



## Review

## Emergence, institutionalization and renewal: Rhythms of adaptive governance in complex social-ecological systems

Brian C. Chaffin<sup>a,\*</sup>, Lance H. Gunderson<sup>b</sup><sup>a</sup> Department of Society and Conservation, University of Montana, 32 Campus Drive, Missoula, MT 59812, USA<sup>b</sup> Department of Environmental Sciences, Emory University, 400 Dowman Drive, Atlanta, GA 30322, USA

## ARTICLE INFO

## Article history:

Received 3 January 2015

Received in revised form

26 August 2015

Accepted 1 September 2015

Available online xxx

## Keywords:

Adaptive governance

Panarchy

Resilience

Environmental governance

Adaptive management

## ABSTRACT

Adaptive governance provides the capacity for environmental managers and decision makers to confront variable degrees of uncertainty inherent to complex social-ecological systems. Current theoretical conceptualizations of adaptive governance represent a series of structures and processes best suited for either adapting or transforming existing environmental governance regimes towards forms flexible enough to confront rapid ecological change. As the number of empirical examples of adaptive governance described in the literature grows, the conceptual basis of adaptive governance remains largely under theorized. We argue that reconnecting adaptive governance with foundational concepts of ecological resilience—specifically Panarchy and the adaptive cycle of complex systems—highlights the importance of episodic disturbances and cross-scale interactions in triggering reorganizations in governance. By envisioning the processes of adaptive governance through the lens of Panarchy, scholars and practitioners alike will be better able to identify the emergence of adaptive governance, as well as take advantage of opportunities to institutionalize this type of governance in pursuit of sustainability outcomes. The synergistic analysis of adaptive governance and Panarchy can provide critical insight for analyzing the role of social dynamics during oscillating periods of stability and instability in social-ecological systems. A deeper understanding of the potential for cross-scale interactions to shape adaptive governance regimes may be useful as society faces the challenge of mitigating the impacts of global environmental change.

© 2015 Elsevier Ltd. All rights reserved.

## Contents

1. Introduction .....	81
2. Governance, resilience and Panarchy in social-ecological systems .....	82
3. Adaptive governance and Panarchy .....	83
3.1. Emergence of adaptive governance .....	83
3.2. Institutionalization of adaptive governance .....	85
3.3. The importance of cross-scale interactions .....	85
4. Conclusion .....	86
Acknowledgments .....	86
References .....	86

## 1. Introduction

Managing environmental issues has become more complex due to expanding scales of the problems (e.g., climate change and widespread land and water degradation) and the dynamic and

\* Corresponding author.

E-mail addresses: [brian.chaffin@umontana.edu](mailto:brian.chaffin@umontana.edu) (B.C. Chaffin), [lgunder@emory.edu](mailto:lgunder@emory.edu) (L.H. Gunderson).

evolutionary characteristics of these problems (Steffen et al., 2011; Rockstrom et al., 2009). One approach to dealing with the complexity of managed resource systems has been to acknowledge the strong coupling between the social and ecological aspects of systems (Berkes and Folke, 1998; Gunderson et al., 1995; Ostrom, 2009). Because of the changing nature of both the ecological and social dimensions, many scholars have proposed the term adaptive governance (AG) as a type of environmental governance that has arisen in systems characterized by large degrees of dynamism, complexity and uncertainty (Dietz et al., 2003; Brunner et al., 2005; Folke et al., 2005; Chaffin et al., 2014b).

While historical reconstructions are subject to multiple interpretations, there is a growing theoretical heuristic that emerged from comparisons of patterns of change over time in coupled social-ecological systems (SESs). Holling (1986) proposed a construct called an adaptive cycle to explain patterns of stability and instability in systems over time. Originally devised to explain irruptive dynamics in ecosystems such as fire, pest, or disease outbreaks, the adaptive cycle has been used to explain historical dynamics of coupled SESs (Gunderson et al., 1995; Gunderson and Holling, 2002).

This construct has been used to understand social phenomena such as natural resource policy cycles (Light et al., 1995), changes in natural resource management institutions (Chapin et al., 2009), as well as legal structures and processes (Garmestani and Allen, 2014). Avelino and Rotmans (2009) describe how power shapes transitions among regimes in social systems. Also, there are recent contributions (Cosens et al., 2014; Chaffin et al., 2014a) linking these patterns to governance trajectories specifically in managed riverine systems. Gunderson and Holling (2002) used the adaptive cycle to propose a theory of cross-scale interactions, called Panarchy. Non-linear dynamics and cross-scale interactions of Panarchy provide a new theoretical lens to explore and test concepts of AG.

AG was originally described by scholars and practitioners in terms of characteristics, structures and processes (Brunner et al., 2005; Folke et al., 2005; Olsson et al., 2006), and recently by a shift toward prescriptions, principles and guidelines (Huitema et al., 2009; Wyborn, 2015). Ongoing theorizations of adaptive governance are exposed to scholarly critiques similar to those directed at the application of ecological resilience to social components of SESs. These critiques include a lack of attention to history, culture, power, and human agency in research framed by the SES and ecological resilience paradigms (Davidson, 2010; Cote and Nightingale, 2012; Welsh, 2013; Fabinyi et al., 2014). However, we find that by reconnecting AG with a foundational concept of ecological resilience—the adaptive cycle of complex systems—we are able to demonstrate that an analytical approach to the contexts of environmental governance generally, and adaptive governance more specifically, has the potential to yield resilience-framed research that explicitly recognizes implications of history, culture, power, and human agency. Using Panarchy to describe governance as a dynamic process clearly highlights the importance of historical and political contexts as key cross-scale interactions that influence critical periods of collapse and rebirth of governance towards forms with an increased capacity to function amidst complexity and uncertainty.

