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Shooting the Rapids: Navigating Transitions to Adaptive Governance of Social-Ecological Systems

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ABSTRACT. The case studies of Kristianstads Vattenrike, Sweden; the Northern Highlands Lake District and the Everglades in the USA; the Mae Nam Ping Basin, Thailand; and the Goulburn-Broken Catchment, Australia, were compared to assess the outcome of different actions for transforming social-ecological systems (SESs). The transformations consisted of two phases, a preparation phase and a transition phase, linked by a window of opportunity. Key leaders and shadow networks can prepare a system for change by exploring alternative system configurations and developing strategies for choosing from among possible futures. Key leaders can recognize and use or create windows of opportunity and navigate transitions toward adaptive governance. Leadership functions include the ability to span scales of governance, orchestrate networks, integrate and communicate understanding, and reconcile different problem domains. Successful transformations rely on epistemic and shadow networks to provide novel ideas and ways of governing SESs. We conclude by listing some rules of thumb" that can help build leadership and networks for successful transformations toward adaptive governance of social-ecological systems.

Key Words: *social-ecological systems; adaptive governance; transformability; shadow networks; leadership; resilience*

INTRODUCTION

The experience of traversing the turbulent reaches of a river in a small vessel is not easily forgotten. The shallow and rapidly flowing water can create treacherous conditions that are characterized by great uncertainty and great risks. We use the phrase "shooting the rapids" as an organizing metaphor because it is analogous to the periods of abrupt change or turbulence observed in managed social-ecological systems (SESs), in which previous rules and social mechanisms may no longer apply. During the period of transit through the rapids, several alternate vessel configurations are possible: one in which the keel points down, another in which the keel points up, and yet another in which the vessel completely disintegrates, with one state more desirable than the others. In this article, we provide insight into how people in various SESs prepare for and navigate periods of transformation, particularly in terms of leadership and social networks.

Many ongoing governance and management approaches to SESs attempt to control key ecosystem variables in their efforts to deliver efficiency, reliability, and optimality of ecosystem goods and services (Holling and Meffe 1996). However, approaches that seek to stabilize a set of desirable goods and services ultimately increase the vulnerability of the system to unexpected change (Folke et al. 2002, Gunderson and Holling 2002). There is an increasing recognition that alternatives to top-down governmental control for governing SESs are needed (Gunderson et al. 1995, Berkes and Folke 1998, Berkes et al. 2003). The growing number of failures among current approaches and the increasing vulnerability of SESs has led to calls for more adaptive governance regimes that can deal with uncertainty and change (Dietz et al. 2003, Folke et al. 2005, Lebel et al. 2006). Governance regimes of this type, capable of matching the inherent complexity of SESs and dealing with uncertainty and change, require substantial changes

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in the way humans currently relate to and govern these systems (Folke et al. 2005).

Adaptive governance relies on polycentric institutional arrangements that are nested, quasi-autonomous decision-making units operating at multiple scales (Ostrom 1996, McGinnis 1999). Spanning from local to higher organizational levels, polycentric institutions provide a balance between decentralized and centralized control (Imperial 1999). M. Lee (*unpublished manuscript*) refers to such adaptive systems of governance as the "new governance" and defines it as a form of social coordination in which actions are coordinated voluntarily by individuals and organizations with self-organizing and -enforcing capabilities. Adaptive governance relies on networks that connect individuals, organizations, agencies, and institutions at multiple organizational levels (Folke et al. 2005). This form of governance also provides for collaborative, flexible, learning-based approaches to managing ecosystems, also referred to as "adaptive co-management" (Folke et al. 2003, Olsson et al. 2004*a*).

In this paper, we explore how the emergence of adaptive governance regimes relates to the concept of transformability. Walker et al. (2004) define transformability as the capacity to create a fundamentally new system when ecological, economic, or social, including political, conditions make the existing system untenable. Transformability means defining and creating novel system configurations by introducing new components and ways of governing SESs, thereby changing the state variables, and often the scales of key cycles, that define the system. Transformations fundamentally change the structures and processes that alternate feedback loops in SESs.

The idea of transformation is not new to the literature on natural resource management. Transformation has been used to describe ecological changes that result in a degraded state (e.g., Turner et al. 1990, Hamilton et al. 2004). Danter et al. (2000) describe the transformations within a government agency that are needed to implement ecosystem management. Transformative change can also occur as a result of (1) ecological crises, during which unexpected or unanticipated ecosystem changes occur; (2) shifts in the social components of the system, such as in social values or resources (Scheffer et al. 2003); or (3) economic or political change (Aberbach and Christensen 2001). Allison and Hobbs (2004) describe how adaptive behavior that fails to respond to environmental feedback in agricultural systems can result in a "lock-in" trap in an undesirable regime from which transformation is the only escape.

In this article, we address transformations of entire governance systems of which government agencies are a part. Transformations toward alternative forms of governance have been addressed by Bressers and Kuks (2004) and Kettl (2000). We investigate how actions have succeeded or failed to transform SESs into more desired configurations; in particular, we study why some windows of opportunity generate dramatic change and others do not. We focus on transformations within the social domain of the SESs that increase our capacity to learn from, respond to, and manage environmental feedback from dynamic ecosystems. Such transformations include shifts in social features such as perception and meaning, network configurations, social coordination, and associated institutional arrangements and organizational structures. Transformations also include redirecting governance into restoring, sustaining, and developing the capacity of ecosystems to generate essential services.

We compare five case studies from the Resilience Alliance to learn from past attempts to implement strategies intended to move vulnerable and unsustainable systems into new trajectories of adaptive governance. The case studies are Kristianstads Vattenrike (KV), Sweden; the Northern Highlands Lake District (NHLD) in Wisconsin and the Florida Everglades, USA; the Mae Nam Ping Basin (MNPB), Thailand; and the Goulburn-Broken Catchment (GBC), Australia.

These SESs are in different stages of the adaptive cycle in the sense defined by Holling (1986). In KV, a wetland landscape, the management regime has undergone a full transformation and is in the front loop of a new adaptive cycle. The social-ecological transformation thwarted an adverse land-use trend resulting from urban sprawl, draining, dredging, and the abandonment of agriculture practices (Olsson et al. 2004*b*) with associated loss of ecosystem services. The management of the Everglades has undergone several transformations (Gunderson et al. 1995) and is currently in the late *K* phase of an adaptive cycle. In the 20th century, the four transformations in Everglades management were triggered by changes in both ecological and social components, and resulted in a fundamentally new

set of management regimes. These four eras represent attempts to (1) control unwanted flood water, (2) sustain the water supply for a growing population, (3) control the nutrients associated with land-use interactions, and (4) bring about ecosystem restoration (Light et al. 1995, Gunderson et al. 2002).

