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The Social-Ecological Resilience of an Eastern Urban-Suburban Watershed: The Anacostia River Basin

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THE SOCIAL-ECOLOGICAL RESILIENCE OF AN EASTERN URBAN-SUBURBAN WATERSHED: THE ANACOSTIA RIVER BASIN

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I. INTRODUCTION

The future of ecological systems, human communities and society, and the institutions that govern people and their environments require adaptive governance systems for social-ecological resilience. Resilience is the capacity of a system to adapt to disturbances and changes while retaining its core structure, functions, and processes.[1] The concept of social-ecological resilience means that the resilience of social systems and ecological systems are interconnected in complex ways with nonlinear dynamics, and thus the resilience of the entire linked system is something more or different than the sum of the resilience of each separate system.[2] Adaptive governance institutions and frameworks are needed in environmental law,[3] water law,[4] and urban and land-use law.[5] Adaptive institutions and frameworks are especially needed for watershed or river basin governance, given the many strong influences that interconnected land-water dynamics have on natural, social, and governance systems.[6]

Efforts to develop adaptive water governance systems for the social-ecological resilience of watersheds tend to focus on large Western U.S. river basins, such as the Columbia,[7] Klamath,[8] Rio Grande,[9] and Platte.[10] These basins face

1. BRIAN WALKER & DAVID SALT, RESILIENCE THINKING: SUSTAINING ECOSYSTEMS AND PEOPLE IN A CHANGING WORLD xiii (2006).

2. *See generally* Carl Folke, *Resilience: The Emergence of a Perspective for Social-Ecological Systems Analyses*, 16 GLOBAL ENVTL. CHANGE 253 (2006); PANARCHY: UNDERSTANDING TRANSFORMATIONS IN HUMAN AND NATURAL SYSTEMS (Lance H. Gunderson & C. S. Holling eds., 2002) [hereinafter PANARCHY]. On the more-than-the-sum-of-the-parts concept, *see* Frances Westley et al., *Why Systems of People and Nature Are Not Just Social and Ecological Systems*, *in* PANARCHY 103–19.

3. *See generally* Craig Anthony Arnold, *Fourth Generation Environmental Law: Integrationist and Multimodal*, 35 WM. & MARY ENVTL. L. & POL'Y REV. (ISSUE 3), 771, 771–77 (2011) [hereinafter *Fourth Generation Environmental Law*]; Craig Anthony (Tony) Arnold & Lance H. Gunderson, *Adaptive Law and Resilience*, 43 ENVTL. L. REP. 10426 (2013) (explaining generally the need for adaptive governance in environmental law).

4. *See* Craig Anthony (Tony) Arnold, *Adaptive Water Law*, 62 KAN. L. REV. 1043, 1070 (2014).

5. *See* Craig Anthony (Tony) Arnold, *Resilient Cities and Adaptive Law*, 50 IDAHO. L. REV. 245, 261 (2014).

6. *See, e.g.*, Craig Anthony Arnold, *Clean-Water Land Use: Connecting Scale and Function*, 23 PACE ENVTL. L. REV. 291–92 (2006); Barbara Cosens & Mark Williams, *Resilience and Water Governance: Adaptive Governance in the Columbia River Basin*, ECOLOGY & SOC'Y, Dec. 2012, at art. 3, *available at* http://www.ecologyandsociety.org/vol17/iss4/art3/; Dave Huitema et al., *Adaptive Water Governance: Assessing the Institutional Prescriptions of Adaptive (Co-)Management from a Governance Perspective and Defining a Research Agenda*, ECOLOGY & SOC'Y, June 2009, at art. 26, *available at* http://www.earthsystemgovernance.org/sites/default/files/publications/files/Huitema-et-al_2009_Adaptive-water-governance.pdf; Kristine T. Nemec et al., *Assessing Resilience in Stressed Watersheds*, ECOLOGY & SOC'Y, Mar. 2014, at art. 34, *available at* http://www.ecologyandsociety.org/vol19/iss1/art34/.

7. Cosens & Williams, *supra* note 6.

8. Hannah Gosnell & Erin Clover Kelly, *Peace on the River? Social-ecological Restoration and Large Dam Removal in the Klamath Basin, USA*, 3 WATER ALTERNATIVES 2, 361 (2010).

9. Melinda Harm Benson et al., *A Classification Framework for Running Adaptive Management Rapids*, ECOLOGY & SOC'Y, Sept. 2013, at art. 30, *available at* http://www.ecologyandsociety.org/vol18/iss3/art30/ (resilience assessment of the Rio Chama basin, a major upper tributary of the Rio Grande basin).

10. Nemec et al., *supra* note 6.

competing uses of water under conditions of uncertainty and disturbance, particularly the effects of climate change like sustained or unprecedented drought.[11] These conditions and disturbances pose threats to the flow regimes, aquatic habitats, and structural integrity of the basins as both ecosystems and important societal organizing units in western communities and economies.[12] However, other types of river basins also need adaptive water governance systems to enhance and sustain ecosystem and social-system resilience to climate change and other uncertainties and disturbance. These include smaller basins, Eastern basins, and basins influenced more by pollution, runoff (urban, suburban, and agricultural), and flooding than by scarcity and drought.[13] The Anacostia River Basin, which stretches from rural and suburban Maryland through the heavily urbanized District of Columbia, has all of these characteristics.

When we started to analyze the resilience of the Anacostia River Basin, we initially used the Resilience Alliance's resilience assessment workbooks for scientists and practitioners.[14] However, our research soon revealed the strong role of institutions, which received too little systematic attention in the workbooks, and we shifted our methods of analysis to an institutional-historical analysis.

Institutions are "the prescriptions that humans use to organize all forms of repetitive and structured interactions . . . at all scales."[15] Institutions are composed of rules, norms, and cultural-cognitive beliefs, all of which shape social action.[16] Institutions include law and legal regimes, formal governance systems and policies, and informal or decentralized systems of governance, including collaborative management of common resources, community norms, loose networks for collective action, and the like.[17] Institutions can be analyzed at macro levels of large-scale struc-

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11. *See, e.g.*, Kathleen A. Miller, *Climate Change and Water in the West: Complexities, Uncertainties, and Strategies for Adaptation*, 27 J. LAND RESOURCES & ENVTL. L. 87, 95 (2007); Holly Doremus & Michael Hanemann, *The Challenges of Dynamic Water Management in the American West*, 26 UCLA J. ENVTL. L. & POL'Y 55, 57 (2008).

12. The American West also has urban watersheds dominated by pollution, channelization, and urban runoff, similar to Eastern watersheds. *See, e.g.*, Daniel Person, *River of No Return*, HIGH COUNTRY NEWS, June 23, 2014, at 12–19 (reporting on a Superfund cleanup and river restoration project in Seattle's Duwamish River watershed).

13. The Everglades is a popular Eastern watershed for resilience analysis, though. *See, e.g.*, Lance H. Gunderson & Carl J. Walters, *Resilience in Wet Landscapes of South Florida*, *in* RESILIENCE AND THE BEHAVIOR OF LARGE-SCALE SYSTEMS 165–82 (Lance H. Gunderson & Lowell Pritchard, Jr. eds., 2001); Sandi Zellmer & Lance Gunderson, *Why Resilience May Not Always Be a Good Thing: Lessons in Ecosystem Restoration from Glen Canyon and the Everglades*, 87 NEB. L. REV. 893, 912–23, 934–42 (2008). The Everglades is a large, complex ecosystem that has been altered by both urban and rural effects on both water supply (including insufficient flows) and water quality. Its distinctive characteristics do not lend themselves to drawing general lessons for many other Eastern watersheds. This resilience assessment of the Anacostia River watershed aims to fill gaps in resilience assessments of Eastern watersheds.

14. RESILIENCE ALLIANCE, ASSESSING AND MANAGING RESILIENCE IN SOCIAL-ECOLOGICAL SYSTEMS: A PRACTITIONERS WORKBOOK (1.0 ed. 2007), *available at* http://www.sustentabilidad.uai.edu.ar/pdf/cs/practitioner_workbook_1.pdf [hereinafter RESILIENCE I]; RESILIENCE ALLIANCE, ASSESSING RESILIENCE IN SOCIAL-ECOLOGICAL SYSTEMS: WORKBOOK FOR PRACTITIONERS (2.0 ed. 2010), *available at* http://www.resalliance.org/workbook/ [hereinafter RESILIENCE II].

15. ELINOR OSTROM, UNDERSTANDING INSTITUTIONAL DIVERSITY 3 (2005), *available at* http://press.princeton.edu/chapters/s8085.pdf [hereinafter OSTROM I].

16. W. RICHARD SCOTT, INSTITUTIONS AND ORGANIZATIONS 48–59 (3d ed. 2008).

17. *See generally* ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION (1990) [hereinafter OSTROM II].

tures and forces in society, at meso levels of organizational and categorizing structures and forces in society, and at micro levels of the interrelationships between institutions and individual behaviors and actions.[18]

Moreover, institutions emerge, evolve, and adapt to changing conditions and needs.[19] The dynamic nature of institutions, both internally and in relationship to the dynamics of social systems and ecological systems, strongly affects systemic resilience and adaptive capacity within watersheds. However, institutions also resist change, sometimes in ways that enhance overall systemic resilience by stabilizing social-ecological systems and sometimes in ways that undermine overall systemic resilience by increasing the rigidity of the status-quo and protecting maladaptive human behaviors.[20] Institutional resistance to change also strongly affects adaptive capacity within watersheds.

As our analysis of the Anacostia River Basin's resilience evolved, we developed a new analytical tool, the Institutional-Social-Ecological Dynamics (ISED) framework, to focus our attention on the dynamics of institutions, social systems, and ecosystems and how change within and between systems affect one another. ISED offers a way for researchers and practitioners to frame their assessments of social-ecological resilience in watersheds that are heavily influenced by institutions, such as the Anacostia.[21]

The ISED framework examines three categories of systems: (1) institutions; (2) social systems; and (3) ecological and physical systems. ISED also examines three types of systemic dynamics: (1) the effects of systems within a category on one another (e.g., institutions affecting other institutions; the interplay among various forces and subsystems in society; dynamics across ecosystems and ecological or physical scales); (2) the effects of systems on another across categories (e.g., the effects of institutions on ecosystems and vice-versa); and (3) change over time within a system. Any of these dynamics might feature sudden change due to system-altering disturbances and lack of adaptive capacity (including systemic reor-

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18. JONATHAN H. TURNER, HUMAN INSTITUTIONS: A THEORY OF SOCIETAL EVOLUTION 3–13 (2003).

19. *See, e.g.*, OSTROM I, *supra* note 15; TURNER, *supra* note 18; CHANGE IN SOCIETAL INSTITUTIONS (Maureen T. Hallinan et al. eds., 1990); Johannes Urpelainen, *Institutional Dynamics: Emergent Patterns in International Environmental Governance*, 7 REV. OF INT'L ORGS. 339 (2011) (book review), *available at* http://link.springer.com/article/10.1007/s11558-011-9131-8/fulltext.html.

20. *Compare* PROTECTING THE COMMONS: A FRAMEWORK FOR RESOURCE MANAGEMENT IN THE AMERICAS (Joanna Burger et al. eds., 2001), *and* David Soskice et al., *Ambition and Constraint: The Stabilizing Role of Institutions*, 8 J. L. ECON. & ORG. 3, 547 (1992) (both emphasizing the benefits of institutional stability), *with* Zellmer & Gunderson, *supra* note 13, *and* Arnold & Gunderson, *supra* note 3 (both emphasizing the harms of institutional stability). For an excellent study comparing flexible governance institutions with institutions that are resistant to change, *see* Elke Herrfahrdt-Pahle & Claudia Pahl-Wostl, *Continuity and Change in Social-Ecological Systems: the Role of Institutional Resilience*, ECOLOGY & SOC'Y, June 2012, at art. 8, *available at* http://www.ecologyandsociety.org/vol17/iss2/art8/.

21. A new alternative framework that also gives substantial attention to the change-causing effects of institutions, governance structures, natural-resource systems, and human and collective forces in society on one another is the Institutions of Sustainability (IoS) framework developed by resource economists at Humboldt University of Berlin. *See Institutions of Sustainability*, HUMBOLDT-UNIVERSITÄT ZU BERLIN, http://www.institutions-of-sustainability.hu-berlin.de/fakultaet-en/departments/daoe/ress-en/forschungskonzep-en/IoS-en (last updated Apr. 29, 2013); Konrad Hagedorn et al., *Institutional Arrangements for Environmental Co-operatives: a Conceptual Framework*, *in* ENVIRONMENTAL COOPERATION AND INSTITUTIONAL CHANGE: THEORIES AND POLICIES FOR EUROPEAN AGRICULTURE. NEW HORIZONS IN ENVIRONMENTAL ECONOMICS 3, 3–25 (Konrad Hagedorn ed., 2002).

ganization or even collapse) or more gradual and adaptive changes in response to disturbances and forces. A diagram of the ISED framework appears in Figure 1.

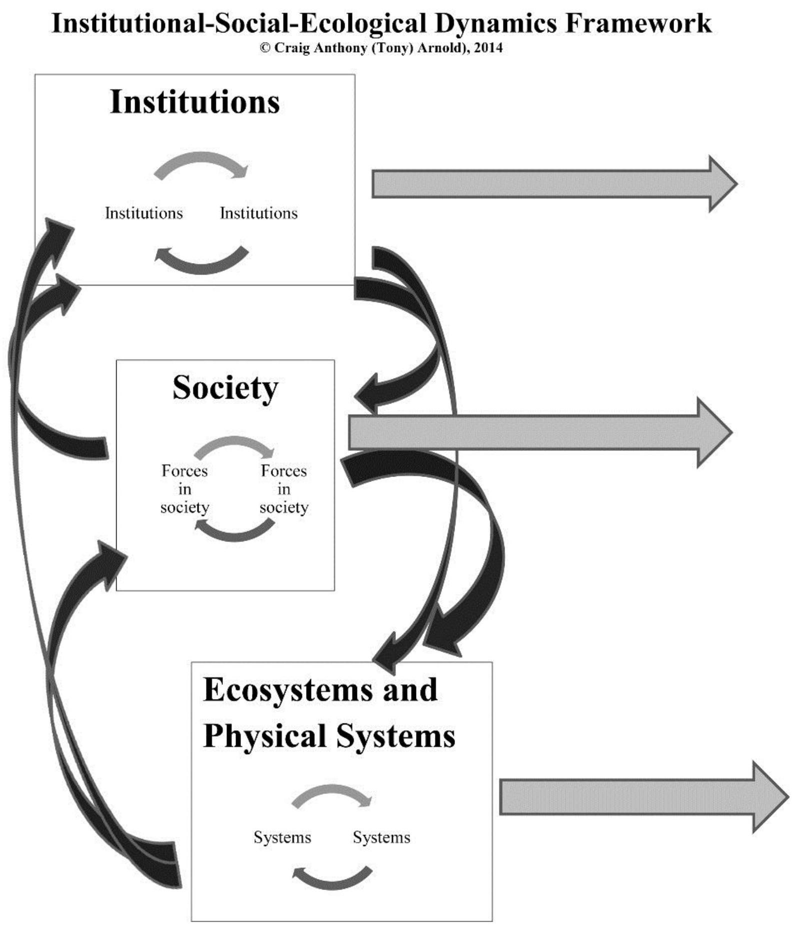

FIGURE 1. Institutional-Social-Ecological Dynamics Framework diagram.