## 2. Governance, resilience and Panarchy in social-ecological systems

Environmental governance generally—the act or process of governing use and access to the environment—differs from “government” in its inclusion of a wide range of institutions, actors, and organizations involved in producing environmental policy and management outcomes. Governance expands the role of

government to include both state and non-state actors and organizations, as well as the “political–economic relationships that institutions embody and how these relationships shape identities, actions, and outcomes” (Lemos and Agrawal, 2006: 298). In this way, governance is a fitting lens for analyzing SESs; governance encompasses interactions and feedbacks between social and bio-physical components of a system and the outcomes of governance differ across SES contexts and nested scales.

AG arose as an alternative to environmental governance regimes that were intended to control and stabilize ecological systems to meet societal goals of sustainable resource use (Folke et al., 2005). AG includes a range of responses to failures to coordinate the management of natural resources in such a way as to avoid environmental degradation and human conflict over resource allocation. The concepts of AG are an outcome of multiple strains of research: 1) institutional analysis of collective action under situations when knowledge is incomplete and uncertainty is high (Dietz et al., 2003); 2) the search for modes of governing sustainability goals by managing for resilience to disturbance in social-ecological systems (Walker et al., 2004; Lebel et al., 2006); 3) applications of adaptive management to structure learning from ecosystem-based management under assumptions of scientific uncertainty (Folke et al., 2005; Gunderson and Light, 2006); and 4) attempts to resolve stagnation between resource management policies that cause gridlocked decision making and conflict over resource use and allocation (Brunner et al., 2005). As a consequence of extending the lens of complex systems analysis from ecological systems to also include interacting social contexts (Berkes and Folke, 1998), AG was initially defined as a mode of environmental governance that facilitated adaptive management to ensure data-driven, ecosystem-based management despite extreme ecological uncertainty (Dietz et al., 2003; Folke et al., 2005).

AG is heavily influenced by the theories of ecological resilience (Holling, 2001; Walker et al., 2004; Walker and Salt, 2006), and some have even referred to AG as “resilience-based governance” (Garmestani and Benson, 2013). Resilience (ecological resilience as opposed to engineering resilience, see Gunderson and Holling (2002)) is a valueless property of systems that describes the capacity of a system to withstand disturbance while still maintaining structure and function. Governance, in context, includes the processes of steering or guiding human activity—mediating what society wants from environmental systems (Pierre, 2000). Thus, unlike resilience (as a property of systems), governance has normative goals, and AG in particular is framed around the goals of social-ecological sustainability (Folke et al., 2005; Gunderson and Light, 2006; Lebel et al., 2006; Elbakidze et al., 2010; Clark and Clarke, 2011) and building sustainable policy solutions to pressing environmental problems (Brunner et al., 2005; Scholz and Stiftel, 2005). The underlying assumption linking sustainability to AG is that the equitable allocation and conservation of life-sustaining resources and ecosystem services is desirable (both now and for future generations). In addition, governance with sufficient adaptive capacity to forward sustainability goals (e.g., AG) is also inherently desirable. It follows then that the normative goals of AG, as well as the normatively framed concept of AG itself, are not only associated with a preferred mode of governance given complexity and uncertainty, but also closely linked with the concept of “good governance”—principles for “how governance actors should exercise their authorities” including fairness, inclusiveness, transparency, and accountability (Lockwood, 2010: 758).

It is critical for us to clarify our assumptions of the relationship between AG, resilience, and sustainability early on as many of the critiques leveled at both resilience and SES-framed research could also be applied to much of the previous work on AG. In their critique of the adequacy of the SES framework for explaining social

change, Cote and Nightingale (2012) use AG explicitly as a broad term to encompass resilience- and SES-based policy tools employed for environmental management. Social scientists have argued that applying an ecological resilience framework to the social components of an SES (including governance) can be problematic because such an application assumes similar dynamics between the social and ecological (Davidson, 2010; Cote and Nightingale, 2012; Fabinyi et al., 2014). Davidson (2010) argues that an ecological resilience framing relies too heavily on structural similarities between social and ecological system components and ignores the role that individual and collective agency plays in social systems alone. Human agency is the foundation of the capacity of a social system to postpone or even avoid social-ecological collapse and thus must be considered as an internal dynamic in SESs. Agency includes the ability to imagine and express creativity as technology, culture, and governance (Davidson, 2010). But agency is distributed unequally across human systems (particularly through governance) and the effective expression of agency as a feedback in SESs is often reserved as a role of privilege. Thus, power and politics as well as the culture and history shaping dominant power relations also play critical roles as internal factors contributing to SES dynamics (Cote and Nightingale, 2012). Much of the previous literature on AG has paid little attention to the interaction of agency, culture, history, and power with the notable exception of some parallel work in the realm of socio-technical transitions (e.g., Smith and Stirling, 2010). However, we feel that this negligence is correctable and that an expanded analysis of resilience-based governance approaches such as AG can create space to integrate these unique facets of the social components of SESs.

