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Introduction: The Adaptive Water Governance Project: Assessing Law, Resilience and Governance in Regional Socio-Ecological Water Systems Facing a Changing Climate

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THE ADAPTIVE WATER GOVERNANCE PROJECT: ASSESSING LAW, RESILIENCE AND GOVERNANCE IN REGIONAL SOCIO-ECOLOGICAL WATER SYSTEMS FACING A CHANGING CLIMATE

INTRODUCTION TO NREL EDITION OF THE IDAHO LAW REVIEW

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The water understands
Civilization well;
It wets my foot, but prettily,
It chills my life, but wittily,
It is not disconcerted,
It is not broken-hearted:
Well used, it decketh joy,
Adorneth, doubleth joy:
Ill used, it will destroy,
In perfect time and measure
With a face of golden pleasure
Elegantly destroy.

Ralph Waldo Emerson[1]

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1. Ralph Waldo Emerson, *Water*, *in* POETS OF THE ENGLISH LANGUAGE (W.H Auden & Norman H. Pearson eds., Viking Press 1950) (1867).

I. INTRODUCTION

For more than two centuries, humans have collectively and intensively pursued control of water resources throughout the United States. From the arid portions of the southwest region to the relatively water rich east, humans have sought to control the pulses of surface waters, in part to avoid the 'elegant destruction' suggested above by Ralph Waldo Emerson. Indeed part of the twentieth century myth of taming nature was to modify basic ecosystem functions for the service of humans. Dams were built in the mighty rivers of the western United States – the Columbia, the Colorado and the Missouri—to control floodwaters and divert scant water resources for human and agricultural consumption. While substantially enhancing a narrow range of services for the benefit of certain sectors of society, such controls have also come at great costs to society—not just in fiscal terms of investment in infrastructure, but also in terms of loss of biodiversity, as indicated by the large number of endangered and threatened species and cultures. Moreover, the planned and inadvertent ecological changes associated with the development of water resources have led to unforeseen shifts in ecosystems characterized as the erosion of ecological resilience.[2]

As the water resources of the U.S. have developed, and resilience has declined, the ways in which humans have valued and governed these systems has also changed.[3] Once viewed as providing sustenance to humans, water is now seen to supply a wide variety of ecosystem goods and services. Such manifold uses of water include irrigation for agriculture, water supplies for major and minor urban centers, and water to sustain ecological structures and functions such as mitigation of flood and water quality. At the close of the 20th century, sustainability became another social objective, which extended the time horizon for achieving social goals

2. *See generally* C. S. Holling, *Resilience and Stability of Ecological Systems*, 4 ANN. REV. OF ECOLOGY & SYSTEMATICS 1 (1973), *available at* http://www.jstor.org/stable/2096802?seq=1; RESILIENCE AND THE BEHAVIOR OF LARGE-SCALE SYSTEMS (Lance H. Gunderson & Lowell Pritchard eds., 2002).

3. LANCE H. GUNDERSON ET AL., BARRIERS AND BRIDGES TO THE RENEWAL OF ECOSYSTEMS AND INSTITUTIONS (1995).

and outcomes by considering the needs of future generations.[4] As these systems have developed over time, the human dimensions (including institutions made up of laws, rules, social norms, and patterns of management) have become more complex. Indeed, attempting to understand such patterns of complexity has led to integrative scholarship that directs attention to linking the social and ecological components of these systems.[5]

Understanding the dynamics of complex social-ecological systems is urgent, as these resource systems are now facing new and relatively unknown changes due to changing climate. Broadly defined, climate is the long-term (decades to centuries) pattern of precipitation and temperature in a particular area.[6] In regional scale water systems, climatic patterns have been central to the design and management of such systems. For example, the Everglades region has a subtropical savanna climate; characterized by little seasonal change in temperature (rare freezing), with pronounced wet and dry seasons.[7] As such, the management system has evolved to control flooding during the wet season, and to supply water to agriculture, urban interests and conservation areas during the dry season. In terms of the operation, the water system is managed according to this annual cycle. Yet a growing body of literature indicates that long-term changes in hydrologic processes are occurring, and hence fundamental assumptions of design and management must be revisited due to this loss of stationarity of ecosystem functions.[8] Moreover, the types of events associated with climate change will continue to test the resilience of the coupled social-ecological system to respond and adapt to these broad scale changes.

In her groundbreaking work, Nobel Laureate Elinor Ostrom put forward a framework for social-ecological systems to aid in understanding why some communities self-organize to regulate their own resource exploitation to achieve sustainability and some do not.[9] As Dr. Ostrom was developing her theories, ecologists were building on the landmark work of Buzz Holling who introduced the under-

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4. The concept of "sustainability" in environmental management is generally traced to the definition of "sustainable development" by the Report of the World Commission on Environment and Development, which defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." REPORT OF THE WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT: OUR COMMON FUTURE (1987), *available at* http://www.un-documents.net/our-common-future.pdf.

5. *See* NAVIGATING SOCIAL-ECOLOGICAL SYSTEMS: BUILDING RESILIENCE FOR COMPLEXITY AND CHANGE (Fikret Berkes et al. eds., 2013).

6. The Intergovernmental Panel on Climate Change defines climate as follows: "[c]limate in a narrow sense is usually defined as the 'average weather', or more rigorously, as the statistical description interms [sic] of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. The classical period of time is 30 years, as defined by the World Meteorological Organization (WMO)." INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, FOURTH ASSESSMENT REPORT: CLIMATE CHANGE 2007: WORKING GROUP II: IMPACTS, ADAPTATION AND VULNERABILITY, app. 1 (2007), *available at* http://www.ipcc.ch/publications_and_data/ar4/wg2/en/annexessglossary-a-d.html.

7. *See* Ilmo Hela, *Remarks on the Climate of South Florida*, 2 BULL. OF MARINE SCI. 438 (1952), *available at* http://idahoid.library.ingentaconnect.com/content/umrsmas/bullmar/1952/00000002/00000002/art00005.

8 *See* P.C.D. Milly et al., *Stationarity is Dead: Whither Water Management?*, 319 SCI. 573, 573–74 (2008), *available at* http://www.sciencemag.org/content/319/5863/573.full.

9. Elinor Ostrom, A General Framework for Analyzing Sustainability of Social-Ecological Systems, 325 SCI. 419 (2009).

standing of the nonlinear behavior of complex ecological systems through the lens of resilience.[10] With this new understanding, ecologists considered a new approach to manage complex non-linear resource systems and developed the concepts of adaptive management.[11] Soon after adaptive management was applied, failures of this management approach gave rise to a new literature in which shortcomings in adaptive management were attributed in part to governance issues.[12] The solution was dubbed adaptive governance.[13]

This volume introduces the initial products of the Adaptive Water Governance (AWG) Project.[14] The AWG Project does not seek to reinvent or critique the body of research on adaptive and environmental governance, instead we seek to add the role of law in adaptive governance approaches in heavily regulated and developed social-ecological systems. The AWG Project brings together ecologists, geographers and political scientists, all of whom approach their work through the lens of resilience, with legal scholars with a research focus on environmental and natural resources law and who have also begun to view that field through the lens of resilience.

We begin with an introduction to the project, followed by the language and concepts of resilience and adaptive governance. We then move to a summary of each of the six basin assessments, and finally conclude with an initial synthesis of the lessons learned from the assessments relevant to the role of law in different governance trajectories. The six basin assessments then follow this article in six separate articles.

II. THE ADAPTIVE WATER GOVERNANCE PROJECT

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10. Holling, *supra* note 2.

11. ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (C.S. Holling ed., 1978); Carl J. Walters & Ray Hilborn, *Ecological Optimization and Adaptive Management*, 9 ANN. REV. ECOLOGICAL SYS. 157 (1978), *available at* http://www.annualreviews.org/doi/pdf/10.1146/annurev.es.09.110178.001105.

12. Thomas Dietz et al., *The Struggle to Govern the Commons*, 302 SCI. 1907 (2003), *available at* http://www.sciencemag.org/content/302/5652/1907.full; RONALD D. BRUNNER ET AL., ADAPTIVE GOVERNANCE: INTEGRATING SCIENCE, POLICY, AND DECISION MAKING (2005); Carl Folke et al., *Adaptive Governance of Social-Ecological Systems*, 30 ANN. REV. ENVTL. RES. 441 (2005), *available at* http://www.annualreviews.org/doi/pdf/10.1146/annurev.energy.30.050504.144511; Lance Gunderson & Stephen S. Light., *Adaptive Management and Adaptive Governance in the Everglades Ecosystem*, 39 POL'Y SCI. 323 (2006), *available at* http://research-legacy.arch.tamu.edu/epsru/Course_Readings/Ldev671MARS689/LDEV671_Readings/PolicySciences_gunderson_light_everglades.pdf.

13. Gunderson & Light, *supra* note 12. *See generally* Brian C. Chaffin et al., *A Decade of Adaptive Governance Scholarship: Synthesis and Future Directions*, 19 ECOLOGY & SOC'Y, no. 3, art. 56 (2014), *available at* http://www.ecologyandsociety.org/vol19/iss3/art56/ (discussing adaptive governance as a form of environmental governance).

14. The Adaptive Water Governance Project is a synthesis project on Social-ecological System Resilience, Climate Change, & Adaptive Water Governance, co-chairs Cosens, B. and Gunderson, L., with the National Socio-Environmental Synthesis Center (SESYNC) under funding from the National Science Foundation DBI-1052875.

