Hahn, T., and B. Nykvist. 2017. Are adaptations self-organized, autonomous, and harmonious? Assessing the social–ecological resilience literature. *Ecology and Society* 22(1):12. https://doi.org/10.5751/ES-09026-220112

Research

Are adaptations self-organized, autonomous, and harmonious? Assessing the social–ecological resilience literature

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ABSTRACT. The paper analyzes how adaptability (adaptive capacity and adaptations) is constructed in the literature on resilience of social–ecological systems (SES). According to some critics, this literature views adaptability as the capacity of SES to self-organize in an autonomous harmonious consensus-building process, ignoring strategies, conflicting goals, and power issues. We assessed 183 papers, coding two dimensions of adaptability: autonomous vs. intentional and descriptive vs. normative. We found a plurality of framings, where 51% of the papers perceived adaptability as autonomous, but one-third constructed adaptability as intentional processes driven by stakeholders; where social learning and networking are often used as strategies for changing power structures and achieving sustainability transformations. For the other dimension, adaptability was used normatively in 59% of the assessed papers, but one-third used descriptive framings. We found no evidence that the SES literature in general assumes a priori that adaptations are harmonious consensus-building processes. It is, rather, conflicts that are assumed, not spelled out, and assertions of "desirable" that are often not clarified by reference to policy documents or explicit normative frameworks. We discuss alternative definitions of adaptability and transformability to clarify or avoid the notion of desirability. Complex adaptive systems framing often precludes analysis of agency, but lately self-organization and emergence have been used to study actors with intentions, strategies, and conflicting interests. Transformations and power structures are increasingly being addressed in the SES literature. We conclude that ontological clashes between social science and SES research have resulted in multiple constructive pathways.

Key Words: *adaptive comanagement; adaptive governance; ecosystems; neoliberalism; structured literature review; sustainable development goals; transformability*

INTRODUCTION

Research on resilience of social–ecological systems (SES) originates from ecology and complex adaptive systems (CAS), focusing on ecological resilience, tipping points, feedbacks, self-organization, and other system properties (Berkes and Folke 1998). The recent shift in focus from resilience of ecosystems to resilience of SES has attracted—and has partly been driven by—social scientists, especially on adaptation and transformation issues. In social science, both adaptation (as action) and adaptability (adaptive capacity) concern agency, i.e., real actors with intentions and conflicting strategies in specific contexts (Nelson et al. 2007). Social science frameworks, therefore, often clash with CAS frameworks, where adaptations in ecosystems are seen as emergent properties of local interacting but autonomous parts (Levin 1998).

There has been a heated debate on whether the research field of SES resilience is still based on ecological ontologies or whether it has changed into a truly interdisciplinary research field that enhances understanding of the coevolution of intertwined social and ecological systems (Folke et al. 2010). According to some authors, this change has already occurred through significant advances in analyzing agency, especially in relation to transformations, focusing on learning, innovation, leadership, and "changes to practices, lifestyles, power relations, norms and values" (Brown 2014:113). Power, agency, and justice issues belong to the priorities for future SES research (Olsson et al. 2014, Fischer et al. 2015). Other authors emphasize the lack of change (Leach 2008, Hornborg 2009, Hatt 2012), claiming that the SES literature views resilience and the necessary adaptations and adaptability as autonomous (spontaneous) and harmonious, assuming consensus building. Nelson et al. (2007:409) argue that the idealized situation—of testing and revising management and institutions based on ecological knowledge in a self-organized process—is rare, and that this approach may reinforce existing inequalities if power relationships are ignored. Cote and Nightingale (2012) suggest that the shortcomings in addressing power relationships and conflicting interests in SES research is due to an assumption that social and ecological systems are essentially similar.

Much of the critique of the SES literature can be codified into two propositions: (i) it uses a framing of autonomous self-organization, which precludes analysis of intentional agents, conflicts, and power; and (ii) it uses a normative framing. By "normative," we mean statements that assume an underling norm of what is desirable. Facts become normative when they "are interpreted through the filter of an assumption that implies an inherent policy preference" (Lackey 2001:439).

In the context of sustainable adaptations, Brown (2011:29) uses resilience as a normative concept, the opposite of vulnerability, and points to "the need for fundamental institutional re-configuration in support of long-term equity and resilience." Hence, social change is necessary for resilience. Other authors make the opposite normative association, equating resilience with social stability (MacKinnon and Derickson 2013), and by associating it to functionalism, arguing "that resilience appears conservative when extended to social change and social relations" (Olsson et al. 2015:6). Assumptions of desirability in the very definitions of adaptability and transformability have also been criticized (Leach 2008).

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Normative issues have been clearly recognized within vulnerability research (Adger 2006, Smit and Wandel 2006), but resilience research has been criticized for often leaving agency and normative statements unclear (Duit et al. 2010, Robards et al. 2011). Brown (2014) shares this critique but argues that the resilience literature contains multiple framings, resulting in rich scholarship. However, a quantitative analysis of agency and normativity has not yet been conducted, and we believe that would enrich this important critical discussion. Therefore, we conduct a quantitative structured literature review to test three hypotheses:

1. The literature on resilience of SES treats adaptability as a capacity of a system to self-organize in an autonomous way, i.e., with no description of actors with intentions and strategies;
2. The literature on resilience of SES makes normative judgements concerning what are "desirable" adaptations; and
3. Power issues and transformations are increasingly being addressed in the SES literature.

This paper is organized in the following way. In the theory section, we analyze contested theoretical and conceptual issues. This is followed by a description of the methods for the structured literature review. We discuss the quantitative results together with the theoretical findings and close by drawing conclusions that inform future research and application of SES resilience concepts.

THEORY

In this section, we analyze different conceptualizations of CAS behavior and discuss definitions of core SES resilience concepts.

Contested definitions

Some critique of the literature on SES resilience (henceforth called SES literature) relates to the very definitions of resilience, adaptability, and transformability, so let us first reflect on this. Resilience is primarily defined analytically/descriptively in a set of well-cited seminal conceptual papers (e.g., Walker et al. 2004, Folke 2006, Folke et al. 2010). In Walker et al. (2004), resilience (of SES) was defined as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks," and adaptability was defined as "the capacity of actors in a system to influence resilience." This separation between resilience and adaptability caused some confusion (see also Gallopin 2006, Folke et al. 2010:2). Folke (2006) instead argued that resilience of SES "incorporates the idea of adaptation, learning and self-organization in addition to the general ability to persist disturbance," making adaptability a part of resilience.

Resilience is used normatively primarily in relation to explicit goals or normative frameworks on natural resource management, like the Millennium Ecosystem Assessment (MA 2005*b*). Adaptability, on the other hand, is often referred to as explicitly normative, determining whether the actors "can successfully avoid crossing into an undesirable system regime" (Walker et al. 2004:3) or "to respond to and shape ecosystem dynamics and change in an informed manner" (Folke 2006:262).

Related to adaptability, but somehow opposite, is transformability, which in the SES literature is about (often deliberatively) eroding resilience of the present state or development path. It is "the capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable" (Walker et al. 2004). Hence, assumptions on what is undesirable or untenable are often made in the conceptualization of adaptability and transformability. We will return to this issue in the next section.

In a multiscale framework, transformability may be viewed as part of resilience in the sense that transformational change at smaller scales (e.g., sectors such as energy or farming systems) may be required for adaptations and hence resilience at larger scales, ultimately the planetary scale (Folke et al. 2010). Therefore, staying within the "planetary boundaries" (Steffen et al. 2015) is about resilience—and it is also a call for major transformations. This is noted by Brown (2014:112) in her critical discussion of the SES literature, but other critics do not appreciate that transformation can be part of the same systems analysis as resilience and still "be in contrast to resilience" (Olsson et al. 2015:2). They seem to interpret the resilience literature as a norm that SES (of whatever state and scale) should be resilient, and that resilient means robust and stable. We call this the "stability fallacy," and note that sustainable development also can be misrepresented as a norm to sustain the present development and social order and hence promote status quo.

Self-organization and desirable states

Already in 1973, Hayek (2012) referred to the market economy as a self-organized "spontaneous order" with market prices being the emergent properties. This framing has served to depoliticize market prices in neoclassical economics, and Bromley (1990, 1998) has criticized the belief that the "spontaneous order" of the free market results in objective prices and promotes efficiency. Hatt (2012:5) has argued that there is "a close affinity between Holling's approach to resilience and Friedrich Hayek's neoliberal economics and their reliance on complex systems theory."

However, the self-organization of CAS may not necessarily be employed to legitimize the present or any other desired social order; it seems rather strange to associate a scientific approach (resilience or CAS) to a political ideology. In a contrasting example, Brown (2014:113) discusses transition towns and argues that "[c]ounter to the argument about resilience as supporting regressive and neoliberal agendas, resilience is being used as an organizing principle by communities to challenge the status quo and to design and shape alternative futures."

Central to this debate on self-organization are the concepts of scale and emergence. In CAS frameworks, actors are often observed from the outside, e.g., from a higher level of a spatial or institutional panarchy (Holling 2001). Such analytical frameworks tend to view the unfolding of events and adaptations made in the system as autonomous and emergent, with adaptation being an inherent self-organized property of CAS (Levin 1999). However, the interaction between agents that results in emerging properties need not be autonomous but may include "players and strategies" (Lansing 2003:196). In SES, self-organization is often used for processes occurring at lower organizational levels, for example, when Ostrom et al. (1999:281) observe that "[n]ational governments can help or hinder local self-organization" or when Folke (2006:260) suggests that self-organization is the opposite of either "lack of organization, or organization forced by external factors." If an ideological interpretation must be made, the two

citations above may reflect a preference for decentralization and voluntary action rather than a preference for Hayek's spontaneous order. Indeed, self-organization in the field of SES research often refers to voluntary organization without assuming harmonious or autonomous processes. For example, Österblom and Folke (2013:2) employ a CAS perspective to study how global governance to combat illegal fishing emerged from interaction among key persons who managed to mobilize networks and formalize cooperation.

Holling's (2001:403) argument that "Self-organization of human institutional patterns establishes the arena for future sustainable opportunity" makes sense from a larger-scale systems perspective, but clearly abstracts from the strategies, leadership, conflicts, alliances, and power imbalances of human actors. However, abstracting from these issues is not the same thing as assuming that adaptations occur harmoniously through consensus; indeed, it says nothing about how adaptations actually occur and gives no information on the strategies, power structures, conflicts, and leadership underlying adaptability.

If we want to understand "the art" of adaptations and transformations, i.e., the personal skills and networks of key change agents navigating the unexpected (Westley 2002, Westley et al. 2013), and not just the need for it, we need to analyze agency in specific contexts. As long as there are plural opinions of what ends society should promote, what means should be employed, and how trade-offs should be dealt with, there will be conflicting interests. This applies even in the case of global consensus on the ends, which the United Nations (2015) suggests exists for the new Sustainable Development Goals. There are often strong economic incentives for actors in SES to strategically plan, advocate, or simply coerce a different state or development trajectory than the one envisioned by the norm of success applied or assumed in the scientific analysis. For example, in a study of water governance in Sweden, Galaz (2005) showed that some actors blocked attempts for social learning and adaptations desired by other stakeholders, an act of obstruction of change linked to the institutional setup where hydropower concessions have been unlimited in time in Sweden (Rudberg et al. 2015).

Ideally, normative statements in science, e.g., assertions of what is desirable, should be evidenced by an explicit reference to a policy document or scientific–political framework with clearly expressed norms like the MA (2005*b*) or the new Sustainable Development Goals. For instance, claims that a clear lake is more "desirable" than a turbid lake are typically normative statements, but beg the question "for whom" or according to what policy framework? If clear lakes are desirable by all or most people in a society and lakes still become turbid, is it due to lack of knowledge or some actors driven by strong monetary incentives or something else?

In the context of natural resource management, an ecosystem that is approaching an "undesirable" threshold according to some actors and that is therefore not assessed as resilient in an ecological sense, may nevertheless be resilient in a social–ecological sense. This is the case if these actors show high adaptability and are able "to respond to change and restore the lake" (Folke et al. 2005:444). Hence, when shifting the perspective from ecosystems to SES, a more explicit reference to agency and normative issues concerning adaptability can be expected.

The harmonious consensus critique

Fuzzy notions of desirability and agency are targeted in the critique that the SES literature portrays adaptations as harmonious consensus building (e.g., Nelson et al. 2007:409, Leach 2008:1791, Hornborg 2009:252, Hatt 2012:3–5, Olsson et al. 2015:4–5). These critics have explicitly referred to seven articles or books together: Berkes and Folke (1998), Berkes et al. (2003), Folke et al. (2005), Olsson et al. (2004*a*, 2006), Walker et al. (2006*a*), and Westley et al. (2002). We have analyzed these seven texts with special emphasis on how they treat the concepts of functionalism, consensus, collaboration, conflict, and shared vision in adaptability.

Functionalism was explicitly referred to only once (in Westley et al. (2002)) but not in the way the critics suggest; there is no preference expressed for maintaining or justifying the existing social order. Other texts (e.g., Berkes et al. 2003:364) discuss different "functions" or roles by key persons to accomplish a transformation: some act as visionaries, others as knowledge carriers, networkers, facilitators, entrepreneurs ,and implementers; again, not to maintain the existing social order, but rather the opposite.

We found no assumptions on consensus, but some texts described shared visions: "Trust-building dialogues [...] 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" (Folke et al. 2005:457).

The citation above by Folke et al. (2005) and the empirical papers it referred to suggest that consensus or harmonious processes are not assumed a priori. The processes for building trust, solving conflicts, and identifying common interests are studied empirically in the case studies described and involve key persons building alliances (networks) among diverse stakeholder groups. Although rarely made explicit, such networking is generally a strategy for changing power structures, and these are not smooth, harmonious processes (Hahn 2011, Crona and Parker 2012). Olsson et al. (2014:4) admit that power is understudied in the SES literature but note that this is changing and that "the redistribution and sharing of power is one of the key conditions for more flexible, collaborative forms of management and governance that contribute to long-term resilience of social–ecological systems." Thus, the SES literature cannot be said to assume harmonious consensus building. Conflicting interests are often implicitly acknowledged (networks are developed to change business-as-usual management and achieve a transformation), so it is rather the "conflicts" that are often assumed, not spelled out.

A high degree of consensus may be achieved in situations of "low politics" (Klijn and Skelcher 2007:596), i.e., when stakes are not high. However, voluntary collaboration is not a panacea, and the SES literature does not generally assume that a voluntary approach to collaborative adaptive governance is sufficient to achieve adaptations or transformation when stakes are high. As discussed before, the SES literature often acknowledges that major actors may obstruct any such process unless they are coerced or otherwise maneuvered to change. For example, turning one-third of the Great Barrier Reef into a marine protected area

started as a collaborative learning process but eventually required political coercion to handle the opposition from fishermen (Olsson et al. 2008). Political coercion was also decisive for curbing illegal and unreported overfishing in the Southern Ocean but, interestingly, the coercion was enabled by a long process of trust building and collaboration between NGOs and civil servants in international networks (Österblom and Sumaila 2011). Thus, trust building, knowledge generation, and collaboration in networks can be an effective strategy for catalyzing government coercion and changing power structures.