Although the KV and the Everglades represent case studies in which it was possible to transform governance for improved management in response to crisis, it is clear that other regions have been less successful at this. Despite the obvious need to transform to a more sustainable trajectory, many SESs either do so too late, in which case significant degradation and loss of utility from the system have already occurred, or they fail to seize windows of opportunity when they arise. In the NHLD, which is in a backloop, changes are happening rapidly (Peterson et al. 2003*a*). These changes include a growing local population as more people move into the area, mounting conflicts over resources, increasing withdrawals of ecosystem services, and more species invasions and habitat degradation. If the actors of the SES are not able to step in and transform it into a new and very different adaptive cycle and trajectory, the system will move further down an unsustainable trajectory toward the degradation of both terrestrial and aquatic ecosystems and the loss of services as a consequence. In contrast, the GBC represents an example of an SES that missed a critical opportunity for transformation and now faces an uncertain future. Confronted with a crisis of increasingly saline groundwater during the mid-1970s, the GBC community put in place many of the building blocks we consider essential to prepare the system for transformation. However, when more radical transformation would have been possible, they opted instead to invest in adaptability, devising strategies to maintain the current production and social systems while attempting to minimize their impacts on local ecosystems.

Similarly in the MNPB, key opportunities to set regional development upon a more sustainable path were missed because problems were repeatedly and incorrectly framed to serve other political and development agendas (Lebel et al. 2004, Luangaramsri 1999). Earlier responses to change have moved the SES closer to a critical threshold at which small changes in supply or demand can have major economic repercussions. With respect to water resources, the system is in a late *K* phase, with a high potential for collapse and major social and ecological changes in how water and watershed services are perceived and delivered. This imminent crisis is arising from the rapidly increasing demand for water for intensified agriculture (Walker 2003) in the lowland irrigated areas and for the rapidly expanding urban settlements and industrial estates that have completely altered the lowland forest floodplains and riparian landscapes (Cohen and Pearson 1998, Pearson 1999).

Even though the NHLD, MNPB, and GBC have not undergone major transformations in this sense, they offer insights into the very real challenges faced by SESs that are trying to transform. When faced with crises of similar magnitudes, the KV and the Everglades were able to transform their governance systems into new SES configurations. Why was transformation possible in these systems and not in others?

The aim of this article is to compare these case studies to deepen our understanding of transformability and identify critical factors in SES transformability that can help provide social sources of renewal and shape reorganization toward desired SES configurations. We start the article by going through the different phases of transformation in the social domain using nsights from Olsson et al. (2004*b*) and present our current view of each phase using illustrations from the case studies. We also investigate the role of windows of opportunity, using the work of Kingdon (1995). We then identify and discuss critical factors for transformation to adaptive governance of SESs. The discussion is inspired by Proposition 14 in Walker et al. (2006), which suggests that the determinants of transformability include incentives, awareness, experimentation, reserves, and governance. We conclude by listing a few steps that should be considered when taking action to transform toward adaptive governance of SESs.

PHASES OF TRANSFORMATION

Social-ecological transformations toward adaptive governance occur in three phases (Olsson et al. 2004*b*). First, systems are generally prepared for the changes that are about to occur. The second phase involves a transition to a new social context for ecosystem management. The third phase is building the resilience of the new direction. In this article, we focus on the two first phases. These two phases

are linked by a window of opportunity that constitutes a critical moment in time between the two phases. The next sections are structured around these phases, beginning with preparations for change, followed by a description of windows of opportunity, and ending with a section on navigating the transition phase.

Preparing for change

Some preparation is needed prior to moving a social-ecological system (SES) into a desirable trajectory. Table 1 summarizes the actions taken in each of the cases studied to prepare the system for change. These preparations can be grouped into categories of (1) exploring new system configurations and alternative approaches for governance and (2) developing strategies for sorting or annealing alternatives that create conditions for adaptive co-management. Those preparations occur in networks that integrate and build knowledge for ecosystem management, as described in the next section. However, learning networks alone are not sufficient preparation, because some form of leadership must emerge to move the system into the next phase, which is discussed below.

Building knowledge and networking

The transformation in the Kristianstads Vattenrike (KV) was preceded by the emergence of a social network for managing the lower Helgeå River at the catchment level. This self-organized process aimed to find integrated landscape-level solutions to the problems of declining bird populations, decreasing water quality and nuisance plant growth in lakes, and decreasing use of flooded meadows for haymaking and grazing. The network included individuals from local groups such as environmental organizations, the Bird Society of Northeastern Scania, and local farmers' associations. It also included actors at other organizational levels such as the Municipality of Kristianstad, the County Administrative Board, WWF Sweden, the National Museum of Natural History, and a national research council (FRN). These individuals were nodes of expertise in the emerging network (Olsson et al. 2004*b*). In addition to connecting people, the process involved trust-building and sense-making, which formed a platform for conflict management and sharing of information between groups. In this way, the network tied together a number of sources of knowledge and experience, which increased the knowledge pool for decision making and helped to develop practices for ecosystem management.

In the Everglades, each governance transformation was preceded by the emergence of networks that represented alternative management approaches with the ultimate goal of bringing about change (Gunderson 1999). The members of these networks were able to suspend extant beliefs, question perceptions, and contrast possible futures to allow for the exploration of new and novel system configurations. These can be viewed as epistemic networks composed of technical and scientific personnel who provided ecological knowledge at critical times. The first was the Soil and Crop Science Society, whose planning efforts in 1939 were a result of documenting ecosystem changes caused by prior drainage efforts. Their work provided the foundation for land-use, management, and governance changes following the flooding crisis of 1947 (Blake 1980, Light et al. 1995). A second network of ecologists and planners at the University of Miami appeared in the 1970s. Impending eutrophication of Lake Okeechobee prompted transformations in the social domain of the SES that eventually led to the restoration of the Kissimmee River and prevented nutrient pollution in the Everglades (Light et al. 1995). Current efforts to restore the ecosystem are the result of the work of the adaptive management group that began in the late 1980s. Through a series of modeling workshops, they concluded that both vegetation trends and long-standing environmental degradation of key wildlife populations were reversible. Subsequent planning efforts have built on this understanding and have led to current restoration efforts (Gunderson 1994). These networks extended beyond the scientific community and into the management and political arenas. The ideas for ecosystem restoration were in essence a search for ecological resilience, that is, an effort to discover whether the resources required for restoration even existed. Upon concluding that the system still had enough resilience, the network was extended to the political realm. In 1992, a colloquy was held to discuss options for ecosystem restoration with key managers and decision makers. That meeting provided the conduit by which scientific innovations were used to move the system toward adaptive governance. The networking at that

Table 1. Comparing the five case studies regarding key factors for preparing the social-ecological system for change.

