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The Competition of Beliefs: A System Dynamics Interpretation of C. S. Holling's Five World Views

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***Abstract**: In a significant article about sustainability, C. S. Holling (1992) notes that, "So much presently seems uncertain or unknown that many of the calls for action or inaction, however well supported by technical argument, are largely determined by beliefs and opinions." He then describes five belief systems, four well recognized and the fifth newly emerging. These, he argues, "are driving present debate and public confusion." Each is distinguished by assumptions about the nature of growth and change. He caricaturizes these as an exponential view, a hyperbolic view, a logistic view, a nested cycles view, and an adaptive evolutionary view.*

My purpose is to surface the assumptions implicit within each belief system. A simple dynamic systems model helps with this by replicating behaviors suggestive of Holling's belief systems. Each belief is described. Its reference behavior is portrayed. The social characteristics and individual values of adherents to each belief system are noted, and generalizations are advanced as to their most applicable domain and range.

The value of this lies in helping to identify the beliefs used by policy decision-makers, to define the shared structure of these beliefs, to understand when each is used appropriately, to stand firm before efforts to privilege but one single belief and to focus upon strengthening the shared structural foundation of competing world views.

Introduction: In a paper titled "New Science and New Investments for Sustainable Development," renowned mathematical ecologist, C. S. Holling (1992), identifies five belief systems. These are relevant to a new class of problems challenging our ability to achieve sustainable development – problems characterized by non-linear causation and intensified spatial connectivity. The complex character of contemporary problems lends to a loss of certitude, to a sense that the old ground rules no longer apply.

> So much presently seems uncertain or unknown that many of the calls for action or inaction, however well supported by technical argument, are largely determined by beliefs and opinions. Because each belief is partially relevant, impressive … arguments can be mobilized for each one no matter how opposite the result in calls for action or inaction. Four beliefs, and an emerging fifth one, are driving present debate and public confusion Each represents different assumptions concerning stability and change (Holling, 1992: 7).

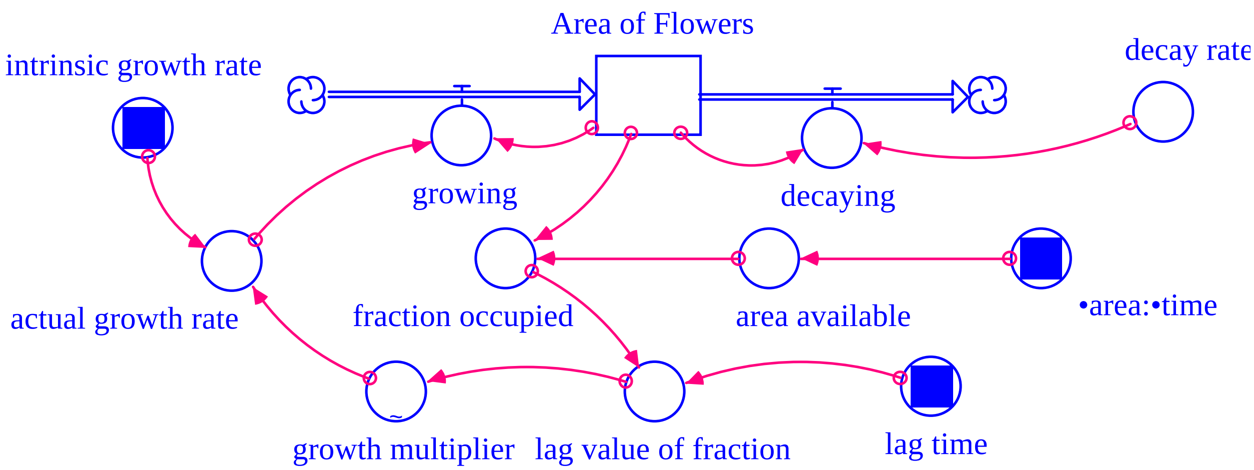
The literature on system dynamics contains frequent reference to the flower patch model. This is a model designed to track growth of wildflowers as they spread across a patch of suitable terrain. In his recent text, Andrew Ford (1999) develops a flower patch model to illustrate oscillatory behavior in a simple system with a lagged response to a constrained resource. With minor modification, Ford's flower patch model can be made to replicate temporal behaviors reminiscent of Holling's five belief systems. My intent is to use the flower patch model to surface assumptions implicit within each belief system and to identify their shared structural foundation.

