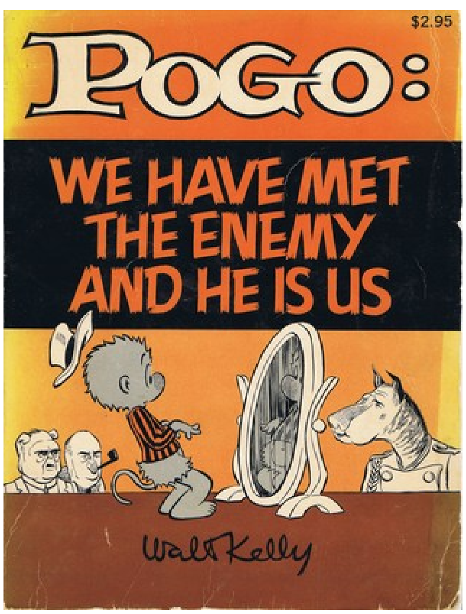
A Systems Thinker's view of how the world works

Our conventional approach to knowledge developed from our attempts to understand and build simple mechanical systems, like most of our man-made ones, from clocks to cars to computers. And that approach works well for those purposes. However, the study of complexity has revealed that many of our problems of understanding, decision making and management stem from trying to apply the same mechanical thinking to the complexity that living systems (biological, ecological and social) exhibit.

By confronting the reality of a complex world, systems thinking (ST) amounts to a whole new worldview and approach to knowledge and management of our affairs. Here I will summarize what the study of complex systems reveals that is useful in improving our thinking and decision making. In a later lecture I will build on this initial summary and contrast it to conventional approaches to knowledge.

Structure as Cause

Pogo the Possum was a quintessential systems thinker. When he said, "We have met the enemy and he is us", he meant that we often blame our problems on outside influences when the cause is the system itself in which we are operating. Then causes are said to be 'structural', or 'systemic'. Or we blame them on others when the source is ourselves. Or we address symptoms when the root cause is deeper in the system.

