

Insight, part of a Special Feature on [Exploring Resilience in Social-Ecological Systems](#)

Governance and the Capacity to Manage Resilience in Regional Social-Ecological Systems

[Louis Lebel¹](#), [John M. Anderies²](#), [Bruce Campbell³](#), [Carl Folke⁴](#), [Steve Hatfield-Dodds⁵](#),
[Terry P. Hughes⁶](#), and [James Wilson⁷](#)

ABSTRACT. The sustainability of regional development can be usefully explored through several different lenses. In situations in which uncertainties and change are key features of the ecological landscape and social organization, critical factors for sustainability are resilience, the capacity to cope and adapt, and the conservation of sources of innovation and renewal. However, interventions in social-ecological systems with the aim of altering resilience immediately confront issues of governance. Who decides what should be made resilient to what? For whom is resilience to be managed, and for what purpose? In this paper we draw on the insights from a diverse set of case studies from around the world in which members of the Resilience Alliance have observed or engaged with sustainability problems at regional scales. Our central question is: How do certain attributes of governance function in society to enhance the capacity to manage resilience? Three specific propositions were explored: (1) participation builds trust, and deliberation leads to the shared understanding needed to mobilize and self-organize; (2) polycentric and multilayered institutions improve the fit between knowledge, action, and social-ecological contexts in ways that allow societies to respond more adaptively at appropriate levels; and (3) accountable authorities that also pursue just distributions of benefits and involuntary risks enhance the adaptive capacity of vulnerable groups and society as a whole. Some support was found for parts of all three propositions. In exploring the sustainability of regional social-ecological systems, we are usually faced with a set of ecosystem goods and services that interact with a collection of users with different technologies, interests, and levels of power. In this situation in our roles as analysts, facilitators, change agents, or stakeholders, we not only need to ask: The resilience of what, to what? We must also ask: For whom?

Key Words: *governance; resilience; adaptive capacity; institutions; accountability; deliberation; participation; social justice; polycentric institutions; multilayered institutions*

INTRODUCTION

Economic growth, rapid technological change, and the expansion of scientific knowledge have made societies more and more confident in their abilities to “manage” regional environmental change. A paradigm based on planning for efficiency, standardizing for easier social control, and reducing variability has come to pervade bureaucratic practices. Environmental problems are framed as technical and administrative challenges devoid of politics. People need to be informed and persuaded about the right and wrong uses of ecosystems, and penalized if they do not follow the right practice.

With good information and technical skills, the future can be blueprinted.

Over the past few decades, this view of the world has been challenged again and again by practical experience (e.g., Ostrom 1990, Ostrom 1999, Anderies et al. 2004). It now appears that some of the earlier confidence was misplaced and that key elements of our understanding of how regional social-ecological systems evolve were wrong (Berkes et al. 2003, Ostrom 2003; E. Ostrom and M. Janssen, *unpublished manuscript*). Uncertainties and nonlinearities often arise from both complex internal feedbacks and from interactions with structures and processes operating at other scales

¹Chiang Mai University, ²Arizona State University, ³Northern Territory University, ⁴Stockholm University, ⁵CSIRO, ⁶James Cook University, ⁷University of Maine

(Gunderson and Holling 2002). Expert knowledge is incomplete and biased, and participation does not always make things better (Jasanoff and Wynne 1998, Rayner 2003). There is no optimal best crop, land management practice, or strategy. Ecosystems may exist in multiple alternate stable states (Scheffer and Carpenter 2003). Regional systems invariably yield a complex mixture of ecosystem goods and services, each with its own set of stakeholders (Walker et al. 2002, Lebel 2004). Taken together, this has meant that attempts by authorities to tighten control, for example, by excluding disturbances like fires or floods or by establishing alternative property rights systems, have often led, paradoxically, to the creation of larger, more difficult challenges for society than the original set of problems (Holling and Meffe 1996).

The alternative to trying to maintain, or transform to, a system configuration that is very narrowly defined is to manage resilience. Resilience is a measure of the amount of change a system can undergo and still retain the same controls on structure and function or remain in the same domain of attraction (Carpenter et al. 2001, Holling 2001, Walker et al. 2002). To derive useful measures for a particular social-ecological system, we need to be specific about both the portfolio of challenges and the components of the system at risk that are of interest (Carpenter et al. 2001). In regional systems, this usually means considering several different interests and ecosystem goods or services. By managing resilience, we mean building or eroding the resilience of particular system configurations. At the regional scale, feasible management interventions by authorities or through social mobilization are, at any particular time, relatively modest compared to the full suite of factors that affect ecosystems and the behavior of the actors involved. Unconventionally, management might consist of discouraging interventions and allowing disturbances such as fires to burn or flood waters to take their course.

Strengthening the capacity of societies to manage resilience is critical to effectively pursuing sustainable development. This pursuit is a dynamic challenge in which it may be desirable, at certain times, to enhance resilience, e.g., when a system is in a domain of attraction associated with a desirable system configuration, and at other times to erode and help transform a system, e.g., when it is in a domain associated with an undesirable configuration. However, who decides when to intervene and

identifies the desirable system configurations? Who decides what portfolio of challenges the system should be made resilient to and which are of priority interest? How are those decisions made? Who controls implementation? What are the consequences of alternative courses of action for different stakeholder groups?

These are fundamentally questions about the politics of managing resilience and vulnerability. In this paper, we look at how various institutions, configurations of actors, and social processes shape such politics. The central question we address in this paper is: How do certain attributes of governance function in society to enhance the capacity to manage resilience?

GOVERNANCE AND THE CAPACITY TO MANAGE RESILIENCE

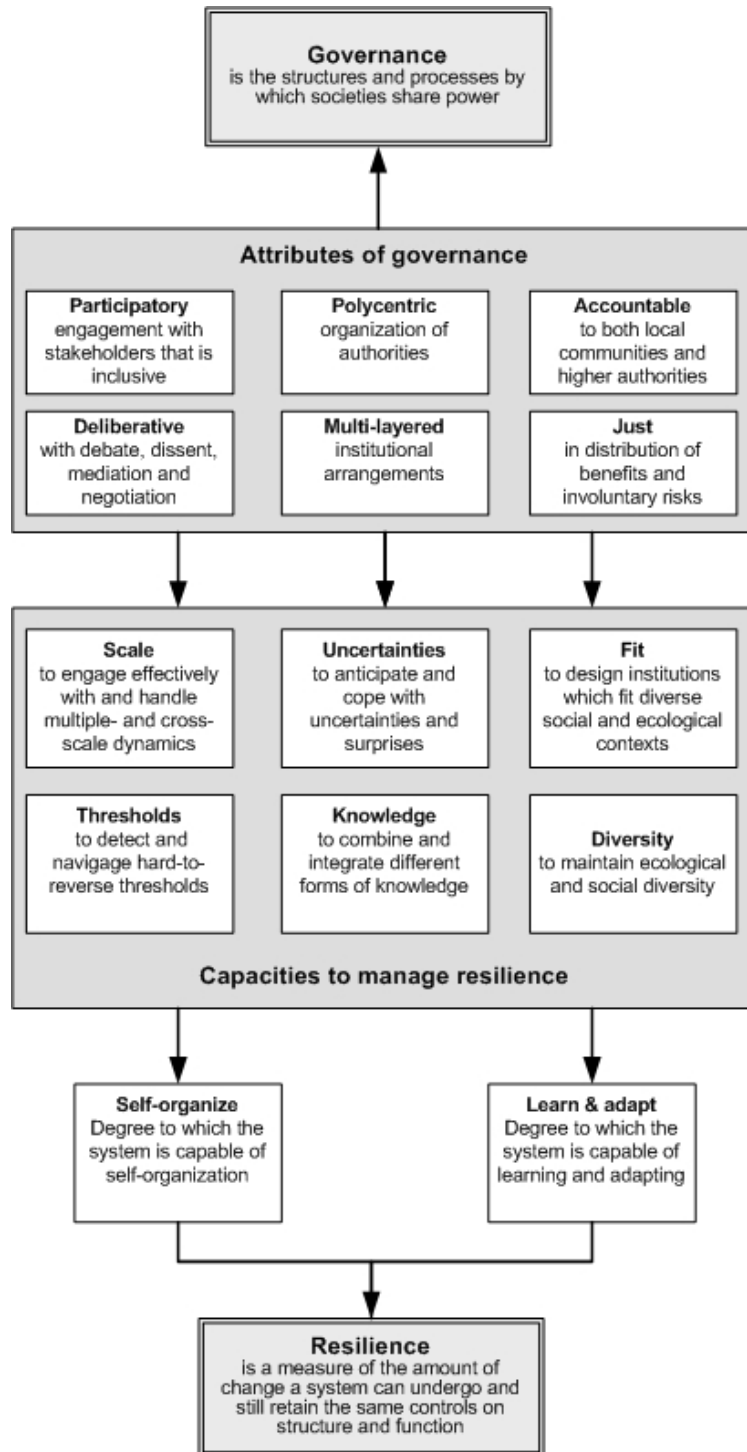
Governance, the structures and processes by which societies share power, shapes individual and collective actions (Young 1992). Governance includes laws, regulations, discursive debates, negotiation, mediation, conflict resolution, elections, public consultations, protests, and other decision-making processes. Governance is not the sole purview of the state through government, but rather emerges from the interactions of many actors, including the private sector and not-for-profit organizations. It can be formally institutionalized or expressed through subtle norms of interaction or even more indirectly by influencing the agendas and shaping the contexts in which actors contest decisions and determine access to resources.

