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Editorial

Theories for Sustainable Futures

C. S. Holling

University of Florida

- Responses to this Article

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Make things as simple as possible. But no simpler. (Albert Einstein)

Sustainable development and management of global and regional resources is not an ecological problem, nor an economic one, nor a social one. It is a combination of all three. And yet actions to integrate all three typically have short-changed one or more.

Sustainable designs driven by conservation interests often ignore the needs for an adaptive form of economic development that emphasizes human economic enterprise and institutional flexibility. Those driven by economic and industrial interests often act as if the uncertainty of nature can be replaced with human engineering and management controls, or ignored all together. Those driven by social interests can act as if community development and empowerment of individuals encounter no limits to the imagination and initiative of local groups. Each view captures its prescriptions in code words: regulation and control; get the prices right; empowerment; stakeholder ownership. These are not wrong, just too partial. Investments fail because they are partial. As a consequence, the policies of governments, private foundations, international agencies, and NGOs flop from emphasizing one kind of myopic solution to another. Over the last three decades, such policies have switched from large investment schemes, to narrow conservation ones to (at present) equally narrow community development ones.

Each group builds its efforts on theory, although many would deny anything but the most pragmatic and nontheoretical foundations. The conservationists depend on theories of ecology and evolution, the developers on variants of free-market models, the community activists on theories of community and social organization. All these theories are correct, in the sense of being partially tested and credible representations of one part of reality. The problem is that they are partial. They are too simple. We lack an integrated theory that can serve as a foundation for sustainable futures, a theory that recognizes the synergies and constraints among nature, economic activities, and people, a theory that informs and emerges from thoughtful practice.

Evidence points to a common cause behind past failures of investments in sustainable development. Historically, the management of forest, rangelands, fisheries, and wildlife resources was dominated by theories of carrying capacity and goals of sustainable yield. Human behavior was ignored. The application of these theories led to the expectation that target variables such as employment could be stabilized and created a demand for a constant flow of product. These policies were successful initially, and profit and employment were, in fact, stabilized. But their very success resulted in slow changes in key ecological, social, and cultural components not captured in the management models: changes that typically led to the collapse of the entire system. The "economic extinction" of cod along the coast of eastern North America is a prime example. From a review of a wide range of failed sustainable development initiatives, a common pathology emerges. At the extreme, the ecological system loses resilience, the industries become dependent and inflexible, the management agencies become rigid and myopic, and the public loses trust in governance.

There are so many examples of this pathology that we have learned the lesson well in theory, if not entirely in practice. We recognize that human behavior and nature′s dynamic are linked in an evolving system. We realize that the seeming paradox of change and stability inherent in evolving systems is the essence of sustainable futures. We now know that to counteract the current pathology we need policies that are dynamic and evolutionary. We need policies that expect results that are inherently uncertain and explicity address that uncertainty through active probing, monitoring, and response. However, we cannot successfully implement these new policies because we have not learned the politics and we ignore the public.

To date, the papers in *Conservation Ecology* that have focused on Adaptive Ecosystem Management and global change have carryied a gloomy message. Many provide examples in which the implementation of probing policies that recognize uncertainty and that allow for learning is frustrated. The realization of these new policies is frustrated by bureaucratic politics within organizations and by power politics outside agencies. Bureaucracies can become as much vested interests as can environmentalists and industries, and the politics of each group can exploit uncertainty in explicit disinformation campaigns. And we scientists provide the ammunition for them when our delight in rigorous analysis of the parts of a system ignores the consequences of the interaction of the parts and blinds us to political realities. It is no wonder that science and scientists have a bad name in so many situations in which collaboration among scientists, small enterprises, and conservationists could so obviously be a benefit to all.

Is the failure to implement dynamic and evolutionary policies the result of the inherent complexity of these ecological, economic, social systems? That view is incisively explored by Emery Roe in his book *Taking Complexity Seriously.* That book is reviewed in this issue of *Conservation Ecology* from four perspectives, including the author's. That view sees complexity as anything we seem not to understand because there apparently are large numbers of interacting elements. Here I present another, alternative view suggesting that such complexity may be in the eye of the beholder, and that most of the "large number of interacting elements" may be, in fact, the consequence of a smaller number of controlling processes. It is this latter view to understanding the smaller number of controlling processes that opens a line of deep enquiry about complex evolving systems. Both views provide the motivation and direction needed to develop alternative perspectives and models. And both provide a focus for the kind of deliberative conversations about difficult issues that *Conservation Ecology* encourages. There is no one path to understanding.