Social-ecological system	Key factors		
	Building knowledge	Networking	Leadership
Kristianstads Vattenrike (creation of the KV)	A new perspective on ecosystem management and integrated landscape-level solutions guided the development of knowledge. It included identifying knowledge gaps for managing the KV and initiating studies to fill them.	The emergence of the network in the mid-1980s connected actors with different interests. This included vertical links and horizontal links between government agencies, NGOs, the municipality, and landowners.	Leadership emerged that was important for connecting people, developing and communicating a vision of ecosystem management, and building trust and broad support for change.
The Everglades (ecosystem restoration)	A few key scientists were frustrated by continuing ecosystem degradation, which they tried to address in workshops. The ecosystem restoration (resilience) perspective guided modeling workshops in which information was synthesized and used to develop composite policies.	A network of scientists emerged in the late 1980s and formed the adaptive management group. In 1992, networking was extended into the management and political arenas to spread the ideas of the adaptive management group, link actor groups operating at different organizational levels, and represent different interests.	Leadership emerged that brought in a novel perspective of ecosystem resilience, built trust, and connected people. The leaders were weary of ongoing legal actions and wished to pursue alternative ways of management. They focused on ensuring the engagement of all groups, not just a few special interest groups.
The Northern Highlands Lake District (sustainable futures)	The polarization among different actor groups hinders the sharing of new ideas and innovations. However, a few bridging efforts are developing, and these could nucleate to provide the necessary institutions for building and sharing knowledge.	Networking at a regional scale that connects different groups of actors is poorly developed.	Leadership for collective action and ecosystem management at the regional level has not emerged. Instead, leadership has emerged for pursuing specific interests.
Mae Nam Ping Basin (sustainable water management)	Knowledge based on the ecosystem approach has been assimilated from a wide range of sources, and innovative ecosystems approaches exist but do not guide networking at the regional level.	Networking at the basin level is lacking. Instead, networks that serve and protect specific interests are developing.	Leadership for collective action and ecosystem management at the basin level has not emerged. Instead, leadership has emerged for pursuing specific interests.
Goulburn-Broken Catchment (sustainable agriculture)	There was a lack of innovation that made it impossible to explore new configurations of the system, in particular, ways to address ecosystem processes. Building knowledge to support the status quo approach to ecosystem management was emphasized.	Networks emerged that connected people and interests at different levels. These networks were later formalized into decision-making and -implementing organizations.	Leadership did emerge for collective action at the catchment level, but not to provide a novel approach to ecosystem management.

meeting linked actor groups operating at different organizational levels and representing different interests, and generated the activities that led to the current restoration plans and actions (Gunderson 1999).

Deep disagreements and conflicting interests can lead to polarization among actor groups, which hinders capacity building for ecosystem management. The Goulburn-Broken Catchment (GBC), the Northern Highland Lake District (NHLD), and the Mae Nam Ping Basin (MNPB) case studies are examples in which social and ecological crises have exacerbated conflicts among special interests. In the NHLD, there is a central disconnect among Native Americans, lakeshore owners, and local nontribal people who are highly dependent on exploitation patterns that a growing number of people believe are no longer tenable in an increasingly crowded region. At another scale, there are conflicting interests between groups such as environmentalists and "silent sport" users, e.g., hikers, bikers, canoers, kayakers; fishers, in some cases substructured by preferred practices; hunters; and advocates of motorized recreation. Responses to crises such as conflicts of interest or species invasions have led to increased polarization among these groups. Although there is some agreement on the driving forces behind the current crisis, the actors cannot agree on what actions should be taken. There are a number of small innovations in resource use, including resource management by indigenous groups, local governance by lake associations, research organizations such as the university field station, a long-term ecological research program, and an experimental management unit operated by the state management agency, the Wisconsin Department of Natural Resources. However, the regional network that should connect these different groups of actors is only poorly developed, which hinders the sharing of new ideas and innovations and the ability to draw on various sources of knowledge at critical times. The individuals in these groups often narrowly pursue their own interests, which further reduces trust among actor groups, deepens polarization, and impedes progress. The most rapid development of focused networks is occurring among the lake associations, some of whose members are running for public office.

In the MNPB, researchers and activists have played a critical role in generating new knowledge and synthesizing existing knowledge that challenges the fundamental basis of watershed management and water allocation policies in northern Thailand. The state bureaucracy no longer has a monopoly on knowledge about forest changes or water resources. Indeed, not-for-profit and commercial consultant companies often have better data and a more in-depth understanding than line agencies. The main problem is that this growing understanding of, e.g., the impacts of land-cover changes on catchment hydrology or increasing urban and industrial water demand and theft is not being critically used. Instead, under the current polarized circumstances, various nongovernmental groups are making use of research to support particular political agendas, which can undermine the credibility of the original research and hinder the development of a common understanding.

Although both the NHLD and the MNPB suffer from the polarization of interest groups, there have been peripheral efforts to reconcile the different clusters of actors for the purposes of identifying a common ground and staking out a new direction for management. In the MNPB, basic ideas about ecosystem management have been introduced into the policy agenda at both the regional and national levels by researchers with good links to policy (e. g., Mingsarn Kaosa-ard 2000, 2001, Thomas 2005). Other studies of high relevance to water resources and irrigation management have also been conducted (Molle 2001, Molle et al. 2001). These and many other key researchers interested in democratizing governance are connected to each other through formal collaborations and meetings. Even though they do not necessarily share identical views about the best institutional designs or balance between conservation and development, they comprise the nodes of a partly independent shadow network that is capable of talking to government at the provincial and national levels. Other networks and movements use different tactics and challenge or avoid engaging the state. This could also be effective, but it seems that both styles of networks are important for bringing about change.

In the NHLD, the number of lake associations, which are organizations for the adaptive co-management of individual lakes or chains of lakes, is increasing. The interests of these associations are somewhat different than those of other actor groups such as local tribes, recreational users, the forest product and construction industries, NGOs, and the state management agency. In the NHLD, some of the actor groups are beginning to consider regional issues, such as invasive species, in a more inclusive

way. For example, a group of scientists has initiated a series of meetings and outreach activities to encourage these groups to work in concert in areas in which their interests overlap. Their activities involve managers and a cross section of stakeholders in the development of scenarios for the future of the NHLD (Peterson et al. 2003*a*,*b*, Carpenter 2006; see also http://lakefutures.wisc.edu). These scenarios are designed to evoke dialogue among the residents in the NHLD about alternative futures. They are also the starting point for a process of evaluating policies in terms of how they shape the ability of the NHLD to respond to potential risks and to use possible opportunities (Peterson 2003*b*).