While Cote and Nightingale (2012) argue that a weakness in applying ecological resilience to social systems stems from the overemphasized role of physical shocks and an under theorization of social dynamics, Davidson (2010) points out that the role of disturbance in social systems represents an important parallel, stating that social systems are “conceived of as proceeding through a continuous evolutionary cycle of temporal change between sustainability and crisis” (1136). This oscillation in the social system is affected by both internal factors (e.g., power and agency), but also by external biophysical disturbances, causing non-linear, episodic change in SESs. These changes may spur parallel changes in governance—adaptations or transformations that shift governance controls that potentially include legal reform or devolution of decision-making authority (Garmestani and Allen, 2014). It is through these disturbances and particularly the oscillation of the social system that a shift in environmental governance—towards an increased capacity for governing uncertainty and complexity (AG)—becomes possible. But a shift in governance toward AG is affected by a myriad of constraints and opportunities originating at scales both above and below the governance of a particular environmental issue or focal scale of a particular SES. More importantly, these cross-scale interactions occur irrespective of time, but may have the most impact in shaping the reorganization of environmental governance during periods of SES growth and collapse.

This article is intended to explore the evolution of AG as a dynamic process in SESs directly influenced by the nested dynamics of cross-scale interactions that include both biophysical disturbances and social forces. We draw insights from published literature on adaptive (environmental) governance that focus on four distinct case studies. These examples range in scale from global to local and are each well-recognized for prior scholarship on adaptive governance. In so doing, we hypothesize that AG is an emergent, self-organized process of an SES that changes form as systems undergo periods of crisis and stability. Crisis is a period when alternative processes control system dynamics, and is characterized by uncertainties of outcomes (Gunderson et al., 1995). Stable periods

occur when system drivers are known and outcomes are assumed to be predictable. While there may be others, we see at least two different sets of AG structures and processes. One that arises during and after instabilities or crises, which we refer to as *emergence*. The other facet of AG includes more formal rules, processes, and structures, which we propose as *institutionalization*. These categories are consistent with prior notions of AG in that institutional settings appear more formal during periods of development, and informal institutions allow for the capacity to adapt following periods of crisis or instability (Folke et al., 2005). Our contention is that forms of AG appear as “emerging” or “institutionalizing,” and correspond to the stages of SES development within which the governance is imbedded (Fig. 1).

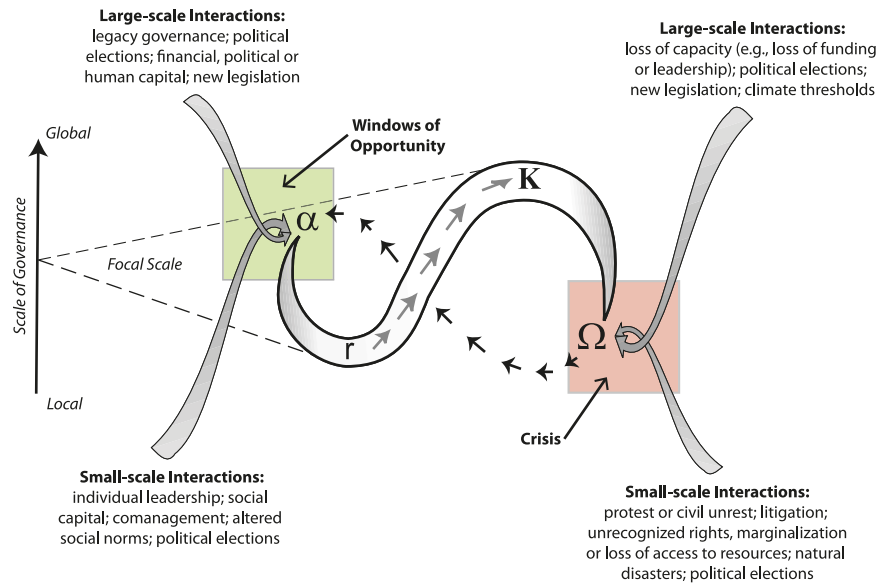
### 3. Adaptive governance and Panarchy

Panarchy theory was developed to explain why many SESs undergo periods of predictable change (stability) and unpredictable change (instability). The building block of Panarchy is Holling's (1986) adaptive cycle which has been used to describe a variety of complex patterns of change in natural resource systems, describing the ecological, economic, social, and political changes that have unfolded over time (Gunderson, 2000; Holling, 2001; Walker and Abel, 2002). Moreover, Panarchy theory generally, and the adaptive cycle specifically, has been used by scholars to describe the dynamic interaction of slow and fast controlling variables in complex SESs, including processes of environmental governance and associated management actions (Beier et al., 2009; Pelling and Manuel-Navarrete, 2011; Chaffin et al., 2014a).

As a metaphor for dynamic change in complex systems, an adaptive cycle links distinct sequences of exploitation (r phase), conservation (K phase), release (omega phase), and reorganization (alpha phase) as shown in Fig. 1. Such phases occur through a gradual process of increasing reliance on a specific configuration of system variables (e.g., the development of management schemes to pursue specific societal goals). Eventually, the system becomes rigid and vulnerable to a disturbance, whether an internal crises such as a lawsuit or social protest seeking to resolve resource conflict, or an external perturbation such as a natural disaster that disrupts social and ecological function (Chaffin et al., 2014b). Following a crisis, an SES undergoes a period of reorganization and renewal (Gunderson and Holling, 2002). In this manner, the adaptive cycle metaphor can be related in two broad phases of change, represented by the fore loop processes of slow growth and stability (exploitation and conservation), and the back loop processes of rapid change and variety (release and reorganization) (Holling, 2001; Gunderson and Holling, 2002; Walker and Salt, 2006). An SES does not necessarily follow a delineated trajectory of change, but instead oscillates between these broad phases of stability and instability. Using the metaphor and visualization (Fig. 1) of the adaptive cycle to describe dynamic change in regimes of environmental governance clearly highlights the potential for an evolution of AG from previous, more rigid systems of governance. In addition, and perhaps most importantly, the lens of Panarchy allows us to view SES governance as nested, affected by cross-scale interactions (spatial and temporal) acting upon both the greater SES and environmental governance during oscillating periods of growth and stability.