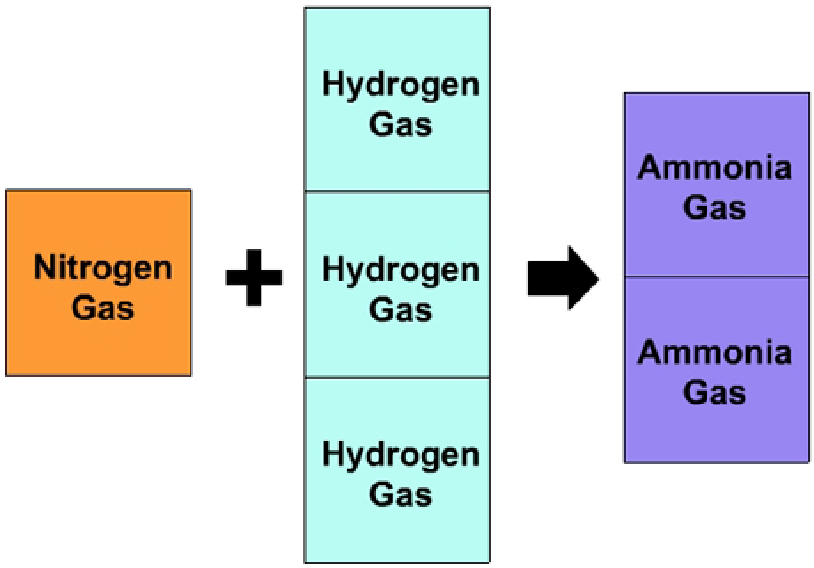


Source

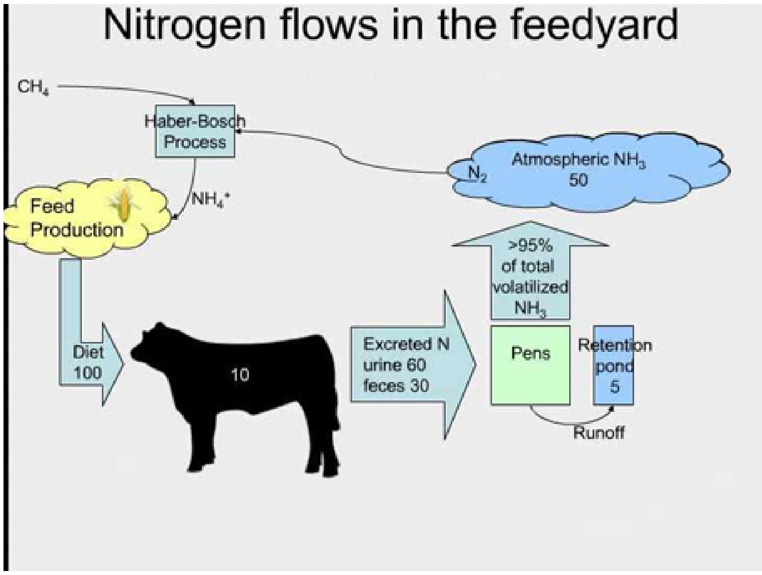
Emergence

Previously in the discussion of mental models, I said that our mental models often do not capture a full understanding of the system of influence, the systemic whole that influences and is affected in a situation that we want to understand. One of the most important concepts of ST is emergence. Wholes exhibit properties said to be emergent because they cannot be understood from a knowledge of their parts. When chemical reactions result in a new compound, that is an *emergent property*. A dramatic example:

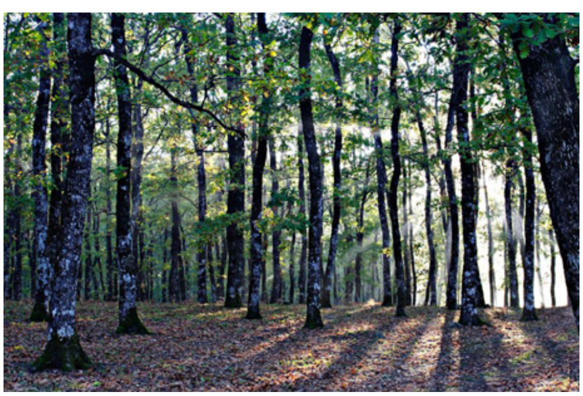
If we take a mixture of the harmless and odorless gases, nitrogen and hydrogen, and heat them to a high temperature, exchange of electrons between the two molecules occurs (symmetry breaking) and ammonia is the product with the emergent properties of a noxious and pungent gas. If this reaction had never been performed, there would be no way to predict, from the physical properties of hydrogen and nitrogen, the properties of ammonia – its properties are emergent.



Moreover, such simple interactions as creating ammonia take place within a complex systemic context, so it requires an even larger systems view of the situation to gain insight about the possible emergent properties in that situation. Example: enough ammonia created in a closed cow barn sickens cows, possibly over time even bankrupting the farmer.



Many examples of emergent properties involve more complex wholes. We are all familiar with the phrase, “not seeing the forest for the trees”. How many things can you think of that happen in a forest, but do not happen and cannot in an environment that consists of individual trees? In a forest, the trees themselves grow differently, more straight and tall, with fewer big lower branches in contrast to the way they grow singly in a pasture.

