Diagram Showing the Basic Components in Modelling Ecosystems, According to Eugene Odum



Entropy Economics

... Bateson presents a simple house thermostat as a prototype model of ecosystem. Unlike Odum's energy model, which requires an initial energy input (E) flowing from outside the boundaries of an eco-subsystem, Bateson's model of a thermostat contains its own self-generating energy. Location of the energy source does not therefore require further elaboration in the model. In Odum's model, the various of organization are folded into a 'black box' of interactions (I). Bateson's model sufficiently unpacks the 'black box' - as any good cybernetic model should do - in order to discuss feedback in relation to the overall levels of structure in the model.

Model 2: Bateson's Model of House Thermostat as "Structure"



Bateson is insistent that there are many other values of ecosystem economics which become determinative before' energy economics' in an ecological system begins to pinch, He called these other values the 'entropy economics' of biological forms.' 'Entropic budgets' represent uncommitted differences of ecological values. They could also be levels termed flexibility budgets' of ecosystems.

Source: Harries-Jones, Peter. 1995. "Two Models of Ecology Compared: Odum and Bateson (Appendix 1)." In A *Recursive Vision: Ecological Understanding and Gregory Bateson*, 235–42. University of Toronto Press.

Systems views of ecology may see (i) the mind as only inside the body, or (ii) the mind as extending into the world

… Bateson recognised two ecologies:

- an ecology of material and energy exchanges, and
- an ecology of ideas.

And it was this second ecology that he christened the ‘ecology of mind’.

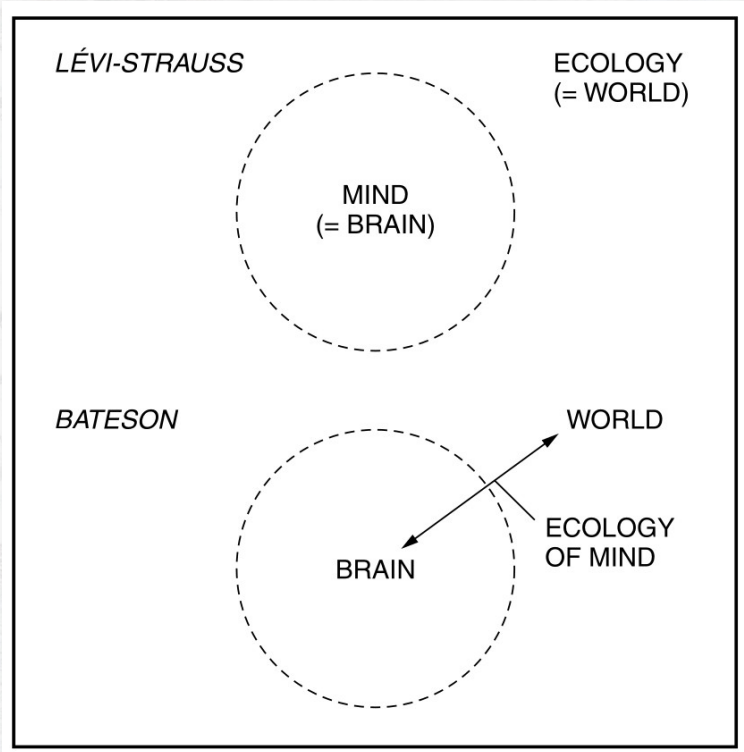
… Lévi-Strauss anchors the mind very firmly in the workings of the human brain.

For Lévi-Strauss ecology meant ‘the world outside’, mind meant ‘the brain’; for Bateson both mind and ecology were isutation in the relation between the brain and the surrounding environment (Figure 1.3).

For Lévi-Strauss, the perceiver could only have knowledge of the world by virtue of a passage of information across the boundary between outside and inside, involving successive steps of encoding and decoding by the sens organs and the brain, and resulting in an inter mental representation.

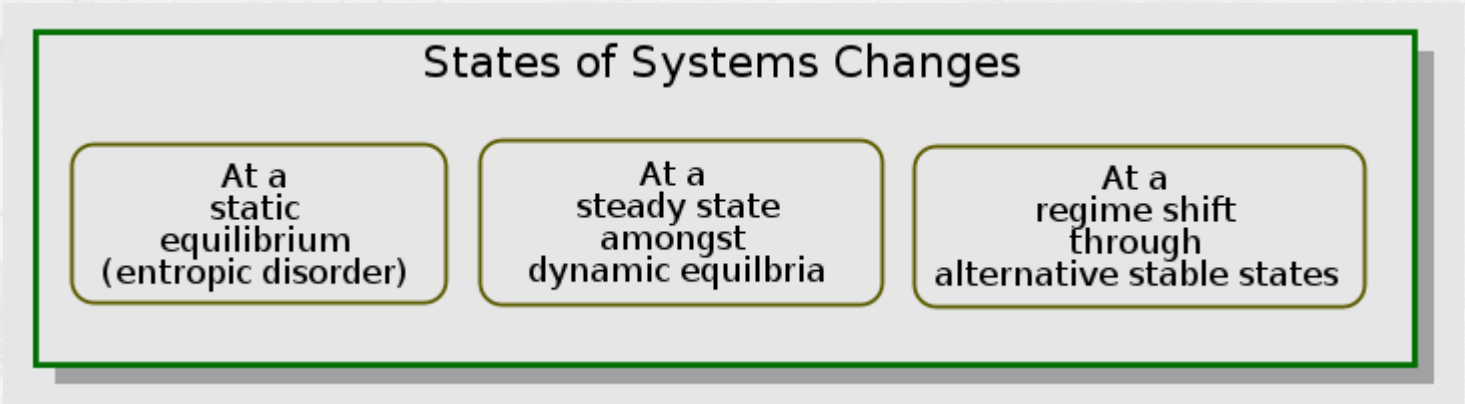
For Bateson, the idea of such a boundary was absurd, a point he illustrated with the example of a blind man’s cane. Do we draw a boundary around his head, at the handle of the cane, at its tip, or halfway down the pavement? If we ask where the mind is, the answer would not be ‘in the head rather than out there in the world’. It would be more appropriate to envisage mind as extending outwards into the environment along multiple sensory pathways of which the cane, in the hands of the blind man, is just one.

Figure 1.3 Schematic comparison of Levi-Strauss’s and Bateson’s views on mind and ecology



Source: Ingold, Tim. 2000. “Culture, Nature, Environment: Steps to an Ecology of Life.” In *The Perception of the Environment: Essays on Livelihood, Dwelling and Skill*, 13–26. Routledge.

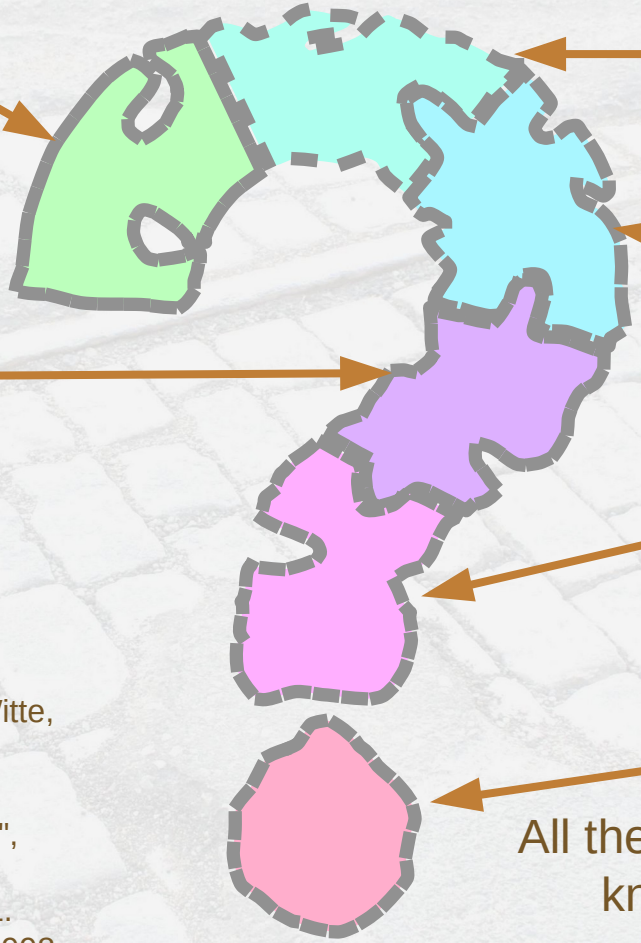
Objects with a material form respect the entropy law, with states as (i) static; (ii) dynamically steady; or (iii) in regime shift



The second law of thermodynamics (order to disorder) applies to life(?)

Sella, Andrea. 2016. *Does This Reaction Break the Second Law of Thermodynamics?* Web Video. The Royal Institution. https://www.youtube.com/watch?v=pXZ-UTfTaOw .

The *Ignorance Map* cautions physicians against overconfidence



Known Unknowns
All the things you know
you don't know

Unknown Unknowns
All the things you don't know
you don't know

Errors
All the things you think
you know but don't

Unknown Knowns
All the things you don't know
you know

Taboos
Dangerous, polluting or
forbidden knowledge

Denials
All the things too painful to
know, so you don't

Marlys H. Witte, Ann Kerwin, and Charles L. Witte,
The University of Arizona College of Medicine
"Curriculum on Medical and Other Ignorance:
Shifting Paradigms on Learning and Discovery",
Memory Distortions and their Prevention,
Margaret-Jean Intons-Peterson and Deborah L.
Best, editors, Lawrence Erlbaum Associates, 1998

Errors in decision-making may come from gaps in knowledge

There are two possible types of decision-making mistakes, which are not equally easy to identify.

(1) **Errors of commission**:
doing something that should not have been done.

(2) **Errors of omission**:
not doing something that should have been done.

Accounting systems are able to identify errors of commission, even though they often fail to do so.

Decisions not to do something are seldom a matter of record.

Ackoff, Russell L. 1994. “It’s a Mistake!” *Systems Practice* 7 (1): 3–7. https://doi.org/10.1007/BF02169161.

Judgment under uncertainty relies on heuristics → 12 cognitive biases

A. **Representativeness**

1. Insensitivity to prior probability of outcomes
2. Insensitivity to sample size
3. Misconceptions of chance
4. Insensitivity to predictability
5. The illusion of validity
6. Misconceptions of regression

B. **Availability**

7. Biases due to the retrievability of instances
8. Biases due to the effectiveness of a search set
9. Biases of imaginability
10. Illusory correlation

C. **Adjustment and Anchoring**

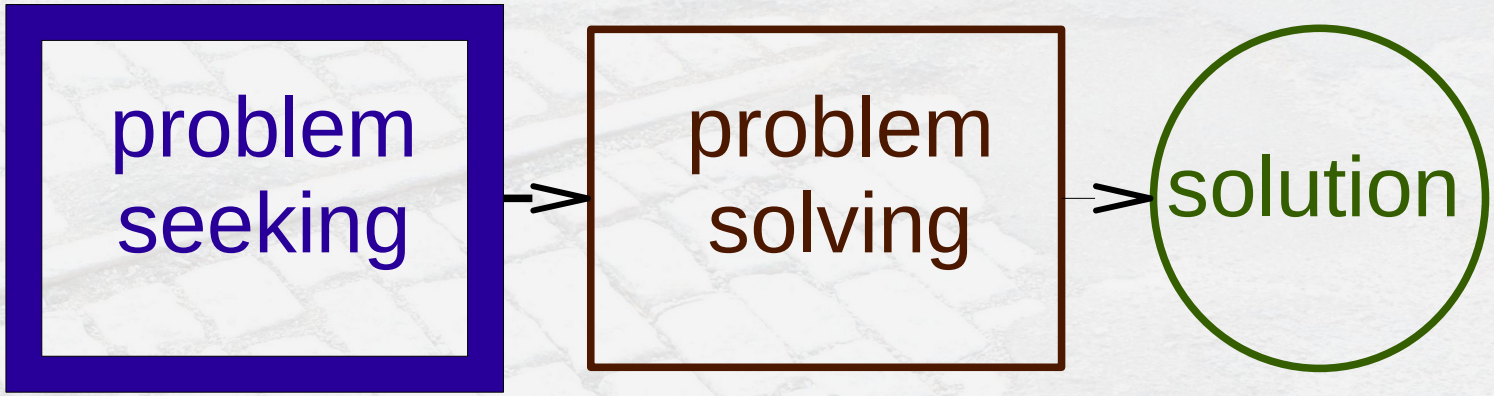
11. Insufficient adjustment
12. Anchoring in the assessment of subjective probability distributions

Tversky, Amos, and Daniel Kahneman. 1974. “Judgment under Uncertainty: Heuristics and Biases.” *Science* 185 (4157): 1124–31. https://doi.org/10.1126/science.185.4157.1124.

In 1969, problem seeking was *architectural programming*, and problem solving was *design*

Programming is a specialized and often misunderstood term. It is "*a statement of an architectural problem* and the requirements to be met in offering a solution. While the term is used with other descriptive adjectives such as *computer* programming, *educational* programming, *functional* programming, etc., in this report, programming is used to refer only to architectural programming.

Why programming? The client has a project with many unidentified sub-problems. The architect must define the client's total problem.



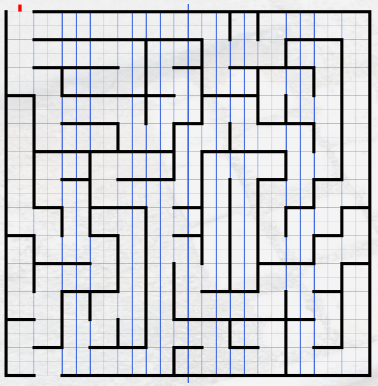
Design is problem solving; programming is problem seeking. The end of the programming process is a statement of the total problem; such a statement is the element that joins programming and design. The "total problem" then serves to point up constituent problems, in terms of four considerations, those of form, function, economy and time. The aim of the programming is to provide a sound basis for effective design. The State of the Problem represents the essense and the uniqueness of the project. Furthermore, it suggests the solution to the problem by defining the main issues and giving direction to the designer (Pena and Focke 1969, 3).