In November of 2010, Stockholm University held the first conference to bring together legal and resilience scholars,[15] in recognition of the fact that after several decades of work on understanding the complexity of ecosystems, the recommended solutions of adaptive management, and adaptive governance were yet to be widely implemented. This led to a special session at the Resilience 2011 Conference,[16] and the publication of three collections on law and resilience.[17] The resulting dialogue recognized that the law presents a barrier to more adaptive forms of governance due to its foundation in an understanding of systems as linear and its focus on economic stability, and yet in the face of destabilizing forces including climate change, the law may also be the vehicle to introduce new approaches while protecting the social need for stability. The perspective legal scholars bring to the study of resilience and adaptive governance is the recognition that legal systems, while establishing boundaries and fostering a primary goal of economic and social stability, nevertheless are inherently adaptable and have throughout history responded to new challenges. This dialogue led to the proposal to the National Socio-Environmental Synthesis Center to bring together ecologists, resilience scholars and legal scholars for the Adaptive Water Governance Project.[18]

The AWG project explores means to link ecological resilience and the law and policy governing the process of water management in complex, multi-jurisdictional water basins. Its members hope to "contribute to the growing effort to connect concepts from science to policy decisions and to move social-ecological systems toward" sustainability even as the water balance and ecological changes resulting from climate change play out.

The AWG project focuses on assessing resilience to climate change and the law in six regional scale watersheds or basins [Figure 1]. The AWG Project uses the setting of these major North American water basins as examples of heavily regulated and developed social-ecological system. We choose to ground the project in case studies to both contextualize our research,[19] and enhance cross-disciplinary understanding through reference to real situations. A common goal that informs the work of the AWG team is to meet the challenge of posing solutions in recognition of the fact that we do not write on a clean slate. Rather than propose a new form of governance, we focus on bridging existing governance to proposed approaches asking how we might get there from here.

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15. Sturle Hauge Simonsen, *The Law for Social-Ecological Resilience*, STOCKHOLM RESILIENCE CENTER (Nov. 1, 2010), http://www.stockholmresilience.org/21/news--events/general-news/11-1-2010-the-law-for-social-ecological-resilience.html.

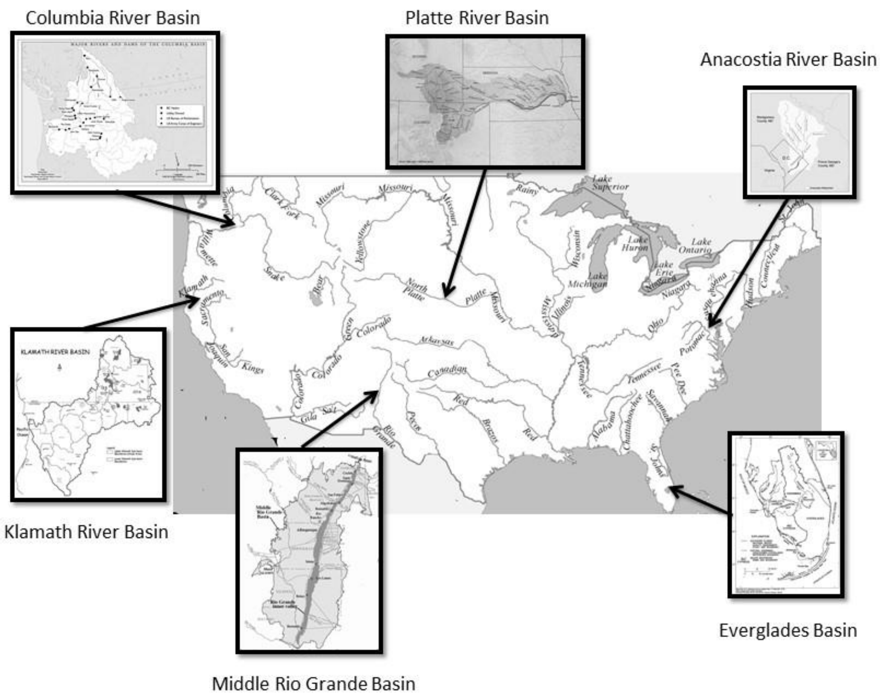
16. Julie Anne Wrigley, *Resilience 2011 - Resilience, Innovation and Sustainability*, ARIZONA ST. U., https://sustainability.asu.edu/events/rsvp/resilience-2011 (last visited Jan. 20, 2015).

17. LAW AND SOCIAL-ECOLOGICAL RESILIENCE, PART I: CONTRIBUTIONS FROM RESILIENCE 2011 (Ahjond S. Garmestani et al. eds., 2013), *available at* http://www.ecologyandsociety.org/issues/view.php/feature/78; LAW AND SOCIAL-ECOLOGICAL RESILIENCE, PART II: CONTRIBUTIONS FROM LAW FOR SOCIAL-ECOLOGICAL RESILIENCE SYMPOSIUM (Jonas Ebbesson & Ellen Hey eds., 2013), *available at* http://www.ecologyandsociety.org/issues/view.php?sf=98.

18. See *Social-Ecological System Resilience*, *supra* note 15.

19. *See, e.g.*, Stephen J. Toope & Jutta Brunnee, *Freshwater Regimes: The Mandate of the International Joint Commission*, 15 ARIZ. J. INT'L. & COMP. L. 273 (1998).

The AWG Project asks four questions on the role of law in adaptive governance. (1) What is the role of law in setting boundaries by identifying approaching thresholds or tipping points in the system? (2) What is the role of law in creating



either a disturbance or window of opportunity in which adaptive forms of governance may emerge? (3) What is the role of law in presenting barriers to adaptive forms of governance? (4) What is the role of law in facilitating adaptive forms of governance? As in the interdisciplinary project itself, we begin here with an understanding of a common language.

FIGURE 1. Map of the AWG Project Six North American Water Basins.

III. THE LANGUAGE AND CONCEPTS OF RESILIENCE AND ADAPTIVE GOVERNANCE

One of the challenges of interdisciplinary research is to develop a common language around concepts that form the communication base of a collaborative project.[20] The following sections provide the understanding of resilience and of adaptive governance used by the AWG team, while recognizing that these terms invoke

20. ALLEN F. REPKO, INTERDISCIPLINARY RESEARCH: PROCESS AND THEORY 263 (2d ed. 2011).

a variety of meanings in other contexts. Our goal is not to resolve debate over definition of these terms, but simply to build from a common platform agreed upon by the natural and social scientists and legal scholars in the study.

A. Resilience: Theories of Change in Social-Ecological Systems

The regional water management systems described in the basin assessments are defined by a great diversity in the aquatic, wetland and terrestrial ecosystems. While these ecosystems are dynamic and change over time due to non-human processes, water management and the history of development of water control has led to dramatic shifts in ecosystem structures and functions. Such shifts are described in ecological theory as being controlled by the property of resilience.[21] Resilience can be defined as "*a measure of the amount of perturbation a social-ecological system can withstand while maintaining its structure and functions; it describes the ability of a complex system to continue to provide the full range of ecosystem services in the face of change.*"[22]

Since the concept was introduced to describe non-linear change in ecosystems, resilience literature has shown that social-ecological systems can exist in very different configurations or regimes, each with sets of reinforcing feedbacks and persistence over time.[23] Such alternative regimes can confer different sets of ecosystem goods and services. For example, undammed or uncontrolled rivers provide many provisioning, regulatory, aesthetic and supporting services, such as flood abatement, nutrient and sediment transport, food production and recreational experiences. Damming of rivers has often switched the bundles of ecosystem services by trading off services such as aesthetic and biodiversity supporting services, in order to provide dependable water and energy supplies as well as reducing vulnerability to flood risk.

How to reconcile such tradeoffs consumes much of the current research and practitioners debates. Since prior management activities have tended to reduce ecological resilience, scenarios of climate and other global drivers indicate that ecological regime shifts that can impact and alter the bundle of ecosystem goods and services are more likely to occur in the future.[24]

A system can be highly resilient either because it is quite adaptable (latitude) or quite resistant to change (resistance).[25] Thus, a nutrient enriched lake that is characterized by algal blooms, low oxygen and changed fish communities may be resistant to returning to its original state when nutrient lading is reduced – it is therefore resilient but not necessarily something we label as good. A brutal military

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21. Holling, *supra* note 2.

22. *See, e.g.*, BRIAN WALKER & DAVID SALT, RESILIENCE THINKING: SUSTAINING ECOSYSTEMS AND PEOPLE IN A CHANGING WORLD (2006).

23. RESILIENCE AND THE BEHAVIOR OF LARGE SCALE SYSTEMS (Lance H. Gunderson & Lowell Pritchard eds., 2002); WALKER & SALT, *supra* note 22.

24. *See, e.g.*, T.P. Hughes et al., *Climate Change, Human Impacts, and the Resilience of Coral Reefs*, 301 SCI. 929 (2003). *See generally* NATURE'S SERVICES: SOCIETAL DEPENDENCE ON NATURAL ECOSYSTEMS (Gretchen Daily ed., 1997).

25. Brian Walker et al., *Resilience, Adaptability and Transformability in Social-ecological Systems*, 9 ECOLOGY AND SOC'Y, no. 2, art. 5 (2004), *available at* http://www.ecologyandsociety.org/vol9/iss2/art5/.

dictatorship may be highly resistant to change—it is therefore resilient but not necessarily something we label as good. We find it more useful to discuss societal goals such as sustainability or the maintenance of ecosystem function, as an emergent outcome from a system of governance. What resilience brings to the discussion is a different perspective in terms of how we respond, adapt or adjust our actions in a complex system to achieve societal goals that is linked to how the system responds to our actions.