#### 3.1. Emergence of adaptive governance

It may be intuitive to think of AG as naturally initiated in the fore loop processes during the life cycle of a particular SES (i.e., the “r-selected” processes of resource exploitation followed by the “K-selected” processes of conservation) (Gunderson and Holling, 2002). However, it is the transition to the chaotic back loop



**Fig. 1.** Panarchy theory and the importance of cross-scale interactions for fostering adaptive governance in complex social-ecological systems. The model suggests that an SES exists at a particular scale (focal scale of analysis, e.g., watershed, landscape, bioregion, etc.). Over time, an SES will develop structure, capital, and complexity as indicated by the progression of arrows from r phases to K phases. This is a period of stabilization as governance becomes more formalized and institutionalized. Crises or periods of creative destruction (omega phase) can arise from large-scale social events (constitutional revision) or ecological events (cyclone or climate change). These periods spawn a relatively quick transition in which informal adaptive governance can emerge as the system reorganizes (alpha phase) into another phase (r), which may be similar or different from the prior regime of the SES. It is during these major transition phases (omega to alpha) that cross-scale interactions have the most potential to influence the emergence and potential institutionalization of adaptive governance.

processes of release and reorganization that mark the *emergence* of AG as a new configuration of governance. At this point, pre-existing regimes of environmental governance have grown stable and rigid over time within the SES, decreasing resilience to disturbances either manifest externally (from higher or lower scales) or as a result of the interactions between cross-scale influences—often expressed as SES collapse or as a socially perceived crisis. These cross-scale interactions may include the loss of capacity or legitimacy for current governance; a disruptive political election or change in political party or ruling power; civil unrest or protest; or the rise in legitimacy of previously unrecognized rights of under-represented or marginalized populations (Fig. 1). Literature on AG suggests that a period of AG emergence is initiated by a crisis, collapse, or release event in an SES (Chaffin et al., 2014b). Much like the back loop processes of release and reorganization in the adaptive cycle, emergence of AG is highly unpredictable, resulting from a self-organization of newly available or dormant capitals following a collapse (Gunderson and Holling, 2002). After a release or collapse such as a social crisis or ecological disturbance, actors and organizations may recognize that current environmental governance arrangements exhibit low resilience to potential disturbances such as the looming effects of climate change, social conflict resulting from resource scarcity, and/or a growing demand for life-sustaining ecosystem services (e.g., clean water, soil fertility, or flood control).

Such was the case in the Klamath River Basin, USA following a crippling drought in 2001 that saw Euro-American irrigators locked in a heated legal, social, and political struggle over water allocation with indigenous tribes and a federal government saddled with the legal responsibility to protect water rights for both Native Americans and endangered aquatic species (Chaffin et al., 2014a). Disturbance in the Klamath River Basin—drought and the over-allocation of water causing resource scarcity and social conflict—precipitated a period of SES release and created space for the influence of cross-scale interactions on current governance arrangements (see “crisis” in Fig. 1). Social unrest and protests amongst communities nested in the Klamath SES were exacerbated

by the historical legacy of racism in the basin between Euro- and Native Americans. Litigation by nested groups of water users forced the federal government to change how larger-scale statutes like the U.S. Endangered Species Act were implemented, with poignant consequences for use and access to water resources among some communities. It was these timely cross-scale interactions during a period of crisis that helped to create the conditions for the emergence of new, adaptive governance arrangements as the Klamath SES cycled through the back loop processes of reorganization and renewal. Contestation over water via lawsuits and media conflict grew stagnant, with no one interest advancing through these processes. Slowly, through the individual agency of key leaders throughout the Basin, actors and organizations began to self-organize into new governance configurations in search of outcomes that could sustain the needs of water users and their interests (Gosnell and Kelly, 2010). Cross-scale interactions continued to play a role during this critical period of AG emergence: as legitimacy for the individual leadership from nested user groups in the Basin, and as supporting capital and capacity provided by both underlying social norms and by the influx of financial and human capital from a federal government interested in solving the local conflict over water for farming, ranching, tribes, and endangered fish (see “windows of opportunity” in Fig. 1).

The Klamath River Basin is just one of many of published examples of the application of Panarchy to the evolution of AG from disturbance or resource crisis. AG emerged in the Kristianstad Vattenrike region of Sweden as a result of a perceived threat of undesirable ecological and cultural resource degradation in the Lower Halgea catchment and coastal plain (Olsson et al., 2004, 2006; 2007). A charismatic individual civic leader mobilized a network of actors and facilitated trust-building among disparate governance actors and conservation organizations that led to an altered perception (by those in influential political leadership) of the wetland as an asset of great social value (Hahn et al., 2006). A similar process of emergence was observed by Olsson et al. (2008) in management of the Great Barrier Reef Marine Park in Australia. A shared sense of urgency developed among key managers within



the Great Barrier Reef Marine Park Authority (GBRMPA) and led to a regional effort to increase biodiversity protection in the park through a rezoning process that engaged stakeholders (e.g., park users, park scientists, and other epistemic groups) in processes for identifying management and decision-making priorities (Olsson et al., 2008).