If they can get you asking the wrong questions, they don't have to worry about answers (Thomas Pynchon)

Type 1 error	**False positive**: finding a (statistical) relation that isn't real
Type 2 error	**False negative**: missing a (statistical) relation that is real
Type 3 error	**Tricking ourselves**: Unintentional error of solving wrong problems precisely (through ignorance, faulty education or unreflective practice)
Type 4 error	**Tricking others**: Intentional error of solving wrong problems (through malice, ideology, overzealousness, self-righteousness, wrongdoing)

Ian I. Mitroff and Abraham Silvers. 2010. *Dirty Rotten Strategies: How We Trick Ourselves and Others into Solving the Wrong Problems Precisely.* Stanford University Press.

What is learning? (a) transmission of representations; or (b) an education of attention?



The maze … offers not one path, but multiple choices, of which each may be freely made but most lead to dead ends. It also differs, however, in that its avenues are demarcated by barriers which obstruct any view other than straight ahead. The maze does not open up to the world …, it encloses, trapping its inmates within the false antimony of freedom and necessity

In walking the labyrinth, by contrast, choice is not an issue. The path leads, and the walker is under the imperative to go where it takes him. But the path is not always easy to follow. …. The danger lies not in coming to a dead end, but in wandering off the track. …. You are, rather, fated to carry on nevertheless, along a path that, if you are not careful, may take you ever further from the living, to whose community you may never make it back.

Tim Ingold, 2013. "The Maze and the Labyrinth: Walking and The Education of Attention." In *Walk On: From Richard Long to Janet Cardiff -- 40 Years of Art Walking*, edited by Cynthia Morrison-Bell and Mike Collier, pp. 6–11, https://issuu.com/stereographic/docs/walkon_for_issuu.

Lifelines co-respond with habit, agencing, and attentionality

Habit, rather than volition:

I become my walking, and that my walking walks me. I am there, inside of it, animated by its rhythm. And with every step I am not so much changed as modified, in the sense not of transition from one state to another but of perpetual renewal. [p. 16]

Agencing, rather than agency:

Interaction goes back and forth as agents, facing each other on opposite banks of the river, trade messages, missiles, and merchandise. But to *correspond*, in my terms, is to join with the swimmer in the midstream. It is a matter not of taking sides but of going along. [p. 18]

Attentionality, rather than intentionality:

Walking calls for the pedestrian's continual responsiveness to the terrain, the path, and the elements. To respond, he must attend to these things as he goes along, joining or participating with them in his own movements. [p. 19]

Ingold, Tim. 2017. "On Human Correspondence." *Journal of the Royal Anthropological Institute* 23 (1):9–27. https://doi.org/10.1111/1467-9655.12541.

Agenda

[preamble] Errors, Attention, and Traps (Ecological Understanding)
- Systems Changes Learning Circle (Bateson, Gibson, Ingold)
- (Resistances to) Changing as primary system of interest

A. Socio-Ecological Systems Perspective
- Tavistock Institute (Emery, Trist)
- Organization as primary system of interest

B. (Social-) Ecological Systems + Panarchy
- Stockholm Resilience Centre (Holling, Walker, Peterson)
- Ecology as primary system of interest

C. The Ecosystem Approach
- Resilience Alliance (Waltner-Toews, Kay)
- Sustainable development project as primary system of interest

The Tavistock Institute developed three systems perspectives

[... the] socio-psychological, the socio-technical and the socio-ecological perspectives ... emerged from each other in relation to changes taking place in the wider social environment. One could not have been forecast from the others. Though **interdependent**, each has its own focus. Many of the **more complex projects require all three perspectives**. [p. 30]

Socio-Psychological Systems Perspective

... in Institute projects, the **psychological forces** are are directed **towards the social field**, whereas in the the Clinic, it is the other way around [with **social forces** directed **toward the psychological field**]. [p. 31]

Socio-Technical Systems Perspective

... the **best match** between the **social** and **technical systems** of an organization, since called the **principle of joint optimization**

... the **second design principle**, the **redundancy of functions**, as contrasted with the **redundancy of parts**. [p. 32]

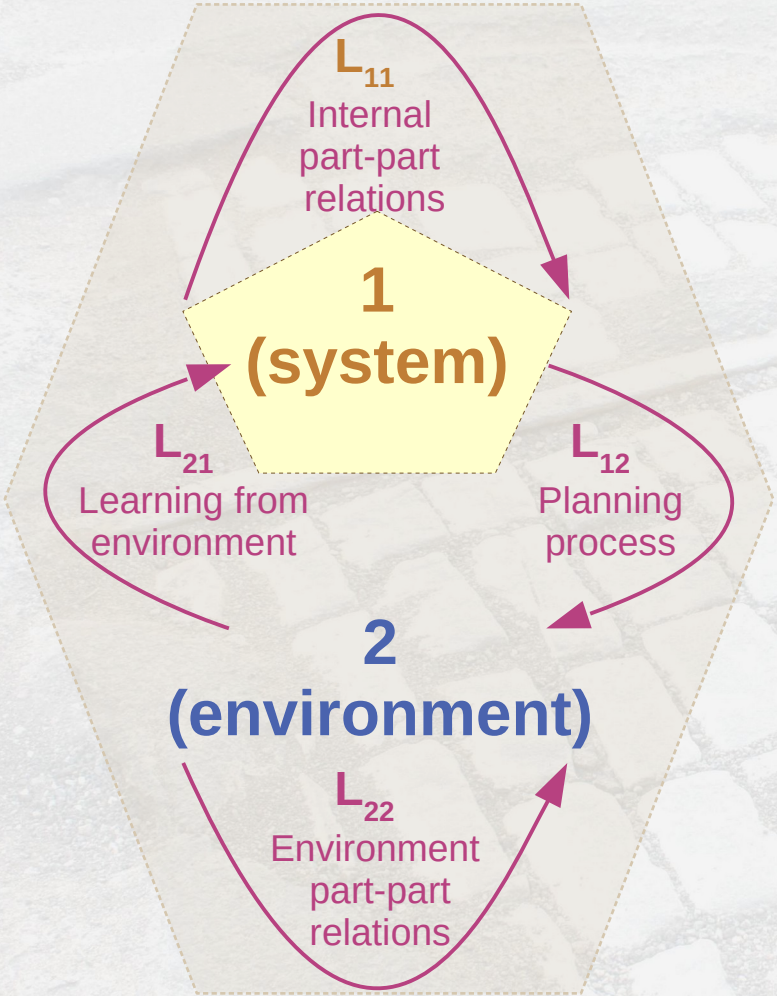
Socio-Ecological Systems Perspective

... the **context** of the **increasing levels of interdependence, complexity and uncertainty** that characterize societies a the present time.

... new problems related to **emergent values** such as **cooperation** and **nurturance**. [p. 33]

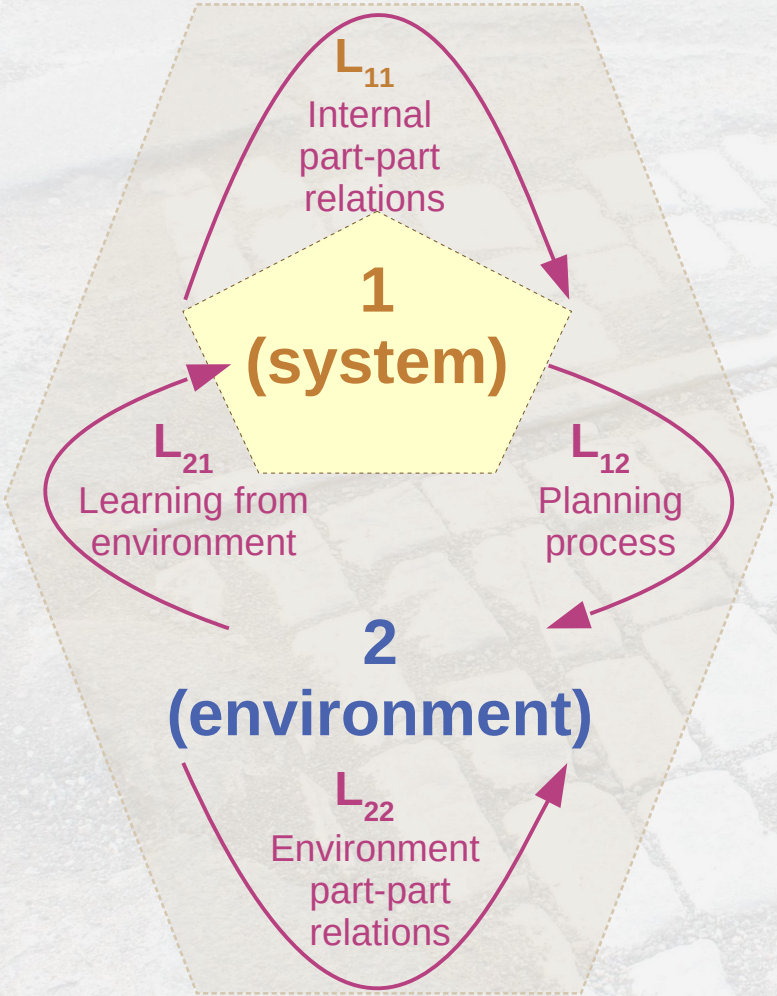
Trist, Eric L., and Hugh Murray. 1997. “Historical Overview: The Foundation and Development of the Tavistock Institute to 1989.” In *The Social Engagement of Social Science: The Socio-Ecological Perspective*, edited by Eric L. Trist, Frederick Edmund Emery, and Hugh Murray, 3:1–35. Philadelphia: University of Pennsylvania Press.

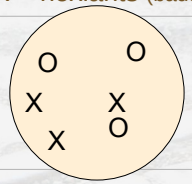
Causal texture theory sees shifts in the field of system + environment



Source: Fred E. Emery, and Eric L. Trist. 1965. "The Causal Texture of Organizational Environments." Human Relations 18 (1) (February): 21–32. doi:10.1177/001872676501800103

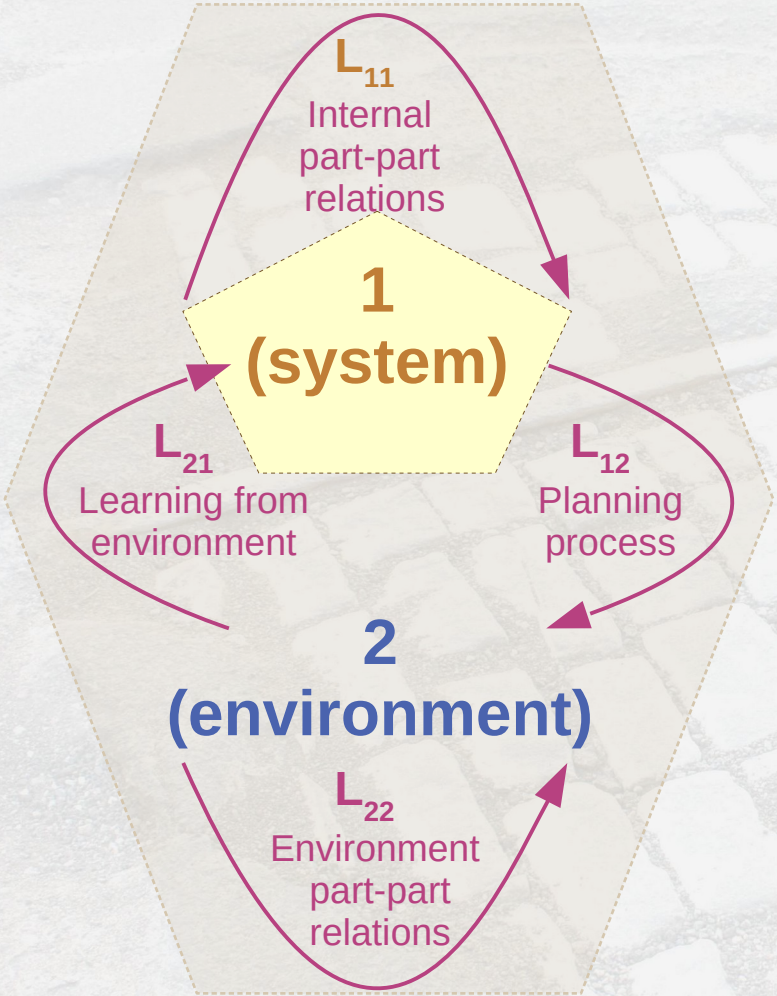
Causal texture theory sees shifts in the field of system + environment

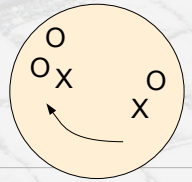


	Where O = goals (goodies), X = noxiants (baddes)	
Type I. Random Placid		Goals and noxiants randomly distributed. Strategy is tactic. "Grab it if it's there". Largely theoretical of micro, design, e.g. concentration camps, conditioning experiments. Nature is not random.

