GOOD GOVERNANCE: COMPLEXITY, INSTITUTIONS, AND RESILIENCE

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Scholars in disciplines from ecology to economics and biology to sociology generally agree that a necessary condition of sustainable development is maintenance of ecosystem services at every scale of social and ecological system. As the rate of global change—both ecological and socio-economic—increases, the characteristics of resilience in ecological and social systems have become an increasingly important focus of research. Resilience is the ability to experience change and disturbance without catastrophic qualitative change in the basic functional organization: it is a measure of the system's integrity (Holling, 1973).

Resilience research, an important subset of sustainability science (Kates et al 2001), is determinedly holistic: it treats social and ecological systems as a fully integrated whole.[1] Thus, the concept of resilience, originally defined within ecology, has been directly applied to social systems as an integral part of the whole social-ecological system. In a related move resilience research has embraced complex systems theory (CST), which, because it is less a theory than a set of ideas, may be better thought of as 'complex systems thinking'.[2] CST is "used to bridge social and biophysical sciences" because "linked systems of people and nature . . . behave as complex adaptive systems (Folke et al 2002, 15 and 12)."

For several reasons elaborated in this paper both the integration of social and ecological systems and the application of complex systems theory to explain integrated social-ecological systems are problematic. While a vision of interdependent social and ecological systems undoubtedly helps conserve ecosystems, the attempt to study the two systems as one creates serious scientific and social problems. In science the integrated vision distorts the application of CST. This 'new science' that emerged from the physical and life sciences is readily adaptable to study of ecological systems. But CST cannot be directly applied to social systems; it requires modifications that have not been considered in depth. Indeed, some scholars are skeptical that social systems are complex systems as is assumed in resilience theory. I am not in that group.

The social effects of this scientific methodology are significant: the effective privileging of environment over the current needs of humans. With hunger still widespread and more than a billion people living in absolute poverty the admonition to balance the needs of the present with the needs of the future cannot be overlooked (World Commission 1987). While the conservation of ecosystem services is important, in human terms it means nothing if development for the poorest is not sustained. Dominated by ecological concerns, the resilience literature largely ignores other aspects of sustainability like equity, innovation, and education (Harrison 2000). Despite the usual affirmation that resilience is essential to sustainable development, the research and theory of resilience is too narrowly ecological for it to be more than a small part of sustainability science. It should be more inclusive of society and, thus, more important. This paper moves in that direction by developing the social aspects of resilience.

The next section outlines the general characteristics of CST. In two following sections, I explain first how integration of ecology and society is scientifically disingenuous and then how this approach unreasonably narrows the concept of sustainable development. From both perspectives, resilience research and sustainability science largely ignore the subtle distinctions between the social and natural sciences and particularly the special character of policy generating

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[1] I call it resilience 'research' because it is largely inductive (relying heavily on case studies). An inchoate theory of 'panarchy' has only emerged in recent years (for example, see Gunderson and Holling 2002).

[2] For one discussion of how CST falls short of theory see Earnest and Roesnau (forthcoming). Not only is there no clear 'theory' but no agreement around the principles that might constitute a theory. Three main 'schools' seem to have developed: complex adaptive systems around the Santa Fe institute, irreversible self-organizing systems around Prigogine, and autopoiesis work by Maturana and his colleagues. Panarchy and most applications of CST to ecological systems appear to reflect irreversible self-organization or autopoiesis.

political systems. Resilience research is, therefore, in danger of losing its scientific integrity and thereby losing its policy authority.

In the fourth section, I show how both social and ecological resilience are founded in institutional arrangements and describe the elements of an applicable complex systems theory of institutions that may be called *institutional resilience*. Finally, in the concluding section, I briefly outline a research agenda for fleshing out and empirically testing the institutional resilience framework.

Complex Systems Theory

CST rejects the naïve realism, reductionism (the whole is equal to the sum of the parts and the system can be known from its parts), and determinism of enlightenment science and has been called "postmodern" science (Best and Kellner 1997). But unlike most postmodern critiques, it offers an alternative that promises to explain how social systems evolve.

A system is a portion of the universe within a defined boundary, outside of which lies an environment. An atom is a system, as is an animal or a country. A complex system has a very large number of parts that, because of their diversity, interact in a very great many ways (Waldrop 1996, 11; also see Levin 1999 and Holland 1995).[3] The complexity of a system may be 'measured' in several ways. Natural scientists measure complexity by the length of the shortest possible message that fully describes the system (Gell-Mann 1994, 30-38). A quark, a unit within an atom, is a simple system; a jaguar in the jungle is more complex. If all the units of a system are identical, system description is shorter; heterogeneity among the units increases description length and system complexity.[4] In social systems, the units are individual agents, groups, organizations, or nation states in which socialization in their system has not eradicated multiple differences. The more diverse individuals, roles, and occupations the more diverse the society.

Table 1: Comparing the Conventional and the Complex

	Conventional View	Complex Systems View
Scientific Paradigm	Newtonian mechanics	Life science/evolution
Ontology	Forces on Units	Emergent Processes, Flow
Unit Characteristics	Standardized, Objectively Rational, Competitive	Diverse, Subjectively Rational, Co-evolving
System & Environment	Closed, Uni-level	Open, Multi-level
System Type	Static, Linear	Dynamic, Nonlinear
Causation	Local, Proportionate	Multiple, Disproportionate
Theoretical Goal	General, Ahistorical	Local, Contextual

[3] According to Best and Kellner (1997, 246 note 11) there are "31 definitions of complexity theory and intense debates over its similarities to and differences from chaos theory." There probably now are more definitions.

[4] Mammal societies are more complex than anthills and bacterial communities. Bacteria have fewer choices of behavior than ants that are, in turn, more regimented and less 'free' than animals. As the 'degrees of freedom' of choice for individual members in a system increase, the range of behaviors increases, making the system more complex. Common knowledge also shortens system description. A bicycle is a simple system in which the identity and function of the parts is determined by their position within the system. "Bicycle" also is a term that conveys to most people a clear image of the system.