Governance attributes

The kinds of attributes we are initially interested in are those frequently considered to be part of “good” governance, e.g., participation, representation, deliberation, accountability, empowerment, social justice, and organizational features such as being multilayered and polycentric (Fig. 1).

The amount of public participation by nonstate actors in decision-exploring processes through to implementation, monitoring, and sanctioning varies from the provision of information by authorities to various levels of consultation, collaboration, and empowerment (IAP2 2004). Public participation often broadens the range of interests and issues that

Fig. 1. Associations between selected attributes of governance systems and the capacity to manage resilience.



need to be considered, because different stakeholders assign different values to different ecosystem services and risks. Deliberation is a process of open communication, discussion, and reflection among actors who have alternative political viewpoints and understandings (Leeuwis 2000, Roling 2002). When it works well, deliberation makes it possible to learn about the views and motivations of others even when their positions remain fixed (Schusler et al. 2003). Deliberation can take place in many settings, both formal and informal, including through networks when people are more dispersed (Dryzek 1999). Deliberative processes can help citizens and scientists or experts better understand each other (Backstrand 2003). Discursive legitimacy may even be an important alternative or complement to representational democracy (Dryzek 1990, Dryzek 1999).

Polycentric institutions, by definition, have multiple centers or authorities. This is thought to create opportunities for understanding and for servicing needs in spatially heterogeneous contexts (Imperial 1999, McGinnis 1999, Cash 2000). Typically, such systems are also multilayered. A simple example is federal systems. Polycentric, multilayered arrangements do not have to be neatly hierarchical. Multilayered institutional arrangements can be important for handling scale-dependent governance challenges as well as cross-scale interactions (Young 1994, Berkes 2002, E. Ostrom and M. Janssen, *unpublished manuscript*). Multilayered governance creates possibilities for moderating vertical interplay among institutions (Berkes 2002, Young 2002, Lebel 2005). The conventional criticism of polycentric and multilayered arrangements is that there is inefficient overlapping of co-ordination and administrative responsibilities.

By accountability, we mean whether authorities are obliged to provide information and explain decisions and actions or inactions and whether they can be sanctioned when those answers are unsatisfactory (Agrawal and Ribot 1999). Although local authorities are often accountable upward to the central authorities of the state, accountability downward is often weak in natural resources management (Ribot 2002). Accountability also applies to more horizontal relationships, for example, between expert advisory or consultant bodies and state resource management agencies (Cash et al. 2003). There are many mechanisms that can contribute to accountability, including

transparency, independent monitoring, polycentricity, separation of powers, legal recourse, budget control, and a free media (Ribot 2002). Social justice is the central goal of good governance. Unjust distribution of benefits and involuntary risks from environmental changes usually requires proactive efforts to address inequities (Low and Gleeson 1998, Forsyth 2003). Injustices arise from repressive social control and, more subtly, from structural inequalities of power and life circumstances (Swyngedouw and Heynen 2003, Barry 2005).

Capacity to manage resilience

A society's ability to manage resilience resides in actors, social networks, and institutions. The condition and properties of the ecosystems that people use can make management an easy or a hard task. As a first step, it is helpful to break down this ability into capacities for self-organization, adaptation, and learning (Fig. 1). A capacity for self-organization means that a system has ways to maintain and re-create its identity. Although most systems are linked to, and impacted by, other systems, self-organizing systems are able to buffer the impacts of other systems and do not need to be continually invested in, subsidized, or replenished from outside to persist (Ostrom 1999, Carpenter et al. 2001, Holling 2001). The ability to learn and adapt implies that a system can get better at pursuing a particular set of management objectives over time and at tackling new objectives when the context changes (Adger et al. 2005, Brooks et al. 2005, Folke et al. 2005). This ability may be further broken down (Fig. 1).

The capacity to cope with nonlinearities or other forms of surprise and uncertainty requires an openness to learning, an acceptance of the inevitability of change, and the ability to treat interventions as experiments or adaptive management (Gunderson 1999, Adger 2000, Pahl-Wostl and Hare 2004, Adger and Vincent 2005). The capacity to effectively combine or integrate understanding gained from different sources and forms of knowledge, including tacit and formal knowledge, increases the likelihood that the key thresholds and components of diversity will be acknowledged (Berkes and Folke 1998, Berkes 1999). The ability to detect hard-to-reverse thresholds in a timely matter is important because it could allow societies to take measures to prevent ecosystems from crossing thresholds and ending up in another

undesirable basin of attraction (Holling 1978, Carpenter et al. 2001, Scheffer and Carpenter 2003). The capacity to build and maintain social and ecological diversity is important as a source of renewal and reorganization following major crises (Peterson 2000, Ostrom 2005). The capacity to build knowledge about ecological processes into institutions should improve the fit between rules and ecosystems even as they go through dynamic cycles (Holling 1986, Walters 1986, Berkes 1999, Gunderson 2000, Young 2002, Folke et al. 2003). The ability to engage effectively at multiple scales is crucial for regional systems because they are invariably subject to powerful external influences, including changes in regulations, investments, and the environment (Berkes 2002, Young 2002).

Association between governance and the ability to manage resilience

This paper explores the association between attributes of governance and the ability to manage resilience in a set of case studies undertaken by the Resilience Alliance (Table 1). The cases are diverse, covering situations in both developed and developing countries and involving marine, wetland, urban, and forested ecosystems. An outcome of the early rounds of exploration of the case studies was an initial list of questions about the relationships between governance and the ability to manage resilience in terms of (1) participation and deliberation, (2) polycentricism and multilayeredness, and (3) accountability and social justice. Most of the studies represented nuanced or more specific variants of Proposition 8 in the overview paper of this special issue, which states that adaptability is primarily determined by (1) the absolute and relative forms of social, human, natural, manufactured, and financial capital and (2) the system of institutions and governance. Over time, this list of questions was refined to three propositions related to attributes of governance and the capacity to manage resilience. The rest of this paper is organized around a discussion of these three propositions. Each section has the same structure. First, we introduce the proposition and explain the reasoning behind it. We then explore three or four case studies in modest depth. We end with comparative observations drawing on additional cases when appropriate and identifying other critical issues.

PARTICIPATION AND DELIBERATION

The first proposition we examine is: Participation builds the trust, and deliberation the shared understanding, needed to mobilize and self-organize.

Our argument is as follows. Public participation allows differences in interests and interactions with other issues to be brought forward for public scrutiny. Deliberation allows the differences in interests, perceptions, and explanations to be explored without forcing consensus. Trust and shared understanding are built up through repeated interactions of stakeholders and enable social learning (T. K. Ahn, *unpublished manuscript*; T. K. Ahn and E. Ostrom, *unpublished manuscript*). These form the foundation for mobilizing around new issues such as looming thresholds and self-organizing around innovative solutions or after crises.

Great Barrier Reef, Australia

Consultation by the authorities to gain public acceptance of unfamiliar management measures and the need for action to support resilience have been an important part of the management of the Great Barrier Reef of Australia. Until relatively recently, public perception of the Great Barrier Reef was of a system that is vast, pristine, and robust. Research, monitoring, and assessments suggest otherwise. The reef has experienced serial depletion of stocks over the past 150 yr as a result of industrial-scale fishing for pearl oyster shell, sea cucumbers, sharks, turtles, dugongs, and whales. Nutrient runoff from land has increased fourfold compared to precolonial times because of changes in agricultural practices. Population explosions of crown-of-thorns starfish have reduced coral cover, which has declined by 50% over the past 40 yr. Bleaching and mortality events caused by global warming are increasing in frequency and scale. The Great Barrier Reef Marine Park Authority (GBRMPA) is the consultative multistakeholder body that manages what is the largest marine protected area in the world. In 2002, it initiated an ambitious consultancy and public participation exercise to assist with plans for enhancing the level of protection of reef resources. There was immense public interest and involvement. More than 31,000 written submissions were received by the GBRMPA in response to 360 meetings and 88 newspaper advertisements. The

Table 1. A concise summary of the main case studies referred to in this paper.

