5
Transformations in Ecosystem Stewardship

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Introduction

Changes in governance are needed to deal with rapid directional change, adapt to it, shape it, and create opportunities for positive transformations of social–ecological systems. Throughout this book we stress that human societies and globally interconnected economies are parts of the dynamics of the biosphere, embedded in its processes, and ultimately dependent on the capacity of the environment to sustain societal development with essential ecosystem services (Odum 1989, MEA 2005d). This implies that resource management is not just about harvesting resources or conserving species but concerns stewardship of the very foundation of a prosperous social and economic development, particularly under conditions of rapid and directional social–ecological change (Table 5.1). We first discussed the integration of the ecological (see Chapter 2) and social (see Chapters 3 and 4) aspects of ecosystem stewardship in relation to directional change and resilience in a globally interconnected world (see Chapter 1), emphasizing processes that reduce the likelihood of passive degradation that might lead to socially undesirable regime shifts. In this chapter we identify ways to enhance the likelihood of constructive transformative change toward stewardship of dynamic landscapes and seascapes and the ecosystem services that they generate. Rapid and directional changes provide major challenges but also opportunities for innovation and prosperous development. Such development requires systems of governance of social–ecological dynamics that maintain and enhance adaptive capacity for societal progress, while sustaining ecological life-support systems.

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An Integrated Social–Ecological Perspective

Over decades, segregated approaches have dominated policy and the structure of governmental departments, agencies, and decision-making bodies, with little communication between sectors. This was true in science

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TABLE 5.1. Features of shift in perspective from command-and-control to complex systems. Adapted from Folke (2003).

From command-and-control	To complex systems
Assume stability, control change	Accept change, manage for resilience
Predictability, optimal control	Uncertainty, risk spreading, insurance
Managing resources for sustained yield	Managing diversity for coping with change
Technological change solves resource issues	Adaptive co-management builds resilience
Society and nature separated	Social–ecological coevolution

as well, with reward systems stimulating within-discipline knowledge generation and limited collaboration across disciplines (Wilson 1998). Resource and environmental management have been subject to similar divisions. Only recently have managers appreciated the significance of a broader systems perspective to deal with rapid and directional change. The integration of the human and the environmental dimensions for ecosystem stewardship is still in its infancy, so analyses of social–ecological systems are not as well developed as those of social or ecological systems alone (Costanza 1991, Ludwig et al. 2001, Westley et al. 2002). A focus that is restricted to the social dimension of ecosystem stewardship without understanding how it is coupled to ecosystem dynamics will not be sufficient for sustainable outcomes. For example, the development of fishing cooperatives in Belize was considered a social success by managers. However, the local mobilization of coastal fishers into socially desirable and economically effective fishing cooperatives became a magnet of fishing efforts to capture **economic rent** (the income gained relative to the minimum income necessary to make fishing economically viable) and resulted in a short-term resource-exploitation boom of lobster and conch, causing large-scale resource-use problems and increased vulnerability (Huitric 2005).

Similarly, focusing only on the ecological aspects as a basis for decision making for sustainability leads to conclusions that are too narrow. Ecosystems can pass a threshold and shift from one state to another, often triggered by human actions (Folke et al. 2004). When a lake shifts from a clearwater state attractive for fishing and recreation to a state of undesired algal blooms and muddy waters, it may look like an ecologically irreversible transition. However, if there is sufficient adaptive capacity in the social system to respond to the shift and foster social actions that return the lake to a clearwater state, the social–ecological system is still resilient to such change (Carpenter and Brock 2004, Bodin and Norberg 2005; see Chapter 9).

Hence, in a social–ecological system with high adaptive capacity, the actors have the ability to renew and reorganize the system within desired states in response to changing conditions and disturbance events. However, there are also situations where it would be desirable to move away from the current conditions and transform the social–ecological system into a new configuration. **Transformation** is the fundamental alteration of the nature of a system once the current ecological, social, or economic conditions become untenable or are undesirable (Walker et al. 2004, Nelson et al. 2007; see Chapter 1). The capacity to learn, adapt to and shape change, and even transform are central aspects of social–ecological resilience and require that learning about resource and ecosystem dynamics be built into management practices (Berkes and Folke 1998b) and supported by flexible governance systems (Folke et al. 2005). **Transformative learning** is learning that reconceptualizes the system through processes of reflection and engagement. It relates to **triple-loop learning** (Fig. 5.1), which directs attention to redefining the norms and protocols upon which single-loop and double-loop learning (see Chapter 4) are framed and governed. This draws together human agency and individual and collective learning with processes of change, uncertainty, and surprise (Keen et al. 2005, Armitage et al. 2007).

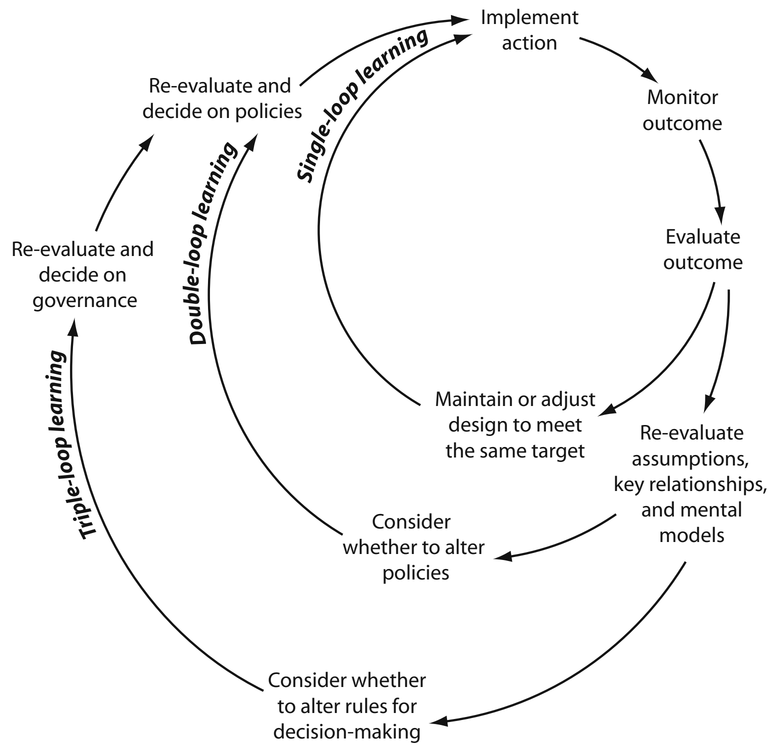


FIGURE 5.1. Triple-loop learning involves the same reevaluation of assumptions and models as double-loop learning (see Fig. 4.2) but considers whether to alter norms, institutions, and paradigms in ways that would require a fundamental change in governance (e.g., a shift from an agricultural systems focused on supporting farmers to a tourist-based economy requiring a broader, more inclusive form of governance).

Dealing with Uncertainty and Surprise

Recognizing and accepting the uncertainty of future conditions is the primary motivation for incorporating resilience thinking into ecosystem stewardship. We are nowhere close to a predictive understanding of the complex interactions and feedbacks that govern trajectories of change in social–ecological systems nor able to anticipate the future human actions that will modify these trajectories. Uncertainty is therefore a central unavoidable condition for ecosystem stewardship. There are several sources of uncertainty, only some of which can be readily reduced (Carpenter et al. 2006a). Both scientific research and the observations and experience of managers and other people provide data that inform our understanding. However, there are many uncertainties regarding the validity of any dataset and its representativeness of the real world (Kinzig et al. 2003). Models, both quantitative computer models and conceptual models of how the world works, also have many uncertainties in assumptions and structure. Models are most useful when based on observations and other data, but there are always important processes for which data are unavailable and data that do not fit our current understanding. Surrounding these uncertainties in data and models are uncertainties in other factors that we know to be important but for which we have neither data nor models—the "known unknowns" (Fig. 5.2). There are also "unknown unknowns" that we cannot anticipate—the surprises that inevitably occur (Carpenter et al. 2006a).