Source: Fred E. Emery, and Eric L. Trist. 1965. "The Causal Texture of Organizational Environments." Human Relations 18 (1) (February): 21–32. doi:10.1177/001872676501800103

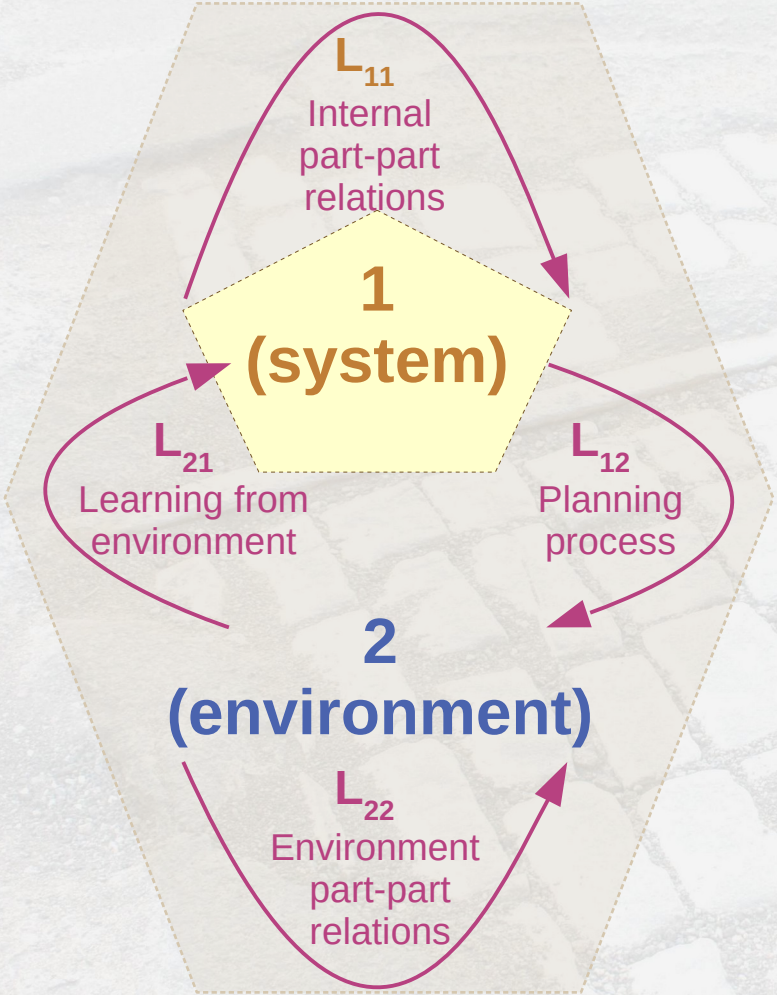
Causal texture theory sees shifts in the field of system + environment

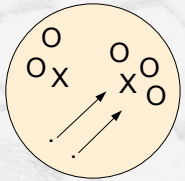


	Where O = goals (goodies), X = noxiants (baddes)	
Type 2. Clustered Placid		Goals and noxiants are lawfully distributed – meaningful learning. Simple strategy – maximize goals, e.g. use fire to produce new grass. Most of human span spent in this form. Hunting, gathering, small village. What people mean by the "good old days".

Source: Fred E. Emery, and Eric L. Trist. 1965. "The Causal Texture of Organizational Environments." Human Relations 18 (1) (February): 21–32. doi:10.1177/001872676501800103

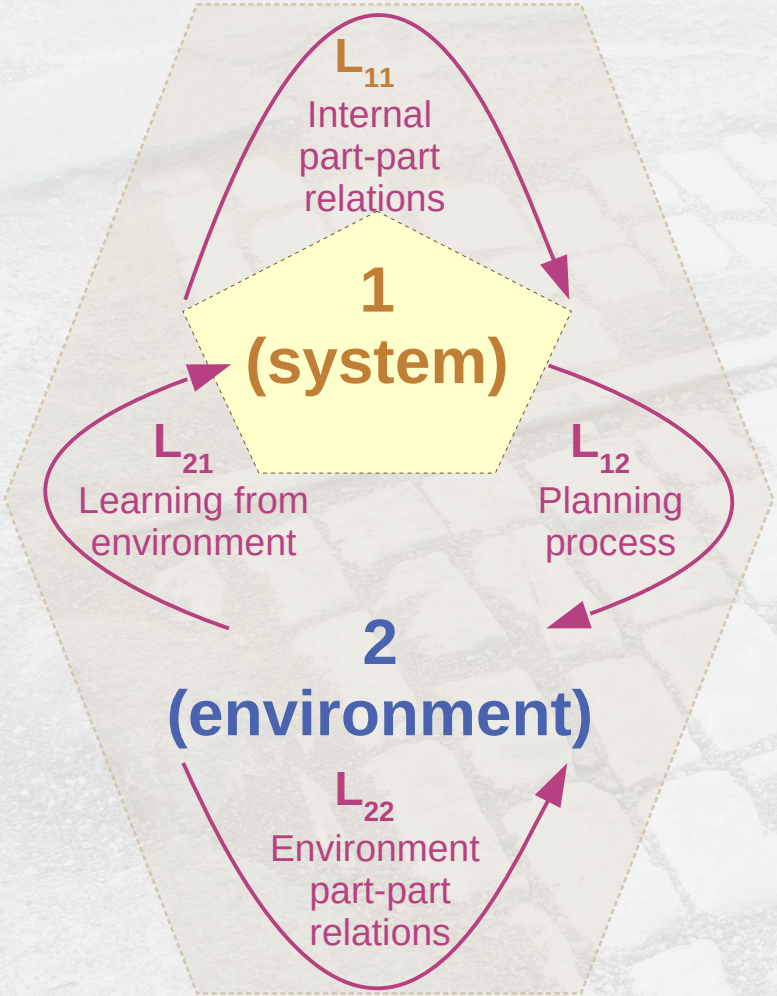
Causal texture theory sees shifts in the field of system + environment

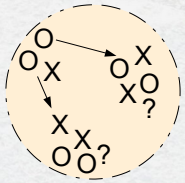


	Where O = goals (goodies), X = noxiants (baddes)	
Type 3. Disturbed Reactive		Type 2 with two or more systems of one kind *competing* for the same resources. Operational planning emerges to out-manoeuvre the competition. Requires extra knowledge of both Ss and E. E is stable so start with a set of givens and concentrate on problem solving for win-lose games. Need to create insturments that are variety-reducing (foolproof) – elements must be standardized and interchangeable. Birth of bureacractic structures where people are redundant parts. Concentrate power at the top – strrategy becomes a power game.

Source: Fred E. Emery, and Eric L. Trist. 1965. "The Causal Texture of Organizational Environments." Human Relations 18 (1) (February): 21–32. doi:10.1177/001872676501800103

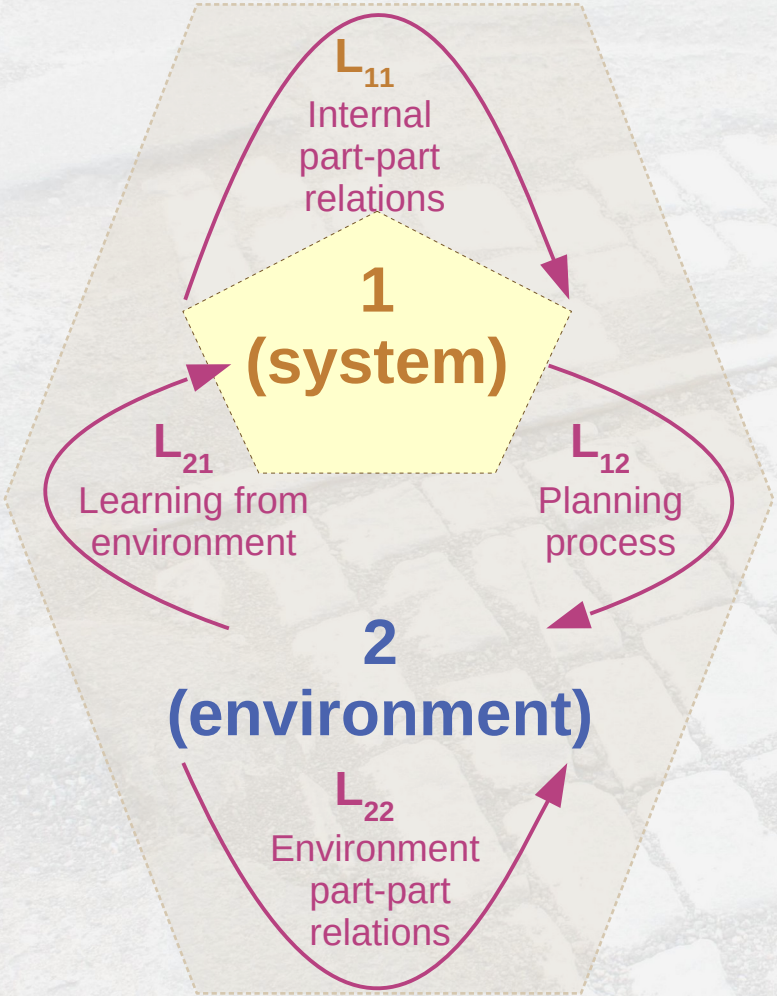
Causal texture theory sees shifts in the field of system + environment

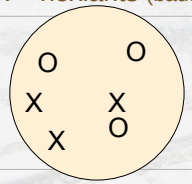
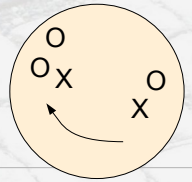
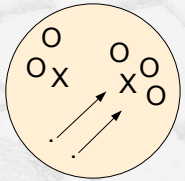
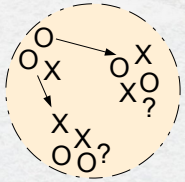


	Where O = goals (goodies), X = noxiants (baddes)	
Type 4. Turbulent		Dynamic, not placid/stable. Planned change in type 3 triggers off unexpected social processes. Dynamism arises from the field itself, creating unpredictability and increasing *relevant uncertainty* and *its continuities*. Linear planning impossible, e.g. whaling disrupted reproduciton, people react to being treated as parts of machine. Birth of open systems thinking, ecology, and catastrophe theory.

Source: Fred E. Emery, and Eric L. Trist. 1965. "The Causal Texture of Organizational Environments." Human Relations 18 (1) (February): 21–32. doi:10.1177/001872676501800103

Causal texture theory sees shifts in the field of system + environment



	Where O = goals (goodies), X = noxiants (baddes)	
Type I. Random Placid		Goals and noxiants randomly distributed. Strategy is tactic. "Grab it if it's there". Largely theoretical of micro, design, e.g. concentration camps, conditioning experiments. Nature is not random.
Type 2. Clustered Placid		Goals and noxiants are lawfully distributed – meaningful learning. Simple strategy – maximize goals, e.g. use fire to produce new grass. Most of human span spent in this form. Hunting, gathering, small village. What people mean by the "good old days".
Type 3. Disturbed Reactive		Type 2 with two or more systems of one kind *competing* for the same resources. Operational planning emerges to out-manoeuvre the competition. Requires extra knowledge of both Ss and E. E is stable so start with a set of givens and concentrate on problem solving for win-lose games. Need to create insturments that are variety-reducing (foolproof) – elements must be standardized and interchangeable. Birth of bureacractic structures where people are redundant parts. Concentrate power at the top – strrategy becomes a power game.
Type 4. Turbulent		Dynamic, not placid/stable. Planned change in type 3 triggers off unexpected social processes. Dynamism arises from the field itself, creating unpredictability and increasing *relevant uncertainty* and *its continuities*. Linear planning impossible, e.g. whaling disrupted reproduciton, people react to being treated as parts of machine. Birth of open systems thinking, ecology, and catastrophe theory.

Source: Fred E. Emery, and Eric L. Trist. 1965. "The Causal Texture of Organizational Environments." Human Relations 18 (1) (February): 21–32. doi:10.1177/001872676501800103

Errors contrasted with breakdowns frame different appreciations

Errors

Systematic

-
-
-

Reformation

-
-

Complicatedness

-

(1)
(2)

(3)

Breakdowns

Systemic

(1)

-
-
-

Transformation

(2)

-
-

Complexity

(3)

-

Errors contrasted with breakdowns frame different appreciations

Errors

Systematic

- Design as an orderly sequence of activities (via an earlier designers and engineers)
- Steps or phases in logical and linear arrangement
- Keeps apart logic from imagination, and problem from solution through external will

Reformation

-
-

Complicatedness

-

(1)

(2)

(3)

Breakdowns

Systemic

- Design as creative, disciplined, decision-oriented inquiry, in iterative cycles
- Not linear or sequential integration of information and knowledge
- Feedback - feedforward; reflection - creation; divergence - convergence

Transformation

-
-

Complexity

-

(1) Banathy, Bela H. 1996. *Designing Social Systems in a Changing World*. Springer. http://dx.doi.org/10.1007/978-1-4757-9981-1. , p. 16

(2)

(3)

Errors contrasted with breakdowns frame different appreciations

Errors

Systematic

-
-
-

Reformation

- Moderate change in behavior without changing structure or function
- Do kinds of things as it has always done, some differently

Complicatedness

-

(1)

(2)

(3)

Breakdowns

Systemic

-
-
-

Transformation

- Radical change in structure and function, often in response to change environment
- May involve risk, willingness to make short-term sacrifices for longer-term gains.

Complexity

-

(1)

(2) Ackoff, Russell Lincoln. 1999. *Re-Creating the Corporation: A Design of Organizations for the 21st Century*. Oxford University Press. Ackoff, Russell Lincoln. 2010. *Differences That Make a Difference: An Annotated Glossary of Distinctions Important in Management*. Triarchy Press Limited.

(3)

Errors contrasted with breakdowns frame different appreciations

Errors

Systematic

-
-
-

Reformation

-
-

Complicatedness

- Elaboration of structure (i.e. more alongside)

(1)

(2)

Breakdowns

Systemic

(1)

-
-
-

Transformation

(2)

-
-

Complexity

(3)

- Elaboration of organization (i.e. more levels)

(3) Allen, Timothy F. H., Joseph A. Tainter, and Thomas W. Hoekstra. 1999. “Supply-Side Sustainability.” *Systems Research and Behavioral Science* 16 (5): 403–27. https://doi.org/10.1002/(SICI)1099-1743(199909/10)16:5<403::AID-SRES335>3.0.CO;2-R .

Errors contrasted with breakdowns frame different appreciations

Errors

Systematic

- Design as an orderly sequence of activities (via an earlier designers and engineers)
- Steps or phases in logical and linear arrangement
- Keeps apart logic from imagination, and problem from solution through external will

Reformation

- Moderate change in behavior without changing structure or function
- Do kinds of things as it has always done, some differently

Complicatedness

- Elaboration of structure (i.e. more alongside)

Breakdowns

Systemic

(1)

- Design as creative, disciplined, decision-oriented inquiry, in iterative cycles
- Not linear or sequential integration of information and knowledge
- Feedback - feedforward; reflection - creation; divergence - convergence

Transformation

(2)

- Radical change in structure and function, often in response to change environment
- May involve risk, willingness to make short-term sacrifices for longer-term gains.

Complexity

(3)

- Elaboration of organization (i.e. more levels)

(1) Banathy, Bela H. 1996. *Designing Social Systems in a Changing World*. Springer. http://dx.doi.org/10.1007/978-1-4757-9981-1. , p. 16

(2) Ackoff, Russell Lincoln. 1999. *Re-Creating the Corporation: A Design of Organizations for the 21st Century*. Oxford University Press. Ackoff, Russell Lincoln. 2010. *Differences That Make a Difference: An Annotated Glossary of Distinctions Important in Management*. Triarchy Press Limited.