The alternative view that I propose argues that there is a requisite level of simplicity/complexity behind complex, evolving systems that, if identified, can lead to understanding that is rigorously developed but also can be lucidly communicated. It argues that if you cannot retain a handful of causes in your explanation, then your understanding is simplistic. If you require more than a handful of causes, then it is unnecessarily complex. If you cannot explain it to your neighbor, you do not truly understand it. That level of understanding is built upon a foundation of adequate integrative theory, rigorously developed, rooted in empirical reality, and communicated clearly with metaphor and example. The first requirement to achieving that level of understanding is to begin to integrate the essence of ecological, economic, and social science theory. And we need to do so with a goal of being "as simple as possible but no simpler".

In the late 1980s, the Royal Swedish Academy of Science established an institute, The Beijer International Institute of Ecological Economics, to bridge the disciplines of economics and ecology and, more generally, the natural and social sciences. One of the inspired creations of the Director, Karl-Göran Mäler, was an annual meeting on an island in the Swedish archipelago of economists, ecologists, mathematicians, and others from the natural and social sciences. There was never an agenda – only one or two general questions. What is poverty? What ecological and human stresses come from population growth? What is resilience of an economy? Of an ecosystem? How to measure values?

Out of those meetings and their deliberative conversations came a growing, deep understanding among the participants of fields other than their own. Not the superficial polarization so characterizing much debate, but understanding of strengths and weaknesses. The surprise was that there was so much agreement between ecologists and economists: the world′s human and natural systems are becoming dangerously stretched; the methods of each discipline had remarkable similarities; the theories and mathematics were strangely similar—and inadequate. The critical differences were amazingly slow to emerge. The desire for collaborative dialogue and the sheer decency of a Swedish context led us to steer away from disagreements. But it is the tension of differences that can crystallize discovery.

It ultimately became clear that there were deep and fruitful differences. Each of the primary fields of economics, ecology, and institutional analysis has developed tested insights. But each is missing key elements that would allow for the kind of integrative theory and practice that is required for sound decision making on sustainable resource use issues. As examples:

Economics: Modern economics has gone far in discovering the various pathways through which millions of expectations of, and decisions by, individuals can give rise to emergent features of communities and societies (e.g., rate of inflation, productivity gains, level of national income, prices, stocks of various types of capital, cultural values, and social norms). Two factors make economic theory particularly difficult. First, individual decisions at any moment are themselves influenced by these emergent features, by past decisions (e.g., learning, practice, and habit), and by future expectations. Second, the emergent features that can be well handled by existing economic theory and policy concern only fast-moving variables. The more slowly emergent properties that affect attitudes, culture, and institutional arrangements are recognized, but are poorly incorporated.

Economists know that success in achieving financial return from fast dynamics leads to slowly emergent, nearly hidden, changes in deeper and slower structures, changes that can ultimately trigger sudden crisis and surprise. But the complexities that arise are such that most modern economists are frustrated in their attempts to understand the interactions between fast- and slow-moving emergent features.

Ecology: Ecosystem ecologists have made it plain for a long while that some of the most telling properties of ecological systems emerge from the interactions between slow-moving and fast-moving processes and between processes that have large spatial reach and processes that are relatively localized. Interactions between, for example, regional patterns of vegetation formed by major disturbance processes like fire and insect outbreak, and local species composition formed by competition among species. Those interactions are not only nonlinear, but also they generate alternating stable states and normal journeys of biotic and abiotic variables through those states. It is those journeys, measured in years, decades, and centuries, that maintain the diversity of species, spatial patterns, and genetic attributes that give resilience to ecological systems.

What this tells us is that variability is not merely an inconvenient characteristic of productive, dynamic systems. Rather, it is critically necessary to their maintenance. Ecologists have made significant advances in understanding the specific role of variability in maintaining the resilience of natural systems and the conditions that cause a system to flip into an irreversible, and typically degraded, state controlled by unfamiliar processes.

However, ecologists have been largely ignorant of human behavior, organizational structures, and institutional arrangements that mediate the relationships between people and nature.

Social Science: Institutional theory and analysis does consider such features, but in a largely static sense. Hence, it also stops just short of the confluence point among the three fields that could provide us with the integration we need. Institutional theory currently provides an understanding of the variety of arrangements and rules that have evolved in different societies to harmonize the relationship between people and nature. Social scientists have gone far in describing the way people store, maintain, and use knowledge in stable circumstances. But an integrative approach requires attention to the very same dynamic dimensions that economics and ecology, each in their own way, have developed.

In order to plan for sustainability, we need to know, and we need to integrate, how information is evaluated and how counterproductive information is rejected at times of deep change. How is new "knowledge" created from competing information sources and incorporated with useful existing knowledge? Which processes create novelty, which smother innovation, which foster it? None of the disciplines of ecology, economics, and institutional theory, as construed at present, can, in isolation, help in these fundamental questions of innovation, emergence, and opportunity.

