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EcoSystems Thinking

Systems Lifecycles “In the Round”

Serendipity! It was back in 1989—I came across an article in Scientific American, *The Yellowstone Fires*, by two researchers, (Romme & Despain, 1989).

The fires were unusual in that they occurred about every 40 years, in a forested area where ***lightning strikes*** were frequent: the *cause* of forest fires was ever present. So, why fires *only after 40 years*? *Curiosity aroused!*

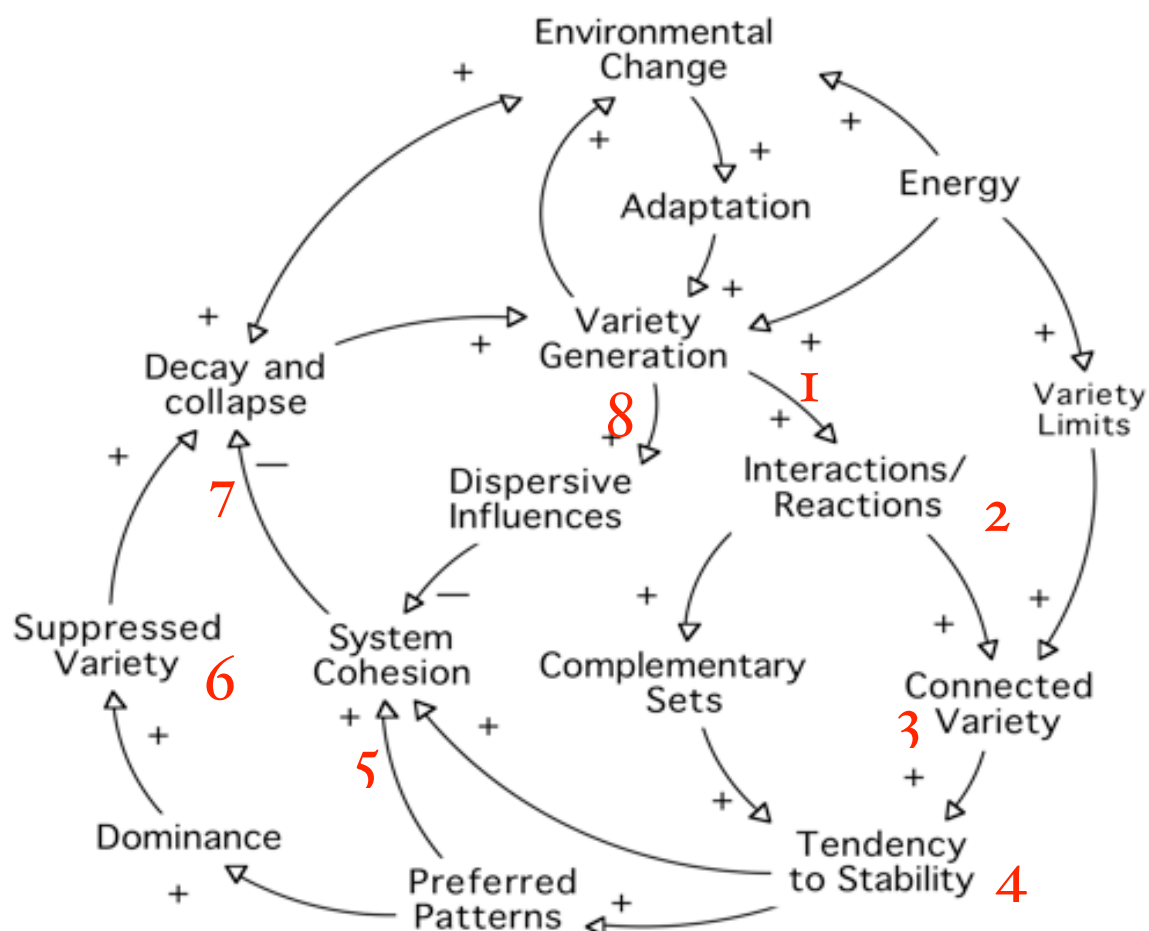
The researchers found that, after each fire, the scorched ground started to come to life with buried, fire-adapted corms sprouting, and with seeds brought into the area by birds and bats. Soon there was vigorous scrub, grasses and bracken, fertilized by the ashes from the previous forest fire.

Tree growth followed. Softwood trees grew fastest, only to die and fall after a few years, and to rot down in the damp undergrowth. That made room for the slower growing hardwoods, which grew tall, their canopies eventually shutting out the rain and sunlight, allowing a dry tinder to form from the rotted vegetation/undergrowth.