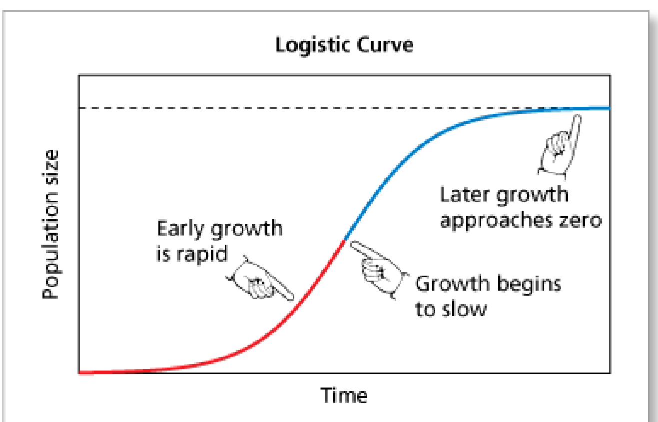


Nonlinear System Dynamics

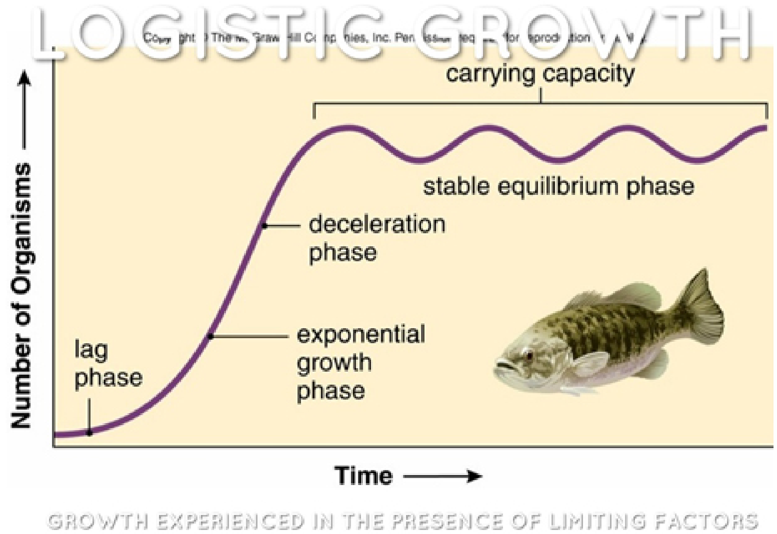
Previously I mentioned the common tendency to misunderstand how things change over time, by expecting change to be linear, so named because it is change that appears as a straight line on a time graph. An example of linear change is the decline in the quantity left in the dogfood bag when my sheepdog eats the same amount - a cupfull - every day. Linear change is highly predictable - I can calculate when I will run out of dogfood.

But much of the change that we can observe in the world is the result of numerous variables interacting to produce nonlinear dynamics including change that accelerates or slows - or even changes direction. Think of the growth of a tree or other organism over its life time. Tree growth accelerates as it gains the ability to absorb food, then slows down as it matures. On a time graph the dynamics appear as an S-curve called the Logistic Curve, which is characteristic of the growth of all living things.

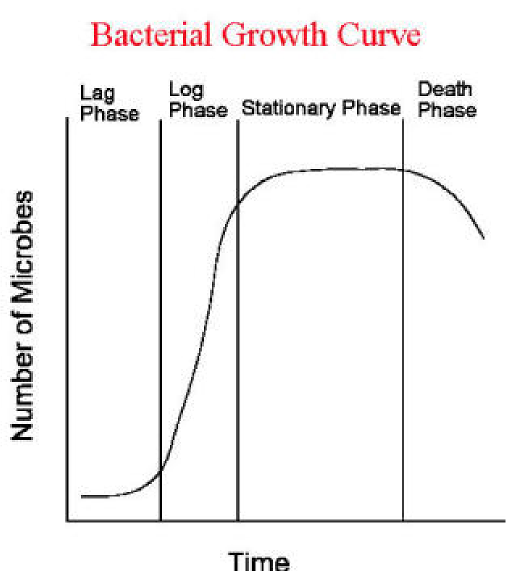
Previously I discussed the common tendency to misunderstand how things change over time, by expecting change to be linear. But much of the change that we can observe in the world is the result of numerous variables interacting to produce nonlinear dynamics including change that accelerates or slows. Think of the growth of a tree or other organism over its life time. Tree growth accelerates as it gains the ability to absorb food, then slows down as it matures. On a time graph the dynamics appear as an S-curve called the Logistic Curve, which is characteristic of the growth of all living things.