Evolution and Complex Systems: Yet, those questions are at the heart of development: the emergence of novelty that creates unpredictable opportunity. It is biological evolutionary theory, expanded to include cultural evolution, that does deal with just those questions. The recent invention of complex systems studies explicitly sees ecological, economic, and social systems each as specialized representations of a complex adaptive system. There have been wonderful advances achieved by borrowing those mechanisms that generate variability from known biological processes and exposing the emergent patterns that result. But, as for each of the other fields, the representations are partial. They are detached from efforts to represent the necessary and just sufficient complexity in natural and human processes, and to test the adequacy and credibility of the results.

Even the most ruthlessly pragmatic goal for developing policies and investments for sustainability needs a theoretical foundation that integrates ecological with economic with institutional with evolutionary theory and that overcomes the disconnect rooted in current theoretical limitations within each field.

It was this diagnosis that launched the "Resilience Project", a five-year effort of an international group of ecologists, economists, social scientists, and mathematicians. The project initiated a search for integrative theory and integrative examples of practice. The goal was to develop and test elements of an integrative theory at the level of simplicity necessary for understanding, but with the complexity required for developing sustainable policy.

The results of Resilience Project are summarized in the final report to the MacArthur Foundation (http://www.resalliance.org/reports/). For me, it was a huge advance in unraveling the puzzles and paradoxes that had confused me over the years in my efforts to understand the interactions between nature and people. The fundamental paradox is that change is essential, and yet stability is necessary. Together with some 120 scientific papers that arose out of the work, the four forthcoming books from the project constitute an important contribution to the theory of sustainable use of natural resources. In the exuberance of discovery, those results were boiled down to 10 conclusions, as noted in the final report: 10 tablets from the Resilience Mountain!

The heart of the work is now developed and described in a book in press with Island Press, edited by Lance Gunderson and C. S.Holling: *Panarchy: Understanding Transformations in Human and Natural Systems.* Panarchy is the term we devised to describe the evolving nature of complex adaptive systems. It encapsulates how novelty and change coexist in a context of persistence and stability. It resolves the paradox of change and stability.

We define panarchy to be the structure in which systems of nature (e.g., forests, grasslands, lakes, rivers, and seas), of humans (e.g., systems of governance, tribes, and cultures), as well as combined human—nature systems (e.g., agencies that control natural resource use), are interlinked in never-ending adaptive cycles of growth, accumulation, restructuring, and renewal. These transformational cycles take place in nested sets at scales ranging, for example, from a leaf to the biosphere, over periods from days to geologic epochs. By understanding these cycles and their scales, it seems possible to identify points at which a system is capable of accepting positive change, and possible to use those leverage points to foster resilience and sustainability within a system.

The panarchy summarizes succinctly the heart of what we define as sustainability. The fast cycles invent, experiment and test; the slower ones stabilize and conserve accumulated memory of past successful, surviving experiments. In a healthy system, each level is allowed to operate at its own pace, protected from above by slower, larger levels, but invigorated from below by faster, smaller cycles of innovation. The whole panarchy is therefore both creative and conserving. The interactions between cycles in a panarchy combine learning with continuity.

This clarifies the meaning of sustainable development. Sustainability is the capacity to create, test, and maintain adaptive capability. Development is the process of creating, testing, and maintaining opportunity. The phrase that combines the two, sustainable development, therefore refers to the goal of fostering adaptive capabilities and creating opportunities. It is therefore not an oxymoron, but represents a logical partnership.

Sustainable futures are ones in which the basic means of human livelihood get easier, human opportunities become richer, and nature's diversity is more sustained — and not only in the rich parts of the world. Utopian, perhaps, but the resilience of nature and the ingenuity of people would make it feasible, if our institutions and those who utilize and control them had sufficient flexibility and vision. The ultimate test of the discoveries and conclusions from the Resilience Project will be the extent to which the resulting solutions generate problems less costly than their predecessors and opportunities more viable.

A new international consortium of researchers, the Resilience Alliance (http://www.resalliance.org), has been established to carry forward the findings of the Resilience Project. The Alliance will use case studies from around the world to test and refine the new theories that emerged from the Resilience Project through thoughtful application and experimentation. The Alliance will also continue to seek new theoretical foundations for the integration of ecology, economics, and social science by further exploring the insights achieved through the Resilience Project.

We call for the submission of papers to *Conservation Ecology* that give examples of these new types of solutions as profiled by the Resilience Project — solutions that fundamentally deepen our understanding of resilience and sustainability.

RESPONSES TO THIS ARTICLE

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Address of Correspondent:
C. S. Holling
Department of Zoology
University of Florida
223 Bartram Hall
Gainesville, Florida 32611-2009 USA
Phone: (352) 543-6955
Fax: (352) 392-3704
holling@zoo.ufl.edu