| Geographic location | Goods and services of interest | | | | | |
|--|--------------------------------|----------|---------|-------------|-----------|-------|
| | Forest | Wetlands | Tourism | Agriculture | Fisheries | Urban |
| Everglades wetlands, Florida, USA | | X | X | X | | X |
| Goulburn-Broken Catchment, Australia | | | | X | | |
| Great Barrier Reef Marine Park, Australia | | | X | | X | |
| Gulf of Maine groundfishery, USA | | | | | X | |
| Kristianstad water realm, Sweden | | X | X | | | X |
| Northern Highlands Lake District, Wisconsin, USA | | | X | X | X | X |
| Mae Nam Ping Basin, Chiang Mai, Thailand | X | | X | X | | X |
| Malinau District, East Kalimantan, Indonesia | X | | | X | | |
| Chisasibi Cree areas, James Bay, Quebec, Canada | X | | | | X | |

| Geographic location | Institutional focus | | | | |
|--|---------------------|--------------------|-------------------------|-------------------|-----------------------|
| | Minority rights | Vertical interplay | Science-policy boundary | User associations | Regional organization |
| Everglades wetlands, Florida, USA | | X | X | | X |
| Goulburn-Broken catchment, Australia | | | X | | X |
| Great Barrier Reef Marine Park, Australia | X | | X | | X |
| Gulf of Maine groundfishery, USA | | X | X | X | |
| Kristianstad water realm, Sweden | | X | | | X |
| Northern Highlands Lake District, Wisconsin, USA | | | X | X | |
| Mae Nam Ping Basin, Chiang Mai, Thailand | X | X | | X | X |
| Malinau District, East Kalimantan, Indonesia | X | X | | | X |
| Chisasibi Cree areas, James Bay, Quebec, Canada | X | | | X | X |

resultant rezoning of the marine park increased the area of no-take reserves from < 5 to 33% from July 2004 (Jago et al. 2004). Strong support for rezoning came from all political parties, the tourism industry, conservation groups, and scientists, with significant opposition from local recreational and commercial fishers. To satisfy the latter, the GBRMPA changed the location of the boundaries drawn on a draft plan, and the federal government compensated commercial fishers who lost income. The new zoning plan incorporates an improved system for managing the sustainable use of the marine park by indigenous communities based on consultative Traditional Use of Marine Resources Agreements (GBRMPA 2004). As a result of improved awareness, fishers are increasingly willing to support no-take reserved areas for the sake of improved resilience and the long-term sustainability of fish stocks. The rezoning would not have been possible without public consultation.

Kristianstad Vattenrike, Sweden

In our next example, a trusted public authority was the outcome rather than the driver of public participation and deliberation. The Kristianstad Water Realm in Sweden was set aside as a reserve in the early 1970s. The wetlands, long viewed as worthless swamps, are interspersed within and around human settlements in a town with 70,000 inhabitants (Magnusson 2004). Management initially struggled to halt the degradation of the land and waterscapes in the reserve. It took 10–20 yr to build trust and create a shared vision and sense of stewardship with regard to the landscape (Magnusson 2004, Olsson et al. 2004). A culture of public involvement through issue-based actor networks that form and disband as issues wax and wane has been instrumental in maintaining high responsiveness and flexibility when faced with ecological uncertainties and changes (Olsson et al. 2004). This capacity has been strengthened by the bottom-up emergence of a municipal-level boundary organization, the Ecomuseum Kristianstads Vattenrike. Sven-Erik Magnusson (SEM) played a pivotal role first as a founder and later as Director of the Ecomuseum. Olsson and colleagues (2004) describe how SEM started as an assistant and then became curator of the Kristianstad County Museum, organizing natural history and cultural exhibitions. SEM started the idea of “outdoor museums” by introducing information panels in the landscape at natural and archaeological sites. This in turn led to

an awareness of the eroding ecological values of the wetland and associated cultural practices such as grazing and haymaking. A series of assessment and restoration activities followed, bringing together new groups and increasing knowledge about local environments (Magnusson 2004). When he established the Ecomuseum, SEM focused on building relationships with key individuals, for example, at universities, the Worldwide Fund for Nature, and the Tourism Board. Over time, the effective mandate of the organization expanded into managing the catchment of the lower Helgeå River (Folke 2003) and shifted from being part of the County Museum to becoming a part of the municipal organization (Olsson et al. 2004).

Goulburn-Broken Catchment, Australia

The Goulburn-Broken Catchment in Australia is beset by multiple water and soil problems as a result of a long history of clearing native vegetation (Binning et al. 2001, Cork et al. 2002). State-sponsored participation has been a key strategy for addressing problems related to soil conservation and dryland salinity. The National Landcare Program launched in 1989 is particularly noteworthy because it is voluntary, participatory, and based on education; these attributes have contributed to the creation of a stewardship ethic (Curtis and Lockwood 2000). Ideas of empowerment and participation were central to the program, perhaps so much so that resources were spread too thinly to deal with more degraded locations (Pannell 2002). In the last few years, Bill O’Kane, the Chief Executive Officer of the Goulburn-Broken Catchment Management Authority, has forged strong links with the scientific and agricultural business communities and media through active participation on numerous boards and committees and in ad hoc meetings. These networks have brought information and resources to the catchment and are helping managers plan and begin to address the fundamental ecological and social challenges facing the basin (CSIRO Sustainable Ecosystems 2003). In many ways, the region remains culturally trapped in a domain of attraction governed by a relatively narrow set of rural-oriented values about what rural landscapes should look like and what livelihoods they should support. Nevertheless, the efforts of the Catchment Management Authority and its partners have undoubtedly strengthened the capacity of the society in the basin to manage resilience (CSIRO Sustainable Ecosystems 2003).

The Everglades, Florida, USA

Since the 1940s, the northern third of the Everglades in Florida, USA, has been transformed into agricultural land, whereas other parts are devoted to urban and conservation land uses (Walker and Solecki 2004). The result of this diversity has been altered flood regimes and a series of ecological surprises and associated policy and management crises (Gunderson 1999). A vegetation shift from sawgrass to cattail marshes, for example, was caused by agricultural runoff after major disturbances such as drought, freezes, and fires. The 1970 drought, for example, led to the creation of a new institution, the South Florida Water Management District, as a way to ensure that a minimum water allocation was delivered to the National Park regardless of rainfall. Deliberation, especially among experts and managers, was an important feature in the 1980s and 1990s and helped to shape alternative visions for the future of the Everglades in Florida. An intense period of consultation workshops primarily among biologists and hydrologists led to new levels of system understanding (Light et al. 1995). The mass media has played an important role in transforming relatively localized flood, drought, or algal bloom events into Everglade-wide issues of importance, effectively forcing a response from higher-level authorities. Pictures of the Lake Okeechobee blooms, for example, started a process that challenged the effectiveness of the water management authority and culminated in a lawsuit. In 1988, a federal suit against the State of Florida and the South Florida Water Management District for failing to stop the flow of eutrophic water into the Everglades National Park gave renewed impetus to various groups seeking to restore the Everglades. Iterative model development (Walters et al. 1992) and scenario assessments (Ogden et al. 1999) in the following years played an important role in the search for and exploration of policy options, and highlighted the importance of focusing on hydrological manipulations in restoration. Gunderson (1999) describes how the group attempted to communicate its assessment through an animation of the water system, a set of one-page fact sheets, and meetings of the South Florida Water Management District with a broader stakeholder group. These actions lead to recommendations for adaptive policies, but no real experimentation with management. Gunderson attributes this failing both to a lack of flexibility in the management bureaucracy and the easy recourse to lawsuits by

stakeholders who might be adversely affected by alternative management interventions. After many years of apparent gridlock during which the costs of restoration have risen tremendously, a significant restoration effort is finally under way. The Army Corps of Engineers is blocking canals, reconverting agricultural lands to wetlands, and, in the process, reversing decades of "land reclamation" logic (Walker and Solecki 2004). Partnerships among NGOs and state agencies committed to the restoration of the Everglades maintain pressure for these measures to be pursued in what is still a polarized situation.

Several insights came from consideration of the role of participatory and deliberative processes in building the capacity to manage resilience across these four regional case studies. First, the process of trust-building takes time, at least one decade and sometimes several. In some cases, it may be too slow to avoid hard or costly-to-reverse thresholds. The capacity to build networks of trust appears to be fundamental to the kinds of self-organizing collective action needed to manage resilience. Second, leadership is important in fostering effective public participation and deliberation. In both the Goulburn-Broken Catchment and the Kristianstad Water Realm, leaders helped their organizations reach across institutional, scale, and other barriers to create links that bring along with them new ideas, skills, and resources. They gave direction, and inspired and motivated others into actions in which significant uncertainty could have led to costly inaction. Third, and more critically, the discourse of managing resilience or vulnerability is subject to its own peculiar forms of politics rooted in relatively narrow ecological reasoning that has impacts on who participates and how. Aboriginal interests, for example, have largely been sidelined in deliberations about land use in the Goulburn-Broken Catchment, whereas they have been much better represented in deliberations over sea use in the Great Barrier Reef. Finally, we note that withholding participation in a process in which your interests cannot be adequately represented may sometimes be a good strategy (Dryzek 2001).

POLYCENTRIC AND MULTILAYERED INSTITUTIONS

The second proposition we examine is: Polycentric and multilayered institutions improve the fit between knowledge, action, and socio-ecological

contexts in ways that allow societies to respond more adaptively at appropriate levels.

Our argument is as follows. An organizational structure with multiple, relatively independent centers creates opportunities for locally appropriate institutions to evolve by tightening monitoring and feedback loops and by enhancing associated institutional incentives (Berkes and Folke 1998). In this situation, local governance arrangements can develop to better match the varied social and ecological contexts and dynamics of different locations. Local monitoring may provide effective early warning systems, and monitoring of interventions allows safe-to-fail experimentation. Local knowledge can inform local actions in ways that a single centralized system cannot. Multilayered institutions, in addition, allow the possibility for level-dependent management interventions as well as explicit mechanisms to address cross-level interactions (D. Cash, W. N. Adger, F. Berkes, P. Garden, L. Lebel, P. Olsson, L. Pritchard, and O. R. Young, *unpublished manuscript*) without undermining the capacity to self-organize at any particular level.