ISED builds on two frameworks developed by Elinor Ostrom: (1) the framework for evaluating the sustainability of social-ecological systems (SES)[22]; and (2) the framework for institutional analysis and development (IAD).[23] Ostrom's frameworks give substantial attention to the role of institutions in complex social-

22. Elinor Ostrom, *A General Framework for Analyzing Sustainability of Social-Ecological Systems*, 325 SCIENCE 419, 419 (2009) [hereinafter OSTROM III].

23. OSTROM I, *supra* note 15, at 8–11; OSTROM II, *supra* note 17, at 192–213. *See also* Michael D. McGinnis, *An Introduction to IAD and the Language of the Ostrom Workshop: A Simple Guide to a Complex Framework for the Analysis of Institutions and Their Development*, 39 POL'Y STUDIES J. 169 (2011) (discussing Ostrom's frameworks).

ecological systems. In particular, the IAD framework lists three exogenous variables affecting system participants' actions – biophysical conditions, community attributes, and rules – that roughly correspond to the ISED framework's elements of ecosystems, social systems, and institutions.[24] However, Ostrom's frameworks do not give enough attention to systemic and institutional change, especially intersystemic nonlinear dynamics such as those studied by resilience scientists.[25] In addition, each framework examines many attributes or features of the system. The SES framework has forty-seven different variables in six categories (e.g., resource systems, resource units, users, governance systems). The IAD framework has eight design principles[26] but over 300 terms and concepts in twenty-one categories.[27] These quasi-encyclopedic methodologies are important to describing any given system or institution thoroughly, but they are not especially functional for identifying a small number of the most important drivers of change and adaptation within linked institutional-social-ecological systems.

ISED also builds on resilience and panarchy models developed by resilience scientists, such as Lance Gunderson and C.S. "Buzz" Holling.[28] Resilience models focus on systemic dynamics, especially abrupt, unexpected changes in regimes when a system is no longer able to absorb or adapt to disturbances while still maintaining its core functions and structure.[29] Panarchy models highlight the roles of a few major drivers of changes across systems and geographic and temporal scales of systems.[30] However, the resilience and panarchy models tend to focus much more on the ecological effects of these dynamics than on the social and institutional effects.[31] Moreover, they do not sufficiently differentiate among various aspects and

24. OSTROM I, *supra* note 15, at 15.

25. Later in her life, Ostrom worked on developing analytical tools to assess institutional change in the context of social and ecological change. *See generally* Elinor Ostrom & Xavier Basurto, *Crafting Analytical Tools to Study Institutional Change*, 7 J. INSTITUTIONAL ECON. 317 (2011), *available at* http://www.indiana.edu/~workshop/publications/materials/reprints/R11-15_OstromBasurto_JOIE.pdf (creating "an analytical tool to study institutional change").

26. *See* OSTROM II, *supra* note 17, at 182–213.

27. McGinnis, *supra* note 23, at 20, 28.

28. *See generally* PANARCHY, *supra* note 2 (discussing the panarchy model); FOUNDATIONS OF ECOLOGICAL RESILIENCE (Lance H. Gunderson et al. eds., 2010) (discussing the resilience model); C.S. Holling, *Resilience and Stability of Ecological Systems*, 4 ANN. REV. ECOLOGY & SYSTEMATICS 1 (1973), *available at* http://www.annualreviews.org/doi/pdf/10.1146/annurev.es.04.110173.000245 (discussing the resilience model).

29. *See* Folke, *supra* note 2, at 254–60; Ahjond S. Garmestani et al., *Introduction: Social-Ecological Resilience and Law*, *in* SOCIAL-ECOLOGICAL RESILIENCE AND LAW 1, 5–6 (Ahjond S. Garmestani & Craig R. Allen eds., 2014); C.S. Holling & Lance H. Gunderson, *Resilience and Adaptive Cycles*, *in* PANARCHY, *supra* note 2, at 25–29.

30. *See* C.S. Holling et al., *In Quest of a Theory of Adaptive Change*, *in* PANARCHY, *supra* note 2, at 3, 7; Holling & Gunderson, *Resilience and Adaptive Cycles*, *in* PANARCHY, *supra* note 2, at 25–29; Ahjond S. Garmestani & Melinda Harm Benson, *A Framework for Resilience-Based Governance of Social-Ecological Systems*, ECOLOGY AND SOC'Y, Mar. 2013, at art. 9, http://www.ecologyandsociety.org/vol18/iss1/art9/.

31. *See, e.g.*, FOUNDATIONS OF ECOLOGICAL RESILIENCE, *supra* note 28; RESILIENCE I, *supra* note 14; RESILIENCE II *supra* note 14. Even in an influential book by Fikret Berkes and Carl Folke that brought attention to social system resilience and its interconnections with ecosystem resilience, many of the chapters examined resilient social systems and processes (e.g., local knowledge) as means to achieving or sustaining the resilience of ecosystems on which communities depend. *See* NAT. RES. INST., LINKING SOCIAL AND ECOLOGICAL SYSTEMS: MANAGEMENT PRACTICES AND SOCIAL MECHANISMS FOR BUILDING RESILIENCE (Fikret Berkes & Carl Folke eds., 1998), *available at* http://lib.icimod.org/record/16819/files/JO130.pdf.

forces of society within the broad category of "social systems." Different social forces and systems – political, economic, socio-cultural, psychological – shape one another. Furthermore, these forces also shape institutions and are shaped by institutions. In the resilience and panarchy models, institutions are treated either as just part of society or, alternatively, as the systemic representation of society (i.e., a proxy for society), instead of looking at how institutions, society, and ecosystems interact with one another.[32] Finally, resilience and panarchy scholars mostly study abrupt regime-flipping changes in systems that can no longer withstand disturbances, but they give less attention to incremental changes that either do not alter the core functions and structure of the system or change systemic features slowly over long periods of time.[33] Both abrupt and incremental changes occur in institutions and institutional-social-ecological linked systems, and both of these dynamics are important to systemic resilience.[34]

ISED is not a new theoretical construct, but rather a functional tool to guide researchers. Guided by ISED, we have assessed the social-ecological resilience of the Anacostia River watershed, threats to the watershed and its resilience, and the implications of our findings for governance of the watershed.

In Part II of this Article, we describe the watershed and how it has changed over time. In particular, we discuss the major drivers of change in the watershed that have pushed its systemic features or state from a watershed of forests, wetlands, and flows to a watershed of agriculture and navigation, and then to an industrialized watershed, followed by transition to a heavily urbanized watershed, and now to a watershed characterized by restoration projects and green-infrastructure initiatives. These transformations of the watershed across key thresholds of systemic structure and function shape the future resilience and adaptive capacity of the watershed as an ecosystem and its human communities and institutions.

In Part III, we assess the resilience of the Anacostia River watershed to future shocks and disturbances, including climate change, which is becoming a major driver of systemic change in many watersheds. We evaluate three possible futures of the basin – the minimal restoration future, the moderate restoration future, and the aggressive restoration future – and conclude that only the aggressive restoration future can build the social-ecological resilience of the watershed due to the countervailing forces that are undermining its resilience, such as land-development pressures.

32. The Berkes and Folke book explores the relationships between institutions and ecosystems but in the overall frameworks of a two-way relationship between social systems and ecosystems. *See generally* LINKING SOCIAL AND ECOLOGICAL SYSTEMS, *supra* note 31. Institutions were the primary element of Folke's representation of social systems in his social-ecological systems analysis. Folke, *supra* note 2, at 261. However, Holling's work calls for study of three-way relationships among economics, ecology, and institutions. Holling et al., *In Quest of a Theory of Adaptive Change*, *in* PANARCHY, *supra* note 2, at 5, 8–10. Green and Perrings analyze the relationships between institutional resilience and ecological resilience in Olivia Odom Green & Charles Perrings, *Institutionalized Cooperation and Resilience in Transboundary Freshwater Allocation*, *in* SOC.-ECOLOGICAL RESILIENCE & L. 176 (Ahjond S. Garmestani & Craig R. Allen eds., 2014).

33. *See, e.g.*, Folke, *supra* note 2, at 254–60; Holling & Gunderson, *supra* note 30, at 49–62.

34. *See generally* ORAN R. YOUNG, INSTITUTIONAL DYNAMICS: EMERGENT PATTERNS IN INTERNATIONAL ENVIRONMENTAL GOVERNANCE (2010) (analyzing throughout the book five categories of institutional change: progressive development, punctuated equilibrium, arrested development, diversion, and collapse).

In Part IV, we assess the adaptive capacity of institutions within the Anacostia River watershed. We begin by analyzing the relationships among institutional, social, and ecological change, guided by the analytical insights of the ISED framework. Then, we assess the potential for adaptive governance institutions to emerge, evolve, or strengthen in order to enhance adaptive capacity and resilience in the system. In particular, we recommend continued and new improvements in watershed governance, restoration and green infrastructure strategies, land use regulation, public engagement with watershed conditions, integration of social justice principles and processes into governance structures and decisions, and monitoring and feedback loops that contribute to scientific and social learning.

In Part V, we conclude that institutions and the ways that institutions change in relationship to social and ecological dynamics strongly affect the social-ecological resilience of watersheds, particularly small, Eastern, urban-suburban watersheds like the Anacostia.

II. INSTITUTIONAL-SOCIAL-ECOLOGICAL CHANGE IN THE ANACOSTIA RIVER WATERSHED

A. The Watershed and Its Characteristics

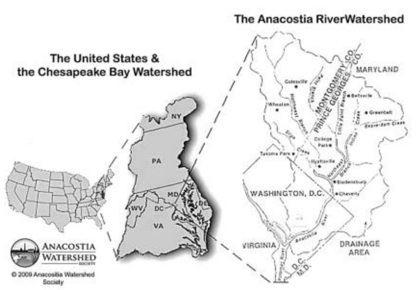

FIGURE 2. Map of the Anacostia River Watershed.

The Anacostia River watershed (or basin)[35] consists of 173 square miles of land in Prince Georges and Montgomery Counties, Maryland, and Washington, D.C., draining into the Anacostia River.[36] *See* Figure 2.[37] The Anacostia River flows into the Potomac River, which in turn flows into the Chesapeake Bay.[38] Ap-

35. In this article, we use the terms "watershed" and "basin" interchangeably.

36. MD. DEP'T OF THE ENV'T, WATERSHED REPORT FOR BIOLOGICAL IMPAIRMENT OF THE NON-TIDAL ANACOSTIA RIVER WATERSHED, PRINCE GEORGES AND MONTGOMERY COUNTIES, MARYLAND AND WASHINGTON D.C.: BIOLOGICAL STRESSOR IDENTIFICATION ANALYSIS RESULTS AND INTERPRETATION 4 (2012), *available at* http://www.mde.state.md.us/programs/Water/TMDL/Documents/BSID_Reports/Anacostia_River_BSID_Report_020112_final.pdf [hereinafter MDEP, WATERSHED REPORT].

37. *Anacostia River Watershed Map*, ANACOSTIA WATERSHED SOC'Y, *available at* http://www.anacostiaws.org/images/maps/WatershedProgression.jpg (last visited Jan. 9, 2015).

38. MDEP, WATERSHED REPORT, *supra* note 36, at 2; *Mid-Atlantic Water Protection: Anacostia River Urban Watershed*, U.S. ENVTL. PROT. AGENCY, http://www.epa.gov/reg3wapd/anacostia_2012.html (last updated Aug. 20, 2013) [hereinafter, EPA, *Anacostia River Urban Watershed*].

proximately 84 percent of the watershed is located within Maryland, with the remaining 16 percent being located within Washington, D.C.[39]

Fourteen subwatersheds and a tidal portion of the Anacostia River make up the basin.[40] Underground streams and seeps in the upper watershed, as well as stormwater runoff from throughout the watershed, feed the streams and main stem of the Anacostia River.[41] The major tributaries are the Northeast Branch, the Northwest Branch, Lower Beaverdam Creek, and Watts Branch, and other tributary streams include Sligo Creek and Paint Branch.[42] Tides influence the main stem of the Anacostia River, as well as lower portions of some tributaries.[43]

The watershed straddles two different ecoregions—the Piedmont and the Coastal Plains—which roughly divide along the county line between Prince Georges and Montgomery Counties.[44] The Piedmont portion of the basin has steep stream valleys, rocky streambeds with steep gradients, well-drained loamy soils, and elevations of 200 to 400 feet above sea level.[45] The Coastal Plains portion has gentle slopes, slowly meandering streams, sandy soils, and elevations of 0 to 200 feet above sea level.[46]

The Anacostia River watershed is heavily urbanized, containing about 1 million residents in the watershed. The 1990 U.S. Census showed an average density of 2.66 people per acre,[47] but the population density is not evenly spread throughout the basin.[48] "The watershed includes highly urbanized areas in DC, old and newly developing suburban neighborhoods in the surrounding metropolitan areas of Maryland, croplands and pastures in the U.S. Department of Agriculture's Beltsville Agricultural Research Center (BARC), and forested parklands throughout the watershed."[49]

The distribution of land uses is 75 percent urban or suburban, 20 percent forest, and 5percent agricultural, and approximately one-quarter of the watershed's lands are covered with impervious surfaces.[50]

Extensive urbanization and industrialization have strongly influenced current watershed characteristics, adversely affecting the basin's biological, hydrological, and physical functions. The Anacostia River has been designated under the Clean Water Act as impaired with respect to nutrients (i.e., phosphorus), sediments (i.e.,

39. MDEP, WATERSHED REPORT, *supra* note 36, at 2.

40. *Anacostia Watershed Restoration, Montgomery County, MD*, U.S. Army CORPS of Eng'rs, Balt. Dist., http://www.nab.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/10470/Article/9181/anacostia-watershed-restoration-montgomery-county-md.aspx (last visited Jan. 9, 2015) [hereinafter Corps, *Fact Sheet*].

41. MDEP, WATERSHED REPORT, *supra* note 36, at 2.

42. *Id.*

43. *Id.*

44. *Id.* at 6.

45. *Id.*

46. *Id.*

47. MARYLAND'S SURF YOUR WATERSHED, WATERSHED PROFILE: ANACOSTIA RIVER (2000), *available at* www.dnr.state.md.us/watersheds/surf/prof/pdf/02140205_wp.pdf [hereinafter MARYLAND'S SURF].

