

Chapter 14

Adaptive Management of Social-Ecological Systems: The Path Forward

Ahjond S. Garmestani and Craig R. Allen

Keywords Adaptive management · Social-Ecological systems · Uncertainty · Resilience · Natural resource management

Introduction

Adaptive management is derived from resilience theory, and originally was developed as a way to explore the resilience of ecosystems without exceeding the resilience of the system of interest (Chap. 2, Holling 1973). Ecosystems are characterized by complexity and in most cases there is basic uncertainty regarding their dynamics. Uncertainty in the response of linked social-ecological systems to management interventions necessitates that an adaptive approach be utilized (Chap. 8, Bown et al. 2013). Adaptive management explicitly tests predictions against observations, which allows for iterative recalibration of the management process at pre-determined decision points as learning occurs (Williams 2011). This learning process allows for management actions to progress as uncertainty is reduced over time (Williams 2011). Adaptive management is not a panacea, but can be a powerful tool for environmental management when applied to appropriate problems in social-ecological systems.

This book is intended to present the state of the art of adaptive management by providing a historical perspective (Chaps. 2 and 3), highlighting bridges and barriers to its implementation (Chaps. 4, 10 and 11), and illuminating the evolution of

A. S. Garmestani (✉)
Office of Research and Development, U.S. Environmental Protection Agency,
26 W. Martin Luther King Drive, Cincinnati, OH 45268, USA
e-mail: garmestani.ahjond@epa.gov

C. R. Allen
U.S. Geological Survey, Nebraska Cooperative Fish and Wildlife Research Unit,
University of Nebraska-Lincoln, Lincoln, NE 68583, USA
e-mail: allencr@unl.edu

© Springer Science+Business Media Dordrecht (outside the USA) 2015
C. R. Allen, A. S. Garmestani (eds.), *Adaptive Management of Social-Ecological Systems*,
DOI 10.1007/978-94-017-9682-8_14

adaptive management since its development over the past 4 decades (Chaps. 5, 6, 7, 8, 9, 12 and 13). However, it is not prescriptive, and readers interested in “how to” should delve into the resources cited in chapter references. Here we discuss some of the recent themes recurring in the adaptive management literature, and discuss the different contexts of adaptive co-management, adaptive governance and resilience-based governance.

Adaptive Management: The Present and the Future

Present

Adaptive management has tremendous traction in the academic literature, demonstrating the persistence of the methodology (Westgate et al. 2013). There are several factors that act as “bridges” for successful adaptive management. These factors include: *collaboration* (Chap. 10, Reeve Morghan et al. 2006, Stringer et al. 2006, Armitage et al. 2009, Johnson 2011, Moore et al. 2011, Williams 2011, Porzecanski et al. 2012, Susskind et al. 2012, Caves et al. 2013, Greig et al. 2013, LoSchiavo et al. 2013, Pratt Miles 2013, Westgate et al. 2013), *funding* (Chap. 4, Chap. 10, Armitage et al. 2009, Moore et al. 2011, Smith 2011, Caves et al. 2013, Greig et al. 2013, LoSchiavo et al. 2013, Rist et al. 2013, Westgate et al. 2013), *clear objectives* (Chap. 3, Chap. 5, Chap. 10, Moore et al. 2011, Williams 2011, Porzecanski et al. 2012, Susskind et al. 2012, Caves et al. 2013, Greig et al. 2013, LoSchiavo et al. 2013, Pratt Miles 2013), *leadership* (Chap. 3, Chap. 7, Chap. 10, Walters 2007, Munaretto and Huitema 2012, Caves et al. 2013, Greig et al. 2013), *presence of intermediaries* (Chap. 7, Stringer et al. 2006, Johnson 2011, Munaretto and Huitema 2012, Greig et al. 2013, Monroe et al. 2013, Pratt Miles 2013), *appropriate scale of project* (Chap. 10, Reeve Morghan et al. 2006, Stringer et al. 2006), and a *favorable institutional, policy and social environment* (Chap. 10, Stringer et al. 2006, Armitage et al. 2009, Moore et al. 2011, Smith 2011, Porzecanski et al. 2012, Susskind et al. 2012, Caves et al. 2013, Greig et al. 2013, LoSchiavo et al. 2013). Some potential “barriers” to adaptive management are the lack of funding for project implementation and monitoring, and shifts in management policies, personnel and leadership (Conclusion, Jacobson et al. 2006, Westgate et al. 2013). In many cases where adaptive management was unsuccessful, the conditions necessary for success did not exist, whether those factors (and the interaction of those factors) are institutional, organizational or social (Chap. 3, Porzecanski et al. 2012). In some cases, adaptive assessments and experimentation have led to innovative environmental management and organizational learning (Chap. 3). Adaptive management isn’t appropriate where there is little uncertainty and little controllability, thus excluding a large range of potential applications. Rather, other methods (e.g., scenario planning, building resilience and maximum sustained yield) may be better fits for the environmental problem to be managed (see Allen et al. 2011) where controllability is weak (i.e., management is largely not possible) or uncertainty is low.