We view the property of ecological resilience to be non-normative or value neutral, unlike the concept of sustainability.[26] However, society does make value judgments about alternative states. Indeed, much of adaptive governance is about contrasting and weighing alternative values of different ecological states. It is within governance that the desire for a particular alternative state is expressed, it is resilience – i.e. the system properties – that tells us how to get there within a complex system.

A second bridging concept from the resilience literature, panarchy, provides a dynamic cross-scale lens through which both social-ecological systems and their systems of governance can be viewed. [27] Panarchy describes the existence of systems in a nested, interconnected, hierarchy in various stages of growth, collapse, innovation and reorganization (Figure 2). Thus, within a social-ecological system at the landscape scale, are multiple interconnected smaller scale systems down to the microscopic in the ecological realm, and down to the individual in the societal realm. Panarchy expands the concept of resilience by recognizing that: a) resilience of a system declines as a system matures or develops; b) larger (slower) and smaller (faster) scale processes interact and can both foster resilience; and c) cross scale interactions may play a role in transformations into new regimes in both ecological and social system configurations. These aspects of panarchy are also observed in our systems of governance.

26. It should be noted that the disaster response literature has adopted the term resilience to describe the vulnerability of a community in terms of how quickly it will recover from a natural disaster. *See, e.g.*, FEMA, CRISIS RESPONSE AND DISASTER RESILIENCE 2030 (2012), *available at* http://www.fema.gov/media-library-data/20130726-1816-25045-5167/sfi_report_13.jan.2012_final.docx.pdf. This is the engineering definition of resilience and has a normative focus in contrast to our use of the definition from ecology.

27. *See generally* Lance H. Gunderson & C. S. Holling, Panarchy: Understanding Transformations in Human and Natural Systems (Lance H. Gunderson & C. S. Holling eds., 2002) [hereinafter Panarchy].

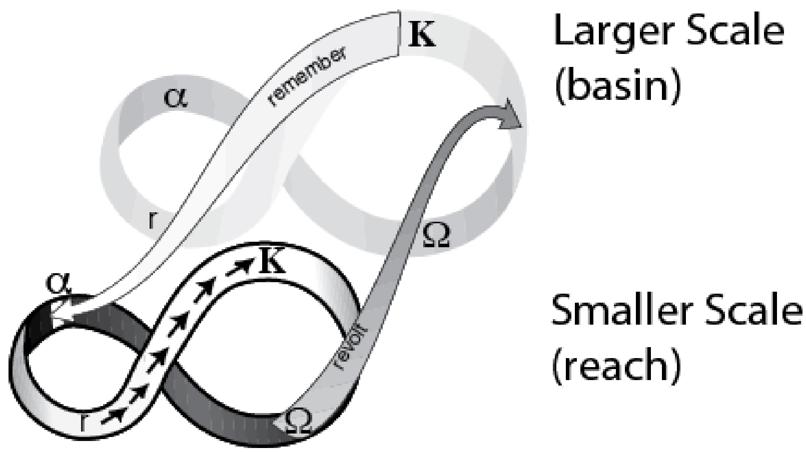

FIGURE 2. Panarchy theory emphasizes four key features of change. One is the important role that diversity has during recovery after a disturbance, a role that can seed novelty, trigger invasions, or spawn innovation in the next sweep of the adaptive cycle (omega to alpha phases). Another is the role of stability between disturbances (omega), where the pattern unrolls predictably as the system grows, as it accumulates capital and ultimately reduces resilience (r to K phases). Still another is the role of an increasing likelihood of collapse across spatial/temporal scales, as collapse at one scale can propagate to larger/slower scales when those scales are vulnerable (revolt). And still another is the inhibition of that process of spreading (i.e., cross-scale collapse) as the memory of the bigger and slower scales sustain lower scale recovery (modified from Gunderson and Holling 2002).[28]

B. Adaptive Governance

Governance refers to the means through which political actors choose goals and make decisions and the means through which they take action to achieve those goals; thus, governance includes not only the laws, regulations, policies, and processes of government, but the formal and informal institutional frameworks in which government acts and private actors take a role in the political process as well as the societal norms that influence policy decisions.[29] Adaptive Governance is simply governance that allows adaptive processes to emerge.[30] In this context, the

28. PANARCHY, *supra* note 27 at 75.

29. Dave Huitema et al., *Adaptive Water Governance: Assessing the Institutional Prescriptions of Adaptive (Co-) Management from a Governance Perspective and Defining a Research Agenda*, 14 ECOLOGY & SOC'Y, no. 1, art. 26 (2009), *available at* http://www.ecologyandsociety.org/vol14/iss1/art26/; Patsy Healey, *Transforming Governance: Challenges of Institutional Adaptation and a New Politics of Space*, 14 EUR. PLAN. STUD. 299 (2006).

30. *See generally* Brian C. Chaffin et al., *A Decade of Adaptive Governance Scholarship: Synthesis and Future Directions*, 19 ECOLOGY & SOC'Y, no. 3, art. 56 (2014), *available at* http://www.ecologyandsociety.org/vol19/iss3/art56.

AWG Project working description of Adaptive Governance is that it *enables society to navigate the dynamic, multi-scalar nature of social ecological systems*. Adaptive governance is appropriate when the system is complex (e.g. lies within multiple jurisdictions), the system faces change with a degree of uncertainty (e.g. climate change) and the system is approaching a potential threshold or regime shift as evidenced by increasing conflict over resources (e.g. litigation), increasing scarcity, or actual identification of an approaching threshold by law or science (e.g. listing of species).

Considerable scholarship has developed through empirical observation of the emergence of adaptive forms of governance to solve common pool problems in the face of uncertainty.[31] These emerging or self-organizing governance mechanisms are variously referred to under the general umbrella of adaptive governance,[32] or more specifically as community-based initiatives [33] and collaborative comanagement.[34] Many of the mechanisms are collaborative in nature and formed at the local level, often in response to the scale of a particular problem. Nobel Laureate Elinor Ostrom in collaboration with her lab at U. Indiana took this work further by identifying the key attributes of the social-ecological systems in which adaptive, self-regulating processes emerge and setting them within their institutional setting.[35] Other resilience scholars have contributed to the understanding of the attributes of adaptive governance.[36]

Rather than reproduce or critique those frameworks, the AWG Project seeks to extract those aspects relevant to legal systems by asking: what role may the law play in either preparing a system for adaptive governance or facilitating the adaptive governance process. The AWG Project has identified three areas of inquiry for assessment of the role of law in: (1) structure; (2) capacity; and (3) process.[37] We also acknowledge that to introduce flexibility into governance while maintaining legitimacy, and to assure attention to all aspects of an interacting social ecological

31. *See generally* ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION (1990); GOVERNANCE FOR THE ENVIRONMENT: NEW PERSPECTIVES (Magali A. Delmas & Oran R. Young eds., 2009).

32. Carl Folke et al., *Adaptive Governance of Social-Ecological Systems*, 30 ANN. REV. OF ENV'T & RES. 441 (2005), *available at* http://www.annualreviews.org/doi/pdf/10.1146/annurev.energy.30.050504.144511; Huitema, *supra* note **Error! Bookmark not defined.**; Chaffin, *supra* note 30.

33. RONALD D. BRUNNER ET AL., FINDING COMMON GROUND: GOVERNANCE AND NATURAL RESOURCES IN THE AMERICAN WEST (2008).

34. Per Olsson & Carl Folke, *Adaptive Comanagement for Building Resilience in Social-Ecological Systems*, 34 ENVTL. MGMT. 75, 75–90 (2004). *See generally* JULIA MARIE WONDOLLECK & STEVEN LEWIS YAFFEE, MAKING COLLABORATION WORK: LESSONS FROM INNOVATION IN NATURAL RESOURCE MANAGEMENT (2000).

35. Elinor Ostrom, *Background on Institutional Analysis and Development Framework*, 39 POL'Y STUD. J. 7 (2011); *see also* Michael D. McGinnis, *An Introduction to IAD and the Language of the Ostrom Workshop: A Simple Guide to Complex Framework*, 39 POL'Y STUD. J. 169 (2011); Elinor Ostrom, *A General Framework for Analyzing Sustainability of Social-Ecological Systems*, 325 SCI. 419 (2009); Elinor Ostrom, *A Diagnostic Approach for Going Beyond Panaceas*, 104 PNAS 15181.

36. *See, e.g.*, Folke, *supra* note 32; Huitema, *supra* note **Error! Bookmark not defined.**. For a eview of the literature on adaptive governance, see generally Chaffin, *supra* note 30.

37. Our initial thoughts on these areas of inquiry for analyzing legal systems are published at Barbara Cosens et al., *Identifying Legal, Ecological and Governance Obstacles, and Opportunities for Adapting to Climate Change*, 6 SUSTAINABILITY 2338 (2014), *available at* http://www.mdpi.com/2071-1050/6/4/2338/pdf. This article continues the development of this approach.

system, requires both diverse and inclusive representation, thus in addition to reliance on the literature on adaptive governance, all three components (structure, capacity and process) incorporate concepts of "good governance."[38]

1. Structure

Structure refers to the multi-level, multi-scalar response needed in the face of uncertainty and requires attention to both polycentricity (i.e. overlapping and connected levels of governance) [39] across spatial scales. This type of structure includes "nested governance" e.g. a hierarchy in which coordination may occur at the basin scale, but flexibility exists for implementation at local scales.[40] In layman's terms the concepts of polycentricity and nested governance require the ability to respond to the same problem at different levels and scales, at the same level from different perspectives and to be able to communicate across those divides. It provides in reference to panarchy, the room for local governance to experiment and adapt while relying on larger scale governance for resources and stability.