CST can be distinguished from conventional social science perspectives along at least seven dimensions (see Table 1). CST rejects the Newtonian mechanics paradigm that describes a universe formed out of particles of homogenous material whose movements in absolute space and time were governed by forces themselves the result of unchanging, universal laws that mathematics can express exactly. Such systems usually are linear and static without external impulse, and effects are proximate to and proportionate with their causes. In contrast CST presumes that each system component is unique and that system organization and behavior emerges from their co-evolving interactions. Because decision-making is distributed to heterogeneous system components, feedback loops make complex systems potentially non-linear and, through long chains of cause-effect relations, small causes can large and distant effects (Cohen and Stewart 1995; Casti 1994).[5]

The key insight of CST is that apparent complexity can originate from the interaction of a few simple rules governing interactions among components (in social systems, 'agents') and, therefore, that complex systems can be simulated (if not explained) by descriptive models or interactive computer models. If a game as simply defined as checkers "provides an almost inexhaustible variety of settings (board configurations)," we should expect that "complexity will be pervasive in the world around us" both natural and social. But the complexity that emerges from the simple rules of checkers also "gives hope that we can find simple rule-governed models of that complexity (Holland 1998, 76)." Thus, despite apparent chaos and non-linearity, CST holds out the possibility of being able to simulate complex systems and, thereby, explain them, if not to be able to predict their behavior. It is not germane to my present purpose to discuss the epistemological issues surrounding simulations but these are significant.[6]

Ecologists have embraced a form of CST – complex adaptive systems (or 'CAS') – as an explanation of ecological systems.[7] By arguing for a holistic approach to explaining an integrated system of social and ecological agents they have implicitly and sometime explicitly assumed that both ecological and social agents behave and interact comparably. I show below that the integrated treatment of ecological and social systems limits and distorts the notion of sustainable development. But in the next section I turn first to the more important problem of the scientific probity of explaining both social and ecological reality with a single CST applied to an integrated system.

Science Problems of Systems Integration

The resilience literature assumes that "linked systems of people and nature . . . behave as complex adaptive systems (Folke et al 2002, 12; Levin 1999)." If the model of complex systems that explains ecological systems does not fit social systems equally well, treating them as a single object of study loses significant information, especially about the political processes that generate policy and govern management functions. There are at least four scientific reasons why social systems should not be assumed to behave like ecosystems and integrated with them. I discuss each of the following problems in turn:

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[5] In an approach that differs from many other scholars, Cohen and Stewart (1995) are concerned with explaining the apparent simplicity that emerges from chaotic processes. They seek universal patterns on complex systems.

[6] For some discussion of the epistemological support for simulation methods see Axelrod (1997) and Axtell and Epstein (1996), and a critique in Earnest and Rosenau (forthcoming).

[7] Several original concepts and ideas have been generated by CST. These include autopoisesis and the comparable concept of self-organization; co-evolution; fitness and fitness landscapes– reflecting 'selection' borrowed from evolutionary theory; and path dependence. Where relevant, I will briefly explain them.

1. While ecological systems may always be complex, some social systems clearly are not and much of the evidence of social and ecological integration comes from simple communities
2. Humans and their collectives are teleological, desiring and anticipating the future in a way that components of natural systems do not and as not modeled by the public choice model of politics favored in resilience research
3. Political systems that produce policy are infused with authority, an influence on agents and processes not found in nature
4. Self-organization, a concept central to ecological resilience, is more limited in social systems and of limited use in explaining how they operate.

Not all Social Systems are Complex

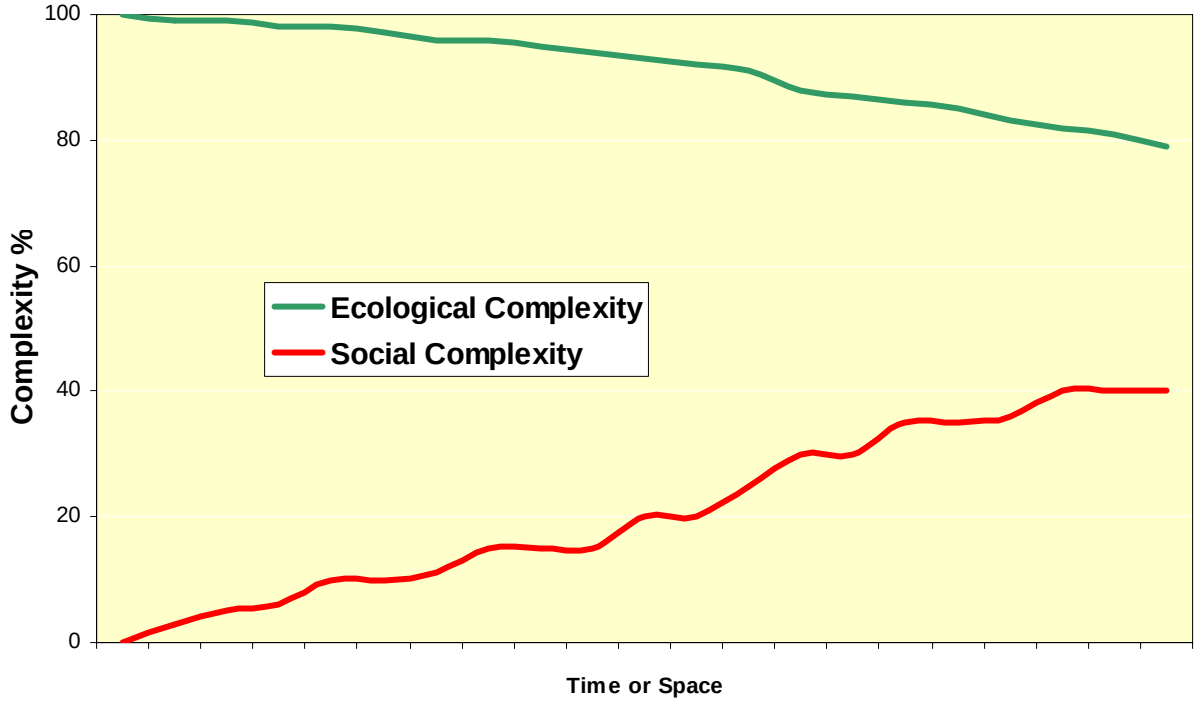
Researching the resilience of social-ecological systems using the CST model implicitly assumes that CST applies to all parts of the system. But not all social systems are complex.