To make use of the flower patch model to explore alternative belief systems, we posit an analogy between changes in the area covered by flowers and change in human wellbeing. We also posit an analogy between a limited patch of suitable terrain and the world's constrained resources.

The model begins with a stock of flowers whose area changes each year as flowers grow and die (see Figure 1). Flowers have an intrinsic growth rate. But each year's actual growth depends upon the proportion of the patch terrain already occupied. As the area remaining to be invaded declines, actual growth declines. The effect of a constrained resource could be immediate, but Ford's model includes a lagged response to resource limitations.

By varying the intrinsic growth rate, the rigidity of terrain constraints and the time lag before constraint recognition, the flower patch model can be made to represent a variety of temporal trajectories in the patch's stock of wildflowers. Producing these responses is aided by adding sliders to modify growth rates, lag times and temporal change in resource availability.

Figure 1. System Map for the Flower Patch Model



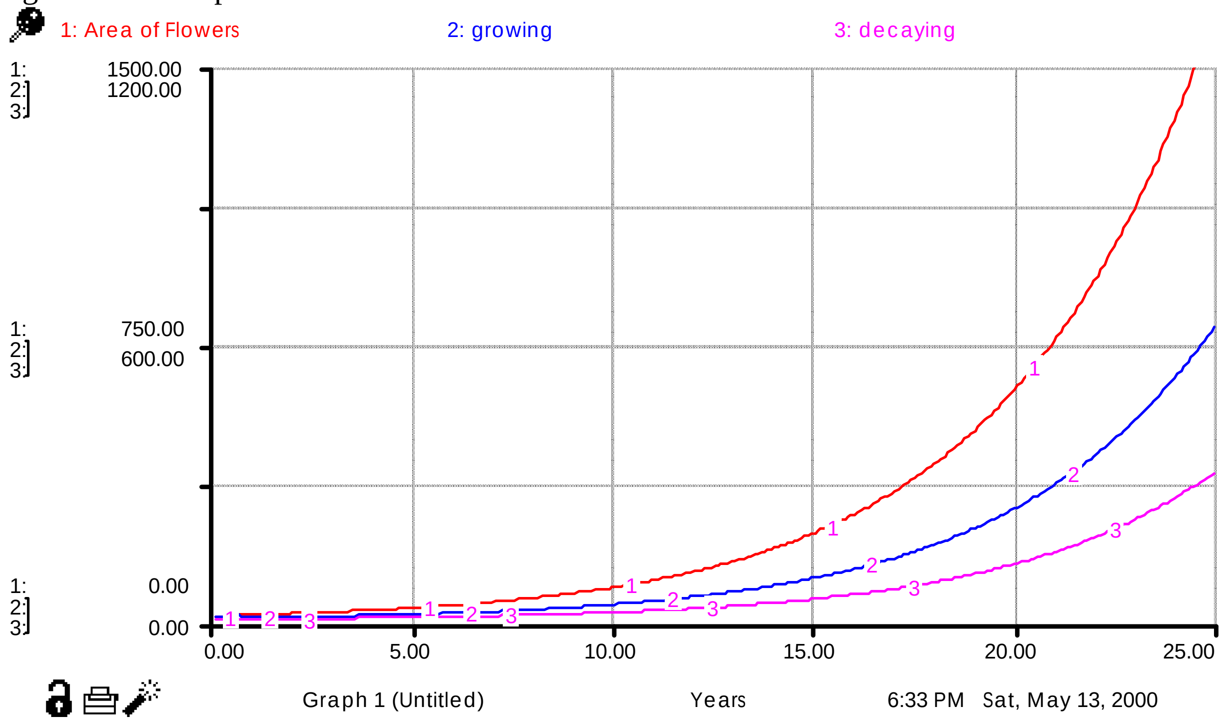
Five Belief Systems: Holling's five belief systems represent worldviews about the nature of social and environmental change (1992). Each is identified by the mathematical function that best corresponds to each belief's view of the trajectory of human well being. The beliefs include the exponential view, hyperbolic view, the logistic view, the nested-cycle view and the adaptive evolutionary view. These views reflect beliefs about the causes of change and the justifications for action. Each has corollaries about the kinds of social characteristics and individual values that society should most endorse. The relevance to issues of sustainability is immediately apparent.