In the United States the current legal framework is focused upon finality of process (e.g., National Environmental Policy Act), and not designed to accommodate iterative mechanisms, which are essential for adaptive management (Chap. 4, Benson and Garmestani 2011). The current focus upon finality in American law results from it being crafted around outdated scientific understanding about the dynamics of social-ecological systems (Garmestani et al. 2013). In essence, American law was built upon the understanding at the time that the world was characterized by a “balance of nature”, which allowed natural resource managers to have a good sense about the manner in which the natural world will behave in the future (Garmestani et al. 2013). Thus, adaptive management is difficult to implement within the scope of current law. In a recent study, a majority of practitioners reported that implementation of adaptive management was hampered by legal constraints (Benson and Stone 2013). For example, most laws in the United States do not explicitly require monitoring, an essential component of adaptive management, and the lack of a regulatory “home” for adaptive management means agencies aren’t typically bound by its requirements (Benson and Garmestani 2011). This means that adaptive management, as it is currently practiced in many of the most visible applications does not possess the legal grounding necessary for enforceability, which is essential to ensuring that the methodology is implemented as it was intended (Chap. 4, Holling 1978, Benson and Garmestani 2011). In addition, several legal scholars have concluded that conducting adaptive management is incompatible with current administrative law, and thus not possible without reform (Ruhl 1998, Karkkainen 2005, Garmestani et al. 2009).

Future

Adaptive management remains underutilized and poorly understood. A large part of this problem can be traced to its implementation through top-down authority or its highly visible but poorly functioning applications to large problems not well-suited to adaptive management purposes. An example of the latter case is the application of adaptive management to large river systems where endangered species recovery is the goal. In such cases, replicated experimentation is impossible and controllability is low. Here, structured decision making, which is closely related to adaptive management, is more appropriate. Top-down control is a problem in many cases where there are mandates to apply adaptive management, for example in some federal agencies, but with little guidance on implementation in the field. Adaptive management’s promise is for a subset of mesoscale environmental problems. These mesoscales—larger and longer than typical graduate student-driven academic research but smaller and shorter than continental watersheds or most climate-driven change—remain poorly understood, but are amenable to replicated experimental manipulations that can yield tangible results in reasonable time frames. Examples include projects such as testing of green infrastructure impacts on water quality and quantity in urban settings, techniques for invasive species removal, and methods of ecological restoration.