Tainter (1988, 23) defines complexity in social systems in terms of "such things as the size of a society, the number and distinctiveness of its parts, the variety of specialized social roles that it incorporates, the number of distinct social personalities present, and the variety of mechanisms for organizing these into a coherent, functioning whole." A simple society is one in which "the population . . . is divided equally among the occupations and roles [are] homogeneously distributed."

The distinction is not that simple: there are degrees of social complexity on temporal and spatial scales: "complex societies, such as states, are not a discrete stage in cultural evolution. Each society represents a point along a continuum from least to most complex (Tainter 1988, 193)." Indigenous communities are very simple: homogenous and unified with weak leadership and authority roles. But they are embedded in and subject to ecological systems. At the other end of the spectrum are urban centers in industrial states that draw ecosystem services from across the globe. In between are various gradations of complexity in social systems. At each level of complexity what can be done and what needs to be done to change institutions and behaviors will be unique to that degree of complexity. Figure 1 graphically illustrates the interaction between more or less complex social systems and their attendant ecosystem (the one(s) on which they rely). It may be viewed as a graphic of the temporal increase in social complexity or the spatial distribution of social and ecological complexity. I would hypothesize a general rule that in the natural course of development as social systems become more complex they tend to simplify their attendant ecosystem. They are "dissipative systems (Prigogine 1997, 66)," drawing energy from their surroundings to maintain themselves and their development, and because they are better able to solve problems, they are less concerned with adapting to ecosystem-generated problems.

Folke et al (2002, 21) comment that "throughout history humanity has shaped nature and nature has shaped development of human society." But where simple communities are embedded in local ecosystems and dependent upon them, complex social systems draw on the resources of the globe. More complex social systems are better problem-solvers and more adaptable. Thus, a corollary to this hypothesis is that their complexity makes complex social systems more resilient and as social resilience grows, ecological resilience usually declines.

Figure 1: Temporal and Spatial Distribution of Social Complexity



If CST cannot be applied to some social systems because they are too simple, evidence of the efficacy of social behaviors in such societies cannot be generalized into a CST theory of resilience. Thus, conclusions in resilience research that management institutions be scaled to the match the target ecosystem (Berkes et al 2003; Folke et al 2002) are called into question. Similarly, it is often inappropriate to use CST to interpret data on effective commons management practices (Ostrom 1999). As the most destructive effects on ecological systems come from very complex social systems, understanding their internal processes is vital and the common presumption that institutions from a simple social system can be equally effective in managing a complex ecosystem is a generalization without support. Most of the evidence to support the benefits of investigating resilience in integrated social-ecological systems comes from case studies of small, sometimes indigenous, communities, often in poor countries (for example, see chapters 5-11 in Berkes and Folke 1998; research summarized in Folke et al 2002, 21-24). Research into the institutional governance of ecosystems similarly is concentrated around small, often poor, communities (Agrawal 2002; Ostrom 1999). For example, using the Institutional Analysis and Development Framework (IAD) a research team has assembled a database of the rules used by simple communities from around the globe to manage their commons (Ostrom 1999). The rules that IAD has identified as effective in simple communities for managing common pool resources can only be, at best, generally indicative of the rules that can and should be used by more complex social systems.

For three other reasons, the extensive IAD database is not useful for understanding social-ecological systems within a CST framework. First, CST cannot be used to explain the social processes that generate environmental governance rules because many of the social systems are too simple. Second, the analysis is static and does not search for the qualities of the

underlying system organization that generate the wide range of observed commons management rules. Third, commons are progressively enclosed as social systems become more complex so the nature of the problem changes with social complexity.

Teleology: Desires and Anticipation

Because the agents in social and ecological systems are different, it is reasonable to assume that different versions of CST should be used to explain them. The components of ecological systems are driven by a more or less hard-wired internal model of their immediate environment. Inherited genetic coding determines responses to external stimuli though in animals some learning and adaptive behavior is possible. Humans are more adaptive – their cognitive skills are more advanced – and they are aware of and plan for the future. Both individual humans and their communities are, therefore, teleological in a way that no component or ecological system is. Resilience researchers recognize this but seem not to grasp its importance, concentrating instead on the evolution of human traits and practices, essentially informal institutions which are discussed in more detail below (for example, Westley et al 2002; Levin 1999, 188-190).

Agents' internal or mental models determine their response to their environmental conditions. Human internal models are constructed from beliefs and values modified by experience, communication, and interaction with other agents, and guided by desire for some future personal condition or social state.[8] Humans act rationally if the act is the best way for them to satisfy their desire based on beliefs that are optimal given the available evidence and as much information as possible given the desire, their beliefs and desires are free of internal contradictions, and their actions are the intended result of beliefs and desires (Elster 1986, 16).

The foundation of the human internal model is desire, a preference for a state of affairs in the future. While animals are homeostatic, humans are driven by desire to act strategically. Just as individuals are forward-looking so are social systems: they seek some future state of society that is different from that available now. The purpose of policy is to create a future state of the social system that accords with some 'vision'. Thus, policy is a principal cause of much ecological destruction just as it could conserve ecosystem services.