The Exponential View. Pundits and policy decision-makers will often affirm a belief in the concept of exponential growth. This belief is grounded in an optimistic assessment of the race between resource scarcity and technological progress. According to this belief, the only scarce resource is human ingenuity. With ample ingenuity, wealth can grow exponentially.

There are corollaries to this belief. If growth is exponential, political conflicts can be resolved by more growth: political discourse is not essential. Expanding wealth can easily resolve struggles over inequitable allocations. Disasters and setbacks can be addressed by drawing upon an expanding supply of off-site resources. So, issues of who gets what should always be settled in favor of those with the greatest ability to innovate. Sensing ironic contradiction in this position, Norgaard (1994: 202) suggests that, "If resources are scarce in the short run yet abundant in the long run, economics ought to be putting all of its emphasis on how to make the long run shorter."

The flower patch model suggests the same effect can be obtained by diverting attention from both constraints and the long run. Let the suitable terrain increase with time, set a low lag-time and focus on the short run. Conveniently, the model plots an exponential growth trajectory. The intrinsic growth rate sets the time for growth to reach near vertical assent. Otherwise, resource constraint relaxation and system response agility determine the model's behavior.

Figure 2. The Exponential View

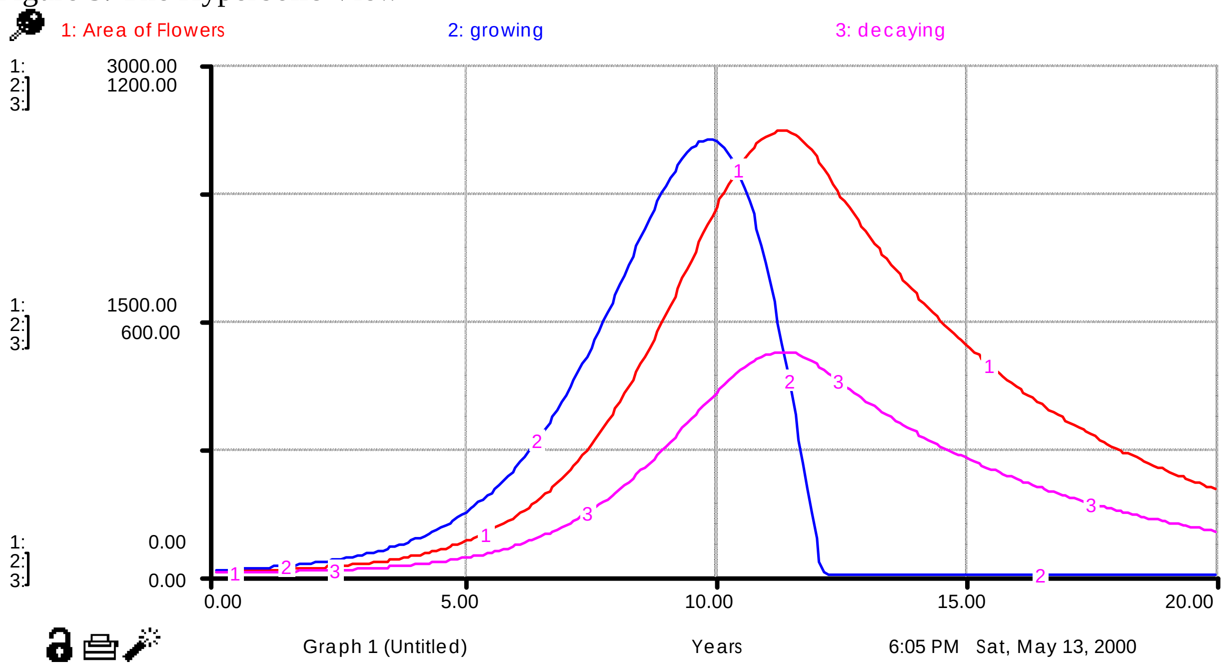


<u>The Hyperbolic View</u>. In opposition to this belief is the hyperbolic view. This is a belief that exponentially expanding systems inevitably exceed carrying capacities and then collapse into disintegration. As technical progress is overwhelmed by resource scarcity, the system collapses under the weight of pestilence, famine, regional wars, plagues and hyperinflation. Debt, not wealth, is the only human construct capable of sustained exponential growth.