(3) Allen, Timothy F. H., Joseph A. Tainter, and Thomas W. Hoekstra. 1999. "Supply-Side Sustainability." *Systems Research and Behavioral Science* 16 (5): 403–27. https://doi.org/10.1002/(SICI)1099-1743(199909/10)16:5<403::AID-SRES335>3.0.CO;2-R .

Agenda

[preamble] Errors, Attention, and Traps (Ecological Understanding)

- Systems Changes Learning Circle (Bateson, Gibson, Ingold)
- (Resistances to) Changing as primary system of interest

A. Socio-Ecological Systems Perspective

- Tavistock Institute (Emery, Trist)
- Organization as primary system of interest

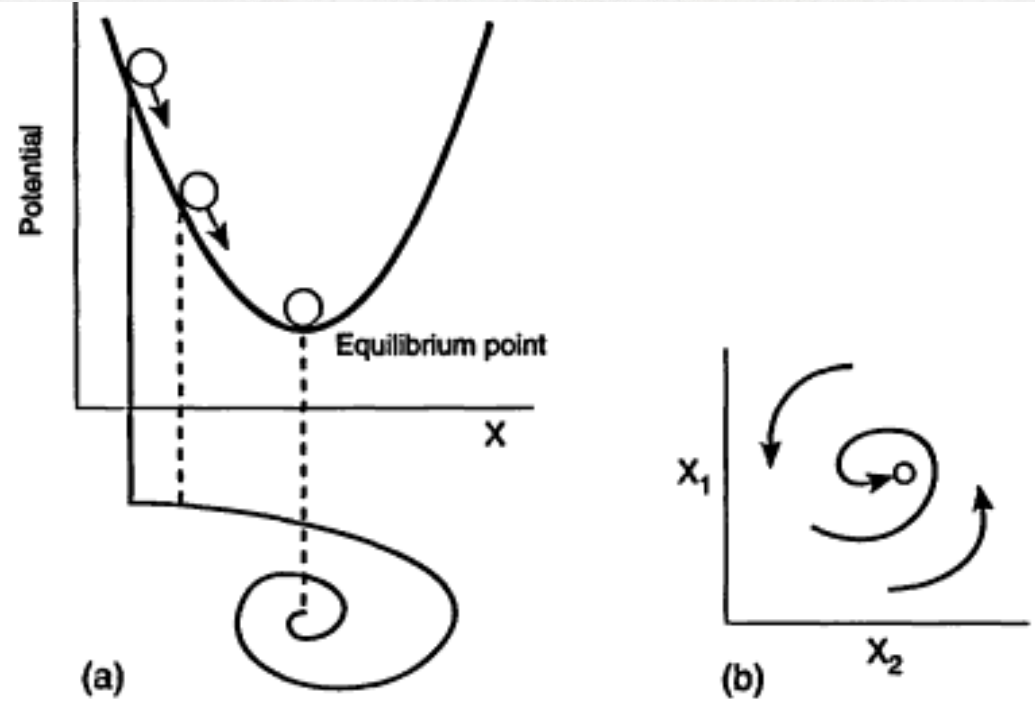
B. (Social-) Ecological Systems + Panarchy

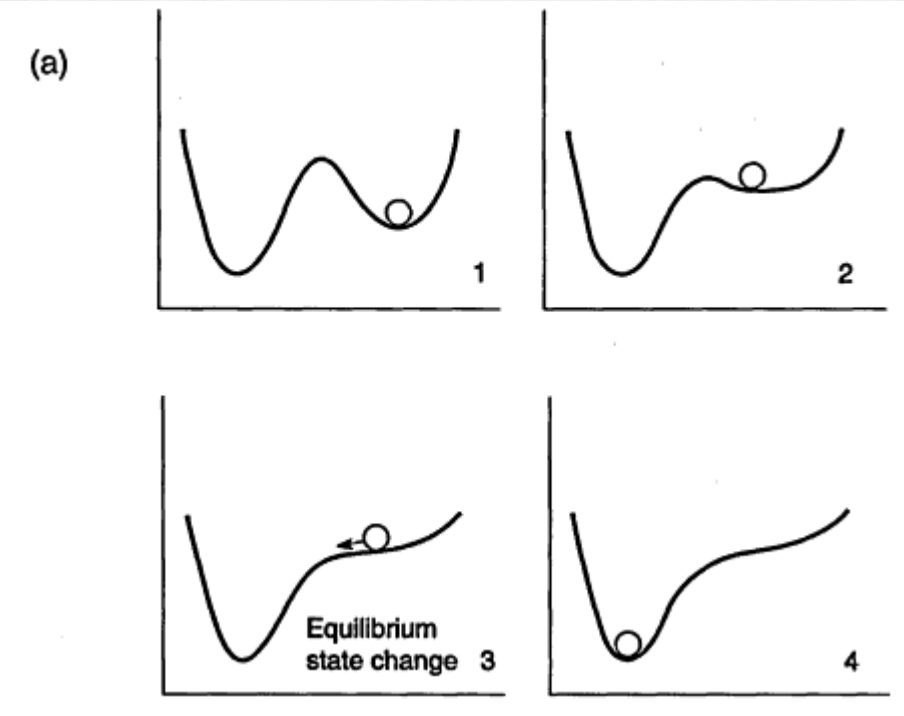
- Stockholm Resilience Centre (Holling, Walker, Peterson)
- Ecology as primary system of interest

C. The Ecosystem Approach

- Resilience Alliance (Waltner-Toews, Kay)
- Sustainable development project as primary system of interest

Engineering resilience returns to a single equilibrium steady state; ecological resilience allows for multiple stable states in nature





Holling, C.S. 1996. “Engineering Resilience versus Ecological Resilience.” In *Engineering Within Ecological Constraints*, edited by Peter C. Schultze, 31–44. Washington, DC: National Academies Press. https://doi.org/10.17226/4919.

Shifts in Equilbrium (2013) MIT K12 Videos
https://www.youtube.com/watch?v=KUSsRrOqynQ&t=21

In a “ball-and-cup” metaphor, systems changes (i) displace a ball away from an attractor, or (ii) alter the landscape beyond cup thresholds

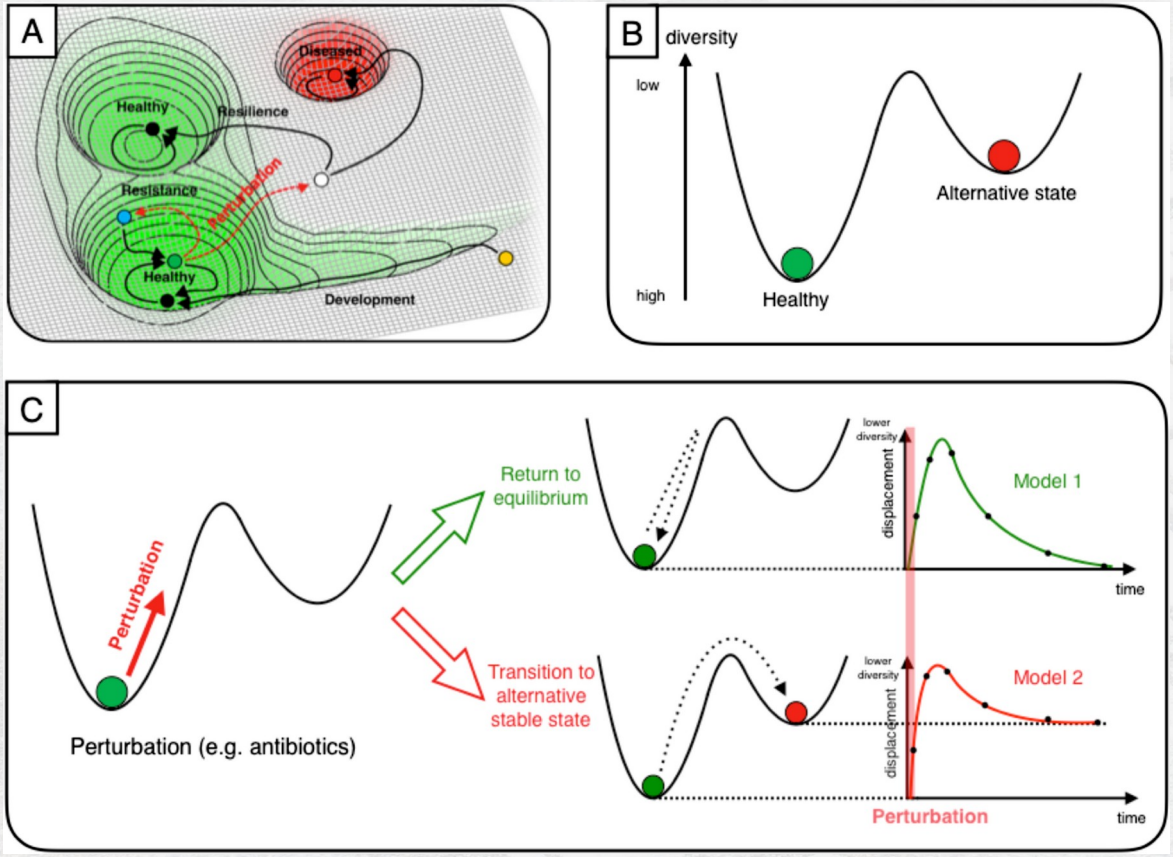


Fig. 1 A stability landscape framework for antibiotic perturbation to the microbiome. We represent the gut microbiome as a unit mass on a stability landscape, where height corresponds to phylogenetic diversity.

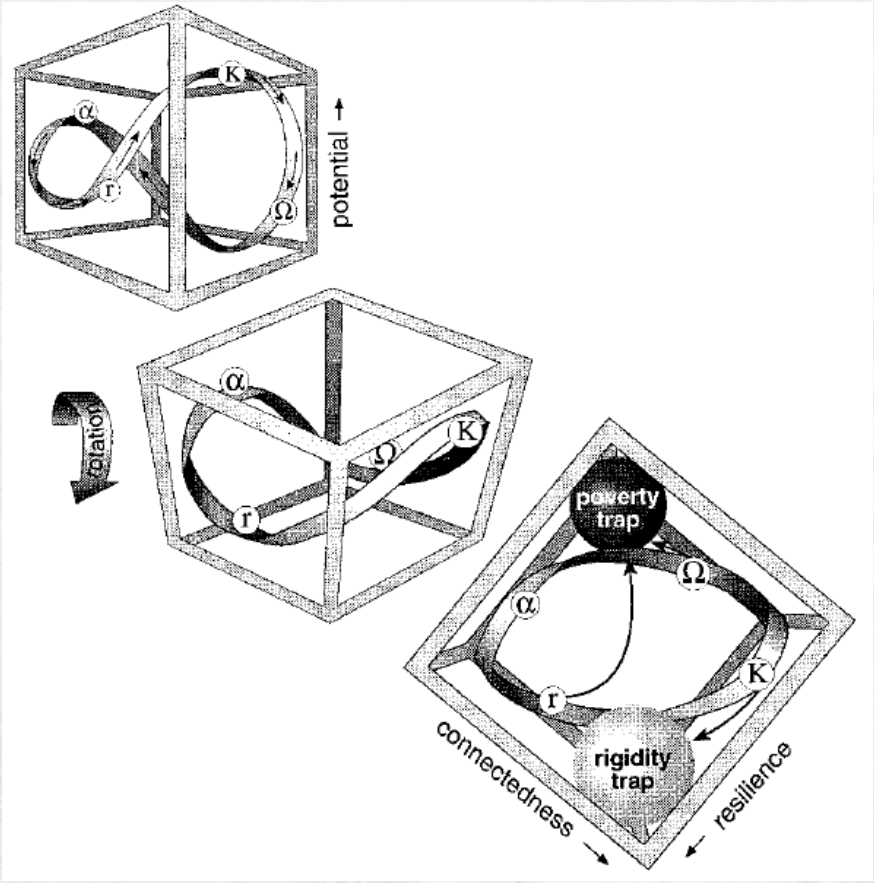
a The healthy human microbiome can be conceptualized as resting in the equilibrium of a stability landscape of all possible states of the microbiome. Perturbations can displace it from this equilibrium value into alternative states (adapted from Lloyd-Price et al. [25]).

b Choosing to parameterise this stability landscape using diversity, we assume that there are just two states: the healthy baseline state and an alternative stable state.

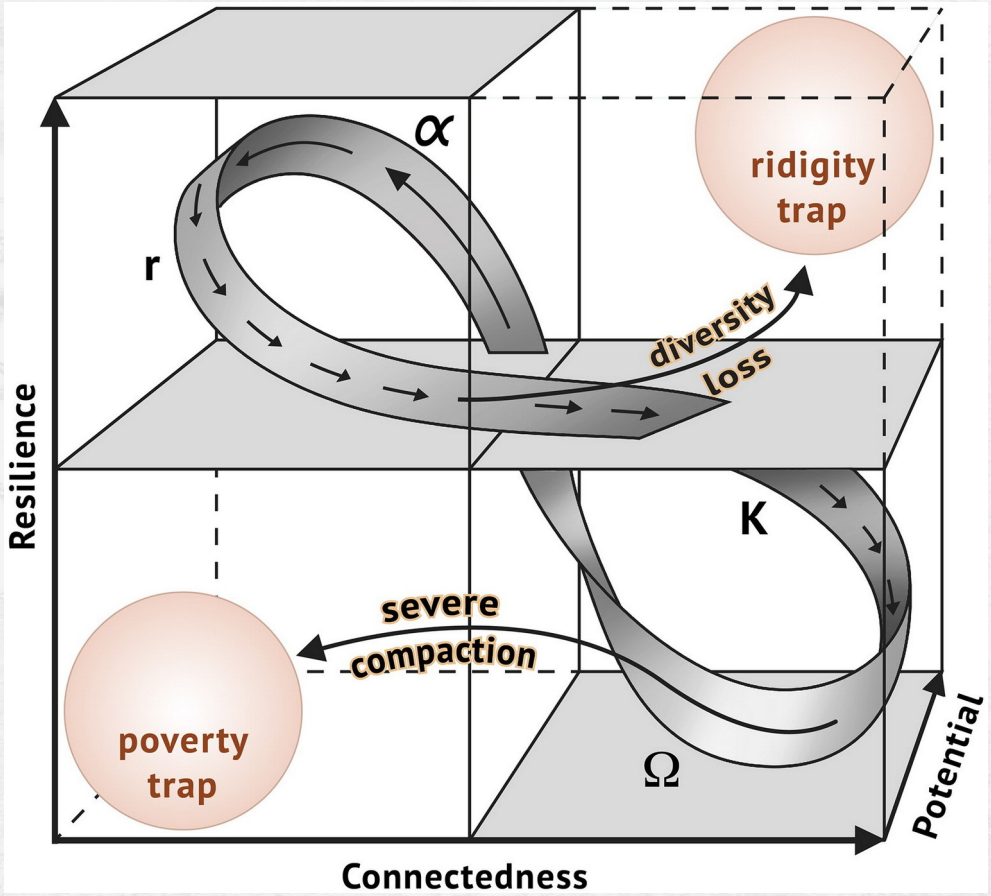
c Perturbation to the microbiome (e.g. by antibiotics) is then modelled as an impulse, which assumes the duration of the perturbation is short relative to the overall timescale of the experiment. We consider the form of the diversity time-response under two scenarios: a return to the baseline diversity; and a transition to a different value of a diversity (i.e. an alternative stable state)

Shaw, Liam P., Hassan Bassam, Chris P. Barnes, A. Sarah Walker, Nigel Klein, and Francois Balloux. 2019. “Modelling Microbiome Recovery after Antibiotics Using a Stability Landscape Framework”. *The ISME Journal: Multidisciplinary Journal of Microbial Ecology* 13: 1845. https://doi.org/10.1038/s41396-019-0392-1.