The process of policy formation is politics. There is not room here to discuss the many theories of politics but I have summarized them elsewhere (Harrison 2000). Resilience scholars appear more comfortable with the rationalist assumptions of economics and the systems view of sociology. As a result, they use public choice theories to investigate political phenomena and ally with those political science scholars who similarly believe that individuals in political settings always act as "egoistic, rational, utility maximizers (Mueller 1989, 1)." But most scholars of politics explicitly reject such assumptions and its derivative propositions (Heckelman and Whaples 2003). If political systems in complex societies are as complicated as they seem, rational choice assumptions of exogenous preference formation are inappropriate. In a complex political system, desires and beliefs are endogenously formed from the interactions within the system. Any CST model of political processes must be concerned with the many influences on internal models and the importance of desires, strategic behavior, and anticipation in political behavior.

[8] The significantly more complex human internal model increases the diversity of individual behavior and, thus, the complexity of social systems. Desires include values – preferences for principles of behavior – as well as material needs and wants.

Impact of Authority

Authority is endemic to all political systems and, thus, most social systems but absent from ecological systems. One definition of politics is that it is the authoritative allocation of valued things (Easton 1953). But even if it is defined in terms of the process of negotiating values (Stone 1988), the reality is that authority is a part of politics. In simple social systems, like the ones that are the subject to many resilience case studies, authority is temporary and limited (Tainter 1988, 24-25). As social complexity grows, so does the role of authority as ever larger organizations of governance from satrap to city to state are constructed. A state simplifies social interaction by imposing decision and policies that frequently overwhelm informal self-organizing social decision processes.

For all the discussion of complexity, there is a simplicity in the resilience and complex systems discussions of social and particularly political systems. Guided by rationalist assumptions (e.g. McCay 2002; also see Ostrom 1999), resilience researchers look to economics and sociology for their social systems exemplars (e.g. Scheffer et al 2002; Holling et al 2002) and overlook the peculiar characteristics of the political system that generates the policies they hope to change and the governance of the ecosystems management that they want to improve (Holling 2001). [9] Their discussion of political systems is usually very general and limited to simplistic analysis of lobbying and interest group interactions (Pritchard and Sanderson 2002; Scheffer et al, 2002). They do not see that complex systems, particularly as specified for ecological systems, have no role for authority because decision making is distributed to the system components (Earnest and Rosenau, forthcoming). While this is not necessarily fatal for a CST of political systems, it does again show that applying CST to an integrated social-ecological system is not scientifically valid. Put another way, in politics the decision set is much larger than in economics or other social interactions. It is no accident that CST models have advanced most in economics, especially in financial economics (Arthur et al 1997) for there we know what drives behavior: the desire for money. In politics, agents may desire many competing and incompatible outcomes.

The hierarchy that generates authority relations in social systems is different from the hierarchy in ecological systems. In ecological systems components "become organized into hierarchies, in which each species interacts strongly with a subset of other species . . . and much more weakly with the rest.. . . [This process] localizes damage and provides resilience (Levin 1999, 162-163)." Hierarchy in social systems similarly groups system components into organizations and structures that interact intensely with selected other organizations. But each individual human plays distinct role in several social hierarchies and is differentially affected by each. Thus, in the complex social systems of the industrialized world authority is not limited to governance organizations but is experienced in every aspect of life. Laws, regulations, and the demands of superiors – people with authority over us – influence human behaviors. Authority relations suffuse human beliefs about how to behave, what is right or wrong (values), and the costs and benefits of individual choices.

[9] Both markets and social systems as studied by sociology emphasize systems of interacting agents in which authority is of diminished importance and usually is excluded from theoretical models. In economics Galbraith (1978) among others has argued that large firms have authority over consumption but this argument has been lost in the dominant neoclassical paradigm of 'free' markets.

Self-Organization

In the resilience literature social-ecological systems are assumed to be self-organizing. For example, in Berkes et al (2003) self-organization is seen as a way to understand renewal in dynamic systems. Levin identifies self-organization as central to complex adaptive systems and, therefore, ecological systems. For him self-organization means that "not all the details, or 'instructions,' are specified in the development of a complex system (12)" that develops in accordance with simple rules "that govern how the system changes in response to past and present conditions, rather than in some goal-seeking behavior." Folke et al (2002, 16) state that "complex systems are self-organizing" by which they mean that "macroscopic system properties and patterns that emerge from the interactions among components feedback to influence the subsequent development of those interactions."[10] Such ideas are intuitively insightful for ecological systems but in what sense can social systems be viewed as self-organizing?

The complexity of social systems increases with the number and diversity of their constituent agents. As social roles and skills become more differentiated, social complexity increases and the system becomes better at problem-solving (Tainter 1988, 38). It would seem that increasing social complexity should encourage self-organization in social systems. But as societies become more complex, the number of formal institutions multiplies and the importance and effect of authority increases. Independent villages give way to feudal monarchies that turn into national-states. Thus, as societies become more complex they become, in some respect, *less* like ecological systems. Informal institutions – informal rules governing social processes – continue to evolve much like rules of interaction in ecosystems. In that sense, society is self-organizing.

Social evolution may occur in response to external threat or pursuit of collective benefits (Tainter 1988, 34-35). The latter reflects greater self-organization as, following Hobbes, an external threat leads to Leviathan, the imposition of authority to protect the people. Simple social systems self-organize when a tribe or village emerges from random families but states are created by authority. But whereas self-organization in ecological systems creates systems "far from equilibrium" that are not stable in the long-term, it is not clear that social systems, especially complex social systems, fit that description. Indeed, hierarchy and authority in social systems is expected to give them stability and, if complex social systems are problem solving, they may remain so in the long term.[11] More 'dissipative' than simpler systems, their organization and their problem-solving capacity (and resilience) comes from the divergent processes of differentiation and hierarchy – and their attendant authority and simplification of relations – as noted by Durkheim (1933).