Chisasibi First Nation of Cree, Quebec, Canada

The Chisasibi First Nation of Cree live in the James Bay area of Quebec, Canada, close to the northern limit of the Coniferous Forest Biome (Berkes 1998). Up until the 1960s or so, they followed a traditional migratory way of life. Although most of them now live in a permanent year-round settlement, activities related to hunting and fishing are still a central component of the regional economy (Berkes 1999). The hunting stewards of the Chisasibi Cree manage caribou, beaver, and fish in ways that reflect differences in resource dynamics (Berkes 1998). Caribou are hunted on overlapping communal territories, whereas beaver are managed at the level of the family. Access to fish, which are abundant relative to needs, is usually not controlled. Rules and enforcement are decided collectively by the stewards, who provide a second governance layer above the community in the form of the Chisasibi Cree Trappers Association. Stewards are accountable for their performance. Berkes (1998), for example, relates the story of how, after the return of the caribou after an absence of 70 yr, a particularly wasteful hunt was followed by the disappearance of most of the herd the following year. Elders

explained that this was because of a lack of respect and related how this had happened before, in 1910 when automatic rifles were first introduced, and had been followed by a 70-yr “retaliatory” absence. The impact on young hunters was profound. The Chisasibi Cree Trappers Association took control of the hunt, as was their people’s right under the James Bay Agreement with the Canadian government. In subsequent years, caribou numbers continued to increase, reinforcing the oral history lessons (Berkes 1999). Traditional management is polycentric, multilayered, and adaptive. It changed in response to natural resource dynamics and over time with development, made errors in management, and learned from those mistakes.

Mae Nam Ping Basin, Thailand

In the main valley of the Mae Nam Ping Basin around Chiang Mai and Lamphun towns in northern Thailand, a surprisingly high level of flexibility in water management has emerged from the interplay of many local and a few higher-level institutions. Over the past two to three decades, the density of institutions has increased, and the management challenges have grown tougher for two main reasons. First, several state projects have substantially expanded dry-season cropping areas both in the basin and much further downstream toward Bangkok (Molle et al. 2001). Second, urban expansion, tourism, and the growth of the industrial sector have resulted in major shifts in land use and in patterns of demand for water in a monsoonal system with very modest dry-season storage capacity (Cohen and Pearson 1998, Lebel et al. 2004). At the same time, decentralization reforms have assigned significant responsibilities for managing smaller-scale water infrastructure to local government administrations with jurisdictional boundaries that often do not correspond closely with those of either irrigation districts, municipalities, or traditional *Muang Fai*, i.e., local weir-based irrigation and water sharing, institutions (Pearson 1999). Additional layers in the form of a River Basin Organization and initially three pilot sub-basin river organizations have also been introduced (Thomas 2005). What is remarkable is that each of these new institutional arrangements has been added on top of older arrangements without necessarily replacing them. This polycentric and multilayered arrangement creates institutional redundancies, but field-level work suggests that water is still distributed reasonably equitably and flexibly within the

constraints of operational guidelines that ensure that urban areas are serviced first. The heads of water user groups call their friends in the irrigation department and have their allocations increased at critical times. Water pumps and wells that are technically illegal are overlooked. Informal, or shadow, institutions help maintain system integrity through dry-season scarcity. The current approach of allowing creative and different solutions in each of the sub-basin organizations (Thomas 2005) should help build additional capacity to manage water resources in locally appropriate ways.

New England fishery, USA

In the New England fishery, there has also been a historical evolution toward additional layers, but they have generally reproduced the management of past regimes rather than learning from the new opportunities created at other scales. Thus, when the International Commission of Northwest Atlantic Fisheries divided its huge jurisdiction into several fishing grounds such as the Gulf of Maine, it continued to focus management on individual commercial species and stock management approaches (Wilson 2002). The groundfishery in the Gulf of Maine has been managed at a relatively broad scale under the assumption that the fish of each species within the managed area comprise a single, spatially distinct stock that is homogeneously distributed within the management area (Costanza et al. 1998, Wilson et al. 1999, Steelman and Wallace 2001). For all practical purposes, the types of complex population structures that might arise from the localized ecological adaptations of fish, for example, local spawning groups, nursery areas, and so on, are ignored or assumed to average out over the management area. However, there is increasingly strong evidence that the population structure of many groundfish species, in the Gulf of Maine and elsewhere, is quite complex (e.g., Robichaud and Rose 2004). This has created a variety of regulatory incentives that confound the goal of conservation (Wilson 2002).

At a broad scale, management has worked out reasonable estimates of the number of fish of each species that exist in the area and from that, and a large number of assumptions, an estimate of how many individuals of each species can be caught, on average, to maintain the population. These estimates are then used to determine the limits on fishing effort. The problem is that fishermen do not fish on

the average spatial distribution of fish. Good fishermen fish where the fish are; they exploit their knowledge of the local adaptations of fish (St. Martin 2001). This would not be a problem if fish conformed to the assumptions of spatial homogeneity; the patches fishermen work would be simply ephemeral expressions of a single large stock. However, if fish really do adapt to the local variations in their environment, then fishing effort will converge on the more abundant local populations. Consequently, the result of the mismatch between scientists' perception of a broad homogeneous environment and fishermen's usually correct perception of a diverse, multiscale environment, is an inadvertent continuation of uncontrolled fishing for each localized stock, even with seemingly strict, broad-scale limits on fishing. Moreover, fishermen, like fish, are diverse and operate on many scales. Some operate locally in very small boats, others steam a little further in somewhat larger boats, others leave home for weeks at a time, and still others range over the globe. Some, usually small-scale fishermen, fish on many species with many kinds of gear, whereas others, generally larger-scale fishers, fish on a few or only one species with a single kind of gear. With the progressive loss of local stocks and the increasing spatial variability of fish abundance, a growing economic premium attaches to size and mobility. To chase down scarce, patchily distributed stocks, a boat must be fast, able to carry a lot of fish, able to stay at sea for extended periods, specialized and technologically up to date, and strongly attached to high-volume, usually urban product markets. These industrial-scale operators, who also have easy access to capital, out-compete smaller-scale local fishers with impacts that cascade through the local economies based on services to fishers and the marketing of fish.

The groundfishery in the Gulf of Maine has collapsed, from both social and ecological perspectives, into a highly resilient but relatively undesirable configuration for many stakeholders. Although groundfish populations and landings have plummeted in the last 20 yr, other species further down the food chain, such as lobster, have become almost hyperabundant (Wilson 2002). Almost everything in these fishing communities today depends on lobster. The great fear is that the condition of the ecosystem may degrade further with disastrous social consequences. Any movement toward an alternative resilient system will require a governance system and a scientific approach that recognize the diversity and multiscale

attributes of the ocean and of fishing. Area-based management might be an effective alternative to management by numbers. Such a decentralized approach would allow appropriate feedback on the behavior of fishers. The mobility of fish and fishers is one of the reasons why polycentric and multilayered approaches may enhance capacities for collective learning (Wilson 2002).

Northern Highlands Lake District, Wisconsin, USA

In Wisconsin's Northern Highlands Lake District, excess phosphorus from intensive applications of fertilizer on agricultural lands and from feeds accumulates in soils. During runoff events, it enters lakes that can then switch from clear to turbid and eutrophic (Bennett et al. 1998, Carpenter et al. 1999). This impacts on recreation, kills fish, and is costly to treat. Although both lake states can be resilient, in practice it is hard to successfully restore lakes once they have collapsed into the turbid state (Lanthrop et al. 1998, Carpenter et al. 2001). Polycentrically arranged lake associations, tribal organizations, and town governments have been an important source of management actions. Modelling and scenario exercises incorporating alternative stable states and complex dynamics from trophic cascades and mobile fishers support the idea of managing the landscape as a set of lakes (Janssen 2001, Peterson et al. 2003). Flexible lake-specific management appears more likely to lead to resilient outcomes in terms of maintaining revenue generated from fisheries without triggering collapse from overfishing than do attempts to harmonize management across all lakes (Carpenter and Brock 2004). The existing social organization of towns, lake associations, and tribal institutions is conducive to a polycentric arrangement, with higher layers providing key coordination functions.

In all four regional case studies, polycentric and multilayered institutions appear to be important to building or enabling the capacity to manage resilience. We highlight three issues worthy of additional exploration. First, users dependent on a heterogeneous resource who have a large stake in it being managed sustainably can come up with institutional arrangements that reflect key properties of the resource (cf. Jodha 2001). The groundfish example, however, underlines how contested knowledge can make it hard to bring about institutional change even after a crisis and

prolonged collapse. How do polycentric and multilayered institutions that support the capacity to manage resilience arise in the first place? Second, although much has been learned about the monitoring and transaction costs of more complex institutional arrangements (e.g., Ostrom 1999), it is far from clear how these considerations can and should be balanced against concerns about sustainability and social justice. How much does it cost to build the capacity to manage resilience, and when is it simply not worth it? Third, all four studies suggest that interest-based networks are flexible and can learn quickly (Folke 2003). This should be particularly valuable in situations of high uncertainty. At the same time, the earlier examples in Kristianstad, the Goulburn-Broken Catchment, and Mae Nam Ping underline the value of institutionalization. What are the trade-offs between the flexibility of actor networks and more formally institutionalized relationships in strengthening the capacity to manage resilience?