Leadership

Leadership is a critical element in preparing the system for change, especially with regard to strategies for exploring new configurations of SESs. In the Everglades, leadership involved integrating the extant scientific understanding of the ecosystem, summarizing that integration, and communicating that understanding to a wider audience. That has been done many times, starting with Marjorie Stoneman Douglas, who was a leading advocate for the Everglades and whose key contribution appeared in the book *The Everglades, River of Grass* (Douglas 1947). That compelling and beautifully written volume was based on conversations and interactions with leading scientists. In the 1960s and 1970s, Arthur R. Marshall provided the same leadership at a research institute at the University of Miami and communicated his understanding with "the zeal and passion of a country preacher" (Light et al. 1995). Two decades later, scientific leadership was provided by the adaptive management group consisting of Buzz Holling, Carl Walters, Lance Gunderson, Steve Davis, and Steve Light (Davis and Ogden 1995).

In KV, a key individual, Sven-Erik Magnusson (SEM), recognized that the problems arising in the area were interrelated. He started to connect key individuals who were already involved in ongoing projects to build the knowledge needed to devise integrated solutions and match the scale of the problems. This included actor groups operating at different organizational levels and representing diverse interests. To frame and give direction to this process, he developed and communicated a vision of ecosystem management for the area. SEM managed to mobilize broad support for a new management approach. Although this included support from key individuals, he also developed a relationship with the local media as a strategy for building public support for the idea. In this way, he provided leadership functions such as connecting key individuals, developing and communicating a vision, and engaging with others to establish direction. He aligned, motivated, and inspired people to invest in an alternative approach and thereby built broad support for change.

In the GBC, small community groups emerged to deal with flooding, waterlogging, and drainage issues after the initial water-table crisis in the mid-1970s. These groups quickly coalesced into larger networks as the true scale of the salinity crisis became more apparent. Leaders emerged to form a regional committee to represent the concerns of the various networks throughout the catchment. These leaders and the committee they formed became a conduit for a wider range of issues, including broader environmental, social, and economic concerns. They pooled existing knowledge, identified gaps, and invested in research and development to address priorities, and they effectively lobbied government agencies for support and resources. The initial leadership group was made up of well known local inhabitants, mostly farmers and business people with a long history of community service in the region; this proved to be a valuable attribute in a small community in which credibility was critical to success. Importantly, the leadership group recruited a series of individuals with skills in local government, education, communication, and media to disseminate information into the community, because the group recognized that knowledge transfer was a key element of their strategy. Targeting leaders with diverse skills and roles in the community ensured that the concerns and issues important to the leadership committee became embedded in other processes and forums within and external to the GBC.

In addition to their roles in preparing the system for transformational change, leaders in many cases helped move the system into the transition phase. However, to do that, a window of opportunity was required. These windows appear to be critical for transformations to occur, as described in the next section.

Windows of opportunity

Kingdon (1995) stresses the importance of timing for initiating policy changes and opening policy windows. He argues that significant changes are most likely when three independently operating "streams," i.e., problems, solutions, and politics, come together at critical times. This type of coupling provides a window of opportunity for change in which " ... a problem is recognized, a solution is available, the political climate makes the time right for change, and the constraints do not prohibit actions" (Kingdon 1995). Here we use the three streams in our comparison of the case studies (Table 2) and our analysis of attempts to transform governance regimes. We also address the role of key individuals, also called "policy entrepreneurs" (Kingdon 1995), in linking these three streams.

Rapid change and ecological crises can provide windows of opportunity that trigger the emergence of networks and promote new forms of governance (Folke et al. 2005). In both KV and the Everglades, a specific opportunity made it possible to move from the preparation phase into the transition phase and complete the transformation. In the Everglades, the emergence of the networks that preceded the transformations was, for example, triggered by algae blooms in Lake Okeechobee or cattail dominance in the freshwater Everglades. In Kristianstad, the emergence of networks for ecosystem management was triggered by a decline in natural and cultural values, including diminishing bird populations, decreased water quality and overgrowth of lakes, and a decrease in the use of flooded meadows for haymaking and grazing. Such networks are not always successful in moving the SES into alternative trajectories. The extent to which the transformation of entire governance regimes is possible appears to be related to the scale at which the crisis most clearly manifests itself and how it is perceived in relation to the scope of change possible.

Our case studies suggest that each of these streams occurs in a different arena (Table 2) and that the coupling of problems, solutions, and politics in SESs requires cross-scale interactions. This involves connecting individuals, organizations, agencies, and institutions at multiple organizational levels. For example, in the Everglades, the problems of ecosystem restoration and the subsequent set of solutions were developed in a series of technical workshops (Davis and Ogden 1994, Holling et al. 1994). Those solutions were vetted in two parallel planning processes; one at the state level by the Governors Commission on Sustainability and the other at the federal level by the Army Corps of Engineers Restudy. These planning processes led to federal and state legislation passed in 2000, which allocated $8 billion for Everglades restoration

In KV, social change and ecological crises at one scale triggered a transformation of the governance of the SES at another scale. Two key circumstances are believed to have placed the management of KV on the municipal political agenda and affected the political will to adopt the new governance approach currently in use (Olsson et al. 2004*b*). First, local politicians were keen to find a new profile for the municipality, which had previously been a center for military training. Second, environmental questions had received a lot of coverage during the national Swedish election in September 1988, probably because of reports that red tides and viral disease were killing a vast number of seals along the Swedish coasts. At this time, the ecosystem approach for integrated landscape-level solutions to environmental problems in KV existed within the network that SEM initiated. With support from a wide range of actor groups at various organizational levels, SEM took the opportunity to bring the idea to two municipal politicians and make them aware of the impending problems in KV and the need for action. SEM managed to change the perceptions of those politicians, who now saw the wetlands as a resource rather than a problem. He also linked the proposal to other goals such as regional development. The politicians acted as policy entrepreneurs and convinced the Municipality Executive Board to support the idea. The political action that followed was needed to enter the transition phase. The leadership of SEM was combined with the political leadership at the municipal level.

In the Everglades, social activists, politicians, or other groups intent on changing extant policy can create a political window of opportunity. Expert panels and lawsuits by environmentalists are two such mechanisms for opening a political window. In these cases, the groups interpret information from ecosystem components, such as data on declining water quality, to support an action to "open up" the system for the renegotiation of rules, norms, and other institutional relationships. For example, the U.S. federal government sued the State of Florida in 1987 to change existing water management

Table 2. Comparing the five case studies regarding windows of opportunity for change and the attributes of the three streams identified by Kingdon (1995).