### 3.2. Institutionalization of adaptive governance

Beyond the initial emergence of AG, the informal nature of individual leadership, collective trust-building, and network formation may gain formal legitimacy through policy change and/or the creation of new organizations (Österblom and Folke, 2013). In addition, slower processes such as shifting social norms may influence the legitimacy of new AG trajectories (Folke et al., 2005; Olsson et al., 2004, 2006). During these processes of AG *institutionalization*, the dynamics of Panarchy continue to influence the degree and longevity of altered governance regimes. For example, in the Kristianstads Vattenrike region of Sweden, the emergence of an individual leader building trust amongst governance actors across multiple levels of existing governance led to the creation of a new, municipal-level organization, the Ecomuseum Kristianstads Vattenrike (EKV) (Olsson et al., 2004). Although membership in the EKV spanned levels of government and scales of influence in order to coordinate relevant conservation actors, activities, information, learning, and public awareness, there was no devolution of power to the organization and no new institutions were created to coordinate governance. However, legitimacy for the organization was generated through the shift in perception among existing leadership (and to some degree the public) which created space for the EKV to act as a bridging organization, formalizing a vision for AG and coordinating this execution of this vision amongst existing authorities (Hahn et al., 2006; Olsson et al., 2007).

Contrast this process of AG institutionalization with that of the self-organized, international (yet informal) governance network established to monitor illegal fishing in the Southern Oceans (Österblom and Folke, 2013). In this case, emergence of AG was catalyzed by individual “policy entrepreneurs” who employed personal capital and networks to create an international network of individuals with a range of organizational capacities and influences across scales related to ocean governance. In addition, this network built a perception of crisis among key leadership across governments, conservation NGOs, and industry, which was essential to legitimizing and institutionalizing the emerging trajectory of governing illegal fishing. The informal governance network created by the original policy entrepreneurs was first formally recognized as an organization with funding from the Australian government, but later also recognized with observer status in the Antarctic Treaty by the international governance body, the Commission for the Antarctic Marine Living Resources (CCAMLR; Österblom et al., 2010; Österblom and Folke, 2013).

The governance of the Great Barrier Reef Marine Park off the coast of Australia offers an additional example of institutionalizing AG, albeit one in which changing societal perceptions during emergence processes may have had more influence on the formalization of a new governance regime. Influential leadership in the GBRMPA built networks and garnered political support that eventually altered public perception in favor of national legislation (approved by popular vote) that improved the management structure, scale, and level of protection for the Great Barrier Reef as a bioregional resource (Olsson et al., 2008). Similarly, influential stakeholder leadership in the Klamath River Basin, USA, garnered enough political support and financial capital to undertake a multi-year conflict resolution process which led to the modeling, drafting, and signing of a set of comprehensive, basin-wide water sharing

agreements explicitly recognizing the complexity of basin water management given the uncertainties of climate change (Chaffin et al., 2014a). Although the Klamath Agreements require U.S. Congressional approval to be codified as law, the non-federal signing parties (water user groups such as tribes, irrigators, and states) are bound to honor many of the terms in the agreements while awaiting Congressional approval; thus, the Klamath Agreements can be considered a degree of AG institutionalization.

Institutionalization of AG may include the formalization of networks into organizations (Österblom and Folke, 2013); the creation of new governance organizations scaled or “fit” to the ecological problem addressed by AG (Olsson et al., 2007; Rijke et al., 2012); the adoption of co-management (Armitage et al., 2009); the devolution of government authority or legal reform to facilitate environmental management (Folke et al., 2005); the implementation of adaptive management (Gunderson and Light, 2006); or changes in social norms (Olsson et al., 2006). In all of these cases, however, a fairly large boost in capacity is needed to facilitate formalizations of emergent AG. By analyzing AG through the lens of Panarchy, it is clear that cross-scale interactions play a pivotal role in providing a window for the addition of necessary capacity to institutionalize emergent AG.

### 3.3. The importance of cross-scale interactions

The influence of cross-scale interactions from scales above and below the SES in question may be ever present. In the Klamath case, for example, these interactions include biophysical (climate), socio-economic (crop market prices), and political (federal environmental law) influences from geographies beyond the basin; pressure or innovation from scales nested within the basin (local community leadership); and the temporal influences of history on the basin. However, it is the interaction of these scale-dependent factors specifically during key periods of SES collapse and rebirth that have the most potential to influence new trajectories of governance. During these critical transition periods, broader scale factors and values such as ethics, equity, or economic considerations are among the ingredients that help determine how AG of the system reconfigures and reorganizes the system for future trajectories (Gunderson and Holling, 2002). Emergence of AG is not structural, but instead consists of the governance processes that support and manage the influence of cross-scale interactions during key times of SES instability. Structural elements of AG suggested by scholars (e.g., polycentric, bioregional in scale, experimental and learning-based, and participatory (Huiteima et al., 2009)) are not the cause of AG emergence, they are characteristics of institutionalized AG. Structural factors of AG are the result of governance processes adapting to the rhythms of SES growth and collapse under the explicit societal goals of sustainability.