Certainly, there is room for improvement in the process of adaptive management. Integrating adaptive management with law will likely require some reforms (see Chap. 4). For example, Benson and Garmestani (2011) have suggested that an American law such as the National Environmental Protection Act (NEPA) could be reconfigured to accommodate adaptive management. In particular, they advocate for a new process within NEPA that is iterative rather than linear, requiring monitoring, and reform that adds substance and structure to NEPA's mandate. The impediment of "final agency action" that serves to foment a linear administrative law process presents a substantial obstacle to adaptive management and has been the subject of recent discourse (Karkkainen 2005, Garmestani et al. 2009, Benson and Garmestani 2011). Karkkainen (2005) has argued for an "adaptive management track" that would be implemented if an agency could demonstrate that such a variation to current administrative law was warranted. Answering this call, Craig and Ruhl (2014) proposed and drafted model legislation that could create an "adaptive management track" for specific agency decisions, within the context of administrative law. This proposed new law, the Model Adaptive Management Procedure Act (MAMPA) could be a leap forward in our pursuit of operationalizing adaptive management (*sensu* Holling) for linked social-ecological systems. MAMPA balances the foundations of administrative law, while accounting for social-ecological resilience, and offers great promise for sound environmental governance (see Craig and Ruhl 2014).

In addition to legal reform, there are other mechanisms for improving the adaptive management process and environmental outcomes. For example, stakeholder evaluations (i.e., "what should be" vs. "what is") of an adaptive management project could be used as one metric for measuring the progress of a project (Berkley 2013). Assessing the context of adaptive management via metrics at each phase of the adaptive management process is another possible mechanism for improving environmental outcomes (Chap. 6). In particular, by assessing each phase of the adaptive management cycle, system-wide learning will occur, even if there are issues with a phase or the entire process (Chap. 6). While adaptive management is supposed to create the conditions for iterative management in response to system feedback, explicitly linking adaptive management to thresholds that require management intervention should be considered (Chap. 5, Garmestani and Allen 2014). Linking adaptive management to ecological and legal thresholds, with the capacity for recalibrating thresholds in light of new information, could be one aspect of the path forward for adaptive management.

Adaptive management is considered to be the best existing approach for dealing with the unpredictability of social-ecological systems (Westgate et al. 2013). While we (Allen et al. 2011) have stated that adaptive management is only appropriate under certain circumstances (e.g., when uncertainty and controllability are high), Rist et al. (2013) argue that there are no boundaries to the application of adaptive management (but see Chap. 10 and Chap. 11). Rather, when to apply adaptive management can be defined by the problem of interest, and the resources available to managers. In making this assertion, Rist et al. (2013) argue that adaptive management should be seen simply as a methodology to reduce uncertainty in

environmental management, separate from the institutional, policy and social environment where management occurs. Their argument turns on the proposition that all environmental management is subject to institutional, policy and social constraints, and these factors are not endemic to adaptive management. Thus, according to Rist et al. (2013), adaptive management needs to be placed within an institutional and governance framework (e.g., adaptive governance) that facilitates its core purpose. In contrast, separating adaptive management from political and social processes is not possible for many adaptive management projects (Chap. 13, Gunderson and Light 2006, Cosens and Williams 2012) and furthermore, whether a project succeeds or fails is dependent upon human and social capital, regardless of the quality of the science (Chap. 7, Cundill et al. 2011). As a result, adaptive management has been integrated with collaborative management (adaptive co-management), which ultimately sets the stage for adaptive governance (Chap. 9, Folke et al. 2005, Munaretto and Huitema 2012). Adaptive governance attempts to take into account formal and informal institutions, and is at the intersection integrating adaptive co-management and governance (Garmestani et al. 2009, Huitema et al. 2009). While adaptive governance has been touted as the manner by which to implement resilience thinking, it is lacking in significant legal grounding that would allow for it to be incorporated into rules and regulations (Ruhl 2012, Garmestani and Benson 2013). Building upon the lack of legal grounding for adaptive governance, Garmestani and Benson (2013) offered a framework for resilience-based governance that integrates resilience theory (i.e., panarchy, adaptive management, and adaptive governance) with reflexive law. Cumming (2013) asserts that this framework has great potential for resilience-based governance, as it explicitly accounts for scale and governance mismatches, but would require major legal reform (Garmestani and Benson 2013).