ACCOUNTABLE AND JUST AUTHORITIES

The third proposition we examine is: Accountable authorities who also pursue just distributions of benefits and involuntary risks enhance the adaptive capacity of vulnerable groups and society as a whole.

Our argument is as follows. Authorities who are obliged to explain and inform, and who can be sanctioned when they perform poorly, can be challenged by groups that unjustly bear large involuntary risks or receive less than their fair share of benefits. The pursuit of social justice by actively protecting the rights and interests of or empowering socially vulnerable groups is a worthy one without additional justification. At the same time, however, socially vulnerable groups are often dependent on, and contribute to the maintenance of, aspects of ecological and social diversity overlooked or undervalued by the mainstream or dominant culture. Often, efforts to improve the just distribution of benefits and involuntary risks from the management of ecosystems and their services also help to maintain diversity and enhance the adaptive capacity of these vulnerable groups. These enhancements, in turn, help reduce the vulnerability of the social-ecological system as a whole by reducing destabilizing conflicts and strengthening weak links.

Malinau District, East Kalimantan, Indonesia

Malinau District in East Kalimantan, Indonesia, was established in 1999 as part of the national decentralization process in Indonesia (e.g., Silver 2003, Thorburn 2004). The district has significant forest resources and logging activity, with 95% of the land area classified as Forest Estate (Barr et al. 2001). This activity yields high resource rents, but the local people receive very few benefits. There are three major stakeholder groups: (1) forest-based indigenous Punan hunter-gatherers and Dayak shifting cultivators, (2) town-based workers and traders who have moved to the area because of its economic opportunities, and (3) the forestry and mining industries, which are externally controlled but locally well connected (Sayer and Campbell 2004). In Malinau, the management of the timber concession was decentralized from the central government to the provinces and districts without any mechanisms to support accountability (Wollenberg and Kartodihardjo 2002). Prior to decentralization, the local people received almost no benefits from logging, but now logging companies are making some attempt to compensate the local people. The amounts involved are small, and promises made about payments or services to be provided are seldom kept. Customary land tenure and associated property rights are frequently contested by different groups and villages. Many of the permits for small-scale forest conversion have gone to larger Malaysian-backed logging companies, which has created opportunities for quick profits from timber exploitation for the district government, forest authorities, and timber brokers (Barr et al. 2001). There has been little monitoring or control of what is actually cut or the impacts of logging on the local ecosystem. The practices of forestry companies granted access by the district appear to be even less environmentally sustainable than those permitted by the previous regime, at least in Malinau.

Governance arrangements are important in at least two ways. First, district officials are elected, largely from local groups, and remain relatively sensitive to the needs and expectations of their constituencies. However, once elected they move to town, which distances them both physically and socially from their communities of origin. Second, the rents generated by resource access deals are shared between the forestry companies, the district government, district officials as a private benefit, and local communities in the form of services and

infrastructure with the occasional cash payment. Although ethnic, economic, and family ties are all important, benefits are often not distributed beyond the key individuals in a village (Barr et al. 2001). Democratic institutions that could foster dual accountability between village, district, and provincial authorities are lacking. In the absence of direct elections, deliberative public meetings, and an independent press, the accountability of state officials remains low (Barr et al. 2001). Even traditional *Adat* institutions have lost credibility because they are strategically and blatantly used to gain access to concessions. Finally, monitoring and enforcement of good logging practices are weak (Smith et al. 2003).

A number of research teams have focused on the most marginalized communities with the explicit objective of empowering the local people so that they can better negotiate with district officials and logging companies. This fostered conflict with the other stakeholders and the research teams associated with them. For example, those researchers interacting with district officials often received complaints about the type of community research being conducted. Several slower, potentially destabilizing feedback loops were also identified. Logging imposes a range of environmental damages and social costs, including reduced water quality, declines in fish and fish catch, and a reduction in nontimber products for consumption and local trade. Existing governance structures do not generally provide mechanisms for managing these impacts. Several local villages object to or prevent logging in their areas. The majority support forestry but seek greater local benefits. One village is opposed to logging in principle and has developed the basis for a local eco-tourism "industry." This village was supported by the research team to the extent that it received a national environmental award, the granting of which raised its standing in the district and probably gave the villagers better negotiating power with other powerful players in the district.

Great Barrier Reef Marine Park

In the Great Barrier Reef Marine Park, progress toward protecting the rights of the indigenous people has also been made. The park stops short of the Torres Straits, between Australia and Papua New Guinea, where the Torres Strait Treaty recognizes the indigenous rights of the traditional

inhabitants (Elmer and Coles 1991). The original act that established the Great Barrier Reef Marine Park Authority (GBRMPA) in 1975 made no specific references to indigenous interests, and it was not until zoning plans were drafted in 1983 that reports on indigenous issues began to be commissioned by GBRMPA (Benzaken et al. 2002). The Mabo court case in 1992 overturned the concept of *terra nullius*, which stated that Australia was not owned prior to the arrival of Europeans, and instead established the concept of “native title.” This decision has heightened expectations for greater involvement by traditional owners in the management of the marine park and their “sea country.” However, customary marine tenure is often difficult to establish, and because it is highly communal and flexible, it is also difficult to legislate using established institutions and western laws. GBRMPA held more than 50 workshops for Aboriginal and Torres Strait Islander people in 2002–2004 as part of its public consultation on rezoning the Barrier Reef. Today many indigenous groups actively seek involvement in the management of the park, although roles beyond employment as community rangers remain limited and uncertain, especially with the major expansion of no-take areas. Hunting for dugongs and sea turtles, highly valued traditional foods, is an ongoing cultural practice of Aboriginal and Torres Strait Islander peoples living adjacent to the Great Barrier Reef. Nonindigenous users of the marine park are not permitted to take these species, which Australia is obliged to protect under various national laws and international conventions. Unfortunately, populations of dugongs and turtles are in sharp decline. Consequently, traditional hunting generates a media controversy that creates pressure to curtail the harvesting of threatened species (Nursey-Bray 2003). Some innovative co-management systems are being developed to allow limited traditional hunting of a dwindling resource. Traditional activities that are forbidden to nontraditional users require a permit or an accredited Traditional Use of Marine Resource Agreement that is designed to “... put in place a range of management procedures that encompasses Aboriginal and Torres Strait Islander cultural values, conservation biodiversity interests and current native title law ...” (GBRMPA 2004).

Local government reforms, capacity building within the bureaucracy, and pressure from an increasingly active citizenry have helped to improve the quality of many aspects of governance in Thai society over the past decade (Arghiros 2002). The

performance of most authorities is now open to public scrutiny, and the press remains relatively free. Nevertheless, a lot still depends on who you are. For ethnic minorities without citizenship status, and even for those who do have it, discrimination makes life difficult and dangerous. Low-quality information on ecological trends, language and other communication difficulties, insecurity, and the threat of violence perpetuate social injustices. Myths about the impacts and performance of upland land-use practices abound (Forsyth 1996, 1998, Walker 2003). Especially in border areas, authorities with low accountability have kept information secret so that, for example, their complicity in illegal or unregulated extraction of a natural resource may continue, or their history of poor management decisions can be covered up. In these contexts, resistance, protest, and other means of dissent may be an important precursor to gaining access to platforms for participation and deliberation that otherwise would not be provided willingly. A substantial amount of effort by nongovernmental agencies has gone into empowering minorities, drawing attention to their plight, and critiquing authorities for their failure to deliver services and support (Luangaramsri 1999, Santasombat 2004). This is important because many households and often entire communities are extremely vulnerable to changes, for example, in access to forest and agricultural lands in the mountains or in employment opportunities in the lowlands. Climate variability is also a source of vulnerability for their rain-fed agriculture, but traditional swidden systems, portfolio-based livelihood strategies, and spatially extensive kin networks that act as social safety nets mean that livelihoods may still be surprisingly resilient well below the poverty line (Lebel 2003, Garden et al. 2005). Institutional arrangements that foster dual accountability among local government and nongovernmental organizations and help coordinate their activities appear to be particularly promising for upper-tributary watershed areas (Thomas et al. 2004, Thomas 2005).

Accountability is usually thought of as one supporting mechanism to achieve the goal of social justice in development and environmental management. Our exploration of regional case studies in this and earlier sections raises four issues (Table 2). First, decentralization without corresponding accountability may reduce the capacity to manage resilience. At all scales, the activities and performance of authorities need to be monitored,

and there should be mechanisms to sanction or remove corrupt or incompetent players. The upward and downward accountability of authorities is a safeguard that prevents the “capture” of the agenda and resources and provides ways to reorganize after failures. Second, accountability appears to enhance the ability of authorities to work at multiple scales and thus to benefit from and not be overwhelmed by cross-scale interactions. This capacity may be particularly important in slowing or avoiding crises and in drawing on other resources for reorganization in the ensuing politics of scale (e.g., Lebel et al. 2005). Third, protecting rights and pursuing justice for ethnic minorities are key actions in building the capacity to manage resilience. In the Indonesian and Thai case studies, insecure rights to farms and forested lands, along with insecure citizenship and the associated implications for credit and other services, leaves ethnic minorities in a difficult situation. Their livelihoods depend strongly on goods such as timber and nontimber forest products as well as indirectly on various soil and hydrological services of watersheds, but these are insecure and threatened by, in the Ping case, conservation and, in Malinau, logging policies. The regaining of rights to self-management for the Chisasibi Cree under the James Bay and Northern Quebec Agreement of 1975 (Berkes 1998) illustrates how protecting the rights of socially vulnerable groups can help them cope better with the types of changes caused by hydroelectric power development projects and huge fluctuations in caribou abundance. Finally, we note that gender issues, surprisingly, went unreported in the case studies. Is this an accurate reflection of the equity in these regional systems, or does it reflect on the politics of how resilience and vulnerability are studied or managed?