48. *Id.*

49. MDEP, WATERSHED REPORT, *supra* note 36, at 4.

50. *Id.*

total suspended solids), fecal bacteria, impacts to biological communities in non-tidal waters, polychlorinated biphenyls (PCBs), heptaculor epoxide, and trash/debris.[51] The Maryland Department of Environmental Protection (MDEP) has determined that many parts of the Anacostia River and its feeder streams have poor biological conditions.[52] Inorganic pollutants, particularly chlorides and sulfates, enter the basin's waters from urban runoff, aided substantially by significant amounts of impervious cover, and affect water quality and biological conditions in intermittent concentrations.[53] At times, portions of the River and its tributaries have been deemed to be too contaminated with toxics or fecal bacteria (often increased from combined sewer overflows during and after storm events) for any human contact.[54]

Pollution adversely affected the health of fish and wildlife in the watershed.PCBs and Polycyclic Aromatic Hydrocarbons (PAHs) in stream and river sediment and their bioaccumulation up the food chain have caused cancerous tumors in fish.[55] One U.S. Fish and Wildlife Service study found that half or more of all brown bullhead catfish in the watershed had cancerous liver tumors and one-quarter had cancerous skin tumors.[56] At the time of the study, the Anacostia River had the highest incidence of liver tumors in catfish in the United States.[57] Government officials have issued health advisories against consumption of several different species of fish in the Anacostia.[58]

Historically, the Anacostia's fisheries had high species richness, though, and were characterized by thriving populations of "sturgeon, American and hickory shad, white and yellow perch, redbreast sunfish, pickerel, catfish, and herring."[59] Many fish species have declined or been extirpated from the river due to industrial pollutants, low dissolved oxygen caused by nutrient contamination and associated algae blooms, lower spring water temperatures and fewer floods from snowmelt, and shallow flows resulting from sedimentation and streambed alterations.[60] Major

51. *Id.* at iii.

52. *Id.* at iv. The MDEP used both Benthic and Fish Indices of Biotic Integrity to assess the conditions and biological stressor identification (BSID) analysis to identify the sources of stresses to biological life in the waters.

53. *Id.*

54. ANACOSTIA WATERSHED SOC'Y, ANACOSTIA RIVER WATER TRAIL GUIDE: A VOYAGE THROUGH TIME: FROM CAPTAIN JOHN SMITH TO THE MODERN DAY (2013), *available at* www.anacostiaws.org/images/maps/AnacostiaRiverWaterTrailGuide.pdf; D.C. DEP'T OF THE ENV'T, ANACOSTIA 2032: PLAN FOR A FISHABLE AND SWIMMABLE ANACOSTIA RIVER, 16–20 (2008), *available at* http://green.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/Anacostia2032.pdf [hereinafter DDOE, ANACOSTIA 2032].

55. U.S. FISH & WILDLIFE SERV., EVALUATING THE HEALTH OF THE TIDAL POTOMAC RIVER WATERSHED: TUMOR SURVEYS IN BROWN BULLHEAD CATFISH (2000), *available at* http://www.fws.gov/chesapeakebay/pdf/bullhead.pdf.

56. *Id.*

57. *Id.*

58. ANACOSTIA WATERSHED SOC'Y, ADDRESSING THE RISK: UNDERSTANDING AND CHANGING ANGLERS' ATTITUDES ABOUT THE DANGERS OF CONSUMING ANACOSTIA RIVER FISH 2 (Anacostia Watershed Soc'y ed., 2013), *available at* www.anacostiaws.org/userfiles/file/AWS_angling_FINAL_web.pdf.

59. U.S. ARMY CORPS OF ENGINEERS ET AL., ANACOSTIA RIVER WATERSHED RESTORATION PLAN AND REPORT, FINAL DRAFT 2 (Anacostia Watershed Restoration Partnership ed., 2010), *available at* http://www.anacostia.net/Restoration_Plan/download/Anacostia-Report-Web-Quality.pdf [hereinafter ARWRPR].

60. *See id.* at 30.

fish kills in warm summer months with low flows have been a problem, although fish kills have been declining over the past two decades.[61]

Much submerged aquatic vegetation (SAV), which is food and habitat for invertebrates, fish, and waterfowl, died off in 1950s through the 1970s due to poor water quality, but improvements in water quality by the 1980s have led to some improvements in SAV.[62] However, there is little to no SAV in the tidal portion of the Anacostia.[63]

The natural channels, meanders, flows, and water levels of feeder streams and the river have been altered both by human channelization of stream segments and the effects of increased runoff from urban impervious surfaces.[64] These effects include channel erosion, scouring of banks and beds, reduced flows, and transportation of suspended sediments. Development of riparian buffer zones, deforestation, and draining and filling of wetlands have also adversely affected several characteristics of the watershed, including water flow regimes, water quality, waterway structural features, flood management capacity, and the healthy functioning of biological communities.[65] Upstream tributaries have flashy runoff and flood characteristics, while the downstream tidal areas of the basin are sluggish and therefore trap sediment that washes downstream.[66] The basin has approximately 120 to 130 human-created barriers to fish migration, including buried utility lines, road culverts, and weirs from channelization.[67]

Many of the core terrestrial, hydrological, and biological features of the Anacostia River watershed have been extensively altered by human development. In the basin, 93 percent of the pre-development tidal wetland acreage and 63 percent of the pre-development non-tidal wetland acreage have been destroyed or altered.[68] Only 2,550 total wetland acres remain in the watershed, often in fragmented segments with impaired flood management capacity, and the watershed's beavers have been extirpated due to development of non-tidal wetlands.[69] More than 70 percent of the watershed has been deforested with the greatest tree loss occurring in riparian areas.[70] However, natural succession processes on former farmlands and acquisition and management of public parklands have led to increased tree coverage in six, primarily upstream, watersheds since the 1930s.[71] Mature hardwood stands on public lands are considered to have especially high ecological value.[72]

There are portions of the watershed that have relatively healthy ecosystem function and provide key support for biodiversity. For example, almost the entire

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61. *Id.*
62. *Id.* at 6.
63. *Id.*
64. MDEP, WATERSHED REPORT, *supra* note 36, at iv–v.
65. *Id.*
66. ARWRPR, *supra* note 59, at 16, 29.
67. *Id.* at 6.
68. *Id.*
69. *Id.* at 21–24.
70. *Id.* at 5. The National Oceanic and Atmospheric Administration (NOAA) estimates that forest loss in the watershed since settlement to be ninety-four percent of the original forests. *The Anacostia: Partnering to Restore an Urban Estuary*, NAT'L OCEANIC & ATMOSPHERIC ADMIN., http://oceanservice.noaa.gov/news/features/mar10/anacostia.html (last updated Jan. 11, 2013).
71. ARWRPR, *supra* note 59, at 22–24.
72. *Id.*

subwatershed of Upper Beaverdam Creek is owned by the U.S. Department of Agriculture and operated by the Beltsville Agricultural Research Center (BARC).[73] This subwatershed serves as critical habitat for wildlife due to "its relatively unfragmented and pristine nature and because it contains some of the healthiest streams and most intact remaining non-tidal wetlands. "In particular, the Upper Beaverdam Creek portion of BARC is a critical wildlife corridor between the Anacostia River watershed and the Patuxent River watershed through which wildlife such as wild turkey and river otter have recently returned to this subwatershed."[74] Even though parts of Upper Beaverdam Creek have nearly pristine waters, growing levels of nutrients have been detected in some parts, believed to be the result of animal waste, stormwater runoff, and a BARC wastewater treatment facility.[75]

B. Transitions Across Thresholds: The History of Systemic Change in the Watershed

1. Drivers of Change

The geography and history of the Anacostia River watershed matter not only to its future but also to our understanding of small, Eastern, urban-suburban watersheds and their social-ecological resilience. In many respects, the Anacostia has played a critical role in supporting and enabling important economic developments in the region and nation: conversion of forests and wetlands to farmland for cash crops; commercial navigation; industrialization, and urbanization.[76] The Anacostia's transformation from a natural watershed system into a heavily polluted and essentially engineered urban watershed was driven by powerful interests seeking to use it as an engine for economic growth.[77]

In another respect, though, the Anacostia has been neglected, in part because it flows through low-income and minority urban neighborhoods. The Anacostia has been called America's "Forgotten River," in the shadow of its much more famous neighbor, the Potomac River, which flows through more elite communities. In the past three decades, the Anacostia has received increasing attention, as citizen groups like the Anacostia Watershed Society, have pressured government agencies

73. *Upper Beaverdam Creek Profile*, ANACOSTIA WATERSHED RESTORATION PARTNERSHIP, http://www.anacostia.net/Subwatershed/Upper_Beaverdam.html (last visited Jan. 9, 2015).

74. ARWRPR, *supra* note 59, at 21.

75. *Upper Beaverdam Creek Profile*, *supra* note 73.

76. *See supra* Part II.A.

77. This theme has pervaded several histories of the Anacostia River watershed. *See generally* Michael L. Kronthal, *Local Residents, the Anacostia River, and "Community*," SOC'Y FOR APPLIED ANTHROPOLOGY, U.S. ENVTL. PROTECTION AGENCY (1998), *available at* https://www.sfaa.net/files/1513/7329/3792/kronthal.pdf; JOHN R. WENNERSTEN, ANACOSTIA: THE DEATH & LIFE OF AN AMERICAN RIVER 8, 11 (2008); Emily C. Haynes, Currents of Change: An Urban and Environmental History of the Anacostia River and Near Southeast Waterfront in Washington, D.C. (May 3, 2013) (unpublished B.A. thesis, Pitzer College) (on file with Claremont Colleges Library), *available at* http://scholarship.claremont.edu/cgi/viewcontent.cgi?article=1033&context=pitzer_theses.

to clean up and restore the Anacostia and its tributaries and to create multi-stakeholder partnerships to develop plans to do so.[78]

During the past four centuries, the Anacostia River watershed has undergone four major transitions in its social-ecological state: from a watershed of forests, wetlands, and flows to a watershed of agriculture and navigation to an industrialized watershed to a heavily urbanized watershed to a watershed of restoration and green infrastructure. The last transition is only partially underway, and it remains to be seen whether this becomes a stable state or temporarily stable state for the watershed or whether the watershed will quickly shift to another regime. In each transition, the fundamental ecological, social, and institutional characteristics of the watershed have changed, and the watershed has crossed a threshold into a new systemic state or regime with reorganized structures, processes, and functions.

However, each of these social-ecological changes has been driven by larger forces of change in linked institutional-social-ecological dynamics, as illuminated by our use of the ISED framework in our study of the Anacostia's history. These forces, which pervade both the history of the Anacostia River watershed and its potential for restoration and improved resilience, are: 1) commodification and consumerism; 2) environmentalism; 3) watershed psychology; 4) inequity, discrimination, and social justice movements; and 5) institutional change.

a. Commodification and Consumerism

The ecological features of the Anacostia River watershed – particularly land cover, river/stream structure, and water quality – have been altered or destroyed for economic gain. The watershed has primarily been governed as a resource for the production of economic goods and services for markets, a generator of commodified resources for human consumption. The land, forests, and wetlands were treated as raw materials to be transformed into agricultural production of marketable crops like tobacco. The river's structural system was treated as a malleable conduit for the transportation of goods in commerce. The river has been and continues to be a sink and drain for waste from industrial production and urban development. Critical watershed lands have been converted into marketable residential and commercial units. Even now, as restoration and green infrastructure policies dominate watershed governance decisions, the river and the watershed are being treated as aesthetic, recreational, and residential amenities for human consumption. The ecosystem is vulnerable to changes in how people value and use the watershed and its features (e.g., the river and riverfront) and to short-term economic uses that conflict with long-term ecological uses.

b. Environmentalism

The rise in environmental values and activism in the United States, especially in the latter half of the twentieth century, has led to several critically important de-

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78. *See generally* U.S. ENVT'L PROTECTION AGENCY, EPA # 903-F-97-001, ANACOSTIA REBIRTH: RESTORATION FOR THE RIVER, RISK REDUCTION FOR THE COMMUNITY (1997), *available at* nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=91017OV3.TXT [hereinafter EPA, Anacostia Rebirth] (discussing pollution and industrial waste problems in the Anacostia watershed).

velopments in watershed governance. These developments include a plethora of environmental laws and regulations, civic and political activism for environmental protection, pro-environmental changes in the missions and actions of government agencies and business entities, and changes in individual and group behaviors. Environmentalism is a major driving force behind many of the current efforts to restore and "green" the watershed and the legal and policy tools that are being used to do so.

Nonetheless, the overall social-ecological-institutional system is vulnerable to shifts in public values, political power, and anti-environmental changes in laws and policies. For example, the American Farm Bureau Federation and twenty-one states (all outside of the Chesapeake Bay basin except for West Virginia) have brought a challenge to the Chesapeake Bay Agreement, which had been voluntarily negotiated by the EPA and the states in the basin to reduce polluted runoff into the Bay.[79] The litigants argue that the Agreement is beyond the EPA's authority under the Clean Water Act and would set a precedent for similar agreements in other basins if upheld.[80] In 2014, twenty bills to weaken Maryland's stormwater laws were introduced in the Maryland legislature but were not acted on.[81] Both litigation and legislation like these are driven by politics and would undermine the legal foundations of watershed protection and stormwater control if either were successful.

Two excellent studies make the case that both watershed governance and urban runoff management are highly political phenomena involving not only choices among many values and interests but also the evolution of relationships among many government entities, stakeholders, and the public.[82] These studies emphasize that politics, not just scientific or technological solutions, play central and dynamic roles in the governance of water resources and watersheds.

c. Watershed Psychology

The effects of psychological orientations towards the watershed are so substantial that they deserve attention as a strong driver of change within the system, even though they are also a part of the environmentalism driver. Place-based connections with or attachments to the watershed have become a significant part of human cognition and emotion, social behavior, and norms, values, and attitudes in the United States and in the Anacostia watershed in particular.[83] Area residents

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79. Assoc. Press, *Challenge to Chesapeake Cleanup Tests EPA Power*, CBS BALTIMORE (Apr. 29, 2014, 9:37 AM), http://baltimore.cbslocal.com/2014/04/29/challenge-to-chesapeake-cleanup-tests-epa-power/.

80. *Id.*

81. E.B. Furgurson III, *League's 2014 Environmental Grades Decry 'Lack of Progress in an Election Year,'* CAPITAL GAZETTE (July 28, 2014, 8:15 AM), http://www.capitalgazette.com/news/cg-leagues-2014-environmental-grades-decry-lack-of-progress-in-an-election-year-20140729,0,5351756.story.

82. ANDREW KARVONEN, POLITICS OF URBAN RUNOFF: NATURE, TECHNOLOGY, AND THE SUSTAINABLE CITY xii (2011); EDELLA SCHLAGER & WILLIAM BLOMQUIST, EMBRACING WATERSHED POLITICS viii (2008).