METHODS

For the first two research questions, we used a structured literature review, an approach common to both social science (Petticrew and Roberts 2006) and natural science (Fink 2005). This part of the analysis was conducted in 2011–2012 (Nykvist 2012), a time when the strongest critiques of SES resilience were being published. We started by developing coding criteria for different conceptualizations of adaptability (Tables 1 and 2). We used the ISI Web of Science database and searched for articles published before 1 January 2011, matching ("social–ecological system*" OR "socio-ecological system*" AND resilience AND adapt*) in title, abstract, and keywords. We used the truncated expression of "adapt*" because we view adaptability as an inclusive concept including adaptive capacity, adaptiveness, and adaptations. The search yielded 193 papers, dating back to 2001. For the third research question, we made a simple quantitative assessment of all 798 papers on resilience, adaptability, and SES published 2001–2015, adding either the words "power" and "transform*" to the search. For each of these two added concepts, we did one analysis for every year to assess possible trends.

Table 1. Coding of research question 1, autonomous vs. intentional. Each row represents sufficient but not necessary conditions

Autonomous	Intentional
Adaptations are characterized as autonomous, that is spontaneously self-organized.	Adaptations are characterized as intentional and strategically planned.
No discussion of actors' strategies, agendas, or leadership occur.	The ways actors organize in order to adapt a SES toward a certain goal are described or analyzed.
Actors can be assumed to have intentions or preferences in modeling.	The strategies or agendas of real actors are analyzed.

For research questions 1 and 2, each paper was searched for each occurrence of paragraphs containing "adapt*." These paragraphs were read, and key statements including definitions, descriptions, or discussions of adaptability were marked. Ten papers were excluded from the study because they actually had no discussions of adaptability in the text, despite passing the search criteria. We critically appraised the remaining 183 papers, analyzing the paragraphs including the word "adapt*" using our coding scheme (Tables 1 and 2) and we categorized the papers according to the two coding dimensions (Table 3). For research question 1, we were not able to code four further papers due to lack of definitions or descriptions. These papers are also excluded in our quantitative results. By having clear predefined categories and by discussing uncertain papers, we tried to minimize the inevitable subjective element of interpretation. Examples of our interpretations are provided in the results section. For more examples of coding and categorization of the 183 papers, see the Appendix (Tables A1–A3). It is important to understand that this method allowed no evaluation of the papers as a whole, only how adaptability was conceptualized and used.

Table 2. Coding of research question 2, descriptive vs. normative. Each row represents sufficient but not necessary conditions.

Descriptive	Normative	Vaguely normative
Adaptability related to how actors in the SES react to change, how they adapt no matter the outcome; no room for "maladaptations" and no normative connotations.	There is a clearly stated norm or goal, e.g., criteria for a well-functioning ecosystem, or a particular ecosystem state (such as clear water) or avoiding crossing a threshold to an undesirable state.	No specific norm is applied, there is only a "need for adaptation" or adaptability is used as an antonym to vulnerability or maladaptation.
Actors' strategies or leadership are described, but no norm or direction of what is a desirable adaptability is offered.	Adaptability is assumed to facilitate or enhance something clearly normative, e.g., sustainable development or a desired SES.	Adaptability is important for enhancing resilience or learning, without giving resilience or learning an explicit normative meaning.

Drawing on Smit and Wandel (2006:288), we operationalized research question 1 by identifying the difference between viewing adaptations as either autonomous or intentional/planned. Adaptations were considered autonomous if they are framed only as self-organized or react according to modeled preferences, e.g., in agent-based models. Agent-based modeling (ABM) can, of course, model strategies, conflicting interests, collaborations, and hence power issues, but we decided to interpret such frameworks as autonomous as the self-organization is autonomous and deterministic. Adaptations were considered intentional if they are described as strategically planned or organized by "real" actors. Intentional framings may or may not include analysis of leadership, conflicting interests, and/or power. General statements that strategies or leadership are important, or that stakeholders need to be considered, do not qualify for a categorization as intentional (see Table 1). Some papers used both intentional and autonomous framings, and we coded these as "Both perspectives."

Research question 2 concerns normative vs. descriptive framings. In a descriptive/analytical framing, adaptability refers to the capacity to adapt, whatever end or outcome. In explicit normative contexts, adaptability is the capacity to enhance the resilience of what is seen as a desirable ecosystem state or trajectory. However, sometimes there is no explicit reference to what is desirable, e.g., when adaptability is just assumed to be good or when adaptability is used in an instrumental way, expected to enhance resilience or learning without giving resilience or learning an explicit normative meaning. We refer to such statements as "vaguely normative" (see Table 2). Some papers used both normative (or vaguely normative) and descriptive framings. We coded these as "Several perspectives."

Table 3. The six possible combinations of framings. For exact coding of each framing, see Methods.

	Descriptive	Normative	Vaguely normative
Autonomous	Descriptive analysis of how the SES adapts to change, no evaluation of outcomes toward a particular norm. No room for maladaptations and no discussion of actors' strategies or agendas, actors are reactive or autonomous.	The SES has a clearly defined desirable state (e.g., coral reef or grassland), or adaptability is clearly linked to sustainability, or resilience, which in turn is normatively discussed. The actors' strategies or agendas are not described, actors are reactive or autonomous.	There is a "need for adaptations," but the reasons for this are not discussed: resilience of what and for whom is unclear. No discussion of actors' strategies or agendas, actors are reactive or autonomous.
Intentional	Descriptive analysis of how the SES adapts to external drivers, no evaluation of outcomes toward a particular norm. Actors and their intentions or strategies for adaptation are discussed.	Analysis of how actors organize and adapt with the aim to enhance resilience of a clearly defined desirable SES, or adapt and change the SES along a more desirable trajectory.	Adaptation is described as something positive, but reasons for this are not discussed. Actors and their intentions and strategies for adaptation are discussed.

RESULTS

Coding for the structured literature review

The 183 papers matching our search criteria were published in 62 journals (Fig. 1), of which *Ecology and Society* accounted for one-third of the papers (56/183).

Autonomous vs. intentional

More than half of the papers (51%) explicitly or implicitly refer to adaptations as autonomous only (Fig. 2A), often in the context of a complex adaptive system (CAS), or explained through the four phases of the adaptive cycle (Holling 2001). This set of papers thus provides no information on intentions, strategic planning, leadership, or power in relation to adaptability. For 31% of the papers, intentions and strategies are discussed in relation to adaptability. Finally, 17% of the reviewed papers include definitions and discussions of adaptability as both intentional and autonomous. This is often the case for review papers or theoretical papers that discuss several uses and references of adaptability.

Descriptive vs. normative

Taken together, explicitly and vaguely normative references and discussions of adaptability were almost twice as common as a descriptive framing (59% compared with 33% in Fig. 2B). Only 8% of the papers used descriptive as well as (vaguely) normative framings. The combination of framings is illustrated in Fig. 2C.

Categories of adaptability

When combining the two analytical dimensions, six types of references to adaptability emerge (see Table 3). A categorization of each individual paper is found in the Appendix (Tables A2 and A3). In the following presentation of results, we merge the categories of normative and vaguely normative and provide illustrations and discussion of the four major categories: Autonomous-Descriptive, Autonomous-Normative, Intentional-Descriptive, and Intentional-Normative. Each category is illustrated by a few citations. Fig. 3 shows the number of papers per year and the proportions of the four categories.

Autonomous and descriptive

A combination of descriptive and autonomous framings were found in 17% of the papers (Fig. 2C). This is a classical natural science analysis of SES as CAS, without discussions of adaptability in relation to intentions and strategies, and without making explicit any system state as more or less desirable. Two citations demonstrate typical contexts. The first involves decisions based on modeling, not real actors, and we refer to this as autonomous (see Methods above). The second citation describes income as a factor determining adaptability without any desired norm.

> *In adaptive management, chosen strategies are seen as experiments that provide information about the system that is being managed, which can be used to refine future strategies [...] Every time an agent makes a decision, it is based on past and learned experiences and is, therefore, adaptive.* (Bodin and Norberg 2005:175–177).

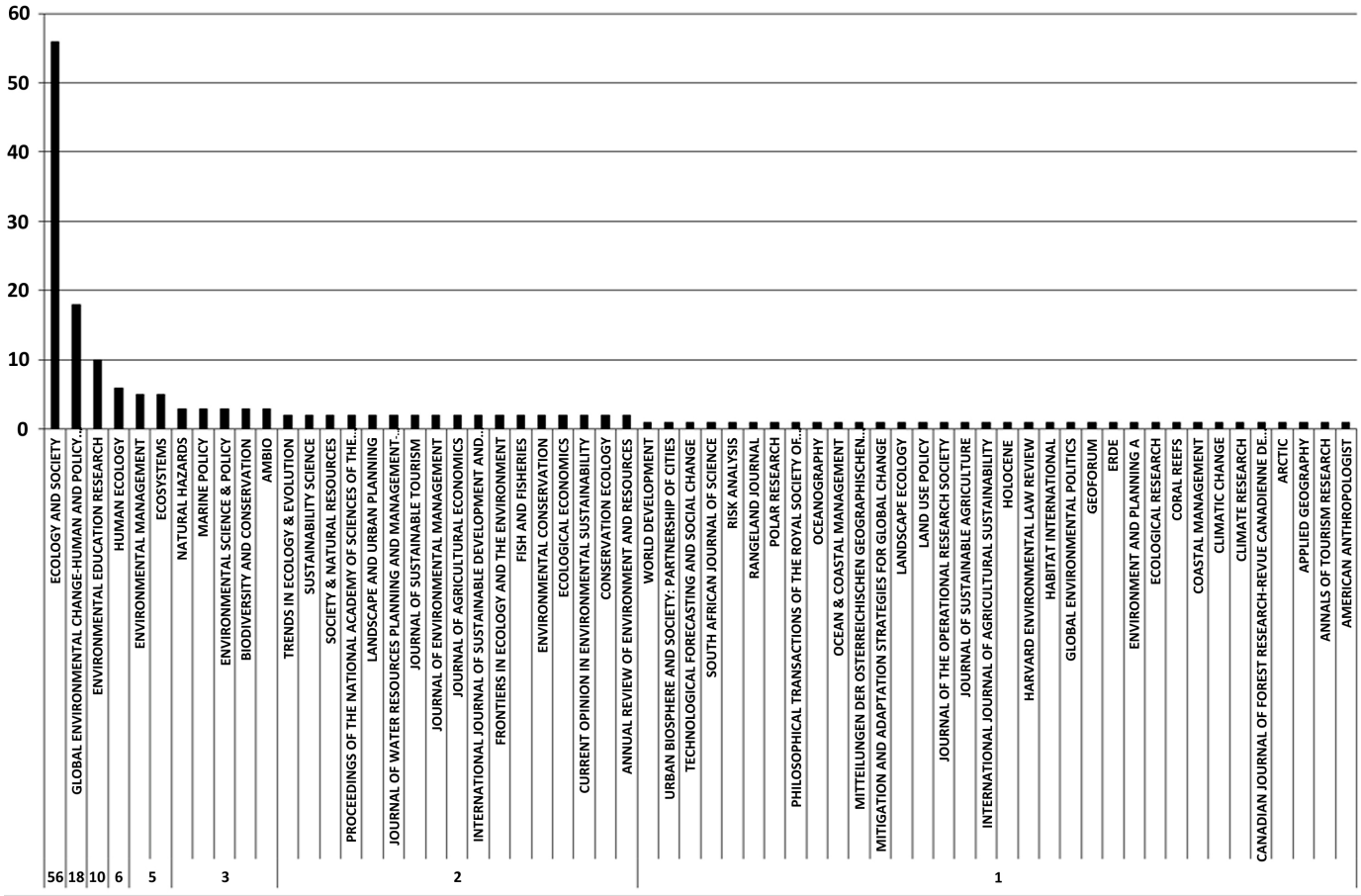
> *Households with a higher and more diverse endowment of these different forms of capital are more capable of coping with perturbations and adapting to change.[...] This diversity of income sources is an adaptive response to variable and unpredictable biophysical and socio-economic environments, but despite this many households in rural areas are chronically poor.* (Vetter 2009:32)

Autonomous and normative

This combination is indeed the most common, appearing in 33% of reviewed material (Fig. 2C). As mentioned before, actors and their intentions or strategies may be discussed in these papers, but if so, such discussions are not related to the adaptability concept. The first citation below combines CAS with a vaguely normative (best fit) outcome. The second uses adaptive capacity vaguely normatively yet includes no reference to intentions or strategies. The third adopts an explicitly normative view but offers no information on how adaptability is self-organized.

> *These [community-based conservation] institutions can be conceptualized as complex adaptive systems because they are composed of interacting agents, have emergent properties resulting from agent interactions, can self-organize to find the best fit with the environment [...] adapt and reorganize during and following the decade-long Maoist insurgency in Nepal.* (Baral et al. 2010:1–3)

Fig. 1. The 62 journals of the 183 papers for the years 2001–2010.



> *Evaluation of parameters that indicate the system's adaptive capacity could, at least, be employed to check that proposed risk treatments are unlikely to reduce system resilience. The adaptive capacity of the system could also be used to provide an indication of its ability to respond to unforeseen impacts and disturbances. Adaptive capacity, therefore, becomes a measure of system performance that improves risk management and that could be included in the suite of performance measures used to evaluate sustainability.*(Blackmore and Plant 2008:231)

> *Interstate and national initiatives have established a water-trading system coupled with a system of catchment-scale regulatory water plans. If this system proves to be more-or-less self-organizing, encourages innovation and adaptation, and reduces salinity and water-table rise, it should enhance resilience.* (Walker et al. 2009:20)

Intentional and descriptive

Some papers discuss adaptability in relation to actors' intentions and/or strategies but do not connect this to normative or prescriptive statements. This combination accounts for only 12% of the papers. It is common for descriptions of adaptive comanagement processes. Below, we cite two rather conceptual papers. The first citation describes a clash of framing and finds the normative definitions within adaptive governance inadequate. The second emphasizes intentions and politics and provides no normative meaning of adaptability.

> *Rather than the implementation of singular plans, adaptive governance emphasises the interaction of multiple institutions in guiding a complex system towards some more favourable state or trajectory (transformability) or maintaining it in a desired state or trajectory (resilience) (Walker et al. 2006*a*). Accepting that the outcomes of intervention will remain uncertain, adaptive governance emphasises flexibility, experimentation, and learning as strategies for anticipating and dealing with unintended consequences. Such governance approaches are thus deemed appropriate to situations of rapid change and high uncertainty. Nevertheless, they tend to assume that there are shared goals around what system properties should remain resilient, or that consensus can be built through the governance process. In this respect, adaptive governance is inadequate to deal with the kinds of clash of framing and value that emerge in the case studies I have described.* (Leach 2008:1791)

> *…adaptation is not a predetermined outcome that arises deterministically from biophysical considerations. It*

depends on human agency, including the role of individuals, collective movements, leaders, and institutions, and it often involves political struggle. (O'Brien et al. 2009:11)

Fig. 2. (a) Autonomous vs. intentional. "Both" refers to discussions of adaptability where reference is made to both perspectives. (b) Descriptive vs. normative and vaguely normative. "Several perspectives" means using descriptive as well as (vaguely) normative framings of adaptability. (c) Categories of adaptability. The combination autonomous and normative is most common framing, appearing in 33% of the categorized papers.

