Chapter 13
Building Transformative Capacity for Ecosystem Stewardship in Social–Ecological Systems

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13.1 Introduction

Current approaches for managing natural resources often fail to match social and ecological structures and processes operating at different spatial and temporal scales (Folke et al. 2007; Carpenter and Gunderson 2001; Cumming et al. 2006; Galaz et al. 2008; Walker et al. 2009a; Rockström et al. 2009). The reasons behind this governance failure lie not only in weak environmental legislation, lack of enforcement power, or poor monitoring and evaluation systems (United Nations Environment Programme 2007), but also in ignorance of ecosystem dynamics and simplistic attempts to control and optimize delivery of specific natural resources (Holling and Meffe 1996). Stabilizing a set of desirable natural resources can create mismatches between institutions and ecosystem dynamics, leading to undesirable regime shifts in the capacity of landscapes and seascapes to generate essential ecosystem services (Scheffer et al. 2001; Galaz et al. 2008). The likelihood of sudden shifts between social-ecological systems, states has profound implications for ecosystem stewardship of essential ecosystem services in a world of rapid and directional change (Chapin et al. 2010). Shifts to more holistic, integrated forms of natural resource management and multilevel governance systems that support ecosystem-based management are urgently needed (Gunderson et al. 1995; Folke et al. 2005). These approaches have the potential to deal with the complexity of interdependent social–ecological systems (SES) and enhance the fit between ecosystem dynamics and governance systems (Berkes and Folke 1998; Berkes et al. 2003).

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The search for better approaches towards sustainable outcomes has helped to develop important design principles and protocols for alternative management and governance approaches (Ostrom 1990; Costanza et al. 1998; National Research Council 1999a). These approaches acknowledge ecosystems as complex, dynamic systems and address the mismatch between social systems and ecosystem dynamics (Norberg and Cummings 2008). Although the literature on environmental management and governance recognizes the need for transitions and transformations (National Research Council 1999b; Raskin et al. 2002; Babcock and Pikitch 2004; Walker et al. 2009b), it offers few empirically based insights into social–ecological innovations and strategies that make the shift to new ecosystem stewardship approaches possible. Different disciplines have studied pieces of the puzzle, such as organizational and institutional aspects (Danter et al. 2000; Imperial 1999) and the role of learning (Pahl-Wostl et al. 2008; Armitage et al. 2008) but have rarely captured interdependent social–ecological dynamics. There is still lack of understanding on how to transform SES into new, improved trajectories that sustain and enhance ecosystem services and human well-being. In this chapter, we aim to contribute to the understanding about the transformative capacity required to shift governance from disintegrated resource and environmental management to ecosystem stewardship in SES.

In the first part of this chapter we use a "resilience lens" to identify gaps in the understanding of transformative capacity and highlight some challenges that needs to be addressed. The second part draws on the organizational evolution literature in combination with the latest insights on SES transformations to give a more detailed understanding of what constitutes transformative capacity. This point is further emphasized in the third part where we use findings on transformative capacity from two empirical studies, the Kristianstads Vattenrike, Sweden, and the Great Barrier Reef, Australia, to exemplify ecological changes and social dynamics that lead to shifts to new flexible management and governance approaches. Lastly, we elaborate the key criteria and future needs for developing a framework for analyzing transformations towards ecosystem stewardship and assessing transformative capacity in SES.

13.2 The Problem of Fit and Lock-in Traps in SES

The mismatch between ecosystems and governance systems is often referred to as "the problem of fit" (Young 2002; Folke et al. 2007; Galaz et al. 2008). Resource management institutions that perform in a socially and economically resilient manner, with well-developed collective action and economic incentive structures, may in ignorance degrade the capacity of ecosystems to provide ecosystem services. Such behavior may cause a shift to a degraded ecosystem state (Scheffer et al. 2001), which, in turn, feeds back into the social and economic domains, with the risk of causing unpleasant surprises and undesirable social–ecological regime shifts (Folke et al. 2003). Hence, the interactions between societies and ecosystems can

create dynamic feedback loops in which humans both influence and are influenced by ecosystem processes. For example, Gordon et al. (2008) show how agricultural modifications of hydrological flows can produce a variety of ecological regime shifts that operate across a range of spatial and temporal scales ranging from soil structure to salinization and vegetation patchiness. These shifts can have severe implications for food production, the quality and quantity of freshwater resources, and other ecosystem services such as climate regulation and downstream coastal ecosystems (see also Resilience Alliance and Santa Fe Institute 2004). 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. A social–ecological resilience approach would treat agriculture as an embedded part of larger landscapes and pay special attention to tipping points and the internal and external dynamics that drive such change in interlinked agricultural, hydrological, and ecological processes (Gordon et al. 2008).

Gunderson and Holling (2002) refer to rigidity traps where people and institutions try to resist change and persist with their current management and governance system despite a clear recognition that change is essential. The tendency to lock into such a pattern comes at the cost of the capacity to respond to new problems and opportunities. In rigidity traps, a high degree of connectivity and the suppression of innovation prolong an increasingly rigid state, which could result in an undesired regime shift in the system. For example, archeological studies shows that people of the Hohokam region, U.S. Southwest, created a way of life that offered few alternatives, which led to a societal collapse (Hegmon et al. 2008). Although conditions worsened, people stayed despite poor health conditions for generations, until the social and physical infrastructure ultimately fell apart. Hence, the misfit between social and ecological systems and the inability to respond to feedbacks can push interconnected SES into undesirable pathways from which it is hard to escape, and may lead to societal collapse and major human suffering.

Scholars from the social sciences and humanities refer to this problem as *path dependence*. A system is path dependent if initial moves in one direction elicit further moves in the same direction; in other words, there are self-reinforcing feedback mechanisms (Kay 2003). Historical institutionalists see institutions as one of the key factors for pushing development along a set of paths (Hall and Taylor 2006) and have focused on explaining how institutions produce such paths. This includes studies of how institutions structure a nation's response to new challenges. Due to stabilizing feedback mechanisms, shifting into new pathways might be very difficult. For example, marine zoning and shifts to ecosystem-based management in the United States have been severely constrained by inflexible institutions, lack of public support, and difficulties in developing acceptable legislation (Crowder et al. 2006). This means that attempts and initiatives to move towards place-based ecosystem management might fail because there are mechanisms, such as peoples' opinions and worldviews, incentives, power relations, and institutions, operating at different scales that do not support such shifts. For example, Berkes et al. (2006) show how trade flows of marine resources at the global level and the lack of legislations to deal with "roving bandits" fishery might stifle attempts to move towards

ecosystem-based management at the local/regional level. Understanding traps and path dependence and identifying barriers to change (and how they, for example, are associated at a specific institutional level) are important for developing strategies for SES transformations.

The resilience lens (capacity to deal with change, also abrupt and surprising, and continue to develop) that we use here to discuss social–ecological transformation emphasizes three facets of resilience: (1) persistence (buffer capacity, robustness), which is the most common interpretation of resilience in the literature; (2) adaptability, which is the capacity to reconfigure or reorganize within the same social–ecological regime in the face of disturbance; and (3) transformability, which is the capacity to create a fundamentally new system when ecological, economic, or social conditions make the existing system untenable. From a resilience perspective, one can argue that unsustainable social–ecological regimes can be very persistent to change because there is path dependence and inertia in the system. This has sparked the notion that resilience as persistence is not necessarily a good thing and that building resilience is not an end in itself, especially if you are in a trap or on an unsustainable path (Walker et al. 2009b). The question is how persistence of the undesired SES regime can be reduced in order to enable shifts to a new regime.