SYNTHESIS AND CONCLUSIONS

This paper explored how certain attributes of governance function in society to enhance the capacity to manage resilience. We approached this by reviewing experiences in a set of regional case studies carried out by the Resilience Alliance (Table 1) against a framework of attributes and capacities (Fig. 1). Three specific propositions were examined: (1) participation builds the trust, and deliberation the shared understanding, needed to mobilize and self-organize; (2) polycentric and multilayered institutions improve the fit between knowledge, action, and socio-ecological contexts in ways that allow societies to respond more adaptively at

appropriate levels; and (3) accountable authorities who also pursue just distributions of benefits and involuntary risks enhance the adaptive capacity of vulnerable groups and society as a whole.

Some support was found for parts of all three propositions. In exploring, debating, and deciding what to do, diverse participation, open communication, and deliberation are important because they help build the trust and shared understanding among diverse stakeholders needed to mobilize resources and people and to foster self-organization. In monitoring, using, and managing natural resource systems, the flexibility provided by polycentric and multilayered systems of governance can create opportunities for learning and decision making in places and scales that match social and ecological contexts much more closely than is possible in monolithic arrangements. Accountable authorities who also pursue social justice by helping to secure the livelihoods of the most vulnerable groups enhance the capacity of society to manage resilience.

These findings are necessarily tentative. The collection of case studies explored in this paper was assembled post hoc, and the individual studies themselves were not designed to address questions about governance. Much of the variation in the association between governance arrangements and the capacity to manage resilience remains unexplained.

Our exploration also raised several theoretical and practical issues. First is the problem of measurement. The capacities of individual actors or institutionalized relationships among them are not straightforward to assess. Although there are methods available, most governance attributes have not been systematically assessed in the same places in which social-ecological relationships are studied. Hence, our understanding of, for example, what makes participation and deliberation effective remains rudimentary (e.g., Rayner 2003, Rowe and Frewer 2004). Second is the problem of experts. Analysis of governance structures and processes sometimes reveals the darker side of conservation in which livelihood needs or the rights of minorities are passed over in the interests of maintaining, say, ecological resilience. Ultimately, these decisions about how to deal with trade-offs and priorities among social and environmental objectives are and should be political, and should not be left to experts and narrowly framed models (Goldman 2004).

Table 2. Comparison of some key organizations and their institutional relationships in a selected set of case studies.

| Organization (date established) | Mandate | Upward accountability | Downward accountability | Key sources of expertise |
|---|--|---|---|---|
| Goulburn-Broken Catchment Management Authority (1997) | Natural resource management | Board of Directors appointed by Minister for Environment and Water in the Victoria State Government | Through three subcatchment committees, each with eight community representatives, and indirectly through stakeholder projects | CSIRO Sustainable Ecosystems |
| Ecomuseum Kristianstads Vattenrike (1989) | Environmental and cultural aspects of catchment management | Municipality of Kristianstad | Issues networks and co-management relationships with stakeholder groups | Knowledgeable local stewards and associations Lund, Kristianstad, and Stockholm Universities; WWF Sweden; Museum of National History |
| Great Barrier Reef Marine Park Authority (1975) | Management of the park for multiple uses | Australian Government, World Heritage Commission | GBR Consultative Committee, 10 local marine advisory committees, high public interest | Reef Cooperative Research Centre, James Cook University, the Australian Institute of Marine Science, the University of Queensland, and Australian National University |
| South Florida Water Management District (1972) | Operation of canals and levees, restoration of ecosystems, and disaster management | Federal agencies, governing board, Florida legislature | Mass media, user groups, and the public monitor performance closely | Many universities, federal and state agencies, consulting firms, and NGOs |
| Chisabisi Cree Trappers Associations (1985) | Management of caribou hunt | Governing board under James Bay Agreement, elders | Hunters, caribou | Traditional knowledge of elders and younger hunters |

Assessments and other tools for managing the science-policy interface can be particularly helpful in these circumstances (Jasanoff and Wynne 1998, Social Learning Group 2001). Third is the problem of causality. Our explorations here indicate that it is possible that the capacity to manage resilience may influence the form that governance takes and that ecological feedbacks may constrain both governance and this capacity.

What is abundantly clear is that, in exploring the sustainability of regional social-ecological systems, we are usually faced with a set of ecosystem goods and service that interact with a collection of users who have different technologies, interests, and levels of power. In this situation, in our roles as

analysts, facilitators, change agents, or stakeholders, we must ask not only: the resilience of what, to what? We must also ask: for whom?

Responses to this article can be read online at:
<http://www.ecologyandsociety.org/vol11/iss1/art19/responses/>

Acknowledgments:

Colleagues in the Resilience Alliance and other stakeholders who contributed to working group sessions discussing interventions and governance issues in social-ecological systems at the

Ecomuseum in Kristianstad, Sweden, in 2003 and at the Mitchell Vineyards in Namadgie, Australia, in 2004 are thanked for their diverse inputs, which eventually led to this paper.

LITERATURE CITED

Adger, N. W. 2000. Institutional adaptation to environmental risk under the transition in Vietnam. *Annals of the Association of American Geographers* 90:738-758.

Adger, N. W., N. W. Arnell, and E. L. Tompkins. 2005. Successful adaptation to climate change across scales. *Global Environmental Change* 15:77-86.

Adger, N. W., and K. Vincent. 2005. Uncertainty in adaptive capacity. *Comptes Rendus Geoscience* 337:399-410.

Agrawal, A., and J. C. Ribot. 1999. Accountability in decentralization: a framework with South Asian and African cases. *Journal of Developing Areas* 33:473-502.

Anderies, J. M., M. A. Janssen, and E. Ostrom. 2004. A framework to analyze the robustness of social-ecological systems from an institutional perspective. *Ecology and Society* 9(1):18. [online] URL: <http://www.ecologyandsociety.org/vol9/iss1/art18/>

Arghiros, D. 2002. Political reform and civil society at the local level: Thailand's local government reforms. Pages 223-246 in D. McCargo, editor. *Reforming Thai politics*. Nordic Institute of Asian Studies, Copenhagen, Denmark.

Backstrand, K. 2003. Civic science for sustainability: reframing the role of experts, policy-makers and citizens in environmental governance. *Global Environmental Politics* 3:24-41.

Barr, C., E. Wollenberg, G. Limberg, N. Anau, R. Iwan, I. M. Sudana, M. Moeliono, and T. Djogo. 2001. *The impacts of decentralization on forest and forest-dependent communities in*

Kabupaten Malinau, East Kalimantan. Center for International Forestry Research, Bogor, Indonesia.

Barry, B. 2005. *Why social justice matters*. Polity Press, Cambridge, UK.

Bennett, E. M., T. Reed-Andersen, J. N. Houser, J. R. Gabriel, and S. R. Carpenter. 1998. A phosphorus budget for the Lake Mendota watershed. *Ecosystems* 2:69-75.

Benzaken, D., G. Smith, and R. Williams. 1997. A long way together: the recognition of indigenous interests in the management of the Great Barrier Reef World Heritage Area. Pages 471-495 in D. Wachenfeld, J. Oliver, and K. Davis, editors. *State of the Great Barrier Reef World Heritage Area Workshop*. Great Barrier Reef Marine Park Authority, Townsville, Australia.

Berkes, F. 1998. Indigenous knowledge and resource management systems in the Canadian subarctic. Pages 98-128 in F. Berkes, C. Folke, and J. Colding, editors. *Linking social and ecological systems: management practices and social mechanisms for building resilience*. Cambridge University Press, Cambridge, UK.

Berkes, F. 1999. *Sacred ecology: traditional ecological knowledge and management systems*. Taylor and Francis, London, UK.

Berkes, F. 2002. Cross-scale institutional linkages for commons management: perspectives from the bottom up. Pages 293-321 in E. Ostrom, T. Dietz, N. Dolsak, P. C. Stern, S. Stonich, and E. U. Weber, editors. *The drama of the commons*. National Academy Press, Washington, D.C., USA.

Berkes, F., J. Colding, and C. Folke, editors. 2003. *Navigating social-ecological systems: building resilience for complexity and change*. Cambridge University Press, Cambridge, UK.

Berkes, F., and C. Folke. 1998. Linking social and ecological systems for resilience and sustainability. Pages 1-25 in F. Berkes, C. Folke, and J. Colding, editors. *Linking social and ecological systems: management practices and social mechanisms for building resilience*. Cambridge University Press, Cambridge, UK.