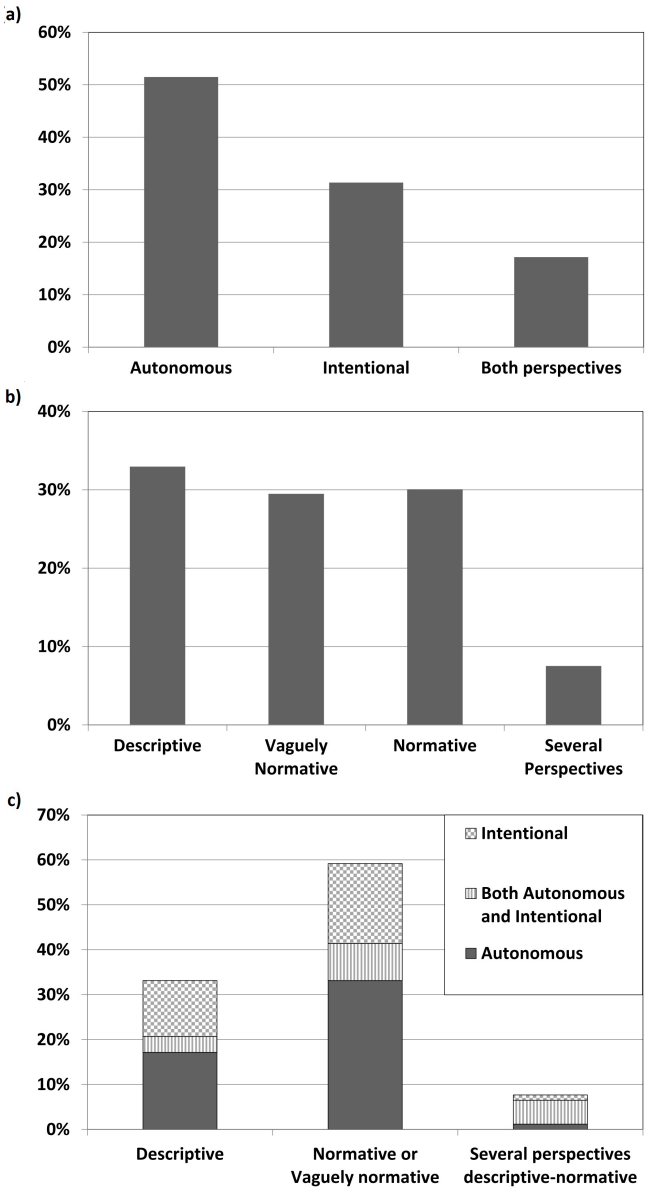
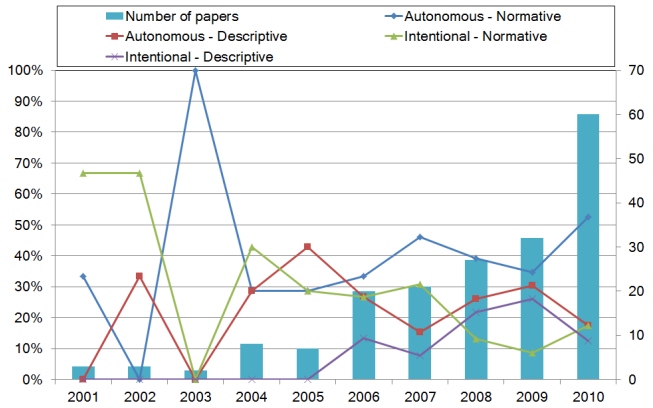


Fig. 3. Share of papers that refer to adaptability according to our four categories (left axis) and total number of papers (right axis). This analysis was based on the first bibliometric search (see Methods).



Intentional and normative

In this set of papers (18% of the papers analyzed), the use of adaptability recognizes the need to study people as strategically planning and intentional actors and also gives a norm on what is considered successful adaptive behavior. The key challenge is often described as mainstreaming of lessons learned, or avoiding socially defined negative outcomes. Unlike the normative-autonomous framing, the normative-intentional combination needs not portray adaptability as something positive. The first two citations below provide explicitly normative frameworks, suggesting that intentional adaptations and strategies of local actors are successful. The third suggests that actors can have incentives to adapt, or even increase their adaptive capacity, in a way that decreases social wellbeing (economic efficiency).

> *In a social–ecological system with high adaptability, the actors have the capacity to sustain the system in desired states in response to changing conditions and disturbance events […] The second section describes the development of [Ecomuseum Kristianstads Vattenrike] and the self-organization process toward an adaptive co-management system […] how one local individual played a critical role in leading change and transforming governance into an adaptive co-management system.* (Olsson et al. 2004*b*:2–4)

> *… because human actions dominate social–ecological systems, the adaptability of such systems is mainly a function of the individuals and groups managing them. Their actions influence resilience, either intentionally or unintentionally (Berkes et al. 2003). Their capacity to manage resilience with intent determines whether they can successfully avoid crossing into an undesirable system regime or succeed in crossing into a desirable one.* (Walker et al. 2006*b*:3)

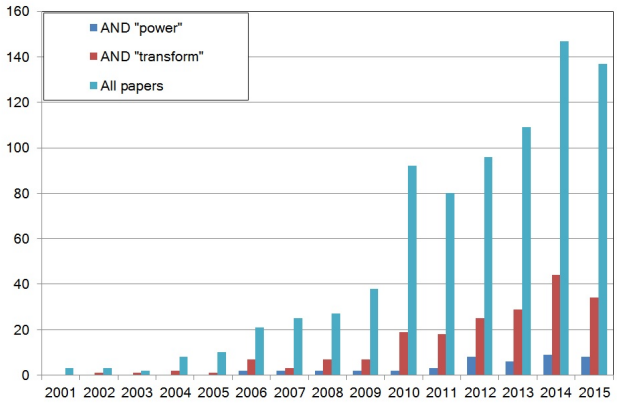
> *In both responses involving rule-breaking—on the part of the Forest Department and local people—perverse*

> *learning results in a positive outcome with respect to the third resilience characteristic, the capacity to learn and adapt [breaking rules]. However, it should be emphasized that the learning is perverse because it benefits few at the expense of many and endangers the forest resource.* (Bingeman et al. 2004:111)

Power issues and transformations

Of the SES resilience literature published in the period 2001–2015, 44 out of 798 papers (less than 6%) mentioned "power" in the title, abstract, or key words, whereas 198 papers (roughly one in four) mentioned "transform*." Fig. 4 shows the total number of papers per year. It is clear that transformation and power issues are increasingly being addressed in SES literature, at least in absolute terms.

Fig. 4. Total number of papers and number of papers that also mention power and transformation, respectively.



DISCUSSION

Our results show that the literature on resilience of SES is very diverse when it comes to how adaptability is defined, analyzed, and discussed. Previous studies have concluded that many strands of scholarship discuss adaptive capacity (not only the field of SES research), and they do so differently (e.g., Plummer and Armitage 2010:7–8).

Our results put numbers on this diversity (Fig. 2): 31% of the assessed papers do address actors with intentions and strategies. An additional 17% use both intentional and autonomous framings. Thus, we must reject the first hypothesis, that the SES literature treats adaptability as a capacity of a system to self-organize in an autonomous way without describing agency. Similarly, we find that 33% of the assessed papers use a descriptive framing, and an additional 8% have several framings. Although a normative use dominates, our results do not support a generalization that adaptability is used normatively in this literature. We can, therefore, also reject the second hypothesis, that SES literature necessarily makes normative judgements concerning what are "desirable" adaptations.

Autonomous or intentional dynamics

As discussed in the theory section, self-organization may refer to either autonomous or intentional processes. The former is inspired by CAS theory and sees self-organization as an uncoordinated process of adaptations resulting in emerging system properties at higher levels of social organization. This is common in the ecosystem resilience literature but, contrary to assertions by Olsson et al. (2015), the SES literature often describes self-organization as voluntary, intentional decentralized actions.

The papers conceptualizing adaptability as only autonomous (51%) did not assess peoples' strategies or social–ecological feedbacks, including learning or organizational/policy change in the context of adaptability, and therefore, did not really address the capacity to adapt. However, these papers seem to have a different purpose, so it may not be accurate to portray them as "failing" to recognize the organizational/political aspects of adaptations. Our impression from the assessed papers is that the analytical focus under study influenced the construction of adaptability: adaptations that appear to be autonomously self-organized in analyses at higher levels of abstraction or when assessing only ecological state and trends (MA 2005*a*), are instead described as driven by actors with (conflicting) intentions and strategies if another analytical focus is chosen. For example, Walker et al. (2004:1) use an autonomous CAS framing "to diagnose known examples of regional development" like the Kristianstad case, whereas local empirical analyses of the same case focus on intentional actors, networking, and institutions (Olsson et al. 2004*b*, Hahn et al. 2006, 2008, Johannessen and Hahn 2012).

The CAS framing in much of this literature has other advantages also in the adaptability discourse: in particular, in analyzing the "need" for adaptability in management of SES and types of capacities that will be required if crises cascade across scales and systems. Complex adaptive systems and other systems approaches in SES research enable analysis of anticipated vulnerability related to thresholds, tipping points, and ecological regime shifts (Walker et al. 2009). Such anticipated vulnerabilities are often analyzed within a (vaguely) normative context, assuming that adaptability is good without discussing agency. Although discussing vulnerability reduction in a normative framework may not necessarily be a problem—people can often agree that avoiding famine and drought is good (Duit et al. 2010—there are cases where famine and food provision are used as political tools (Keller 1992), and in such cases, an autonomous-normative framework is of course not very useful.

There is a huge leap from an analysis of adaptability as "needed" to an analysis of how it is organized by real people (Berkes 2009); whether or not related to a certain desired outcome. Recent literature on social learning and adaptive comanagement opens up the "black box" of self-organization and acknowledges that learning is not value free and that power issues are important parts of the system dynamics in a SES that sometimes block "desirable" adaptations and transformations (e.g., Plummer and Armitage 2007, Armitage et al. 2008, Berkes 2009, Reed et al. 2010, Österblom and Folke 2013, Nykvist 2014). This also holds for social–ecological memories as contributing to adaptability and resilience (Nykvist and von Heland 2014).

Identifying the need for adaptation is one research endeavor, and assessing the capacity to adapt, or the art of adaptation, is another. There seems to be a division of labor between researchers

with different foci, just like Brand and Jax (2007:10–11) suggest a division of labor between a descriptive use of resilience in ecology (ecosystem resilience) and a "vague and malleable" use of resilience (social–ecological resilience) in transdisciplinary research (see also Folke 2006). Therefore, a transition from ecosystem resilience to social–ecological resilience (the focus for this paper), where adaptability is a part of resilience, can be expected to have some implications for the conceptualization of adaptability. The old (Garrett Hardin) framing of the "Tragedy of the Commons" used a maximum sustainable yield rather than a CAS framing, but like CAS, it tended to overlook the role of intention, communication, and collaboration. Hardin's analysis was "based on an extremely sparse view of the commons" (Ostrom 2007:15183).

Interestingly, the SES literature sometimes combines a CAS framing with agency by opening up the self-organization box and filling it with real people and political action. In the theory section, we exemplified this by the emergence of global governance to combat illegal fishing (Österblom and Folke 2013). In a second example, in an evaluation of adaptive comanagement, Plummer and Armitage (2007:65) used CAS and "the lens of resilience to [analyze] the role of institutions and power." Third, Galaz et al. (2010:371) used CAS theory to assess cascading ecological crises, arguing that the "policy failures that occurred were often not inevitable." Inside the self-organization box of adaptation, they discussed a combination of psychological, bureau-organizational, and political factors that decreased the adaptive capacity. Finally, the panarchy multiscale version of the adaptive cycle (Holling et al. 2002) has been employed by Hahn (2011) to analyze how the social memory at higher institutional levels was used strategically by some actors to change power structures and further develop the biosphere trajectory at the lower municipal level of Kristianstad.

Normative or descriptive positions

If science is what scientists do, we may conclude that "adaptability" is primarily a normative term in the context of resilience and SES. One-third of the assessed papers used adaptability in an explicitly normative way. Another third used a vaguely normative framing (Fig. 2). However, as 33% of the papers in this review suggest, it is of course possible to make a descriptive analysis of adaptability, just as democracy and other concepts with normative connotations can be analyzed descriptively. The fact that "maladaptation" is normative (negative) does not necessarily make "adaptation" normative (positive). Although "adaptation" is a more descriptive term in the literature, reflecting its original ecological use (Plummer and Armitage 2010:7), "having a capacity to adapt" appears to have normative connotations, e.g., in relation to capacity building.

A high capacity or ability to adapt is, of course, related to an expected increase in human wellbeing. Still, some caution is warranted. A high adaptability in multistakeholder situations characterized by genuine uncertainty, wicked problems (Ludwig 2001), or postnormal science (Funtowicz and Ravetz 1992) may result in lowering human wellbeing ex post. And perverse learning, perverse incentives, and economic rent-seeking may also coexist with high adaptability and result in lower human wellbeing overall (see citation above by Bingeman et al. 2004). Thus, adaptability should not be equated with a sustainable, or any other, outcome. Similarly, stakeholder participation cannot be assumed to be a suitable and/or sufficient method to achieve social learning in the sense of deeper learning among a range of actors (Elbakidze et al. 2013, Nykvist 2014). And social learning in turn should not be equated with proenvironmental or sustainable behavior or other desirable outcome (Reed et al. 2010).

As mentioned before, even if there is normative agreement on goals, such as the UN's announcement of its Sustainable Development Goal as the new global consensus, we should expect conflicting interests when policies are formulated for adaptations and transformations to meet these goals. Words like "desirable" should either be avoided in SES resilience literature or be conditional on the identification of an explicit normative framework or specific actors. Following this reasoning, adaptability could be defined as the capacity of actors to change ecosystem management and thereby avoid what they regard as undesirable regime shifts. Transformability could be defined nonnormatively as the capacity to break path dependency and shift toward a new development trajectory justified by a fundamentally different narrative.

Pluralism in social science

We found little support for associating the SES literature to the conservative social equilibrium ideas of sociological functionalism and its "inability to explain rapid social change" (Olsson et al. 2015:5). In fact, during the last decades, systems approaches like complexity theory have provided diversity and promising approaches in social science (Byrne 1998, Urry 2003, Castellani and Hafferty 2009). For example, Schwandt and Szabla (2003) identify a conceptual congruence between Giddens' structure and agency theory and complexity theory, and CAS has also inspired anthropology (Lansing 2003).

Our review of the 183 papers indicates that complexity theory and CAS can be applied to the issue of adaptation in many different ways; our categorization shows that it provides pluralism. Pluralism is ironically what Olsson et al. (2015:9) also advocate while they dismiss the resilience approach, which they argue is "rooted in complexity theory" and functionalism and therefore "becomes the equivalent of stability and harmony" (Olsson et al. 2015:5).