A release, collapse, or crisis provides room for some “creative destruction” of existing governance, and thus serves as a catalyst for the reorganization of governance actors and organizations (Avelino and Rotmans, 2009; Schumpeter, 2008). But a question remains: why does environmental governance shift from the status quo towards AG? Why would governance not oscillate back towards the path of least resistance—presumably the status quo? The beginnings of an answer lay in the dynamic nature of Panarchy and the capacity generated by cross-scale interactions during key periods of crisis and windows of opportunity for governance innovation in SES. Cross-scale interactions at influential times of SES collapse and rebirth can usher in periods of contestation or periods of memory, both with the potential for either innovation or reinforcement of existing governance structures. It is at these key junctures that interdisciplinary research lenses—particularly those of the social sciences—are critical to furthering our understanding

of transitions toward AG and the sustainable use and conservation of natural resources. Panarchy highlights the importance of cross-scale interactions in evolving governance trajectories during the oscillations of an SES between stability and instability. We suggest that it is within the explicit and contextual analysis of these cross-scale interactions (only some of which are represented in Fig. 1) that scholars will advance understanding of the emergence and institutionalization of AG. Moreover, the study of cross-scale interactions provides a potential window for those critical of resilience-based governance approaches to explore the role of power, politics, culture, agency, and history in transitions of environmental governance towards forms (e.g., AG) more adapted to increasing global complexity and the uncertainties accompanying climate change.

#### 4. Conclusion

Much of 20th century resource management focused on approaches that managed to a) control unwanted temporal variation in resource systems, and b) to manage for equilibrium conditions in SESs (Gunderson and Holling, 2002). As a result of these command and control approaches, many of these systems became more vulnerable and less resilient (Holling and Meffe, 1996). The ensuing crises led in part to the development of concepts of adaptive governance (Brunner et al., 2005; Gunderson and Light, 2006).

The theories of Panarchy clearly illustrates that social and ecological processes interact in ways that can not only lead to a shift in environmental outcomes, but also to changes in governance approaches or to the retention of prior policies, rules, processes, and institutions. AG highlights one way of navigating through oscillating periods of SES stability and instability. AG is no panacea (Ostrom, 2009), but it instead opens up discussions about processes and situations that allow for the reorganization of governance in a manner flexible enough to guide resource management despite extreme uncertainty and complexity in SESs. AG is not about a focus on getting the policy 'right' before acting, but rather about environmental governance that supports the emergence of policies, in a learning context, that allow for adaptation in a dynamic system. Knowledge of these processes combined with lessons from an expanding literature describing transitions from emergent to institutionalized AG present a significant opportunity for future governance of SESs. Scholars and governance practitioners alike can be prepared with the understanding required to foster AG processes through targeted interventions—either through infusions of capacity following periods of crisis; creation of or readiness for taking advantage of windows of opportunity; or through engineered disturbances that cause a breakdown or weakening of controls on dominant systems of inflexible environmental governance. With an increase in surprising extreme weather events, and concomitant decline in ecological resilience, climate change will likely provide more crises or periods of instability in both the ecological and social components of complex systems. As such, these may be viewed as opportunities for innovation and reorganization. Societal interventions, especially creative destruction, must not be made frivolously, but instead deliberately, after significant and inclusive analytic debate (Dietz et al., 2003; Brunner et al., 2005; Lebel et al., 2006). This can be accomplished through an increased research focus on the influence that cross-scale interactions have on governance, with specific emphasis on the interaction of dynamic social forces such as power, politics, culture, and agency. In addition, rigorous monitoring, evaluation, and adjustment of governance—applying the systematic process of adaptive management to governance as well as to finer scales of environmental management—must be made if governance is to become more adaptive as it seeks a broad range of sustainability outcomes.

#### Acknowledgments

We would like to acknowledge the U.S. Environmental Protection Agency FP917277 for support of graduate student research that contributed to the development of concepts presented in this article, specifically through a Science to Achieve Results (STAR) Graduate Fellowship. The development of ideas in this article was further supported by the National Socio-Environmental Synthesis Center (SESYNC) under funding from the National Science Foundation DBI-1052875. We would also like to thank Dr. A.S. Garmestani, Dr. H. Gosnell and Prof. B. Cosens for graduate and postgraduate student mentoring (Chaffin) and ongoing correspondence that contributed to the development of concepts herein.