There are several types of surprises (Gunderson 2003). **Local surprises** occur locally. They may be created by a narrow breadth of experience with a particular system, either temporally or spatially. Local surprises have a statistical distribution, and people respond to these surprises by forming subjective probabilities that are updated when new

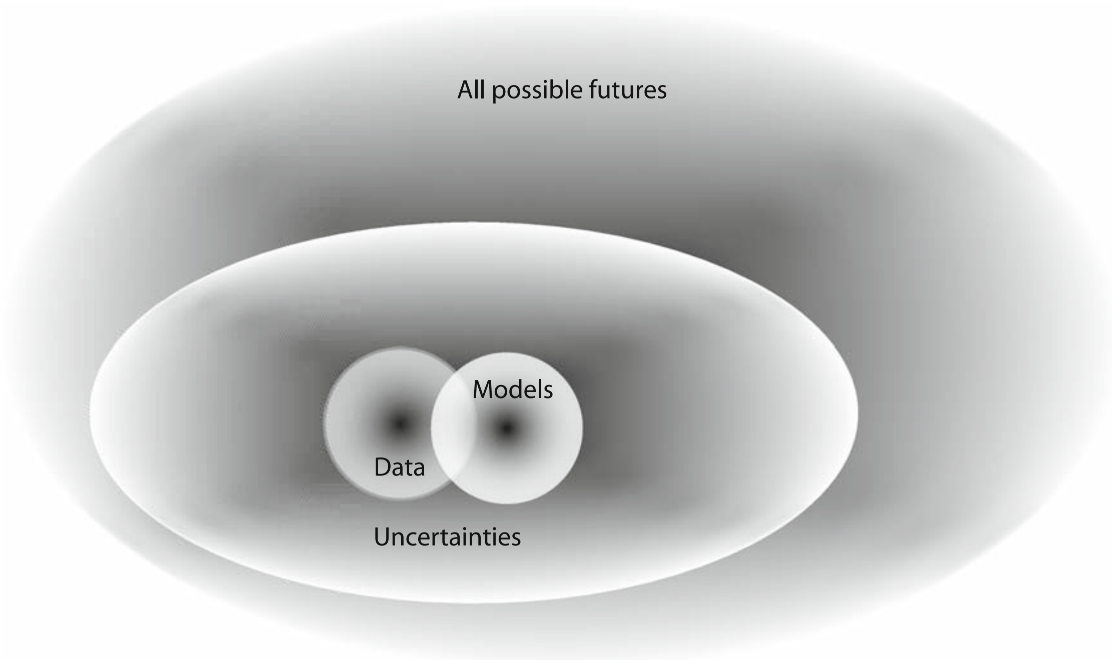


FIGURE 5.2. The full set of possible futures of social–ecological systems is only partially represented in available data and models. Together, the data and models allow us to project some uncertainties (knowable unknowns). The probability that any model projection of future conditions will actually occur depends on the full set of all possible futures, most of which are unknown. Redrawn from Carpenter et al. (2006a).

information becomes available. Based on these estimates, there is a wide range of adaptations to risk that are economically rational to individuals, including risk-reducing strategies and risk-spreading or risk-pooling among independent individuals. Local surprises are manageable by individuals and groups of individuals. Their detection requires a comprehensive systems perspective (e.g., an ecosystem rather than a single-species approach). Adaptation-to-risk strategies fail when surprises are not local.

Cross-scale surprises occur when there are cross-scale interactions, such as when local variables coalesce to generate an unanticipated regional or global pattern, or when a process exhibits contagion (as with fire, insect outbreak, and disease). Cross-scale surprises often occur as the unintended consequences of the independent actions of many individual agents who are managing at different scales. Although individual responses are generally ineffective, individuals acting in concert can address these surprises, if appropriate cross-scale institutions are available or are readily formed (see Chapter 4).

True-novelty surprises constitute never-before-experienced phenomena for which strict preadaptation is impossible. However, systems that have developed mechanisms for reorganization, learning, and renewal following sudden change may be able to cope effectively with true-novelty surprises. These are the social–ecological features that nurture resilience to deal with unexpected change.

Directional change in the context of global and climatic change creates a situation of increased likelihood of unknowable surprises. It is within these sources of uncertainty and surprise that ecosystem stewardship must function and where a resilience approach becomes essential.

Preventing Social–Ecological Collapse of Degrading Systems

The Interplay Between Gradual and Abrupt Change

Theories, models, and policies used in resource management have historically been developed for situations of gradual or incremental change with implicit assumptions of linear dynamics. These approaches generally disregard interactions that extend beyond the temporal and spatial scales of management focus. The resilience approach to ecosystem stewardship and the adaptive-cycle framework outlined in Chapters 1 and 4 indicate that there are times when change is incremental and largely predictable and other times when change is abrupt, disorganizing, or turbulent with many surprises. It also draws attention to ways in which such social–ecological dynamics interact across temporal and spatial scales (the concept of **panarchies**, see Chapter 1; Gunderson and Holling 2002). This dynamic interaction challenges management to learn to live with uncertainty, be adaptive, prepare for change, and build it into ecosystem stewardship strategies. Periods of large abrupt changes in social and ecological drivers, including climatic change and economic globalization, are occurring more frequently (Steffen et al. 2004; see Chapter 14), increasing the likelihood of abrupt social–ecological change. In the absence of resilience-based stewardship, these changes are quite likely to trigger shifts from one state to another that may be socially and ecologically less desirable. A focus on resilience in social–ecological systems is needed to deal with the challenging new global situation of rapid and directional social–ecological change.

Behaviors that reduce the adaptive capacity to deal with interactions between gradual and abrupt change may push systems toward a threshold that precipitates regime shifts or critical transitions. The existence of thresholds between different regimes or domains of attraction has been described for several ecological systems (Scheffer et al. 2001; Fig. 5.3).

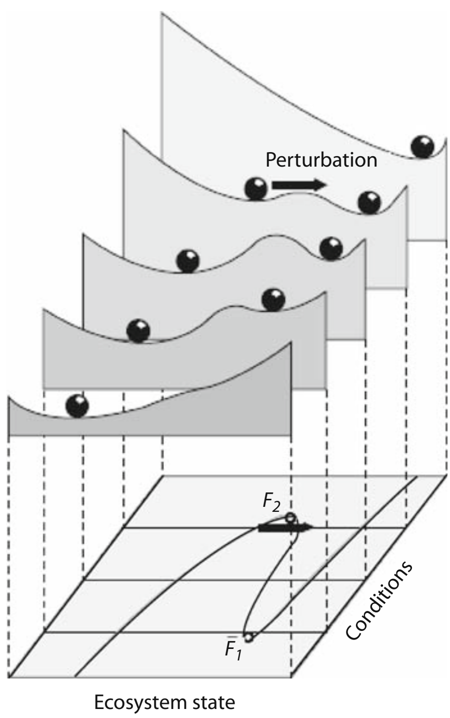
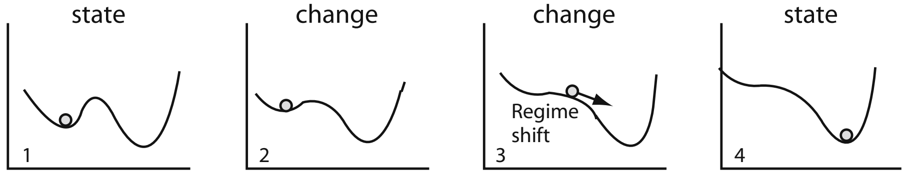


FIGURE 5.3.



