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Guest Editorial, part of a Special Feature on Exploring Resilience in Social-Ecological Systems

Exploring Resilience in Social-Ecological Systems Through Comparative Studies and Theory Development: Introduction to the Special Issue

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ABSTRACT. This special issue of *Ecology and Society* on exploring resilience in social-ecological systems draws together insights from comparisons of 15 case studies conducted during two Resilience Alliance workshops in 2003 and 2004. As such, it represents our current understanding of resilience theory and the issues encountered in our attempts to apply it.

Key Words: *resilience; theory; resilience application; resilience synthesis; resilience case studies*

INTRODUCTION

The concept of resilience in ecological systems was introduced by C. S. (Buzz) Holling (1973), who published a classic paper in the *Annual Review of Ecology and Systematics* on the relationship between resilience and stability. His purpose was to describe models of change in the structure and function of ecological systems. The notion of resilience is growing in importance as a concept for understanding, managing, and governing complex linked systems of people and nature (Folke et al. 2004). A good example is coral reef systems subjected to multiple human interventions (Adger et al. 2005, Hughes et al. 2005). T. P. Hughes (*personal communication*) recently found several thousand records after Googling the phrase "coral reef resilience," indicating the current prevalence of the term. Although some ecologists (e.g., Pimm 1991) consider resilience to be a measure of how fast a system returns to an equilibrium state after a disturbance, Holling (1973) defined it as a measure of how far the system could be perturbed without shifting to a different regime. The former definition, i.e., return time, is now known as "engineering resilience" (Holling 1996). However, this special issue uses the latter definition, which Holling (1996) called "ecological resilience"; this concept is further defined in the following article.

SPECIAL ISSUE

This *Special Issue on Exploring Resilience in Social-Ecological Systems* continues the expansion and application of theories and ideas about resilience in interlinked systems of people and ecosystems, with expansions into some areas of social science. Similar ideas appear to have had a parallel evolution in fields such as psychology (Deveson 2003) or mental health (Walsh 2003). Over the last decade, however, much work has been done to expand and test the applicability of these concepts to fields that are linked to ecology. One of the first was the edited volume by Berkes and Folke (1998), which explored traditional and current management in linked social-ecological systems. That work was expanded by the Resilience Network, an ephemeral research group that produced four edited volumes, each of which explored different interdisciplinary connections. Gunderson and Pritchard (2002) focused on ecological state changes resulting from human actions in a variety of ecosystems. Berkes et al. (2003) documented how humans across a wide range of cultural settings have adapted to ecosystem changes in ways that influence the resilience of the combined social-ecological system. Dasgupta and Mäler (2004) explored the economic implications of state changes in ecosystems, and Gunderson and Holling (2002) attempted to develop a theoretical synthesis based on preliminary investigations into linked systems.

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The case study comparisons and this special issue were orchestrated by The Resilience Alliance, an international consortium of 15 research groups that grew out of the Resilience Network. One specific objective of the group is to bring together ecologists, economists, political scientists, mathematicians, social scientists, and archaeologists to begin an interdisciplinary assessment of the ideas developed in previous works.

To continue building resilience "theory," it would, of course, be most desirable to develop a set of hypotheses, conduct controlled experiments to test them, and through this process develop a set of basic facts or "laws of social-ecological system dynamics." Unfortunately, these classical scientific approaches work best under highly reduced and controlled conditions. They are of far less use in the real-world situations of coupled social-ecological systems in which variables cannot be tightly controlled and independently manipulated, replication can be difficult or impossible, and people are understandably reluctant to subject themselves and their livelihoods to experimental manipulations for the sake of advancing scientific understanding.

Rather, we must of necessity rely on developing general theory based on well developed principles from the natural and social sciences, in particular ecology, economics, and political science, and confront it through comparative analyses of many cases. By combining the insights gained through theory development and those derived from qualitative analysis of these case studies, we can improve our understanding of how social-ecological systems operate, and extract generalities about the fundamental processes that structure the interactions between human societies and ecological systems. Examples of how this progression of theory development and generalization has worked so far includes research on lakes and wetlands (Carpenter et al. 1999*a*,*b*, Gunderson 2001, Carpenter and Brock 2004, Olsson et al. 2004), rangelands (Perrings and Walker 1997, Janssen et al. 2000, Anderies et al. 2002, Janssen et al. 2004), irrigation systems (Redman and Kinzig 2003, Anderies 2005), coral reefs (Hughes et al. 2003, Bellwood et al. 2004, Hughes et al. 2005), plus more general theoretical and synthesis work (Carpenter et al. 2001, Scheffer et al. 2001, 2003, Walker et al. 2002, 2004). The work presented here is a continuation of this process, including new insights emerging from the comparison of an ever-growing set of cases.