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[10] Because the approach is relatively new, CST scholars disagree about the importance and meaning of self-organization. Waldrop (1992, 102) defines self-organization as "matter's incessant attempts to organize itself in to ever more complex structures" and for Kauffman (1995) self-organization is "order for free" that has undergirded the origin of life itself . . . [and] undergirded the order in organisms as they have evolved." For him the concept is essential to an understanding of complex living system. But Holland (1995 and 1998) never mentions the concept though he does discuss 'self-reproductive' systems in the latter book (it is not referenced in the index and I have not noticed it in the text). It is interesting to note that the resilience literature often approvingly mentions Holland's (1998) use of checkers to illustrate complex systems. But in what sense can checkers be considered self-organizing?

[11] Tainter (1988) shows that complex societies can collapse when the costs of complexity exceed the benefits it bestows. But technological innovation (from steam to electricity to the information revolution) has reduced the costs of complexity and increased its benefits. There is no certainty that this trend can continue and the resilience researchers seem convinced that it cannot.

As they become more complex, social systems become more orderly and organized. Formal institutions are designed for specific purposes and reflect the teleological aspect of human groups: they are centrally created through authority-governed processes to achieve specific changes in the behavior of society's constituent agents. Thus, they are only indirectly, and much less, responsive to the interactions of agents than informal institutions. As they become more complex, social systems become more ordered and organized; formal institutions and organizations multiply. Organizations are established to maintain or enforce formal institutions. They can become increasingly powerful social agents with interests and an identity of their own, separate from employees or owners, pursuing their own purposes through authority-governed internal interactions.[12]

With the growth of authority in society and the increasing power of organizations, the self-organizing processes of autonomous individual agents (through informal institutions) becomes less important even as complexity and problem-solving ability increases. Policy acting though formal institutions is used to orient society to construct a preferred future. The process by which this is achieved is complex involving scientific and indigenous knowledge, values and beliefs, and power through organizations.

The next section briefly explains how the lack of integration of ecological resilience with other social concerns fails the test of sustainable development. Following that section I show how institutions are the essence of both ecological and social resilience.

Social Problems of Systems Integration

Elsewhere I have shown that disciplines interpret the concept of sustainable development through their disciplinary precepts and thereby narrow and, in effect, gut the concept and its integrative purpose (Harrison 2000). Sustainable development is a social process in which the future ecological foundation of continued development cannot be mortgaged to satisfy current social needs. Because resilience research treats human activities as just another part of the biosphere (for example, see Holling 2001), this inevitable tension between advancement along social and ecological paths is overlooked. While ecological systems are the foundation of social systems without which social activity would not occur, sustainable development must mean more than conservation of ecosystem services.

The resilience literature is unified in rejecting the common practice of managing single species. For example, Wilson (2002) notes the defects in single-species fisheries management and more generally Holling et al (2002, 6) conclude that while a "target variable . . . is identified and successfully controlled" leading to inevitable "slow changes in other ecological, social, and cultural components - changes that can ultimately lead to the collapse of the entire system." Folke et al (20022, 41) comments that "command and control processes in simplified landscapes" inevitably fail to sustain consumption. The recommended solution, adaptive management, is a multi-level integrated management of a "problem domain (Westley 2002)" in which actions carefully calibrated to changing knowledge pursue multiple objectives (Folke et al 2002; Levin et al 1998. Yet, in resilience research the social domain is limited to ecosystem management; other social needs – both those that drive economic processes and those that may be relatively independent of them – are almost never considered.

[12] Management and organization theorists have been attracted to CST as an explanation of the internal processes of organizations. There are several different approaches, mostly descriptive, in this nascent effort and none has yet produced much understanding. But see Stacey 2000 for one of the better efforts.

Lélé (1991) described sustainable development as all things to all people, as a "'metafix' that will unite everybody from the profit-minded industrialist and the risk-minimizing subsistence farmer to the equity-seeking social worker, the pollution-concerned or wildlife-loving First Worlder, the growth-maximizing policymaker, the goal-oriented bureaucrat, and therefore, the vote counting politician." But it is more than a politically unifying concept with no intrinsic meaning. The earliest well-accepted definition of sustainable development is based in equity rather than ecology (World Commission on Environment and Development 1987, 43). Development, that which is to be sustained, is a qualitative change in human existence "by which a population and all its components move away from patterns of life perceived in some significant way as 'less human' toward alternative patterns of life perceived as 'more human.' . . . Moreover, cultural and ecological diversity must be nurtured. Finally, esteem and freedom for all individuals and societies must be optimized (Goulet 1977, x)." The point is: sustainable development is primarily about a qualitative improvement in the conditions of human life. Poorly managed, ecological systems prevent such social change.

Sustainable development is better thought of as the process of increasing human life chances. Life chances are "the sum total of opportunities offered to the individual by his [or her] society (Dahrendorf 1979, 28-30)." Life chances are a "mould" that may challenge an individual to grow or force them to resist. Opportunities provided by social (and economic) conditions) for "individual growth, for the realization of talents, wishes and hopes." To the extent that development provides more life chances it is "more human." Life chances have two parts: choices and linkages. Choices are opportunities and possibilities for accumulation and personal growth. Linkages are the social connections that help to form self-identity and give life meaning, such as family and community relations and belonging to and participating in organizations and civic groups.

Choices and linkages pull in different directions. The market economy increases the choice of products and services available to the consumer but can reduce linkages (Putnam 2000 and 1993). Indefinitely increasing life chances is a delicate balancing act between more choices and more linkages, between economic growth and equity, between individual and community. For homogenous communities dependent on a single natural resource – like Newfoundland fishing towns or villages in the forests of India (Harrison, in draft; Kothari, forthcoming) – choices and linkages are equally dependent on the health of an ecological system. Their resilience is limited by their dependence and their sustainability is closely tied to the quality of ecosystem management. But for more diverse communities loss of ecosystem services may not be the most immediate threat to their life chances. It may neither reduce their choices nor their communal linkages (which may already be diminished by markets). In such cases, conservation of ecosystem services may depend more on modifying social arrangements than on ecosystem management. For example, increasing linkages extends identity with, and support of, local communities, which are essential to adaptive management. I discuss adaptive management and policy for sustainable development in more detail below. In rich industrial societies and increasingly in the megacities of the South not only have connections with nature been severed by technology and trade (Bookchin 1986; Dodge 1981) but also connections with other peopoe and other social groups have been diminished. Both are social problems with environmental consequences that can feedback to reduced life chances.