Maladaptation departs the adaptive cycle as rigidity or poverty trap

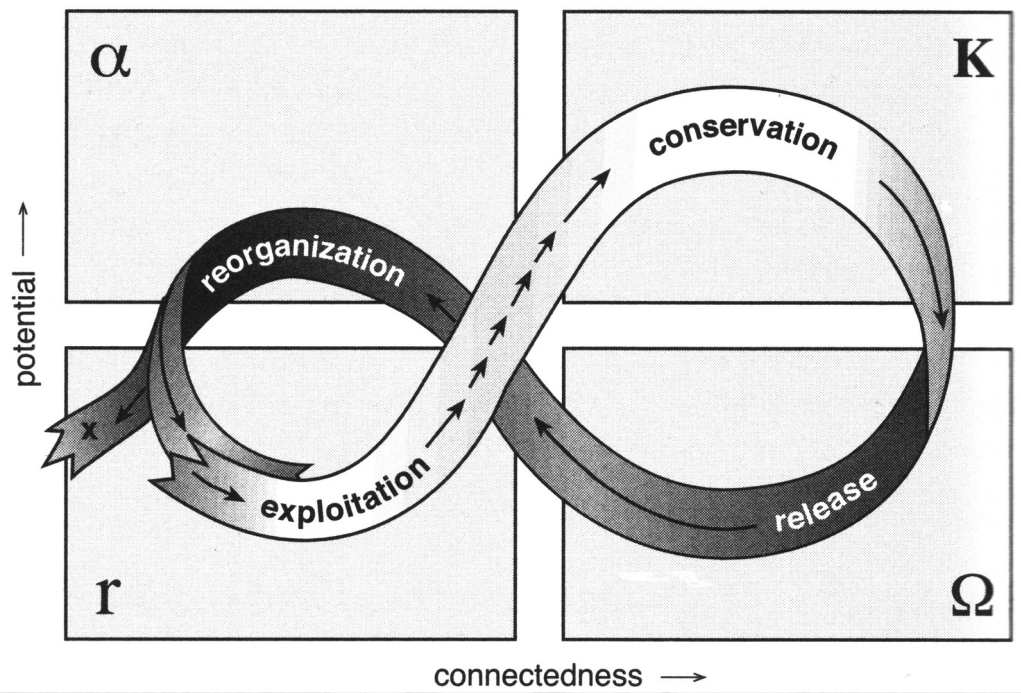


Holling, C. S. 2001. "Understanding the Complexity of Economic, Ecological, and Social Systems." *Ecosystems* 4 (5): 390–405. https://doi.org/10.1007/s10021-001-0101-5.



Ludwig, Marie, Paul Wilmes, and Stefan Schrader. 2018. "Measuring Soil Sustainability via Soil Resilience." *Science of The Total Environment* 626 (June): 1484–93. https://doi.org/10.1016/j.scitotenv.2017.10.043.

Adaptive cycle has two dimensions of change: potential and connectedness



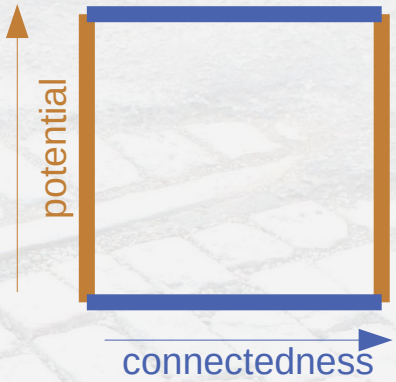
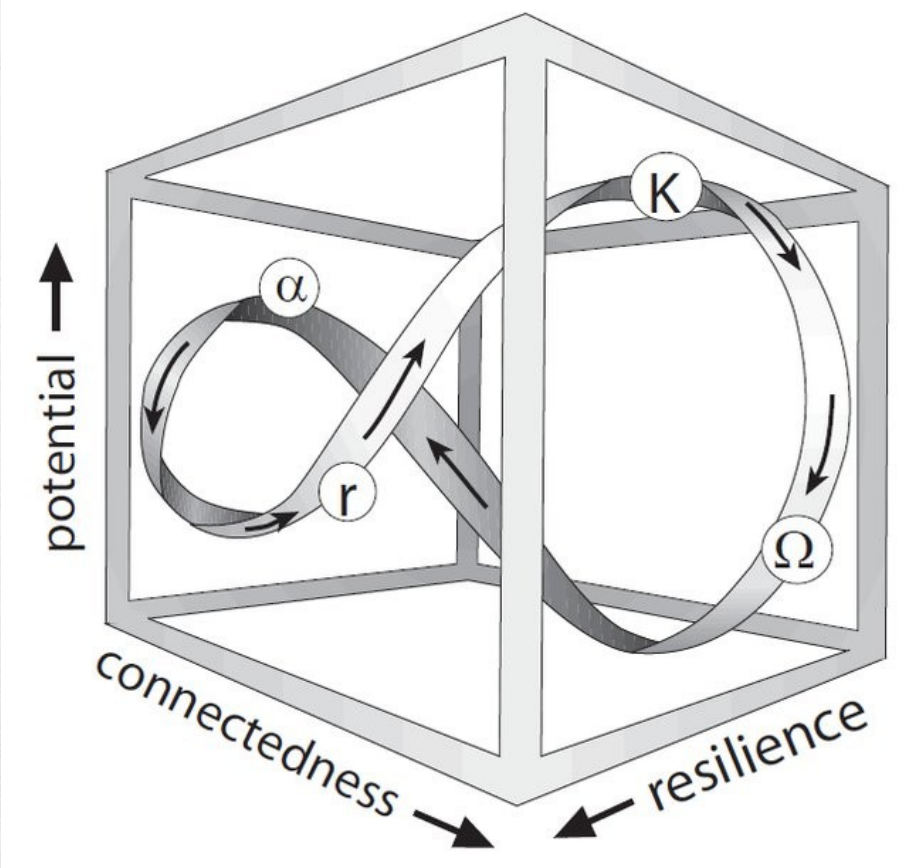
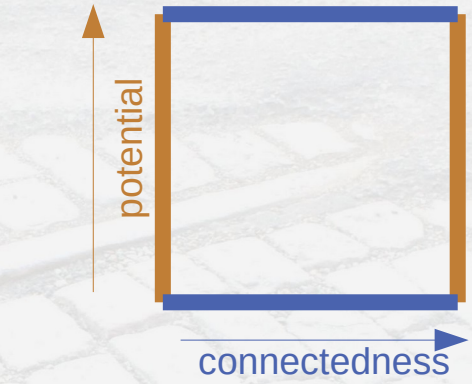


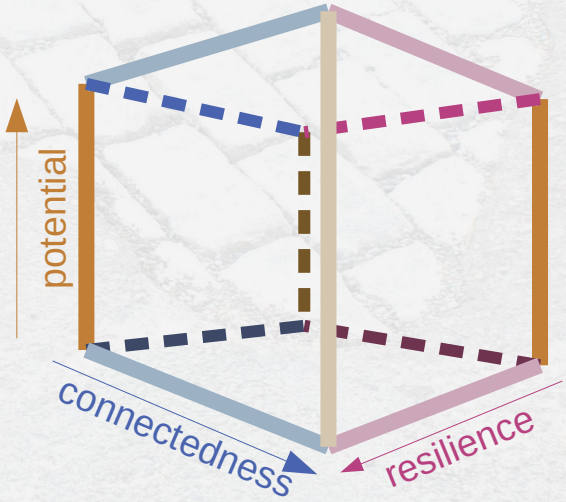
Figure 4. A stylized representation of the four ecosystem functions (r, K, Ω, α) and the flow of events among them.

Source: C. S. Holling 2001. "Understanding the Complexity of Economic, Ecological, and Social Systems." *Ecosystems* 4 (5): 390–405. doi:10.1007/s10021-001-0101-5. http://dx.doi.org/10.1007/s10021-001-0101-5.

Resilience is a third dimensions of change in the adaptive cycle

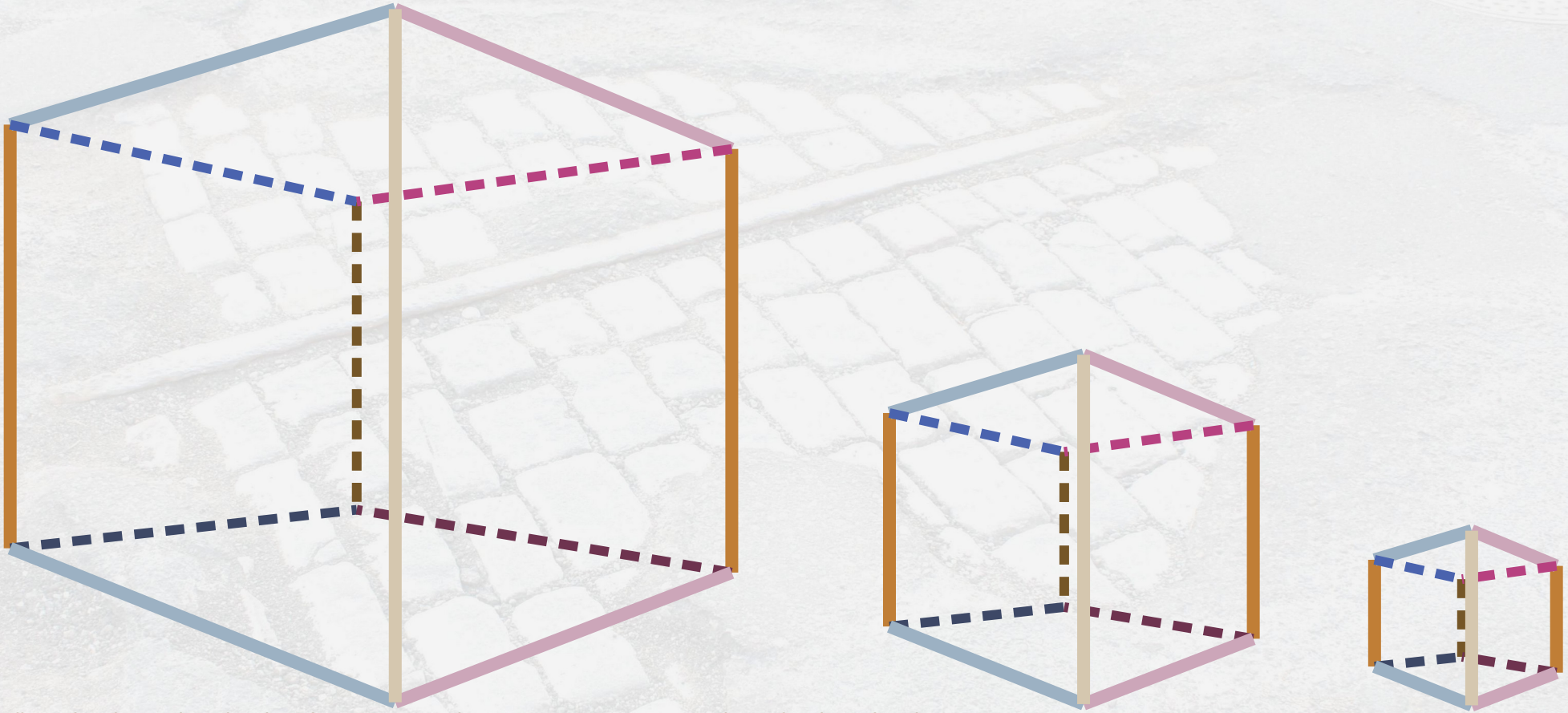






Neff, Brian P. 2013. "Traps and Transformations of Grenadian Water Management." Ph.D. dissertation, University of Waterloo. http://hdl.handle.net/10012/8018, modified from Gunderson & Holling 2002.

With hierarchy theory, holons have simultaneous wholeness and partness



Allen, Timothy, and Mario Giampietro. 2014. “Holons, Creaons, Genons, Environs, in Hierarchy Theory: Where We Have Gone.” *Ecological Modelling*, Systems Ecology: A Network Perspective and Retrospective, 293 (December): 31–41. https://doi.org/10.1016/j.ecolmodel.2014.06.017.