Social-ecological system	Problem awareness	Solutions available	Political action
Kristianstads Vattenrike	The environmental problems in the area were identified by a few individuals and networked across organizational levels and key actor groups. They were also communicated to key individuals in the municipal government.	The network made it possible to coordinate and link ongoing projects to create integrated landscape-level solutions that were based on the ecosystem approach.	The municipal politicians were made aware of the problems and supported the solution that had been developed in the emerging network
The Everglades (the latest transformation)	The problems that emerged in the area were identified by the adaptive management group. The group communicated these problems to managers and politicians.	The colloquy developed policies that were based on the ecosystem restoration and resilience approach. Two parallel processes emerged from the colloquy; one federal (the Corps of Engineers Restudy) and one state (the Governor's Commission). Both processes vetted solutions.	Plans were presented to state and federal governments. Legislation was passed that authorized $8 billion for Everglades restoration.
The Northern Highlands Lake District	There is a general awareness among actor groups of the emerging environmental problems in the region.	Integrated solutions that are based on an ecosystem and resilience approach exist in a few nodes but are not well networked across the region	At the time of writing, nuclei for action are emerging, but the shape of regional action is not yet clear.
Mae Nam Ping Basin	There are different views of what the problem is and different explanations of the causes.	There is no consensus and a lack of alternatives. Solutions based on ecosystem management at the basin level exist among some actor groups but are not well networked	There is a lack of political support and action.
Goulburn-Broken Catchment	There was a general awareness of the problem of salinization of soils among a wide range of actor groups at different organizational levels.	An engineering solution was put forward and adopted by local leaders and farmers.	Local politicans recognized the problem and supported the engineering solution.

policies in the Everglades that were damaging federal resources (John 1994). This lawsuit changed agricultural management practices and forced the development of technology that uses wetlands to improve the water quality of runoff from agricultural areas, but it also increased polarization among stakeholders.

In contrast to the Everglades and KV, the GBC community devised strategies to maintain the current production and social system while attempting to minimize the impacts on native ecosystems. Local leaders took advantage of government’s eagerness to invest in regional communities, riding a wave of environmental concern and institutional reforms at higher scales. In 1997, a new catchment-wide organization was set up to coordinate local networks, government agencies, and their various strategies. This structure, called the Catchment Management Authority, now includes more than 160 community leaders on various committees and provides an avenue of input

for thousands of people across the catchment. However, the solution that was put forward was an engineering solution that masks signals of environmental and ecosystem change. The reason for this seems to be a combination of things. It had taken more than a decade from the initial water-table crisis in the mid-1970s before the community had sufficient organization and resources to make any real change in the system. During that time, the climate had shifted back toward a dry phase, and water tables began to decrease slightly, which made many farmers believe that the threat from rising water tables had diminished. Another reason was that there had been some minor local successes in controlling rising water tables using a combination of groundwater pumps, surface drainage, land forming to improve irrigation efficiency, and tree planting that minimized the direct costs to farmers and initially lowered water tables. Some leaders pointed to these successes as the way forward and believed that, if they could expand these engineering works across the region, the impacts of salinity and waterlogging could be controlled with minimal social and economic impact. Finally, the adaptability approach had enormous financial benefits for farmers, many of whom were finding it hard to remain economically viable. The engineering works would dramatically increase irrigation productivity, with the added bonus that government would subsidize a large proportion of the costs; as a result, there was little real incentive for farmers to make any radical changes in their practices.

In the NHLD, the funding, staffing, and influence of the state management agency, the Wisconsin Department of Natural Resources, is waning because of declining support from the public and cuts in government funding. This shift in the political landscape creates a leadership vacuum and opportunities for change. New trajectories could come from collaboration among the innovative organizations in the region, such as the tribes, lake associations, and research organizations. Alliances among the tribes, the lake associations, and forward-looking business people in the community could be remarkably powerful in effecting change. Although changes seem to be nucleating, the directions of change were not clear at the time of this writing.

In the years immediately following a financial crisis in the MNPB, several sweeping administrative, legal, and other reforms were introduced that gave people a sense that democratic decentralization might, at last, become something of a reality. For northern Thailand, this matters a lot, because it could create opportunities for natural resource management that better reflects the local context and resources, which are rather dissimilar from those of the rest of the country. The formation of a new ministry with a specific environmental mandate could also be seen as an opportunity because of institutional changes at larger scales. Unfortunately, the overwhelming political dominance of the Thai Rak Thai party under Thaksin Shinawatra's leadership has resulted in many reversals of the trend toward more open and decentralized decision making (Pasuk Phongpaichit and Baker 2004). One of the specific challenges in the MNPB is that the institutional innovations that might create windows of opportunity are often introduced by adding new layers to the management structure governing the SES, rather than by reforming or replacing outdated departments or practices. For example, the management of canals in the basin is in a state of confusion, with local government authorities, communal systems, and an irrigation department each claiming or disclaiming particular responsibilities. As a result, the system is almost completely unmanaged in those areas in which farmers, universities, households, and businesses take as much water as they want with pumps and wells. A transformation would include improving the accountability of existing authorities, especially of local government, groups of water users, and basin organizations. It would also include securing extensive public participation, changing rights to water that are culturally bound, and encouraging the pursuit of livelihoods other than agriculture. A crisis of water conflicts and rationing caused by an unusually dry year in the area could trigger this type of change, but, given recent politics, this is unlikely to come out favorably for farmers.

These case studies provide a rich set of examples of windows of opportunity. These windows can be a result of environmental crises, policy failure, fiscal crises, activist groups, lawsuits, or slowly changing institutional structures. Although there are many ways to open a window, the opportunity for change is often limited to a very short period of time. To transform the system, a set of activities must be pursed that makes it possible to navigate a transition to a new system.

Navigating the transition

The transition phase is not well understood because it is so unpredictable and turbulent. The transition to adaptive governance can only be navigated, not planned. Navigating requires the type of preparation described earlier as well as flexibility and the ability to improvise and modify the game plan to meet changing conditions and maintain momentum. During the transition, new social structures and processes can be established that link individuals, organizations, agencies, and institutions at multiple organizational levels and allow adaptive governance to emerge. The dynamics of cross-scale interactions, a key element of transformations, are described in panarchy theory (Gunderson and Holling 2002). Another key element during the transition period is the management of problems in different domains (Westley 2002) and the development of composite policies or solutions to these different problems. Leadership, diversity, and timing seem to be key factors in this respect. Examples of navigation strategies are described below.