Binning, C., S. Cork, R. Parry, and D. Shelton. 2001. *Natural assets: an inventory of ecosystem*

goods and services in the Goulburn-Broken Catchment. CSIRO Sustainable Ecosystems, Canberra, Australia.

Brooks, N., N. W. Adger, and P. M. Kelly. 2005. The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change* 15:151-163.

Carpenter, S. R., and W. A. Brock. 2004. Spatial complexity, resilience, and policy diversity: fishing on lake-rich landscapes. *Ecology and Society* 9:8. [online] URL: <http://www.ecologyandsociety.org/vol9/iss1/art8/>.

Carpenter, S. R., D. Ludwig, and W. A. Brock. 1999. Management of eutrophication of lakes subject to potentially irreversible change. *Ecological Applications* 9:751-771.

Carpenter, S. R., B. H. Walker, J. M. Anderies, and N. Abel. 2001. From metaphor to measurement: resilience of what to what? *Ecosystems* 4:765-781.

Cash, D. W. 2000. Distributed assessment systems: an emerging paradigm of research, assessment and decision-making for environmental change. *Global Environmental Change* 10:241-244.

Cash, D. W., W. Clark, F. Alcock, N. Dickson, N. Eckley, D. Guston, and J. Jager. 2003. Knowledge systems for sustainable development. *PNAS Early Edition* [need more info; this is an online service]:1-6.

Cohen, P. T., and R. E. Pearson. 1998. Communal irrigation, state, and capital in the Chiang Mai Valley (Northern Thailand): twentieth-century transformations. *Journal of Southeast Asian Studies* 29:86-110.

Cork, S. J., R. Proctor, D. Shelton, N. Abel, and C. Binning. 2002. The ecosystem services project: exploring the importance of ecosystems to people. *Ecological Management and Restoration* 3:143-146.

Costanza, R., F. Andrade, P. Antunes, M. van den Belt, D. Boersma, D. F. Boesch, F. Catarino, S. Hanna, K. Limburg, B. Low, M. Molitor, J. G. Pereira, S. Rayner, R. Santos, and J. Wilson. 1998. Principles for sustainable governance of the oceans. *Science* 281:198-199.

CSIRO Sustainable Ecosystems. 2003. *Natural values: exploring options for enhancing ecosystem services in the Goulburn Broken Catchment*. CSIRO Sustainable Ecosystems, Canberra, Australia.

Curtis, A., and M. Lockwood. 2000. Landcare and catchment management in Australia: lessons for state-sponsored community participation. *Society and Natural Resources* 13:61-73.

Dryzek, J. S. 1990. *Discursive democracy: politics, policy, and political science*. Cambridge University Press, Cambridge, UK.

Dryzek, J. S. 1999. Transnational democracy. *Journal of Political Philosophy* 7:30-51.

Dryzek, J. S. 2001. Resistance is fertile. *Global Environmental Politics* 1:11-17.

Elmer, M., and R. Coles. 1991. Torres Strait fisheries management. Pages 283-293 in D. Lawrence, and T. Cansfield-Smith, editors. *Sustainable development for traditional inhabitants of the Torres Strait: Proceedings of the Torres Strait Baseline Conference* (Cairns, 1990). Workshop Series Number 16. Great Barrier Reef Marine Park Authority, Townsville, Australia.

Folke, C. 2003. Freshwater for resilience: a shift in thinking. *Philosophical Transactions: Biological Sciences* 358:2027-2036.

Folke, C., J. Colding, and F. Berkes. 2003. Synthesis: building resilience and adaptive capacity in social-ecological systems. Pages 352-387 in F. Berkes, J. Colding, and C. Folke, editors. *Navigating social-ecological systems: building resilience for complexity and change*. Cambridge University Press, Cambridge, UK.

Folke, C., T. Hahn, P. Olsson, and J. Norberg. 2005. Adaptive governance of social-ecological systems. *Annual Review of Environmental Resources* 30:441-473.

Forsyth, T. 1996. Science, myth and knowledge: testing Himalayan environmental degradation in Thailand. *Geoforum* 27:275-292.

Forsyth, T. 1998. Mountain myths revisited: integrating natural and social environmental science. *Mountain Research and Development* 18:126-139.

Forsyth, T. 2003. *Critical political ecology: the politics of environmental science*. Routledge, London, UK.

Garden, P., C. Chirangworapot, and L. Lebel. 2005. *Knowledge in development: making ends meet in Omkoi, northern Thailand*. USER Working Paper WP-2005-14. Unit for Social and Environmental Research, Chiang Mai University, Chiang Mai, Thailand.

Great Barrier Reef Marine Park Authority (GBRMPA). 2004. *Facilitating the traditional use of marine resources*. Sea Country Number 11. GBRMPA, Townsville, Australia.

Goldman, M. 2004. Imperial science, imperial nature: environmental knowledge for the World (Bank). Pages 55-80 in S. Jasanoff, and M. L. Martello, editors. *Earthly politics: local and global environmental governance*. Massachusetts Institute of Technology, Cambridge, Massachusetts, USA.

Gunderson, L. H. 1999. Resilience, flexibility and adaptive management--antidotes for spurious certitude? *Conservation Ecology* 3(1):7. [online] URL: <http://www.consecol.org/vol3/iss1/art7/>.

Gunderson, L. H. 2000. Ecological resilience in theory and application. *Annual Review of Ecology and Systematics* 31:425-439.

Gunderson, L. H., and C. S. Holling, editors. 2002. *Panarchy: understanding transformations in human and natural systems*. Island Press, Washington, D.C., USA.

Holling, C. S., editor. 1978. *Adaptive environmental assesment and management*. John Wiley, New York, New York, USA.

Holling, C. S. 1986. The resilience of terrestrial ecosystems: local surprise and global change. Pages 292-317 in W. C. Clark and R. E. Munn, editors. *Sustainable development of the biosphere*. Cambridge University Press, Cambridge, UK.

Holling, C. S. 2001. Understanding the complexity of economic, ecological and social systems. *Ecosystems* 4:390-405.

Holling, C. S., and G. K. Meffe. 1996. Command and control and the pathology of natural resource

management. *Conservation Biology* 10:328-337.

Imperial, M. T. 1999. Institutional analysis and ecosystem-based management: the institutional analysis and development framework. *Environmental Management* 24:449-465.

International Association for Public Participation (IAP2). 2004. *Code of ethics for public participation practitioners*. International Association for Public Participation, Denver, Colorado, USA.

Jago, B., J. Day, L. Fernandes, L. Thompson, J. Hall, and K. Sampson. 2004. *Bringing the Great Barrier Reef Marine Park zoning into the 21st century: an overview of the representative areas program*. Great Barrier Reef Marine Park Authority, Townsville, Australia.

Janssen, M. A. 2001. An exploratory integrated model to assess management of lake eutrophication. *Ecological Modelling* 140:111-124.

Jasanoff, S., and B. Wynne. 1998. Science and decisionmaking. Pages 1-87 in S. Rayner, and E. L. Malone, editors. *Human choice and climate change: the societal framework*. Batelle Press, Columbus, Ohio, USA.

Jodha, N. S. 2001. *Life on the edge: sustaining agriculture and community resources in fragile environments*. Oxford University Press, New Delhi, India.

Lanthrop, R. C., S. R. Carpenter, C. A. Stow, P. A. Soranno, and J. C. Panuska. 1998. Phosphorus loading reductions needed to control blue-green algal blooms in Lake Mendota. *Canadian Journal of Fisheries and Aquatic Sciences* 55:1169-1178.

Lebel, L. 2003. *Surrogates for assessing resilience of livelihood systems: an initial conceptual framework and illustration from the uplands of Northern Thailand*. USER Working Paper WP-2003-05. Unit for Social and Environmental Research, Chiang Mai University, Chiang Mai, Thailand.

Lebel, L. 2004. *The politics of scale in environmental assessment*. USER Working Paper WP-2004-07. Unit for Social and Environmental Research, Chiang Mai University, Chiang Mai, Thailand.