The growth of populations tends to follow a similar pattern, eventually being limited by the carrying capacity of the environment. Carrying capacity determines the dynamics of all populations in ecosystems, and is an essential concept of ecological science.



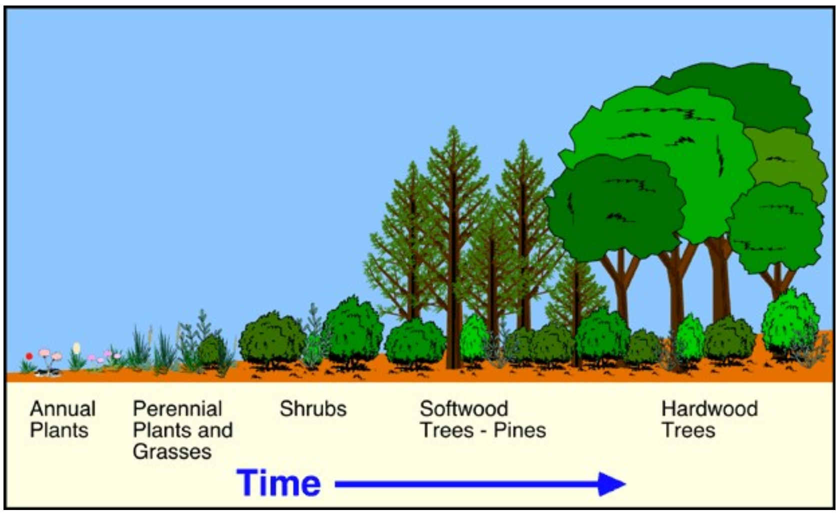
Under some conditions, populations overshoot carrying capacity, which begins to erode, causing populations to collapse. Bacteria populations in a wine making vat increase, following the logistics curve until they use up so much of the finite amount of sugar in the grapes, and produce so much alcohol that it becomes toxic, collapsing and killing the bacteria population. The rise and fall of civilizations throughout history follow a similar pattern as they deplete inputs and generate toxic outputs.



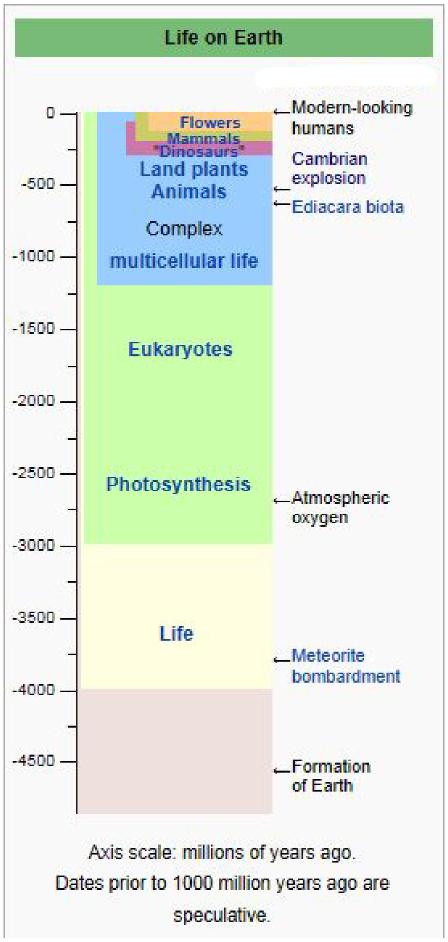
Such nonlinear dynamics are the result of chains of causation in systems that go around in circles. They are called *feedback* because the effect of initial changes ripples around the circle and further alters the initial change, either accelerating it or slowing it down.

Learning how to identify feedback effects and include them in our mental models is an essential of systems thinking and thus a prime objective of this course.

Because change is often nonlinear, it is important in systems thinking to see change in an appropriately broad time frame that captures those dynamics. In an interconnected universe, elements and their environments are always changing each other, provoking adaptation throughout the system, and causing the whole system to evolve. An example of this process is ecological succession, where whole communities of species change their environment so much that they can no longer adapt, and are replaced by other communities that do well in the new environment.