Structural considerations must also pay attention to the level or scale at which implementation is appropriate and the degree of inclusiveness. This captures the notions of fit of management and response to purpose, [41] and subsidiarity (i.e. the concept that decisions should be made as close as possible to the individual citizen[42]). Although recently adopted as furthering a conservative agenda in reducing the role of government, the principle of subsidiarity has broader origins, and has generally been intended to further individual empowerment within the context of a government that plays "a significant role in fostering the conditions for its implementation."[43] Subsidiarity increases the chances that feedback from the ecological system will be linked to the appropriate governance level and allows for greater use of local knowledge, increased speed in response to change and provides a means for small scale innovation under an umbrella of basin-wide stability (again, in reference to panarchy).[44]

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38. Thomas M. Franck, *Legitimacy in the International System*, 82 Am. J. Int'l L. 705 (1988); WORLD WATER ASSESSMENT PROGRAMME, UNITED NATIONS, WORLD WATER DEVELOPMENT REPORT: WATER FOR PEOPLE, WATER FOR LIFE 370–384 (2003), *available at* http://unesdoc.unesco.org/images/0012/001297/129726e.pdf#page=387.

39. Huitema, *supra* note **Error! Bookmark not defined.**.

40. Vincent Ostrom et al., *The Organization of Government in Metropolitan Areas: a Theoretical Inquiry*, 55 AM. POL. SCI. REV. 831, 837 (1961), *available at* http://dx.doi.org/10.2307/1952530; *see also* POLYCENTRIC GOVERNANCE AND DEVELOPMENT: READINGS FROM THE WORKSHOP IN POLITICAL THEORY AND POLICY ANALYSIS (Michael McGinnis ed., 1999); Huitema, *supra* note **Error! Bookmark ot defined.**.

41. Jeroen Rijke et al., *Fit-for-Purpose Governance: A Framework to Make Adaptive Governance Operational*, ENVTL. SCI. & POL'Y 22, 76–80 (2012).

42. Robert K. Vischer, *Subsidiarity as a Principle of Governance: Beyond Devolution*, 35 IND. L. REV. 103, 110 (2001). We adopt this broader view of subsidiarity. For application in a legal document, *see e.g.*, Treaty on the Functioning of the European Union, art. 69, Oct. 30, 2010, 83 O.J.(C) 74, which states "National Parliaments ensure that the proposals and legislative initiatives submitted under Chapters 4 and 5 comply with the principle of subsidiarity, in accordance with the arrangements laid down by the Protocol on the application of the principles of subsidiarity and proportionality." Treaty for the Functioning of the European Union, Oct. 30, 2010, 83 O.J.(C) 74, *available at* http://www.en.parlamento.pt/EuropeanAffairs/DisposPNsEN.pdf.

43. *Id.*

44. *See* PANARCHY, *supra* note 27, at 195–240.

Assessment of governance structure to identify the role of law must include questions such as: What are the system boundaries? Who are the entities with authority to make decisions, respond to, or influence the system you identified? What is the scope of that authority? Do all stakeholders who are affected by management of the system have representation within the structure?[45]

2. Capacity

Capacity encompasses both the resources and authority to respond to change (adaptive capacity),[46] and the right and resources to have a role in decision making (participatory capacity).[47] Adaptive capacity requires the availability of tools for adaptive management, such as the model administrative law for adaptive management recently developed by Craig and Ruhl.[48] Participatory capacity is primarily related to the local ability to participate in decision making. For marginalized populations, participatory capacity may require access to judicial processes to establish rights as a precursor to capacity building, as described in the basin assessments below.

Assessment of governance capacity to identify the role of law must include questions such as: Who participates in decision making affecting the system? Do local leaders have the resources (including time and knowledge) to participate? How is information made available to those who are affected by decision making? What venues are available to express interests? What authority do management entities have to consider expressed interests in management actions?

3. Process

Process elements are the ones most frequently overlooked in the scientific application of adaptive management and necessarily focus on assuring the resilience of society. The degree of flexibility needed for more adaptive forms of governance that can manage the level of uncertainty associated with the impacts of climate change is in tension with the notion that a functional system of governance must foster stability. Appropriate process may aid in addressing this tension. Social resilience requires that the processes used to achieve adaptive governance incorporate elements of "good governance" focused on equity and justice, captured through the

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45. Modified from the following workbook by the AWG Project in collaboration with the Resilience Taskforce for IUCN to reflect a focus on governance attributes: RESILIENCE ALLIANCE, ASSESSING RESILIENCE IN SOCIAL-ECOLOGICAL SYSTEMS - A WORKBOOK FOR SCIENTISTS, 7–13 (2007), *available at* http://www.resalliance.org/index.php/resilience_assessment.

46. Claudia Pahl-Wostl, *A Conceptual Framework for Analyzing Adaptive Capacity and Multi-Level Learning Processes in Resource Governance Regimes*, GLOBAL ENVTL. CHANGE 19, 354–365 (2009).

47. *See* Huitema, *supra* note **Error! Bookmark not defined.**, at 3. *see also* G.T. (Tom) aadgever et al., *Assessing Management Regimes In Transboundary River Basins: Do They Support Adaptive Management?*, 13(1) ECOLOGY & SOC'Y 14 (2008), *available at* http://www.ecologyandsociety.org/vol13/iss1/art14/; Susan S. Hanna, *Institutions for Managing Resilient Salmon (Oncorhynchus Spp.) Ecosystems: the Role of Incentives and Transaction Costs*, 13(2) ECOLOGY & SOC'Y 35 (2008), *available at* http://www.ecologyandsociety.org/vol13/iss2/art35/.

48. Robin Kundis Craig & J.B. Ruhl, *Designing Administrative Law for Adaptive Management*, 67 VAND. L. REV. 1, 50–59 (2014).

lens of legitimacy and inclusiveness.[49] Inclusiveness is addressed by participatory capacity. Legitimacy is addressed through processes that place bounds on the exercise of discretion in implementation of flexible management; that consider both biophysical and social/economic timeframes in setting periods for adjustment; that establish processes to ensure accountability in adjustment of goals; and that provide an avenue for broad, inclusive public input.[50]

Assessment of governance process to identify the role of law must include questions such as: What are the means to resolve conflicts? Are there multiple ways to participate? Who is left out? What groups are marginalized by these processes? Do any of the means of participation encourage problem solving, learning, critique of the decision making process, innovation, collaboration? What types of information informs decision making (e.g. science, local knowledge)? How are the timeframes for adjustment of management actions set? How are the benefits and burdens of management of the system distributed?

C. Bridging Resilience and Adaptive Governance

The adaptive cycle described as a feature of panarchy above, is a useful tool for bridging concepts of resilience and adaptive governance. The adaptive cycle of complex systems not only describes non-linear change in these systems, but is also a building block for understanding the effects of cross-scale interactions (figure 2). We use the adaptive cycle here along with examples from the basin assessments to highlight the mechanisms responsible for the emergence of adaptive forms of governance (figure 3).

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49. Thomas M. Franck, *Legitimacy in the International System*, 82 AM. J. INT'L L. 705, 713–25 (1988); *see also* Daniel Bodansky, *The Legitimacy of International Governance: A Coming Challenge for International Environmental Law?*, 93 AM. J. INT'L L. 596, 603–06 (1999); Daniel C. Esty, *Good Governance at the Supranational Scale: Globalizing Administrative Law*, 115 YALE L.J. 1490, 1515–21 (2006); UNITED NATIONS, WATER FOR PEOPLE, WATER FOR LIFE: A JOINT REPORT BY THE TWENTY THREE UN AGENCIES CONCERNED WITH FRESHWATER, 370–84 (2003); Barbara Cosens, *Legitimacy, Adaptation, and Resilience in Ecosystem Management*, 18(1) ECOLOGY & SOC'Y 3 (2013), *available at* http://www.ecologyandsociety.org/vol18/iss1/art3/.

50. Cosens, *supra* note 49.

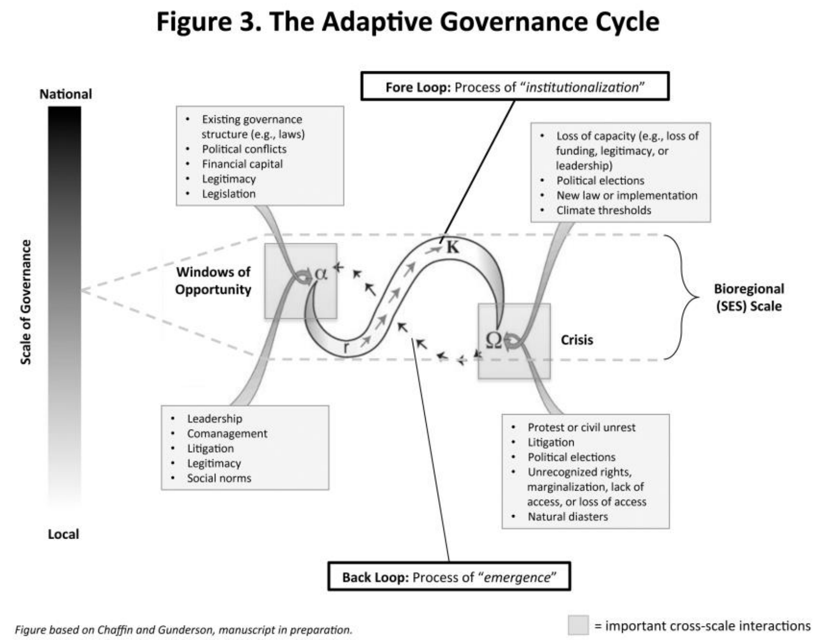

FIGURE 3. The Adaptive Governance Cycle.