This whole process took some forty years, by which time the stage had been set for *lighting to strike* the now-dry tinder, and voila, the next forest fire...and the cycle repeated.

I was intrigued. Nice piece of research. Well done. Yet, could it be, perhaps, *a metaphor for any system's lifecycle—an ecosystem's lifecycle?* And, since an ecosystem is not only a community of interacting organisms and their physical environment, but also—more generally—a complex network or interconnected system, perhaps... Could this prove interesting?

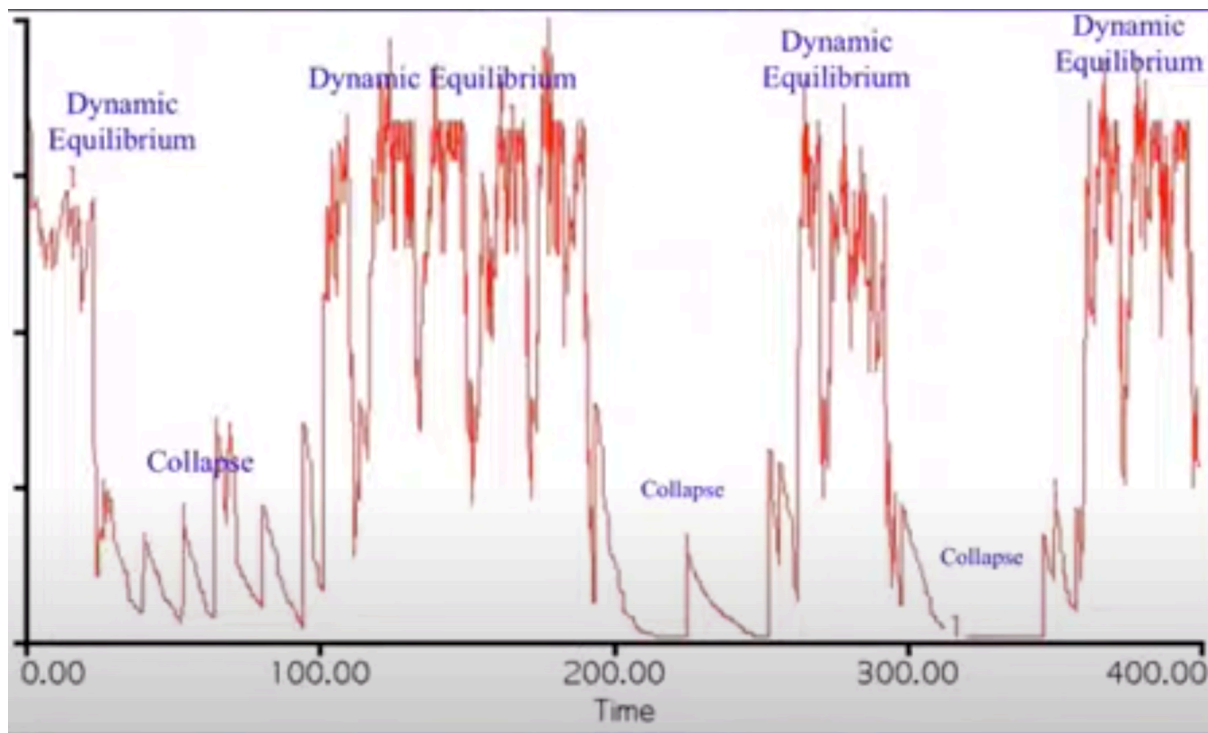
The Lifecycle Map



Note the positive feedback loop: Variety generation; Dispersive influences (i.e. Variety that does NOT interact constructively), System Cohesion, Decay and Collapse. May trigger sudden collapse of 'Moribund System' when there is a Environmental Change...

Eventually, I came up with the clockwise Lifecycle Map, ostensibly for any complex system—and the more complex, the better. The Lifecycle Map is, evidently, a continuous causal loop model, so—naturally—I explored its *system dynamics* over an extended period, with the following, interesting results:—