Resilience research in transformability focuses on how to "unlock" a locked-in regime and the ability to escape or get out of traps. Gunderson et al. (2009) argues that there are at least two ways to unlock the system. One is the role of crises (external variation that overwhelms system resilience). This means that a crisis, like the current climate change crisis, food crisis, and financial crisis, can potentially be used productively to stimulate experimentation, innovation, novelty, and learning within society (Cumming GS, Olsson P, Chapin FS III, Holling CS (manuscript) "Coping with climate change: the urgent need for a learning agenda", in preparation). The other way is the more "quiet revolution" where internal processes, sometimes eroded by broader scale processes and drivers, reduce the resilience of the system and the resistance to change. As mentioned earlier, lock-in mechanisms operate at different levels and scales and in different parts of the system (social, economical, ecological) and strategies need to be developed to understand such mechanisms and find ways to unlock them. Although Gunderson and Holling (2002) and Gunderson et al. (2009) offers insights on some of the key features for reducing the resilience of undesired regimes, the capacity to unlock social–ecological regimes needs to be explored further.

13.3 Enhancing the Fit and Unlocking SES

Researchers in social sciences and humanities have long recognized that rigidity, lock-in traps, and path dependence are common characteristics of institutional development and public policymaking. They have also focused on understanding sudden change and "punctuated equilibrium," where long periods of stability and incremental change interact with abrupt, nonincremental, large-scale change (e.g.,

Baumgartner and Jones 1991; True et al. 1999). For example, in 1970 the United States experienced an abrupt burst of environmental policy innovations and a number of environmental laws were passed in rapid succession (Repetto 2006). This period lasted for about 5 years and was exceptional in terms of public concern over environmental protection, political mobilization, and legislative consensus. The literature on punctuated equilibrium recognizes that there are *critical junctures* and *branching points* from which historical development moves onto a new path. Understanding the sequence of events that leads to such junctures is of crucial importance for understanding transformative capacity.

Work on environmental and resource regimes has generally focused on institutional arrangements. While historical institutionalists argue for the need to change institutions in order to move into new pathways, other scholars go beyond institutions and argue that whole societal regimes have to be shifted (White 2000; Pahl-Wostl 2009; Fischer-Kowalski and Rotmans 2009). Holtz et al. (2008:629) define a societal regime as follows: "a regime comprises a coherent configuration of technological, institutional, economic, social, cognitive and physical elements and actors with individual goals, values and beliefs." Hence institutions are only one of the components that constitute a regime. Similarly, in the socio-technical literature, a societal regime is defined as "a conglomerate of structure (institutional setting), culture (prevailing perspective) and practices (rules, routines and habits)" (Fischer-Kowalski and Rotmans 2009:12). A regime's institutions provide stability and structure of societal systems, but they can also limit innovation and stifle attempts to deal with new challenges (Geels 2005). This literature recognizes that transformations are more than mere institutional change but rather systemic regime shifts. It points to a broader set of issues that need to be addressed as part of transformative capacity, such as power and social relations, political and economic dynamics, worldviews, and cultural differences.

In the same line, Pahl-Wostl (2009) and Armitage et al. (2008) offer a learning perspective on systemic regime shifts. Learning strategies are particularly pertinent for dealing with complex adaptive social–ecological system where uncertainty is high. Learning strategies involve monitoring, evaluating, and responding to signals of environmental and social change. This literature describes transformations as stepwise social learning processes that involves single-, double-, and triple-loop learning. According to Pahl-Wostl (2009), *single-loop learning* refers to a refinement of actions to improve performance without changing guiding assumptions and question established routines. *Double-loop learning* refers to changing the frame of reference and questioning of guiding assumptions. Reframing implies a reflection on management goals and how problems are framed (define priorities, include new aspects, change boundaries of system analysis) and assumptions on how goals can be achieved. *Triple-loop learning* refers to a change in management paradigms and also in the underlying norms and values that determine the frame of reference. It builds on the recognition that paradigms and structural constraints can impede innovations and effective reframing of resource management. Triple-loop learning most likely needs to be involved in transformation from one regime to another.

Although this literature provides insights on the magnitude of change that needs to happen in order to avoid or escape unsustainable pathways and lock-in traps, the question still remains, what constitutes the capacity to initiate and navigate such transformations? The literature on socio-technological transitions offers some important insights. Geels and Schot (2007) for example, present a typology of transitions in social–technological systems. This literature recognizes transformations as multilevel, multiphase processes that move along in fits and starts. The challenge in SES research is to also capture the ecological dimension of transformations. Addressing only the social dimension of resource management without an understanding of resource and ecosystem dynamics will not be sufficient to guide society toward sustainable outcomes. Societies may go through major regime shifts without improving the capacity to learn from, respond to, and manage environmental feedback from dynamic ecosystems, which in turn can lead to further ecological degradation, SES regime shifts, and deep traps difficult to get out of. For example, the mobilization of Belizian coastal fishermen into cooperatives, which was socially desirable and economically successful, led ultimately to excessive harvesting of stocks of lobster and conch (Huitric 2005). Similarly, focusing only on the ecological aspects as a basis for decision making for sustainability leads to conclusions that are too narrow.

For the reasons outlined above, studies on transformative capacity need to focus on the interconnected SES and more specifically on changes of the feedback loops in these systems (Walker et al. 2004; Chapin et al. 2010). Transformations fundamentally change the structures and processes that alternate feedback loops in SES (Gunderson and Holling 2002), and transformability means defining and creating novel system configurations by introducing new components and ways of governing SES, thereby changing the state variables, and often the scales of key cycles, that define the system (Carpenter and Gunderson 2001).

SES transformations are not scale independent and require an understanding of cross-scale interactions. Changes at smaller scales can trigger changes at larger scales and changes at larger scales can open up and provide windows of opportunity for transformations at regional to local scales, like those in focus here. Transformations from one social–ecological regime will often require sources of resilience, for example, a memory of experiences for creating novelty and innovation, drawn from other scales or other systems (Gunderson and Holling 2002). For example, Gelcich et al. (Gelcich S, Olsson P, Castilla J, Hughes T, Folke C (in preparation) “Governance transformation for the sustainable management of marine coastal SES”) describe how, in the late 1980s in Chile, a new governance approach for marine resources emerged at a time of marine resource crisis and political turbulence. The resource crisis triggered a few collaboration initiatives between fishers and scientists who for different reasons started to solve problems together. The political turbulence in the late 1980s provided a window of opportunity for fishers to organize and influence the new national fishery legislation. Hence, transformations at one scale do not take place in a vacuum but in a cross-scale context.

13.4 Initiating and Navigating Purposeful Transformations

In initiating and navigating transformation in SES, developing new ideas and alternatives to existing governance structures is of fundamental importance (Westley 1995, 2002; Gunderson et al. 1995; Gunderson and Holling 2002). Olsson et al. (2004a) describe a sequence of events for the development of new ecosystem management approaches in response to ecological change:

- An ecosystem management approach expands from individual actors, to group of actors, to multiple actor processes.
- Organizational and institutional structures are developed as a response to deal with the broader set of environmental issues.
- Knowledge of social–ecological dynamics develops as a collaborative effort and becomes part of the organizational and institutional structures.
- Social networks are developed to connect institutions and organizations across levels and scales. Social networks facilitate information flows, identify knowledge gaps, and create nodes of expertise of significance for ecosystem management.
- Knowledge for ecosystem management (including local knowledge and scientific knowledge) is mobilized through social networks and complements and refines local practice for ecosystem management.