The alleged assumption of harmonious consensus building requires reflection on the intentional-normative framing: that people are described as having intentionality and seeking common interests. An insight from social science, prominent in the critiques of resilience, is that harmony and consensus can never be assumed, not even on knowledge. Adaptability of SES has been defined as the capacity to adapt and respond to change "in an informed manner" (Folke 2006). This raises the question of whose knowledge should count, or which knowledge systems (local, indigenous, or scientific) and strategies qualify as more or less "informed."

Consider two adaptive strategies proposed to feed the poor and achieve the second Sustainable Development Goal (Zero Hunger): agroecology and genetically modified organisms (GMO). Pretty et al. (2006) and an international report (United Nations 2011) have suggested agroecology as a promising strategy to adapt or transform agriculture in low-income countries to enhance yields sustainably. Other actors have suggested input

subsidies to GMOs and another "green revolution" for the same purpose (Huang et al. 2002, Carpenter 2010). These two different strategies reflect different worldviews and priorities held by different stakeholders. They are both supported by scientific research and thus ecologically "informed." They are both "desirable" within their respective political and scientific frameworks, and from an analytical perspective, both manifest adaptive capacity.

The ultimate normative challenge concerns claims for efficiency, which means connecting a particular adaptation or transformation strategy to desirable outcomes. The agricultural example above suggests that both ex ante and ex post evaluations of such strategies (e.g., what is efficient and desirable for whom?) sometimes belong to the political struggle of establishing the (scientific) truth.

CONCLUSION

We conclude by emphasizing the plurality of approaches in the research on resilience and SES. There are signs that ontological clashes between social sciences and SES research have resulted in constructive pathways for dealing with questions of adaptation and adaptability, drawing on core concepts and insights "from both sides." Rather than assuming consensus and self-organization, resilience in SES has been employed empirically to explain how social learning and networking are used to alter power structures and achieve adaptations and transformations. We believe this constructive debate needs to continue to advance science and provide adequate policy support for sustainability transformations.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/9026

Acknowledgments:

We would like to thank Ryan Plummer for comments on a previous version of this paper, as well as Sarah Cornell and Jamila Haider for proofreading. This research was financed by the Swedish Research Council Formas, through the projects EKOKLIM and SAPES, and the Swedish Foundation for Strategic Environmental Research (Mistra), through the project Mistra Financial Systems (MFS), and a core grant to the Stockholm Resilience Centre.

LITERATURE CITED

Adger, W. N. 2006. Vulnerability. *Global Environmental Change* 16:268–281. http://dx.doi.org/10.1016/j.gloenvcha.2006.02.006

Armitage, D., M. Marshcke, and R. Plummer. 2008. Adaptive co-management and the paradox of learning. *Global Environmental Change* 18:86–98. http://dx.doi.org/10.1016/j.gloenvcha.2007.07.002

Baral, N., M. Stern, and J. T. Heinen. 2010. Growth, collapse, and reorganization of the Annapurna Conservation Area, Nepal: an analysis of institutional resilience. *Ecology and Society* 15(3):14.

Berkes, F. 2009. Evolution of co-management: Role of knowledge generation, bridging organizations and social learning. *Journal of Environmental Management* 90(5):1692–1702. http://dx.doi.org/10.1016/j.jenvman.2008.12.001

Berkes, F., J. Colding, and C. Folke. 2003. *Navigating Social–ecological systems: building resilience for complexity and change.* Cambridge University Press, New York, New York, USA. http://dx.doi.org/10.1017/cbo9780511541957

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

Bingeman, K., F. Berkes, and J. S. Gardner. 2004. Institutional responses to development pressures: resilience of social–ecological systems in Himachal Pradesh, India. *International Journal of Sustainable Development and World Ecology* 11:99–115. http://dx.doi.org/10.1080/13504500409469815

Blackmore, J. M., and R. A. J. Plant. 2008. Risk and resilience to enhance sustainability with application to urban water systems. *Journal of Water Resources Planning and Management* 134 (3):224–233. http://dx.doi.org/10.1061/(asce)0733-9496(2008)134:3(224)

Bodin, O., and J. Norberg. 2005. Information network topologies for enhanced local adaptive management. *Environmental Management* 35:175–193. http://dx.doi.org/10.1007/s00267-004-0036-7

Brand, F. S., and K. Jax. 2007. Focusing the meaning(s) of resilience: resilience as a descriptive concept and a boundary object. *Ecology and Society* 12(1):23. http://dx.doi.org/10.5751/es-02029-120123

Bromley, D. W. 1990. The ideology of efficiency: searching for a theory of policy analysis. *Journal of Environmental Economics and Management* 19:86–107. http://dx.doi.org/10.1016/0095-0696(90)90062-4

Bromley, D. W. 1998. Searching for sustainability: the poverty of autonomous order. *Ecological Economics* 24:231–240. http://dx.doi.org/10.1016/S0921-8009(97)00145-6

Brown, K. 2011. Sustainable adaptation: an oxymoron? *Climate and Development* 3:21–31. http://dx.doi.org/https://doi.org/10.3763/cdev.2010.0062

Brown, K. 2014. Global environmental change I: a social turn for resilience? *Progress in Human Geography* 38:107–117. http://dx.doi.org/https://doi.org/10.1177/0309132513498837

Byrne, D. 1998. *Complexity theory and the social sciences: an introduction.* Routledge, London, UK.

Carpenter, J. E. 2010. Peer-reviewed surveys indicate positive impact of commercialised GM crops. *Nature Biotechnology* 28:319–321. http://dx.doi.org/10.1038/nbt0410-319

Castellani, B., and F. W. Hafferty. 2009. *Sociology and complexity science: a new field of inquiry.* Springer, Berlin/Heidelberg, Germany. http://dx.doi.org/10.1007/978-3-540-88462-0

Cote, M., and A. J. Nightingale. 2012. Resilience thinking meets social theory: situating social change in socio-ecological systems (SES) research. *Progress in Human Geography* 36(4):475–489. http://dx.doi.org/10.1177/0309132511425708

Crona, B. I., and J. N. Parker. 2012. Learning in support of governance: theories, methods, and a framework to assess how

bridging organizations contribute to adaptive resource governance. *Ecology and Society* 17(1):32. http://dx.doi.org/10.5751/es-04534-170132

Duit, A., V. Galaz, K. Eckerberg, and J. Ebbesson. 2010. Governance, complexity, and resilience: introduction. *Global Environmental Change-Human and Policy Dimensions* 20:363–368. http://dx.doi.org/10.1016/j.gloenvcha.2010.04.006

Elbakidze, M., T. Hahn, V. Mauerhofer, P. Angelstam, and R. Axelsson. 2013. Legal framework for biosphere reserves as learning sites for sustainable development: a comparative analysis of Ukraine and Sweden. *Ambio* 42:174–187. http://dx.doi.org/10.1007/s13280-012-0373-3

Fink, A. 2005. *Conducting research literature reviews: from the internet to paper.* Second edition. Sage Publications, Thousand Oaks, California, USA.

Fischer, J., T. A. Gardner, E. M. Bennett, P. Balvanera, R. Biggs, S. Carpenter, T. Daw, C. Folke, R. Hill, T. P. Hughes, et al. 2015. Advancing sustainability through mainstreaming a social–ecological systems perspective. *Current Opinion in Environmental Sustainability* 14:144–149. http://dx.doi.org/10.1016/j.cosust.2015.06.002

Folke, C. 2006. Resilience: the emergence of a perspective for socio-ecological systems analyses. *Global Environmental Change* 16:253–267. http://dx.doi.org/10.1016/j.gloenvcha.2006.04.002

Folke, C., S. Carpenter, B. Walker, M. Scheffer, T. Chapin, and J. Rockström. 2010. Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society* 15(4):20.

Folke, C., T. Hahn, P. Olsson, and J. Norberg. 2005. Adaptive governance of social–ecological systems. *Annual Review of Environment and Resources* 30:441–473. http://dx.doi.org/10.1146/annurev.energy.30.050504.144511

Funtowicz, S. O., and J. Ravetz. 1992. Three types of risk assessment and the emergence of post-normal science. Pages 251–273 *in* S. O. Funtowicz and J. Ravetz, editors. *Social theories of risk*. Praeger, London, UK.

Galaz, V. 2005. Social–ecological resilience and social conflict: institutions and strategic adaptation in Swedish water management. *AMBIO: A Journal of the Human Environment* 34:567–572. http://dx.doi.org/10.1579/0044-7447-34.7.567

Galaz, V., F. Moberg, E. Olsson, E. Paglia, and C. Parker. 2010. Institutional and political leadership dimensions of cascading ecological crises. *Public Administration* 89:361–380. http://dx.doi.org/10.1111/j.1467-9299.2010.01883.x

Gallopin, G. C. 2006. Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change* 16:293–303. http://dx.doi.org/10.1016/j.gloenvcha.2006.02.004

Hahn, T. 2011. Self-organized governance networks for ecosystem management: who is accountable? *Ecology and Society* 16(2):18. http://dx.doi.org/https://doi.org/10.5751/ES-04043-160218

Hahn, T., P. Olsson, C. Folke, and K. Johansson. 2006. Trust-building, knowledge generation and organizational innovations: the role of a bridging organization for adaptive co-management of a wetland landscape around Kristianstad, Sweden. *Human Ecology* 34:573–592. http://dx.doi.org/10.1007/s10745-006-9035-z

Hahn, T., L. Schultz, C. Folke, and P. Olsson. 2008. Social networks as sources of resilience in social–ecological systems. Pages 119–148 *in* J. Norberg and G. Cumming, editors. *Complexity theory for a sustainable future.* Columbia University Press, New York, New York, USA; Chichester, West Sussex, UK.

Hatt, K. 2012. Social attractors: a proposal to enhance "resilience thinking" about the social. *Society and Natural Resources* 26 (1):30–43. http://dx.doi.org/10.1080/08941920.2012.695859

Hayek, F. 2012. *Law, legislation and liberty: a new statement of the liberal principles of justice and political economy.* Routledge, Abingdon, UK.

Holling, C. S. 2001. Understanding the complexity of economic, ecological, and social systems. *Ecosystems* 4:390–405. http://dx.doi.org/10.1007/s10021-001-0101-5

Holling, C. S., L. H. Gunderson, and G. D. Peterson. 2002. Sustainability and panarchies. Pages 63–102 *in* C. S. Holling and L. H. Gunderson, editors. *Panarchy: understanding transformations in human and natural systems.* Island Press, Washington, D.C., USA.

Hornborg, A. 2009. Zero-sum world: challenges in conceptualizing environmental load displacement and ecologically unequal exchange in the world-system. *International Journal of Comparative Sociology* 50:237–262. http://dx.doi.org/10.1177/0020715209105141

Huang, J., C. Pray, and S. Rozelle. 2002. Enhancing the crops to feed the poor. *Nature* 418:678–684. http://dx.doi.org/10.1038/nature01015

Johannessen, Å., and T. Hahn. 2012. Social learning towards a more adaptive paradigm? Reducing flood risk in Kristianstad municipality, Sweden. *Global Environmental Change* 23(1):372–381. http://dx.doi.org/10.1016/j.gloenvcha.2012.07.009

Keller, E. J. 1992. Drought, war, and the politics of famine in Ethiopia and Eritrea. *Journal of Modern African Studies* 30:609–609. http://dx.doi.org/10.1017/S0022278X00011071

Klijn, E.-H., and C. Skelcher. 2007. Democracy and governance networks: compatible or not? *Public Administration* 85(3):587–608. http://dx.doi.org/https://doi.org/10.1111/j.1467-9299.2007.00662.x

Lackey, R. T. 2001. Values, policy, and ecosystem health. *BioScience* 51:437–443. http://dx.doi.org/10.1641/0006-3568(2001)051[0437:VPAEH]2.0.CO;2

Lansing, J. S. 2003. Complex adaptive systems. *Annual Review Anthropology* 32:183–204. http://dx.doi.org/10.1146/annurev.anthro.32.061002.093440

Leach, M. 2008. Pathways to sustainability in the forest? Misunderstood dynamics and the negotiation of knowledge, power, and policy. *Environment and Planning A* 40:1783–1795. http://dx.doi.org/10.1068/a40215

Levin, S. A. 1998. Ecosystems and the biosphere as complex adaptive systems. *Ecosystems* 1:431–436. http://dx.doi.org/10.1007/s100219900037

Levin, S. 1999. *Fragile dominion.* Perseus Publishing, Cambridge, Massachusetts, USA.

Ludwig, D. 2001. The era of management is over. *Ecosystems* 4:758–764. http://dx.doi.org/10.1007/s10021-001-0044-x

MacKinnon, D., and K. D. Derickson. 2013. From resilience to resourcefulness: a critique of resilience policy and activism. *Progress in Human Geography* 37(2):253–270. http://dx.doi.org/10.1177/0309132512454775

Millennium Ecosystem Assessment. 2005*a*. *The millennium ecosystem assessment, ecosystems and human well-being: current state and trends.* Island Press, Washington D.C., USA.

Millennium Ecosystem Assessment. 2005*b*. *The millennium ecosystem assessment, ecosystems and human well-being: synthesis.* Island Press, Washington, D.C., USA.

Nelson, D., N. Adger, and K. Brown. 2007. Adaptation to environmental change: contributions of a resilience framework. *Annual Review of Environmental Resources* 32:395–419. http://dx.doi.org/10.1146/annurev.energy.32.051807.090348

Nykvist, B. 2012. *Social learning in the Anthropocene.* Dissertation in Natural Resources Management. Stockholm University, Stockholm, Sweden.