It is difficult to determine where adaptive governance begins or can begin relative to a social ecological system trajectory along the adaptive cycle, but empirical observations suggest that the development of adaptive governance is often the result of a perceived or actual resource crisis.[51] During the early fore loop of the adaptive cycle (*r* or exploitation phase) the governance regime in river basin social ecological system generally encourages growth. In North American the existence of clearly defined rights to land and water is important in fueling growth.[52] Similarly, clear definition of the rights to shared water basins are important and are reflected in North America in the form of international treaties[53] and interstate compacts.[54] As growth and exploitation continues the system enters a more stable state of conservation (*K* phase), the focus of these governance tools shifts from development to implementation and enforcement in order to meet multiple, often competing social

51. Brian C. Chaffin et al., *A Decade of Adaptive Governance Scholarship: Synthesis and Future Directions*, 19(3) ECOLOGY & SOC'Y 56 (2014).

52. For example, the prior appropriation doctrine recognized by states in the western U.S. recognizes clearly defined property rights to the use of shared water sources*See generally*, WELLS A. HUTCHINS, WATER RIGHTS LAWS IN THE NINETEEN WESTERN STATES 6–14 (1971). In contrast, until recently Native American water rights although recognized (Winters v. United States), have not been clearly defined, contributing to the slower rate of economic development on Native American reservations. Daniel McCool, *Winters Comes Home to Roost*, *in* FLUID ARGUMENTS: FIVE CENTURIES OF WESTERN WATER CONFLICT 121 (Char Miller ed., 2001).

53. *See, e.g.*, The Columbia Treaty, U.S.-Can., Jan. 17, 1961, *available at* http://www.crt2014-2024review.gov/Files/International%20Documents%20ColumbiaRiverTreaty.pdf.

54. *See, e.g.*, South Platte River Compact, Pub. L. No. 37, 44 Stat. 195.

goals. At this stage, internal conflicts over goals and external disturbances causing resource scarcity may lead to the rise of new voices and the development of new legal mechanisms to redistribute benefits and curb the external impacts of resource exploitation.[55] However, as the growth (*K*) phase persists, the optimization of resource management for the exploitation of select services and the implementation of the policies themselves lead to rigidity in management with considerable reduction in resilience latitude (i.e. little room for adaptation). This can be further exacerbated by interactions from higher scales that support growth in the face of scarcity.[56] At this point the system is vulnerable to internal conflict and to external disturbance. The potential for collapse is high.

It is also at this point that any strong interaction from social and/or ecological scales either above or below the system of focus can exploit the rigidity of governance causing a "release" i.e., a collapse or loss of function.[57] As the system reorganizes, so too does its system of environmental governance. The sudden release of previous governance controls during a crisis (Ω or "release" phase) creates space for a reorganization of those controls, often with new sources of input. In the wake of a resource crisis (e.g., a scarcity such as drought resulting in food shortage and economic loss, or failure to anticipate or control a flood resulting in catastrophic property damage), a leadership vacuum can appear. During this period of social and ecological "crisis" the seeds of adaptive forms of governance may be sown through the "creative destruction" of previously dominant governance processes.[58]

It is the hypothesis of the AWG Project that a social ecological system prepared to facilitate emergence of more adaptive forms of governance through development of the appropriate structures, capacity and processes, will be more likely to navigate this transition smoothly without substantial disruption in social and economic systems. The shift in governance needed during the transition from release to reorganization (Ω to α) in a system's adaptive cycle is one in which space is created for the "emergence" of adaptive forms of governance.[59] Emergence is characterized by the infusion of new or dormant leadership, trust building amongst govern-

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55. For example, the development of a major body of federal environmental laws such as the Endangered Species Act of 1973, 16 USC §§1531-154; National Environmental Policy Act of 1969, 42 USC §§4321-4370h; and Clean Water Act, 33 USC §§1251-1387, in the 1960's and 70's in the United States reflects this phase, as well as the legal recognition of Native American rights in federal courts described in both the Columbia and Klamath River Basin assessments infra.

56. For example, federal subsidy of western irrigation in the United States may develop water to such a high level of efficiency based on historic water supply that little room remains for adaptation when faced with climate change.

57. *See generally* PANARCHY, *supra* note 27. Examples of this might include: a lawsuit filed in 1988, when the US government sued the State of Florida for allowing nutrient releases from agricultural fields to damage federal resources as described in the Everglades assessment infra; a disruptive judicial or political action (e.g., enforcement of the Endangered Species Act and resulting changes in Reclamation water deliveries described in the Klamath basin assessment infra, or extended drought as a result of climate change as described in the Middle Rio Grande basin assessment infra.

58. C.S. Holling & Lance H. Gunderson, *Resilience and Adaptive Cycles*, *in* PANARCHY: UNDERSTANDING TRANSFORMATIONS IN HUMAN AND NATURE SYSTEMS 25, 34 (Lance C. Gunderson & C. S. Holling eds., 2002); *See generally* JOSEPH A. SCHUMPETER, CAPITALISM, SOCIALISM, AND DEMOCRACY (3d ed. 2008).

59. B.C. CHAFFIN & LANCE GUNDERSON, EMERGENCE AND INSTITUTIONALIZATION: ADAPTIVE GOVERNANCE AND THE ADAPTIVE CYCLE OF COMPLEX SOCIAL-ECOLOGICAL SYSTEMS (manuscript in preparation for *Resilience: International Policies, Practices and Discourses*).

ance actors, and often, a trial-and-error method of establishing new or novel governance mechanisms in an attempt to attain broader social and ecological goals in avoidance of the processes that led to earlier collapse in system function.

As the new system configuration emerges and becomes dominant, the system moves from reorganization (α phase) back to exploitation (r phase). In order for the characteristics of adaptive governance to become lasting, some degree of "institutionalization" must take place, e.g., a change in law, rule, or social norm, a significant shift or devolution in decision making authority, or the recognition of an informal adaptive governance network as a formal governance organization.[60] The influence of cross-scale interactions is critical and law may play a prominent role. The degree to which an emergent regime of adaptive governance is institutionalized depends on constraints or catalysts emanating from scales above and below the system. For example, existing laws and policies could fail to support and even fragment emerging networks of governance actors, causing the failure of adaptive governance and the return to the status quo.[61] On the other hand, a new or changed law may support emerging governance networks by providing adequate funding, authority, and the necessary legitimacy to formally reconfigure the system towards adaptive governance.[62] These boosts in capacity have been termed "windows of opportunity" and have been shown to be essential for the ongoing institutionalization of adaptive governance.[63] As adaptive governance continues to develop along the trajectory of the adaptive cycle, the new system of governance will need to be recognized and solidified both formally and informally to varying degrees through changes in laws, policies, organizational structures, and social norms—the institutionalization of adaptive governance.

In reality, social ecological systems are nonlinear, even in their progress along an adaptive cycle. Thus, as discussed below, a system may move back from the brink of collapse through changes that include restoration of ecological function or redistribution of benefits from resources. Intervention from a higher scale such as the federal government may artificially fuel growth beyond the capacity of the existing system, but may also provide the stability and resources necessary for a smooth local transition or for restoration. We turn now to a summary of the six basin assessments, before returning to the theme of governance trajectories below.

IV. RESILIENCE AND GOVERNANCE ASSESSMENT OF SIX NORTH AMERICAN WATER BASINS

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60. *Id.*

61. *See infra* Part IV.B. For example, the broadly collaborative approach of the treaty review process may be undermined by resort of currently dominant interests seeking to maintain the status quo to Congressional leaders.

62. *See infra* Part IV.C. For example, federal funding for the dam removal solution developed through local collaborative processes will be essential to institutionalization of the new governance collaborations in the basin.

63. Per Olsen et al., *Shooting the Rapids: Navigating Transitions to Adaptive Governance of Social-Ecological Systems*, 11, 1 ECOLOGY AND SOC'Y, at art. 18 (2006), *available at* http://www.ecologyandsociety.org/vol11/iss1/art18/.

Six articles in this volume each provide an assessment of a North American water basin. These assessments illustrate that with the onset of water balance impacts from climate change some of the water supplies relied on in North America are close to irreversible thresholds that, once crossed, will alter natural ecosystem services and the adequacy of engineered infrastructure, potentially impairing existing water-based economies. This collection of articles forms the starting point in the AWG Project for assessment of our capacity to govern in the face of change by recognizing the conditions under which approaches to adaptive governance emerge and, in particular, the role of law in not only preventing and facilitating this form of governance, but in providing the boundaries that may trigger its emergence. Although the AWG project goal is to identify the legal tools necessary for adaptive governance, it is also clear from these assessments that major investment in conservation, green infrastructure, ecological restoration, and re-operation of dams,[64] will be necessary to increase the adaptability of water-based economies in the face of climate change. In this call for investment, we echo the recent recommendations from the Johnson Foundation in its report on a six year study of U.S. water systems.[65]

The six basin teams have used a variety of approaches that build off earlier approaches to resilience assessment,[66] by adding assessment of governance and the role of law. By testing different approaches to evaluate basin governance, these assessments will form the basis for development of a governance assessment method as one of the outcomes of the AWG Project. The following sections briefly summarize each of the assessments.

A. Anacostia

The following paragraph introduces the Anacostia basin assessment by Craig Anthony (Tony) Arnold, Olivia Odom Green, Daniel DeCaro, Alexandra Chase, and Jennifer-Grace Ewa.