Initial state	Causes of change	Triggers of change	Alternate state
Clear-water lakes	Phoshorus accumulation in agricultural soil and lake mud	Flooding, warming, overfishing, species invasions	Turbid-water lakes
Coral-dominated reefs	Overfishing, coastal eutrophication	Disease, bleaching, hurricane	Algae-dominated reefs
Grassland	Fire prevention	Good rains, continuous heavy grazing	Shrub-bushland
Grassland	Hunting of herbivores	Disease	Woodland
Kelp forests	Elimination of top predators	Thermal event, storm, disease	Sea urchin dominance
Pine forest	Microclimate and soil changes, loss of pine regeneration	Decreased fire frequency, increased fire intensity	Oak forest
Seagrass beds	Removal of grazers, lack of hurricanes, salinity moderation, spatial homogenization	Thermal event	Phytoplankton blooms
Tropical lake with submerged vegetation	Nutrient accumulation during dry spells	Nutrient release with water table rise	Floating-plant dominance

FIGURE 5.3. Regime shifts in ecosystems: **Previous page**: Cup-and-ball model illustrating the shift from one ecosystem regime to another. The bottom plane shows the hysteresis-curve, which highlights the nonlinear relation of moving from one regime to another. Modified from Scheffer et al. (2001). **Above**: Alternate states in different ecosystems (1, 4) and some causes (2) and triggers (3) behind loss of resilience and regime shifts. For more examples, see Thresholds Database on the Web site www.resalliance.org. Modified from Folke et al. (2004).

Thresholds may also occur in resilient ecological systems, but fostering resilience reduces the likelihood of this occurring. Experience suggests that critical ecosystem transitions are occurring increasingly often as a consequence of human actions and seem to be more common in human-dominated landscapes and seascapes (Folke et al. 2004). Human actions that are most likely to cause loss of resilience of ecosystems include

- introduction or removal of functional groups of species that reduce effect and response diversity, including loss of entire trophic levels (top-down effects),
- impact on ecosystem resources and toxins via emissions of waste and pollutants (bottom-up effects), and
- alteration of the magnitude, frequency, and duration of disturbances to which the biota is adapted.

Similarly there are features of social systems that impact social–ecological resilience like

- degradation of the components of human well-being, including public education and income levels,

- erosion of social capital and adaptive capacity, for example, through corruption, rent seeking, and loss of new opportunities for the future, and
- dysfunctional institutions, causing, for example, weak or insecure property rights and high inequality in power and wealth.

The loss of resilience through the combined and synergistic effects of such factors makes social–ecological systems increasingly vulnerable to changes that previously could be absorbed. As a consequence they are more likely to shift from desired to less desired states. In some cases, these regime shifts or critical transitions may be irreversible or too costly to reverse. Irreversibility is a reflection of changes in critical slow variables (e.g., biogeochemical, hydrological, climatic, constitutional, cultural) and loss of diversity and of social–ecological interactions that support renewal and reorganization into desired states. A challenge for resilience-based stewardship is to address such changes in a more integrated fashion than is usually done today.

In light of the risk for irreversible shifts and their implication for well-being, the self-repairing capacity of social–ecological systems in the face of directional change should not be taken for granted. It must be nurtured. Critical features have been identified (Folke et al. 2003; see Chapter 1) for fostering adaptive capacity and resilience in social–ecological systems:

- learning to live with change and uncertainty,
- cultivating diversity for reorganization and renewal,
- combining different types of knowledge systems for learning,
- creating opportunity for self-organization toward social–ecological sustainability, and
- experimenting and innovating to test understanding and implement solutions.

Adaptive management (see Chapter 4) and adaptive governance of resilience (discussed later in this chapter) will be required, for example, in the context of scenarios of plausible futures to prevent social–ecological degradation or to transform systems into more desired states.

Multiple Regimes

Shifts between social–ecological states can occur because of external perturbations, like a climatic event or a political crisis. They can also occur because of complex cross-scale dynamics within the social–ecological system, with myriad localized interactions among smaller entities serving as a source of adaptation and novelty, and larger-scale emergent constructs such as political systems or climatic conditions serving to frame the behavior and dynamics at smaller scales.

Critical transitions or regime shifts have been described primarily for either ecological systems (e.g., Folke et al. 2004) or social and economic ones (e.g., Repetto 2006). However, shifts also occur due to interactions and feedbacks between social and ecological processes that are triggered by external events or internal dynamics that cause a loss of resilience (Gunderson and Holling 2002, Kinzig et al. 2006). For example, 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 transition to a degraded ecosystem state that in turn feeds back into the social and economic systems, causing unpleasant surprises and social–ecological regime shifts. As a consequence, the social–ecological system may fall into a rigidity or poverty trap (Gunderson and Holling 2002). In **rigidity traps** 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 adjust to new situations. This behavior constrains the ability of people to respond to new problems and opportunities. A **poverty trap**, a social–ecological system with persistent poverty, also reflects a loss of options to develop or deal with change (Bowles et al. 2006). It is locked into persistent degraded conditions and would need external support to get out of it. However, simply providing money, technical expertise, infrastructure, and public education is seldom sufficient to move out of a poverty trap. Escape from rigidity and poverty traps depends on the capacity of people within the social–ecological system to create continuously new opportunities. New opportunities, in turn, are strongly linked to the existence of sources of resilience and adaptive capacity (see Chapter 3) to help people find ways to move out of traps. Hence, the risks or possibilities of sudden shifts between social–ecological states have profound implications for stewardship of essential ecosystem services in a world of rapid and directional change.

Thresholds and Cascading Changes

The movement of a social–ecological system across a threshold to a new regime alters social–ecological interactions, triggering new sets of feedbacks with cascading social and ecological consequences. Once a system has exceeded a threshold, many changes occur that can only be understood or predicted in the local context. However, certain repeatable patterns emerge that provide a basis for designing appropriate management strategies (see Chapters 3 and 4). New interactions frequently become important, and social–ecological processes become sensitive to different slow variables. These changes require a reassessment of management goals and priorities and flexibility to seek new solutions through innovation in institutions and approaches (double-loop learning; see Fig. 4.3). In the absence of these resilience-based strategies, the system may continue to degrade. In Western Australia, for example, extensive areas of native heath vegetation were converted to wheatlands (Kinzig et al. 2006; see Chapter 8), leading to a radically different system, both socially and ecologically, than the shrub savanna occupied by Aborigines. Replacement of deep-rooted heath by shallow-rooted cereals altered the hydrologic cycle by reducing transpiration rate, causing the saline water table to rise close to the surface, creating saline soils that reduced productivity. Declines in production, in turn, caused people to leave the region. The combination of declining population and productivity (33% of the land too saline to farm), coupled with changes in national farm policy, led to amalgamation of farms into larger units that could remain profitable due to economies of scale (a social transformation). As population declined, many towns could no longer support a service sector, causing still more people to leave and towns to be abandoned. This made it difficult for people who stopped farming to find other jobs, compounding the levels of social stress. This example of cascading consequences of exceeding a social–ecological threshold illustrates several points (Kinzig et al. 2006).

- New sets of interactions come into play when a social–ecological system crosses a threshold, leading to a cascading set of social and ecological consequences.
- The reorganization of the system after crossing the threshold increases the vulnerability to further degradation and threshold changes.
- Each successive transformation is more resilient, in the sense that it would be more difficult to return it to its original state or to some other more desirable state.

The cascading changes that occur when a threshold is exceeded are typical of the behavior of complex adaptive systems (Levin 1999; see Chapter 1), in which any change in the system triggers additional changes in its fundamental properties and feedback structure. New feedbacks then develop that stabilize the system in a new state, making it progressively more difficult to return to the original state.

Directional changes in external drivers such as climate can trigger similar regime shifts and passive degradation. Changing sea surface temperatures in the Atlantic Ocean, for example, reduced rainfall in the Sahel region of sub-Saharan Africa. This reduced precipitation, causing declines in vegetation, which increased regional albedo, weakening the monsoon and stabilizing the drought conditions (Foley et al. 2003a; see Chapter 2). The declines in vegetation caused people to concentrate their herds on the remaining vegetation, causing further increases in albedo and strengthening the drought. These drought-induced feedbacks probably contributed to the long (30-year) duration of drought. Fortunately, large-scale circulation changes eventually ended the drought. Other potential interventions might have included strategies to reduce albedo by increasing vegetation cover (e.g., through planting of forests that tap deep groundwater or introduction of drought-resistant crops that might provide enough food that grazing pressure by cattle could be reduced). It is quite likely that current rates of climate change, if they continue, will trigger regime shifts and cascading social–ecological changes in many parts of the planet. If these are extensive, they could exceed a global **tipping point**—i.e., in this context a threshold for transformational change to a new system, leading to novel global changes in climate, economy, and politics (Plate 3).