Panarchy crosses scales as larger-slower and smaller-faster relations

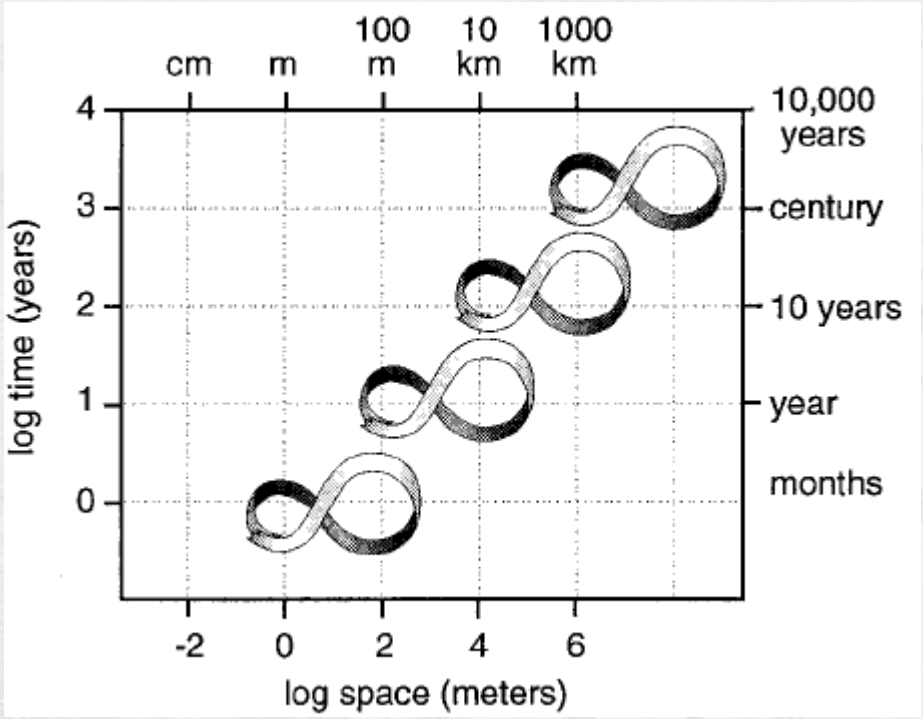


Figure 6. A stylized panarchy. A panarchy is a cross scale, nested set of adaptive cycles that indicates the dynamic nature of structures depicted in the previous plots.

Holling, C. S. 2001. "Understanding the Complexity of Economic, Ecological, and Social Systems." *Ecosystems* 4 (5): 390–405. https://doi.org/10.1007/s10021-001-0101-5.

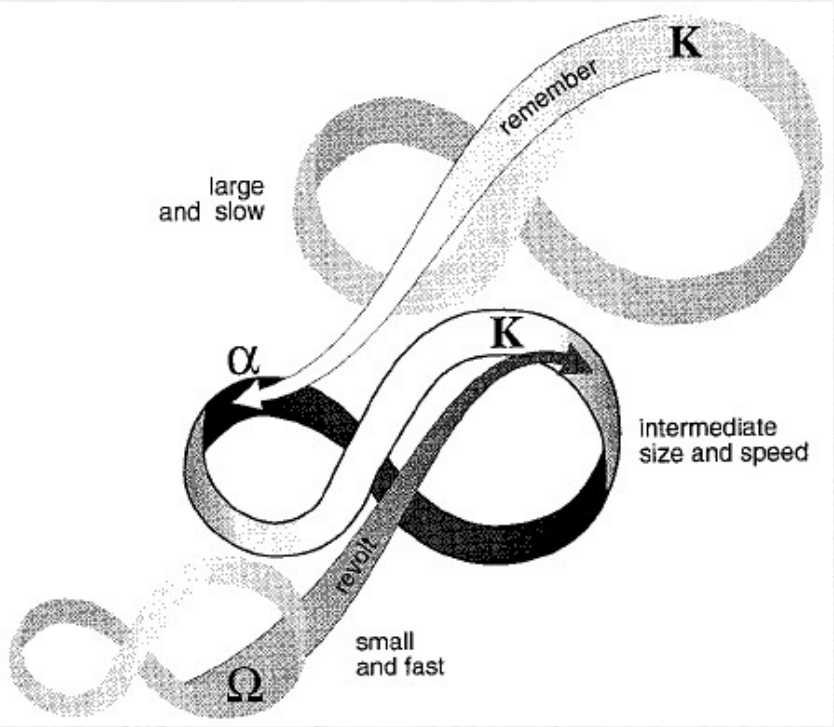
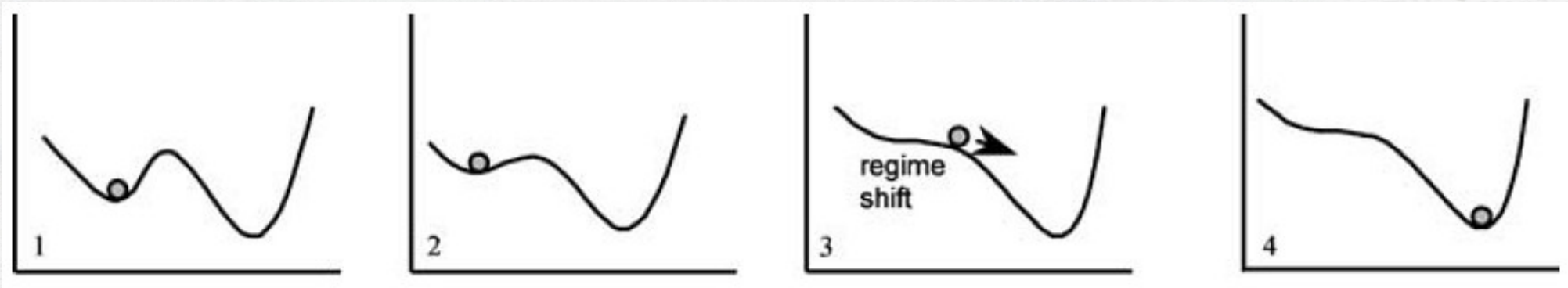


Figure 7. Panarchical connections. [....] the "revolt" connection ...can cause a critical change in one cycle to cascade up to a vulnerable stage in a larger and slower one. The ... "remember" connection ... facilitates renewal by drawing on the potential that has been accumulated and stored in a larger, slower cycle.

Regime shifts occur when limits on thresholds are exceeded

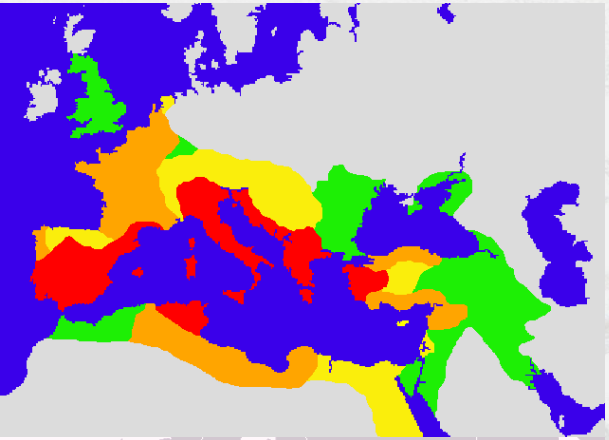


clear-water lakes	phosphorous accumulation in agricultural soil and lake mud	flooding, warming, overexploitation of predators	turbid-water lakes
coral-dominated reefs	overfishing, coastal eutrophication	disease, bleaching hurricane	algae-dominated reefs
grasslands	fire prevention	good rains, continuous heavy grazing	shrub-bushland
grassland	hunting of herbivores	disease	woodland
...	...	...	...

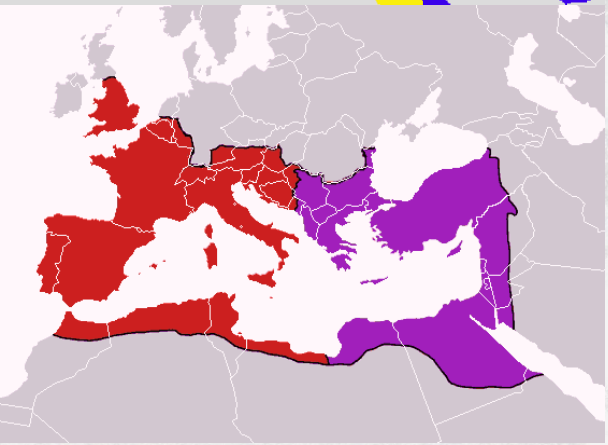
Figure 2: Alternate states in a diversity of ecosystems (1, 4) and the causes (2) and triggers (3) behind loss of resilience and regime shifts.

Folke, Carl, Steve Carpenter, Brian Walker, Marten Scheffer, Thomas Elmqvist, Lance Gunderson, and C.S. Holling. 2004. "Regime Shifts, Resilience, and Biodiversity in Ecosystem Management." *Annual Review of Ecology, Evolution, and Systematics* 35 (1): 557–81. https://doi.org/10.1146/annurev.ecolsys.35.021103.105711.

Breakdowns in history see expansion and collapse – Roman Empire (167 BC - 486 AD) c.f. Byzantine Empire (491 AD to 1025 AD)



The extent of the Roman Empire in around
133 BC (red),
44 BC (orange),
14 AD (yellow), and
117 AD (green).



After the death of Theodosius I, in 395 AD.
Western Roman Empire (dark red);
Eastern Roman Empire (magenta)

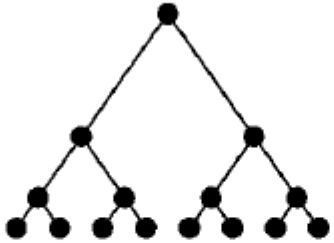
The Byzantine Empire and its provinces at the death of Basil II, 1025

Source: Atlas of Ancient Rome at https://commons.wikimedia.org/wiki/Atlas_of_Ancient_Rome; Atlas of the Byzantine Empire at https://commons.wikimedia.org/wiki/Atlas_of_the_Byzantine_Empire

Changing scales (de-)complexifies or (de-)complicates

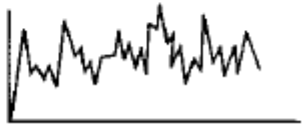
Complexity

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



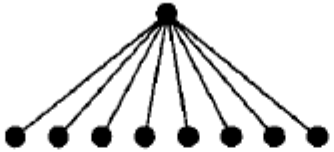
Behavior

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



Allen, Timothy F. H., Joseph A. Tainter, and Thomas W. Hoekstra. 1999. "Supply-Side Sustainability." *Systems Research and Behavioral Science* 16 (5): 403–27. https://doi.org/10.1002/(SICI)1099-1743(199909/10)16:5<403::AID-SRES335>3.0.CO;2-R.

Agenda

[preamble] Errors, Attention, and Traps (Ecological Understanding)

- Systems Changes Learning Circle (Bateson, Gibson, Ingold)
- (Resistances to) Changing as primary system of interest

A. Socio-Ecological Systems Perspective

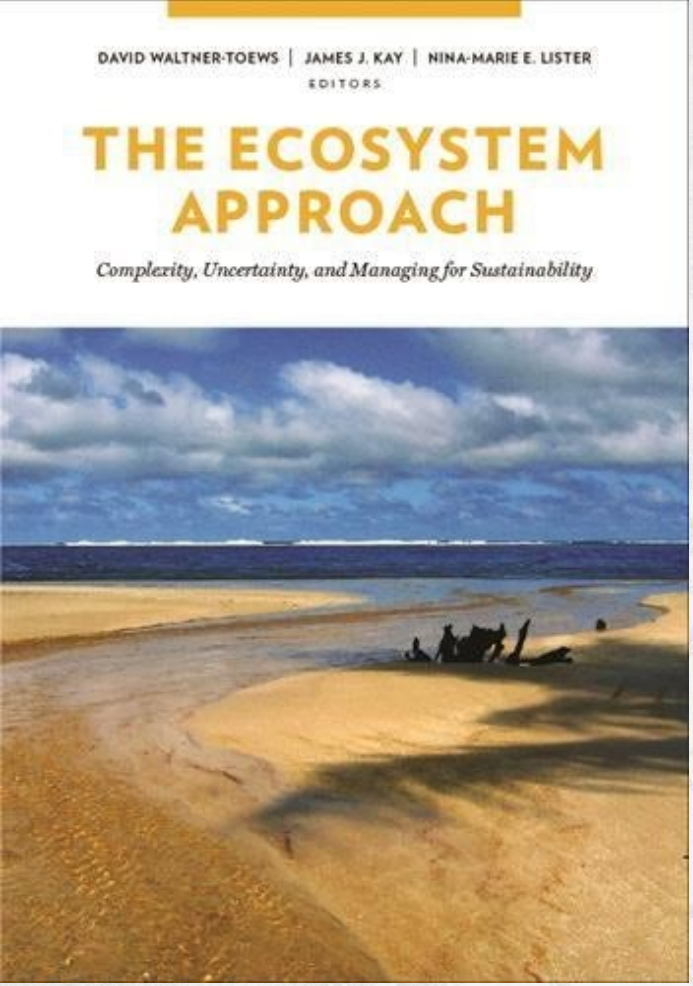
- Tavistock Institute (Emery, Trist)
- Organization as primary system of interest

B. (Social-) Ecological Systems + Panarchy

- Stockholm Resilience Centre (Holling, Walker, Peterson)
- Ecology as primary system of interest

C. The Ecosystem Approach

- Resilience Alliance (Waltner-Toews, Kay)
- Sustainable development project as primary system of interest



Waltner-Toews, David, James (James J.) Kay, and Nina-Marie E. Lister. 2008. *The Ecosystem Approach: Complexity, Uncertainty, and Managing for Sustainability*. Complexity in Ecological Systems Series. New York: Columbia University Press.

James J. Kay

I have a tenured faculty appointment at the University of Waterloo (Waterloo, Ontario, Canada) but I have been on indefinite leave since August 2002. From 1982 till August 2002 I was in Environment and Resources Studies. I was also cross appointed to the department of Systems Design Engineering, and at various points to the School of Planning, the department of Geography, and the department of Management Sciences at Waterloo and the School of Rural Planning and Development at the University of Guelph.

> "The law that entropy increases - the Second Law of Thermodynamics - holds, I think, the supreme position among the laws of Nature. If someone points out to you that your pet theory of the Universe is in disagreement with Maxwell's equations - then so much the worse for Maxwell's equations. If it is found to be contradicted by observation - well, these experimentalists do bungle things sometimes. But if your theory is found to be against the Second Law of Thermodynamics I can give you no hope; there is nothing for it but to collapse in deepest humiliation."

- Sir Arthur Eddington, The Nature of the Physical World. New York: MacMillian; 1930.