In the sequence of events, the ability to deal with uncertainty and surprise can be improved, which increases the capacity to deal with future change. Olsson et al. (2004b, 2006) also point out that these transformations are often multilevel and multiphase processes that involve incremental as well as abrupt change. They have identified three phases of SES transformation (Fig. 13.1): (1) preparing for transformation, (2) navigating the transition, and (3) building resilience of the new governance regime. Phases (1) and (2) are linked by a window of opportunity. Important factors for accomplishing transformations include the role of innovation,

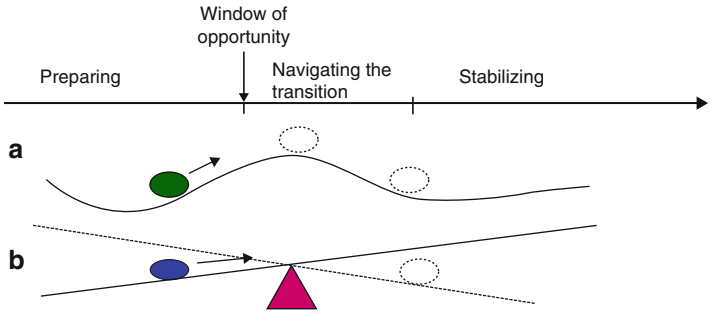

Fig. 13.1 Three identified phases of a social–ecological transformation: preparing for transformation, navigating the transition, and building resilience of the new direction. A window of opportunity links the first and second phases. The transformation is illustrated in two ways: (**a**) as a regime shift between multiple stable states, passing a threshold or (**b**) as a tipping point

transition strategies, enabling legislations, dynamic networks, entrepreneurship, and leadership.

The challenges of initiating and navigating purposeful transformations in SESs have some similarities with developing new commercial organizations. Organizational science has paid much attention to the role of networks, agency, and innovation in transformations. Therefore, we suggest that much can be learnt about transformative capacity in SES by theoretically linking emerging insights from resilience research with theories in the organizational sciences. We focus on the literature on how organizations are created and how these may evolve from early startups to established firms. This line of organizational research is labeled "evolutionary" (Fig. 13.2), and we draw on the seminal work on evolving organizations by Aldrich (1999). We recognize that the amount of literature on organizational change is huge and we do not intend to cover it all in this chapter.

Establishing a new commercial organization in a complex environment involves carrying out many different activities and being able to respond to various challenges in a timely and responsive way. Hence, the nascent entrepreneurs need to be able to cope with uncertainties and to conduct businesses in an adaptive, ad hoc approach (Aldrich 1999). Consequently, few startup attempts are able to survive beyond this very initial phase. Organizational research, as well as research on transformations of SES, is therefore occupied with identifying factors that enable organizations to emerge and develop.

13.4.1 Agency and Dynamic Network

The importance of informal social networks is strongly emphasized in the evolutionary perspective of evolving organizations (Aldrich 1999). Traditionally, much

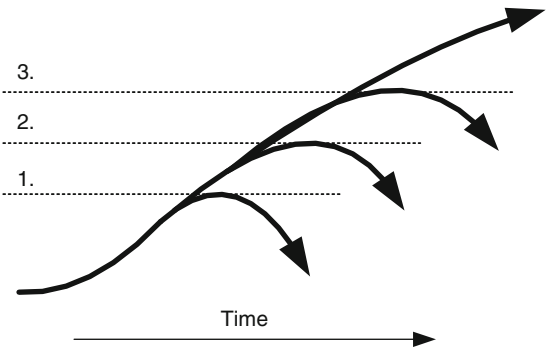

Fig. 13.2 A conceptual model of emerging organizations (adapted from Aldrich 1999). Through time, the organization goes through different phases and challenges (1, 2, and 3 in the figure). At these stages, the organizations will either adaptively embrace the challenges or continue to evolve and develop, or they may not and therefore fail in sustaining themselves. This multiphase model of emerging organizations is here suggested to also capture the vulnerable processes characterizing transformations of social–ecological systems

attention has been directed to the personal characteristics of the commercial entrepreneur, but more recent studies have not been able to identify general characteristics of these entrepreneurs that explain successful take-off of organizations (e.g., Garner et al. 1992). Instead, research has highlighted the role of the social network around entrepreneurs and how these networks can provide for example social, emotional, financial, and material support, which is of crucial importance for successful start-ups (Aldrich 1999). Two specific aspects of the social network is emphasized, namely *diversity* and *strength*.

Firstly, diversity refers to the heterogeneity of the entrepreneurs' contacts in terms of age, sex, occupations, industry affiliations, etc. A high diversity implies access to a wider circle of information, knowledge, capital, and markets, whereas a low diversity means a homogeneity of contacts that only provide access to resources and competencies similar to what the entrepreneur already possesses (see, for example, Granovetter 1973; Carlsson and Sandström 2008). Of particular interests are the relational ties that exclusively bridge different groups of actors. A broker is an actor possessing bridging ties connecting different actors not being directly connected themselves. Such nonredundant ties gives the broker not only access to a diverse sets of actors, but it also enables him/her to strongly influence the flow of information going between the different groups; an ability that by itself provides the broker with a social advantage that can be utilized for various objectives (Burt 1992).

Secondly, the strength of the relational ties is of importance. A strong tie implies a close and durable relationship characterized by a high level of trust and reciprocity, and is typically used for giving/receiving advice, assistance, and support spanning many different areas in life. Strong ties often form the core of a founding team of a new organization (Aldrich 1999). Weaker ties, on the other hand, are typically associated with ties to actors of a different kind, and thus provide the entrepreneur with the diversity discussed above (Granovetter 1973). Conclusively, a common characteristic among many successful commercial entrepreneurs is a diverse and far-reaching social network composed of a mix of strong and weak relational ties (Aldrich 1999).

Emerging insights from empirical research on SES transformations support these findings by ascribing similar characteristics to successful change agents' social networks (e.g., Olsson et al. 2007). For example, Gunderson (1999) and Olsson et al. (2006) identify the role of informal social networks (or shadow networks) for initiating and navigating transformations. These networks emphasize political independence outside the fray of regulation and implementation in places in which formal networks and many planning processes fail. They also emphasize the role of these shadow networks as incubators for new ideas and approaches to governing SES. In this context, a successful change agent often needs to devote considerable amounts of time and energy to expand and reorganize its social network for dealing with new problems and to keep the momentum of the transformational processes. Understanding network dynamics and the ability of key actors to maneuver networks is an important part of the transformative capacity.

A new commercial organization needs to define itself as a bounded entity in order to (1) become a visible actor that can cooperate and compete with other actors and (2) to create a sheltered space where new ideas, concepts, competences, and processes can be initially nurtured and developed internally (Aldrich 1999). From a change agent's perspective, these processes involves defining different roles within the organization, developing work processes, recruiting personnel and external supporters, and making sure that competence and knowledge are developed, maintained, and reproduced within the organization. Also, sooner or later the organization needs to define itself in an *organizational network* of other actors/organizations in order to establish legitimacy and acceptance. However, the organizational networks (where the basic social unit is an organization and not a person and the relations are ties among organizations) referred to here are conceptually different from the previously discussed personal social network of the entrepreneur, even though personal social networks are often used as vehicles to create ties between organizations.