Endogenous changes in social–ecological systems can also trigger regime shifts with cascading effects. Several ancient societies such as the Roman Empire and Mayan Civilization appear to have collapsed at least in part because of unsustainable practices that caused environmental degradation and loss of the productive potential of the ecosystems on which they depended (Janssen et al. 2003, Diamond 2005). Similarly, collapse of the Soviet Union in 1990 was a regime shift with many social, economic, and political consequences.

Institutional Misfits with Ecosystems: A Frequent Cause of Regime Shifts

It is no longer rational to manage systems so they will remain the same as in the recent past, which has traditionally been the reference point for managers and conservationists (see Chapter 1). We must instead adopt a more flexible approach to managing resources—management to sustain and enhance the *functional* properties of integrated social–ecological systems that are important to society under conditions where the system itself is constantly changing. Sustaining and enhancing such properties and recombining them in new ways are the essence of sustaining social–ecological development and the very core of the resilience approach to ecosystem stewardship (Folke 2006).

The problem of fit between institutions and ecosystem dynamics in social–ecological systems (see Chapter 4) is one of the most frequent causes of undesirable regime shifts. This interplay takes place across temporal and spatial scales and institutional and organizational levels in a dynamic manner (see Table 4.4).

Temporal Misfits in Social–Ecological Systems

The implementation of conventional resource management tends to lead to governance systems that invest in controlling a few selected ecosystem processes, often successfully in the short term, in order to fulfill immediate economic or social goals, such as the production of wood by forests. But this success tends to turn into a longer term failure through the erosion of social–ecological resilience and key functions (Holling and Meffe 1996; see Chapter 2). "Science-of-the-parts" perspectives (see Chapter 4) have contributed to resource-management systems that focus on producing a narrow set of resources, often in vast monocultures like tree plantations or resource-intensive systems like chicken farms, or salmon aquaculture operations. The widespread approach of "optimal production of single resources" underlying these production systems (Table 5.1) may be successful during periods of stable environmental and economic conditions (Holling et al. 1998). In situations of uncertainty and surprise, however, they become vulnerable because they lack backup systems and sources of reorganization and renewal. These systems are therefore seriously challenged by rapid directional change.

This challenge may also hold true for more diverse management systems with seemingly flexible institutional and organizational arrangements. The Maine lobster fishery, for example, is a sophisticated collective action and multilevel governance system that has sustained and regulated the economically valuable lobster fisheries. It has been considered one of the classic cases of successful people-oriented local management of common-pool resources. However, when the linkage of the social domain to the production of lobsters is taken into account, the Maine fishery seems to have followed the historical pattern of fishing-down food webs (Jackson et al. 2001). Depletion of the cod fishery opened up space for the expansion of species lower down in food webs, like lobsters. Currently the coastline is massively dominated by lobsters, like a coastal monoculture, with the bulk of the lobster population artificially fed with herring supplied as bait in lobster pots. The lobster has a high market price and sustains the social organization and the fishery. However, such simplification of marine systems through removal of functional diversity (see Chapter 2) has created a highly vulnerable social–ecological system waiting for an accident, like a lobster disease, to happen. If such a "surprise" occurs, the lobster population might be decimated over huge areas, perhaps triggering a shift into a very different social–ecological system in which coastal waters no longer provide a viable livelihood for local fishers (R. Steneck and T. Hughes, pers. comm.). Because lobster fishing is central to regional identity, the potential loss of lobster fishing could have severe social as well as economic impacts.

Similar mismatches between short-term success (a governance system that delivers short-term economic and social benefits) and long-term failure of resource management (lack of an ecosystem approach and ecosystem stewardship leading to erosion of resilience) have occurred in forests and lake fisheries (Regier and Baskerville 1986), other coastal and regional fisheries (Finlayson and McCay 1998), crop production (Allison and Hobbs 2004), and a range of other situations (Gunderson et al. 1995; see Chapters 6–14). The question remains to what extent such patterns of resource and ecosystem exploitation can foster adaptive capacity to either prevent passive degradation or actively transform landscapes and seascapes to more beneficial states through sustainable ecosystem stewardship.

Spatial Interdependence of Social–Ecological Systems

Human societies are now globally interconnected, through technology, financial markets, and systems of governance with decisions in one place influencing people elsewhere. However, the interplay between globally interconnected societies and the planet's ecological life-support systems is not yet fully appreciated. The seriousness and challenges of the climate issue have begun to mentally reconnect people to their dependence on the functioning of the biosphere. The common policy response to climate change has been to focus on mitigation of greenhouse gases through technical means or on social and economic adaptation to climatic change. The urgent policy response that is beginning to emerge as a critical complement is the stewardship of the social–ecological capacity to sustain society with ecosystem services and its links to adaptation, resilience, and vulnerability in the face of unprecedented directional changes (see Chapters 2, 3, and 14). It requires systems of governance that are adaptive and that allow for ecosystem-based management of landscapes and seascapes (see Chapter 4).

Governance to address global issues must be aware of, account for, and relate to the dynamic interactions of people and ecosystems across local-to-global scales. For example, the efforts by large chains of food stores in developed regions and urban centers to reduce temporal fluctuations in the supply of fish, fruits, and other commodities has increased both the extraction and the exploitation of resources in remote areas, creating spatial dependence on other nations' ecosystems (Folke et al. 1997, Deutsch et al. 2007). People in the cities of Sweden, for example, depend on ecosystem services over an estimated area about 1000 times larger than the actual area of the cities, corresponding to about 2–2.5 ha of ecosystem per person (Jansson et al. 1999; see Chapter 13). In this broader context it becomes clear that patterns of production, consumption, and well-being depend not only on locally sustainable practices but also on managing and enhancing the capacity of ecosystems *throughout the world* to support societal development. For example, salmon and shrimp produced in aquaculture operations in temperate and tropical regions, respectively, are traded on global markets and consumed in developed regions and urban centers (Lebel et al. 2002). The feed input to produce these aquaculture commodities comes from coastal ecosystems all across the planet. Shrimp produced in ponds in Thailand, for example, use meal from fish caught in the North Sea. Similar globally interconnected patterns, made possible by fossil-fuel-based technology and supported by information technology, exist in agricultural food and energy production. Demand in one corner of the world shapes landscapes and seascapes in other parts of the planet (see Chapters 12 and 14).

Stewardship of ecosystems is continuously subject to global drivers (Lambin et al. 2001). In this context it becomes important to address the underlying social causes challenging ecosystem capacity to generate services. They include the structure of property rights; macro-economic, trade, and other governmental policies; economic and legal incentives; the behavior of financial markets; causes behind population pressure; transfer of knowledge and technology; misguided development aid; patterns of production and consumption; power relations in society; level of democracy; and worldview, lifestyle, religion, ethics, and values.

In the UK in the 1980s, for example, tax concessions on afforestation were increased but not for the purchase of land. Investors therefore minimized land purchases and located forest plantations on economically low-valued land, such as wetlands, heath, and moorland, thereby depleting ”unpriced” wildlife values (Wibe and Jones 1992). In the Brazilian Amazon, one could only acquire a title to land by living on and ”using” the land, with logging as a proof of the land being occupied and used. A farm containing “unused” forests was taxed at higher rates than one containing pastures or cropland. The real interest rate on loans for agriculture was lower than for other land uses, and agricultural income was almost exempt from taxation (Binswanger 1990). Hence, policies and activities that, at first glance, seem to be unrelated to the capacity of ecosystems to generate services may indirectly counteract ecosystem stewardships. Such policies serve as subsidies from society to use living resources and ecosystem capacity in unsustainable manners. They need to be redirected into incentives for more sustainable resource use.