83. NAT'L WILDLIFE FED'N LAKE RESEARCH PARTNERS, RESTORING THE ANACOSTIA RIVER: DETERMINING THE BEST PATH FORWARD AND BUILDING PUBLIC WILL FOR ACTION 6–8, 15–17 (2012), *available at* http://www.summitfdn.org/wp-content/uploads/downloads/2012/10/Anacostia-Report-Best-Path-Forward.pdf; Craig Anthony (Tony) Arnold, *Working Out an Environmental Ethic: Anniversary Lessons from Mono Lake*, 4 WYO. L. REV. 1, 26 (2004); *see generally* MICHAEL L. KRONTHAL, LOCAL

have become increasingly aware of the watershed and its functions and processes.[84] Resource issues and governance problems are cognitively framed as watershed issues and problems of watershed governance.[85] Collective action is organized around watershed protection and restoration, and people adjust their behaviors based on the effects that they could have on the watershed's health and functioning.[86] Social organizations and institutions develop around the watershed as the central organizing element.[87]

While integration and internalization of a regard for the watershed and its social-ecological functions into people's psychological processes offer more lasting hope for governance of the watershed for its social-ecological resilience than reliance on mercurial political forces, there are vulnerabilities here too. People, groups, and societies are capable of framing the watershed in many different ways.[88] Extreme or traumatic events can alter how people perceive the watershed and make decisions about it.[89] Other psychological phenomena, including heuristics, self-reification, group-think, and self-deception, can produce decisions and actions that undermine the social-ecological resilience of the watershed.[90]

d. Inequality, Discrimination, and Social Justice Movements

Human communities in the Anacostia watershed, as well as the watershed's overall resilience, have been harmed or weakened by many manifestations of racism and socio-economic inequality: slavery and its legacies; segregation of people and land uses by race and class; environmental injustices that placed low-income people and racial and ethnic minorities in close proximity to pollution and intensive land uses; redevelopment practices that gentrified communities and displaced existing low-income and minority residents; disparities in the distribution of infrastructure and civic and social services; and differences in the amount of attention that the Potomac and the Anacostia received, based in large part on where society's elites live. These phenomena have driven change in the watershed socially, ecologically, and institutionally. By the 1980s, when the Anacostia River waterfront in Washington, DC, was polluted, crime-ridden, physically deteriorating, industrialized, urbanized, unhealthy, and ignored, the strong interconnections between social decline and ecological decline were hard to miss.

RESIDENTS, THE ANACOSTIA RIVER, AND "COMMUNITY," *available at* http://www.sfaa.net/files/1513/7329/3792/kronthal.pdf.

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85. Craig Anthony (Tony) Arnold, *Framing Watersheds*, *in* ENVIRONMENTAL LAW AND CONTRASTING IDEAS OF NATURE: A CONSTRUCTIVIST APPROACH 276, 282–83 (Keith Hirokawa ed., 2014).

86. *Id.* at 281.

87. *Id.*

88. *Id*. at 281.

89. Keith H. Hirokawa, *Driving Local Governments to Watershed Governance*, 42 ENVTL. L. 157, 167 (2012); JARED ORSI, HAZARDOUS METROPOLIS: FLOODING AND URBAN ECOLOGY IN LOS ANGELES 36 (2004).

90. *See generally* Alana Cornforth, *Behaviour Change: Insights for Environmental Policy Making from Social Psychology and Behavioural Economics*, POL'Y Q., Nov. 2009, 21, *available at* http://ips.ac.nz/publications/files/5831f842e9c.pdf; JANET SWIM ET AL., PSYCHOLOGY AND GLOBAL CLIMATE CHANGE: ADDRESSING A MULTIFACETED PHENOMENON AND SET OF CHALLENGES 64–69 (2009), *available at* http://www.apa.org/science/about/publications/climate-change-booklet.pdf.

However, civil rights and social justice movements, including environmental justice movements, are changing the direction of the watershed's social-ecological conditions and governance processes. The Anacostia neighborhood residents are engaging with the river and its watershed features and participating in watershed groups and governance activities. As a result, watershed governance patterns are changing. Moreover, informal but productive cooperation between upstream suburban conservation and restoration activities and downstream urban conservation and restoration activities is producing a relatively integrated approach to watershed governance, even if it is only loosely coordinated. Nonetheless, the potential that restoration activities could be used to create recreational, residential, and commercial amenities for wealthy whites, to the detriment or exclusion of low-income and minority residents, is troubling.

e. Institutional Change

A major driver of social-ecological change in the Anacostia River basin has been institutional change: changes in the systems of rules that shape human behaviors and structure social action.[91] As new statutory and regulatory regimes have developed and common-law and constitutional-interpretation regimes have evolved, the dominant uses of watershed lands and waters have changed. For example, congressional enactments of the Clean Water Act (CWA) and amendments to the CWA to regulate municipal stormwater systems have stimulated efforts to address and reverse the effects of impervious surface-cover and urban-suburban pollution. Also, the primary mission and focus of the powerful US Army Corps of Engineers has changed from re-engineering waterways and wetlands for commercial navigation to re-engineering them for urban development and flood control to re-engineering them for watershed restoration and wetland mitigation.

Informal institutions of social norms and self-governance systems have also changed in important ways. For example, the norms of the tobacco plantation society that dominated the watershed's pre-Civil War period proved unsustainable and gave way to other exploitative uses of the watershed. In recent years, watershed-focused organizations and governance collaborations have emerged with robust energy and activity to change trends in the basin's land cover and hydrology.

Total institutional change is rare, though; often elements of past rules, norms, and beliefs remain in a new system in co-existent or hybridized ways. Institutional facilitation of urban growth and industrial pollution persist in or alongside the new "green-infrastructure" regimes, for example. Moreover, while legal changes have prohibited once-dominant institutions of slavery,[92] *de jure* racial segregation,[93] private-sector racial discrimination, and outward expressions of social norms regarding race have changed considerably in the U.S.,[94] structural elements of racial bias

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91. *See* OSTROM I, *supra* note 15; SCOTT, *supra* note 16.
92. U.S. CONST. amend. XIII.
93. *See* Brown v. Bd. of Educ., 347 U.S. 483, 496 (1954) (overruling Plessy v. Ferguson, 163 U.S. 537 (1896)).
94. HOWARD SCHUMAN ET AL., RACIAL ATTITUDES IN AMERICA: TRENDS AND INTERPRETATIONS (1997).

and discrimination persist,[95] as evidenced by continued patterns of racial and ethnic residential segregation[96] and the potential for African American neighborhoods to be disrupted or even displaced by gentrification under the label of environmental restoration.[97] Thus, the dynamics of institutional change include systemic resistance to change, hybridization of new and old system features, and the potential for a system to "flip back" to a prior dominant regime if the new regime proves unstable under new or increased disturbances.

2. Transformations of the Watershed

The five broad forces or drivers of systemic change have shaped the Anacostia River basin throughout four major transitions: 1) *the agricultural transformation* (e.g., deforestation, draining and filling wetlands, sedimentation from poor farming practices); 2) *the navigational transformation* (e.g., channelization, dredging, the engineering of locks, dams, canals, and ports); 3) *the industrial transformation* (e.g., industrial development along the riverfront, the discharge or runoff of toxic pollutants into the river); and 4) *the urban transformation* (e.g., impervious cover, removal of trees and vegetation, destruction or alteration of wetlands, sewage disposal and sewer overflows, environmental and recreational uses of the waters). These alterations have had mostly to do with land-cover or land use changes and alterations of basic stream and river structure. In each transition, the linked institutional, social, and ecological conditions of the watershed crossed major thresholds in systemic characteristics and resilience to distinctly different social-ecological states. The watershed is arguably undergoing yet another major cross-threshold transformation to a "greening" of the watershed with restored natural features and new green infrastructure.

a. The Watershed of Forests, Wetlands, and Flows

When Captain John Smith sailed up what he referred to as the "Eastern Branch" of the Potomac River in 1608, he discovered the Necostan or Anacostan Native Americans and their settlement Nacotchtank on the banks of the Anacostia River.[98] By this time, the Anacostia River watershed had undergone previous regime shifts, including a climate-driven transition approximately 2,500 years ago from boreal forests and colder temperatures to forests dominated by white pine, hemlock, birch, fir, ash, and oak and waters inhabited by shellfish.[99] As Native American tribes developed settlements and a society based on agriculture and trad-

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95. EDUARDO BONILLA-SILVA, RACISM WITHOUT RACISTS: COLOR-BLIND RACISM AND THE PERSISTENCE OF RACIAL INEQUALITY IN AMERICA 26–27 (4th ed. 2013).

96. Casey J. Dawkins, *Evidence on the Intergenerational Persistence of Residential Segregation by Race*, 42(3) URB. STUD. 545 (2005), *available at* http://usj.sagepub.com/content/42/3/545.full.pdf+html; JOHN R. LOGAN, SEPARATE AND UNEQUAL: THE NEIGHBORHOOD GAP FOR BLACKS, HISPANICS AND ASIANS IN METROPOLITAN AMERICA 9 (2011), *available at* http://www.s4.brown.edu/us2010/Data/Report/report0727.pdf.

97. Brett Williams, *Gentrifying Water and Selling Jim Crow*, 31(1) URB. ANTHROPOLOGY & STUD. OF CULTURAL SYST. & WORLD ECON. DEV. 93 (2002), *available at* http://www.jstor.org/stable/40553558?seq=1.

98. WENNERSTEN, supra note 77, at 8–11.

99. *Id.* at 5.

ing (including a "commodity culture"), they altered the watershed with forest burns to create fields, meadows, and areas for settlement.[100] By the early seventeenth century, the Anacostia—whose name comes from the Indian word *anaquash*, meaning "village trading center"—was a thriving hub of economic prosperity.[101]

Nonetheless, the dominant features of the Anacostia in the early seventeenth century were lush vibrant forests, rich wetlands, and clear natural stream and herring, the staple food of the local Nanchotank villagers.[102] The ecosystem was highly productive with hydrologically and biologically positive feedback among lands, waterways, and biotic communities.[103]

b. The Watershed of Agriculture and Navigation

As Europeans settled the lands within the Anacostia watershed and greater Chesapeake Bay region, they fundamentally altered both the landscape and the river structure. They cleared forests to create farms.[104] The Anacostia lost nearly half its forests in a span of only seventy years.[105] They drained or filled wetlands, which were sources of diseases like malaria and which had rich soils that could be farmed.[106] They channelized the Anacostia River to support commercial navigation, building locks, dams, docks, ports, and the like on the river.[107] The fundamental structure of the Anacostia shifted to a watershed of agriculture and navigation.[108]

The dominant, at times almost exclusive, type of farming was tobacco plantations, worked by indentured servants, immigrant tenant farmers, and African slaves.[109] With a few notable exceptions, early in the colonial period, the major tobacco planters (i.e., plantation owners) were related to one another, creating relatively rigid class structures by the late colonial period and replication of unsustainable land management methods throughout the region.[110] Soil depletion on tobacco plantations happened relatively quickly, which created incentives to simply clear more land for new fields but eventually led to a shift to corn and other crops, truck farms, and timbering (which further increased deforestation).[111] "A tobacco field could only produce four years of good yields before it drained the soil of nitrogen and potassium. In less than a decade, land went from forests to tobacco fields to broom sedge and little pines."[112]

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100. *Id.* at 6–12.

101. *Anacostia: River of Recovery*, MD. DEP'T OF NAT. RES. (Feb. 6, 2002), http://www.dnr.state.md.us/forests/anacostia/history.html.

102 *Cleaning up the Anacostia River*, Nat'l Res. Def. Council (Feb. 21, 2013), http://www.nrdc.org/water/pollution/fanacost.asp [hereinafter NRDC].

103. ARWRPR, *supra* note 59, at 2–5.

104. WENNERSTEN, *supra* note 98, at 21.

105. *Id.*

106. *Historical Changes of the Watershed*, ANACOSTIA WATERSHED RESTORATION PARTNERSHIP, http://www.anacostia.net/history/history.html (last visited Jan. 8, 2015).

107. *Id.*

108 *Id.*

109. WENNERSTEN, *supra* note 98, at 16–35; LOUISE DANIEL HUTCHINSON, THE ANACOSTIA STORY: 1608–1930, at 7–16 (1977).

110. WENNERSTEN, *supra* note 98, at 16–35; HUTCHINSON, *supra* note 109, at 7–16.

111. WENNERSTEN, *supra* note 98, at 16–35; HUTCHINSON, *supra* note 109, at 7–16.

112. WENNERSTEN, *supra* note 98, at 21.

Land management practices in the Anacostia tobacco economy contributed to the eventual decline of farming in the watershed, as well as another core aspect of the watershed during the agricultural period: the River as a conduit of commercial navigation. Poor farming practices—including harmful cultivation methods, indiscriminate clearing of trees, failure to rotate crops, and soil depletion—created erosion and sediment runoff that would eventually clog the Anacostia's tributaries and then the Anacostia River itself, raising the riverbed.[113] Over time, ocean-going ships and even smaller vessels were unable to navigate the increasingly shallow river.

The Anacostia River had become a major transportation channel for ships traveling to the ocean long before sedimentation problems, though.[114] In 1742, a major port and town of Bladensburg was established on the upper Anacostia River at a river depth of forty feet, deep enough that ocean-going ships could reach upriver tobacco supplies.[115] It soon became the second most used port in the American colonies based on tonnage shipped (after Yorktown) despite suffering heavy siltation to its docks within twenty years of its founding.[116]

The U.S. Navy established the Washington Navy Yard in 1799 with the Anacostia River as the southern boundary of the property.[117] The Navy did most of its shipbuilding and shipfitting at the Washington Yard during the 19th century, increasing activity along the river and employing many riverside residents.[118] The increasing expansion of the shipyard and its activities aggravated soil erosion and siltation of the river.[119] Portions of the river were filled in order to expand the Yard, decreasing the tidal marshes of the Anacostia.[120] Tidal marshlands are nutrient-rich and serve a diversity of aquatic species.[121] Marshes are extremely effective at cleaning polluted waters within the watershed; unfortunately the effectiveness of the Anacostia's tidal marsh decreased as they were filled in.[122]

During the eighteenth and nineteenth centuries, the Anacostia River and its watershed became engines of economic growth for a new nation. The region's economic success was largely due to the river's support of a successful trading post, transit opportunities, and farmland fertility.[123] In an effort to increase their financial success, wealthy proprietors and politicians encouraged the ideas to create wa-

113. *Id.* at 62–63.

114 D.C., OFFICE OF PLANNING, THE ANACOSTIA WATERFRONT FRAMEWORK PLAN 14 (2003), *available at* http://www.anacostiawaterfront.org/awi-documents/the-anacostia-waterfront-framework-plan-2003/.

115. WENNERSTEN, *supra* 98, at 17, 30–33.

116. *Id.* at 33.

117. *Id.* at 51–52.

118. *Id.* at 51–52, 73–75.

119. *Id.* at 74.

120. U.S. GEN. SERVS. ADMIN. NAT'L CAPITAL REGION, THE YARDS IN-WATER DEVELOPMENT FINAL ENVIRONMENTAL ASSESSMENT 3 (2010), *available at* http://www.gsa.gov/graphics/regions/The_Yards_Final_EA_7_16_10.pdf.

121 *Marshes*, EPA, http://water.epa.gov/type/wetlands/marsh.cfm (last visited Jan. 8, 2015).