The decision to treat social and ecological systems as one system has social and political consequences: it directly influences, by directing attention away from, consideration of social problems other than conservation of ecosystem services. The next section shows that there are

good scientific reasons why social and ecological systems should be separately researched, primarily because CST adapted to ecological systems does not 'fit' political systems.

Institutional Resilience

Dominated by ecologists, resilience research assumes that social and ecological processes operate in a single, holistic system. I have show that it is not possible to explain an integrated social-ecological system with a single complex systems theory. Not all social systems are as complex as ecological systems, authority interferes with the CST representation of decision-making and agent behavior, and self-organization only operates in part of the social system and not as often or as effectively in the policymaking part of social systems. Because the ontology of social and ecological systems is necessarily different, they must be treated as separate and theories adjusted accordingly. That integration also distracts attention from other legitimate social concerns, only serves to reinforce the need to consider the systems separately. In this section I sketch the outline of a theory of institutional resilience – resilience in social and ecological systems from institutional arrangements. Based on this discussion, in the next and concluding section I suggest some avenues for further research into the effect of institutions on social and ecological resilience and, thus, sustainable development.

Society and Resilience

The central problem of sustainable development is how to order society to simultaneously increase social resilience and ecological resilience (Harrison 2000). Given the discussion above, these are distinct, though related, problems. To date, resilience research has focused on ecological resilience and somewhat overlooked social resilience; some scholars have addressed it in passing as an aspect of the resilience of an integrated system. The nature of social arrangements, however, influences both forms of resilience and that is my present concern.

Ecological resilience is enhanced by complexity caused by diversity among the constituent parts of the system (Folke et al 2002, 15-20; Levin 1999, 12). This complexity is enhanced through adaptive management, the requirements of which have been much discussed (Holling et al 2002; Westley 2002; Berkes 2002;Levin 1999, 199-201). The fit and scale of institutional forms must be appropriate to the target ecosystem and institutions at different scales must interact flexibly (Young 2002). Larger scale institutions move more slowly than and constrain smaller scale institutions but larger scale institutions eventually adjust to the needs of smaller scale institutions in a form of self-organizing emergence (Holling et al 2002). This conception of social-ecological systems draws and elaborates on Simon's (1965:70) comments that complex societies are constructed from social units that are potentially stable and independent dynamic systems. The importance of states and the trend to globalization suggest that many social systems are not able to function independent of the social system in which they are embedded just as they are less connected to individual ecosystems.

Adger (2000) has defined social resilience as "the ability of human communities to withstand external shocks or perturbations to their infrastructure, such as environmental variability or social, economic, or political upheaval, and to recover from such perturbations." But a more elaborate definition can be adapted from the more intensively studied ecological resilience. Drawing on Carpenter et al (2001), the Resilience Alliance defines resilience as:

1. the amount of disturbance a system can absorb and still remain within the same state of domain of attraction,

2. the degree to which the system is capable of self-organization (versus lack of organization, or organization forced by external factors) and
3. the degree to which the system can build and increase the capacity for learning and adaptation.

The first criterion is the essential property of resilience. The other two are mechanisms for obtaining resilience.

How much social change is a resilient response? At what point does stress to the system cause change that turns the social system into something it was not before? A flip in an ecological system can change a forest to a desert and overwhelm a lake with vegetation (Mäler 2000). The ecological system remains the same even as it adapts to exogenous stresses up to the point when a flip occurs. Then it becomes something else. Comparably, a social system can change indefinitely as long as it remains a social system. That is, a social system is resilient if, while changing, its constituent agents remain in the society because it continues to benefit them. However, again authority intrudes, as there are many instances in which agents are not permitted to leave a society that no longer serves their needs. Indeed, the complex societies of modern states are so suffused with authority and regulation of nationality and movement of people that many have little opportunity to avoid the dangers of a failing state.[13] This raises questions of the uses and abuses of authority that I shall not pursue here. But it also illustrates again the differences between ecological and social systems.

The related ideas of self-organization and learning are assumed to increase the adaptive capacity that enhances resilience. As discussed above, social systems are less self-organizing than ecological systems but may be better at learning and adapting, particularly if they are more complex (Tainter 1988). Case studies show that many simple social systems enhance ecological resilience because they self-organize to *adapt to* the ecosystem in which they are embedded.[14] Though complex societies are more adaptive and better problem solvers, they have a greater impact on local and distant ecosystems.[15] Their size and their problem solving ability allow them to dominate ecosystems and not to have to subordinate themselves to ecosystem needs – at least in the short run.[16]

Despite their differences, there is a substantial and permanent link between ecological and social resilience: both are based in and derive from the organization of social relations. Social systems are most usefully distinguished by their informal institutions or culture and their formal governance institutions. Thus, resilience—both the resilience of the social system to any external changes (socio-economic or ecological) and the resilience that it causes in the ecosystems with which it interacts—is a function of the types institutions and the relationships among them. *Institutional resilience* is resilience in the society and in any systems with which it has open interaction, such as ecosystems, that is generated by institutions. The question is: what institutional arrangements cause social and ecological resilience?

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[13] Examples as diverse as Rwanda, Congo, Sierra Leone, North Korea and Iraq come to mind. In local communities, movement from failing communities may be restricted in many ways such as the absence of a marketable skill or trade, reliance on subsistence agriculture and an absence of savings, and government regulation such as internal passports. Slum shanty towns such as the *favelas* of Brazil are examples of the voluntary movement between locations within a state and the self-organization of new communities.

[14] For example, see Ostrom 1999, Trosper 2002, Kalikoski et al 2002.