Global market drivers sometimes operate so quickly that local governance responses do not have time to respond or adapt, as illustrated by the “roving bandits” phenomena in coastal fisheries (Berkes et al. 2006), where exploiters linked to global markets rapidly move from one fish stock to another over wider and wider spatial scales. This implies that sustainable adaptive governance systems for ecosystem stewardship need to be prepared to deal in a constructive manner with sudden external shocks like the rapid development of a new market demand or sudden shifts in governmental policies.

Fostering Desirable Social–Ecological Transformations

Identifying Dysfunctional States

Dysfunctional states occur when society cannot meet the basic needs of human well-being or when environmental, ecological, social, or political determinants of well-being are degraded to the point that loss of well-being is highly likely to occur. Some social–ecological systems persist in dysfunctional states, such as dictatorships, persistent civil strife, and extreme poverty, for extended periods of time. Other dysfunctional states result from natural disasters such as floods, hurricanes, and tsunamis or from social disasters such as wars. When such systems experience shocks and surprises they may lack the adaptive capacity to reorganize, or they may reorganize in ways that increase the likelihood of future shocks. Getting out of dysfunctional states often requires external institutional, financial, and/or political support, and many bodies from local nongovernmental organizations (NGOs) to international aid organizations like the Red Cross or economic ones like the World Bank work actively to support such transformations. However, external aid is insufficient. Escape from dysfunctional states also requires local development of adaptive capacity for innovation.

Systems can also degrade due to gradual loss of ecosystem services and resilience; increased demand for ecosystem services because of population growth or excessive consumption of services; and various social or political trends. As this degradation proceeds, there is often a spectrum of opinion among stakeholders about whether to fix the current system by incrementally addressing specific problems or enhancing resilience to deliberately explore transformation to a new social–ecological state. In the Goulburn-Broken Catchment in Australia, the agricultural development trajectory was strongly embedded socially and culturally and economically supported, making it difficult to explore new ways to manage the land. Local resources and institutions were initially focused on maintaining a system that fostered a continual downward spiral into a dysfunctional and nonresilient state. More recently, crisis awareness at the system level triggered shifts in perception and action and transformed whole management and governance systems toward ecosystem stewardship of the social–ecological system (Walker and Salt 2006). Similar shifts toward ecosystem stewardship at regional scales are evident in landscapes of southern Sweden and the vast Great Barrier Reef seascape of Australia (Olsson et al. 2006, 2008).

Recognizing Impending Thresholds for Degradation

Scenarios of plausible future changes provide a starting point for exploring policy options that reduce the likelihood of undesirable regime shifts. Global, national, and local assessments often provide clear evidence of trends in environmental, ecological, and social conditions that are leading in unsustainable directions for social–ecological systems at local-to-planetary scales. The causes of many of these trends are increasingly well understood, providing a basis for quantitative or conceptual models that project some of these trends into the future, assuming that people continue their current patterns of behavior ("business-as-usual" scenarios). Continuation of current trends in fossil-fuel use, for example, will likely cause "dangerous" climatic change within the next few decades by altering Earth's climate system beyond a tipping point that would have serious ecological and societal consequences and be difficult to reverse (Stern 2007, IPCC 2007a, b). Similarly, current declines in biodiversity and ecosystem services are degrading livelihoods and well-being of social–ecological systems globally, particularly for underprivileged segments of society (MEA 2005a; see Chapters 2, 3 and 4).

Scenarios represent plausible futures that are based on our understanding of past and current trends. They are not predictions because of the considerable uncertainties that surround future trajectories. Scenarios are most useful for assessing gradual changes that are controlled by processes for which we have both data and models. Trends in global climate, for example, reflect predictable biophysical interactions that can be projected with reasonable confidence over decadal time scales. These trends include resource consumption, fossil-fuel emissions, land-use change, and local-vs-global resource dependence. Scenarios can also be defined that assume a suite of policies and human actions with predictable biophysical, ecological, and social outcomes. These "what-if games" allow comparisons of alternative potential future states, depending on policies that society chooses to implement. Two scenarios commonly accepted by policy makers and the public are that (1) there will be no directional change in controls over social–ecological processes (today's world will remain unchanged) or (2) people will continue their current behavior (business as usual). Scenarios can explore the logical social–ecological consequences of these assumptions or alternative policies that might lead to more desirable outcomes.

The greatest shortcomings of scenarios are that they do not capture (1) the uncertainty associated with processes that are well-understood; (2) the effects of processes that are missing from assumptions and models; (3) many of the complexities of social–ecological interactions and feedbacks; and (4) the unknowable surprises that are an increasingly common property of social–ecological dynamics. Given these severe shortcomings in the capacity of scenarios to predict the future, why would anyone want to use them? Clearly, scenarios should be treated as plausible futures rather than predictions. Scenarios are most useful when used comparatively to explore the logical consequence of *differences* in assumptions about how the world works or policy options that might differ in their social–ecological consequences.

World leaders in industry, government, and the environment disagree about how best to achieve social–ecological sustainability. The Millennium Ecosystem Assessment (MEA) sought to explore the consequences of this spectrum of world opinion by describing four general scenarios of policy strategies intended to enhance social-ecological sustainability (Bennett et al. 2003, MEA 2005c). These scenarios differed in the extent to which policies were global or regional in their design/implementation and whether ecosystem management was reactive (responding to ecosystem degradation after it occurred) or proactive (deliberately seeking to manage ecosystem services in sustainable ways (Cork et al. 2006; Table 5.2). In Global Orchestration, there is global economic liberalization with strong policies to reduce poverty and inequality and substantial investment in public goods such as education. In Order-from-Strength, economies become more regionalized, and nations emphasize their individual security. Adapting Mosaic also has more regionalized economies, but there is emphasis on multiscale, cross–sectoral efforts to sustain ecosystem services. In TechnoGarden, the economy is globalized, with substantial investments in sound environmental technology, engineered ecosystems, and market-based solutions to environmental problems (MEA 2005c, Carpenter et al. 2006a). A combination of quantitative and qualitative modeling suggested that these alternative policy options would lead to quite different ecological and social outcomes. In each of them there are tradeoffs among ecosystem services and among social benefits. The most encouraging result was that all scenarios except the Order from Strength would reduce the current net degradation of ecosystem services and improve human well-being, relative to today's uncoordinated spectrum of global policies. Nonetheless, these net improvements result from quite different patterns of tradeoffs and social equity. Some of the key lessons from these scenarios were (Cork et al. 2006):

Table 5.2. Defining characteristics of four scenarios[1].

	Global orchestration	Order from strength	Adapting mosaic	Technogarden
Dominant approach for sustainability	Sustainable development, economic growth, public goods	Reserves, parks, national-level policies, conservation	Local-regional co-management, common-property institutions	Green-technology, ecoefficiency, tradable ecological property rights
Economic approach	Fair trade (reduction of tariff boundaries), with enhancement of global public goods	Regional trade blocs, mercantilism	Integration of local rules regulates trade; local nonmarket rights	Global reduction of tariff boundaries, fairly free movement of goods, capital, and people, global markets in ecological property
Social policy foci	Improve world; global public health; global education	Security and protection	Local communities linked to global communities; local equity important	Technical expertise valued; follow opportunity; competition; openness
Dominant social organizations	Transnational companies (Companies that spread seamlessly across many countries): global NGO and multilateral organizations	Multinational companies (Companies that consist of loose alliances of largely separate franchises in different countries)	Local cooperatives, global partnerships, and collaborations established as local groupings recognize the need to share experiences and solutions	Transnational, professional associations, NGOs

Reprinted from Cork et al. (2006).

- No utopian solution is likely to emerge because of tradeoffs among ecosystem services and among social benefits.
- Global cooperation to deal with social and environmental challenges would lead to better outcomes than lack of cooperation.
- Proactive environmental policies would lead to lower risks of major environmental problems and loss of well-being than would reactive policies.
- Participation by a breadth of stakeholders in designing the scenarios clarified the variation in visions about how to achieve sustainability and acceptance of the conclusions of the study.
- Comparison of a small number (2–4) scenarios allowed a diverse but manageable set of options to be considered.