The Anacostia is a watershed in Maryland and Washington DC that is tributary to the Potomac River which along with numerous other rivers, drains to the Chesapeake Bay (figure 1), and in contrast to the other basins in this study, the Anacostia is predominantly urban-suburban with roughly one and a half million people living within the watershed and only 30% of the basin devoted to forests or agriculture. The river is highly channelized by human development with substantial loss of wetlands and is listed as impaired under the Clean Water Act, with the level of toxics and fecal coliform bacteria high enough to render human contact unwise.

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64. *See* Brian D. Richter & Gregory A. Thomas, *Restoring Environmental Flows by Modifying Dam Operations*, 12, 1 ECOLOGY & SOC'Y, at art. 12 (2007), *available at* http://www.ecologyandsociety.org/vol12/iss1/art12/.

65. *See* THE JOHNSON FOUND. AT WINGSPREAD, NAVIGATING TO NEW SHORES: SEIZING THE FUTURE FOR SUSTAINABLE AND RESILIENT U.S. FRESHWATER RESOURCES (2014), *available at* http://www.johnsonfdn.org/sites/default/files/reports_publications/CNW_NavigatingToNewShoresFullReport.pdf.

66. *See generally* LANCE GUNDERSON ET AL., ASSESSING RESILIENCE IN SOCIAL-ECOLOGICAL SYSTEMS: WORKBOOK FOR PRACTITIONERS (2007), *available at* http://www.resalliance.org/workbook; Kristine T. Nemec et al., *Assessing Resilience in Stressed Watersheds*, 19, 1 ECOLOGY & SOC'Y at art. 34 (2014), *available at* http://www.ecologyandsociety.org/vol19/iss1/art34/ (presenting a simplified approach).

The once rich aquatic life is substantially reduced and impaired due to both low water quality and barriers to migration, but no aquatic species are listed on the Endangered Species List. One of the dichotomies in the story of the Anacostia is that while its development has been in the name of economic growth, its status as the "Forgotten River" in this time of greater attention to restoration may be largely the result of its inhabitance by primarily low-income and minority populations. An aspect of the social system in the basin not apparent in our other basins is the legacy of slavery both in the development history and the continuing marginalization of minority populations in the watershed today. Nevertheless, the river is part of the efforts to restore the Chesapeake Bay and has been listed as a watershed for national priority under various federal initiatives and has been the focus of restoration and economic revitalization initiatives by both the Maryland and DC governments. The basin assessment traces the history of the Anacostia from a watershed of forests and wetlands, to agriculture and navigation, to industrialization, to urbanization, to potential restoration through development of green infrastructure. Numerous citizen and community-led watershed governance institutions have developed in recent decades and are involved in multi-agency and multi-stakeholder collaborations, increasing potential adaptive capacity. The primary legal driver of restoration has been the Clean Water Act. Climate change will likely intensify both storm events and dry periods, which – when coupled with land development pressures and existing impervious cover – will increase the quantity and velocity of stormwater runoff. The Anacostia basin assessment looks at alternative potential futures and the adaptive governance mechanisms necessary to achieve the more desirable of those. Of particular interest in the Anacostia basin assessment is the application of a new framework (Institutional-Social-Ecological Dynamics (ISED)) developed by lead author Tony Arnold, to understand the changes in three systems: institutional, social and ecological and the interaction of those changes in the social-ecological system. Application of the ISED to the Anacostia basin reveals that law and litigation have forced the emergence of more innovative solutions and that the rise of locally-based watershed organizations have been the vehicle for much of this innovation.

B. Columbia

The following paragraph introduces the Columbia River basin assessment by Barbara Cosens and Alexander Fremier.

The Columbia River Basin located in the Pacific Northwest is shared by the United States and Canada and is heavily developed for purposes of flood control, hydroelectric generation, irrigation and navigation. The authors approach to assessing governance is to look at changes to key system variables through time in response to increased alteration of natural ecosystem services as infrastructure was developed to serve society. The authors focus on four specific historical time periods: (1) pre – Contact defines the era in which indigenous populations lived a subsistence life style and were highly adaptive to changes in salmon runs and other natural variables, yet vulnerable to outside disturbance; (2) Contact defines the period of transition from an indigenous society to one of European settlement in which both populations were reliant on either federal aid or eastern investment for survival, and settlers began changing the uplands through monoculture and the river through development of locks for navigation; (3) Dam building defines the period of the first half of the twentieth century in which heavy federal investment substantially changed the river hydrograph through development of dams for hydropower production, flood control and irrigation, including dams built in the river headwater in Canada as the result of an international treaty; and (4) Environmental Justice and Civil Rights defines a period beginning in the 1970's in which assertion of rights by Native American tribes altered the power balance in river management and the resulting increase in capacity elevated certain tribes to co-managers of the fishery, yet to date the changes have been primarily in governance, with only small incremental changes to river operation and optimization for hydropower production continues to dominate. By mapping the changes to variables used to define system resilience, the authors note the severance of feedback to governance when flood control infrastructure and water storage alleviate direct impacts from extremes in water supply. The massive development of the river in the twentieth century increased mainstem modularity and thus ability to hold back flood, but did so at the expense of habitat variability and diversity for salmon. While federal investment during this period greatly improved the lives of many reliant on the basin's services, it also increased the vulnerability of the basins iconic salmon populations. Of interest in the Columbia River assessment is the use of this mapping of resilience variables to identify the types of restoration needed to increase resilience latitude and move the basin away from a threshold. Climate change is likely to alter the timing of runoff to earlier, increase water temperature, and increase demand for both irrigation water and summer electric generation. The basin is currently undergoing a major review process for the Treaty with Canada that controls much of the operation of the river mainstem and it remains to be seen whether this will be an opportunity for introducing greater flexibility to basin governance.

C. Florida Everglades

The following paragraph introduces the Florida Everglades basin assessment by Lance H. Gunderson, Ahjond Garmestani, Keith W. Rizzardi, J.B. Ruhl, and Alfred Light.

The Florida Everglades is a biologically rich subtropical wetland social ecological system, within which water is managed to sustain urban, agricultural and conservation areas. The social ecological system supplies water to about 8 million people in the watershed, a multi-billion dollar agriculture enterprise, and the conservation needs of a U.S. National Park. Over the past century the system was altered to ameliorate flooding, to supply water during drought, and to assure clean water. This massive effort to engineer control and stability of the Everglades water has fostered economic and human development along the southeast coast of Florida, while at the same time eroding the ecological resilience of the natural biodiversity. The authors describe a nonlinear process of water infrastructure development in response to flood events, with a shared (and shifting) responsibility between the state and federal governments. In response to a severe drought and rising populations, local water management districts were established under state law in the 1970's, with authority to manage water including distribution, flood control and water quality. Water quality crisis in the 1980's led to initial diversion of pollution from agriculture away from locally valued resources toward federally protected areas and subsequent litigation ultimately led to development of wetlands to manage agricultural runoff and return flow. In the 1990's, continued deterioration of environmental values led to an increased focus on ecosystem restoration culminating in passage of the Everglades Restoration Act in 2000 by Congress. Yet, interests reliant on the current engineering and management of the system have stalled implementation of this Act. Climate change predictions for the region suggest a shift in seasonal wet/dry cycles; changes in long term flood/drought cycles with great frequency and a shortened timeframe between flood and drought; the likelihood of stronger and more frequent storms and rising sea level. Of particular interest in the Florida Everglades assessment is the application of resilience to identify four types of change: 1) declining resilience over time due to flood control policies, increased development and rising sea level; 2) rhythms of stability and instability that have led to infrastructure development to respond to flood and drought, yet is not adaptive to changes in the frequency and magnitude of these events; 3) cascading change that may result from fire suppression or invasive species, but can also result from social change such as increase in value placed on restoration; and 4) windows of transformative change that include flood and drought, yet past response seeking to maintain the same type and level of services from the system with increasing population has placed the Everglades region in a rigidity trap and thus vulnerable to the disturbances that are expected with climate change The authors look at three management strategies focused on system resilience: (1) management to avoid crossing a threshold such as a water quality standard; (2) management to reduce resilience and thus facilitate regime shift – a necessary approach for ecosystem restoration and one that requires a high level of flexibility for experimentation; and (3) management for transformation approached by the authors by laying out three scenarios for future regimes. The authors conclude by evaluating the current capacity of the Everglades system for adaptive governance to address the three management strategies concluding that while many of the attributes necessary for adaptive governance such as identification of thresholds, authority to experiment (e.g. adaptive management authority) and diversity of institutions exist in the Everglades; their implementation is, however, hindered by use of their own tools – planning and litigation – leaving the social-ecological system of the Florida Everglades very constrained in their capacity to adapt to climate change.

C. Klamath

The following paragraph introduces the Klamath basin assessment by Brian C. Chaffin, Robin Kundis Craig, and Hannah Gosnell.