Comparing this finding with insights from research on adaptive governance of SES, we argue that since such systems includes juridical, social, economic, and ecological features that interact across multiple levels, a single actor/organization will have a hard time to accomplish transformations if not firmly connected (in partnerships for example) to other organizations and actors within these spheres. In fact, a key success factor in transforming SES from sectoral natural resource management to ecosystem stewardship of dynamic landscapes and seascapes is the existence of organizations being able to develop and utilize ties with various different actors on different scales. Boundary and bridging organizations are examples of such organizations (Cash et al. 2006; Hahn et al. 2006). The ability among actors to form those connections and shape change depends on the opportunity context and the ability of actors to take advantage of such context.

13.4.2 Making New Approaches Stick

If an organization is successful in moving through the three phases in Fig. 13.1 and develops along a new pathway, it might still be vulnerable to change in its early stages of existence. As for emerging management and governance systems in SES, the question is how to make them "stick". Aldrich (1999) argues that the firm establishment of an organization that is introducing something new is achieved first when several related organizations, together as a group, are able to establish their own common niche in the organizational landscape. The evolving population of organizations can create legitimacy in society, which may involve shifts in existing legislation and cultural norms. Therefore, an important part of transformative capacity is the ability of a single organization to establish itself in an organizational network and collaborate with relevant organization in developing the common niche. Such collaboration is also crucial in facilitating collective learning among

organizations, which itself a factor that helps to build resilience of the emerging population of organizations (Aldrich 1999 and references therein).

Again, these insights harmonize with pending insights from recent SES research. For example, Ernstson et al.'s (in press) study on social movements and ecosystem management has shown how a network of volunteer organizations concerned with the protection of green areas in an intensively developed urban region has established itself as an important player with a specific role to play in land-use planning. The network is part of the organizational landscape and is acknowledged as an informal but still legitimate entity by various planning authorities. As we will illustrate in the following sections, the development of new networks, like the shadow networks described earlier, as well as their ability to challenge and change well-established decision-making processes, is an important part of transformative capacity.

13.5 The Kristianstads Vattenrike Biosphere Reserve

The following information is drawn from Olsson et al. (2004b); Hahn et al. (2006) and Schultz et al. (2007). The flooded meadows of Kristianstads Vattenrike Biosphere Reserve have been shaped over several millennia by agricultural practices in combination with the annual flooding of the Helgeå River. Continuous livestock grazing and mowing for haymaking have resulted in a landscape with unique values – biological as well as cultural–historical.

Over the last three centuries, draining, dredging and building of embankments have altered the hydrology and the wetlands have shrunk accordingly. During the 1900s, wetlands were largely seen as wastelands and were used as a dumping ground in the 1960s. However, in 1975, the 35-km stretch of wetlands along the lower Helgeå River came under the protection of the Convention on Wetlands of International Importance. The county administrative board became responsible for managing the Ramsar Convention Site (RCS), which included privately owned land as well as municipal and state-owned. They suggested that almost the whole area (49 km^2) should eventually become a nature reserve.

The Ramsar designation resulted in several conservation plans, policy documents, and protection efforts. However, the natural values continued to disappear even in nature reserves on state-owned land (covering 3% of the RCS in 1989). Inventories conducted by the Bird Society of Northeastern Scania (BSNES) since the 1950s recorded declining waterfowl populations, eutrophication, and overgrowth of lakes subsequently linked to the decreasing use of flooded meadows for grazing and haymaking. Farmers abandoned marginal lands across the country, as agricultural technology enabled intensification of other types of land.

The links between nature and culture were simultaneously explored and illustrated in a series of exhibitions at the Kristianstads County Museum starting in the late 1970s by the curator, Sven-Erik Magnusson (SEM). During the 1980s, the museum established several outdoor museums to give visitors on-site information,

to help them interpret the landscape, and to increase their interest and commitment to its associated values.

In 1986, the Municipality of Kristianstad initiated a cultural heritage program and funded an inventory of meadows and pastures focused on the link between biodiversity and agricultural practices in the flooded meadows. It was designed by SEM in collaboration with a member of BSNES, Hans Cronert (HC), and resulted in a detailed land-use map, which helped define and prioritize areas for improving land-use practices, estimate funding needed to maintain and develop these practices, and identify habitats for unique flora and fauna. At this time, BSNES approached officials at the national and county levels responsible for managing the nature reserves and convinced them to improve management practices in these areas. BSNES also proposed that parts of the RCS be made into a national park, but this idea was never realized.

Encouraged by the inventories and inspired by ecomuseums in Europe, SEM created an ecomuseum on the lower Helgeå River. To coordinate ongoing activities under one concept, he coined the term "*Kristianstads Vattenrike*." The name *Vattenrike* roughly translates as "water realm" and "water riches" and underscored the notion of the wetlands as having great value, rather than as water-logged, unhealthy swamps. In early 1988, the term *Ecomuseum Kristianstads Vattenrike* (EKV) had become not just an outdoor museum, but also an organization working to initiate, improve, and build upon ecosystem management of the catchment of the lower Helgeå River.

Once the flooded meadows become overgrown, it is difficult to restore them and the ecosystem assumes an alternative stable state, which is arguably less desirable to users. Several individuals perceived this threat and conducted inventories, produced maps, and worked to increase public awareness of the values and their disappearance. They also initiated restoration projects and analyses of the underlying processes that sustained the flooded meadows. There were parallel processes of sense-making, knowledge generation, and vision building during this stage, the release phase of flooded meadows, and their management. Efforts were largely uncoordinated and took the form of informal meetings between SEM and the BSNES, and between the BSNES and the official managers of the nature reserves.

To garner support for the EKV project, SEM established close relationships and trust with change agents in key organizations. These early contacts resulted in support from five individuals: a researcher at Lund university interested in linking a research project on nutrient loads from agriculture to the EKV; an official at World Wildlife Fund (WWF) Sweden, interested in the project's nature conservation aspects; the rector at Kristianstads university interested research, education, and pedagogy; a hotel director and former president of the Tourism Board intrigued by the EKV's potential to attract tourists, and the director of the National Museum of Natural History. With their support, SEM prepared the first proposal to charter the EKV in late 1988.

An important meeting was held in October 1988 between SEM and a senior municipal politician, who subsequently convinced the chair of the Municipal Executive Board to support the project. By early 1989, SEM had assembled a broad base of

support for the EKV from key individuals within various local groups as well as the municipality, the county administrative board, and national organizations. A window of opportunity to establish the EKV and flexible and collaborative management of the ecosystems of KV opened as local politicians were keen to find a profile for the municipality with good potential for recreation and tourism. The municipal board also knew SEM and trusted his capacity, and environmental issues were high on the political agenda in Sweden at the time.

In March 1989, a small team including SEM was funded by the Municipality to develop the EKV idea further. Other funding backers were WWF Sweden and Sweden's National Cultural Advisory Board. In September 1989, SEM and a colleague from the County Museum began working full time with the EKV project at the Municipality. SEM became the Director of the EKV.

The recognition of the value of the flooded meadows and the threats to their future was growing in Kristianstad. Simultaneously, SEM built support for the EKV proposal as a solution to this management failure. He developed a network of potential partners and contacts, leveraged resources to develop the idea further, and made deals with a range of funding sources.