If growth is hyperbolic and collapse is inevitable, then issues of economic justice and allocation are central. Social reproduction and economic allocation should be decentralized. Local initiatives should be privileged. Massively parallel provisions should be organized to reduce associated risks.

To plot a hyperbolic pattern, set the resource constant and lag-time high. Growth rate variation has little effect. The hyperbolic view depends on limitations in our willingness and ability to respond to the constraints presumably imposed by non-renewable, non-substitutable resources.

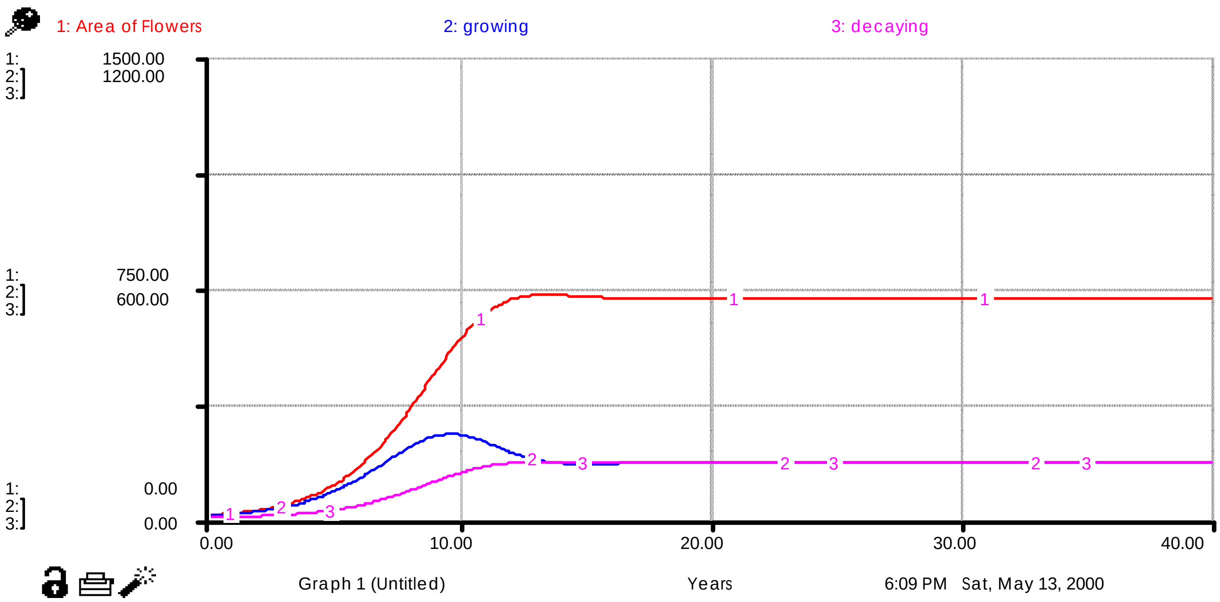
Figure 3. The Hyperbolic View



<u>The Logistic View</u>. The logistic view holds that exponential growth is but the initial phase of system organization. With growing evidence of resource constraints, growth slows down and approaches capacity limits in ever-smaller increments. The system approaches but does not exceed sustainable limits on activity levels. The corollary here directs attention to the value of resource monitoring, environmental conservation, systems maintenance and growth control.

In the flower patch model, the only important difference between the hyperbolic view and the logistic view is a significantly more agile response to a resource constraint. A willingness and ability to respond to limitations is the only difference between sustainability and collapse. (Allowing suitable terrain to change with time accommodates flexibility in resource constraint. Then, patch growth approaches asymptotically a controlled expansion in resources.)