122. *Id.*

123 FREDERICK GUTTHEIM & ANTOINETTE J. LEE, WORTHY OF A NATION: WASHINGTON D.C. FROM L'ENFANT TO THE NATIONAL CAPITAL PLANNING COMMISSION 58 (1977), *available at* http://www.openisbn.com/preview/0801883288/.

terways connecting the Anacostia to other bodies of water.[124] Canals and locks, though a risky investment at the time, proved to be lucrative for the settlers in the area.[125] Public support for these projects was so fierce that the true financial expenditure was underestimated by politicians and citizens alike.[126] A major canal in the Anacostia operated from 1815 until the mid-1850s.[127]

During this time, the Washington D.C. government purchased the canal, incurring massive debt in an attempt to maintain the structure and expand it. The Washington City Canal initially connected the Anacostia to Tiber Creek and the Potomac; the municipality expanded the canal to include a connection to the Chesapeake and the Ohio Canal.[128] Plans to extend the canal to the Ohio River were abandoned due to financial constraints, and slowly the canal came into disuse and neglect, as the government could no longer expend funding to maintain the canal system.[129]

Social system changes in the colonial and early Republic periods of American history altered the watershed. The changes in the structure of the Anacostia's lands and waterways were driven in part by economic, political, and social forces to exploit the lands and river for wealth-generation, and in part by the growth of national and special-interest power. Moreover, the watershed's domination by both agricultural and commercial navigation activities emerged from the creation of a new society characterized by the co-existence of Jefferson's vision of a yeoman-farmers' democracy and Hamilton's vision of a commercial republic.[130]

However, these changes were also driven by concurrent changes in existing institutions and emergence of new institutions. Colonial laws and social norms mandated that landowners put their lands to economically productive uses, including clearing forests and eliminating wetlands, even at the risk of forfeiting their lands if they failed to do so.[131] In the Chesapeake Bay region (including the Anacostia watershed), colonial and state laws protected tobacco farming by regulating product quality and providing public regulated markets that limited oversupply, thus keeping prices up.[132] The U.S. Constitution created a new federal government

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124. Thomas Law, *Observations on the Intended Canal in Washington City* (1804), *in* 8 RECORDS OF THE COLUMBIA HISTORICAL SOCIETY, WASHINGTON, D.C. 158–68 (1905), *available at* http://www.jstor.org/stable/pdfplus/40066906.pdf.

125 Cornelius W. Heine, *The Washington City Canal*, *in* 53 RECORDS OF THE COLUMBIA HISTORICAL SOCIETY, WASHINGTON, D.C. (1953), *available at* http://www.jstor.org/stable/pdfplus/40067664.pdf.

126 *Id.* at 6–7.

127 WILHELMUS BOGART BRYAN, A HISTORY OF THE NATIONAL CAPITAL FROM ITS FOUNDATION THROUGH THE PERIOD OF THE ADOPTION OF THE ORGANIC ACT 104 (1914), *available at* https://ia700306.us.archive.org/5/items/historyofnationa02brya/historyofnationa02brya.pdf; Heine, *supra* note 125, at 18.

128 Tom Fuchs, *The Canal Connection*, HISTORICAL MARKER DATABASE, http://www.hmdb.org/Marker.asp?Marker=211 (last visited Jan. 9, 2015).

129. Heine, *supra* note 125, at 21.

130. THE OXFORD COMPANION TO UNITED STATES HISTORY 405 (Paul S. Boyer & Melvyn Dubofsky, eds. 2001); REGINALD HORSMAN, THE NEW REPUBLIC: THE UNITED STATES OF AMERICA 1789-1815 (2014) (describing the classic Hamilton-Jefferson debate, but noting that Jefferson wanted to develop markets for farmers' crops).

131. John F. Hart, *Colonial Land Use Law and Its Significance for Modern Takings Doctrine*, 109 HARV. L. REV. 1252, 1261(1996).

132. LAWRENCE M. FRIEDMAN, A HISTORY OF AMERICAN LAW 78–79 (2d ed. 1985).

with powers and duties to protect and advance interstate commerce,[133] mostly at the time through navigation; this constitutional principle still today shapes and limits the federal government's authority to regulate water quality and protect wetlands under the Clean Water Act.[134] The U.S. Army Corps of Engineers was created in 1802 to manage and alter navigable waterways for both military and commercial purposes.[135]

The institution of slavery was a core element of the agricultural economy and land management system in the Anacostia. "Starting in 1671 the Maryland legislature began to sanction and encourage the importation of African slaves into the colony. There were laws to protect the investment of slave owners, while brutal and oppressive slave codes were designed to control the laborers."[136] Initially slave emancipation was legally easier than it later became, as new laws were passed to presume that any black person was a slave, to authorize the maiming or killing of any black person who resisted whites, and to impose torturous and humiliating punishments on slaves.[137] Thus, the harmful, exploitive institution of slavery became more entrenched and rigid, just as the tobacco economy and norms of harmful, exploitive land management became more entrenched and rigid.[138] Even one and a half centuries after the Thirteenth Amendment to the U.S. Constitution outlawed slavery,[139] the injustices created by the institution of slavery in Maryland and DC have perpetuated social, economic, and political disparities, including in watershed governance.[140]

c. The Industrialized Watershed

In the latter half of the nineteenth century, two major transformations in the Anacostia watershed began in somewhat overlapping yet distinctive ways: industrialization and urbanization. The rapid development of industrial activities and the pollution that they generated quickly altered the fundamental characteristics of the watershed from farming-dominated and navigation-dominated functions to industry-dominated functions, particularly in the lower reaches of the basin in and near Washington, D.C.[141] The advent of the railroad (i.e., reducing the economic dominance of commercial navigation) and the Industrial Revolution in the American economy generally contributed to this shift.[142] Urbanization, however, was a slower but more lasting altering force. The conversion of lands, including riparian lands, forests, and wetlands, to urban development began in the colonial and early Republic period and continued to grow through the industrial period.[143] However, urbani-

133. U.S. CONST. art. I, § 8, cl. 3.
134. *See* Rapanos v. United States, 547 U.S. 715, 742 (2006).
135. *The U.S. Army Corps of Engineers: A Brief History*, U.S. ARMY CORPS OF ENG'RS, http://www.usace.army.mil/About/History/BriefHistoryoftheCorps/Introduction.aspx (last visited Jan. 8, 2015).
136. HUTCHINSON, *supra* note 109, at 14.
137. *Id.* at 14–15.
138. *Id.*
139. U.S. CONST. amend. XIII.
140. *See, e.g.*, Williams, *supra* note 97.
141. WENNERSTEN, *supra* note 98, at 73–75, 121–23.
142. *Id.*
143. *See* discussion *infra* Part II.B.2.c.

zation has been an increasing and relentless phenomenon in the watershed, even now, reshaping the watershed and its structure long after heavy industry began its decline and efforts emerged to clean up industrial pollution within the river and throughout the watershed.[144] Thus, the dominance of extensive urbanization as the major organizing feature of the watershed became well established in the twentieth century, even though the effects of the industrialized watershed persisted into this period.

By 1900, the southeast and southwest sections of Washington, DC, near the Anacostia River had become major industrial areas.[145] The U.S. Navy Yard gradually shifted from being a shipyard to being a manufacturing facility to build or retrofit ships, with Congress authorizing the creation of a ship gun foundry to manufacture heavy ordnance for battleships.[146] A large industrial complex developed at the Navy Yard, including a copper rolling mill, cranes, and large manufacturing facilities that at the time constituted "'the most modern ordnance plant in the world.'"[147] By 1880, nearly $4 million (between $84 million and $6.4 billion in value by 2013 standards[148]) in non-Navy manufacturing facilities also developed in the area, including printing, flour and grist milling, foundries, machine shops, brick yards, railroad yards, sand and gravel operations, coal yards, scrap yards, ice houses, textile manufacturing, lumber yards, carpentry shops, and repair facilities.[149] More than seven thousand people were employed in non-governmental manufacturing.[150] Industrial waste, including waste from the Navy Yard, was regularly dumped into the Anacostia River, contaminating the water and riverbed soils for a century or more.[151] One of the major sources of industrial pollution today was a manufactured gas plant, operated by Washington Gas and Light from 1888 to 1948, and another was a Pepco Energy coal-fired and then oil-fired facility that operated from 1906 to 2012 and had several releases of environmental contaminants from 1987 to 2003.[152] Not all major industrial activity developed on the riverfront in Washington, D.C., though. Currently, the Lower Beaverdam Creek and Indian Creek subwatersheds in Maryland have the highest percent of land use devoted to industrial activity.

Industrial pollutants, many of which are now heavily regulated or banned, continue to affect the watershed today, despite efforts to improve water quality and remediate polluted soils. Toxic chemicals have bio-accumulated in the food chain.[153] Pathogens from sewage and runoff make the river unsafe for swimming.[154]

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144. *See* discussion *infra* Part II.B.2.d.

145. WENNERSTEN, *supra* note 98, at 73–75, 121–23.

146. *Id.*

147. *Id.* at 74 (quoting TAYLOR PECK, ROUND-SHOT TO ROCKETS: A HISTORY OF THE WASHINGTON NAVY YARD AND U.S. NAVAL GUN FACTORY 188 (U.S. Naval Inst. Press 1949)).

148. *Seven Ways to Compute the Relative Value of a U.S. Dollar Amount – 1774 to Present*, MEASURINGWORTH, http://www.measuringworth.com/uscompare/ (last visited Jan. 9, 2015).

149. WENNERSTEN, *supra* note 98, at 74–45, 121–23.

150. *Id.* at 75.

151. *Id.* at 73–75.

152. ARWRPR, *supra* note 59, at 34–35; *Demolition of the Pepco Benning Road Power Plant*, ANACOSTIA WATERSHED SOC'Y (Oct. 30, 2013, 4:09 PM), http://www.anacostiaws.org/news/blog/demolition-pepco-benning-road-power-plant.

153. DDOE, ANACOSTIA 2032, *supra* note 54, at 16–20.

154. *Id.*

Oil and grease are ubiquitous in the environment.[155] Organic chemicals tend to stick to sediments and remain on the river bottom.[156] Even if all of the PCBs were eliminated from all streams feeding the Anacostia River for the next twenty years, the river sediment would still be so polluted with legacy PCBs that the river would not meet water quality standards for organic pollutants.[157]

Institutions supported an industrialized economy. For example, Congress expressly authorized the creation of a large, intensive ordnance manufacturing facility at the Navy Yard on the banks of the Anacostia River.[158] Pollution-control laws were lax or non-existent, and social norms tended to favor using rivers as a drain for industrial and human wastes.[159] Dominant social norms about property rights and freedom of contract impeded the authority of legislatures and regulators to protect public health and environmental conditions against corporations' "freedoms" to pollute waterways mostly unchecked.[160] Both land use laws and environmental laws facilitated and even promoted the location of industrial facilities and industrial pollution in or near low-income and minority neighborhoods.[161]

d. The Heavily Urbanized Watershed

Urbanization, both past and continuing land development, has substantially altered the ecological, social, and institutional characteristics of the Anacostia River Basin, "flipping" the interconnected watershed system into a heavily urbanized state in the twentieth century. Over 70 percent of the watershed is now developed, and 45 percent of the watershed is residential development.[162] Both Washington, D.C., and its Maryland suburbs grew rapidly after World War I.[163] Especially sub-

155. *Id.* at 17.

156. *Id.* at 19.

157. *Id.* at 20.

158. WENNERSTEN, *supra* note 98, at 74.

159. *See generally* Tom Horton, *Protection of the Chesapeake Bay: Environmentally Legal, Eminently Uninhabitable?*, 47 MD. L. REV. 406, 407–09 (1988).

160. *See, e.g.*, Michael J. Gerhardt, *On Revolution and Wetland Regulations*, 90 GEO. L.J. 2143, 2172 (2002) (arguing that constitutional jurisprudence of the so-called *Lochner* era limited economic regulations but did not limit environmental regulations, yet legislatures failed to enact such regulations at the time). For an example of the U.S. Supreme Court striking down environmental regulations as interfering with private property rights, see generally Pa. Coal Co. v. Mahon, 260 U.S. 393 (1922).

161. *See generally* Craig Anthony (Tony) Arnold, *Planning Milagros: Environmental Justice and Land Use Regulation*, 76 DENVER U. L. REV. 1 (1998); LUKE W. COLE & SHEILA R. FOSTER, FROM THE GROUND UP: ENVIRONMENTAL RACISM AND THE RISE OF THE ENVIRONMENTAL JUSTICE MOVEMENT (Richard Degado & Jean Stefancic eds., 2001); Yale Rabin, *Expulsive Zoning: The Inequitable Legacy of Euclid*, *in* ZONING AND THE AMERICAN DREAM (Charles M. Haar & Jerold S. Kayden eds., 1990); STEVE LERNER, SACRIFICE ZONES: THE FRONT LINES OF TOXIC CHEMICAL EXPOSURE IN THE UNITED STATES (2010). Weak or disparate enforcement of environmental laws against industry, disparate decisions about pollution remediation, and legal barriers to the residential mobility of low-income and minority neighborhood residents have perpetuated the industrial-era legacy of environmental injustices. *See, e.g.*, DORCETA E. TAYLOR, TOXIC COMMUNITIES: ENVIRONMENTAL RACISM, INDUSTRIAL POLLUTION, AND RESIDENTIAL MOBILITY (2014).

162. *Anacostia Watershed Environmental Baseline Conditions and Restoration Report*, METROPOLITAN WASH. COUNCIL GOV'TS 8 (2010) [hereinafter MWCOG], *available at* http://www.anacostia.net/Restoration_Plan/download/PLAN_report_Jan_2010.pdf; ARWRPR, *supra* note 59, at 19.

163. WENNERSTEN, *supra* note 98, at 106–10.

stantial suburban growth occurred in the 1980s and 1990s,[164] with an 18.3 percent growth in the suburbs from 1980 to 1994.[165] The city of Washington, D.C. underwent another major growth spurt starting in the late 1990s.[166]

Several effects of urbanization on the watershed began well before the watershed became heavily urbanized, but increased substantially as urban development grew. For example, the federal government has played a major role in the development of the Anacostia River watershed since Washington, D.C., was designated as the nation's capital. In addition to locating the U.S. Navy Yard on the Anacostia, the federal government placed the U.S. Capitol Building and offices, U.S. Supreme Court, Library of Congress, Federal Judicial Center, U.S. Secret Service Training Center, National Arboretum, Fort NcNair, U.S. Soldiers' Home, Marine Barracks, Goddard Space Flight Center, Food and Drug Administration White Oak Campus, U.S. Government Insane Asylum, and Southeast Federal Center within the basin.[167] The federal government owns 12.3 percent of the lands in the Anacostia River watershed.[168] Over 90 percent of lands along the river's shoreline within Washington, D.C. are publicly owned lands, owned mostly by the federal government or the District of Columbia government.[169] Convenient and relatively affordable housing for government employees, including Capitol Hill workers, developed in the shadow of the Capitol.[170] The federal government also used its powers and resources to facilitate a wide range of public and private land development, including the U.S. Army Corps of Engineers filling tidal wetlands along the Anacostia, federal, state, and local funding and construction of sprawl-facilitating transportation infrastructure, and congressional authorization of planning and redevelopment in Washington, D.C.[171] One of the major themes of urban development in the Anacostia basin is the role of real estate speculation driven by being located within the nation's capital.[172]

Another early effect of urban development was the contamination of the Anacostia River with sewage. From the creation of Washington, D.C., the river was used as an open sewer and wastewater system, but the problem became much greater with military camps along or near the river during the Civil War.[173] The amount of sewage in the Anacostia's waterways not only produced terrible smells but also deadly cholera outbreaks and other diseases.[174] Even as government agencies built sanitary sewer systems and wastewater treatment facilities under intense pressure from the public, new facilities could not keep up with growing urban and

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164. Uwe Steven Brandes, *Bankside Washington, D.C.*, *in* RIVERTOWN: RETHINKING URBAN RIVERS 47, 51 (Paul Stanton Kibel ed., 2007) [hereinafter RIVERTOWN].