Conclusion

Adaptive management remains at the forefront of environmental management nearly 40 years after its original conception, largely because we have yet to develop other methodologies that offer the same promise (Allen et al. 2011). Despite the criticisms of adaptive management and the numerous failed attempts to implement it, adaptive management has yet to be replaced. The concept persists because it is seen as critical to managing for resilience, and therefore an essential aspect of social-ecological resilience (Garmestani and Allen 2014). Moving forward, adaptive management of social-ecological systems provides policymakers, managers and scientists a powerful tool for managing for resilience in the face of uncertainty. The methodology has been developing for nearly half a century, and continues to resonate for environmental management, even though there are numerous barriers to its implementation. Over time, we have come to learn that “barriers” to adaptive management include: *lack of collaboration* (Plummer and Armitage 2007, Allen and Gunderson 2011, Allen et al. 2011, Johnson 2011, Keith et al. 2011, Williams

2011, Munaretto and Huitema 2012, Porzecanski et al. 2012, Susskind et al. 2012, Westgate et al. 2013), *lack of funding* (Plummer and Armitage 2007, Walters 2007, Allen and Gunderson 2011, Greig et al. 2013, LoSchiavo et al. 2013, Westgate et al. 2013), *lack of clear objectives* (Allen and Gunderson 2011, Porzecanski et al. 2012, Susskind et al. 2012, Greig et al. 2013, Pratt Miles 2013, Rist et al. 2013), *lack of leadership* (Gunderson and Light 2006, Walters 2007, Allen and Gunderson 2011, Munaretto and Huitema 2012, Westgate et al. 2013), *lack of intermediaries* (Stringer et al. 2006, Munaretto and Huitema 2012, Bown et al. 2013, Greig et al. 2013), *inappropriate scale of projects* (Chap. 10, Reeve Morghan et al. 2006, Stringer et al. 2006), and *lack of a favorable institutional, policy and social environment* (Chap. 3, Plummer and Armitage 2007, Armitage et al. 2009, Allen and Gunderson 2011, Keith et al. 2011, Porzecanski et al. 2012, Susskind et al. 2012, Bown et al. 2013, LoSchiavo et al. 2013). Adaptive management can be successful under the right circumstances, and at the right scale. Large-scale, river basin projects (e.g., Everglades) have been extensively treated in the literature and unfortunately, many have met with limited success. This has led some commentators to claim that adaptive management is a failed management strategy. However, the limitations of adaptive management simply illuminate that adaptive management is not an appropriate strategy for large-scale social-ecological systems, with a host of complicating factors ranging from the ecosystem to the institutional, organizational and policy environment. Any of these factors individually, or in combination, likely dooms these large-scale adaptive management projects from their inception. Rather, adaptive management can be successful (e.g., waterfowl harvests, green infrastructure) at an appropriate scale and under appropriate conditions, especially in cases when there is a favorable institutional, organizational and policy environment.

Importantly, adaptive management is not a solution for every context, and should not be viewed as such. Rather, adaptive management should be viewed as flowing from social-ecological resilience and a critical component of adaptive governance, and therefore resilience-based governance (Garmestani and Benson 2013). Ultimately this means that adaptive management is a very useful tool for sound environmental management and governance (Chap. 12).

References

- Allen, C. R., & Gunderson, L. H. (2011). Pathology and failure in the design and implementation of adaptive management. *Journal of Environmental Management*, 92, 1379–1384.
- Allen, C. R., Fontaine, J. J., Pope, K. L., & Garmestani, A. S. (2011). Adaptive management for a turbulent future. *Journal of Environmental Management*, 92, 1339–1345.
- Armitage, D. R., Plummer, R., Berkes, F., Arthur, R. I., Charles, A. T., Davidson-Hunt, I. J., Di-duck, A. P., Doubleday, N. C., Johnson, D. S., Marschke, M., McConney, P., Pinkerton, E. W., & Wollenberg, E. K. (2009). Adaptive con-management for social-ecological complexity. *Frontiers in Ecology and the Environment*, 7, 95–102.
- Benson, M. H., & Garmestani, A. S. (2011). Embracing panarchy, building resilience and integrating adaptive management through a rebirth of the National Environmental Policy Act. *Journal of Environmental Management*, 92, 1420–1427.