The Klamath River basin is physically reversed from most river basins in that the upper basin is a broad plain in which agriculture thrives in areas where there once were marshes and wetlands, and the lower basin drains mountainous, forested terrain protecting significant salmon spawning habitat. Between the upper and lower basin, the drainage necks down to pass through the Cascade Mountain Range, providing ideal sites for the development of hydroelectric dams, and at this point, crosses the state line between Oregon (upper basin) and California (lower basin). The Klamath Basin has been the stage for a classic water conflict among Native American Tribes, commercial and recreational fishing interests, and environmental groups on one side, and irrigators relying on a federal reclamation project on the other—a conflict that reached crisis proportions in 2001. The authors use the metaphor of the adaptive cycle to trace an evolution of governance and social interaction through stages of vulnerability, resilience and transformation. In doing so, the authors describe the early stages of exploitation and conservation as development of the basin with the encouragement of federal law and policy, including the development of hydropower, the authorization of a reclamation project, and the offering of irrigated tracts to returning World War I and II veterans. However, in the same timeframe, the marginalization of Native American populations placed these smaller-scale basin communities in a state of collapse, i.e., the release phase of the adaptive cycle. As the conservation phase continued with increased development of the river, climate impacts from extended periods of drought began to reveal potential vulnerability through indicators such as increasing conflict over the allocation of water and other resources. The authors highlight the role of law—in particular the Endangered Species Act and the assertion of Native American reserved water rights—as the catalyst for emergence of local adaptive solutions as both the Native American and irrigation communities approached the reorganization phase of the adaptive cycle. In a "window of opportunity" created by legal triggers including relicensing of hydropower projects and resolution of Native American water rights, basin communities began to shape a new direction for the basin—one that would create space for adaptation. The shifting balance between irrigation and tribal water interests created through litigation brought a more diverse array of interests to the table. The ultimate outcome of the emergence of this new approach is still playing out in the basin. Of particular interest in the Klamath basin assessment is the recognition that emergent solutions based on collaboration and adaptive governance remain vulnerable if not institutionalized formally through the legal process. With the high potential for climate change to negatively impact water resources in the basin, the authors explore various scenarios on how the future of the basin might play out.

D. Middle Rio Grande

The following paragraph introduces the Middle Rio Grande basin assessment by Melinda Harm Benson, Dagmar Llewellyn, Ryan Morrison and Mark Stone.

The Middle Rio Grande is the 155 mile reach of the Rio Grande River that runs from Cochiti Dam to Elephant Butte Reservoir in central New Mexico and includes the urban areas of Santa Fe and Albuquerque. The reach includes six Native American Pueblos with pre-European settlement irrigation water rights, and irrigation dependent acequia communities with origins dating back to Spanish settlement. The 1848 Treaty of Guadalupe Hidalgo brought this region into the United States and subsequent Anglo-American settlement culminated in the federal water projects that provide the book ends to this reach of the river. Cochiti Dam along with channelization of much of the river reach provides flood control, whereas Elephant Butte Reservoir is part of a federal reclamation project. Elephant Butte Reservoir is also the regulating point on the Rio Grande River for delivery of water from the United States to Mexico pursuant to a 1944 Treaty, and delivery of water from New Mexico to Texas pursuant to a 1939 Compact which is currently in litigation before the U.S. Supreme Court with Texas asserting shortfalls in water delivery. In recent decades the Endangered Species Act has played a role in the basin with listing of aquatic and riparian habitat dependent species. The federal projects have been found to jeopardize listed species forcing change to past operations. The authors suggest that over allocation of water pursuant to the prior appropriation doctrine, development of groundwater hydrologically connected to the river to serve growing urban populations, and extended drought combined with the initial impacts of climate change that are reducing water supply and altering the upland forest ecosystem and fire regime, are combining to place the Middle Rio Grande very close to a threshold. Of particular interest in the Middle Rio Grande basin assessment are the specific recommendations for water management including reconfiguring the operation of reservoirs to meet new demands for storage and supply; re-examining of the system of water allocation regimes including integration of water allocation and land use decisions; managing of the riparian corridor to restore habitat; engaging in open and transparent discussion regarding the fact that the upland forests are already crossing a threshold and management must adapt to smooth that transition; and diversifying flood management to prepare for the more intense localized flooding anticipated with climate change.

E. Platte

The following paragraph introduces the Platte River basin assessment by Hannah E. Birge, Craig R Allen, Robin Kundis Craig, Ahjond S. Garmestani, Joseph A. Hamm, Christina Babbitt, Kristine Nemec, and Edella Schlager.

The North and South Platte Rivers converge in Nebraska and the entire Platte River basin drains approximately 90,000 square miles in Colorado, Nebraska and Wyoming before joining the Missouri River where the Missouri forms the border between Nebraska and Iowa. Prior to development, the low gradient and braided nature of the river combined with flood from snowmelt from the Rocky Mountains to feed the grasslands of the prairie and was characteristic of the rivers of the Great Plains of the United States. The river and the plains sustained indigenous populations until, under federal law and policy, white settlement beginning in the mid-1800’s became dominant by the end of that century. Farming in the arid Platte Valley required irrigation. Scarcity was already prevalent in the early twentieth century and led to negotiation of the South Platte River Compact between Nebraska and Colorado, ratified in 1923, and to equitable apportionment of the North Platte River among Nebraska, Wyoming and Colorado by the U.S. Supreme Court in 1945. Resolution of conflict led to development including federal irrigation projects that transformed 335,000 acres of sage and grass land to farmland. Today, fifteen major reservoirs or dams and numerous smaller projects store an average of more than 7.1 million acre-feet. The dams substantially altered the hydrograph of the Platte, dampening the ability of the river to mobilize sediment and reducing transport between the river and its floodplain. The dams also eliminated the connectivity of the aquatic system, isolating species and potentially reducing genetic diversity and adaptive capacity. The result has been transformation from a braided river system to a deep, channelized stream with well-defined and static edges, armored with invasive herbaceous and woody vegetation. River development has buffered agricultural water users from drought of historic magnitude and provided increased services for irrigation and hydropower. Yet, development to maximize these values is dependent on the historic hydrograph and this combined with the loss of many other ecosystem services leaves the system vulnerable in the face of climate change. The states of Nebraska, Colorado and Wyoming have recently entered into the Platte River Recovery Implementation Plan, which may provide an avenue for improvements in flow and habitat restoration and takes an adaptive management approach by providing for adjustment over the period of implementation. The collaborative approach was triggered by a federal level recovery plan following listing of several species reliant on the basin ecosystem. The recovery program is governed by a committee consisting of a representative from three states, the U.S. Bureau of Reclamation and Fish & Wildlife Service, water users, and environmental interest groups. Implementation of the plan has required state level legislation to provide the necessary authority to achieve the goal of the plan. The authors recommend either transformation to an alternative state that removes the current pressure from over development of the river, or restoration to bring back key ecosystem services.

V. SYNTHESIS: GOVERNANCE OF WATER BASINS IN A CHANGING CLIMATE

Our analysis of the six basin assessments and the literature reveals at least three governance configurations that correspond to resilience in an SES: (1) maintaining a desired state; (2) enhancing lost resilience; and (3) attempting a regime shift.[67] The following paragraphs describe these trajectories and rely on examples from the basin assessments to consider within each: (1) What is the role of law in setting boundaries by identifying thresholds or tipping points in the system? (2) What is the role of law in creating either a disturbance or window of opportunity in which adaptive forms of governance may emerge? (3) What is the role of law in presenting barriers to adaptive forms of governance? (4) What is the role of law in facilitating adaptive forms of governance? This initial synthesis will form the basis for the next stage of the AWG Project in which existing legal tools and new legal models for facilitating the emergence of adaptive forms of governance will be explored.

A. Trajectory #1: Maintenance of Desired State

This configuration occurs when a social ecological basin exists in a desirable state, with considerable latitude for absorbing disturbance and substantial distance from any potential threshold. This system has room to adapt to changes in the water balance. Law sets the bounds by identifying approaching thresholds through mechanisms such as the establishment of water quality standards under the Clean Water

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67. The three governance trajectories bear resemblance to the three adaptation pathways described in MARK PELLING, ADAPTATION TO CLIMATE CHANGE: FROM RESILIENCE TO TRANSFORMATION 3 (2011) ("Here we propose three such pathways leading to resilience (maintaining the status quo), transition (incremental change) and transformation (radical change)."), *available at* http://talos.unicauca.edu.co/gea/sites/default/files/Adaptation%20to%20Climate%20Change%20From%20 Resilience%20to%20Transformation.pdf. As a researcher in the disaster literature, Pelling uses the engineering definition of resilience, i.e. the ability of a system to bounce back following a specific disturbance. We note that despite the difference in our approach to resilience, the similarity in trajectories (pathways) suggests that our consideration of the legal context for adaptive governance may also have relevance in the disaster response field.

Act,[68] identification of the conditions under which listing of basin species might occur under the Endangered Species Act,[69] and the establishment of water schemes that will provide the basis for management in the event of a shortage.[70]

Although none of the basins studied are in this charmed position of meeting all water quality standards, having no listed species and no conflict over water allocation, it must still be noted that it is nevertheless no trivial matter to identify these thresholds. The science alone is fraught with uncertainty, making it difficult to identify a threshold until it is crossed.[71] Furthermore, the actual threshold is likely to change over time and in response to other changes in the system.[72] The process is further complicated by the fact that the setting of bounds implicates the interests of the basin's society including the water-based economic system. In addition, once set, current management assumes a linear path from the current state of the system to crossing the threshold.[73] Not only does resilience tell us this is not likely to be the case, but that once crossed, it will be much more difficult to return the system to its prior configuration.[74]

The law may play an important facilitative role by providing authority for implementation of adaptive management[75] to increase the potential for approaching threshold detection; however the fragmented nature of water management with separate authorities responsible for water allocation, quality and land use, [76]may mask evidence of an approaching threshold. Thus, in a complex system such as a water basin with multiple management authorities at multiple levels, adaptive management alone is insufficient without the mechanisms for governance in the next trajectory. Nevertheless, a basin society in this stage may be complacent and unlikely to employ new approaches until moved into Trajectory #2.