165. NRDC, *supra* note 102.

166. RIVERTOWN, *supra* note 164, at 51.

167. MWCOG, *supra* note 162, at 14; HUTCHINSON, *supra* note 109, at 54–59.

168. MWCOG, *supra* note 162, at 14.

169. Brandes, *supra* note 164, at 49–50.

170. WENNERSTEN, *supra* note 98, at 122–23.

171. *Id.* at 114–21, 130–61, 176–78, 212, 227–31.

172. *See generally* WENNERSTEN, *supra* note 98; HUTCHINSON, *supra* note 109 (both texts explore these themes in several places throughout their histories of the Anacostia).

173. WENNERSTEN, *supra* note 76, at 57-58, 64-67..

174. *Id.* at 58–62, 64–67. In the 1930s, typhoid fever could be contracted by merely wading in the river. DANIEL MCCOOL, RIVER REPUBLIC: THE FALL AND RISE OF AMERICA'S RIVERS 205 (2012).

suburban populations.[175] Conflict developed between Washington, D.C. and its upstream Maryland suburbs over whether the Maryland suburbs could transport their wastewater to the D.C. system (or continue to discharge the waste into Anacostia River feeder streams) and who would pay for it.[176] Even when the parties agreed to combine the systems, they were also combined with stormwater systems, producing overflows of sewage into surface waters during storm events, and were built with technology that is aging and unable to keep pace with capacity needs.[177] Progress in public health standards and wastewater treatment technology has been offset, at least to some degree, by rapid urbanization.

Race has also been an important element of the basin's urbanization and its effects. Washington, D.C. was created out of Virginia and Maryland, the two states with the greatest black populations in the U.S. in 1790.[178] In fact, in 1800, about one-quarter of all residents of the District were black, both slave and free.[179] The river itself became an attractive area for African American settlements, particularly of freed slaves. New communities of African American residents, farms, and businesses emerged and grew in places like Good Hope, Uniontown, and Barry's Farm.[180] The famed African American leader, Frederick Douglass, was a leading resident of the emerging Anacostia region.[181] While the area still had a semirural character in 1920, it was a growing urban community that lacked basic municipal services and infrastructure.[182] The prevalence of African American residents and lower-income residents meant disparities and segregation in basic services in a racist society. Moreover, white supremacists in Congress used their power over District of Columbia governance,[183] to attempt to drive blacks out of Washington, D.C., in order to attract white middle class residents and businesses.[184]

Moreover, blacks living within the D.C. portion of the Anacostia basin were displaced by public-private redevelopment accomplished through government planning, exercises of eminent domain, and urban renewal projects from the 1920s to the early 1970s.[185] Municipal use of eminent domain to accomplish the massive

175. WENNERSTEN, *supra* note 98, at 84–91, 161–68.

176. *Id.* at 163–66.

177. *Id.* at 84–91, 163–68.

178. HUTCHINSON, *supra* note 109, at 21.

179. *Id.* Incidentally, Washington, D.C., including the area along the Anacostia River, was surveyed for the new federal government by black astronomer and mathematician Benjamin Banneker. *Id.* at 19.

180. HUTCHINSON, *supra* note 109, at 46–54, 75–90, 99–117.

181. *Id.* at 108–17.

182. *Id.* at 135–36.

183. Much of the congressional power over the District of Columbia's governance was ceded to the D.C. government with the District of Columbia Home Rule Act in 1973. Pub. L. 93-198; 87 Stat. 777; D.C. Code § 1-201 *passim*.

184. WENNERSTEN, *supra* note98, at 146.

185. RIVERTOWN, *supra* note 164, at 50–51. All histories of the Anacostia emphasize the disparities and injustices experienced by people and communities of color, especially low-income African American communities. Different authors offer different explanations or narratives, though. According to Gillette, planners preferred creating a beautiful city of monuments over a socially just city. HOWARD GILLETTE, JR., BETWEEN JUSTICE AND BEAUTY: RACE, PLANNING, AND THE FAILURE OF URBAN POLICY IN WASHINGTON, D.C. 88–108 (1995). Wennersten attributes disparate conditions to decision makers' racial prejudices that perceived African American neighborhoods as unsanitary, dysfunctional, and undesirable, especially in comparison to white residential and commercial development. WENNERSTEN, *supra* note 98, at 130–61. McCool emphasizes classist and racist neglect of the Anacostia and its neighborhoods.

urban renewal project in D.C.'s southwest quadrant was upheld unanimously by the U.S. Supreme Court in 1954 in *Berman v. Parker*,[186] which was roundly criticized more than fifty years later by Justice Clarence Thomas in his dissent in *Kelo v. City of New London*, for allowing government agencies to use eminent domain powers to benefit powerful private interests at the expense of the least powerful groups in society.[187] The combined efforts of planners, housing professionals, land developers and speculators, business interests, segregationists, government bureaucrats, and political leaders aimed to eliminate what were deemed "blight," "slums," or "unsanitary conditions," even if they actually constituted thriving, diverse, but economically modest historic neighborhoods.[188] Entire communities were razed and replaced with new development that existing residents could not afford, a process known as gentrification.[189]

With the loss of existing neighborhoods in the Southwest Quadrant and an influx of new low-income residents from the rural South and other locations, the demand for affordable housing became intense and spurred a building boom of apartments and public housing—often overcrowded and of poor construction—in the Southeast Quadrant.[190] These housing conditions, concentrations of poverty in *de facto* racially segregated neighborhoods, intensive industrial land uses, and poor and unhealthy river conditions fell disproportionately on African American residents along and near the Anacostia River in Washington, D.C. They came to see the river as a dangerous, repulsive place: characterized by crime, pollution, deteriorating conditions, and even death.

Urban development, through street building, residential and commercial construction, and deforestation (among other activities), has vastly increased the amounts of impervious surface in the basin and reduced capacity of the ecosystem to absorb, infiltrate, transpire, and otherwise redistribute stormwater. In effect, urbanization severed the hydrologic cycle by capturing precipitation and conveying it to either an urban stream for direct discharge (i.e., municipal separate storm sewer systems, or MS4s, which are prevalent in the headwaters of the Anacostia watershed) or to a wastewater treatment plant in combination with sewage for treatment prior to discharge (i.e., combined sewer systems, or CSS, which dominate the older, downstream stretches of the Anacostia). This severance of the hydrologic cycle in heavily urbanized areas has had detrimental implications for both water quality and quantity and varies depending on the type and age of the stormwater infrastructure (i.e., whether separate or combined), all of which are relevant and dominant

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MCCOOL, *supra* note 174 at 204–06. Moreover, he points out that the neglect was internalized by area residents. Initially, African American neighborhood residents paid more attention to crime and education than to watershed restoration and environmental conditions. *Id.* at 209. Brandes gives attention to the political economy of the Anacostia and the evolving exploitation of its lands and waters by powerful economic interests. Brandes, *supra* note 209, at 47–51. Brandes emphasizes the poverty of Washington, D.C.'s Anacostia neighborhoods and disinvestment in the watershed's green infrastructure. *Id.* According to Williams, institutionalized structures of neoliberal capitalism combined political and economic power to isolate, fragment, and gentrify the Anacostia River neighborhoods and thus perpetuate segregated conditions. Williams, *supra* note 97.

186. Berman v. Parker, 348 U.S. 26 (1954).

187. Kelo v. City of New London, 545 U.S. 469, 505–21 (2005) (Thomas, J., dissenting).

[188] WENNERSTEN, *supra* note 98, at 157-61.

189. *Id.* at 139–57.

190. *Id.* at 157–61; RIVERTOWN, *supra* note 164, at 51.

drivers in the Anacostia where approximately twenty-five percent of the watershed is impervious.[191]

In separated systems, or MS4s, stormwater runs off the urban landscape, picking up urban contaminants as it flows, is captured in storm drains, and is conveyed via pipes and tunnels (i.e., grey infrastructure) directly to an urban water body for discharge.[192] Frequent contaminants found in MS4 discharge include fecal coliform from animal waste and illicit sewer connections, nutrients, oil and grease from automobiles, sediments from construction and other ground disturbing activities, sediments that are contaminated with PAHs and PCBs[193] from legacy sites, excess pesticides and fertilizers from lawn applications, and thousands of tons of litter, all of which pollute the Anacostia via approximately 3,000 storm drain outfalls in the watershed.[194] All of the Maryland (i.e., upstream) sections of the Anacostia are served by MS4s, though much of the infrastructure is nearing the end of its service life, which leads to leakage both into and out of the separated sewer pipes.[195]

Wet weather discharges from MS4s are flashy and intense, in contrast not only to natural systems that temper wet weather through infiltration and transpiration but also to the relatively stagnant natural flow patterns of the Anacostia.[196] Urbanization in the Anacostia River basin began substantially increasing peak discharge rates in the 1950s, starting a period of nonstationarity in flood flows.[197] Intense pulses of stormwater discharge degrade urban streams through bank erosion, which leads to higher sediment loads downstream.[198] The Maryland Department of the Environment estimates that 70 to 75 percent of the Anacostia's sediment load is from stream channel erosion from stormwater outfalls in its upstream tributaries.[199]

The most intense urbanization along the Anacostia occurred in its downstream stretches, in Washington D.C., which is predominantly served by combined sewer systems (CSS). In CSSs, stormwater is captured in storm drains and con-

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191. MWCOG, *supra* note 162.

192. *Municipal Separate Storm Sewer System (MS4) Main Page*, U.S. ENVTL. PROTECTION AGENCY, *available at* http://water.epa.gov/polwaste/npdes/stormwater/Municipal-Separate-Storm-Sewer-System-MS4-Main-Page.cfm (last visited Jan. 8, 2015).

193. PAHs and PCBs in sediments and bioaccumulation in higher trophic levels have led to extremely high levels of liver and skin tumors in brown bullhead catfish. As a result, local health warnings advise against consuming catfish, carp, and eel from the Anacostia River. DAVID J. VELINSKY & JAMES C. CUMMINS, DISTRIBUTION OF CHEMICAL CONTAMINANTS IN WILD FISH SPECIES IN THE WASHINGTON D.C., (Interstate Commission on the Potomac River Basin eds.,1994); DAVID J. VELINSKY & JAMES C. CUMMINS, DISTRIBUTION OF CHEMICAL CONTAMINANTS IN 1993-1995 WILD FISH SPECIES IN WASHINGTON, D.C. (Interstate Commission on the Potomac River Basin eds.,1996); Alfred E. Pinkney, et al., *Tumor Prevalence and Biomarkers of Exposure and Response in Brown Bullhead (Ameiurus Nebulosus) from the Anacostia River, Washington, D.C. and Tuckahoe River, Maryland, USA*, 23 ENVTL. TOXICOLOGY & CHEMISTRY 638, 638–47 (2004).

194. ARWRPR, *supra* note 59, at 29–36.

195. Commonly referred to as INI (infiltration/inflow), sanitary sewers often gain water through groundwater leaking in through aging pipes (infiltration) and illicit or otherwise inappropriate connections to sewer lines (inflow), such as roof downspouts which should instead connect to storm drains. Stormwater inflow can lead to sanitary sewer overflows, which pose severe risks to public and environmental health.

196. Christopher J. Walsh et al., *The Urban Stream Syndrome: Current Knowledge and the Search for a Cure*, 24 J. N. AM. BENTHOL. SOC'Y 706, 708–10 (2005).

197. Saeid Eslamian et al., *Climate Change Detection and Modeling in Hydrology*, in CLIMATE CHANGE: RESEARCH AND TECHNOLOGY FOR ADAPTATION AND MITIGATION 87, 90–91 & Fig. 2 (Juan Blanco ed. 2011).

198. Walsh et al, *supra* note 196, at 710.

199. ARWRPR, *supra* note 59, at 29.

veyed to wastewater treatment facilities in the same infrastructure as sewage. During wet weather, the infrastructure is frequently overwhelmed with the volume of stormwater, thus triggering combined sewer overflows (CSOs) of raw sewage directly into receiving waterbodies.[200] The Anacostia receives approximately 1.5 to 2.1 billion gallons of CSO annually through its 15 outfalls and 75 to 82 CSO events.[201] CSOs are the primary driver of water quality degradation in the Anacostia, and the EPA listed the river as impaired for nutrients in 1996 in large part due to CSOs.[202] CSOs cause approximately 61 percent of bacterial loading and 14 percent of biochemical oxygen demand and exceeded both Maryland and D.C.'s fecal coliform standards from 1986 to 2007.[203]

The consequences of anthropogenic activity in the Anacostia stretch beyond stormwater, as native forest and wetlands have been destroyed due to shoreline building, dredge and fill practices, land conversion to agricultural use, sand and gravel mining, and flood protection in addition to urban development.[204] In total, these activities have resulted in a loss of 6,500 acres of tidal and non-tidal wetlands in the past fifty years alone.[205] The remaining 2,550 acres of wetlands are largely degraded and fragmented, which greatly impairs their function.[206] For example, the loss of wetland habitat has resulted in the complete extirpation of beavers from the non-tidal zones of the Anacostia.[207] Landfilling, erosion, and siltation from urbanization, urban development, and agriculture gradually raised the river bed.[208] The river's ecology changed as the river became increasingly shallow; the environment needed to support deep-water wildlife could not be sustained.[209]

Likewise, urbanization caused deforestation. The basin has lost seventy percent of tree cover since European settlement, with substantial losses since the 1930s and riparian areas experiencing the greatest loss.[210] Much like wetland loss, the patterns of deforestation have left small, fragmented stands that range from 1 to 12 acres.[211] Such fragmented tracts impede species migration and functional capacity of both wetland and forest ecosystems.

Despite the known consequences of urbanization on water quality in the Anacostia, development pressure continues in the headwater streams of Maryland. Two

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200 *Combined Sewer System (CSS)*, D.C. WATER AND SEWER AUTHORITY, http://www.dcwater.com/wastewater_collection/css/ (last visited Dec. 2, 2014).

201. Range reflects implementation of Phase I CSO controls in 1991. D.C. WATER & SEWER AUTHORITY, BIANNUAL REPORT: COMBINED SEWER OVERFLOW (CSO) CONTROL ACTIVITIES UPDATE (2010), *available at* https://www.dcwater.com/news/publications/october2010_cso.pdf.