Short Biography (the official sort) (updated November 2002)

About (These are in the process of being refurbished.)
- The Ecosystem Approach (updated March 2002)
- An adaptive ecosystem approach based on a Self-organizing Hierarchical Open (SOHO)
- Systems persepctive and descriptions (updated March 2002)
- The diamond diagram and variations (updated March 2002)
- Thermodynamics and Ecology (updated March 2002)
- The Systems Approach (updated July 1999)
- Complexity and Self-organization (updated July 1999)
- Post Normal Science (to appear soon)
- Exergy (updated May 2002)

Teaching:

Courses which I taught and have designed WWW pages for:

SD761/ERS675S: The epistomology of systems thinking

ERS 218: Introduction to Sustainable Environmental and Resource Systems
Introductory lectures on systems thinking, energy, water and waste management systems, complex systems dynamics, sustainable livelihoods, ecological integrity, ecological footprint, industrial ecology and life cycle analysis can be found on this site: ersserver.uwaterloo.ca/jjkay/ers218/lecture.html

ERS 305/ 605: The Ecosystem Approach
This site includes a listing and commentary on some of the crucial papers on the Ecosystem Approach

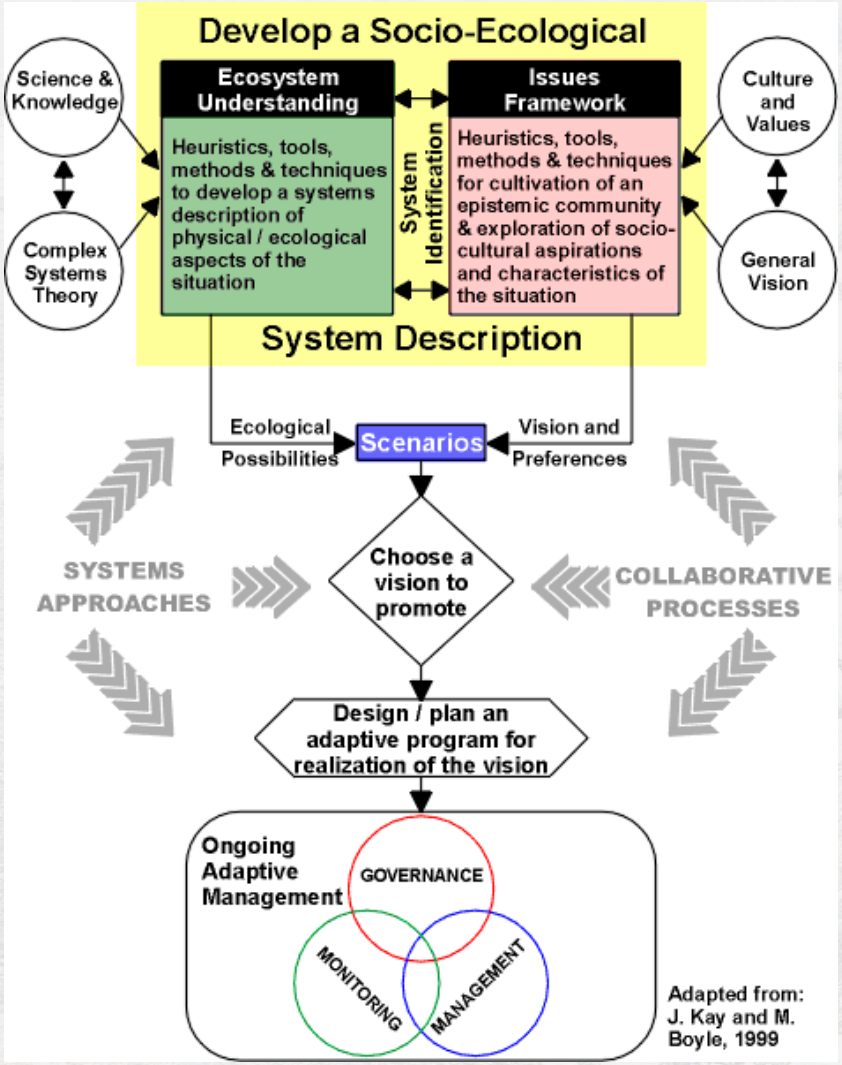
ERS 285: Greening the Campus
(This is the course on sustainability mentioned in the April 2001 issue of *University Affairs.)*

ERS 385: Technologies and Lifestyles for a Conserver Society

ME 772/ 592 Urbanization: Can We Design With Nature?

ERS 669 Project Work in Environmental Studies

ERS 390 Project work in Environmental Studies



In 1982, Lee et al. (1982) collated a variety of "ecosystem approaches" to planning and management in the Great Lakes Basin. In 1993, ***The Ecosystem Approach***, a seminal report to the International Joint Commission, drew on

- **Soft Systems Methodology** (Checkland 1981, Checkland and Scholes 1990) and
- advances in **hierarchy theory** to further enrich and elucidate an ecosystem approach to managing eco-social systems (Allen et al. 1993).
- Further work on **complexity theory, hierarchy theory**, and **post-normal science** pointed to the need to incorporate multiple perspectives, including those of actors within the system being defined and managed, to approach an understanding of how to not only understand, but also manage, such complex systems (Funtowicz and Ravetz 1993, Kay and Schneider 1994).

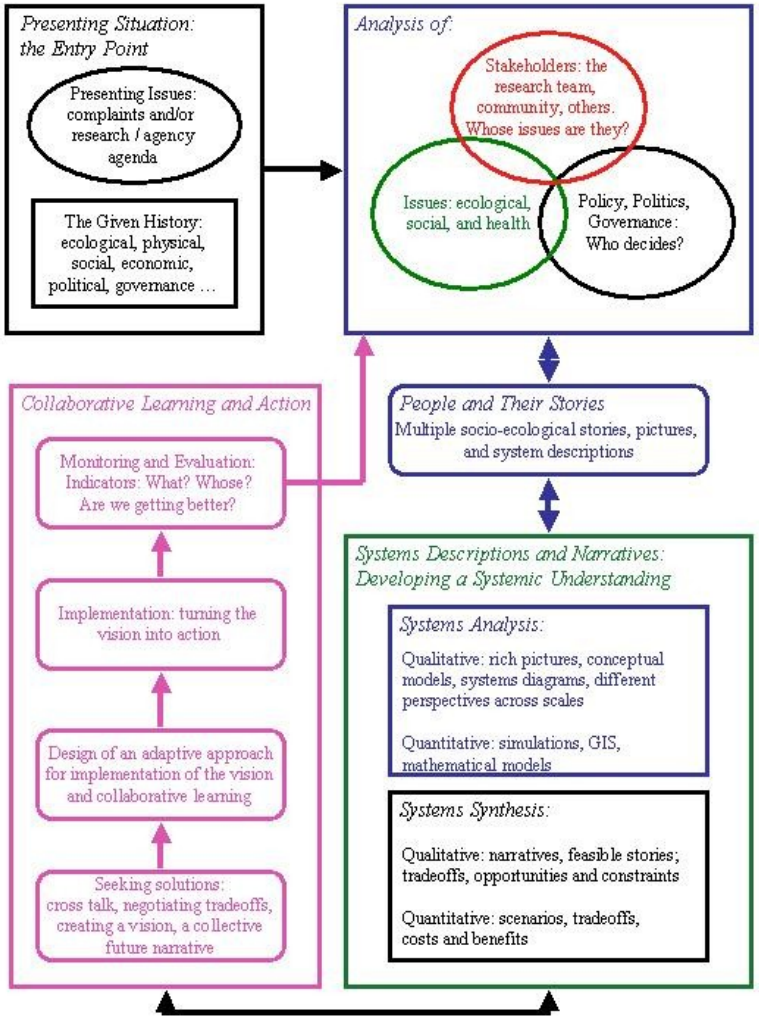
These ideas of ecosystems with people in them, ecosystem management driven by perspective and preference, and an ecosystem approach that incorporates an understanding of social process as much as ecology provided major challenges to both investigators and practitioners in the rapidly expanding field of what some referred to as **sustainable development**.

Beginning in 1994, James Kay and his colleagues developed the

- first of several heuristics referred to by users as "**the diamond schematic**" (Kay 1994, Kay et al. 1999).
- Over the next decade, they argued that our emerging understanding of complexity in eco-social systems, which took the form of theories of **resilience, integrity**, and **self-organizing, holarchic, open systems** (Holling 1986, Kay 1997, Kay et al. 1999), combined with the fundamental assumption that nature itself has no preferences, required policy makers to decide which **attractors** they preferred.

Kay argued that "... the challenge facing the practice of environmental management is to learn how to work with these self-organizing processes in a way which allows us to meet our species needs, while still preserving the integrity of ecosystems, that is to say the integrity of the self-organizing processes ..." (Kay 1994). The "diamond" in the diamond schematic was the nexus in which ecological understanding and sociocultural preferences met and interfaced with policy makers and managers.

Waltner-Toews, David, and James Kay. 2005. "*The Evolution of an Ecosystem Approach: The Diamond Schematic and an Adaptive Methodology for Ecosystem Sustainability and Health*". Ecology and Society 10 (1): a38. https://doi.org/10.5751/ES-01214-100138.



Based on the work in Kenya, Nepal, and Peru and on complementary work in Canada not discussed here, we identified the following series of **relevant components** to an effective ecosystem approach:

1. The **situation** is brought to someone's **attention**, often because the local people, researchers, or some third-party agency perceives a problem.
2. The "responders" attempt to **understand** the situation systemically by incorporating a variety of **multiscalar social and ecological perspectives**.
3. Some combination of local stakeholders and researchers identifies **system-based alternative courses of action** at **various scales** and from **various perspectives**.
4. Stakeholders choose a **course of action**, develop a plan that incorporates a **collaborative learning system** , begin implementation, and **ensure** that **governing, monitoring, and management co-evolve** with the changing situation.
5. **Outside investigators** have the **responsibility** to try to understand the system, the process, and how the process interacts with, and perhaps determines, our understanding.

AMESH draws on a set of guiding principles rather than prescriptive actions. Methodological processes are described in terms of sets of activities, and these are elaborated in terms of guiding questions.

The **four guiding principles** that arise from an understanding of self-organizing, holarchic (SOHO) eco-social systems are as follows:

1. **Self-organization**, which may incorporate threshold effects and "creative destruction" (see Holling 1986, Kay et al. 1999, Boyle et al. 2001, Gunderson and Holling 2002), occurs **within holons**.
2. There are **hierarchical / holarchical cross-scale feedbacks**.
3. The first two principles **compromise** our **ability to predict**.
4. Therefore, we must use **methodological pluralism** and incorporate **multiple perspectives** from all legitimate stakeholders.

Waltner-Toews, David, and James Kay. 2005. "*The Evolution of an Ecosystem Approach: The Diamond Schematic and an Adaptive Methodology for Ecosystem Sustainability and Health*". Ecology and Society 10 (1): a38. https://doi.org/10.5751/ES-01214-100138.

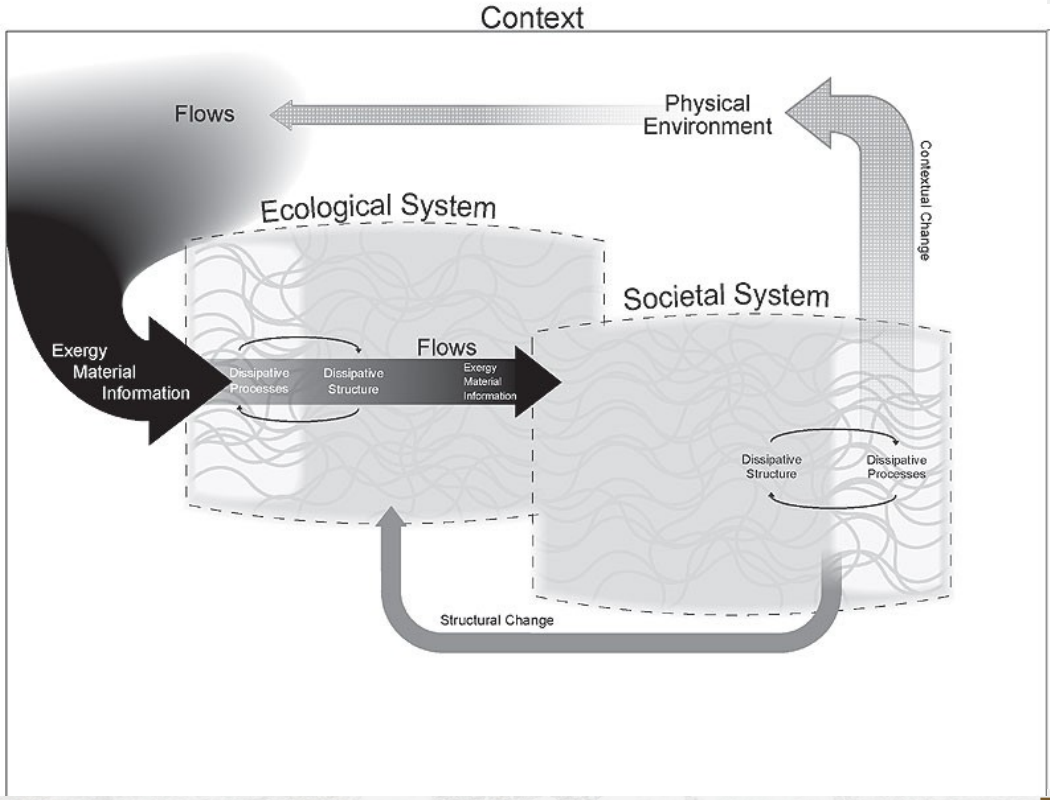


Fig. 4. A model of a single holarchical level of ecosystems and their interactions. Dotted lines represent one system forming the context for another. The arrow across the bottom represents direct societal influence on the ecological system, i.e., changing structure. The larger arrow across the top represents indirect societal influence on the ecological system, i.e., changing the context for the ecological system that cascades down to change the societal system.