- Benson, M. H., & Stone, A. B. (2013). Practitioner perceptions of adaptive management implementation in the United States. *Ecology and Society*, 18(3), 32. <http://dx.doi.org/10.5751/ES-05613-180332>.
- Berkley, J. (2013). Opportunities for collaborative adaptive management progress: integrating Stakeholder assessments into progress measurement. *Ecology and Society*, 18(4), 69. <http://dx.doi.org/10.5751/ES-05988-180469>.
- Bown, N. K., Gray, T. S., & Stead, S. M. (2013). Co-management and adaptive co-management: Two modes of governance in a Honduran marine protected area. *Marine Policy*, 39, 128–134.
- Caves, J. K., Bodner, G. S., Simms, K., Fisher, L. A., & Robertson, T. (2013). Integrating collaboration, adaptive management, and scenario-planning: experiences at Las Cienegas National Conservation Area. *Ecology and Society*, 18(3), 43. <http://dx.doi.org/10.5751/ES-05749-180343>.
- Cosens, B. A., & Williams, M. K. (2012). Resilience and water governance: Adaptive governance in the Columbia River basin. *Ecology and Society*, 17(4), 3. <http://dx.doi.org/10.5751/ES-04986-170403>.
- Craig, R. K., & Ruhl, J. B. (2014). Designing administrative law for adaptive management. *Vanderbilt Law Review*, 67, 1–87.
- Cumming, G. S. (2013). Scale mismatches and reflexive law. *Ecology and Society*, 18(1), 15. <http://dx.doi.org/10.5751/ES-05407-180115>.
- Cundill, G., Cumming, G. S., Biggs, D., & Fabricius, C. (2011). Soft systems thinking and social learning for adaptive management. *Conservation Biology*, 26, 13–20.
- Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources*, 30, 441–473.
- Garmestani, A. S., & Benson, M. H. (2013). A framework for resilience-based governance of social-ecological systems. *Ecology and Society*, 18(1), 9. <http://www.ecologyandsociety.org/vol18/iss1/art9/>
- Garmestani, A. S., & Allen, C. R. (2014). *Social-ecological resilience and law*. New York: Columbia University Press.
- Garmestani, A. S., Allen, C. R., & Cabezas, H. (2009). Panarchy, adaptive management and governance: Policy options for building resilience. *Nebraska Law Review*, 87, 1036–1054.
- Garmestani, A. S., Allen, C. R., & Benson, M. H. 2013. Can law foster social-ecological resilience? *Ecology and Society*, 18(2): 37. <http://www.ecologyandsociety.org/vol18/iss2/art37/>
- Green, O. O., & Garmestani, A. S. (2012). Adaptive management to protect biodiversity, best available science and the Endangered Species Act. *Diversity*, 4, 164–178.
- Greig, L. A., Marmorek, D. R., Murray, C., & Robinson, D. C. E. (2013). Insight into enabling adaptive management. *Ecology and Society*, 18(3), 24. <http://dx.doi.org/10.5751/ES-05686-180324>.
- Gunderson, L. H., & Light, S. S. (2006). Adaptive management and adaptive governance in the Everglades. *Policy Sciences*, 39, 323–334.
- Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecological Systems*, 4, 1–23.
- Holling, C. S. (1978). *Adaptive environmental assessment and management*. Chichester: Wiley.
- 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. *Ecology and Society*, 14(1), 26. <http://www.ecologyandsociety.org/vol14/iss1/art26/>.
- Jacobson, S. K., Morris, J. K., Sanders, J. S., Wiley, E. N., Brooks, M., Bennetts, R. E., Percival, H. F., & Marynowski, S. (2006). Understanding barriers to implementation of an adaptive land management program. *Conservation Biology*, 20, 1516–1527.
- Johnson, F. A. (2011). Learning and adaptation in the management of waterfowl harvests. *Journal of Environmental Management*, 92, 1385–1394.
- Karkkainen, B. C. (2005). Panarchy and adaptive change: Around the loop and back again. *Minnesota Journal of Law, Science & Technology*, 7, 59–77.
- Keith, D. A., Martin, T. G., McDonald-Madden, E., & Walters, C. (2011). Uncertainty and adaptive management for biodiversity conservation. *Biological Conservation*, 144, 1175–1178.