[15] Urban areas have always drawn on ecosystem beyond their immediate proximity through trade (Odum 1983). But modern conurbations are so large, and trade systems so effective and efficient, that they live off a global ecosystem.

[16] Because the ecosystems on which they feed are widely distributed and distant, and because often replacements are available, the ecosystem effects of their voracity is only noticed by indigenous peoples in distant lands.

Toward Theory

Institutions have been defined as "sets of rules of the game or codes of conduct that serve to define social practices, assign roles to the participants in these practices, and guide the interactions among occupants of these roles (Young 1994, 3; also see Ostrom et al. 2001, xiv). But in the context of my earlier discussion of authority, this definition must be extended to include their effects on agents' internal models and though this route on their behavior (McCay 2002; Wendt 1992). That is, the more common definition that presumes a limited rational human agent (the public choice version of humanity that is, like *homo economicus*, a self-interested maximizer) must be extended to include learning. Cognitive processes are culturally determined through informal institutions and framed by formal education that usually is guided and defined by governmental institutions. Equally, path dependent social practices – the 'way we do things here' – limit and channel responses to threats. Thus, how agents understand and respond to problems is not only a matter of rational response to the social rules embodied in institutions; problems are framed by how they think about the problem, how they learn, and the institutional limitations on what solutions can be imagined.[17]

Case studies of ecologically supportive institutional arrangements do not help to identify the qualities of the institutions that increase resilience. The IAD project has captured and classified the institutions of a very large number of (usually) simpler societies (Ostrom 1999). In such societies changes that increase complexity and introduce authority, as usually happens in the development process, can be said to change the organization of the society.[18] Unfortunately, projects like IAD are of limited value in considering institutional change as they are static measures of institutional response to ecological change and sometime socio-political stresses (as in conflict with national government regulations) but do not identify the underlying processes that cause institutional change (Agrawal 2002, 46). Also, because the data are from societies in which authority plays a small role and self-organization in informal institutions, their conclusions cannot be generalized. Finally, the data have been collected and classified using a rationalist definition that excludes institutions that act on behavior through the desires, beliefs and values in mental models. Despite these methodological issues, current knowledge of institutions does suggest that self-organizing, informal institutions are less problematic than formal institutions.[19]

I argue that there are four critical elements of institutional resilience: directed self-organization, adaptive formal institutions, openness, and subsidiarity.

The first element, that is central to the adaptability of less complex societies, is the self-organizing nature of informal institutions. In social systems, the "capability for self-organization" refers to the system's ability to change the behavior of its components – individual and organizational agents – in response to external stress and remain beneficent to its constituent agents. Drawing on ecological examples, complex, diverse, and self-organizing systems are expected to optimize system adaptive capacity principally through informal institutions in which the participants collectively agree on rules that they enforce among themselves without the

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[17] This approach reflects the thinking of Michel Foucault and is best represented in the modern literature on the politics of the environment in Litfin (1994).

[18] As discussed earlier, development is a qualitative change in society. It is a value judgment whether the changes that constitute development (however defined) are good or bad.

[19] As one example, the Mayan civilization collapsed into villages that have survived more than a thousand years (Tainter 1988,152-175). For whatever reason, the larger more complex society was less useful to its members than smaller, simpler, and more self-organizing units.

intrusion of authoritative governance structures. But most societies now have to contend with increasing authority and the expanded role of formal institutions. So how can societies overcome the rigidities of authority and the dead hand of formal institutions?

The second element of institutional resilience is to increase the *adaptive contribution of formal institutions*. The lesson of research to date is that the wide variety of inflexible formal institutions in complex systems may be a source of social cohesion and resilience but they limit society's support of ecological resilience. However, except for the most remote villages, all social systems are now more or less embedded in complex systems of regional, state, and international governance. Not only are they affected by the ecological effects of complex societies but they also are intertwined in the formal institutions of organized government. Thus, the characteristics of formal institutions that generate social and ecological resilience becomes the critical issue. Increasing their flexibility and permissiveness contributes to adaptive formal institutions.

If social rules can directly constrain behavior and also change internal models and cause learning, resilience is increased by formal institutions that are more responsive to the innovative social practices that emerge out of agent interactions. Put simply, formal institutions that are more flexible allow for a greater range of social experimentation and more rapid change in institutions and behaviors. Thus, they increase the potential for resilient responses to stress. This necessitates a different view of organizations, both governmental and commercial, and how they select and pursue their goals. Organizations by their nature are riven with authority. How then can they freely select and adapt to new purposes? One way is to increase their openness to customers' needs. It has become a law of commercial enterprise to 'stay close to customers', which is one way of expressing the importance of openness for the flexibility of organizations.[20] Organizations that are open to their environment are more adaptive. Openness, discussed further below, also increases inter-agency cooperation.

Innovative agent behavior is the result of changes in internal models caused by learning.[21] Learning is incited by the agent's experience of institutional constraints on behavior and by communication with other agents. Formal institutions that are permissive allow greater contact between agents, less rigorously constrain those interactions, and foster the exchange of ideas. In short, institutional resilience is enhanced by formal institutions that encourage and respond to innovative agent behavior.[22]

The third element is *openness*, a criterion of complex systems. While the full integration of social activity into a social-ecological whole rarely, as I have argued, makes scientific or social sense, the social system must be fully open to the ecological system. Odum (1983, 2) and Bookchin (1986) have argued in very different ways that the problem in the modern world is the separation of the individual from the source of their sustenance. The essential requirement of adaptive management of ecological systems is the collection and dissemination of detailed information about the current state and apparent path of the target ecosystem. In practical terms, both indigenous and scientific knowledge of ecological changes and social needs and demands

[20] Governmental organizations frequently fail this test as they often are more concerned with maintaining themselves and their employees' jobs than satisfying customers desires.

[21] As described above, internal models are not just a rationality engine but include desires and beliefs.