Figure 4. The Logistic View


1: Area of Flowers
2: growing
3: decaying
1: 1500.00
2: 1200.00
3:
1: 750.00
2: 600.00
3:
1: 0.00
2: 0.00
3:
0.00
10.00
20.00
30.00
40.00
Graph 1 (Untitled)
Years
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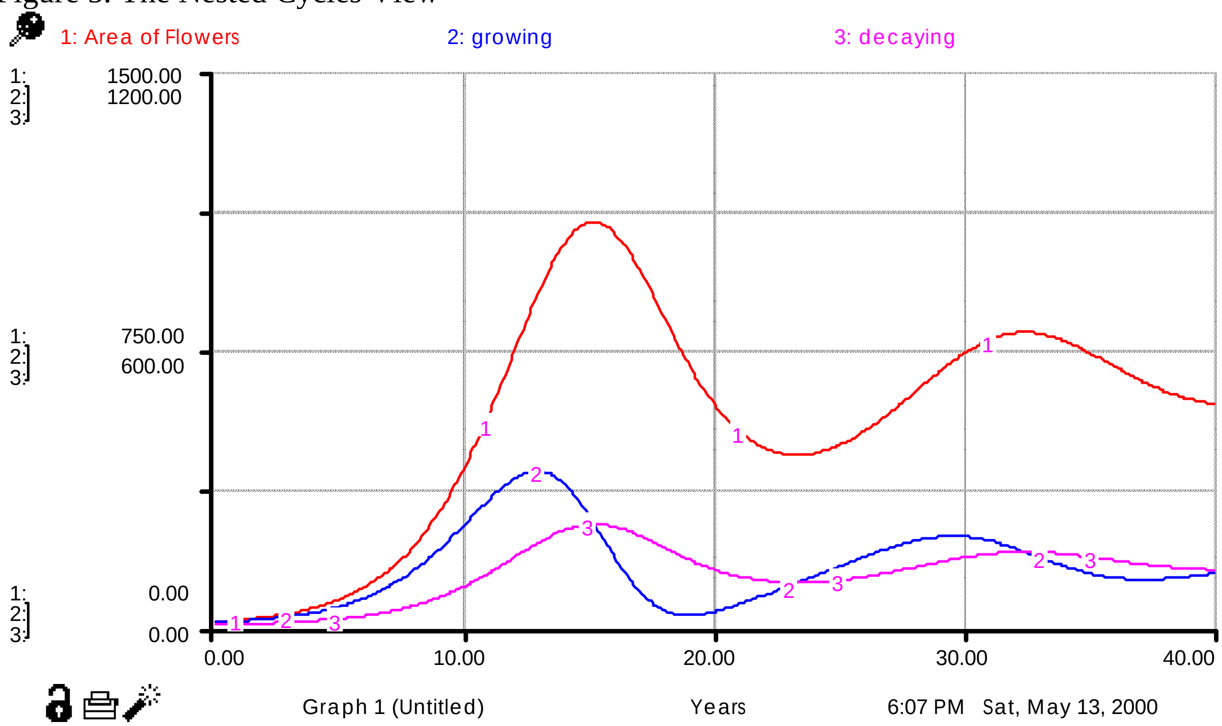
The Nested Cycles View. A fourth view sees change as occurring in nested cycles, with periods of exponential growth, stasis, collapse, readjustment and recovery initiated by discontinuous events and non-recurring processes. This concept of change is closely associated with the concept of progress as both accumulation and dissipation. With progress, things are continually gained and lost as we move along a path that wanders through all possible realms (cf. Toulmin, 1972).

The corollary here is that society will find itself in a variety of circumstances. Policy choices will be largely contextual. Thus, tools for system monitoring, prognostication and risk mitigation are especially valued: so, too, are tools for the conservation of landmarks and cultural traditions.

With some stretching of our analogy, the flower patch model can be made to replicate this behavior, too. Retain the feature of a constrained resource. Set the growth rate and the response lag-time to intermediate values. The model generates an oscillating pattern. Adding a random factor to the growth rate or the lag-time keeps oscillations from being stable. The resulting pattern captures both Holling's and Toulmin’s sense of the nested cycles view. A familiar variation is obtained by letting resources increase through time: a pattern of long term growth with cyclical variation results.