One strategy used by SEM in KV was to have a portfolio of possible projects that could be launched whenever there was an opening and the time was right. The initial idea for KV, formulated in an early proposal, was to make the area a UNESCO "Man and the Biosphere" (MAB) reserve, and the Ecomuseum Kristianstads Vattenrike (EKV) would be part of that structure. However, because of the lack of support for the MAB idea at the time, SEM instead pushed the idea of the Ecomuseum, which was more acceptable and appealing to key actor groups. In June 2005, KV became a MAB area. The establishment of the EKV as a bridging organization created opportunities for new interactions between actors at different organizational levels (Olsson et al. 2004*b*, Hahn et al. 2005). The Ecomuseum provides an arena for trust-building, sense-making, learning, collaboration, and conflict resolution, all of which are key conditions for the emergence of adaptive governance (Folke et al. 2005). It communicates, translates, and mediates scientific knowledge to make it relevant to policy and action and also uses its network of stakeholders to mobilize knowledge in turbulent times, which in turn helps management deal with uncertainty and shape change. Financial sponsors within the network were crucial for navigating the transition. Different parts of the EKV project appealed to different sponsors, and all the sponsors made their support conditional on broader participation by other sponsors. Having a diversity of funding opportunities that provide economic incentives at critical times seems to make navigating the backloop smoother.

The transformations among management and governance in the Everglades in 1947, 1971, and 1983 all resulted in the creation of physical infrastructure and new formal institutions. The institutional solutions were the Flood Control District (1947), the South Florida Water Management District (1971), and the Everglades Coalition (1983). The most recent transformation for ecosystem restoration resulted in a bridging or meshing network that involves government and nongovernmental groups as well as other key stakeholders (Gunderson 2003). In these cases, either new institutions or new institutional arrangements were created during the transformation period, largely as a way of solving the problem that led to the crisis. In all of the transformations, a massive influx of money from higher levels of government (Gunderson et al. 2002) and technological solutions were key ingredients.

As stated above, the GBC failed to transform to a new trajectory following the water table crisis in the mid-1970s. A possible reason is because there was no process for exploring new configurations for the SES. Despite the development of social networks at the catchment level, the creation of a new institutional layer, social and institutional reforms at scales above, and the generation of knowledge and resources that could provide the foundations for the emergence of adaptive governance, community leaders opted to invest in adaptation rather than transformation. The decision-making body had a majority of farmers and local business owners, the people most likely to bear the brunt of the costs associated with transformation, which meant that the decision was probably biased by vested interests. The decision reduced the short-term social and economic costs of transforming, but, as a result, the region now faces even greater challenges. Its hydrology continues to track toward a new equilibrium in which salinity and waterlogging will ultimately have a more severe effect on the community and the regional economy than the initial crisis did (Anderies 2004). The costs of maintaining the current system continue to mount, the natural resource base is degrading further, and the

regional economy is becoming increasingly brittle. The system has become vulnerable to a wider range of shocks and disturbances from biophysical, political, social, and/or economic events (Anderies et al. 2006).

In the MNPB, earlier responses to various crises failed to deal with social and ecological problems at the level of the basin, which pushed the SES closer to collapse. It is now on the verge of a transition that could easily go in a number of different directions. On the one hand, there is the government-led view that water security is best achieved by augmenting supply through a "Thai water grid," which in fact means interbasin transfers from Burma and Lao PDR. On the other, there is a diversity of related views and prospects in which water and watershed management could more closely reflect the ecological and social contexts of different basins, both as constraints and comparative advantages.

CRITICAL FACTORS FOR TRANSFORMING SOCIAL-ECOLOGICAL SYSTEMS

Inspired by the proposition stated in the introduction, we have investigated in this article how the social determinants of transformability played out in the two phases of the transformation of social-ecological systems (SESs) in five different regional systems. Through this comparison, we have identified at least two other critical factors of SES transformability: the emergence of shadow networks and the essential role of leadership. Alternative approaches for governing SESs may develop and reside in shadow networks. One feature of these networks is a willingness to experiment and generate alternative solutions to emerging problems. Shadow networks can also equip themselves with the tools and data needed to navigate the transition and institutionalize the new approach during windows of opportunity, including the identification and mobilization of economic incentives for change. Social transformation toward ecosystem management seems to involve shifts in perceptions and awareness as well as "reserves" of experience, e.g., social memory (Olick and Robbins 1998, McIntosh 2000)) in the existing and emerging social networks. This means that networking can be orchestrated during the front loop of the adaptive cycle, and this orchestration may facilitate transition in the backloop. The comparison also suggests that successful transformations of governance require leadership that can provide certain functions throughout the preparation and navigation phases. In the following section, we discuss critical factors for the emergence of shadow networks and leadership for transformation toward adaptive governance of SESs.

Emergence of shadow networks

Successful transformations toward adaptive governance seem to be preceded by the emergence of informal networks that help to facilitate information flows, identify knowledge gaps, and create nodes of expertise of significance for ecosystem management that can be drawn upon at critical times. As shown in the KV and Everglades case studies, these networks emphasize political independence outside the fray of regulation and implementation in places in which formal networks and many planning processes fail (Gunderson 1999). Gunderson (1999) also emphasized the role of these shadow networks as incubators for new approaches to governing SESs. These informal, outside the fray shadow groups seem to be where new ideas arise and flourish. It is these "skunkworks" who explore flexible opportunities for resolving resource issues, devise alternative designs and tests of policy, and create ways to foster social learning. Because the members of these networks are not always under scrutiny or the obligations of their agencies or constituencies, they are freer to develop alternative policies, dare to learn from each other, and think creatively about how to resolve resource problems. Gunderson (1999) also points out the challenge in developing and fostering shadow networks for adaptive governance.

Evans (1996) argues that the social capital important for economic development is often built in the intermediate organizations and informal policy networks in the interstices between state and society. In the same issue of the journal *World Development*, Ostrom (1996) explores the possibility of constructing synergies between governments and groups of engaged citizens. Similarly, social networks that link the state and local communities can support capacity building for ecosystem management (Berkes 2002, Olsson et al. 2004*a*, Folke et al. 2005).

We argue that the emergence of shadow networks for adaptive governance is a self-organizing process often triggered by a social or ecological crisis. The

impetus for this is often the recognition of the need for an alternative approach for governing SESs. Olsson et al. (2004*a*) observe that self-organizing processes toward adaptive co-management of ecosystems usually start with responses to crises by individual actors that expand to groups of actors and eventually become multiple-actor processes. Knowledge develops as part of this process and becomes embedded in the emerging organizational and institutional structures. The shadow networks in the Everglades and KV emerged in this way. In the Everglades, the development of a new and effective integrated understanding of that system within shadow networks preceded the transformation in the late 1980s and helped establish the foundations for models of the integrative Everglades system. It also established an entirely new discussion among warring parties that set the foundations for the multi-jurisdictional agreement to renovate the Everglades system that involved the South West Water Management District, the State of Florida, the U.S. government, and various stakeholders. Similarly, in the MNPB and the NHLD, epistemic communities exist that can provide new knowledge critical for developing an alternative approach and moving toward adaptive co-management. However, this knowledge is not well networked across the region, partly because of institutional gaps and the fact that the groups of actors do not trust each other.