Nykvist, B. 2014. Does social learning lead to better natural resource management? A case study of the modern farming community of practice in Sweden. *Society and Natural Resources* 27(4):436–450. http://dx.doi.org/10.1080/08941920.2013.861562

Nykvist, B., and J. von Heland. 2014. Social–ecological memory as a source of general and specified resilience. *Ecology and Society* 19(2):47. http://dx.doi.org/10.5751/es-06167-190247

O'Brien, K., B. Hayward, and F. Berkes. 2009. Rethinking social contracts: building resilience in a changing climate. *Ecology and Society* 14(2):12. http://dx.doi.org/10.5751/es-03027-140212

Olsson, P., C. Folke, and F. Berkes. 2004*a*. Adaptive comanagement for building resilience in social–ecological systems. *Environmental Management* 34:75–90. http://dx.doi.org/https://doi.org/10.1007/s00267-003-0101-7

Olsson, P., C. Folke, and T. Hahn. 2004*b*. Social–ecological transformations for ecosystem management: the development of adaptive co-management of a wetland landscape in southern Sweden. *Ecology and Society* 9(4):2. http://dx.doi.org/https://doi.org/10.5751/ES-00683-090402

Olsson, P., C. Folke, and T. P. Hughes. 2008. Navigating the transition to ecosystem-based management of the Great Barrier Reef, Australia. *Proceedings of the National Academy of Sciences* 105(28):9489–9494. http://dx.doi.org/10.1073/pnas.0706905105

Olsson, P., V. Galaz, and W. J. Boonstra. 2014. Sustainability transformations: a resilience perspective. *Ecology and Society* 19(4):1. http://dx.doi.org/10.5751/es-06799-190401

Olsson, P., L. H. Gunderson, S. R. Carpenter, P. Ryan, L. Lebel, C. Folke, and C. S. Holling. 2006. Shooting the rapids: navigating transitions to adaptive governance of social–ecological systems. *Ecology and Society* 11(1):18. http://dx.doi.org/10.5751/es-01595-110118

Olsson, L., A. Jerneck, H. Thoren, J. Persson, and D. O'Byrne. 2015. Why resilience is unappealing to social science: theoretical and empirical investigations of the scientific use of resilience. *Science Advances* 1(4):e1400217. http://dx.doi.org/10.1126/sciadv.1400217

Österblom, H., and C. Folke. 2013. Emergence of global adaptive governance for stewardship of regional marine resources. *Ecology and Society* 18(2):4. http://dx.doi.org/10.5751/es-05373-180204

Österblom, H., and U. R. Sumaila. 2011. Toothfish crises, actor diversity and the emergence of compliance mechanisms in the Southern Ocean. *Global Environmental Change* 21(3):972–982. http://dx.doi.org/10.1016/j.gloenvcha.2011.04.013

Ostrom, E. 2007. A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Sciences* 104(39):15181–15187. http://dx.doi.org/10.1073/pnas.0702288104

Ostrom, W., J. Burger, C. B. Field, R. B. Norgaard, and D. Policansky. 1999. Revisiting the commons: local lessons, global challenges. *Science* 284(5412):278–282. http://dx.doi.org/10.1126/science.284.5412.278

Petticrew, M., and H. Roberts. 2006. *Systematic reviews in the social sciences.* Blackwell Publishing, Malden, Massachusetts, USA; Oxford, UK: Victoria, Australia. http://dx.doi.org/10.1002/9780470754887

Plummer, R., and D. Armitage. 2007. A resilience-based framework from evaluating adaptive co-management: linking ecology, economics and society in a complex world. *Ecological Economics* 61(1):62–74. http://dx.doi.org/https://doi.org/10.1016/j.ecolecon.2006.09.025

Plummer, R., and D. R. Armitage. 2010. Integrating perspectives on adaptive capacity and environmental governance. Pages 1–19 *in* R. Plummer and D. R. Armitage, editors. *Adaptive capacity and environmental governance.* Springer, New York, New York, USA. http://dx.doi.org/10.1007/978-3-642-12194-4_1

Pretty, J., A. Noble, D. Bossio, J. Dixon, R. E. Hine, F. W. T. Penning de Vries, and J. I. L. Morison. 2006. Resource-conserving agriculture increases yields in developing countries. *Environmental Science and Technology* 40(4):1114–1119. http://dx.doi.org/10.1021/es051670d

Reed, M. S., A. C. Evely, G. Cundill, I. Fazey, J. Glass, A. Laing, J. Newig, B. Parrish, C. Prell, C. Raymond, and L. C. Stringer. 2010. What is social learning? *Ecology and Society* 15(4): r1.

Robards, M. D., M. L. Schoon, C. L. Meek, and N. L. Engle. 2011. The importance of social drivers in the resilient provision of ecosystem services. *Global Environmental Change* 21(2):522–529. http://dx.doi.org/10.1016/j.gloenvcha.2010.12.004

Rudberg, P. M., M. Escobar, J. Gantenbein, and N. Niiro. 2015. Mitigating the adverse effects of hydropower projects: a comparative review of river restoration and hydropower regulation in Sweden and the United States. *The Georgetown International Environmental Law Review* 27:251–273

Schwandt, D. R., and D. B. Szabla. 2013. Structuration theories and complex adaptive social systems: inroads to describing human interaction dynamics. *Emergence: Complexity and Organization* 15(4):1–20.

Smit, B., and J. Wandel. 2006. Adaptation, adaptive capacity and vulnerability. *Global Environmental Change* 16(3):282–292. http://dx.doi.org/10.1016/j.gloenvcha.2006.03.008

Steffen, W., K. Richardson, J. Rockström, S. E. Cornell, I. Fetzer, E. M. Bennett, R. Biggs, S. R. Carpenter, W. de Vries, and C. A. de Wit. 2015. Planetary boundaries: guiding human development on a changing planet. *Science* 347(6223):1259855. http://dx.doi.org/10.1126/science.1259855

United Nations. 2011. *Report submitted by the Special Rapporteur on the right to food, Olivier De Schutter.* [online] URL: http://www.srfood.org/en/report-agroecology-and-the-right-to-food

United Nations. 2015. *Consensus reached on new sustainable development agenda to be adopted by world leaders in September.* [online] URL: http://www.un.org/sustainabledevelopment/blog/2015/08/transforming-our-world-document-adoption/

Urry, J. 2003. *Global complexity.* Polity Press, Cambridge/Oxford, UK.

Vetter, S. 2009. Drought, change and resilience in South Africa's arid and semi-arid rangelands. *South African Journal of Science* 105:29–33.

Walker, B., N. Abel, J. Anderies, and P. Ryan. 2009. Resilience, adaptability, and transformability in the Goulburn-Broken Catchment, Australia. *Ecology and Society* 14(1):12. http://dx.doi.org/10.5751/es-02824-140112

Walker, B., J. Anderies, A. Kinzig, and P. Ryan. 2006*a*. Exploring resilience in social–ecological systems through comparative studies and theory development: introduction to the special issue. *Ecology and Society* 11(1):12. http://dx.doi.org/https://doi.org/10.5751/ES-01573-110112

Walker, B., L. Gunderson, A. Kinzig, C. Folke, S. Carpenter, and L. Schultz. 2006*b*. A handful of heuristics and some propositions for understanding resilience in social–ecological systems. *Ecology and Society* 11(1):13. http://dx.doi.org/https://doi.org/10.5751/ES-01530-110113

Walker, B., C. S. Holling, S. R. Carpenter, and A. Kinzig. 2004. Resilience, adaptability and transformability in social–ecological systems. *Ecology and Society* 9(2):5. http://dx.doi.org/10.5751/es-00650-090205

Westley, F. 2002. The devil in the dynamics: adaptive management on the front lines. Pages 333–360 *in* L. H. Gunderson and C. S. Holling, editors. *Panarchy: understanding transformations in human and natural systems.* Island Press, Washington, D.C., USA.

Westley, F., S. R. Carpenter, W. A. Brock, C. S. Holling, and L. Gunderson. 2002. Why systems of people and nature are not just social and ecological systems. Pages 103–119 *in* L. H. Gunderson and C. S. Holling, editors. *Panarchy: understanding transformation in human and natural systems.* Island Press, Washington, D.C., USA.

Westley, F. R., O. Tjornbo, L. Schultz, P. Olsson, C. Folke, B. Crona, and Ö. Bodin. 2013. A theory of transformative agency in linked social–ecological systems. *Ecology and Society* 18:27. http://dx.doi.org/10.5751/es-05072-180327

Appendix

Table A1. Twelve examples of coding.

Reference	Important statements	Assessment Q1 Spontaneous(S) vs. Intentional(I) (B indicates Both)		Assessment Q2 Descriptive(D) vs. Normative(N)/Vaguely Normative(VN) (SP indicates Several Perspectives)	
Berkes (2010)	p. 495 Hence, successive loops of learning-as-participation help combine elements of adaptive management with elements of co-management. Each cycle starts with observation and identification of problems and opportunities, leading to action-reflection and further action. Outcomes of successive plans need to be monitored and evaluated, followed by reflection, to lead to the next cycle. Each cycle provides new information for the next iteration, and also serves as a learning step, leading to co-management at successively larger scales over time (Berkes 2009).	No reference to intentions or strategies. Loops of learning are assumed to emerge to co-management.	S	No particular system state or desirable end is referred to. The process of adaptive co-management is discussed descriptively.	D
Allison and Hobbs (2004)	p. 5 If each of the three properties (potential, connectedness, and resilience) in the adaptive cycle is given two nominal levels, either low or high, then the adaptive cycle model uses only four of a possible eight combinations (23) of the three properties, and two of the other four combinations are suggested as pathological states, labeled the poverty trap and the rigidity trap by Holling et al. (2002c), which are departures from the adaptive cycle (Fig. 3).	No discussion of strategies of actors, all events are just unfolding.	S	Adaptive cycle has pathological states that are less desirable, but no clear definitions of what these states are. Vaguely normative.	VN
Barthel et al. (2005)	p.16: need to develop a social capacity for urban ecosystem management to respond to change, and to develop policy directions that can help build resilience to deal with further change. Berkes et al. (2003) refer to such a capacity as “adaptive capacity.” p.16: A crucial part of building adaptive capacity is a governance system that can learn from experience and generate knowledge across organizational levels. p. 2: Finally, we discuss how their integration in adaptive co-management systems may provide more efficient management of biodiversity and ecosystem services in the NUP…. investigate how adaptive capacity can be built to better respond to social–ecological change	Building adaptive capacity requires governance and learning from experience, generating knowledge across organizational levels. No discussions of strategies or agendas.	S	Adaptive co-management tied to more efficient management of biodiversity and ecosystem services enabling better responses to social–ecological change	N
Schluter et al. (2009)	p 497 A farmer bases his labor allocation decision on an evaluation of the returns per effort obtained from his farming and fishing activities in the previous year. Hence, he adapts his strategy by learning from past experiences to find the mixture of activities that yields the highest returns per effort. p 501 This learning process and its transient dynamics can lead to suboptimal outcomes when agents do not have enough time or capital to adapt their strategy to the local conditions before going bankrupt. Diversification of water use by balancing the needs of different water users as demonstrated here can contribute to an enhancement of adaptive capacity and thus resilience.	Farmers are assumed to spontaneously learn from experience on a single parameter (yield). No analysis of actors strategies or agendas. Agents are predictable.	S	Several: both descriptive in terms of actors adaptations in the model studied; and vaguely normative, in terms of the overarching frame of enhancing resilience; and normative connotations to suboptimal outcomes.	SP

Atwell et al. (2010)	p. 1083. Resilience is not a normative term; system configurations characterized as resilient may be either desirable or undesirable. In particular, resilience theorists are interested in understanding where resilience, adaptive capacity, and the potential for innovation reside in linked social-ecological systems and how these attributes can be gained, lost, or preserved (Walker et al., 2002). p. 1083. In this type of trap, which has been referred to as the rigidity trap by resilience theorists (Gunderson and Holling, 2002; Allison and Hobbes, 2004; Atwell et al., 2009b), the high adaptive potential and connectedness of social actors makes it possible to continue to invest in the current way of doing agriculture, in spite of the mounting social and ecological deficits and economic inefficiencies (Harvey, 2004), associated with this trajectory. p. 1087. Our participants indicated that regional coordination of scientific monitoring, adaptive management, and enforceable environmental standards are foundational to long term,multi-objective change given the complexity of the Corn Belt system. While such an approach was seen by our workshop participants as having the potential to link agricultural and conservation objectives, they also indicated that macro-scale programs intended to mandate or coerce landscape change across private property boundaries are often resisted by stakeholder groups."	Clear discussions of different actors and interest of different groups	I	Resilience, and adaptive capacity, clearly seen as descriptive concepts.	D
Armitage et al. (2008)	p. 89. Woodhill (2002) considers social learning to be a ‘‘process by which society democratically adapts its core institutions to cope with social and ecological change in ways that will optimize the collective wellbeing of current and future generations’’. p. 91. In principle, the core of this learning-by-doing or ‘adaptive management’ approach involves flexible institutional and organizational arrangements that encourage reflection and innovative responses (e.g., modifying resource management strategies in the face of change). p. 93. foster more adaptive forms of co-management may require strategic combinations of various experimental approaches (from both the natural and social sciences) to enable diverse learning outcomes. p. 92. ‘where there is evidence of ongoing or continuous social learning, then social capital may be produced and/or increased, and a group or network may be open to new ideas and adaptive’ … highlight the importance of structured experimentation as a basis to foster more adaptive forms of co-management. p. 93. The participatory nature of adaptive co-management creates ideal conditions for collaboration required to support different learning strategies and enable different types of learning.... A potential strength of adaptive co-management is that it links groups and fosters knowledge synthesis	Adaptive management refers to reflexive arrangements by a group or network with regard to modify resource management strategies. Strategies of actors are thus considered. (Detta exempel visar hur svårt det kan bli för egentligen diskuterar de inte intentioner eller strategier explicit, men aktörer framställs som reflexiva vilket är vårt tredje krav	I	Adaptability linked to social learning which is framed as desirable, optimizing collective wellbeing for future generations	VN
Beier et al. (2009)	p. 9. Tongass system became rigid and maladaptive in response to a confluence of events that fostered simultaneous collapse dynamics in the policy and economic subsystems. Within 5 years of the passage of the TTRA, Tongass timber production declined by roughly 85% and stabilized at an output level equivalent to the pre-industrial production level (Fig. 1). p. 11. The preceding narrative suggests the importance of changes in federal policy and larger-scale economic factors as the key drivers of adaptive-cycle dynamics in Tongass governance. Policy mobilized much of the initial growth, provided much of the stability during the conservation phase, and served to destabilize—at first incrementally and then rather suddenly—the industrial forestry regime of the Tongass. p. 13. In the current state, Tongass managers are pitted between environmental advocacy groups (via litigation and appeals) and pro-timber legislators and executive officials (via budgets and national leadership). This situation acts to maintain day-to-day Tongass decision making in a highly stable but inflexible state that constrains managers from responding adaptively to changing conditions and, ultimately, from finding a sustainable direction for the future governance of the Tongass. As long as the dominant venues of stakeholder input in Tongass decision making are adversarial—i.e., through appeals and litigation— the institutional subsystem will remain “trapped” in the collapse [Ω] phase	Narrative draws on adaptive cycles, but results are clearly discussed in context of strategies of actors, and of policy making.	I	Maladaptive response equated with decline/collapse of forestry system. Inflexibility constrains adaptive responses and ultimately sustainability.	N