The Ecomuseum has maintained a firm direction and vision since its inception: to enhance the ecosystem services in the area while using them sustainably through strategic collaboration with a diversity of actors. The work relies on voluntary participation by local stewards and actors at the municipal, county, national, and international levels, and depends on trust-building, skilled communication, and identifying benefits for both nature conservation and other public and private goals. Over the past 15 years, the organization has maintained its flexibility, opening and closing projects depending on needs and available resources. Grazed and mowed areas have increased, and so have water fowl populations. The area protected as nature reserves has also increased. The flooded meadows would appear to have a new image among the people of Kristianstad; they are now seen to offer unique esthetic, cultural–historical, and ecological values, as well as services like flood control and recreational opportunities. In 2005, Kristianstads Vattenrike was given Biosphere Reserve status by UNESCO, partly in recognition of these achievements.

13.6 The Great Barrier Reef Marine Park

The following information is drawn from Olsson et al. (2008). The Great Barrier Reef Marine Park (GBRMP) covers 344,000 km^2, an area almost the size of California. Like many other coral reefs, the Barrier Reef generates a multitude of essential ecosystem services. The Park contributes AU$6.9 billion annually to the Australian economy, 85% of which is from tourism. The Australian government enacted The Great Barrier Reef Marine Park Act in 1975 in response to threats to the reef from oil drilling, mining, and unexplained outbreaks of coral-eating starfish. In 1981, the Great Barrier Reef region was also declared a World Heritage

Area. The marine park allows a range of uses based on spatial zoning. The Great Barrier Reef Marine Park Act also established the marine park authority (GBRMPA) in 1976 and required the new agency to initiate zoning plans for the marine park. Between 1983 and 1988, each of the four sections of the park (Far Northern, Cairns, Central, and southern Mackay/Capricorn sections) were zoned for the first time. No-take areas together accounted for 5% of the marine park, mainly in the remote Far Northern area and predominantly covering coral reefs (reefs actually make up only 6% of the entire GBRMP).

Gradually, it became clear that the initial level of protection established for the park did not ensure that the entire ecosystem remained healthy, productive, and resilient. Despite the Act and associated management efforts, studies showed that the Great Barrier Reef was still showing signs of degradation caused by sediment runoff from land, overharvesting, and, more recently, from global warming. Demographic and economic data gathered in the 1980s and 1990s showed rapid growth in human population, land clearing, coastal development, tourist visits, and fishing pressure.

In the late 1990s, there was growing awareness among scientists and reef managers that inshore and deeper habitats were poorly represented in existing no-take zones and that connectivity of larvae and other poorly understood interactions between reef and nonreef habitats were important to the resilience of the entire ecosystem. Unprecedented regional bleaching occurred in the summer of 1997/1998, affecting large parts of the GBR and other reefs in the Western Pacific and most of the tropical Indian Ocean. The initial zoning network did not adequately protect the range of biodiversity of the reefs and hence could not maintain the GBR's resilience in the face of recurrent ecological disturbances. Combined with increased human pressures on the GBR, including the challenges of climate change, individual actors within the GBRMPA were triggered to search for more holistic approaches to governance and management of this large marine ecosystem.

In 1998, the GBRMPA initiated a major rezoning of the marine park called the Representative Areas Program (RAP) protecting representative examples of each type of habitat within a network of no-take areas. Focus was on protecting biodiversity and maintaining ecosystem function and services rather than on maximizing the yield of commercially important fisheries. The idea to rezone the entire reef in one push was controversial and the RAP process required skilful leadership by GBRMPA and its executive team (the Chair and two Executive Directors to whom senior managers report). Five important areas had to be addressed: (1) internal organizational changes, (2) bridging science and policy, (3) changing people's perceptions, (4) facilitating public consultation and participation, and (5) gaining political support.

The emerging concept of rezoning the entire marine park initially occupied a small group, understaffed and underfinanced. By the early 2000s, however, almost all of GBRMPA was involved in the RAP process. The executive team established a Senior Managers' Forum to coordinate activities and advise the organization's Chair. The Senior Management Forum unified internal management and communicated a common vision throughout the organization. The Forum established and

nurtured an environment where creativity was encouraged and innovative solutions to problems could emerge. Importantly, this process was achieved without any additional funding and relied entirely on a flexible internal redeployment of staff. The Senior Managers Forum established four regional teams responsible for the comprehensive public consultations associated with the RAP. Using teams helped avoid competition between sectors, increase internal collaboration, and pool experiences and resources.

The RAP process relied heavily on scientific expertise and a new synthesis of data on species and habitats of the Great Barrier Reef. Therefore, GBRMPA created new opportunities for interaction, dialog, and information sharing with researchers. This included establishing committees and panels, facilitating workshops, and communicating GBRMPA's overall vision and goals for the RAP and rezoning. For example, two independent advisory committees (the Scientific Steering Committee and the Social, Economic, and Cultural Steering Committee) were convened to develop operating principles to guide the RAP process. Beginning in 1998–1999, experts compiled more than 40 datasets to characterize the biological and physical diversity of the GBRMP. GIS-based tools and analytical methods identified and mapped 70 bioregions, of which 30 were reef bioregions. Scientists were encouraged to think beyond their individual sample sites or specialized expertise. This dialog was facilitated by a longstanding relationship between GBRMPA and researchers at universities, the Australian Institute of Marine Sciences, and the Cooperative Research Centre for the Great Barrier Reef World Heritage Area (CRC Reef).

Because of its iconic status, there was overwhelming support both nationally and locally for conserving the Great Barrier Reef, which gave the RAP process political leverage. However, not everyone was aware of the threats to the reef or agreed with the proposed management changes. Some local recreational fishers were vocal in their opposition to no-take zones. Many still perceived the Great Barrier Reef as pristine, protected from human impacts by its sheer size and relative isolation. To address this issue, GBRMPA produced a ''reef under pressure'' information campaign showing threats to the reef from coastal development, land use, shipping, tourism, and fishing. The campaign included Web sites, posters, pamphlets, and television advertisements with celebrity spokespeople. The campaign was followed up by continuous polling to monitor changes in public perceptions.

Public consultation for the RAP greatly exceeded the requirements of the Act and was by far the most extensive in the history of the marine park. GBRMPA attended every public meeting they were invited to. Instead of organizing large public meetings that could be dominated by a few people, they held several hundred community information sessions in regional and local community centers. Periodic updates on the RAP process were posted online. The public response was overwhelming: over 31,000 submissions. A ''factory'' was set up for handling them, quickly allocating human and financial resources within the organization without additional external funding.

GBRMPA reports to the Australian Federal Minister for Environment and Heritage, whose support was crucial for the RAP process. The rezoning legislation

had to pass the two federal houses of Parliament. A new minister for environmental issues was appointed in 2002. The timing of submitting the plan to the Senate was crucial; the new zoning plan needed to be submitted in December 2003 in order to become operational before the upcoming federal election. This provided a narrow political window of opportunity that set the time frame for GBRMPA and the minister to prepare a smooth passage of the plan through both houses of Parliament. Throughout the planning process, senior staff from GBRMPA made frequent trips to inform critical players such as governmental departments and agencies responsible for fisheries and the environment, Members of Parliament and senators (especially those representing constituencies along the Queensland coast), shipping interests, port authorities, and the Defense Department. Senior scientists, conservation nongovernmental organizations, and lobbyists for the tourism and fishing industries also played a role in convincing politicians of the need to pass the reef legislation.