Creating Thresholds for Transformation from Undesirable States

How can ecosystem stewardship help people, communities, and societies escape rigidity and poverty traps? In a rigidity trap there is a tendency to lock management and governance into their existing attitudes or worldviews, making it difficult to respond to changing conditions. Even if there is a general feeling that something needs to be done, it can be surprisingly difficult to get a group out of such gridlock, and the investment in a certain perspective or behavior may be so strong that it is hard to create incentives that are strong enough to change it. Rigidity is deeply rooted because it develops as a way to ensure consistency. In such situations, the "exceptional few" individuals play an important role in catalyzing tipping points and shifting management and governance over a threshold into a new direction. Some individuals appear to be able to mobilize groups to remove the inertia and change management behavior and world views. They may, for example, be particularly well connected, have high social capital, be innovators or early adopters by nature, or have the charisma to cause emotional contagion. The absence of such leaders makes a social group as a whole rigid and weak when adaptation to change is required (Scheffer and Westley 2007).

It is more difficult to create tipping points to escape from a poverty trap, because these traps are generally characterized by very low levels of social capital and adaptive capacity; initial poverty is often self-reinforcing; and concentrated poverty tends to undermine processes of community organization (Bowles et al. 2006). Even if the group or community can mobilize internally and build adaptive capacity to get out of the trap, it may be overwhelmed by broader-scale factors, such as changes in regional and global markets, governmental corruption, or low level of education in a country as whole. There is often a long historical path dependence of political and economic goals and institutional structures that push a social-ecological system into a poverty trap (Engerman and Sokoloff 2006). The challenges of moving out of poverty traps are huge. Although economic capital and technology support are important, they are often insufficient to help social-ecological systems escape such traps (Bowles et al. 2006).

Moving out of traps requires not just a shift in the social (including economic) dimensions but also active stewardship of ecosystem processes. A major challenge is to secure, restore, and develop the capacity of ecosystems to generate ecosystem services because this capacity constitutes the very foundation for the social and economic development needed to escape from poverty traps (Enfors and Gordon 2007). Ecological restoration and ecological engineering are subdisciplines of ecology that focus on enhancing the capacity of ecosystems to provide services. These fields tend to emphasize the growth and conservation phases of the adaptive cycle. More recently, research on biological diversity as sources of resilience is gaining momentum (Folke et al. 2004). Biological diversity provides the ingredients for regenerating an ecosystem within its current state after disturbance or the seeds for alternative states that might be more viable under new conditions (see Chapter 2). Hence, biodiversity plays a central role in the release and renewal phases of the adaptive cycle. Diverse landscapes and seascapes with resilience have higher capacity to regenerate in the face of disturbance and thereby sustain the supply of ecosystem services. Management that focuses on using protected areas and reserves as reservoirs of bioidveristy to strengthen resilience is gaining ground (e.g., Bengtsson et al. 2003). For example, to enhance the resilience to climate change and secure ecosystem services of the Great Barrier Reef in Australia, the seascape has been rezoned into 70 habitats, each of which has fully protected areas as insurance for ecosystem regeneration after disturbance. A major task of ecosystem stewardship is to identify and manage the role of functional groups of organisms, their redundancy, and their response diversity in relation to ecosystem services at the landscape and seascape scale (Walker 1995, Naeem 1998, Elmqvist et al. 2003, Nyström 2006; see Chapter 2).

Resource management for poverty reduction has tended to focus on water use, food production, or management of other crucial resources, but, in our view, these resources need to be managed in the broader social-ecological context as part of ecosystems and landscape dynamics. Managing for ecosystem resilience is a necessary but insufficient condition for social-ecological transformations from poverty traps into improved states.

Recent work on social interactions also reveals the significance of diversity in human interactions, in institution building, and for collective action (Ostrom 2005, Page 2007). Diversity is a crucial element of resilience for coping with extreme events in a world characterized by accelerating directional change. **Redundancy** (backups), functional diversity of roles (of species in ecosystems, or of people and institutions in social systems), and response diversity (different responses of species, landscape elements, individuals or institutions to suites of disturbances) provide options for flexible outcomes and help social-ecological systems reorganize and develop (see Chapter 2).

These insights illustrate that the search for blueprint solutions, i.e., uniform solutions to a wide variety of problems that are clustered under a single name based on one or more successful exemplars, lead to resource-management failures (Ostrom et al. 2007; see Chapter 4). Yet, diversity seems to be eroding in many dimensions. It is declining systematically in agriculture and most land- and seascapes (MEA 2005a; see Chapter 12). At the same time, in human societies, the benefits of efficiency, rationality, and standardization have resulted in an emphasis on "best practice", efficiency, and a tendency toward monoculture and a dominance of the few. All this challenges resilience, because it leaves us with an impoverished set of sources of novelty for renewal.

Such erosion of resilience can, for example, be counteracted by increasing the diversity of problem solvers in a team, community or society, thereby stimulating a wide range of mental models and also allowing for transparency regarding conflicting viewpoints (e.g., disciplinary background, methodology, conflict and learning styles, age, gender, and cultural background). **Complex problems** (problems with many potential solutions that are quite different in execution and rankable in quality of outcome) may be solved more effectively by a diverse team of competent individuals than by a team composed of the best individual problem solvers (Page 2007). In this sense, social diversity contributes to the sources of resilience that strengthen social-ecological systems. Combining social, ecological, and economic sources of resilience in times of directional and often unexpected change provides the seeds not only for adaptive capacity but also for transforming social-ecological systems into new and potentially more desirable states.

New global institutional structures emerge during rapid globalization from financial markets, multinational companies, trade agreements, IT-developments, and intergovernmental treaties. Currently, however, we lack or have primarily weak international institutions to deal with ecosystem stewardship for sustainability (see Chapter 14). Important advances like UN declarations and the IPCC are still largely disconnected from powerful economic and political institutions. We envision that, in pace with climatic change and associated disturbances, new regional and global governance structures will emerge that will truly merge the ecological and social dimensions for improved stewardship of ecological life-support systems and ecosystem services. For example, structures such as the European Water Directive and the MEA are already emerging. Institutional scholars talk about these structures as multilevel governance systems, and some propose a **polycentric governance structure**, in which citizens are able to organize in multiple democratic governing bodies at differing scales in a specified geographical area to deal with common pool resources and stewardship of ecosystems. Selforganized resource governance systems within a polycentric system may be organized as special districts, nongovernmental organizations, or parts of local governments. These are nested in several levels of general-purpose governments that provide civil equity as well as criminal courts. The smallest units can be viewed as parallel adaptive systems that are nested within ever-larger units that are themselves parallel adaptive systems. The strength of polycentric governance systems in coping with complex, dynamic biophysical systems is that each of the subunits has considerable autonomy to experiment with diverse rules for using a particular type of resource system and with different response capabilities to external shock. In experimenting with rule combinations within the smaller-scale units of a polycentric system, citizens and officials have access to local knowledge, obtain rapid feedback from their own policy changes, and can learn from the experience of other parallel units. Redundancy builds in considerable capabilities and small-scale disasters that may be compensated by the successful reaction of other units in the system (Ostrom 2005).

Navigating Transformation Through Adaptive Governance

The capacity to adapt to and shape change is a central component of resilience of social–ecological systems. When there is high adaptability, actors have the capacity to reorganize the system within desired states in response to changing conditions and surprises. But high adaptability may also be recombined with innovation and novelty to transform a social–ecological system into a new regime. **Adaptive governance** has emerged as a framework for understanding transformations by expanding the focus from adaptive management of ecosystems to address the broader social contexts that enable shifts in governance systems toward ecosystem-based management (Folke et al. 2005).