202. ARWRPR, *supra* note 59, at 4–5.

203. D.C. WATER & SEWER AUTHORITY, COMBINED SEWER SYSTEM LONG-TERM CONTROL PLAN 9–17 (2002), *available at* https://www.dcwater.com/workzones/projects/pdfs/ltcp/Complete%20LTCP%20For%20CD.pdf.

204. ARWRPR, *supra* note 59, at 22–24.

205. *Id.* at 5–6.

206. *Id.* at 24.

207. *Id.*

208. *Changes in the Anacostia River*, NAT'L PARK SERVICE http://www.nps.gov/anac/forteachers/changes-in-the-anacostia-river.htm (last visited Jan. 9, 2015).

209. *Id.*

210. ARWRPR, *supra* note 59, at 22–24. This is despite the increase of forest cover from natural succession in six subwatersheds due to parkland acquisition and the retiring of agricultural fields.

211. *Id.*

large, proposed developments—a mixed use shopping center and a transportation corridor—threaten the relatively few undeveloped areas of Indian Creek, Little Paint Branch, Paint Branch, and Northwest Branch with additional pollutants, such as total suspended solids, nitrogen, phosphorus, bacteria, and trash, and the loss of palustrine[212] wetlands.[213]

e. The Watershed of Restoration and Green Infrastructure

The current structure of the Anacostia watershed's urbanized regime is poorly adapted to the hydrological, ecological, and socio-political pressures from urbanization's adverse effects on the watershed's functioning. Just as urbanization has driven the Anacostia watershed toward a threshold that may be categorized as functional severance of the hydrologic cycle, there is a movement toward reversing this trend by reconnecting the hydrologic cycle through green infrastructure.[214] Communities in both Maryland and DC aim to install bioinfiltration techniques and watershed-wide infrastructure upgrades in order to move the social-ecological system away from the hydrologic tipping points that trigger CSOs and MS4 discharges.[215] Yet, urbanization and its forces persist. The system appears to be undergoing some degree of release and reorganization into a modified regime in which urbanization forces and biophilic restoration and design principles are integrated with one another.

Institutional change is driving the watershed across a threshold to more ecosystem-regarding governance. This major systemic transformation in the linked institutional-social-ecological characteristics of the Anacostia watershed began in the 1980s. Watershed governance institutions have emerged and evolved in response to the environmental and social unsustainability of a polluted, degraded, re-engineered river basin. New "green" policies and actions have included cleaning up pollution, restoring essential watershed features, improving overall water quality and flows, using green infrastructure instead of grey infrastructure to manage stormwater runoff, and planning watershed-supporting land uses throughout the basin. Moreover, new watershed-focused groups of area residents have emerged to address the environmental harms and social injustices of land use patterns and watershed degradation. New multi-jurisdiction, multi-agency, multi-stakeholder part-

212. Small patches of hydric soils in riparian zones.

213. ARWRPR, *supra* note 59, at 41.

214. Green infrastructure utilizes natural capital, or ecosystem services, to absorb and redistribute stormwater *in situ*, most commonly in urban areas. *See What is Green Infrastructure?*, U.S. ENVTL PROTECTION AGENCY, http://water.epa.gov/infrastructure/greeninfrastructure/gi_what.cfm (last visited Jan. 9, 2015). Properties such as bioinfiltration and evapotranspiration are maximized through soil and plant media and, in some definitions, rainwater harvesting. *Id.* Rain gardens, constructed wetlands, pervious pavement, and street trees are common examples. *Id.* Other names include low impact development and stormwater best-management practices. *See Id.*

215. *See generally* ARWRPR, *supra* note 59. D.C. Water is also bound to invest in grey infrastructure in the Combined Sewer System Long Term Control Plan, which was approved by EPA in 2004 and will reduce CSOs to two per year. *See* D.C. WATER & SEWER AUTHORITY, *supra* note 201. On the Anacostia, capital costs of grey infrastructure upgrades, such as a 49 million gallon storage tunnel and pumping station rehabilitation, are projected at $940 million with annual operation and maintenance costs of $8.03 million. D.C. WATER & SEWER AUTHORITY, WASA'S RECOMMENDED COMBINED SEWER SYSTEM LONG TERM CONTROL PLAN EXECUTIVE SUMMARY ES-7 (2002), *available at* http://www.dcwater.com/workzones/projects/pdfs/ltcp/Executive_Summary.pdf.

nerships have been created to govern the watershed with attention to its social-ecological resilience. Today, the Anacostia is governed by a complex network of governmental and non-governmental organizations, operating in different regions of the watershed and at multiple scales, and undertaking a variety of activities both independently and together. The evolution and adaptive capacity of watershed governance institutions in the Anacostia will continue to have significant effects on the characteristics, resilience, and duration of this new restoration-and-green-infrastructure regime.

Emergent watershed-focused organizations and multi-agency, multi-stakeholder collaborations have created many new green initiatives and improved watershed governance capacity. Over twenty community-based or citizen-based organizations have arisen with a focus on the Anacostia River watershed or one of its subwatersheds.[216] They range, for example, from the highly active Anacostia Watershed Society (AWS), founded by Robert Boone in 1989 to promote conservation and protection of the entire watershed,[217] to the Anacostia Riverkeeper, which is part of broader regional and national waterkeeper organizational networks,[218] to the Eyes of Paint Branch, a grassroots group formed in 1994 to preserve and enhance the ecology of the Paint Branch subwatershed.[219] These organizations engage public education, restoration and cleanup projects, lobbying, letter-writing, testifying at hearings, litigating against government agencies or polluters, and participating in multi-stakeholder governance partnerships.[220]

Several different multi-agency or multi-stakeholder watershed partnerships or collaborations have arisen to address watershed issues in or involving the Anacostia River basin: Agreement of Federal Agencies on Ecosystem Management in the Chesapeake Bay;[221] Anacostia Ecosystem Initiative;[222] Anacostia Waterfront Initiative;[223] Anacostia Watershed Citizens Advisory Committee;[224] Anacostia Watershed Management Committee;[225] Anacostia Watershed Restoration Partnership;[226]

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216. The number of watershed-focused organizations perhaps approaches thirty, depending on how organizations are classified.

217. MCCOOL, *supra* note 174, at 207–08.

218. *About Us*, ANACOSTIA RIVERKEEPER, http://www.anacostiariverkeeper.org/about-us#.U9z9M0nD8qQ (last visited Jan. 9, 2015).

219. *Our Mission*, EYES OF PAINT BRANCH, http://www.eopb.org/about/about_EOPB.php (last visited Jan. 9, 2015).

220 *See id.*

221. AGREEMENT OF FEDERAL AGENCIES ON ECOSYSTEM MANAGEMENT IN THE CHESAPEAKE BAY, CHESAPEAKE BAY PROGRAM (1994), *available at* http://www.chesapeakebay.net/documents/SKMBT_75012100115450.pdf.

222. EPA, Anacostia Rebirth, *supra* note 78.

223. Ethan Goffman, *Anacostia Waterfront Initiative: Development and the Environment*, PROQUEST, http://www.csa.com/discoveryguides/ern/04may/overview.php (last visited Nov. 11, 2014); Brandes, *supra* note 164, at 52–53.

224. ANACOSTIA WATERSHED RESTORATION PARTNERSHIP, *Anacostia Watershed Citizens Advisory Committee (AWCAC)*, ANACOSTIA WATERSHED RESTORATION PARTNERSHIP, http://www.anacostia.net/AWCAC.html (last visited Nov. 11, 2014).

225. *Anacostia Watershed Management Committee (AWMC)*, ANACOSTIA WATERSHED RESTORATION PARTNERSHIP, http://www.anacostia.net/AWMC.html (last visited Jan. 9, 2015).

226. Anacostia Watershed Restoration Partnership, *Anacostia River Watershed Restoration Plan*, METROPOLITAN WASH. COUNCIL GOV'TS, http://www.anacostia.net/index.html (last visited Jan. 9, 2015. *See also* ARWRPR, *supra* note 59; MCCOOL, *supra* note 174, at 207. Interestingly, the partnership developed out of interstate agreements among Prince George's and Montgomery Counties, the State of Mary-

Anacostia Watershed Steering Committee;[227] Anacostia Watershed Toxics Alliance;[228] Clean Rivers, Green District Green Infrastructure Partnership;[229] Chesapeake Bay Program;[230] Chesapeake Bay Watershed Agreement;[231] Urban Rivers Restoration Initiative;[232] Urban Waters Federal Partnership;[233] and various subwatershed partnerships.[234]

Some are composed solely of government agencies or even just federal government agencies, but several involve community-based groups and other nongovernmental stakeholders. Each has a distinctive set of participants and a distinctive set of watershed problems to address, but there is a considerable amount of overlap among them. Many federal, state, and local government agencies and community-based groups are participants in several different partnerships, and virtually all of them are aimed at improving the environmental conditions and social-ecological functions of the degraded Anacostia River and its watershed. The participants are engaged in collaborative problem-solving and sharing information and resources. Nonetheless, conflict, litigation, the use of traditional regulatory tools, the implementation of legal mandates, and other processes that are not purely grassroots collaboration also play roles in the iterative, evolving actions of these partnerships.

Major legal changes have improved environmental protection and management for watershed function in the Anacostia River Basin. Federal environmental statutes and regulations have stimulated action to restore the watershed, control

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land, and the District of Columbia. Eventually several federal agencies, including the EPA, Corps of Engineers, National Park Service, and NOAA, were given formal roles in the partnership's governance structure. Nongovernmental organizations, businesses, and members of the public also play substantial roles. *Mid-Atlantic Water Protection, Anacostia Urban Watershed*, U.S. ENVT'L PROTECTION AGENCY, http://www.epa.gov/reg3wapd/anacostia_2012.html (last visited Jan. 9, 2015).

227. *Anacostia Watershed Steering Committee (AWSC)*, ANACOSTIA WATERSHED RESTORATION PARTNERSHIP, http://www.anacostia.net/AWSC.html (last visited Jan. 9, 2015).

228. *Anacostia Watershed*, U.S. ENVT'L PROTECTION AGENCY, http://www.epa.gov/oswer/onecleanupprogram/anacostia.htm (last visited Jan. 9, 2015).

229. DIST. OF COLUMBIA WATER AND SEWER AUTH. ET AL., CLEAN RIVERS, GREEN DISTRICT: GREEN INFRASTRUCTURE PARTNERSHIP AGREEMENT 1 (2012), *available at* http://www.epa.gov/reg3wapd/pdf/pdf_chesbay/GreenPartnshipAgreement.pdf.

230. *See generally* CHESAPEAKE BAY PROGRAM, http://www.chesapeakebay.net/ (last visited Nov. 16, 2014).

231. *Chesapeake Bay Watershed Agreement*, CHESAPEAKE BAY PROGRAM, http://www.chesapeakebay.net/chesapeakebaywatershedagreement/page (last visited Jan. 9, 2015).

232. *Urban Rivers Restoration Initiative*, U.S. ENVT'L PROTECTION AGENCY, http://www.epa.gov/landrevitalization/urbanrivers/ (last updated Feb. 2, 2012).

233. *Anacostia Watershed (Washington, DC/Maryland)*, U.S. ENVT'L PROTECTION AGENCY, http://www.urbanwaters.gov/anacostia/index.html (last updated June 9, 2014).

234. *See, e.g.*, *Strategic Plan for Friends of Sligo Creek*, FRIENDS OF SLIGO CREEK (June 1, 2004), http://www.fosc.org/StrategicPlan.htm (describing partnership between the Maryland-National Capitol Park and Planning Commission and the Friends of Sligo Creek for the management of Sligo Creek/Park); *Lower Beaverdam Creek Clean Up*, CLEAN WATER ACTION, http://www.cleanwateraction.org/feature/lower-beaver-dam-creek-clean (last visited Jan. 9, 2015) (describing the multi-organization collaboration to clean trash out of the Lower Beaver Dam Creek and build youth engagement with the watershed); CITY OF ROCKVILLE, MD, WATTS BRANCH WATERSHED STUDY AND MANAGEMENT PLAN FINAL REPORT i-ii (2001), *available at* http://www.rockvillemd.gov/DocumentCenter/View/1751 (describing the collaboration among several departments in the City of Rockville, the Watts Branch Partnership, the Center for Watershed Protection, and two consulting firms).

runoff and pollution, and increase the use of green infrastructure. Numerous federal statutes empower the EPA to provide guidance for water governance: the 1977 Clean Water Act (CWA),[235] the 1976 Resource Conservation and Recovery Act (RCRA),[236] the 1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA),[237] and others. The CWA is a primary driver of water quality improvements through the National Pollution Discharge Elimination System (NPDES)permitting system, which applies to point sources of contamination (e.g., industrial outfalls, wastewater treatment plants) and, in some cases, nonpoint source pollutants.[238]

RCRA and CERCLA govern hazardous waste management. Under the authority of CERCLA, the EPA audited and compelled federal facilities (e.g., Washington Navy Yard) to comply with water quality policies, beginning with cleaning up legacy toxins.[239] For example, the National Park Service is currently undertaking cleanup projects in the following locations: Kenilworth Park, the site of a former landfill; the wetlands and wildlife habitat of Poplar Point; and Washington Gas-East Station, which is contaminated from gas production.[240]

Federal control over navigable waters from the General Survey Act,[241] the Rivers and Harbors Appropriation Act of 1899,[242] and the 1917 and 1936 Flood Control Acts[243] granted the U.S. Army Corps of Engineers expansive authority to control development along canals and navigable waterways (e.g., harbors, dams, bridges) and to modify natural waterway characteristics (e.g., path, capacity) in order to facilitate transportation and mitigate flooding.[244] The federal government used these powers to facilitate the urbanization of the Anacostia watershed, but it is now using them to pursue watershed restoration goals.

Unlike most other watersheds,[245] though, the Endangered Species Act (ESA)[246] has had very little impact. In recent history, the only federally listed spe-

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235. Federal Water Pollution Control Act, 33 U.S.C.A. §§ 1281(a), 1294–1297 (West 2012).

236. Resource Conservation and Recovery Act of 1976, 42 U.S.C.A. §§ 6901–6975 (West 2012).

237. Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C.A. §§ 9601–9675 (West 2012).

238. The Clean Water Act § 402 authorizes the NPDES program. *See Clean Water Act, Section 402: National Pollutant Discharge Elimination System*, U.S. ENVT'L PROTECTION AGENCY, http://water.epa.gov/lawsregs/guidance/wetlands/section402.cfm (last updated Mar. 6, 2012). Phase I and II Stormwater Rules apply to large and mid-sized municipal separated storm sewer systems, requiring NPDES permits for urban stormwater runoff from a variety of sources, many of which are nonpoint sources. *See* STORMWATER PHASE II FINAL RULE, U.S. ENVT'L PROTECTION AGENCY (2005), http://www.epa.gov/npdes/pubs/fact1-0.pdf.