UST—Ecosystem Dynamics



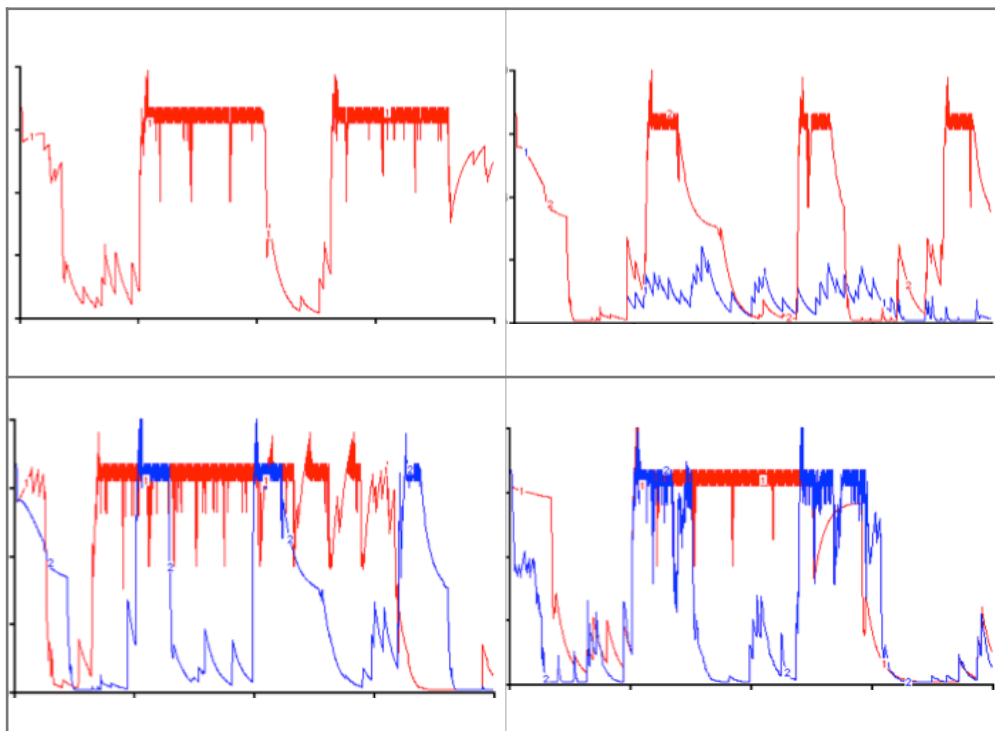
The graph differed every time it was run, but always followed the same general form: periods of dynamic equilibrium, themselves highly dynamic, but within limits; interspersed with periods of collapse, also within limits as shown, during which the ecosystem seemed to be trying to revive...

But, surely this is how ecosystems ‘behave’? Not necessarily a whole ecosystem at one time. So, in an extended ecosystem, there may be a fire or disease in one part, while the rest carries on, relatively unaffected. And in a city

‘ecosystem,’ with many districts, suburbs, arrondissements, etc., similarly, some may become ‘poorer’, crime-ridden, run-down, only to be revitalized later, while the others remain largely unaffected.

On the other hand, some civilizations seem to have behaved *en masse* like the graph—notably, ancient Egypt with its 3 kingdoms: Old Kingdom, or Pyramid Age; Middle Kingdom; and, New Kingdom. Interspersed with brief, so-called Intermediate Periods of relative chaos...

Varying Ecosystem Parameters...



- a) Upper left: nominal/reference behavior.
- b) Upper right: varying variety/diversity; low line 1, moderate line 2.
- c) Lower left: varying available energy; low line 2, higher, line 1.
- d) Lower right: varying dispersives; moderate dispersives, line 1, high dispersives line 2.