Because such processes are not controlled, but are an effect of interaction, we say they are a product of self-organization, a characteristic of complex systems. The evolution of life on earth, ecological succession writ large over several billion years, is an example of self-organization.

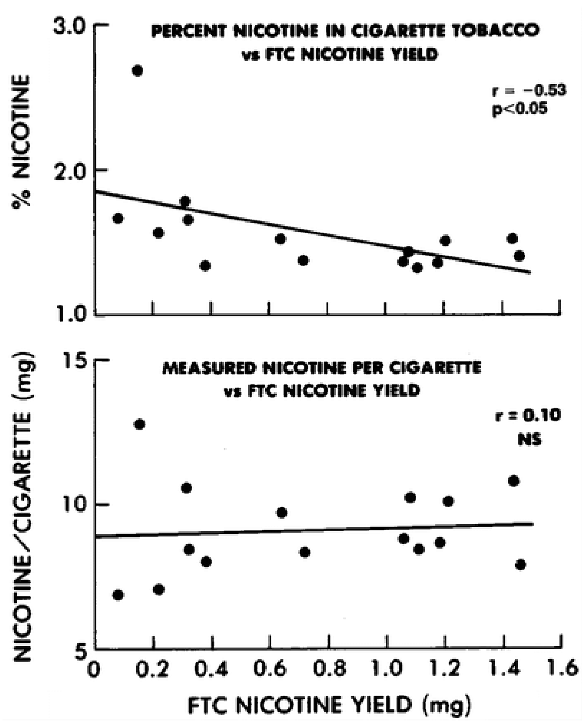


Policy Resistance, Resilience and Counterintuitive Behavior

An important but sometimes surprising characteristic of complex systems is their tendency to resist change. When disturbed, they tend revert to behavior patterns that are normal for elements in a particular structure of causal relations, if that is not changed. This property can be an advantage, or not, depending on one's management goals for the system. We want our gardens and farms to be designed to produce well despite weather changes from one season to the next. We try to design a business to be profitable despite changes in the larger economy. This quality we call resilience. But if we want to change the pattern of behavior in a system we often encounter unexpected resistance to the new policy. Here are some examples of policy resistance.

- Paving dirt roads in mountain areas leads to **decrease** in safety

- Low tar and low nicotine cigarettes actually **increase** intake of carcinogens, CO, etc.



- US policy of fire suppression has increased the size and strength of forest fires in many areas.

Policy resistance arises because we do not understand the full range of feedbacks operating in the system. In the first example of policy resistance below, paving dirt roads led to higher car speeds and more traffic, which led to more accidents, feeding back into a decrease in transport safety. Can you discover the feedbacks that are operating in the other examples to generate the unintended consequence? These unexpected consequences seem counterintuitive because our educational culture has provided little guidance in understanding the behavior that arises from complexity.

Have you ever asked yourself why does the face and even the political party in the Oval Office change but the most important policies remain the same? According to one long time insider, the reason is not so much a conspiracy or bureaucratic inertia, only smart, hard-working, public-spirited people acting in good faith who are *responding to systemic incentives*. In other words, barring deep changes systemic structure, which a new administration is often unwilling or unable to achieve, its attempts at new policies will meet resistance.

Possible Assignments:

- The pattern of living systems Michelle Holliday http://www.youtube.com/watch?v=RUIStx-nZ3I
- Meadows, http://clexchange.org/ftp/documents/Roadmaps/RM1/D-4143-1.pdf
- Counter-intuitive behavior of Social Systems: http://clexchange.org/ftp/documents/Roadmaps/RM1/D-4468-2.pdf
- Exercises: Describe in writing examples in your experience of the following qualities. You can use examples from many areas of life: Permaculture, Municipal planning, food security, food and healthcare, the economy and business, natural systems, etc.
    - System structure as Cause
    - Emergence
    - Nonlinear Behavior
    - Counterintuitive Behavior

- Policy Resistance
- Resilience