The new, more sophisticated approach that emerged addressed both ecosystem dynamics and the intricate web of interactions in SES. A small team working within the GBRMPA planned the rezoning of the entire marine park, which subsequently led to critical support from the Authority's executive team for the major rezoning effort and the allocation of internal resources for developing the RAP. This happened in three stages, from (1) a relatively minor project within GBRMPA to (2) incorporation across all parts of the Authority and status as an agency priority, to (3) changing national legislation and influencing other areas in Australia (such as the Ningaloo Reef in Western Australia) and becoming a role model for policy development elsewhere.

13.7 Discussion

Drawing on the literature and our case studies, we can identify some key features of transformative capacity. There are at least three distinct dimensions of SES transformations that require capacity building: (1) understanding where you are, (2) figuring out where to go, and (3) developing strategies for how to get there. SES transformations involve agency for changing management paradigms, power distributions, regulatory frameworks, underlying norms and values, knowledge production, and network configurations and interactions among actors. These changes are all important for altering and creating new feedback loops in SES.

Understanding where you are includes identifying the current regime and key feedback mechanisms that keep the social–ecological system in its regime, engaging key actors to recognize dysfunctional states, and raising awareness of the problem. In the Kristianstads Vattenrike case, individual actors were involved in sense-making processes, interpreting ecosystem changes and creating a meaningful order captured in the project proposals as a call for action. The sense-making process helped link ecosystem changes and degradation to social factors including values and perspectives, organizational structures, and institutions at multiple levels.

In the Great Barrier Reef case, collaborative efforts were made to compile a 25-year strategy that made sense of data and information that had been collected over decades. Global, national, and local assessments often provide an understanding of the causes of the trends in environmental, ecological, and social conditions that lead to unsustainable directions for SES at the local to planetary scales. However, this kind of information is often fragmented and requires a capacity to access, compile, and make sense of it in a specific context. In both our case studies, as part of enhancing the fit between ecosystem and governance system, strategies were developed and orchestrated by key agency in bridging organizations to overcome organizational structural problems that produced fragmented responses to change.

Figuring out where to go includes identifying plausible alternative pathways for the social–ecological system. In the Kristianstad case, there was a process of seeking a collective vision for the future and communicating and building support for this vision. Key factors included dialog, conflict resolution, trust-building, and sense-making. The shared vision of ecosystem management helped define the arena for collaboration, connect and coordinate ongoing activities, and develop social networks. In the GBR, a collective vision for the management of the Great Barrier Reef was developed in the *25-Year Strategic Plan for the Great Barrier Reef World Heritage Area* (1994). In addition, a vision was also developed for GBRMPA to guide the interorganizational changes that were instigated in the late 1990s. Scenario building is another key tool for collectively identifying possible futures (Peterson 2007; Carpenter and Folke 2006; Enfors et al. 2008). Building visions and scenarios requires a capacity to coordinate and draw on a number of sources of knowledge including scientific knowledge and local knowledge.

Developing strategies for how to get there includes strategies for identifying and overcoming barriers, keeping the momentum of the transformation and building stability of the new regime. In both cases, knowledge gaps were identified and new knowledge was generated in order to fill these gaps, which were key processes for enhancing the fit in the SES. For example, GBRMPA played a key role in facilitating and coordinating scientists to produce the bioregional map, which was necessary for establishing a network of reserves and managing the GBR at the seascape level. New scientific insights on marine connectivity and spatial ecological resilience were also incorporated in the new approach. Similarly in KV, as part of developing the new approach, the shadow network provided agency and coordinated the synthesis of existing knowledge and initiated a number of inventories that provided new insights for managing social–ecological processes at the landscape level. As an important part of this knowledge production, both case studies show how experiments were initiated to generate innovations that could support the new approaches. In Kristianstad, collaborative experiments were set up to reduce nutrient loads to the rivers, and the GBR experiments showed that the biomass of coral trout was up to six times lower on heavily fished near-shore reefs compared to adjacent no-take areas. Such social–ecological system innovations were important to enhance the fit between the ecosystems and governance systems. This is in line with the findings by scholars in transition management (e.g., Loorbach 2007) who

argue that the ability to coordinate experiments in such a manner that they contribute to system innovation is of crucial importance in order to unlock the current lock-in and enable shifts towards new trajectories.

In both case studies, strategies were developed to change peoples' values and perspectives, which were identified as major obstacles to change. The capacity to develop strategies to change public perceptions and attitudes were important to unlock and change existing regimes. The case of Kristianstads Vattenrike Biosphere Reserve also show that it is important within which groups such shifts occur in order to reduce the resilience of the unsustainable regime. Hence, the change in attitudes among a few local politicians was a critical tipping point for moving into a new SES trajectory. Similar linkages between microagency and macrostructures have been described for shifting to more integrated forms of water management in the Netherlands (van den Brink and Meijerink 2005): a shift that was also preceded by a change in people's mental models, from "fighting the water" to "living with the water." A key issue for future research on SES transformations is to go beyond attitudes and mental models and address the cultural dimensions of transformations, like changes in identity.

Transformations in SES require skills that go beyond the capabilities of individual actors. Therefore, networking strategies are needed for connecting nodes of expertise and developing networks of motivated actors. In the Kristianstad case, the development of a shadow network of individuals representing a diversity of skills and backgrounds was crucial for building moral, financial, and political support for the new approach. Both case studies show that, in order to move from an idea that existed in a small network of engaged actors to the institutionalization of the new approach, linking into the political arena was of crucial importance. This means that the entrepreneurial network and their new ideas had to be connected to a strong political leadership in order to create a regime shift. It often happens that the entrepreneurs who are good at developing new ideas and innovations lack the leadership capabilities required to change the social–ecological regime.

The ability of actors to form network connections and shape change depends on the opportunity context and the ability of change agents to take advantage of such context. Both case studies highlight the role of individual actors to scan for and use windows of opportunity to develop and utilize ties with various different actors on different scales and launch new initiatives and innovations. Transformational change is most likely to occur at times of crisis, when enough stakeholders agree that the current system is dysfunctional (Chapin et al. 2010). As a crisis deepens, stakeholders are more likely to negotiate a transformation. However, our case studies also show a capacity to respond to early warning (smaller scale crisis) and steer away from a pending large-scale social–ecological crisis. Using crises occurring at other times or places, change agents developed strategies that enable people to move beyond a state of denial and accept that the system cannot (or should not) continue on its current trajectory. Our social–ecological case studies put the finger on the importance of incorporating understanding and capacity to respond to ecosystem dynamics as an essential part in order to initiate transformations.

13.8 Conclusion

In this chapter, we have developed criteria for a framework to analyze and assess transformations and transformative capacity in SES, or more specifically the capacity to transform SES trajectories toward ecosystem stewardship. These include experimentation and innovation, agency and social networks, opportunity context, diversity, boundaries, and collaboration. We have only started to explore these issues and researchers need to continue to develop such frameworks. This would involve developing criteria for monitoring and evaluating transformations that could provide orientation of "where we are" and the status of transformations at any particular time.

Important questions for future research on SES transformations are *what* needs to be transformed and *how* transformations happen. The *what* question involves research on regime shifts and systemic changes, on trajectories and interconnected SES, and on how to alter and create new feedback loops in SES that sustain flows of essential ecosystem services to society. The *how* question involves understanding the multiphase and multilevel and cross-scale interaction aspects of SES transformations as well as links between microagency and macrostructures. More specifically, it involves research on how to reduce resilience in terms of persistence in undesirable regimes and build transformative capacity; on path dependence and lock-in traps; on unlocking mechanisms and transition strategies; on how to make new approaches stick; on innovations and opportunity contexts; on triggers for transformations and the role of crisis; on dynamic interactions between individuals (including entrepreneurs), organizations, and institutions at multiple levels, and on the aspects of social learning.