In KV, networking facilitated the generation of new knowledge for finding an integrated solution to the emerging problems in the area. For example, it facilitated the development of a new way of conducting inventories and acquiring ecological knowledge that in turn led to more efficient management efforts (Olsson et al. 2004*b*). These inventories constituted the basis for actions and helped target certain areas for management. Links between key individuals in existing organizations and formal networks in a self-organized shadow network generated innovation and new ways of doing things that were critical for adaptive co-management.

Linking different networks and creating opportunities for new interactions are important when dealing with uncertainty and change. They are also critical factors for learning and nurturing integrated adaptive responses to change (Stubbs and Lemon 2001). Tompkins and Adger (2004) argue that the ability to link different networks makes it easier to avoid following the customary response paths and facilitates flexible learning-based management. In the NHLD, the polarization caused by conflicts of interest and distrust among actor groups hinders such links and could lock the SES into an undesired trajectory. Westley (2002) argues that the ability to deal with the interactive dynamics of SESs requires that the entire network of interacting individuals and organizations at different levels create the right links, at the right time, around the right issues. In KV, the different networks and the numerous cross-level linkages that developed during the preparation phase can be activated at critical times, which contributes to the flexibility and robustness of the SES and can therefore be viewed as sources of resilience (Olsson et al. 2004*b*, Hahn et al. 2006, Folke et al. 2005).

The emergence of shadow networks can take a long time or happen quickly as pre-existing shadow networks are mobilized to address an impending crisis. In the first instance, it takes time to build trust and a collective view of the system that accommodates the diverse viewpoints and mental models of the participants (Wondolleck and Yaffe 2000, Singleton 1998). Social capital is built up in formal organizations and networks of prevailing governance structures, and shadow networks can provide a platform/arena for collaboration in which this capital can be reorganized and recombined; this in turn can generate innovation and nurture renewal in times of reorganization. The nodes of these networks become reservoirs of collective knowledge and memory (Folke et al. 2003, Folke et al. 2005), with continual reinforcement and renewal of key ideas or past events through the day-to-day interactions of the network participants.

In KV, linking actors from various groups in shadow networks helped to create an organization and management practices that better matched social-ecological processes and interactions across spatial and temporal scales (Olsson et al. 2004*b*). This helped tighten feedback loops (Levin 1999) and build the resilience of the SES, thereby increasing the network's ability to secure and develop the capacity of ecosystems to generate services. Similarly, in the GBC, local networks deliberately created a new institutional layer at the scale above, i.e., the Catchment Management Authority, recognizing that hydrological processes operate at catchment and subcatchment scales well above the influence of local networks. However, it still maintained structures that contributed to masking environmental feedback (in the sense of Ludwig et

al. 1993, Huitric 2004), eroding resilience, and moving the SES further down an undesired trajectory.

In the MNPB, the deliberative processes introduced with post-1997 decentralization reforms include the establishment of a new Ping River Basin Organization. Such organizations have the potential to link individuals and networks and provide the leadership necessary to initiate negotiations, collaboration, and partnerships among actor groups. The emergence of the social networks in KV and the establishment of the EKV as a mid-level organization facilitated cross-scale interactions in the adaptive co-management process of the wetland landscape. Mid-level entities of this type have been referred to as "bridging organizations" (Hahn et al. 2006). Bridging organizations increase the potential to redirect external forces into opportunities, serve as catalysts and facilitators between different levels of governance, and bring in resources, knowledge, and other incentives for ecosystem management (Folke et al. 2005). The GBC case study shows, however, that organizations such as the Catchment Management Authority do not always facilitate transformation, but instead become the barriers for such change.

Emergence of leadership

Leadership provides key functions for transformations toward adaptive governance of SESs. This includes trust-building, sense-making, managing conflict, linking key individuals and initiating partnerships among actor groups, compiling and generating knowledge, developing and communicating vision, mobilizing broad support for change, and gaining and maintaining the momentum needed to navigate the transitions and institutionalize new approaches (Berkes et al. 2003, Olsson 2004*b*, Folke et al. 2005).

Kotter (1995) and Bass (1990) refer to transformational leadership, which Kotter defines as " ... a process to establish direction, align people, motivate and inspire—with the ultimate goal of producing movement or change." Westley (1995) shows that visionary leaders can appear at times of crisis to forge new alliances between knowledge and action when the paradigms that forged the old bridges have proven bankrupt as a platform for the effective management of ecosystems. The crisis in the GBC triggered processes similar to those in KV and the Everglades, but transformational leadership for moving the SES toward adaptive governance did not emerge as it did in those two cases. Therefore, the GBC process lacked the vision of a novel approach that could direct and frame the self-organizing process of emerging shadow networks in the preparation phase. It also lacked the knowledge and understanding of the long-term consequences of not transforming, which led to the masking of feedback signals and moved the SES further down the undesired trajectory. Leadership emerged in the GBC and was critical in organizing the system, but these leaders then played a "dampening" role by promoting adaptability rather than more radical suggestions for transformation. The vision they developed was in fact a vision for stability, i.e., a continuation of the current trajectory.

The GBC example shows that the emergence of leadership does not necessarily guarantee the transformation of SESs toward adaptive governance but instead can constitute a barrier for such change. In the Everglades and KV, successful SES transformations occurred because of the ability of the leaders to:

- reconceptualize issues;
- generate and integrate a diversity of ideas, viewpoints, and solutions;
- communicate and engage with key individuals in different sectors;
- move across levels of governance and politics, i.e., span scales;
- promote and steward experimentation at smaller scales;
- recognize or create windows of opportunity; and
- promote novelty by combining different networks, experiences, and social memories.

Successful leaders such as Sven-Erik Magnusson in KV or Art Marshall in the Everglades are able to understand and communicate a wide set of technical, social, and political perspectives regarding the particular resource issues at hand. They play a key role in integrating, understanding, and communicating in multiple arenas. Usually, that integration involves networking with key groups,

including shadow or epistemic groups. We also see that effective leaders are able to span and link key individuals operating in multiple arenas of discourse. Key individuals develop and communicate the visions of ecosystem management that frame self-organizing processes. Visionary leaders fabricate new and vital meanings, overcome contradictions, create new syntheses, and forge new alliances between knowledge and action (Westley 1995). Our case studies also suggest that SES transformations require linked leadership at various organizational levels.