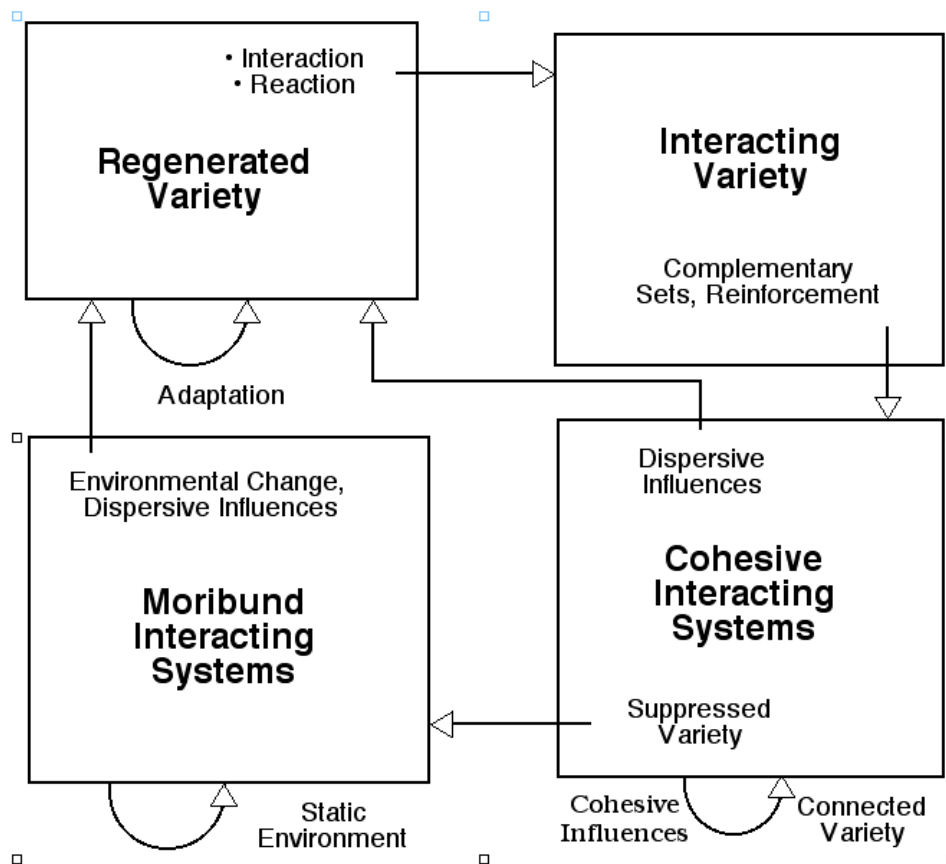
Experimenting with the parameters: Variety/Diversity; Energy; and, Dispersives in the Lifecycle Map resulted in the characteristic patterns shown above:—

- Decreasing variety/diversity in the ecosystem resulted in fewer, short-lived periods of dynamic equilibrium (homeostasis). Decreasing diversity even more prevented the ecosystem from reaching homeostasis, i.e., no substantial ecosystem ever formed...
- Reducing the available energy entering the ecosystem also resulted in fewer, short-lived period of homeostasis. Alternatively, increasing the energy resulted in a near-continuous homeostasis interspersed with longer periods of collapse, albeit with increasingly complex, highly charged dynamics.
- Finally, with more dispersives generated, the briefer, more separated in time, and more irregular were the periods of homeostasis...The dispersives (generated varieties that did not interact constructively to become connected variety) effectively served as pathogens...

Results such as these might be seen to cast doubt on some much favored governmental policies. Diversity, for instance, is seen as a *sine qua non*, and—to be sure—Diversity helps to build a robust, complex ecosystem—***provided*** the diverse elements act cooperatively. If they do not then, rather than help, Diversity *threatens* homeostasis... For example, criminal gangs and drug peddlers might be diversity too far. Obviously. But so might some sects, cultures and

characters that want to keep themselves apart, not to cooperate, but to create separate elements, isolated from the rest... perhaps intent on overthrowing society, or achieving retribution... *Unqualified Diversity* may not be all it is cracked up to be...

Unified Systems Theory—Finite State Transition Diagram



There are four states, as shown. With dominance suppressing variety, it is possible for the ecosystem to become Moribund. In this state, the system may appear unchanged. However, it lacks the variety necessary to cope with any environmental change. When that change eventually occurs, as it surely must, the whole collapses, often suddenly, and in collapsing it creates variety for the next incarnation. A classic example of such a so-called domino collapse would be that of the Soviet Union after the Cold War...and possibly the demise of the dinosaurs.

And, perhaps it's me, or does Diversity—which is about *difference*—rather contradict that other *sine qua non*: Equality—

which has to be about *sameness*. Originally, I think, about Equal Opportunity, but transmogrified into everyone being somehow equal, no matter how impossible that might be? After all, I am not equal to the me of 10 years ago, 20 years ago...70 years ago, 80 years ago. Oh! And, surely, men and women are *complementary*, not equal. Basic Biology. No, like *Unqualified* Diversity, *Unqualified* Equality is seriously suspect...

The UST can help predict the outcome of ecosystem behavior. Take Global Warming, f'rinstance. That injects more heat *energy* into the atmosphere, which absorbs more moisture. so, we may expect: not only, prolonged heatwaves; but also prolonged and deeper depressions, rainstorms, cold spells, etc. Then, prolonged droughts and prolonged floods. Altogether, more extreme weathers, maintained for longer periods...and, paradoxically for Global Warming, extended periods of cold weather, too...all courtesy of UST.

UST, also helps to cast doubt on some established hypotheses. The catastrophic end of the dinosaurs is one such. It is supposed that a meteor struck the earth some 64 million years ago, killing of all dinosaurs. Only...dinosaurs were reptiles, *yet other reptiles—crocodiles, alligators, turtles, etc.—alongside the dinosaurs—were unaffected*. As were insects, early mammals, etc. Moreover, the records show that the dinosaurs were beginning to fade out some time before the meteor strike, and lasted tens of thousands of years after it...