Adger (2006)	p. 277. As a result, adaptive actions often reduce the vulnerability of those best placed to take advantage of governance institutions, rather than reduce the vulnerability of the marginalized, or the undervalued parts of the social-ecological system (Adger et al., 2005a). p. 277. Adaptation does not necessarily entail changes in system boundaries in order to build resilience. And in the same fashion, adaptation strategies that include radical change of resource use (in location, economics or significant land use change for example) may not necessarily be a symptom of a lack of resilience.	Discussion of how adaptive actions in relation to vulnerability and resilience vary among actors with different opportunities.	I	Refer to undervalued parts of the social-ecological system which is clearly normative, but the adaptation process as such is described descriptively, with adaptations having different outcomes. Both normative and analytical use.	SP
Gotts (2007)	p. 6. There is a systematic ambiguity in the term "adaptive," as used in "adaptive cycle." The key question is: What adapts? In Holland (1992:184-185), adaptation is a property of organisms or of analogous components of an artificial system. p. 7. The panarchical perspective has also had little to say about the long-term growth of world population, energy use and polity size, and the power of technology available for human use. As with the comparative neglect of conflict and elite dynamics, this is perhaps unsurprising, given its disciplinary roots in economics, ecosystem science, institutional research, and adaptive complex system theory (Holling 2003). However, all these factors have enormous implications for the past and future development of social-ecological systems at all scales.	Several perspectives, review of adaptive cycle and adaptations therein. Notes that the adaptive cycle critically does not address power and political dimensions.	B	No particular norm. Theoretical discussion on adaptations only.	D
Janssen et al. (2007)	p. 309. systems subjected to a particular type and degree of variability may become highly optimized to tolerate this variability (this characteristic of adaptive systems is referred to as highly optimized tolerance or HOT). In so doing, how ever, the system may become more brittle and susceptible to changes that may occur in the type and degree of variability to which it has become highly adapted or to new types of disturbances. p. 311. We may distinguish two classes of adaptations. First, people have developed institutions over time, intentionally or not, to spread resource-use intensity over space and/or time in accordance with particular variability regimes. p. 312. The second class of adaptations is characterized by those directed at managing discrete disturbances like droughts, cyclones, and price fluctuations. p. 312. For example, from the perspective of higher level authorities, local SES might not be recognized as being well adapted to the challenges it faces The ambitions of higher level authorities may lead to changes in local institutions in the expectation of meeting their goals. Lack of understanding of the SES leads to an inability to meet participants' goals and a reduction of the performance of local and sometimes larger scale SESs.	Adaptations mentioned as intentional or not. Different agendas of actors referred to. But also framing of adaptations as spontaneous by 'systems' optimized to tolerate variability.	B	Vaguely normative e.g. local SES not recognized as being well adapted. Adaptation is about managing (negative) disturbance.	VN
Duit et al. (2010)	p. 364. Not only can the natural world be analyzed as a complex dynamic system. It is also possible to view human-made governance systems consisting of institutions, networks, bureaucracies, and policies as examples of complex systems inwhich adaptive agents respond to external and internal impulses (cf. Jervis, 1997; Arthur, 1999; Kooiman, 2003; Teisman et al., 2009). p 364. From field work across the world, the 23 case studies reveal a rich variety of circumstances ranging from environmental emergency migrants, flooding and resettlement suggesting an analytical distinction between rapid- and slow-onset events. She notes that the development community often characterizesmigration as a failure of adaptation, rather than as a formof adaptation to environmental and climate change. p 365. Such thorny normative and conceptual issues notwithstanding, resilience thinking also holds a great deal of potential for renewing thewider governance research agenda. In particular, it invites us to consider fundamental issues of change and stability, adaptation and design, hierarchy and self-organization in the study of multilevel governance systems. Moreover, in addition to ''tradi- tional'' benchmarks such as	Review CAS as applied to SES, but also discusses problem with spontaneous view and recognise that adaptations are always towards a norm.	Both	Discusses whether migration is a failure of adaptation. Vulnerability resulting from mal-adaptation is part of normative evaluation. But adaptation is also discussed in terms of adaptive agents responding to impulses.	SP

	efficacy, accountability, and equity usedwhen assessing public governance, a resilience perspective on governance would also consider issues of human–environmental interactions, vulnerability resulting from mal-adaptations, and innovation capacity as integral parts of evaluating a given governance system (Nelson et al., 2007).				
Hicks et al. (2009)	No discussion. "adapt*" appear in keywords only	NA	NA	NA	NA

Table A2. Categorisation of all 183 papers.

	Descriptive	**Normative**	**Vaguely normative**	**Several perspectives**
Spontaneous	Berkes, 2010; Bodin, 2009; Bodin, 2005; Bohensky, 2008; Booher, 2010; Carpenter, 2008; Cook et al., 2010; Cumming, 2005; Cundill, 2009; Folke, 2004; Folke et al., 2002; Gunderson et al., 2006; Guzy et al., 2008; Lebel et al., 2006; Levrel, 2008; Liu et al., 2007; Lubchenco, 2010; Mahon et al., 2008; Marschke, 2005; Matthews, 2006; McAllister et al., 2006; McIntyre, 2009; Moen, 2010; Nkhata, 2010; Robards, 2004; Saavedra, 2009; Strickland-Munro et al., 2010; Tyler et al., 2007; Vetter, 2009	Alessa et al., 2008; Anderies et al., 2006; Baral et al., 2010; Barthel et al., 2005; Chapin et al., 2010; Dearing, 2008; Elmqvist et al., 2004; Engle, 2010; Evans, 2008; Fischer et al., 2009; Gonzalez et al., 2008; Grafton, 2010; Hagerman et al., 2010; Hagerman et al., 2010; Holling, 2001; Krasny, 2010; Langridge et al., 2006; Loring, 2007; McFadden et al., 2009; O'Rourke, 2006; Peter et al., 2009; Rammel et al., 2007; Rescia et al., 2010; Sendzimir et al., 2008; Walker et al., 2009; Wang, 2009	Allison, 2004; Andrew et al., 2007; Badjeck et al., 2009; Beratan, 2007; Berkes, 2005; Biggs et al., 2010; Blackmore, 2008; Borgstrom et al., 2006; Brown, 2009; Buchmann, 2009; Bunce et al., 2010; Cowling et al., 2008; Darnhofer et al., 2010; Dawson et al., 2010; Fernandez-Gimenez et al., 2008; Hagerman et al., 2010; Higgins et al., 2010; Jackson et al., 2010; Kalikoski et al., 2010; Krasny, 2009; Lundholm, 2010; Marschke, 2006; Milestad, 2003; Milestad et al., 2010; Moser, 2010; Munoz-Erickson et al., 2007; Plummer, 2010; Schianetz, 2008; Turner et al., 2007; Warner, 2010	Schluter et al., 2009; Zhou et al., 2010
Intentional	Artwell et al. 2010; Ballard, 2010; Berkes, 2006; Brooks et al., 2008; Camargo et al., 2009; Cundill, 2010; Fazey, 2010; Fennell et al., 2008; Goldstein, 2008; Gooch, 2009; Hodge, 2007; Leach, 2008; Lof, 2010; Miller et al., 2008; O'Brien et al., 2009; Plummer, 2009; Robinson, 2009; Serrat-Capdevila et al., 2009; Smith, 2010; Trainor et al., 2009; Tschakert et al., 2008; Young et al., 2006	Abel et al., 2006; Armitage et al., 2009; Berkes, 2007; Bingeman et al., 2004; Birkmann, 2010; Ericksen, 2008; Fabricius et al., 2007; Folke et al., 2005; Galaz, 2005; Hahn et al., 2006; Milman, 2008; Olsson, 2001; Olsson et al., 2004a; Powell et al., 2009; Schultz, 2010; Spies et al., 2010; Walker et al., 2002; Walker et al., 2006	Armitage et al., 2008; Barnett, 2001; Berkes, 2002; Boyd, 2010; Chapin et al., 2006; Fazey et al., 2007; Kofinas et al., 2010; Marshall, 2007; Nelson et al., 2010; Olsson et al., 2004b; Sandstrom, 2010	Adger, 2006; Biermann et al., 2010
Both spontaneous and intentional	Gotts, 2007; Gunderson, 2010; Gupta et al., 2010; Miller et al., 2010; Schluter, 2007; van der Brugge, 2007	Beier et al., 2009; Folke, 2003; Folke et al., 2007; Olsson et al., 2007; Olsson et al., 2006; Rescia et al., 2008; Walker et al., 2004	Janssen et al., 2007; Nelson et al., 2007; Nelson, 2009; Renaud et al., 2010; Tidball et al., 2010; Wardekker et al., 2010; Young, 2010	Duit et al., 2010; Folke, 2006; Gallopin, 2006; Johnson, 2010; Marshall, 2010; Osbahr et al., 2008; Osbahr et al., 2010; Plummer, 2009; Turner, 2010

Table A3. List of all 183 papers for the structured literature review.

Author (AU)	Year (PY)	Title (TI)	Source (SO)	Volu-me (VL)	Issue (IS)	Page from (BP)	Page to (EP)
Abel, N; Cumming, DHM; Anderies, JM	2006	Collapse and reorganization in social-ecological systems: Questions, some ideas, and policy implications	ECOLOGY AND SOCIETY	11	1		
Adger, WN	2006	Vulnerability	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	16	3	268	281
Alessa, L; Kliskey, A; Busey, R; Hinzman, L; White, D	2008	Freshwater vulnerabilities and resilience on the Seward Peninsula: Integrating multiple dimensions of landscape change	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	18	2	256	270
Allison, HE; Hobbs, RJ	2004	Resilience, adaptive capacity, and the "Lock-in trap" of the Western Australian agricultural region	ECOLOGY AND SOCIETY	9	1		
Anderies, JM; Ryan, P; Walker, BH	2006	Loss of resilience, crisis, and institutional change: Lessons from an intensive agricultural system in southeastern Australia	ECOSYSTEMS	9	6	865	878
Andrew, NL; Bene, C; Hall, SJ; Allison, EH; Heck, S; Ratner, BD	2007	Diagnosis and management of small-scale fisheries in developing countries	FISH AND FISHERIES	8	3	227	240
Armitage, D; Marschke, M; Plummer, R	2008	Adaptive co-management and the paradox of learning	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	18	1	86	98
Armitage, DR; Plummer, R; Berkes, F; Arthur, RI; Charles, AT; Davidson-Hunt, IJ; Diduck, AP; Doubleday, NC; Johnson, DS; Marschke, M; McConney, P; Pinkerton, EW; Wollenberg, EK	2009	Adaptive co-management for social-ecological complexity	FRONTIERS IN ECOLOGY AND THE ENVIRONMENT	7	2	95	102
Asah, ST	2008	Empirical Social-Ecological System Analysis: From Theoretical Framework to Latent Variable Structural Equation Model	ENVIRONMENTAL MANAGEMENT	42	6	1077	1090
Atwell, RC; Schulte, LA; Westphal, LM	2009	Linking Resilience Theory and Diffusion of Innovations Theory to Understand the Potential for Perennials in the US Corn Belt	ECOLOGY AND SOCIETY	14	1		
Atwell, RC; Schulte, LA; Westphal, LM	2010	How to build multifunctional agricultural landscapes in the US Corn Belt: Add perennials and partnerships	LAND USE POLICY	27	4	1082	1090
Badjeck, MC; Mendo, J; Wolff, M; Lange, H	2009	Climate variability and the Peruvian scallop fishery: the role of formal institutions in resilience building	CLIMATIC CHANGE	94	40545	211	232
Ballard, HL; Belsky, JM	2010	Participatory action research and environmental learning: implications for resilient forests and communities	ENVIRONMENTAL EDUCATION RESEARCH	16	40669	611	627
Baral, N; Stern, MJ; Heinen, JT	2010	Growth, Collapse, and Reorganization of the Annapurna Conservation Area, Nepal: an Analysis of Institutional Resilience	ECOLOGY AND SOCIETY	15	3		

Barnett, J	2001	Adapting to climate change in Pacific Island Countries: The problem of uncertainty	WORLD DEVELOPMENT	29	6	977	993
Barthel, S; Colding, J; Elmqvist, T; Folke, C	2005	History and local management of a biodiversity-rich, urban cultural landscape	ECOLOGY AND SOCIETY	10	2		
Beier, CM; Lovecraft, AL; Chapin, FS	2009	Growth and Collapse of a Resource System: an Adaptive Cycle of Change in Public Lands Governance and Forest Management in Alaska	ECOLOGY AND SOCIETY	14	2		
Beier, CM; Patterson, TM; Chapin, FS	2008	Ecosystem services and emergent vulnerability in managed ecosystems: A geospatial decision-support tool	ECOSYSTEMS	11	6	923	938
Beratan, KK	2007	A cognition-based view of decision processes in complex social-ecological systems	ECOLOGY AND SOCIETY	12	1		
Berkes, F	2007	Understanding uncertainty and reducing vulnerability: lessons from resilience thinking	NATURAL HAZARDS	41	2	283	295
Berkes, F	2010	Devolution of environment and resources governance: trends and future	ENVIRONMENTAL CONSERVATION	37	4	489	500
Berkes, F; Jolly, D	2002	Adapting to climate change: Social-ecological resilience in a Canadian Western Arctic community	CONSERVATION ECOLOGY	5	2		
Berkes, F; Seixas, CS	2005	Building resilience in lagoon social-ecological systems: A local-level perspective	ECOSYSTEMS	8	8	967	974
Berkes, F; Turner, NJ	2006	Knowledge, learning and the evolution of conservation practice for social-ecological system resilience	HUMAN ECOLOGY	34	4	479	494
Biermann, F; Betsill, MM; Vieira, SC; Gupta, J; Kanie, N; Lebel, L; Liverman, D; Schroeder, H; Siebenhuner, B; Yanda, PZ; Zondervan, R	2010	Navigating the anthropocene: the Earth System Governance Project strategy paper	CURRENT OPINION IN ENVIRONMENTAL SUSTAINABILITY	2	3	202	208
Biggs, R; Westley, FR; Carpenter, SR	2010	Navigating the Back Loop: Fostering Social Innovation and Transformation in Ecosystem Management	ECOLOGY AND SOCIETY	15	2		
Bingeman, K; Berkes, F; Gardner, JS	2004	Institutional responses to development pressures: Resilience of social-ecological systems in Himachal Pradesh, India	INTERNATIONAL JOURNAL OF SUSTAINABLE DEVELOPMENT AND WORLD ECOLOGY	11	1	99	115
Birkmann, J; von Teichman, K	2010	Integrating disaster risk reduction and climate change adaptation: key challenges-scales, knowledge, and norms	SUSTAINABILITY SCIENCE	5	2	171	184
Blackmore, JM; Plant, RAJ	2008	Risk and resilience to enhance sustainability with application to urban water systems	JOURNAL OF WATER RESOURCES PLANNING AND MANAGEMENT-ASCE	134	3	224	233
Bodin, O; Crona, BI	2009	The role of social networks in natural resource governance: What relational patterns make a difference?	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	19	3	366	374
Bodin, O; Norberg, J	2005	Information network topologies for enhanced local adaptive management	ENVIRONMENTAL MANAGEMENT	35	2	175	193