#### References

- Armitage, D.R., Plummer, R., Berkes, F., Arthur, R.I., Charles, A.T., Davidson-Hunt, I.J., Diduck, A.P., Doubleday, N.C., Johnson, D.S., Marschke, M., McConney, P., Pinkerton, E.W., Wollenberg, E.K., 2009. Adaptive co-management for social-ecological complexity. *Front. Ecol. Environ.* 7 (2), 95–102. <http://dx.doi.org/10.1890/070089>.
- Avelino, F., Rotmans, J., 2009. Power in transition: an interdisciplinary framework to study power in relation to structural change. *Eur. J. Soc. Theory* 12, 543–556. <http://dx.doi.org/10.1177/1368431009349830>.
- Beier, C., Lovcraft, A.L., Chapin III, F.S., 2009. Growth and collapse of a resource system: an adaptive cycle of change in public lands governance and forest management in Alaska. *Ecol. Soc.* 14 (2), 5. Retrieved from <http://www.ecologyandsociety.org/vol14/iss2/art5/>.
- Berkes, F., Folke, C., 1998. *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge University Press, Cambridge, UK.
- Brunner, R.D., Steelman, T.A., Coe-Juell, L., Cromley, C.M., Edwards, C.M., Tucker, D.W., 2005. *Adaptive Governance: Integrating Science, Policy, and Decision Making*. Columbia University Press, New York.
- Chaffin, B.C., Craig, R.K., Gosnell, H., 2014a. Resilience, adaptation, and transformation in the Klamath river basin social-ecological system. *Ida. Law Rev. Nat. Resour. Environ. Law Ed.* 51 (1), 157–193.
- Chaffin, B.C., Gosnell, H., Cosens, B.A., 2014b. A decade of adaptive governance scholarship: synthesis and future directions. *Ecol. Soc.* 19 (3), 56. Retrieved from <http://www.ecologyandsociety.org/vol19/iss3/art56/>.
- Chapin III, F.S., Kofinas, G., Folke, C. (Eds.), 2009. *Principles of Ecosystem Stewardship*. Springer, New York.
- Clark, J.R.A., Clarke, R., 2011. Local sustainability initiatives in English national parks: what role for adaptive governance? *Land Use Policy* 28, 314–324. <http://dx.doi.org/10.1016/j.landusepol.2010.06.012>.
- Cosens, B.A., Gunderson, L.H., Chaffin, B.C., 2014. The adaptive water governance project: assessing law, resilience and governance in regional socio-ecological water systems facing a changing climate. *Ida. Law Rev. Nat. Resour. Environ. Law Ed.* 51 (1), 1–28.
- Cote, M., Nightingale, A.J., 2012. Resilience thinking meets social theory: situating social change in socio-ecological systems (SES) research. *Prog. Hum. Geogr.* 36 (4), 475–489. <http://dx.doi.org/10.1177/0309132511425708>.
- Davidson, D.J., 2010. The applicability of the concept of resilience to social systems: some sources of optimism and nagging doubts. *Soc. Nat. Resour.* 23, 1135–1149. <http://dx.doi.org/10.1080/08941921003652940>.
- Dietz, T., Ostrom, E., Stern, P.C., 2003. The struggle to govern the commons. *Science* 302, 1907–1912. <http://dx.doi.org/10.1126/science.1091015>.
- Elbakidze, M., Angelstam, P.K., Sandstrom, C., Axelsson, R., 2010. Multi-Stakeholder collaboration in Russian and Swedish public forest initiatives: adaptive governance toward sustainable forest management? *Ecol. Soc.* 15 (14). Retrieved from <http://www.ecologyandsociety.org/vol15/iss2/art14/>.
- Fabinyi, M., Evans, L., Foale, S.J., 2014. Social-ecological systems, social diversity, and power: insights from anthropology and political ecology. *Ecol. Soc.* 19 (4), 28. Retrieved from <http://www.ecologyandsociety.org/vol19/iss4/art28/>.
- Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of social-ecological systems. *Annu. Rev. Environ. Resour.* 30, 441–473. <http://dx.doi.org/10.1146/annurev.energy.30.050504.144511>.
- Garmestani, A.S., Benson, M.H., 2013. A framework for resilience-based governance of social-ecological systems. *Ecol. Soc.* 18 (1), 9. Retrieved from <http://www.ecologyandsociety.org/vol18/iss1/art9/>.
- Garmestani, A.S., Allen, C.R., 2014. *Socio-ecological Resilience and Law*. Columbia University Press, New York.
- Gosnell, H., Kelly, E.C., 2010. Peace on the river? social-ecological restoration and large dam removal in the Klamath basin, USA. *Water Altern.* 3, 361–383. Retrieved from <http://www.water-alternatives.org/index.php/alldoc/articles/vol3/v3issue2/98-a3-2-21/file>.
- Gunderson, L.H., 2000. Ecological resilience—in theory and application. *Annu. Rev. Ecol. Syst.* 31, 425–439.
- Gunderson, L.H., Holling, C.S. (Eds.), 2002. *Panarchy: Understanding Transformations in Human and Natural Systems*. Island Press, Washington, DC.