The first paper in this special issue (Walker et al. 2006) deals with the set of developing propositions that emerged from the two workshops. Although they are incomplete and will undoubtedly change, they serve as a useful interim set of statements that reflect our current understanding. Each of these propositions is addressed in one or more of the papers that follow.

The main part of the special issue consists of seven papers that present some of the insights gained from comparisons of 15 of the social-ecological systems that have been the subjects of research by members of the Resilience Alliance. Some have been studied for many years and have a wealth of detailed information; others have been undertaken only in the past three years. All of them, however, consider the social-ecological systems with which they are concerned at multiple scales and examine the feedbacks within and between the social and ecosystem domains. The first paper in this group (Cumming et al. 2006) examines the origins and effects of scale mismatches - a hypothesized cause of loss of resilience. The next (Janssen et al. 2006) takes a network perspective of social-ecological systems and looks at how changing structures and connections in systems influence their resilience to external shocks. The third paper (Gunderson et al. 2006) provides an overview of how resilience, adaptability, and transformability play out in lake and wetland systems. The following three papers focus on different aspects of how the dynamics of social-ecological systems are determined. Abel et al. (2006) examine how two different outcomes occurred in each of two regions during the rapid "backloop" phases of change and the attributes of the systems that determined the outcomes. Next, the paper by Olsson et al. (2006), on navigating toward adaptive governance, compares five case studies in terms of their capacity to undergo transformation and identifies networks, especially "shadow" networks, and leadership as crucial attributes. The third paper in this set (Lebel et al. 2006) deals with governance and resilience, addressing the question: Do certain governance attributes enhance the capacity of a society to manage resilience? The comparisons of a wide range of case studies produced a set of eight governance-related attributes that influence the resilience of the social-ecological systems involved. The last of the main papers (Kinzig et al. 2006) offers a new insight into the complex ways in which multiple regime shifts occur in social-ecological systems, across domains, and across scales. The view of resilience that

encompasses a single regime shift caused by a threshold on one, albeit dominant, variable, as in much of the work on lakes, rangelands, and irrigation systems mentioned above, is expanded to a more holistic view in which social-ecological systems have a number of thresholds at different scales and in both the ecological and socio-economic domains. [ERRATUM].

The concluding paper (Anderies et al. 2006) draws together the insights that have come out of the comparisons. The title reflects the conclusion that top-down optimization for defined "products" from linked social-ecological systems is a policy and management strategy that finally deserves "burial" some 30 yr after the publication of a paper that offered an epitaph for the concept of maximum sustainable yield (Larkin 1977). Although top-down optimization allowed for increased welfare in the early phases of natural resource use and exploitation, the secondary effects of this narrow approach are now accumulating everywhere, and we must move on. The reasoning is embodied in the insights from the 15 case studies, which offer an alternative, resilience-based approach to resource management and governance. The complexity of linked social-ecological systems is such that a tight body of theory governing their dynmaics is unlikely in the near future, if ever, and it is proposed instead that an evolving framework that allows for generalization and transportability of results is what we should aim for. Managing social-ecological systems will always be a combination of "art" and science, but the science is a very important part when it comes to avoiding costly mistakes. The key insights from the preceding papers are presented, followed by a set of 11 tentative "messages" for policy and management.

This special issue marks the end of a phase of research, much of which was made possible through a grant from the James S. McDonnell Foundation. It represents an expansion of the concepts in the book *Panarchy: Understanding Transformations in Human and Natural Systems* (Gunderson and Holling 2002) and presents insights from the first efforts to compare, in some detail, the resilience of linked social-ecological systems at regional scales. The aim of publishing these papers as an integrated special issue is to bring this collective set of new and emerging ideas to a wide scientific audience. Our hope is that it might serve as a platform for a greatly increased program of research in many countries and organizations, which will lead to a better basis for sustainable development and an approach that we might tentatively call "adaptive governance for resilient social-ecologcial systems."

Responses to this article can be read online at:
http://www.ecologyandsociety.org/vol11/iss1/art12/responses/

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