The flower patch model shows the parameters producing an oscillatory pattern to be little different from those of a logistic or a hyperbolic pattern. An oscillatory system is either a poorly responsive logistic system or a more effectively responsive hyperbolic system.

Figure 5. The Nested Cycles View



An Intermediate Summary. A review of Table 1 indicates that the main differences among the four belief systems are not due to differences in intrinsic growth rates. Growth rates appear not to be at issue. Rather, behavioral differences are due to the rigidity of resource limitations, the agility of system response and the length of ones time horizon. While resource constraints appear important, basic behavioral patterns can be maintained with both a modestly increasing and a modestly decreasing resource base.

In the short run, system behaviors appear to be either exponential or hyperbolic. Over a longer term, behaviors appear to be either logistic or oscillatory. Rapidly responsive systems are either exponential or logistic. Poorly responsive systems are either hyperbolic or oscillatory. Thus ones preference among belief systems depends importantly on ones temporal perspective and ones view of the system's agility.

<u>The Adaptive Evolutionary View</u>. A fifth emerging view sees system change as the adaptive co-evolution of values, organizations, technologies, environments and knowledge in flexible, organic fashion responding to the need for a continued re-equilibration of social contradictions (Norgaard, 1994). Systems are currently unknowable. Holling's ecosystem management puzzle explains why initially successful management leads to more brittle, more vulnerable systems, to dependent societies and more rigid management policies. According to the fifth view, the paradoxes of ecosystem management are mere reflections of instrumentally oriented human intentions.

This view suggests that instrumental intention be replaced by respect for process. Flexibility, redundancy, networking and communication strategies are emphasized as contributing to adaptive judgments. A special premium is placed on honesty, sincerity, truthfulness and comprehensibility. Rationality is no longer regarded as an individual or local optimization. Instead, it is seen as a collective, deliberative process seeking to balance multiple considerations out of respect for the integrity inherent in natural systems and in diverse and competing interpretations of reality.

Manipulating the parameters of the flower patch model offers no direct analogy. Instead, the analogy is forged by reflection upon the model itself. Someone intrigued by this fifth view is inclined to ask questions about the model and its parameters. Which resources are truly non-renewable and non-substitutable? Are we in the first world enjoying the benefits of expanded human ingenuity? Or does the geographic transfer of globally limited resources sustain our current wellbeing? Why do certain actors and institutions consistently favor either a short term or a long-term view of reality? Why do certain actors and institutions consistently favor an increase in system monitoring? Why do others consistently seek to selectively direct this activity? Which values, organizations, technologies, environments and epistemologies are consistent with which belief systems? How do societies break out of reliance upon belief systems and develop systematic understandings of their inherent condition?

An analogy is also forged by the run-time manipulation of the flower patch model. The first four belief systems represent the world as parametrically set and then launched into motion. There is no possibility of stopping the model in mid-course, adjusting its parameters and setting it in motion again. Nor are there ways to densify the model's structure to make it more robust. An adherent of the fifth view would see the flower patch model as adjustable. She would recognize the need to shorten lag times in response to resource diminution. She would recognize the need to intensify innovation or curtail growth and would add structures to pass information and initiate action, not simply to maintain production, but rather to respect system integrity and enhance its robustness in response to unforeseen perturbations.

Table 1. Parametric Settings for the Flower Patch Model

		Behavioral Trajectory		
parameter	Exponential	Hyperbolic	Logistic	Oscillatory
intrinsic growth rate	0.8	0.8	0.7	0.6
• area : • time	300	0.0	0.0	0.0

response lag time	0.1	5.0	1.0	3.8

Concluding Observations. Each belief represents a partial truth. In an appropriate context, each is supportable. The issue is not which is right or which is wrong. The issue is to realize how human intentionality and the quest for certainty compel recourse to a set of beliefs whose shared structure is embarrassingly simple. Contesting which belief shall dominate displays a will to ignorance that can be comprehended only in terms of the will to power. Moving beyond this condition requires abandoning both in favor of a will to systematic understanding.

References.

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Norgaard, R. B. (1994) *Development Betrayed*, Routledge, London.

Toulmin, S. J. (1972) *Human Understanding*, Princeton University Press, Princeton.