- Gunderson, L.H., Light, S.S., 2006. Adaptive management and adaptive governance in the everglades ecosystem. *Policy Sci.* 39, 323–334. <http://dx.doi.org/10.1007/s11077-006-9027-2>.
- Gunderson, L.H., Holling, C.S., Light, S.S. (Eds.), 1995. *Barriers and Bridges to the Renewal of Ecosystems and Institutions*. Columbia University Press, New York, NY.
- 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. *Hum. Ecol.* 34, 573–592. <http://dx.doi.org/10.1007/s10745-006-9035-z>.
- Holling, C.S., 1986. The resilience of terrestrial ecosystems: local surprise and global change. In: Clark, W.C., Munn, R.E. (Eds.), *Sustainable Development of the Biosphere*. Cambridge University Press, Cambridge, UK.
- Holling, C.S., 2001. Understanding the complexity of economic, ecological, and social systems. *Ecosystems* 4, 390–405. <http://dx.doi.org/10.1007/s10021-001-0101-5>.
- Holling, C.S., Meffe, G.K., 1996. Command and control and the pathology of natural resource management. *Conserv. Biol.* 10 (2), 328–337. <http://dx.doi.org/10.1046/j.1523-1739.1996.10020328.x>.
- Huitema, D., Mostert, E., Egas, W., Moellenkamp, S., Pahl-Wostl, C., Yalcin, R., 2009. Adaptive water governance: assessing the institutional prescriptions of adaptive (co-) management from a governance perspective and defining a research agenda. *Ecol. Soc.* 14 (1), 26. Retrieved from: <http://www.ecologyandsociety.org/vol14/iss1/art26/>.
- Lebel, L., Anderies, J.M., Campbell, B., Folke, C., Hatfield-Dodds, S., Hughes, T.P., Wilson, J., 2006. Governance and the capacity to manage resilience in regional social-ecological systems. *Ecol. Soc.* 11, 19. Retrieved from: <http://www.ecologyandsociety.org/vol11/iss1/art19/>.
- Lemos, M.C., Agrawal, A., 2006. Environmental governance. *Annu. Rev. Environ. Resour.* 31, 297–325. <http://dx.doi.org/10.1146/annurev.energy.31.042605.135621>.
- Light, S.S., Gunderson, L.H., Holling, C.S., 1995. The everglades: evolution of management in a turbulent ecosystem. In: Gunderson, L.H., Holling, C.S., Light, S.S. (Eds.), *Barriers and Bridges to the Renewal of Ecosystems and Institutions*. Columbia University Press, New York, pp. 103–168.
- Lockwood, M., 2010. Good governance for terrestrial protected areas: a framework, principles and performance outcomes. *J. Environ. Manag.* 91, 754–766. <http://dx.doi.org/10.1016/j.jenvman.2009.10.005>.
- Olsson, P., Folke, C., Hahn, T., 2004. Social-ecological transformation for ecosystem management: the development of adaptive co-management of a wetland landscape in southern Sweden. *Ecol. Soc.* 9 (4), 2. Retrieved from: <http://www.ecologyandsociety.org/vol9/iss4/art2/>.
- Olsson, P., Gunderson, L.H., Carpenter, S.R., Ryan, P., Lebel, L., Folke, C., Holling, C.S., 2006. Shooting the rapids: navigating transitions to adaptive governance of social-ecological systems. *Ecol. Soc.* 11 (1), 18. Retrieved from: <http://www.ecologyandsociety.org/vol11/iss1/art18/>.
- 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. *Ecol. Soc.* 12 (1), 28. Retrieved from: <http://www.ecologyandsociety.org/vol12/iss1/art28/>.
- Olsson, P., Folke, C., Hughes, T., 2008. Navigating the transition to ecosystem-based management of the Great Barrier Reef, Australia. *Proc. Natl. Acad. Sci.* 105, 9489–9494. <http://dx.doi.org/10.1073/pnas.0706905105>.
- Österblom, H., Folke, C., 2013. Emergence of global adaptive governance for stewardship of regional marine resources. *Ecol. Soc.* 18 (2), 4. Retrieved from: <http://www.ecologyandsociety.org/vol18/iss2/art4/>.
- Österblom, H., Sumaila, U.R., Bodin, Ö., Sundberg, J.H., Press, A.J., 2010. Adapting to regional enforcement: fishing down the governance index. *PLoS One* 5 (9), e12832. Retrieved from: <http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0012832>.
- Ostrom, E., 2009. A general framework for analyzing sustainability of social-ecological systems. *Science* 325, 419–422. <http://dx.doi.org/10.1126/science.1172133>.
- Pelling, M., Manuel-Navarrete, D., 2011. From resilience to transformation: the adaptive cycle in two Mexican urban centers. *Ecol. Soc.* 16 (2), 11. Retrieved from: <http://www.ecologyandsociety.org/vol16/iss2/art11/>.
- Pierre, J., 2000. *Debating Governance: Authority, Steering, and Democracy*. Oxford University Press, London, UK.
- Rijke, J., Brown, R., Zevenbergen, C., Ashley, R., Farrelly, M., Morison, P., van Herk, S., 2012. Fit-for-purpose governance: a framework to make adaptive governance operational. *Environ. Sci. Policy* 22, 73–84. <http://dx.doi.org/10.1016/j.envsci.2012.06.010>.
- Rockstrom, J., Steffen, W., Noone, K., Persson, A., Chapin, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sorlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., Foley, J.A., 2009. A safe operating space for humanity. *Nature* 461 (7263), 472–475. <http://dx.doi.org/10.1038/461472a>.
- Scholz, J.T., Stiffler, B. (Eds.), 2005. *Adaptive Governance and Water Conflict: New Institutions for Collaborative Planning*. Resources for the Future Press, Washington, DC.
- Schumpeter, J.A., 2008. *Capitalism, Socialism, and Democracy*, third ed. Harper-Collins, New York, NY.
- Smith, A., Stirling, A., 2010. The politics of social-ecological resilience and sustainable socio-technical transitions. *Ecol. Soc.* 15 (1), 11. Retrieved from: <http://www.ecologyandsociety.org/vol15/iss1/art11/>.
- Steffen, W., Persson, Å., Deutsch, L., Zalasiewicz, J., Williams, M., Richardson, K., Crumley, C., Crutzen, P., Folke, C., Gordon, L., Molina, M., Ramanathan, V., Rockström, J., Scheffer, M., Schellnhuber, H.J., Svedin, U., 2011. The anthropocene: from global change to planetary stewardship. *Ambio* 40 (7), 739–761. <http://dx.doi.org/10.1007/s13280-011-0185-x>.
- Walker, B., Abel, N., 2002. Resilient rangelands—adaptation in complex systems. In: Gunderson, L.H., Holling, C.S. (Eds.), *Panarchy: Understanding Transformation in Human and Natural Systems*. Island Press, Washington, DC, pp. 293–314.
- Walker, B., Salt, D., 2006. *Resilience Thinking: Sustaining Ecosystems and People in a Changing World*. Island Press, Washington, DC.
- Walker, B., Holling, C.S., Carpenter, S.R., Kinzig, A., 2004. Resilience, adaptability and transformability in social-ecological systems. *Ecol. Soc.* 9 (2), 5. Retrieved from: <http://www.ecologyandsociety.org/vol9/iss2/art5/>.
- Welsh, M., 2013. Resilience and responsibility: governing uncertainty in a complex world. *Geogr. J.* 180 (1), 15–26. <http://dx.doi.org/10.1111/geoj.12012>.
- Wyborn, C., 2015. Co-productive governance: a relational framework for adaptive governance. *Glob. Environ. Change* 30, 56–67. <http://dx.doi.org/10.1016/j.gloenvcha.2014.10.009>.