By **governance systems** we mean the interaction patterns of actors, their sometimes conflicting objectives, and the instruments chosen to steer social and environmental processes within a particular policy area. Institutions are a central component in this context, as are the interactions between actors and the multilevel institutional setting, creating complex relationships between people and ecosystem dynamics (Galaz et al. 2008, see Chapter 4).

A transformation of governance may include both shifts in perceptions or mental models and changes in institutions and other essential social features. Adaptive governance research addresses transformations of entire governance systems from one state to another. Transformations that increase the capacity to learn from, respond to, and manage ecosystem feedbacks generally require shifts in social features such as perception and meaning; social network configurations and patterns of interactions among actors; and associated institutional arrangements and organizational structures. In this book we are concerned with transformations that redirect governance into restoring, sustaining, and developing the capacity of ecosystems to generate essential services.

Path Dependence and Windows of Opportunity

We still know relatively little about how social–ecological transformations can be orchestrated and the enabling social processes that make it possible for actors to actively push systems from one trajectory to another. Why do certain strategies succeed and suddenly take off, while others utterly fail? There is a need to understand transformative capacity, the capacity to shift from trajectories of unsustainable resource use to sustainable ones in the face of increased resource depletion and global change (Chapin et al. 2006b). Path-dependence characterizes most institutional development and public policy-making (Duit and Galaz 2008). These paths often show a **punctuated equilibrium**, in which long periods of stability and incremental change are separated by abrupt, nonincremental, large-scale changes (Repetto 2006).

Windows of opportunity often trigger these large-scale changes. Sometimes windows open due to exogenous shocks and crises, including shifts in underlying economic fundamentals like a rapid rise in energy price, a change in the macro-political environment, new scientific findings, regime shifts in ecosystems, or rapid loss of ecosystem services. For example, a window for changing direction opened up in water management for agricultural and urban areas in California. Water management had been locked for decades into a highly engineered infrastructure that reinforced one policy and excluded others and pushed the social–ecological system into a crisis. As a response, a new awareness emerged among multiple stakeholders in Californian water management that business-as-usual was no longer a viable option. The window of opportunity opened through the awareness of the crisis. As a necessity, policy and management shifted and broadened to incorporate a wider array of state and federal agencies as well as private and public organizations to address the crisis (Repetto 2006). The social–ecological system seems to be going through a transformation.

Leadership, Actor Groups, Social Networks, and Bridging Organizations

Leadership in Transformations

The interplay between individual actors, organizations, and institutions at multiple levels is central in social-ecological transformations. A literature on the role of leadership strategies in transformations to ecosystem-based management is emerging (Westley 2002, Olsson et al. 2004b, Fabricius et al. 2007; see Chapter 15), with a focus on the relationship between social structures and **human agency** (see Chapters 1 and 4). In the governance systems of the Everglades in Florida in the USA and Kristianstad Vattenrike in southern Sweden, successful transformations occurred because of the ability of leaders to

- reconceptualize key 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, and
- recognize or create windows of opportunity and promote novelty by combining different networks, experiences, and social memories.

Leaders who navigate transformations are able to understand and communicate a wide set of technical, social, and political perspectives regarding the particular ecosystem stewardship issues at hand. Visionary leaders fabricate new and vital meanings, overcome contradictions, create new syntheses, and forge new alliances between knowledge and action.

Diversity of Actor Groups and Social Networks

People with different social functions operating in teams or actor groups play significant roles in mobilizing social networks to deal with change and unexpected events and to reorganize accordingly. Social roles in networks also interact to create tipping points and transformations. Gladwell (2000) identified tipping point roles and labeled them **mavens** (altruistic individuals with social skills who serve as information brokers, sharing and trading what they know) and **connectors** (individuals who know many people (both numbers and especially types of people). They enhance the information base of their social network. Mavens are data banks and provide the message. Connectors are social glue and spread the message. There are also **salesmen** who have the social skills to persuade people unconvinced of what they are hearing. Other social roles of key individuals operating in actor groups include knowledge carriers, knowledge generators, stewards, leaders, people who make sense of available information, knowledge retainers, interpreters, facilitators, visionaries, inspirers, innovators, experimenters, followers, and reinforcers (Folke et al. 2005).

Social capital (see Chapter 4) focuses on relationships among groups, i.e., the bridging and bonding links between people in **social networks** (Wasserman and Faust 1994). Applied to adaptive governance, these relationships must be fed with relevant knowledge about ecosystem dynamics. This is related to the capacity of teams to acquire and process information, to make sense of scientific data and connect it to a social context, to mobilize the social memory of experiences from past changes and responses, and to facilitate adaptive and innovative responses. Social roles of actor groups are all important components of social networks and essential for creating the conditions that we argue are necessary for adaptive governance of ecosystem dynamics during periods of rapid change and reorganization. Linking different societal levels and knowledge systems requires an active role of individuals as coordinators and facilitators in co-management processes. Intermediaries, or middlemen can, for example, play a role in linking local communities to outside markets (Crona 2006). Bringing together different actor groups in networks and creating opportunities for new interactions are important for dealing with uncertainty and change and critical factors for learning and nurturing integrated adaptive responses to change.

Bridging Organizations Connect Different Levels of Governance

Bridging organizations coordinate collaborations among local stakeholders and actors at multiple organizational levels (Westley 1995, Hahn et al. 2006). Bridging organizations provide arenas for trust-building, vertical and horizontal collaboration, learning, sense-making, identification of common interests, and conflict resolution. As an integral part of adaptive governance of social–ecological systems, bridging organizations reduce transaction costs of collaboration and provide social incentives to participate in ecosystem stewardship. The initiative behind a bridging organization may come from bottom-up, top-down, or from, for example, NGOs or companies that bridge local actors with other levels of governance to generate legal, political, and financial support. Such bridging organizations may also filter external threats and redirect them into opportunities and help transform social–ecological systems toward resilience-based stewardship (Olsson et al. 2004b, 2008). Their role in resilience and sustainability needs further investigation.

Interplay Between the Micro and the Macro

How do new multilevel governance systems emerge? What are the enabling conditions for the emergence of innovative initiatives to deal with ecosystem change, uncertainty and crisis, and the social mechanisms that diffuse innovations across scales? The micro level involves encounters and patterned interaction among individuals (which include communication, exchange, cooperation, and conflict), and the macro level refers to structures in society (groups, organizations, institutions, and cultural productions) that are sustained by mechanisms of social control and that constitute both opportunities and constraints on individual behavior and interactions (Münch and Smelser 1987). Could social innovations generated at local/regional scales influence and transform governance at a global scale? Can multi-actor experiments be designed that generate new knowledge, network across scales, pressure governance regimes, and ultimately lead to tipping points and transformations to more ecosystem-benign management and governance? These issues are beginning to be addressed in the context of adaptive governance (Dietz et al. 2003, Folke et al. 2005).

Learning Platforms as Part of Adaptive Governance

The adaptive governance framework suggests a learning approach that includes fostering a

diversity of approaches and creating "learning platforms" to experiment with social responses to uncertainty and change. Such a learning approach has great potential to enhance the resilience of interconnected social–ecological systems and enhance the capacity of ecosystems to produce services for human well-being. For example, initiatives like UNESCO's Man and the Biosphere Programme identifies potential learning sites and policy laboratories. The creation of transition arenas in the Netherlands is another example of experimenting with new approaches for managing and governing water resources (van der Brugge and van Raak 2007).

Successful large and long-lived companies that depend on continuous innovation, such as Phillips or IBM, have addressed the tension between moving forward in a conventional fashion and exploring by "encapsulating" creative or explorative units (Epstein 2008). They often physically separate the research and development departments or teams from the production teams and train special managers who can champion and shepherd the innovation process while buffering it from the demands of production. This allows the company to build up a bank of new ideas and products to draw upon in future launches, while simultaneously producing and marketing successful initiatives (Kidder 1981, Kanter 1983, Quinn 1985). Others implement the ideas when they are successful enough, thereby avoiding the diversion of energy from creativity to production (Mintzberg and Westley 1992).