- Lebel, L.** 2005. Institutional dynamics and interplay: critical processes for forest governance and sustainability in the mountain regions of northern Thailand. Pages 531-540 in U. M. Huber, H. K. M. Bugmann, and M. A. Reasoner, editors. *Global change and mountain regions: an overview of current knowledge*. Springer-Verlag, Berlin, Germany.
- Lebel, L., P. Garden, and M. Imamura.** 2005. Politics of scale, position and place in the governance of water resources in the Mekong region. *Ecology and Society* 10(2): 18. [online] URL: <http://www.ecologyandsociety.org/vol10/iss2/art18/>.
- Lebel, L., J. Manuta, P. Garden, D. Huaisai, S. Khrutmuang, and D. Totrakool.** 2004. *Urbanization in the Mae Nam Ping Basin: are transitions in the Chiang Mai-Lamphun corridor contributing to regional sustainability?* USER Working Paper WP-2004-02. Unit for Social and Environmental Research, Chiang Mai University, Chiang Mai, Thailand.
- Leeuwis, C.** 2000. Reconceptualising participation for sustainable rural development: towards a negotiation approach. *Development and Change* 31:931-959.
- Light, S. S., L. H. Gunderson, and C. S. Holling.** 1995. The Everglades: evolution of management in a turbulent environment. Pages 103-168 in L. H. Gunderson, C. S. Holling, and S. S. Light, editors. *Barriers and bridges to the renewal of ecosystems and institutions*. Columbia University Press, New York, New York, USA.
- Low, N., and B. Gleeson.** 1998. *Justice, society, and nature: an exploration of political ecology*. Routledge, London, UK.
- Luangaramsri, P.** 1999. The ambiguity of watershed: the politics of people and conservation in northern Thailand, a case study of the Chom Thong conflict. In M. Colchester, and C. Erni, editors. *Indigenous peoples and protected areas in South and Southeast Asia*. IWGIA Document Number 97. International Work Group for Indigenous Affairs, Copenhagen, Denmark.
- Magnusson, S-E.** 2004. The changing perception of the wetlands in and around Kristianstad, Sweden: from waterlogged areas toward a future water kingdom, Kristianstads Vattenrike Biosphere Reserve. *Annals of the New York Academy of Sciences* 1023:323-327.
- McGinnis, M., editor.** 1999. *Polycentric governance and development: readings from the Workshop in Political Theory and Policy Analysis*. University of Michigan Press, Lansing, Michigan, USA.
- Molle, F., Chatchom Chompadist, Thippawal Srijantr, and Jesda Keawkulaya.** 2001. *Dry-season water allocation and management in the Chao Phraya Delta*. Kasetsart University, Bangkok, Thailand.
- Nursey-Bray, M.** 2003. *Fishing for answers: the incorporation of indigenous knowledge in northern Australia: developing cross cultural literacy*. Fisheries Centre, University of British Columbia, Vancouver, British Columbia, Canada.
- Ogden, J. C., J. A. Browder, J. H. Gentile, L. H. Gunderson, R. Fennema, and J. Wang.** 1999. Environmental management scenarios: ecological implications. *Urban Ecosystems* 3:279-303.
- Olsson, P., C. Folke, and T. Hahn.** 2004. Social-ecological transformation for ecosystem management: the development of adaptive co-management of a wetland landscape in southern Sweden. *Ecology and Society* 9(4):2. [online] URL: <http://www.ecologyandsociety.org/vol9/iss4/art2/>.
- Ostrom, E.** 1990. *Governing the commons*. Cambridge University Press, Cambridge, UK.
- Ostrom, E.** 1999. Coping with tragedies of the commons. *Annual Review of Political Science* 2:493-535.
- Ostrom, E.** 2003. How types of goods and property rights jointly affect collective action. *Journal of Theoretical Politics* 15:239-270.
- Ostrom, E.** 2005. *Understanding institutional diversity*. Princeton University Press, Princeton, New Jersey, USA.
- Pahl-Wostl, C., and M. Hare.** 2004. Processes of social learning in integrated resources management. *Journal of Community and Applied Social Psychology* 14:193-206.

Pannell, D. J. 2002. Dryland salinity: economic, scientific, social and policy dimensions. *Australian Journal of Agricultural and Resource Economics* 45:517-546.

Pearson, R. 1999. *A political economy analysis of the impact of agrarian change and urbanisation on communal irrigation systems in the Chiang Mai valley, northern Thailand*. Department of Anthropology. Macquarie University, Sydney, Australia.

Peterson, G. D. 2000. Political ecology and ecological resilience: an integration of human and ecological dynamics. *Ecological Economics* 35:323-336.

Peterson, G. D., T. D. J. Beard, B. Beisner, E. Bennett, S. R. Carpenter, G. S. Cumming, C. L. Dent, and T. D. Havlicek. 2003. Assessing future ecosystem services: a case study of the Northern Highlands Lake District, Wisconsin. *Conservation Ecology* 7(2):1. [online] URL: <http://www.consecol.org/vol7/iss2/art1/>.

Rayner, S. 2003. Democracy in the age of assessment: reflections on the roles of expertise and democracy in public-sector decision making. *Science and Public Policy* 30:163-170.

Ribot, J. C. 2002. *African decentralization: local actors, powers and accountability*. Democracy, Governance and Human Rights Paper Number 8. United Nations Research Institute for Social Development, Geneva, Switzerland.

Robichaud, D., and G. A. Rose. 2004. Migratory behaviour and range in Atlantic cod: inference from a century of tagging. *Fish and Fisheries* 5:185-214.

Roling, N. 2002. Moving beyond the aggregation of individual preferences. Pages 25-47 in C. Leeuwis and R. Pyburn, editors. *Wheelbarrows full of frogs: social learning in rural resource management*. Koninklijke Van Gorcum, Assen, The Netherlands.

Rowe, G., and L. J. Frewer. 2004. Evaluating public-participation exercises: a research agenda. *Science, Technology and Human Values* 29:512-556.

Santasombat, Y. 2004. Karen cultural capital and the political economy of symbolic power. *Asian*

Ethnicity 5:105-120.

Sayer, J., and B. Campbell. 2004. *The science of sustainable development: local livelihoods and the global environment*. Cambridge University Press, Cambridge, UK.

Scheffer, M., and S. R. Carpenter. 2003. Catastrophic regime shifts in ecosystems: linking theory to observation. *Trends in Ecology and Evolution* 18:648-656.

Schusler, T. M., D. J. Decker, and M. J. Pfeffer. 2003. Social learning for collaborative natural resource management. *Society and Natural Resources* 15:309-326.

Silver, C. 2003. Do the donors have it right? Decentralization and changing local governance in Indonesia. *Annals of Regional Science* 37:421-434.

Smith, J., K. Obidzinski, Subarudi, and I. Suramenggala. 2003. Illegal logging, collusive corruption and fragmented governments in Kalimantan, Indonesia. *International Forestry Review* 5:293-302.

Social Learning Group. 2001. *Learning to manage global environmental risks: a comparative history of social responses to climate change, ozone depletion and acid rain*. MIT Press, Cambridge, Massachusetts, USA.

St. Martin, K. 2001. Making space for community resource management in fisheries. *Annals of the Association of American Geographers* 91:122-142.

Steelman, T. A., and R. L. Wallace. 2001. Property rights and property wrongs: why context matters in fisheries management. *Policy Sciences* 34:367-379.

Swyngedouw, E., and N. C. Heynen. 2003. Urban political ecology, justice and the politics of scale. *Antipode* 35:898-918.

Thomas, D. E. 2005. *Developing organizational models in pilot sub-basins: an interim report to Office of Natural Resources and Environmental Policy and Planning, Ministry of Natural Resources and Environment*. World Agroforestry Centre, Chiang Mai, Thailand.

Thomas, D. E., Pornchai Preechapan, and Pornwilai Saipothong. 2004. *Landscape agroforestry*

in upper tributary watersheds of northern Thailand. Faculty of Agriculture, Chiang Mai University, Chiang Mai, Thailand.

Thorburn, C. 2004. The plot thickens: land administration and policy in post-New Order Indonesia. *Asia Pacific Viewpoint* 45:33-49.

Walker, A. 2003. Agricultural transformation and the politics of hydrology in northern Thailand. *Development and Change* 34:941-964.

Walker, B., S. R. Carpenter, J. Anderies, N. Abel, G. S. Cumming, M. A. Janssen, L. Lebel, J. Norberg, G. D. Peterson, and R. Pritchard. 2002. Resilience management in social-ecological systems: a working hypothesis for a participatory approach. *Conservation Ecology* 6(1):14. [online] URL: <http://www.consecol.org/vol6/iss1/art14/>.

Walker, R., and W. Solecki. 2004. Theorizing land-cover and land-use change: the case of the Florida Everglades and its degradation. *Annals of the Association of American Geographers* 94:311-328.

Walters, C. J. 1986. *Adaptive management of renewable resources.* MacMillan, New York, New York, USA.

Walters, C. J., L. H. Gunderson, and C. S. Holling. 1992. Experimental policies for water management in the Everglades. *Ecological Applications* 2:189-202.

Wilson, J. 2002. Scientific uncertainty, complex systems and the design of common pool resources. Pages 327-359 in E. Ostrom, T. Dietz, N. Dolsak, P. Stern, S. Stonich, and E. U. Weber, editors. *The drama of the commons.* National Academy Press, Washington D.C., USA.

Wilson, J., B. Low, R. Costanza, and E. Ostrom. 1999. Scale misperceptions and the spatial dynamics of a social-ecological system. *Ecological Economics* 31:243-257.

Wollenberg, E., and H. Kartodihardjo. 2002. Devolution and Indonesia's new forestry law. Pages 81-109 in C. J. P. Colfer and I. A. P. Resosudarmo, editors. *Which way forward? People, forests, and policymaking in Indonesia.* Resources for the Future, Center for International Forestry Research, and Institute of Southeast Asian Studies, Washington, D.C., USA.

Young, O. R. 1992. The effectiveness of international institutions: hard cases and critical variables. Pages 160-194 in J. N. Rosenau and E.-O. Czempiel, editors. *Governance without government: order and change in world politics.* Cambridge University Press, Cambridge, UK.

Young, O. R. 1994. The problem of scale in human/environment relationships. *Journal of Theoretical Politics* 6:429-447.

Young, O. R. 2002. *The institutional dimensions of environmental change: fit, interplay and scale.* MIT Press, Cambridge, Massachusetts, USA.