The figures above, with their supporting narratives, indicate the basis for the Unified Systems Theory (UST) (Hitchins, 2003) and suggest some seven systems principles, as follows:

1 **The Principle of Reactions (a.k.a. Le Chatelier's Principle)** addresses the tendency to react to change and towards equilibrium:

If a set of interacting systems is at equilibrium and, either a new system is introduced to the set, or one of the systems or interconnections undergoes change then, in so far as they are able, the other systems will rearrange themselves so as to oppose the change and establish a new point of equilibrium.

2 **The Principle of Cohesion** addresses the changing form of an interacting system and limits to growth:

A system's form is maintained by balance, static or dynamic, between cohesive and dispersive influences. The form of an interacting set of systems is similarly maintained.

3 **The Principle of Adaptation** addresses the ability of a system to endure in a changing environment:

For continued system cohesion, the mean rate of system adaptation must equal or exceed the mean rate of change of environment

4 **The Principle of Connected Variety** addresses the basis of stability between interacting systems:

Interacting systems stability increases with variety/diversity, and with the degree of connectivity of that variety/diversity within the environment

5 **The Principle of Limited Variety** addresses the limits to differentiation in interacting systems, and hence the limits to stability:

Variety/diversity in interacting systems is limited by the available space (degrees of freedom) and the degree of differentiation

6 **The Principle of Preferred Patterns** addresses the emergence of dominance:

The probability that interacting systems will adopt locally stable configurations increases both with the variety of systems and with their connectivity.

7. ***The Principle of Cyclic Progression***, importantly, examines life cycle:
“Interconnected systems driven by an external energy source will tend to a cyclic progression in which system variety is generated, dominance emerges to suppress the variety, the dominant mode decays or collapses, and survivors emerge to regenerate variety.”

These principles, and particularly the last, provide the basis for conceiving and understanding the value and application of a new "Law of Complexity"—the proposed Law of Entropic Cycling

What would such a new Law of Entropic Cycling be about? Like Kelvin’s Second Law of Thermodynamics, it will be about everything in general, but about nothing in particular. In fact, it should complement the Second Law; which applies exclusively to closed systems. The Law of Entropic Cycling, on the other hand, applies to complex, *open* systems in a not-dissimilar way.

The following is proposed as a new Law of Entropic Cycling:

Open, interacting systems' entropy cycles continually at rates and levels determined by available energy

The law applies to many, open, interacting systems, containing many systems in self-similar hierarchies, with the ordering mediated by connected variety.

In this it is unusual, since it does not seek to operate within any boundary, unlike the Second Law which, by refer-

ring to isolated systems, implies a boundary across which energy does not pass in either direction.

The Law of Entropic Cycling applies to a never-ending network of systems, providing a basis for understanding parts of this infinite network without bounds or preconceptions. Instead of isolation, the Law of Entropic Cycling embraces openness and interchange, with energy entering and leaving any part of the infinite network that may be of interest.

Lastly, UST illustrates how it would be possible to ‘dismantle’ an ecosystem, or—on the other hand—perpetuate an ecosystem...

To dismantle an ecosystem, it would be necessary only to progressively reduce its connected variety/diversity. A common example of this would be the practice of corporate accountants who, during an economic downturn, dispense with employees and trades considered unnecessary to core survival. Subsequently, when the economy picks up, the company will find itself unable to respond as it then lacks the variety/diversity to take on new business.

A recent instance concerns UK airports, during and after the COVID lockdown, when trades such as security, baggage handling, etc., were deemed superfluous. Come the recovery, the airports found great difficulty in recruiting, and handling returning passenger traffic, while airlines found themselves offering capabilities that, in the event, they no longer possessed.

Alternatively, to maintain an ecosystem indefinitely, it would be necessary to eliminate dispersive elements, and to continually refresh and maintain connected variety to accommodate the inevitably-changing environment. Examples of this are to be found in long-lived organizations that continually ‘re-invent’ themselves, and their product ranges, such as Apple and Microsoft...

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References:

Hitchins, D.K., 2003, Advanced Systems Thinking, Engineering and Management, (Chapter 6. Systems Life-cycle Theory), Artech House, Boston MA

Romme, W. H. & Despain, D. G. (1989) The Yellowstone Fires, *Scientific American*, **261**, (5).