Transformations are needed to overcome the mismatch between ecosystems and governance systems where the institutional capacities to manage the earth's ecosystems are evolving more slowly than man's overuse of the same systems. The problem is that transformations of the magnitude that we discuss in this chapter, and that are needed to deal with the global problems that humanity is facing, might take a long time. We argue that if we can increase our understanding of SES transformations and provide strategies and guidelines for initiating and navigating SES' transformations, we could better prepare for and potentially speed up the responses to the rapid changes in the capacity of the earth's ecosystems to sustain our own development and civilization. The issue is pressing, considering the windows of opportunity for transformations towards sustainability that are currently wide open due rapid, pervasive global changes in many dimensions.

References

Aldrich H (1999) Organizations evolving. Sage, London

Allison HE, Hobbs RJ (2004) Resilience, adaptive capacity, and the "lock-in trap" of the Western Australian agricultural region. Ecol Soc 9(1):3, [online] URL: http://www.ecologyandsociety.org/vol9/iss1/art3/

Armitage D, Marschke M, Plummer R (2008) Adaptive co-management and the paradox of learning. Glob Environ Change 18(1):86–98

Babcock EA, Pikitch EK (2004) Can we reach agreement on a standardized approach to ecosystem-based fishery management? Bull Mar Sci 74:685–692

Baumgartner FR, Jones BD (1991) Agenda dynamics and policy subsystems. J Polit 53 (4):1044–1074

Berkes F, Folke C (eds) (1998) Linking social and ecological systems: management practices and social mechanisms for building resilience. Cambridge University Press, Cambridge

Berkes F, Colding J, Folke C (eds) (2003) Navigating social–ecological systems: building resilience for complexity and change. Cambridge University Press, Cambridge

Berkes F, Hughes TP, Steneck RS, Wilson JA, Bellwood DR, Crona B, Folke C, Gunderson LH, Leslie HM, Norberg J, Nyström M, Olsson P, Österblom H, Scheffer M, Worm B (2006) Globalization, roving bandits, and marine resources. Science 311:1557–1558

Burt R (1992) Structural holes: the social structure of competition. Harvard University Press, Cambridge

Carlsson L, Sandström A (2008) Network governance of the commons. Int J Commons 2:33–54

Carpenter SR, Folke C (2006) Ecology for transformation. Trends Ecol Evol 21:309–315

Carpenter SR, Gunderson LH (2001) Coping with collapse: ecological and social dynamics in ecosystem management. Bioscience 51(6):451–457

Cash DW, Adger W, Berkes F, Garden P, Lebel L, Olsson P, Pritchard L, Young O (2006) Scale and cross-scale dynamics: governance and information in a multilevel world. Ecol Soc 11(2):8, (online) URL: http://www.ecologyandsociety.org/vol11/iss2/art8/

Chapin FS III, Carpenter SR, Kofinas GP, Folke C, Abel N, Clark WC, Olsson P, Stafford Smith DM, Walker B, Young OR, Berkes F, Biggs R, Grove JM, Naylor RL, Pinkerton E, Steffen W, Swanson FJ (2010) Ecosystem Stewardship: Sustainability Strategies for a Rapidly Changing Planet. Trends Ecol Evol 25:241–249

Costanza R et al (1998) Principles for sustainable governance of the oceans. Science 281:198–199

Crowder LB et al (2006) Resolving mismatches in U.S. ocean governance. Science 313:617–618

Cumming GS, Cumming DHM, Redman CL (2006) 'Scale mismatches in social–ecological systems: causes, consequences, and solutions'. Ecol Soc 11(1):14, (online) URL: http://www.ecologyandsociety.org/vol11/iss1/art14/

Cumming GS, Olsson P, Chapin FS III, Holling CS (in preparation) Coping with climate change: the urgent need for a learning agenda

Danter KJ, Griest DL, Mullins GW, Norland E (2000) Organizational change as a component of ecosystem management. Soc Nat Resour 13:537–547

Enfors EI, Gordon LJ, Peterson GD, Bossio D (2008) Making investments in dryland development work: participatory scenario planning in the Makanya catchment, Tanzania. Ecol Soc 13(2):42, [online] URL: http://www.ecologyandsociety.org/vol13/iss2/art42/

Ernstson H, Sörlin S, Elmqvist T. Social movements and ecosystem services – the role of social network structure in protecting and managing urban green areas in Stockholm. Ecol Soc 13 (2):39, [online] URL: http://www.ecologyandsociety.org/vol13/iss2/art39/)

Fischer-Kowalski, Rotmans (2009) Conceptualizing, observing and influencing social ecological transitions. Ecol Soc 14(2):3, [online] URL: http://www.ecologyandsociety.org/vol14/iss2/art3/

Folke C, Colding J, Berkes F (2003) Synthesis: building resilience and adaptive capacity in social–ecological systems. In: Berkes F, Colding J, Folke C (eds) Navigating social–ecological systems: building resilience for complexity and change. Cambridge University Press, Cambridge, pp 352–387

Folke C, Hahn T, Olsson P, Norberg J (2005) Adaptive governance of social–ecological knowledge. Annu Rev Environ Resour 30:441–473

Folke C, Pritchard L, Berkes F, Colding J, Svedin U (2007) 'The problem of fit between ecosystems and institutions: ten years later'. Ecol Soc 12(1):30, (online) URL: http://www.ecologyandsociety.org/vol12/iss1/art30/

Galaz V, Olsson P, Hahn T, Folke C, Svedin U (2008) The problem of fit among biophysical systems, environmental and resource regimes, and broader governance systems: insights and emerging challenges. In: Young OR, King LA, Schröder H (eds) Institutions and environmental change – principal findings, applications, and research frontiers. The MIT, Cambridge, pp 147–182

Garner WB, Bird B, Starr J (1992) Act as if: differentiating entrepreneurial from organizational behavior. Entrepren Theor Pract 16(3):13–32

Geels FW (2005) The dynamics of transitions in socio-technical systems: a multi-level analysis of the transition pathway from horse-drawn carriages to automobiles (1860–1930). Tech Anal Strat Manag 17(4):445–476

Geels FW, Schot J (2007) Typology of socio-technical transition pathways. Res Policy 36 (3):399–417

Gelcich S, Olsson P, Castilla J, Hughes T, Folke C (in preparation) Governance transformation for the sustainable management of marine coastal social–ecological systems

Gordon LJ, Peterson GD, Bennett EM (2008) Agricultural modifications of hydrological flows create ecological surprises. Trends Ecol Evol 23(4):211–219

Granovetter M (1973) The strength of weak ties. Am J Soc 76:1360–1380

Gunderson LH (1999) Resilience, flexibility and adaptive management: antidotes for spurious certitude? Conserv Ecol 3(1):7, (online) URL: http://www.consecol.org/vol3/iss1/art7

Gunderson LH, Holling CS (eds) (2002) Panarchy: understanding transformations in social–ecological systems. Island, London

Gunderson LH, Holling CS, Light SS (eds) (1995) Barriers and bridges to renewal of ecosystems and institutions. Columbia University Press, New York

