

Carl Folke

Social–ecological systems and adaptive governance of the commons

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The issues of complex adaptive systems and cooperative behaviour that are raised in the paper by Levin (2006), with a comment by Vincent (2006) adding the importance of backing up social norms with economic incentives, are of great significance to the prosperous development of society. Such insights can contribute to managing the global commons in a more sustainable manner and, in particular, the ecological life-support systems on which societal development ultimately depends. Progress in the interface between ecology, economics and other social sciences has been substantial during the past decades, and the new insights are shaping science and policy. The recent Millennium Ecosystem Assessment (<http://www.millenniumassessment.org>) is one example, stressing the significance of sustaining the capacity of the environment to generate ecosystem services and the conditions, trends and futures of this capacity.

The recognition is spreading that many ‘disciplinary maps’ only partially capture the understanding we need to interpret the dynamic world that we live in (e.g. Ludwig et al. 2001). New and better maps are required in the attempt at integrative science for real world sustainability, and three general features are increasingly emphasized in this context; First, *social and ecological systems are deeply interconnected* and co-evolving across spatial and temporal scales. It has proven difficult to truly understand ecosystem dynamics and the ability to generate services without accounting for the human dimension that shapes and is shaped by nature. Doing the natural science first, with the social dimension added on later in the processes, misses essential feedbacks of

complex adaptive social–ecological systems. The same is true for social sustainability. Despite a vast literature on the social dimension of resource and environmental management, studies have often focused on the social domain only, treating the ecosystem largely as a black box, assuming that, if the social system performs adaptively or is well organized institutionally, it will also manage ecosystems in a sustainable fashion. A human society may show great ability to cope with change and adapt if analysed only through the social dimension lens. But, such an adaptation may be at the expense of changes in the capacity of ecosystems to sustain the adaptation and may generate traps and breakpoints in social–ecological systems (Berkes et al. 2003; Walker and Meyers 2004).

Secondly, contemporary resource and environmental management and associated policies, including economic instruments and incentives, have, to a large extent, been based on steady-state views and assumptions. The *complex adaptive systems approach*, to which Levin (1998, 1999) has substantially contributed, contests models and policies that are based on assumptions of linear dynamics, with a focus on optimal solution in the vicinity of a single equilibrium (Dasgupta and Mäler 2003). Interdisciplinary research has illustrated that applications of such theories and world views tend to develop governance systems with policies that invest in controlling a few selected ecosystem processes, causing loss of key ecological support functions, in the urge to produce particular resources to fulfill economic or social goals (Holling and Meffe 1996). These practices tend to reduce the capacity to deal with change and options to continue to develop and may result in vulnerable social–ecological systems subject to regime shifts (Holling 1973; Scheffer et al. 2001; Folke 2006).

The third aspect is about *cross-scale and cross-systems interactions*. As emphasized by Levin and Vincent, scale issues are central in dealing with complex adaptive systems. Social–ecological systems have links across temporal and spatial scales, and levels of organization and decisions in one place affect people elsewhere (Gunder-

C. Folke
Centre for Transdisciplinary Environmental Research (CTM)
and Department of Systems Ecology, Stockholm University,
10691 Stockholm, Sweden
E-mail: calle@ecology.su.se

son and Holling 2002). A social–ecological system can avoid vulnerability at one time scale through the technology it has adopted. Similarly, actions at one spatial extent can be subsidized from a broader scale, a common pattern in human cultural evolution (Redman 1999) and currently exacerbated by capital markets and driving forces that seldom capture environmental feedback (Berkes et al. 2006). Local groups and communities are subject to decision from regional levels and are connected to global markets, and vice versa. Levin (2006) emphasizes that patterns at the macroscopic level emerge from interactions all the way down to individual agents, which, in turn, are shaped by macroscopic factors. Levin’s work on cross-scale dynamics (1992) has been very influential in this context, and new insights are emerging on cross-scale interactions in social–ecological systems (e.g. Gunderson and Holling 2002; Young 2000; Brown 2003; Anderies et al. 2004; Carpenter and Brock 2004; Cash et al. 2006), including dynamics of social and economic drivers of land use change (Lambin et al. 2003), and on governance systems that allow for learning and responding to environmental feedback and change (Dietz et al. 2003).

Both Levin and Vincent stress the evolution of cooperation and social norms as part of the self-organization of complex adaptive systems. Cooperation among agents may be self-organized into sophisticated governance systems that allow for management of ecosystem services in dynamic landscapes (Ostrom 1990; Olsson et al. 2004). Social norms are essential in such processes and are expressed in the interplay between individuals (e.g. leadership, teams, actor groups); the emergence of nested organizational structures, institutional dynamics, and power relations bind together in dynamic social networks where feedback loops are tightened. These are examples of features that seem critical in adaptive governance that allows for ecosystem management in fluid social–ecological landscapes and for responding to environmental feedback across scales (Folke et al. 2005). The emergence of such governance systems is often facilitated through enabling legislation, economic incentives and by bridging organizations that connect institutions across levels and scales to enhance their capacity to deal with change.

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