- LoSchiavo, A. J., Best, R. G., Burns, R. E., Gray, S., Harwell, M. C., Hines, E. B., McLean, A. R., Clair, T. St., Traxler, S., & Vearil, J. W. (2013). Lessons learned from the first decade of adaptive management in comprehensive Everglades restoration. *Ecology and Society*, 18(4), 70. <http://dx.doi.org/10.5751/ES-06065-180470>.
- Monroe, M. C., Plate, R., & Oxarart, A. (2013). Intermediate collaborative adaptive management strategies build stakeholder capacity. *Ecology and Society*, 18(2), 24. <http://dx.doi.org/10.5751/ES-05444-180224>.
- Moore, C. T., Lonsdorf, E. V., Knutson, M. G., Laskowski, H. P., & Lor, S. K. (2011). Adaptive management in the U.S. National Wildlife Refuge System: Science-management partnerships for conservation delivery. *Journal of Environmental Management*, 92, 1395–1402.
- Munaretto, S., & Huitema, D. (2012). Adaptive comanagement in the Venice lagoon? An analysis of current water and environmental management practices and prospects for change. *Ecology and Society*, 17(2), 19. <http://dx.doi.org/10.5751/ES-04772-170219>.
- Plummer, R., & Armitage, D. R. (2007). Charting the new territory of adaptive co-management: A Delphi study. *Ecology and Society*, 12(2), 10. <http://www.ecologyandsociety.org/vol12/iss2/art10/>.
- Porzecanski, I., Saunders, L. V., & Brown, M. T. (2012). Adaptive management fitness of watersheds. *Ecology and Society*, 17(3), 29. <http://dx.doi.org/10.5751/ES-05061-170329>.
- Pratt Miles, J. D. (2013). Designing collaborative processes for adaptive management: Four structures for multistakeholder collaboration. *Ecology and Society*, 18(4), 5. <http://dx.doi.org/10.5751/ES-05709-180405>.
- Reever Morghan, K. J., Sheley, R. L., & Svejcar, T. J. (2006). Successful adaptive management—the integration of research and management. *Rangeland Ecology and Management*, 59, 216–219.
- Rist, L., Felton, A., Samuelsson, L., Sandström, C., & Rosvall, O. (2013). A new paradigm for adaptive management. *Ecology and Society*, 18(4), 63. <http://dx.doi.org/10.5751/ES-06183-180463>.
- Ruhl, J. B. (1998). The Endangered Species Act and private property: A matter of timing and location. *Cornell Journal of Law and Public Policy*, 8, 37–53.
- Ruhl, J. B. (2012). Panarchy and the law. *Ecology and Society*, 17(3), 31. <http://dx.doi.org/10.5751/ES-05109-170331>.
- Smith, C. B. (2011). Adaptive management on the central Platte River—Science, engineering, and decision analysis to assist in the recovery of four species. *Journal of Environmental Management*, 92, 1414–1419.
- Stringer, L. C., Dougill, A. J., Fraser, E., Hubacek, K., Prell, C., & Reed, M. S. (2006). Unpacking “participation” in the adaptive management of social–ecological systems: A critical review. *Ecology and Society*, 11(2), 39. <http://www.ecologyandsociety.org/vol11/iss2/art39/>.
- Susskind, L., Camacho, A. E., & Schenk, T. (2012). A critical assessment of collaborative adaptive management in practice. *Journal of Applied Ecology*, 49, 47–51.
- Walters, C. (2007). Is adaptive management helping to solve fisheries problems? *Ambio*, 35, 304–307.
- Westgate, M. J., Likens, G. E., & Lindenmayer, D. B. (2013). Adaptive management of biological systems: A review. *Biological Conservation*, 158, 128–139.
- Williams, B. K. (2011). Passive and active adaptive management: Approaches and an example. *Journal of Environmental Management*, 92, 1371–1378.