[22] Institutional resilience is one component of social resilience, the other being the material capabilities with which the society can reduce its vulnerability. These material capabilities include technology, and human and physical capital, which are themselves linked to institutional arrangements.

are necessary to appropriately adjust social behaviors. Formal and informal institutions may be associated with collecting, interpreting, and acting upon such knowledge.

The fourth element is *subsidiarity*, a term borrowed from studies of the European Union where it is used to describe the principle that all decisions should be made at the smallest practical scale of governance. In CST terms subsidiarity is using authority to increase the emergent properties of decision-making by driving it down to lower scales than centralizing authority might otherwise prefer. If followed, subsidiarity pushes decision-making down toward the self-organizing informal institutions that we know often solve commons issues and conserve ecological diversity. Despite the arguments of skeptics and the exhortation of bumper stickers, global environmental problems cannot be solved through local action: it requires some coordination of local activities through formal institutions. Similarly, local problems do not require global institutions for their solution.

Subsidiarity can also be applied to governance institutions. If their rules, regulations, organizational structures, and activities are designed with subsidiarity in mind, they are more likely to respond to ecological problem at the scale at which they are likely to be most effective (Young 2002).

The principle of subsidiarity finds an echo in the theory of panarchy that assumes that larger, slower moving systems constrain the smaller scale and quicker moving systems from which the larger systems emerge and on which they depend. However, the incursion of authority in social systems means that the relationship between smaller and larger scale systems is not only emergent; other complications enter into the interaction between the systems, many of which are contextual. For example, different state constitutional structures affect these relations. In France the center is dominant on nearly all matters at all times while the U.S. has a federal structure with continuing tension between federal and state institutions on many issues including the environment. The effects of authority have to be modeled in any theory of institutional resilience.

In the next and concluding section I summarize the findings of the paper and suggest a research agenda to construct and test a theory of institutional resilience.

Conclusion

In his plenary talk to the Fifth Open Meeting of the Science Committee of the Human Dimensions of Global Environmental Change (October 18, 2003) Roger Kasperson argued that science needed to work with integrated social-ecological systems to avoid the effects of disciplinary specialization. This paper shows that this worthy goal is not achievable. The reality of social systems is sufficiently different from that of ecological systems that application of a single scientific methodology to an integrated society-nature system is misleading and unscientific. It is not interdisciplinary science to apply the precepts of a single discipline to all aspects of a holistic social-ecological system. Nor does it privilege social wants over ecological needs to apply different methods to explaining very different social and ecological phenomena. Ecological conservation is poorly served by predicating the social as an integral part of a global ecological system in order to prevent dominance of ecological concerns by social needs. By focusing attention on the social processes that generate environmental policy and govern environmental management, resilience research distracts attention from the need for integrative policy processes that balance competing social and ecological policy paths (Harrison 2000, 112-113).

Resilience research has overlooked an important paradox. Most of what we have learned about management of integrated social-ecological systems has come from case studies of simple

social systems embedded in complex ecological systems. But the social systems that threaten the survival of ecological systems across the globe are much more complex. Simple societies are often are sustainable by resort to self-organizing informal institutions. Complex social systems (that are good at solving *social* problems) are substantially detached from their local ecosystems and influence ecosystems across the globe (including those in which simpler, more sustainable societies are embedded). They are unsustainable. Thus, social complexity solves social problems as it causes ecological problems and simplicity subjugates social needs to ecological conditions.

I have argued that understanding the role of institutions in social and ecological resilience is central to moving increasingly complex social systems and increasingly simplified ecological systems on to sustainability paths. A theory of institutional resilience must integrate knowledge from many disciplines including ecology, anthropology, political science, organizational theory, and management theory within a complex systems theory adapted to the reality of political systems that generate policy. It is evident that social systems are complex but not *in the same* way as ecological systems. CST holds real promise for explaining social systems and improving policy choices. But much of the work on the application of CST to the social sciences, beyond economics, is theoretically sloppy. In particular, the special characteristics of politics demand some careful consideration of the philosophy of science, both ontology and epistemology. And it may be that the popular method of agent-based modeling may need radical re-thinking to apply to issues where politics is important.

The litany of theoretical and empirical research necessary for a useful understanding the role of institutions in resilience is long. Here, I briefly outline a research agenda. It will be necessary to extend research beyond simple societies; as a practical matter, this may require simulation rather than case research. Simulations of the effects of authoritative ideas and teleology on mental models and agent behavior, and of authority on centralizing decision-making also may play an important role. Current knowledge on institutions and especially the IAD database should be sifted to look for underlying processes in informal institutional formation. What processes generate informal institutions? Are they self-organizing or does authority intrude? The thesis that more complex societies are better problem social solvers and the related paradox that they inevitably simplify attendant ecosystems should be tested, possibly by using longitudinal models of social development and selected cross-national, or cross-regional, comparisons.

We can be sure of one thing: sustainable development demands substantial social changes, both positive and painful. Referring to policy for rainforests, Brian Arthur commented that in the complexity perspective “there is basically no duality between man and nature.. . . We are part of nature ourselves. We're in the middle of it. . . . So once you drop the duality . . . then the questions change. You can't then talk about optimization, because it is meaningless. It would be like parents trying to optimize their behavior in terms of 'us versus the kids,' which is a strange point of view if you see yourself as a family.. . . . So the question is how to maneuver in a world like that. And the answer is that you want to keep as many options open as possible. You go for viability, something that's workable, rather than what's 'optimal'. . . because optimization isn't well defined anymore. What you're trying to do is maximize robustness, or survivability, [that is, resilience] in the face of an ill-defined future. And that, in turn, puts a premium on becoming aware of nonlinear relationships and causal pathways as best we can. You observe the world very, very carefully, and you don't expect circumstances to last (quoted in Waldrop 1992, 331-334).” In short, as a famous policy studies theory proposes (Lindblom 1959) humans usually “muddle through” and institutions will be central to how well they do it.

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