Gunderson L, Allen C, Holling CS (2009) Fundamentals of ecological resilience. Island, Washington

Hahn T, Olsson P, Folke C, Johansson K (2006) Trust-building, knowledge generation and organizational innovations: the role of a bridging organization for adaptive comanagement of a wetland landscape around Kristianstad, Sweden. Human Ecol 34:573–592

Hall PA, Taylor RCR (2006) Political science and the three new institutionalisms. Polit Stud 44:936–957

Hegmon M, Peeples MA, Kinzig A, Kulow S, Meegan CM, Nelson MC (2008) Social transformation and its human costs in the Prehispanic U.S. Southwest. Am Anthropol 110:313–324

Holling CS, Meffe GK (1996) Command and control and the pathology of natural resource management. Conserv Biol 10(2):328–337

Holtz G, Brugnach M, Pahl-Wostl C (2008) Specifying "regime" – a framework for defining and describing regimes in transition research. Technol Forecasting Soc Change 75:623–643

Huitric M (2005) Lobster and conch fisheries of Belize: a history of sequential exploitation. Ecol Soc 10(1):21, http://www.ecologyandsociety.org/vol10/iss1/art21/

Imperial MT (1999) Institutional analysis and ecosystem-based management: the institutional analysis and development framework. Environ Manag 24:449–465

Kay A (2003) Path dependency and the CAP. J Eur Public Pol 10:405–420

Loorbach DA (2007) Transition management: new mode of governance for sustainable development. International Books, Utrecht

National Research Council (1999a) Sustaining marine fisheries. National Academy, Washington

National Research Council (1999b) Our common journey. National Academy, Washington

Norberg J, Cumming G (eds) (2008) Complexity theory for a sustainable future. Columbia University Press, New York

Olsson P, Folke C, Berkes F (2004a) Adaptive co-management for building social–ecological resilience. Environ Manag 34(1):75–90

Olsson P, Folke C, Hahn T (2004b) 'Social–ecological transformation for ecosystem management: the development of adaptive co-management of a wetland landscape in southern Sweden'. Ecol Soc 9(4):2, (online) URL: http://www.ecologyandsociety.org/vol9/iss4/art2

Olsson P, Gunderson LH, Carpenter SR, Ryan P, Lebel L, Folke C, Holling CS (2006) 'Shooting the rapids: navigating transitions to adaptive governance of social–ecological systems'. Ecol Soc 11(1):18, (online) URL: http://www.ecologyandsociety.org/vol11/iss1/art18/

Olsson P, Folke C, Galaz V, Hahn T, Schultz L (2007) Enhancing the fit through adaptive comanagement: creating and maintaining bridging functions for matching scales in the Kristianstads Vattenrike Biosphere Reserve Sweden. Ecol Soc 12(1):28, [online] URL: http://www.ecologyandsociety.org/vol12/iss1/art28/

Olsson P, Folke C, Hughes TP (2008) Navigating the transition to ecosystem-based management of the Great Barrier Reef, Australia. Proc Nat Acad Sci USA 105:9489–9494

Ostrom E (1990) Governing the commons: the evolution of institutions for collective action. Cambridge University Press, Cambridge

Pahl-Wostl C (2009) A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. Glob Environ Change 19:354–365

Pahl-Wostl C, Mostert E, Tàbara D (2008) 'The growing importance of social learning in water resources management and sustainability science'. Ecol Soc 13(1):24, online) URL: http://www.ecologyandsociety.org/vol13/iss1/art24/(last visit November 2008

Peterson GD (2007) Using scenario planning to enable an adaptive co-management process in the northern highlands lake district of Wisconsin. In: Berkes F, Armitage D, Doubleday N (eds) Adaptive co-management: collaboration, learning, and multi-level governance. UBC, Vancouver, pp 289–307

Raskin P, Banuri T, Gallopín G, Gutman P, Hammond A, Kates R, Swart R (2002) Great transition – the promise and lure of the times ahead. Stockholm Environment Institute, Boston

Repetto R (ed) (2006) Punctuated equilibrium and the dynamics of U.S. environmental policy. Yale University Press, New Haven

Resilience Alliance and Santa Fe Institute (2004) Thresholds and alternate states in ecological and social–ecological systems, Resilience Alliance (online) URL: http://www.resalliance.org/index.php?id=183

Rockström J, Steffen W, Noone K, Persson A, Chapin FS 3rd, Lambin EF, Lenton TM, Scheffer M, Folke C, Schellnhuber HJ, Nykvist B, de Wit CA, Hughes T, van der Leeuw S, Rodhe H, Sörlin S, Snyder PK, Costanza R, Svedin U, Falkenmark M, Karlberg L, Corell RW, Fabry VJ, Hansen J, Walker B, Liverman D, Richardson K, Crutzen P, Foley JA (2009) A safe operating space for humanity. Nature 461, 472–475

Scheffer M, Carpenter SR, Foley JA, Folke C, Walker B (2001) Catastrophic shifts in ecosystems. Nature 413(6856):591–696

Schultz L, Folke C, Olsson P (2007) Enhancing ecosystem management through social–ecological inventories: lessons from Kristianstads Vattenrike, Sweden. Environ Conserv 34(2):140–152

True JL, Baumgartner FR, Bryan DJ (1999) Explaining stability and change in American policymaking: the punctuated equilibrium model. In: Sabatier P (ed) Theories of the policy process. Westview, Boulder, pp 97–115

United Nations Environment Programme (2007) Global environment outlook: environment for development, vol 4. Progress Press Ltd, Valletta

van den Brink M, Meijerink S (2005) Implementing policy innovations: resource dependence, struggle for discursive hegemony and institutional inertia in the Dutch river policy domain. Paper prepared for the ERSA Congress, Amsterdam 23–27, August 2005

Walker B, Barrett S, Polasky S, Galaz V, Folke C, Engström G, Ackerman F, Arrow K, Carpenter SR, Chopra K, Daily G, Ehrlich P, Hughes T, Kautsky N, Levin S, Mäler K-G, Shogren J, Vincent J, Xepapadeas T, de Zeeuw A (2009) Looming global-scale failures and missing institutions. Science 325:1345–1346

Walker BH, Holling CS, Carpenter SR, Kinzig A (2004) Resilience, adaptability and transformability in social–ecological systems. Ecol Soc 9(2):5, [online] URL: http://www.ecologyandsociety.org/vol9/iss2/art5/

Walker BH, Abel N, Anderies JM, Ryan P (2009b) Resilience, adaptability, and transformability in the Goulburn-broken catchment, Australia. Ecol Soc 14(1):12, [online] URL: http://www.ecologyandsociety.org/vol14/iss1/art12/

Westley F (1995) Governing design: the management of social systems and ecosystems management. In: Gunderson LH, Holling CS, Light S (eds) Barriers and bridges to the renewal of ecosystems and institutions. Columbia University Press, New York, pp 391–427

Westley F (2002) The devil in the dynamics: adaptive management on the front lines. In: Gunderson LH, Holling CS (eds) Panarchy: understanding transformations in human and natural systems. Island, Washington, pp 333–360

White L (2000) Changing the "whole system" in the public sector. J Org Change Manag 13:162–177

Young OR (2002) Institutional interplay: the environmental consequences of cross-scale interactions. In: Ostrom E, Dietz T, Dolsak N, Stern P, Stonich S, Weber EU (eds) The drama of the commons. National Academy, Washington, pp 265–291