The MNPB is on the verge of a transition or a tipping point (Gladwell 2000). There are several notable representatives of various networks outside of responsible agencies who speak out regularly on issues of river, water resource, and watershed management. However, they have not yet been able to mobilize the diverse interests in the basin for the transition to adaptive governance, nor have they garnered the broad support at different organizational levels needed to pull along a wider constituency. This is partly because their use of science in advocacy is too obviously ideologically colored for it to be convincing to other key actors.

Comparing the cases makes it clear that changing the opinions and values of key individuals in an SES is critical for successful transformation. Scheffer et al. (2003) show that it is harder to bring about an opinion shift if credible authorities are downplaying the problem or if it has to compete for attention with other problems at the same time. In the MNPB example, nongovernmental groups are making use of research to support particular political agendas. This tends to undermine the credibility of the original research and knowledge that could be critical for developing an alternative approach. Scheffer et al. (2003) also recognize that key individuals such as charismatic leaders may catalyze opinion shifts, which can reduce the time lag between problem and solution. This way fundamental change in an SES can occur quickly. Leadership that can engage and change the opinions and values of a critical mass of people to create an "epidemic" movement toward an idea has also been referred to as "tipping-point leadership" (Kim and Mauborgne 2003). It seems that the kind of leadership that could "tip" the SES into a trajectory toward adaptive governance has not yet emerged in the MNPB.

In KV, Sven-Erik Magnusson (SEM) identified the areas in which the interests of actor groups coalesced and found starting points for dialogue and collaboration. This was a first step toward changing the perceptions of key individuals and overcoming their resistance to transformational change. Transformational leadership therefore includes recognizing opportunities and identifying and transforming constraints and barriers such as conflicts of interest, values, and opinions. This is critical for reducing the resilience of undesired trajectories and building up the momentum needed to move into new trajectories.

In the NHLD, the emergence of a dialogue among interest groups evokes hope that leadership and networks will develop that can help transform the SES toward adaptive governance. In the Everglades, leadership emerged out of the scientific community. Such leadership can also emerge from the local community/public sector, for example, from local entrepreneurs as in KV. In this case, the vision helped stake out a new trajectory of adaptive governance. The transformational leadership that SEM provided helped broaden the perceptions of key actors and empowered them to act. His leadership was crucial for navigating the transition toward adaptive co-management.

SHOOTING THE RAPIDS

We began this paper with a description of the experience of shooting the rapids as a metaphor for transformational change in social-ecological systems (SESs). Navigating white water and getting through turbulent periods on the way to adaptive governance share certain other characteristics as well, such as the role of leadership and the timing of interventions and actions.

In this article, we have analyzed and compared five regional cases, with a focus on transformations within the social domain of their respective SESs. This focus has been on shifts in the social features of governance systems that enable ecosystem management, in particular, the features behind the emergence of adaptive governance. Such features include perception and meaning, network configurations, social coordination, and associated institutional arrangements and organizational structures.

The objective has been to gain insight into critical factors of SES transformability that promote shifts in social features. These factors include leadership functions, which we argue are important for the emergence of shadow networks and for preparing the system for change, navigating the transition, and charting a new direction for management. These findings represent a first step in improving our understanding of SES transformations and why some windows of opportunity generate dramatic changes of governance and others do not.

The comparison shows how novel ideas and places to explore new configurations of the SES are crucial for transforming governance regimes from those that mask environmental feedback to those that have viable social-ecological feedback loops. In Kristianstads Vattenrike (KV) and the Everglades, such innovations were developed in shadow networks during a preparation phase and continued through a navigating phase. Successful ideas propagated across scales because of linkages that were established during the preparation phase. In the Mae Nam Ping Basin and the Northern Highlands Lake District, novel ideas exist but are still at the periphery and have not been adopted on a regional scale. In the Goulburn-Broken Catchment, problems were dealt with at the regional scale, but they failed to explore new configurations of the SES.

The role of leadership is important, yet highly variable and hard to predict. Leadership is critical to the emergence and effectiveness of shadow networks. Moreover, our comparison suggests that the emergence of leadership does not necessarily lead to improved governance of SESs. These uncertainties suggest important research questions, such as: Is leadership random and idiosyncratic? Are there social mechanisms that increase the chances for leadership to emerge? What characterizes the particular type of leadership that can transform an SES toward adaptive governance?

Perhaps one reason that leadership is crucial has to do with the nature of windows of opportunity. If the window is driven by resource dynamics, as for example in the Everglades and KV, then successful leaders recognize the opening as an opportunity to orchestrate change. As indicated, this is a highly unpredictable dynamic. However, many leaders can create such a window for change, especially if there is a sense that current approaches are either failing or perceived as failing.

Comparing the regional case studies also shows that leadership can be concentrated in one or a few people or dispersed in a network of several actor groups. This is very similar to the idea of a camarilla, suggested by Holling and Chambers (1973). Social-ecological systems that depend on one or a few individuals to provide leadership functions can be highly vulnerable. If, for example, Sven-Erik Magnusson in KV had moved or for some other reason disappeared at a critical time, the direction of management would have been highly uncertain and the transformation might have taken another pathway. When might reliance on one or a few key individuals make change highly vulnerable to accidents of history? Are there ways to institutionalize, diversify, and secure leadership functions? What is the role of bridging organizations for this purpose?

Finally, based on our comparison we suggest some considerations and actions for successful transformations of SESs toward adaptive governance:

- Change attitudes among groups to a new, shared vision; differences are good, polarization is bad.
- Check for and develop persistent, embedded leadership across scales; one person can do it for a time, but several are better locally, regionally, and politically.
- Design resilient processes, e.g., discourse and collaborations, not fixed structures.
- Evaluate and monitor outcomes of past interventions and encourage reflection followed by changes in practices.
- Change is both bottom-up and top-down. Otherwise, scale conflicts ultimately compromise the promise; globalization is good but can destroy adaptive capacity both regionally and locally.
- Develop and maintain a portfolio of projects, waiting for opportunities to open.
- Always check larger scales in different sectors for opportunities; this is not science, but politics.

- Know which phase of an adaptive cycle the system has reached and identify thresholds; talk about it with others.
- Plan backloop actions differently than front loop ones; efficiency is on the front loop and resilience on the back loop.
- The time horizon for effect and assessment is at least 30–50 yr; restructuring resilience is all about slow dynamics.
- Create cooperation and transform conflict, but always be happy with some rhythm of conflict and ensure that channels for expressing dissent and disagreement are always open.
- Create novel communication face to face, individual to individual, group to group, and sector to sector.
- Encourage small-scale revolts and recoveries, not large-scale collapses.
- Try to facilitate adaptive governance by allowing just enough flexibility in institutions and politics.

Hopefully, these suggestions will help managers to more effectively navigate the periods of uncertainty and turbulence that appear to be an unavoidable component of any transformation of a social-ecological system.

Responses to this article can be read online at:
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