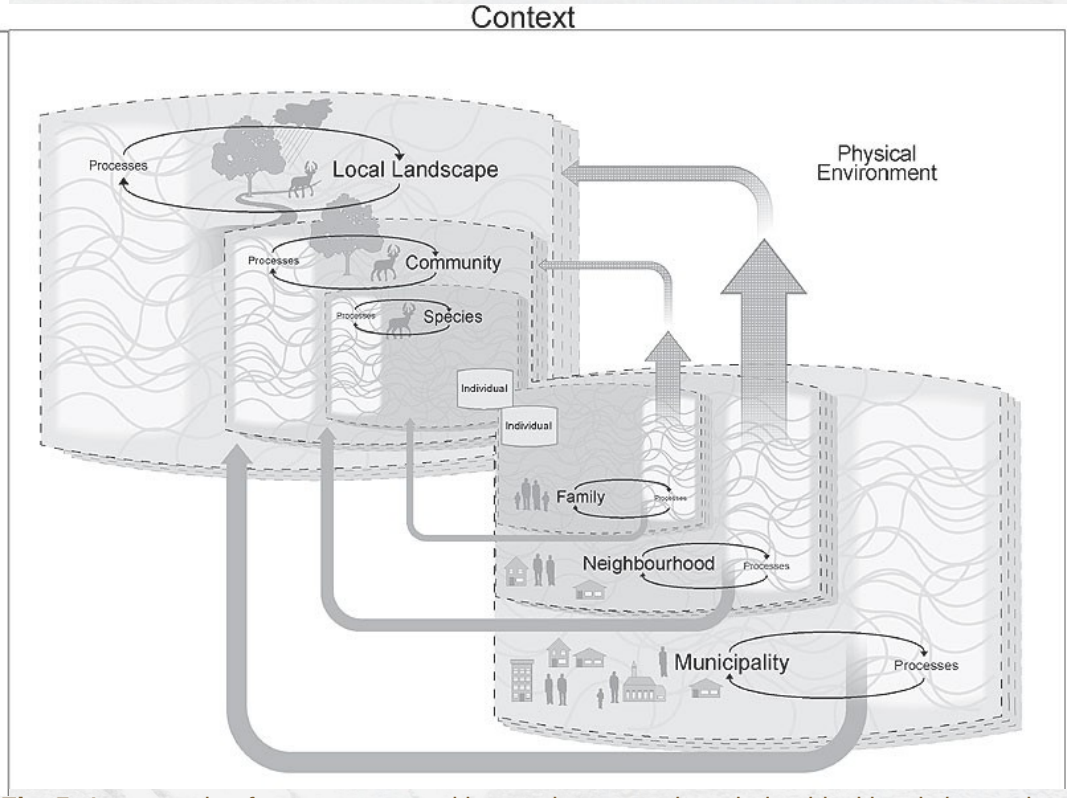


Fig. 5. An example of components and interactions over three holarchical levels beyond the individual. The "stacked deck" effect is a reminder that each level is made up of a conglomeration of defined systems, i.e., that many species together comprise an ecological community and many communities together form the local landscape. It is the aggregation of these local landscapes that makes up the landscape mosaic of a region such as a province or state. On the societal side, families and businesses comprise neighborhoods. Municipalities are made up of neighborhoods, and, finally, the province/state is politically divided into municipalities and counties. Note that this diagram demonstrates only one possible way of parsing the system.

Waltner-Toews, David, and James Kay. 2005. "*The Evolution of an Ecosystem Approach: The Diamond Schematic and an Adaptive Methodology for Ecosystem Sustainability and Health*". Ecology and Society 10 (1): a38. https://doi.org/10.5751/ES-01214-100138.

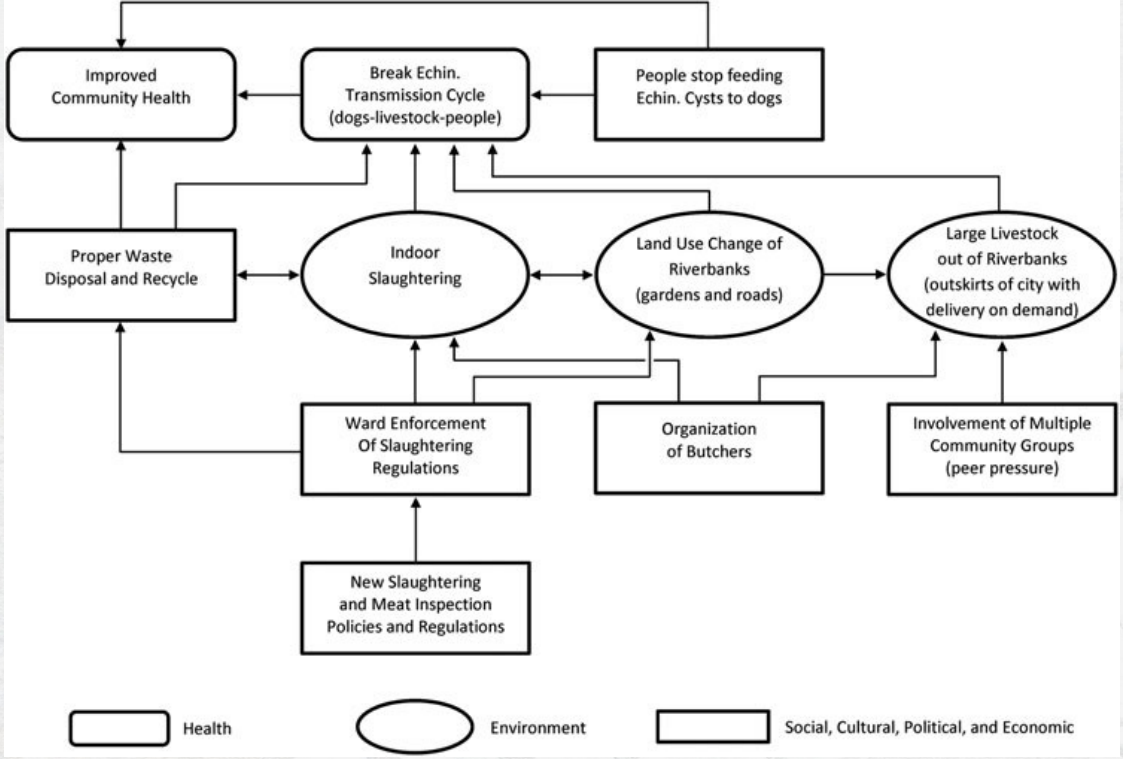


Figure 4 Social and ecological outcome pathway for breaking the cycle of echinococcosis transmission in Wards 19 and 20,Kathmandu, Nepal (Redrawn from Joshi et al. (2012))

CYSTIC HYDATIDOSIS IN KATHMANDU

The traditional 'normal science' approach failed when faced with a situation of complexity. The team decided to take another tack. As relayed by Neudoerffer et al. (2005, p. 4 [online]) "while human health remained the ultimate goal, we had decided that this could best be achieved by improving the health of the eco-social system within which that health was one outcome (i.e., taking an ecosystem approach to health)."

This ecosystem approach to the problem **widened the focus** from a single zoonotic relationship to a **wider social–ecological system**. The process became much **more participatory**, identifying and empowering various stakeholder groups such as butchers and street sweepers. They then better understood the **human social part** of the situation that was **coupled to the biophysical system**. And because the process became participatory, local stakeholders took **ownership** of the interventions, making them both more appropriate and more sustainable.

By the turn of the millennium, the 18 stakeholder groups that participated in the investigation were able to identify, implement, and successfully maintain interventions (Joshi et al., 2012). These included a biogas plant to compost organic waste, the transformation of the riverbank to community gardens, removal of livestock from the river bank, and improved and community-maintained sanitation facilities. Importantly, even though the project expanded beyond the original zoonotic point of en- try, the echinococcus transmission cycle was, in the end, broken by these multiple and interacting interventions on the landscape. For example, in Figure 4 you can track peer pressure from multiple community groups through to the removal of live- stock from the river, which is one of several contributing factors to break the cycle.

Bunch, Martin J. 2016. "Ecosystem Approaches to Health and Well-Being: Navigating Complexity, Promoting Health in Social–Ecological Systems." *Systems Research and Behavioral Science* 33 (5): 614–32. https://doi.org/10.1002/sres.2429 .

Figure 5 A photograph of a community map of Anju Kudisai, Chennai, India. The photographs were taken by men, women, and children during modified transect walks through the community that incorporated photovoice techniques. Community members took pictures of places and situations in their community that they perceived as important, and then explained their rationale to project team members. These explanations are the photo captions (in Tamil). ©NESH, with permission

ENVIRONMENT AND HEALTH IN A CHENNAI SLUM

We worked with two 'worst case scenario' communi- ties in Chennai in southern India. One of these was partially destroyed on 26 December 2004 by a Tsunami, and the population relocated to relief and rehabilitation camps, and finally to tenement structures (Bunch et al., 2005). We worked with the other, known as Anju Kudisai (or Anjukudusai) ('five huts' in Tamil), from 2004 to 2009.

The **initial regime**, for example, was characterized internally by isolation and lack of trust, a dependency relationship to outside agencies and organizations, and a physical environment that acted as a waste dump and presented health risks such as vectors for, and exposure to, enteric pathogens, cholera, typhoid, dengue, chikungunya, malaria and tuberculosis. Many of these relationships contributed to the **resilience** of the system. For example, it is well known that the illegality of the existence of such communities, that is, lack of tenure, dissuades residents from making investments in their homes and community (Durand-Lasserve and Royston, 2002).

So the team built rapport with the community, while employing a number of techniques common to participatory development. Figure 5 shows a community map that was developed as part of this process. It is illustrated with photographs taken by men, women and children in the community and captioned in Tamil.

Bunch, Martin J. 2016. "Ecosystem Approaches to Health and Well-Being: Navigating Complexity, Promoting Health in Social–Ecological Systems." *Systems Research and Behavioral Science* 33 (5): 614–32. https://doi.org/10.1002/sres.2429 .

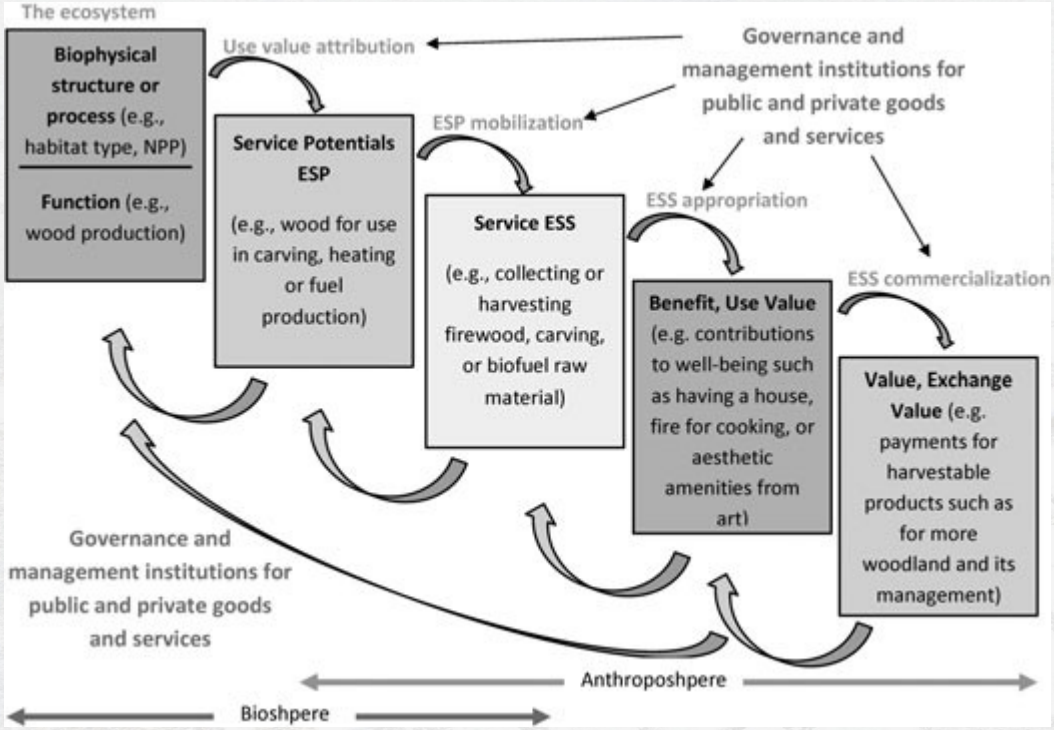


Figure 7 The cascade model of ecosystem services (modified from Verina Ingram et al. (2013) after Haines-Young and Potshin (2010) ©NESH, with permission). (NPP: Net Primary Production | ESP: EcoSystem Potentials | ESS: Eco-System Services)

Credit River Watershed

In the first phase, the focus of our project was to bring together information about **relationships between human well-being and ecosystem health** and to create a way for the public, and environ-mental managers and planners, to learn about and use that information. We hope to build awareness among communities residing and working in the watershed in order to promote watershed health and human well-being. Our approach has been to identify indicators of such relationships that are relevant to the Credit River watershed, and then to develop a web-based geographic information system (web-GIS) to allow stakeholders to explore and understand those relationships.

Figure 7 is a version of the **'cascade model' of ecosystem services** developed by Haines-Young and Potschin (2010) that we use to operationalize the relationships among ecosystems and human well-being for the purposes of developing scenarios. It demonstrates, in general, terms, how ecosystem structure and process contribute to human well-being (benefits derived from active use, passive use, and commercialization). It also nicely illustrates the **coupling of human and natural spheres in a social-ecological system**, both through this cascade and through feedback (e.g., pressures on the biophysical system and responses to mitigate pressures such as conservation actions).

Bunch, Martin J. 2016. "Ecosystem Approaches to Health and Well-Being: Navigating Complexity, Promoting Health in Social–Ecological Systems." *Systems Research and Behavioral Science* 33 (5): 614–32. https://doi.org/10.1002/sres.2429 .

Agenda

[preamble] Errors, Attention, and Traps (Ecological Understanding)

- Systems Changes Learning Circle (Bateson, Gibson, Ingold)
- (Resistances to) Changing as primary system of interest

A. Socio-Ecological Systems Perspective

- Tavistock Institute (Emery, Trist)
- Organization as primary system of interest

B. (Social-) Ecological Systems + Panarchy

- Stockholm Resilience Centre (Holling, Walker, Peterson)
- Ecology as primary system of interest

C. The Ecosystem Approach

- Resilience Alliance (Waltner-Toews, Kay)
- Sustainable development project as primary system of interest

Image CC-BY Mike Cassano (2009) *Most Interesting Pothole*