B. Trajectory #2: Loss of Resilience Latitude

The basin has been developed with key services in mind and as a result, the original spectrum of natural ecosystem services has been eroded. Species have been listed, certain water quality standards are exceeded, and there is some conflict over the allocation of water. The legacy of engineered optimization for a limited number of services is twofold. First, it fuels economic growth in the sectors reliant on those

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68. 33 U.S.C. § 1313 (2014).

69. 16 U.S.C. § 1533 (2014).

70. *See generally* I WELLS A. HUTCHINS, WATER RIGHTS LAWS IN THE NINETEEN WESTERN STATES (1971) (providing a general overview of prior appropriation followed in some form by western U.S. states and discussion of riparian rights followed in some form by the rest of the U.S. states), *available at* http://archive.org/stream/waterrightslawsi12061hutc/waterrightslawsi12061hutc_djvu.txt.

71. Marten Scheffer et al., *Anticipating Critical Transitions*, 388 SCIENCE 344, 347 (2012).

72. *Resilience Alliance – Thresholds Database*, RESILIENCE ALLIANCE, http://www.resalliance.org/index.php/thresholds_database (last visited Jan. 20, 2015).

73. Ahjond S. Garmestani et al., *Can Law Foster Social-ecological Resilience?*, 18, 2 ECOLOGY & SOC'Y, at art. 37 (2013), *available at* http://www.ecologyandsociety.org/vol18/iss2/art37/.

74. *Resilience Alliance – Thresholds Database*, *supra* note 72.

75 Robin Kundis Craig, *Designing Administrative Law for Adaptive Management*, 67 VAND. L. REV. 1, 14 (2014).

76 Barbara A. Cosens & Craig A. Stow, *Resilience and Water Governance: Addressing Fragmentation and Uncertainty in Water Allocation and Water Quality Law*, *in* SOCIAL-ECOLOGICAL RESILIENCE AND LAW 142, 142–45 (Ahjond Garmestani et al. eds., 2014) [hereinafter *Addressing Fragmentation and Uncertainty*].

services that have been optimized (e.g. hydropower in the Columbia River Basin, irrigation in the Platte River Basin) creating not only a financially and politically powerful constituency for their maintenance but a regional economic dependency on their continuation. Second, the development of engineered services to the optimum level of provisioning leaves little latitude for adaptation to changing water balance leaving the basin vulnerable to any disturbance. In particular, change in the water balance due to climate change may destabilize the economic system and move the basin over a threshold from which it will be difficult to return. In this trajectory, law once again has played a role in establishing the boundaries that indicate approaching regime shift.

Once an approaching threshold is signaled, experimentation may pose unacceptable risk. For example, once species are listed, the ESA leaves little room for experimentation on recovery.[77] Yet to advocate for removal of this a barrier ignores the fact that the legal rigidity of the ESA reflects a societal value that once a species is listed, considerable care must be exercised due to the irreversibility of extinction.[78]

Instead, resilience points to an alternative management approach – that of restoration. Rather than gamble with a system close to a threshold, restoration may not only move the system away from the threshold, but increase latitude for adaptation. For example, restoration in the Columbia River to increase the latitude for adaptation might include measures such as reconnecting rivers to some of their former floodplain,[79] altering dam operation to mimic natural hydrographs,[80] restoring riparian habitat,[81] altering release points at dams[82] to reduce instream temperature regimes, and altering hatcheries for careful selection of genetic stock and layout to mimic natural rearing.[83] Diversification of sources of the services the system is optimized for may also breathe space into the system. Thus, increasing local flood control measures in the Columbia can free up some storage for use for other purposes as well as provide redundancy to handle unexpected flows.[84]

77. *See* Melinda Harm Benson, *Intelligent Tinkering: the Endangered Species Act and Resilience*, 17, 4 ECOLOGY & SOC'Y, at art. 28 (2012), *available at* http://www.ecologyandsociety.org/vol17/iss4/art28/; John M. Volkman & Willis E. McConnaha, *Through a Glass, Darkly: Columbia River Salmon, the Endangered Species Act, and Adaptive Management*, 23 ENVTL. L. 1249, 1271–72 (1993).

78. *Id.*, at 1264–66.

79. Barbara Cosens, *Resilience and Law as a Theoretical Backdrop for Natural Resource Management: Flood Management in the Columbia River Basin*, 42 ENVTL. L. 241, 243 (2012) [hereinafter Backdrop].

80. John Shurts, *Rethinking the Columbia River Treaty*, *in* THE COLUMBIA RIVER TREATY REVISITED: TRANSBOUNDARY RIVER GOVERNANCE IN THE FACE OF UNCERTAINTY 192, 193–95 (Barbara Cosens ed., 2012).

81. NOAA, ENDANGERED SPECIES ACT SECTION 7(A)(2) SUPPLEMENTAL BIOLOGICAL OPINION 234 (2014), *available at* http://www.westcoast.fisheries.noaa.gov/publications/hydropower/fcrps/2014_supplemental_fcrps_biop_final.pdf.

82. *Id.* at 144–45.

83. *Production Projects*, NEZ PERCE TRIBE DEP'T FISHERIES, http://www.nptfisheries.org/Divisions/Production/ProductionProjects/198335000.aspx (last visited Jan. 21, 2015).

84. *Backdrop*, *supra* note 79, at 252.

Each of the six basins studies has certain aspects of this trajectory. Sustainability of economic and cultural systems while incrementally broadening the range of services provided through reduction in optimization and restoration of key natural services to increase resilience latitude in the face of change and uncertainty requires both adaptive governance and financial investment. The role of law is in preparation of the formal system of government to allow emergence of adaptive forms of governance when disturbance occurs, whether in the form of a natural crisis or a human induced crisis such as litigation. Examples of law playing a role in preparation for the emergence of adaptive processes include empowerment of indigenous communities through litigation in both the Columbia and Klamath basins, and the development of local watershed groups in the Anacostia facilitated and sometimes funded through the Clean Water Act.

It is also clear that the authority for adaptive processes such as adaptive management, the corresponding processes to assure legitimacy in the implementation of adaptive management, and the network development needed for collaborative management, to name a few, could be facilitated by the development of a suite of administrative law process tools for use in appropriate circumstances. The development of such tools and guidelines for the choice and tailoring of their use to meet local circumstances are the key focus of the next step in the AWG process.

C. Trajectory #3: Regime Shift

Either through over development, a disturbance, or a combination of both, the system has crossed a threshold and is an alternative, generally stable configuration. A major change in management as well as financial investment will be needed to traverse a threshold while minimizing harmful impacts to society. In complex systems regime shift is not a simple matter of a single variable (e.g. river temperature or sediment supply) being out of balance. Given climate change, basin response may include changes in precipitation and temperature with complex secondary impacts on everything from biota to water demand.[85] It is difficult to imagine a smooth navigation of regime shift without assistance in both leadership and financing from a larger scale entity. In the Klamath Basin, crisis led to the emergence of local leadership and a local collaborative process, yet it was facilitated through federal funding to provide capacity for participation by Native American Tribes and a federal and state process for participation in water settlement. The solution, removal of key dams will require substantial federal funding to accomplish and at the time of this writing, remains uncertain. In the Florida Everglades the collaborative efforts of local water management districts and key scientists led to passage of a federal act with funding for restoration, yet the fragmentation of water allocation and quality law combined with entrenched interests may stand in the way of the regime shift needed to prepare the social-ecological system for climate change. Adaptive governance alone, at least as conceived here, will not navigate regime shift. It must be coupled with changes in the law that allow for cross-sector and cross-scale integrated water management. It must be coupled with leadership and

85. *See generally* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: IMPACTS, ADAPTATION, AND VULNERABILITY 1–32 (2014), *available at* http://www.ipcc.ch/report/ar5/wg2/.

funding from outside the basin. It must be coupled with the political and personal will to transform water-based economies to new livelihoods. This more radical shift to transformative governance is beyond the scope of the initial AWG Project, but remains under study by members of the team.

VI. CONCLUSION

Two preliminary findings emerge from the initial phase of the Adaptive Water Governance Project presented in the following six basin assessments. First, the value of an historical approach to assessment to understand both the change in resilience and governance attributes through time and their legacy effect today, including the key role of governance in both the facilitation of and barriers to adaptation. Second, the role of law in: establishing boundaries, that once crossed, signal approaching thresholds; in creating conditions for establishment of rights that alter expectations sufficiently to open a window to new and sometimes collaborative approaches to water governance; in providing an avenue for the development of new process tools to facilitate emergence of adaptive forms of governance; and in presenting barriers to adaptation as a result of rigid and fragmented authority.

We must also pose a word of caution from our basin assessment findings. It is clear that the ability of those benefiting from the status quo to stall change through litigation and political channels and to obtain federal level subsidy for continued optimization may be moving some basins perilously close to a threshold (e.g. Everglades). Re-analysis of the role of federal investment in water development away from engineered optimization and toward increased resilience latitude will be a key factor in adaptive capacity going forward. In addition, the legacy impact of engineered infrastructure is apparent in each of the six basin assessments. In other words, once major investment occurs in water infrastructure, it is highly resistant to change. There is strong incentive to shore up rather than alter infrastructure once built. There are legal, economic and cultural dependencies on the built environment. Thus, while the massive investment in water infrastructure of the 20th Century vastly improved the lives of several generations of North Americans, the legacy effect is to lock in future generations to infrastructure that is obsolete in terms of the water supply and demand of the coming century, the values of the people who live in these basins, and thus the future economic stability of water dependent communities. Nothing short of major investment in re-engineering these systems to modernize them for the 21st Century and a process that recognizes this will be needed every few generations will suffice. It is now time.