Bohensky, EL	2008	Discovering Resilient Pathways for South African Water Management: Two Frameworks for a Vision	ECOLOGY AND SOCIETY	13	1		
Booher, DE; Innes, JE	2010	Governance for Resilience: CALFED as a Complex Adaptive Network for Resource Management	ECOLOGY AND SOCIETY	15	3		
Borgstrom, ST; Elmqvist, T; Angelstam, P; Alfsen-Norodom, C	2006	Scale mismatches in management of urban landscapes	ECOLOGY AND SOCIETY	11	2		
Boyd, E; Osbahr, H	2010	Responses to climate change: exploring organisational learning across internationally networked organisations for development	ENVIRONMENTAL EDUCATION RESEARCH	16	40669	629	643
Brooks, S; Reynolds, J; Allison, E	2008	Sustained by Snakes? Seasonal Livelihood Strategies and Resource Conservation by Tonle Sap Fishers in Cambodia	HUMAN ECOLOGY	36	6	835	851
Brown, HCP	2009	Climate change and Ontario forests: Prospects for building institutional adaptive capacity	MITIGATION AND ADAPTATION STRATEGIES FOR GLOBAL CHANGE	14	6	513	536
Buchmann, C	2009	Cuban Home Gardens and Their Role in Social-Ecological Resilience	HUMAN ECOLOGY	37	6	705	721
Bunce, M; Brown, K; Rosendo, S	2010	Policy misfits, climate change and cross-scale vulnerability in coastal Africa: how development projects undermine resilience	ENVIRONMENTAL SCIENCE & POLICY	13	6	485	497
Camargo, C; Maldonado, JH; Alvarado, E; Moreno-Sanchez, R; Mendoza, S; Manrique, N; Mogollon, A; Osorio, JD; Grajales, A; Sanchez, JA	2009	Community involvement in management for maintaining coral reef resilience and biodiversity in southern Caribbean marine protected areas	BIODIVERSITY AND CONSERVATION	18	4	935	956
Carpenter, SR; Brock, WA	2008	Adaptive Capacity and Traps	ECOLOGY AND SOCIETY	13	2		
Chapin, FS; Carpenter, SR; Kofinas, GP; Folke, C; Abel, N; Clark, WC; Olsson, P; Smith, DMS; 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 IN ECOLOGY & EVOLUTION	25	4	241	249
Chapin, FS; Lovecraft, AL; Zavaleta, ES; Nelson, J; Robards, MD; Kofinas, GP; Trainor, SF; Peterson, GD; Huntington, HP; Naylor, RL	2006	Policy strategies to address sustainability of Alaskan boreal forests in response to a directionally changing climate	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	103	45	16637	16643
Cook, DC; Liu, SG; Murphy, B; Lonsdale, WM	2010	Adaptive Approaches to Biosecurity Governance	RISK ANALYSIS	30	9	1303	1314
Cowling, RM; Egoh, B; Knight, AT; O'Farrell, PJ; Reyers, B; Rouget'll, M; Roux, DJ; Welz, A; Wilhelm-Rechman, A	2008	An operational model for mainstreaming ecosystem services for implementation	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	105	28	9483	9488
Craig, RK	2010	STATIONARITY IS DEAD - LONG LIVE TRANSFORMATION: FIVE PRINCIPLES FOR CLIMATE CHANGE ADAPTATION LAW	HARVARD ENVIRONMENTAL LAW REVIEW	34	1	9	73
Cumming, GS; Collier, J	2005	Change and identity in complex systems	ECOLOGY AND SOCIETY	10	1		
Cundill, G; Fabricius, C	2009	Monitoring in adaptive co-management: Toward a learning based approach	JOURNAL OF ENVIRONMENTAL MANAGEMENT	90	11	3205	3211

Cundill, G; Fabricius, C	2010	Monitoring the Governance Dimension of Natural Resource Co-management	ECOLOGY AND SOCIETY	15	1		
Darnhofer, I; Fairweather, J; Moller, H	2010	Assessing a farm's sustainability: insights from resilience thinking	INTERNATIONAL JOURNAL OF AGRICULTURAL SUSTAINABILITY	8	3	186	198
Dawson, TP; Rounsevell, MDA; Kluvankova-Oravska, T; Chobotova, V; Stirling, A	2010	Dynamic properties of complex adaptive ecosystems: implications for the sustainability of service provision	BIODIVERSITY AND CONSERVATION	19	10	2843	2853
Dearing, JA	2008	Landscape change and resilience theory: a palaeoenvironmental assessment from Yunnan, SW China	HOLOCENE	18	1	117	127
Dikau, R	2006	Complex systems in geomorphology	MITTEILUNGEN DER OSTERREICHISCHEN GEOGRAPHISCHEN GESELLSCHAFT	148		125	150
Duit, A; Galaz, V; Eckerberg, K; Ebbesson, J	2010	Governance, complexity, and resilience Introduction	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	20	3	363	368
Elmqvist, T; Colding, J; Barthel, S; Borgstrom, S; Duit, A; Lundberg, J; Andersson, E; Ahrne, K; Ernstson, H; Folke, C; Bengtsson, J	2004	The dynamics of social-ecological systems in urban landscapes - Stockholm and the National Urban Park, Sweden	URBAN BIOSPHERE AND SOCIETY: PARTNERSHIP OF CITIES	1023		308	322
Engle, NL; Lemos, MC	2010	Unpacking governance: Building adaptive capacity to climate change of river basins in Brazil	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	20	1	4	13
Ericksen, PJ	2008	What Is the Vulnerability of a Food System to Global Environmental Change?	ECOLOGY AND SOCIETY	13	2		
Evans, GR	2008	Transformation from "Carbon Valley" to a "Post-Carbon Society" in a Climate Change Hot Spot: the Coalfields of the Hunter Valley, New South Wales, Australia	ECOLOGY AND SOCIETY	13	1		
Fabricius, C; Folke, C; Cundill, G; Schultz, L	2007	Powerless spectators, coping actors, and adaptive co-managers: a synthesis of the role of communities in ecosystem management	ECOLOGY AND SOCIETY	12	1		
Fazey, I	2010	Resilience and Higher Order Thinking	ECOLOGY AND SOCIETY	15	3		
Fazey, I; Fazey, JA; Fischer, J; Sherren, K; Warren, J; Noss, RF; Dovers, SR	2007	Adaptive capacity and learning to learn as leverage for social-ecological resilience	FRONTIERS IN ECOLOGY AND THE ENVIRONMENT	5	7	375	380
Fennell, D; Plummer, R; Marschke, M	2008	Is adaptive co-management ethical?	JOURNAL OF ENVIRONMENTAL MANAGEMENT	88	1	62	75
Fernandez-Gimenez, ME; Ballard, HL; Sturtevant, VE	2008	Adaptive Management and Social Learning in Collaborative and Community-Based Monitoring: a Study of Five Community-Based Forestry Organizations in the western USA	ECOLOGY AND SOCIETY	13	2		
Fischer, J; Peterson, GD; Gardner, TA; Gordon, LJ; Fazey, I; Elmqvist, T; Felton, A; Folke, C; Dovers, S	2009	Integrating resilience thinking and optimisation for conservation	TRENDS IN ECOLOGY & EVOLUTION	24	10	549	554
Folke, C	2004	Traditional knowledge in social-ecological systems	ECOLOGY AND SOCIETY	9	3		

Folke, C	2003	Freshwater for resilience: a shift in thinking	PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY OF LONDON SERIES B-BIOLOGICAL SCIENCES	358	1440	2027	2036
Folke, C	2006	Resilience: The emergence of a perspective for social-ecological systems analyses	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	16	3	253	267
Folke, C; Carpenter, S; Elmqvist, T; Gunderson, L; Holling, CS; Walker, B	2002	Resilience and sustainable development: Building adaptive capacity in a world of transformations	AMBIO	31	5	437	440
Folke, C; Hahn, T; Olsson, P; Norberg, J	2005	Adaptive governance of social-ecological systems	ANNUAL REVIEW OF ENVIRONMENT AND RESOURCES	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	ECOLOGY AND SOCIETY	12	1		
Galaz, V	2005	Social-ecological resilience and social conflict: Institutions and strategic adaptation in Swedish water management	AMBIO	34	7	567	572
Gallopin, GC	2006	Linkages between vulnerability, resilience, and adaptive capacity	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	16	3	293	303
Goldstein, BE	2008	Skunkworks in the embers of the Cedar fire: Enhancing resilience in the aftermath of disaster	HUMAN ECOLOGY	36	1	15	28
Gonzalez, JA; Montes, C; Rodriguez, J; Tapia, W	2008	Rethinking the Galapagos Islands as a Complex Social-Ecological System: Implications for Conservation and Management	ECOLOGY AND SOCIETY	13	2		
Gooch, M; Warburton, J	2009	Building and Managing Resilience in Community-Based NRM Groups: An Australian Case Study	SOCIETY & NATURAL RESOURCES	22	2	158	171
Gotts, NM	2007	Resilience, panarchy, and world-systems analysis	ECOLOGY AND SOCIETY	12	1		
Grafton, RQ	2010	Adaptation to climate change in marine capture fisheries	MARINE POLICY	34	3	606	615
Gunderson, L	2010	Ecological and Human Community Resilience in Response to Natural Disasters	ECOLOGY AND SOCIETY	15	2		
Gunderson, LH; Carpenter, SR; Folke, C; Olsson, P; Peterson, G	2006	Water RATs (resilience, adaptability, and transformability) in lake and wetland social-ecological systems	ECOLOGY AND SOCIETY	11	1		
Gupta, J; Termeer, C; Klostermann, J; Meijerink, S; van den Brink, M; Jong, P; Nooteboom, S; Bergsma, E	2010	The Adaptive Capacity Wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society	ENVIRONMENTAL SCIENCE & POLICY	13	6	459	471
Guzy, MR; Smith, CL; Bolte, JP; Hulse, DW; Gregory, SV	2008	Policy Research Using Agent-Based Modeling to Assess Future Impacts of Urban Expansion into Farmlands and Forests	ECOLOGY AND SOCIETY	13	1		
Hagerman, S; Dowlatabadi, H; Chan, KMA; Satterfield, T	2010	Integrative propositions for adapting conservation policy to the impacts of climate change	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	20	2	351	362

Hagerman, S; Dowlatabadi, H; Satterfield, T; McDaniels, T	2010	Expert views on biodiversity conservation in an era of climate change	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	20	1	192	207
Hagerman, SM; Dowlatabadi, H; Satterfield, T	2010	Observations on Drivers and Dynamics of Environmental Policy Change: Insights from 150 Years of Forest Management in British Columbia	ECOLOGY AND SOCIETY	15	1		
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 ECOLOGY	34	4	573	592
Hicks, CC; McClanahan, TR; Cinner, JE; Hills, JM	2009	Trade-Offs in Values Assigned to Ecological Goods and Services Associated with Different Coral Reef Management Strategies	ECOLOGY AND SOCIETY	14	1		
Higgins, AJ; Miller, CJ; Archer, AA; Ton, T; Fletcher, CS; McAllister, RRJ	2010	Challenges of operations research practice in agricultural value chains	JOURNAL OF THE OPERATIONAL RESEARCH SOCIETY	61	6	964	973
Hodge, I	2007	The governance of rural land in a liberalised world	JOURNAL OF AGRICULTURAL ECONOMICS	58	3	409	432
Holling, CS	2001	Understanding the complexity of economic, ecological, and social systems	ECOSYSTEMS	4	5	390	405
Jackson, L; van Noordwijk, M; Bengtsson, J; Foster, W; Lipper, L; Pulleman, M; Said, M; Snaddon, J; Vodouhe, R	2010	Biodiversity and agricultural sustainagility: from assessment to adaptive management	CURRENT OPINION IN ENVIRONMENTAL SUSTAINABILITY	2	40545	80	87
Janssen, MA; Anderies, JM; Ostrom, E	2007	Robustness of social-ecological systems to spatial and temporal variability	SOCIETY & NATURAL RESOURCES	20	4	307	322
Johnson, DS	2010	Institutional adaptation as a governability problem in fisheries: patron-client relations in the Junagadh fishery, India	FISH AND FISHERIES	11	3	264	277
Kalikoski, DC; Neto, PQ; Almudi, T	2010	Building adaptive capacity to climate variability: The case of artisanal fisheries in the estuary of the Patos Lagoon, Brazil	MARINE POLICY	34	4	742	751
Kofinas, GP; Chapin, FS; BurnSilver, S; Schmidt, JI; Fresco, NL; Kielland, K; Martin, S; Springsteen, A; Rupp, TS	2010	Resilience of Athabascan subsistence systems to interior Alaska's changing climate	CANADIAN JOURNAL OF FOREST RESEARCH-REVUE CANADIENNE DE RECHERCHE FORESTIERE	40	7	1347	1359
Krasny, ME; Lundholm, C; Plummer, R	2010	Environmental education, resilience, and learning: reflection and moving forward	ENVIRONMENTAL EDUCATION RESEARCH	16	40669	665	672
Krasny, ME; Roth, WM	2010	Environmental education for social-ecological system resilience: a perspective from activity theory	ENVIRONMENTAL EDUCATION RESEARCH	16	40669	545	558
Krasny, ME; Tidball, KG	2009	Applying a resilience systems framework to urban environmental education	ENVIRONMENTAL EDUCATION RESEARCH	15	4	465	482
Krasny, ME; Tidball, KG; Sriskandarajah, N	2009	Education and Resilience: Social and Situated Learning among University and Secondary Students	ECOLOGY AND SOCIETY	14	2		

Langridge, R; Christian-Smith, J; Lohse, KA	2006	Access and resilience: Analyzing the construction of social resilience to the threat of water scarcity	ECOLOGY AND SOCIETY	11	2		
Leach, M	2008	Pathways to Sustainability in the forest? Misunderstood dynamics and the negotiation of knowledge, power, and policy	ENVIRONMENT AND PLANNING A	40	8	1783	1795
Leach, M; Scoones, I; Stirling, A	2010	Governing epidemics in an age of complexity: Narratives, politics and pathways to sustainability	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	20	3	369	377
Lebel, L; Anderies, JM; Campbell, B; Folke, C; Hatfield-Dodds, S; Hughes, TP; Wilson, J	2006	Governance and the capacity to manage resilience in regional social-ecological systems	ECOLOGY AND SOCIETY	11	1		
Levrel, H; Bouamrane, M	2008	Instrumental Learning and Sustainability Indicators: Outputs from Co-Construction Experiments in West African Biosphere Reserves	ECOLOGY AND SOCIETY	13	1		
Liu, JG; Dietz, T; Carpenter, SR; Folke, C; Alberti, M; Redman, CL; Schneider, SH; Ostrom, E; Pell, AN; Lubchenco, J; Taylor, WW; Ouyang, ZY; Deadman, P; Kratz, T; Provencher, W	2007	Coupled human and natural systems	AMBIO	36	8	639	649
Lof, A	2010	Exploring adaptability through learning layers and learning loops	ENVIRONMENTAL EDUCATION RESEARCH	16	40669	529	543
Loring, PA	2007	The most resilient show on earth: The circus as a model for viewing identity, change, and chaos	ECOLOGY AND SOCIETY	12	1		
Lubchenco, J; Petes, LE	2010	The Interconnected Biosphere: Science at the Ocean's Tipping Points	OCEANOGRAPHY	23	2	115	129
Lundholm, C; Plummer, R	2010	Resilience and learning: a conspectus for environmental education	ENVIRONMENTAL EDUCATION RESEARCH	16	40669	475	491
MacMynowski, DP	2007	Across space and time: Social responses to large-scale biophysical systems	ENVIRONMENTAL MANAGEMENT	39	6	831	842
Mahon, R; McConney, P; Roy, RN	2008	Governing fisheries as complex adaptive systems	MARINE POLICY	32	1	104	112
Marschke, M; Berkes, F	2005	Local level sustainability planning for livelihoods: A Cambodian experience	INTERNATIONAL JOURNAL OF SUSTAINABLE DEVELOPMENT AND WORLD ECOLOGY	12	1	21	33
Marschke, MJ; Berkes, F	2006	Exploring strategies that build livelihood resilience: a case from Cambodia	ECOLOGY AND SOCIETY	11	1		
Marshall, GR; Smith, DMS	2010	Natural resources governance for the drylands of the Murray-Darling Basin	RANGELAND JOURNAL	32	3	267	282
Marshall, NA; Marshall, PA	2007	Conceptualizing and operationalizing social resilience within commercial fisheries in northern Australia	ECOLOGY AND SOCIETY	12	1		
Matthews, R; Selman, P	2006	Landscape as a focus for integrating human and environmental processes	JOURNAL OF AGRICULTURAL ECONOMICS	57	2	199	212
McAllister, RRJ; Abel, N; Stokes, CJ; Gordon, IJ	2006	Australian pastoralists in time and space: The evolution of a complex adaptive system	ECOLOGY AND SOCIETY	11	2		
McFadden, L; Penning-Rowsell, E; Tapsell, S	2009	Strategic coastal flood-risk management in practice: Actors' perspectives on the integration of flood risk management in London and the Thames Estuary	OCEAN & COASTAL MANAGEMENT	52	12	636	645