Three Phases of Social–Ecological Transformation

Transformation can be triggered by perceived threats to an area's cultural and ecological values. In the wetland landscape of Kristianstad in southern Sweden, for example, people of various local steward associations and local government responded to perceived threats by mobilizing and moving into a new configuration of ecosystem management within about a decade (Olsson et al. 2006). This self-organizing process was led by a key individual who provided visionary leadership in directing change

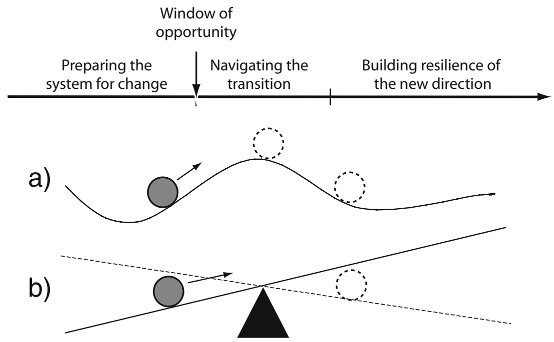


FIGURE 5.4. Three phases of social-ecological transformation, linked by window of opportunity–preparing the system for change, navigating the transition, and building resilience of the new direction. The transformation is illustrated in two ways: (**a**) as a regime shift between multiple stable states, passing a threshold or (**b**) as a tipping point.

and transforming governance. The transformation involved three phases, where phases (a) and (b) are linked by a window-of-opportunity (Fig. 5.4):

(a) preparing the system for change,
(b) navigating the transition, and
(c) building resilience of the new governance regime.

Trust-building dialogues, mobilization of social networks with actors and teams across scales, coordination of ongoing activities, sense making, collaborative learning, and creating public awareness were part of the process.

A comprehensive framework with a shared vision and goals that presented conservation as development and turned problems into opportunities was developed and contributed to a shift in values and meaning of the wetland landscape among key actors. The shift was facilitated through broader-scale crises, such as seal deaths and toxic algal blooms in the North Sea, which raised environmental issues to a top national political priority at the time that the municipality was searching for a new identity. This coincidence of events opened a window of opportunity at the political level, making it possible to tip and transform the governance system into a trajectory of adaptive co-management of the landscape with extensive social networks of practitioners engaged in multilevel governance (Fig. 5.4).

A broader analysis of five case studies confirms this pattern of social–ecological transformation (Olsson et al. 2006). The strategies of preparing for change are shown in Table 5.3. Key leaders and **shadow networks** (informal networks that are politically independent from formal organizations) play a key role in preparing a system for change by exploring alternative system configurations and developing strategies for choosing 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 are often preceded by the emergence of informal networks that help to facilitate information flows, identify knowledge gaps, and create nodes of expertise in ecosystem management that can be drawn upon at critical times. In the Kristianstads Vattenrike Biosphere Reserve and in the Everglades, these networks were politically independent from the fray of regulation and implementation in places where formal networks and many planning processes fail. These shadow networks serve as incubators for new approaches to governing social–ecological systems (Gunderson 1999). These informal, outside-the-fray shadow groups are places where new ideas often arise and flourish. These groups often 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.

In Australia, a flexible organization, the Great Barrier Reef Marine Park Authority, was crucial in initiating a tipping point of governance toward ecosystem-based management (Olsson et al. 2008). This agency was also instrumental in the subsequent transformation of governance systems, from the level of local fisher organizations to national political processes, and provided leadership throughout the process. The Great Barrier Reef study identifies social features and strategies that made it possible to shift the direction of an already existing multilevel governance regime toward large-scale ecosystem-based management. Strategies involved active internal reorganization and management innovation, leading to

- an ability to coordinate the scientific community,
- increased public awareness of environmental issues and problems,
- involvement of a broader set of stakeholders, and
- maneuvering the political system for support at critical times.

The transformation process was driven by increased pressure on the Great Barrier Reef (from terrestrial runoff, overharvesting, and global warming) that triggered a new sense of urgency to address these challenges. It shifted the focus of governance from protection of selected individual reefs to ecosystem stewardship of the larger-scale seascape.

The study illustrated the significance of stewardship that can change patterns of interactions among key actors and allow new forms of management and governance to emerge in response to environmental change. The study also showed that enabling legislation or other forms of social bounds were essential, but not sufficient for shifting governance toward adaptive co-management of complex marine ecosystems.

In contrast to the Great Barrier Reef case, marine zoning in the USA has been severely constrained due to inflexible institutions, lack of public support, difficulties developing acceptable legislation, and failures to achieve desired results even after zoning is established. Understanding successes and failures of governance systems is a first step in improving their adaptive capacity to secure ecosystem services in the face of uncertainty and rapid change.

The case studies discussed here show that transformation is more complex than simply changing legislation, providing economic

TABLE 5.3 Key factors for preparing five different social–ecological systems for tansformation[1].

Social–ecological system	Key factors building knowledge	Networking	Leadership
Kristianstads Vattenrike (creation of the KV)	A new perspective on ecosystem management of 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 areas 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.

1. Reprinted from Olsson et al. (2006).

incentives or introducing new restrictions on resource use. As observed by McCay (1994), the change of perceptions and mental models of the significance of ecosystems for human well-being is an important part of ecosystem stewardship and can change human behavior on a fairly large scale without involving the political processes of making and changing institutions.

Actions that foster successful transformations of social–ecological systems toward adaptive governance of landscapes and seascapes often include:

- 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 outcome; 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 actions for surprise and renewal differently than growth and conservation; efficiency is on the last part and resilience on the first.
- The time horizon for effect and assessment is at least 30–50 years; restructuring resilience requires attention to slow dynamics.
- Create cooperation and transform conflict, but some level of conflict ensures that channels for expressing dissent and disagreement remain open.
- Create novel communication face-to-face, individual-to-individual, group-to-group, and sector-to-sector.
- Encourage small-scale revolts, renewals and reorganizations, not large-scale collapses.
- Try to facilitate adaptive governance by allowing just enough flexibility in institutions and politics.

These generalizations can help managers navigate more effectively the periods of uncertainty and turbulence that are unavoidable components of any social–ecological transformation.

Summary

This book emphasizes the need for ecosystem stewardship to generate a deeper understanding of integrated social–ecological systems undergoing change. It requires an expansion of focus from managing natural resources to stewardship of dynamic and evolving landscapes and seascapes in order to sustain ecosystem services. Such stewardship requires governance systems that actively support ecosystem-based management and allow for learning about resource and ecosystem dynamics. A challenge is to develop governance systems that are flexible, adaptive, and have the capacity to transform. It requires dealing with change—not just incremental and predictable change, but uncertain, abrupt, and surprising change. Chapter 5 has identified and discussed features of social–ecological systems that create barriers and bridges for transformations to more desired states and presents strategies for building and enhancing their resilience in times of directional change.

The first five chapters of the book presented existing and emerging theory and concepts in relation to resilience-based ecosystem stewardship and serve as the foundation for the remaining chapters. The following chapters, structured into major types of social–ecological resource systems covering local-to-global scales, illustrate this foundation and provide insights, challenges, and implementation strategies for improved stewardship of terrestrial and marine ecosystems and the services and fundamental support that they provide to humanity.

Review Questions

1. How does transformation differ from adaptation?
2. What types of surprises occur in social–ecological systems? How do management strategies differ in preparing for and responding to each type of surprise?
3. What human actions can change resilience? In what ways might they interact and lead to regime shifts of social–ecological systems? What intervention strategies might address these interactions and reduce the likelihood of undesirable regime shifts?
4. How might appropriate intervention strategies differ between poverty traps, rigidity traps, and cascading effects of regime shifts?
5. In what ways can mismatches of institutions and ecosystems lead to surprises and regime shifts?
6. What tools are available to deal with true uncertainty?
7. What is adaptive governance and how does it differ from adaptive co-management?
8. Which are the major phases of transformations and their social features? In what ways can management actions foster social–ecological resilience to facilitate actively navigated transformations?

Additional Readings

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