McIntyre, N	2009	Rethinking Amenity Migration: Integrating Mobility, Lifestyle and Social-Ecological Systems	ERDE	140	3	229	250
Milestad, R; Darnhofer, I	2003	Building farm resilience: The prospects and challenges of organic farming	JOURNAL OF SUSTAINABLE AGRICULTURE	22	3	81	97
Milestad, R; Westberg, L; Geber, U; Bjorklund, J	2010	Enhancing Adaptive Capacity in Food Systems: Learning at Farmers' Markets in Sweden	ECOLOGY AND SOCIETY	15	3		
Miller, F; Osbahr, H; Boyd, E; Thomalla, F; Bharwani, S; Ziervogel, G; Walker, B; Birkmann, J; van der Leeuw, S; Rockstrom, J; Hinkel, J; Downing, T; Folke, C; Nelson, D	2010	Resilience and Vulnerability: Complementary or Conflicting Concepts?	ECOLOGY AND SOCIETY	15	3		
Miller, TR; Baird, TD; Littlefield, CM; Kofinas, G; Chapin, FS; Redman, CL	2008	Epistemological Pluralism: Reorganizing Interdisciplinary Research	ECOLOGY AND SOCIETY	13	2		
Milman, A; Short, A	2008	Incorporating resilience into sustainability indicators: An example for the urban water sector	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	18	4	758	767
Moen, J; Keskitalo, ECH	2010	Interlocking panarchies in multi-use boreal forests in Sweden	ECOLOGY AND SOCIETY	15	3		
Moser, SC	2010	Now more than ever: The need for more societally relevant research on vulnerability and adaptation to climate change	APPLIED GEOGRAPHY	30	4	464	474
Munoz-Erickson, TA; Aguilar-Gonzalez, B; Sisk, TD	2007	Linking ecosystem health indicators and collaborative management: a systematic framework to evaluate ecological and social outcomes	ECOLOGY AND SOCIETY	12	2		
Nelson, DR; Adger, WN; Brown, K	2007	Adaptation to environmental change: Contributions of a resilience framework	ANNUAL REVIEW OF ENVIRONMENT AND RESOURCES	32		395	419
Nelson, DR; Finan, TJ	2009	Praying for Drought: Persistent Vulnerability and the Politics of Patronage in Ceara, Northeast Brazil	AMERICAN ANTHROPOLOGIST	111	3	302	316
Nelson, R; Kokic, P; Crimp, S; Meinke, H; Howden, SM	2010	The vulnerability of Australian rural communities to climate variability and change: Part I-Conceptualising and measuring vulnerability	ENVIRONMENTAL SCIENCE & POLICY	13	1	8	17
Nkhata, BA; Breen, C	2010	A Framework for Exploring Integrated Learning Systems for the Governance and Management of Public Protected Areas	ENVIRONMENTAL MANAGEMENT	45	2	403	413
Nkhata, BA; Breen, CM	2010	Performance of community-based natural resource governance for the Kafue Flats (Zambia)	ENVIRONMENTAL CONSERVATION	37	3	296	302
O'Brien, K; Hayward, B; Berkes, F	2009	Rethinking Social Contracts: Building Resilience in a Changing Climate	ECOLOGY AND SOCIETY	14	2		
Olsson, P; Folke, C	2001	Local ecological knowledge and institutional dynamics for ecosystem management: A study of Lake Racken Watershed, Sweden	ECOSYSTEMS	4	2	85	104
Olsson, P; Folke, C; Berkes, F	2004a	Adaptive comanagement for building resilience in social-ecological systems	ENVIRONMENTAL MANAGEMENT	34	1	75	90
Olsson, P; Folke, C; Galaz, V; Hahn, T; Schultz, L	2007	Enhancing the fit through adaptive co-management: Creating and maintaining bridging functions for matching scales in the Kristianstads Vattenrike Biosphere Reserve, Sweden	ECOLOGY AND SOCIETY	12	1		
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	ECOLOGY AND SOCIETY	9	4		

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	ECOLOGY AND SOCIETY	11	1		
O'Rourke, E	2006	Biodiversity and land use change on the Causse Mejan, France	BIODIVERSITY AND CONSERVATION	15	8	2611	2626
Osbahr, H; Twyman, C; Adger, WN; Thomas, DSG	2008	Effective livelihood adaptation to climate change disturbance: Scale dimensions of practice in Mozambique	GEOFORUM	39	6	1951	1964
Osbahr, H; Twyman, C; Adger, WN; Thomas, DSG	2010	Evaluating Successful Livelihood Adaptation to Climate Variability and Change in Southern Africa	ECOLOGY AND SOCIETY	15	2		
Peter, C; de Lange, W; Musango, JK; April, K; Potgieter, A	2009	Applying Bayesian modelling to assess climate change effects on biofuel production	CLIMATE RESEARCH	40	40577	249	260
Plummer, R	2009	The Adaptive Co-Management Process: an Initial Synthesis of Representative Models and Influential Variables	ECOLOGY AND SOCIETY	14	2		
Plummer, R	2010	Social-ecological resilience and environmental education: synopsis, application, implications	ENVIRONMENTAL EDUCATION RESEARCH	16	40669	493	509
Plummer, R; Fennell, DA	2009	Managing protected areas for sustainable tourism: prospects for adaptive co-management	JOURNAL OF SUSTAINABLE TOURISM	17	2	149	168
Powell, RB; Cuschnir, A; Peiris, P	2009	Overcoming Governance and Institutional Barriers to Integrated Coastal Zone, Marine Protected Area, and Tourism Management in Sri Lanka	COASTAL MANAGEMENT	37	6	633	655
Rammel, C; Stagl, S; Wilfing, H	2007	Managing complex adaptive systems - A co-evolutionary perspective on natural resource management	ECOLOGICAL ECONOMICS	63	1	9	21
Renaud, FG; Birkmann, J; Damm, M; Gallopin, GC	2010	Understanding multiple thresholds of coupled social-ecological systems exposed to natural hazards as external shocks	NATURAL HAZARDS	55	3	749	763
Rescia, AJ; Pons, A; Lomba, I; Esteban, C; Dover, JW	2008	Reformulating the social-ecological system in a cultural rural mountain landscape in the Picos de Europa region (northern Spain)	LANDSCAPE AND URBAN PLANNING	88	1	23	33
Rescia, AJ; Willaarts, BA; Schmitz, MF; Aguilera, PA	2010	Changes in land uses and management in two Nature Reserves in Spain: Evaluating the social-ecological resilience of cultural landscapes	LANDSCAPE AND URBAN PLANNING	98	1	26	35
Robards, M; Alessa, L	2004	Timescapes of community resilience and vulnerability in the circumpolar north	ARCTIC	57	4	415	427
Robinson, LW	2009	A Complex-Systems Approach to Pastoral Commons	HUMAN ECOLOGY	37	4	441	451
Romieu, E; Welle, T; Schneiderbauer, S; Pelling, M; Vinchon, C	2010	Vulnerability assessment within climate change and natural hazard contexts: revealing gaps and synergies through coastal applications	SUSTAINABILITY SCIENCE	5	2	159	170
Saavedra, C; Budd, WW	2009	Climate change and environmental planning: Working to build community resilience and adaptive capacity in Washington State, USA	HABITAT INTERNATIONAL	33	3	246	252
Sandstrom, A; Rova, C	2010	Adaptive Co-management Networks: a Comparative Analysis of Two Fishery Conservation Areas in Sweden	ECOLOGY AND SOCIETY	15	3		
Schianetz, K; Kavanagh, L	2008	Sustainability Indicators for Tourism Destinations: A Complex Adaptive Systems Approach Using Systemic Indicator Systems	JOURNAL OF SUSTAINABLE TOURISM	16	6	601	628
Schluter, M; Leslie, H; Levin, S	2009	Managing water-use trade-offs in a semi-arid river delta to sustain multiple ecosystem services: a modeling approach	ECOLOGICAL RESEARCH	24	3	491	503
Schluter, M; Pahl-Wostl, C	2007	Mechanisms of resilience in common-pool resource management systems: an agent-based model of water use in a river basin	ECOLOGY AND SOCIETY	12	2		

Schultz, L; Lundholm, C	2010	Learning for resilience? Exploring learning opportunities in biosphere reserves	ENVIRONMENTAL EDUCATION RESEARCH	16	40669	645	663
Sendzimir, J; Magnuszewski, P; Flachner, Z; Balogh, P; Molnar, G; Sarvari, A; Nagy, Z	2008	Assessing the Resilience of a River Management Regime: Informal Learning in a Shadow Network in the Tisza River Basin	ECOLOGY AND SOCIETY	13	1		
Serrat-Capdevila, A; Browning-Aiken, A; Lansey, K; Finan, T; Valdes, JB	2009	Increasing Social-Ecological Resilience by Placing Science at the Decision Table: the Role of the San Pedro Basin (Arizona) Decision-Support System Model	ECOLOGY AND SOCIETY	14	1		
Smith, A; Stirling, A	2010	The Politics of Social-ecological Resilience and Sustainable Socio-technical Transitions	ECOLOGY AND SOCIETY	15	1		
Spies, TA; Giesen, TW; Swanson, FJ; Franklin, JF; Lach, D; Johnson, KN	2010	Climate change adaptation strategies for federal forests of the Pacific Northwest, USA: ecological, policy, and socio-economic perspectives	LANDSCAPE ECOLOGY	25	8	1185	1199
Steinberg, PF	2009	Institutional Resilience Amid Political Change: The Case of Biodiversity Conservation	GLOBAL ENVIRONMENTAL POLITICS	9	3	61	+
Strickland-Munro, JK; Allison, HE; Moore, SA	2010	USING RESILIENCE CONCEPTS TO INVESTIGATE THE IMPACTS OF PROTECTED AREA TOURISM ON COMMUNITIES	ANNALS OF TOURISM RESEARCH	37	2	499	519
Tidball, KG; Krasny, ME; Svendsen, E; Campbell, L; Helphand, K	2010	Stewardship, learning, and memory in disaster resilience	ENVIRONMENTAL EDUCATION RESEARCH	16	40669	591	609
Trainor, SF; Calef, M; Natcher, D; Chapin, FS; McGuire, AD; Huntington, O; Duffy, P; Rupp, TS; DeWilde, L; Kwart, M; Fresco, N; Lovecraft, AL	2009	Vulnerability and adaptation to climate-related fire impacts in rural and urban interior Alaska	POLAR RESEARCH	28	1	100	118
Tschakert, P; Huber-Sannwald, E; Ojima, DS; Raupach, MR; Schienke, E	2008	Holistic, adaptive management of the terrestrial carbon cycle at local and regional scales	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	18	1	128	141
Turner, BL	2010	Vulnerability and resilience: Coalescing or paralleling approaches for sustainability science?	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	20	4	570	576
Turner, RA; Cakacaka, A; Graham, NAJ; Polunin, NVC; Pratchett, MS; Stead, SM; Wilson, SK	2007	Declining reliance on marine resources in remote South Pacific societies: ecological versus socio-economic drivers	CORAL REEFS	26	4	997	1008
Tyler, NJC; Turi, JM; Sundset, MA; Bull, KS; Sara, MN; Reinert, E; Oskal, N; Nellemann, C; McCarthy, JJ; Mathiesen, SD; Martello, ML; Magga, OH; Hovelsrud, GK; Hanssen-Bauer, I; Eira, NI; Eira, IMG; Corell, RW	2007	Saami reindeer pastoralism under climate change: Applying a generalized framework for vulnerability studies to a sub-arctic social-ecological system	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	17	2	191	206
Walker, B; Carpenter, S; Anderies, J; Abel, N; Cumming, G; Janssen, M; Lebel, L; Norberg, J; Peterson, GD; Pritchard, R	2002	Resilience management in social-ecological systems: a working hypothesis for a participatory approach	CONSERVATION ECOLOGY	6	1		
Walker, B; Gunderson, L; Kinzig, A; Folke, C; Carpenter, S; Schultz, L	2006	A handful of heuristics and some propositions for understanding resilience in social-ecological systems	ECOLOGY AND SOCIETY	11	1		
Walker, B; Hollin, CS; Carpenter, SR; Kinzig, A	2004	Resilience, adaptability and transformability in social-ecological systems	ECOLOGY AND SOCIETY	9	2		
Walker, BH; Abel, N; Anderies, JM; Ryan, P	2009	Resilience, Adaptability, and Transformability in the Goulburn-Broken Catchment, Australia	ECOLOGY AND SOCIETY	14	1		

van der Brugge, R; van Raak, R	2007	Facing the adaptive management challenge: Insights from transition management	ECOLOGY AND SOCIETY	12	2		
Wang, CH; Blackmore, JM	2009	Resilience Concepts for Water Resource Systems	JOURNAL OF WATER RESOURCES PLANNING AND MANAGEMENT-ASCE	135	6	528	536
Wardekker, JA; de Jong, A; Knoop, JM; van der Sluijs, JP	2010	Operationalising a resilience approach to adapting an urban delta to uncertain climate changes	TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	77	6	987	998
Warner, K	2010	Global environmental change and migration: Governance challenges	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	20	3	402	413
Vetter, S	2009	Drought, change and resilience in South Africa's arid and semi-arid rangelands	SOUTH AFRICAN JOURNAL OF SCIENCE	105	40545	29	33
Yang, LH; Wu, JG	2009	Scholar-participated governance as an alternative solution to the problem of collective action in social-ecological systems	ECOLOGICAL ECONOMICS	68	40764	2412	2425
Young, OR	2010	Institutional dynamics: Resilience, vulnerability and adaptation in environmental and resource regimes	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	20	3	378	385
Young, OR; Berkhout, F; Gallopin, GC; Janssen, MA; Ostrom, E; Leeuw, SVD	2006	The globalization of socio-ecological systems: An agenda for scientific research	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	16	3	304	316
Zhou, HJ; Wang, JA; Wan, JH; Jia, HC	2010	Resilience to natural hazards: a geographic perspective	NATURAL HAZARDS	53	1	21	41