239. EPA, Anacostia Rebirth, *supra* note 78, at 2.

240. *Anacostia Park Environmental Cleanup Projects*, NAT'L PARK SERV., http://www.nps.gov/nace/parkmgmt/apecp.htm (last visited Jan. 9, 2015).

241. Haynes, *supra* note 77.

242. Rivers and Harbors Appropriation Act of 1899, 33 U.S.C.A. §§ 401–403, 406–409, 411–416, 418, 502, 549, 686, 687 (West 2012).

243. Flood Control Act of 1917, 33 U.S.C.A. §§ 701–703 (West 2012); Flood Control Act of 1936, 33 U.S.C.A. § 701 (West 2012).

244. *See, e.g.*, William Arthur Atkins & Faye Anderson, *Army Corps of Engineers, U.S.*, WATER ENCYCLOPEDIA: SCIENCE & ISSUES, http://www.waterencyclopedia.com/A-Bi/Army-Corps-of-Engineers-U-S.html (last visited Jan. 9, 2015).

245. *See, e.g.*, HOLLY DOREMUS & DAN TARLOCK, WATER WAR IN THE KLAMATH BASIN: MACHO LAW, COMBAT BIOLOGY, AND DIRTY POLITICS (2008); Melinda Harm Benson, *Intelligent Tinkering: The Endangered Species Act and Resilience*, ECOL. & SOC'Y, Dec. 2012, at art. 28, http://www.ecologyandsociety.org/vol17/iss4/art28/.

cies within the Anacostia was the threatened American bald eagle, which has been delisted due to increases in its population.[247] However, there are a handful of Maryland state-protected species within the watershed.[248]

Changes in watershed governance have resulted not only from broad statutory standards and power, but also the implementation of these standards through regulations and enforcement actions. Most significantly, state and local governments have had to seek new watershed-oriented solutions due to the terms of a) MS4 permits under the CWA; b) settlements of litigation over CSOs that violate the CWA; c) plans to achieve compliance with TMDLs developed pursuant to the CWA; and d) remediation plans for contaminated sites under CERCLA.[249] Watershed groups have been active in commenting on proposed terms of these legal instruments and seeking tougher standards.[250]

In addition, federal agencies have responded to legal and public mandates to incorporate ecosystem protection into their regulatory and resource management responsibilities, and state and local governments have enacted new laws and regulations aimed at improving watershed conditions. For example, in 2012, the Maryland General Assembly enacted a statute requiring ten localities, including Prince George's and Montgomery Counties, to impose stormwater fees on all non-government land and dedicate those revenues to watershed protection and restoration. The District of Columbia Department of the Environment (DDOE) has enacted new stormwater regulations:

> In July 2013, DDOE finalized new District-wide stormwater regulations, updated as required to implement the MS4 permit's 1.2-inch retention standard for newly developed and redeveloped properties. In addition, the regulations require that substantial improvements to existing properties (such as significant interior renovations) incorporate stormwater management practices to meet a 0.8-inch retention standard. The retention standard must be met using practices that infiltrate, evapotranspirate, and/or reuse stormwater, including green infrastructure. The regulations include a first-of-its-kind trading program that allows regulated properties to purchase retention "credits" from properties that are retrofitted with excess retention capacity. This trading program is expected to result in the installation of new green infrastructure practices more broadly throughout the District. Because the program contains several loopholes that threaten its effectiveness—including unlimited banking of credits, a lack of geographic restrictions on trades, and issuance of credits for previously installed projects—implementation must be monitored closely to ensure that the-

246. Endangered Species Act of 1973, 16 U.S.C.A. §§ 1531–1544 (West 2006).

247. ARWRPR, *supra* note 59, at 40.

248. *Id.*

249. *See* EPA, *Anacostia River Urban Watershed*, *supra* note 38 (listing several regulatory and enforcement actions).

250. *See, e.g.*, NATURAL RESOURCES DEFENSE COUNCIL ET AL., COMMENTS ON DRAFT MS4 PERMIT NO. 11-DP-3314 / MD0068284 FOR PRINCE GEORGE'S COUNTY, MARYLAND (June 27, 2013), *available at* http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/Documents/Final%20PG%20MS4%20comments%206-27-2013.pdf [hereinafter COMMENTS ON DRAFT] (letter submitted by ten environmental and watershed groups on draft MS4 permit for Prince George's County, arguing for stronger permit provisions due to continued impaired water conditions after three prior MS4 permit cycles).

> program will function as intended. DDOE recently finalized a discount program, RiverSmart Rewards, for its stormwater fee that allows residents to receive a discount of up to 55 percent when they manage stormwater using green infrastructure. Discounts are available for new and previously installed practices.[251]

Enforcement actions brought under the CWA are responsible for the current trend toward drastic reductions in combined sewer overflows[252] via long term control plans.[253] Associated NPDES permits for municipal combined and separated systems are driving a profound transformation in urban stormwater management[254] by both the D.C. Water and Sewer Authority[255] and the State of Maryland.[256] In furtherance of CWA mandates, the EPA conducts routine monitoring of watershed health in the Anacostia, publishing the results online in technical databases and more accessible reports.[257] CWA provisions also establish the State Revolving Fund to finance water quality improvement and ecosystem restoration via low-interest loans and grants, such as educational programs organized by the Anacostia Watershed Society.[258]

Litigation has also been a major influence on the shift towards a restoration-and-green-infrastructure regime in the Anacostia. Both DC Water and the Washington Sanitary Sewer Commission are under federal consent decrees, enforced by the EPA, to reduce or eliminate CSOs.[259] In the past three to four decades, environmental and community-based groups have filed numerous lawsuits against government agencies for under-protection of the watershed and against governmental and non-governmental polluters to stop present and future pollution and hold them liable to remedy past pollution. The Anacostia Watershed Society, for example, sued the U.S. Navy in 1996 over the Navy Yard's pollution and obtained not only a favorable settlement but also a new and strong ally—the U.S. Navy—in watershed restoration efforts.[260] Then, the AWS sued the District of Columbia in 1999, resulting in

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251. JANIE CHEN & KAREN HOBBS, ROOFTOPS TO RIVERS II: GREEN STRATEGIES FOR CONTROLLING STORMWATER AND COMBINED STORMWATER AND COMBINED SEWER OVERFLOWS 17 (2013), *available at* http://www.nrdc.org/water/pollution/rooftopsii/files/rooftopstoriversII-update.pdf.

252. *See supra* Part II.B.2.d.

253. D.C. WATER & SEWER AUTHORITY, *supra* note 201.

254. *See* Ruben Kertesz et al., Modeling the Hydrologic and Economic Efficacy of Stormwater Utility Credit Programs for Single Family Residences, __WATER SCI. & TECH. __ (in press, 2014).

255. Consent Decree, Anacostia Watershed Soc'y v. D.C. Water and Sewer Auth. (D.D.C. Mar. 25, 2005) (No. CV-00183TFH), *available at* https://www.dcwater.com/workzones/projects/pdfs/ltcp/ltcp_consent_decree.pdf.

256. Stormwater Management Act, MD. CODE. ANN., ENVIR. §§ 4-201.1, 4-203 (West 2012).

257. Federal Water Pollution Control Act, 33 U.S.C.A. § 1315(b) (West 2014); EPA, *Partners in Progress: EPA Update on Federal Facility Cleanup and Reuse*, NAT'L SERV. CTR. FOR ENVTL. PUBLICATIONS 8 (2003). In addition, since 2000 the National Oceanic and Atmospheric Administration has maintained the Anacostia River Watershed Database and Mapping Project, an open-access, yet highly technical, geospatial database of contamination sites and cleanup projects. U.S. DEPT. OF COMMERCE, NAT'L OCEANIC AND ATMOSPHERIC ADMIN., WATERSHED DATABASE AND MAPPING PROJECTS/ANACOSTIA RIVER (MARYLAND/DISTRICT OF COLUMBIA) (2007), *available at* http://archive.orr.noaa.gov/book_shelf/111_Anacostia_508.pdf.

258. Federal Water Pollution Control Act of 1977, 33 U.S.C.A. §§ 1296, 1319 (West 2012). CWA § 1296 applies to publicly-owned treatment works, while CWA § 1319 applies to nonpoint source projects.

259. *See* EPA, *Anacostia River Urban Watershed*, *supra* note 38.

260. MCCOOL, *supra* note 174, at 209–10.

an agreement by the District Water and Sewer Authority to make billions of dollars of improvements to its sewer system.[261] In 2004, the AWS and other environmental groups successfully sued the Washington Suburban Sanitation Commission for illegal sewage leaks from broken, dilapidated, and exposed sewer pipes and infrastructure in Maryland, winning $200 million in commitments to inspect, repair, and upgrade pipes in the Anacostia watershed (part of a $1 billion plan in four watersheds) and $1.1 million in a civil penalty to the State of Maryland.[262] More recently, a permit challenge brought by NRDC and community-based watershed groups led to a negotiated modification of the District of Columbia's MS4 permit.[263]

Another major development in the Anacostia has been the creation and implementation of a wide range of policies, plans, and projects to improve the ecological, hydrological, and social functions of the watershed, or at least prevent their continued deterioration. Several major plans could, in the aggregate, help to improve the social-ecological resilience of the watershed, if they are implemented.

The centerpiece plan is the Anacostia River Watershed Restoration Plan, developed by the Anacostia Watershed Restoration Partnership.[264] It calls for eight restoration strategies—stormwater retrofits, stream restoration, wetland creation and restoration, fish blockage removal, replanting and managing vegetation (forests, meadows, urban/suburban trees, control of invasive species), trash reduction, toxic remediation, and parkland acquisition—and 3,018 specific restoration projects.[265] Projected outcomes, if the plan is fully implemented over its ten-year time frame, include control of runoff from 10,600 acres of pavement and roofs, acquisition of 2,512 acres of parkland, and restoration of 72.5 miles of streams, 137.4 acres of wetlands, and 347 acres of trees and meadows.[266] The various subwatersheds in the Anacostia also have restoration plans, developed under the Anacostia Watershed Restoration Partnership framework.[267]

In addition, DDOE adopted a plan in 2008 for making the Anacostia River fishable, swimmable, boatable, visually presentable, and supportive of stable fish and wildlife populations by 2032.[268] Arising out of ongoing restoration efforts and multistakeholder collaborations,[269] the plan sets forth both regulatory and voluntary strategies, both inside the District's jurisdiction and in the Maryland portion of the watershed, that will address several pollutants: trash, oil and grease, E. coli, sediment, low dissolved oxygen, inadequate fish and wildlife habitat, and toxic metals

261. *Id.* at 210.

262. WENNERSTEN, *supra* note 98, at 247–48.

263. CHEN & HOBBS, *supra* note 251, at 17.

264. ARWRPR, *supra* note 59.

265. ANACOSTIA RIVER WATERSHED PARTNERSHIP, TURN IT AROUND: IMPLEMENTING THE ANACOSTIA WATERSHED RESTORATION PLAN: A PROGRESS REPORT (2011) [hereinafter ARWP, RESTORATION PLAN PROGRESS REPORT]; ANACOSTIA RIVER WATERSHED PARTNERSHIP, TURN IT AROUND: A VISION FOR RESTORING THE ANACOSTIA WATERSHED 6 (2010) [hereinafter ARWP, A VISION FOR RESTORING THE ANACOSTIA WATERSHED].

266. ARWP, RESTORATION PLAN PROGRESS REPORT, *supra* note 265.

267. *See generally* Northwest Branch Subwatershed Action Plan, *available at* http://www.anacostia.net/Restoration_Plan/download/ActionPlans/NWB_SWAP_FINAL.pdf (last visited Jan. 9, 2015).

268. DDOE, ANACOSTIA 2032, *supra* note 54, at 20–24.

269. *Id.* at 5, 9–10.

and organic chemicals.[270] Each strategy identifies its benefits, estimated costs, responsible agencies and partners, implementation timeline, and performance measures.[271] Progress has been made toward most of the goals, but no deadlines for goal achievement had been met by 2014.[272] Some goals were deemed practically unreachable due to financial constraints and the long ecological timescale needed for meaningful transformation.[273]

The Metropolitan Washington Council of Governments prepared an Anacostia Watershed Forest Management and Protection Strategy for the Anacostia Watershed Restoration Partnership in 2005 in order to protect the remaining forests and trees in the watershed and to engage in strategic reforestation for watershed restoration and conservation purposes.[274] The District of Columbia Department of the Environment prepared a Remedial Investigation Work Plan for the Anacostia River Sediments Project in 2014 in order to prepare for remediation of contaminated river sediments.[275] The Anacostia Waterfront Initiative is a plan to revitalize the river's waterfront in the Washington, D.C., area with river-focused commercial, recreational/entertainment, and mixed-income residential redevelopment, parks, better connectivity between neighborhoods, and improved ecological conditions for the River and riparian lands.[276]

Locally, several incentive programs exist to promote environmentally friendly retrofits. For instance, in Montgomery County, Maryland, eligible residential property owners can earn up to $2,500 in rebates for installing rain gardens, green roofs, permeable pavement, and other stormwater controls, while commercial and institutional properties can earn up to $10,000.[277] Washington, D.C. offers a similar opportunity through its RiverSmart program.[278] In 2009, the D.C. government also passed the Anacostia River Clean Up and Protection Act ("Bag Law"), which places a tax on disposable paper and plastic bags to encourage businesses to reduce their usage, while generating a fund for restoration projects.[279]

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270. *Id.* at 24–69.

271. *Id.*

272. *Id.* at 7.

273. *Id.*

274. *See generally* KATE LEVENDOSKY ET AL., THE METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS, DEPARTMENT OF ENVIRONMENTAL PROGRAMS, ANACOSTIA WATERSHED FOREST MANAGEMENT AND PROTECTION STRATEGY (2005), *available at* http://www.anacostia.net/restoration/Reports_and_Data/Final_FMPS.pdf.

275. *For a Cleaner Anacostia River – The Anacostia River Sediment Project,* DIST. DEP'T OF THE ENV'T (Nov. 12, 2014), http://ddoe.dc.gov/anacostiasediment [hereinafter *Remedial Investigation Work Plan*].

276. Brandes, *supra* note 164, at 53–58; Toni L. Griffin, *A Tale of Two Publics: Washington, D.C. and the Anacostia Waterfront, in* IN SEARCH OF THE PUBLIC: NOTES ON THE CONTEMPORARY AMERICAN CITY 54, 59–63 (Mario Gandelsonas et al. eds., 2012).

277. *What Are RainScapes?*, MONTGOMERY COUNTY, MD, ENVIRONMENTAL PROTECTION, http://www.montgomerycountymd.gov/dep/water/rainscapes.html (last visited Jan. 9, 2014).

278. DIST. DEP'T OF THE ENV'T, DISCOUNTS THROUGH STORMWATER MANAGEMENT: DDOE'S RIVERSMART REWARDS PROGRAM AND DC WATER'S CLEAN RIVERS IMPERVIOUS SURFACE AREA CHARGE INCENTIVE PROGRAM 4–12 (2013), *available at* http://green.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/RiverSmart%20Rewards%20Guidelines%20and%20Instructions_07262013.pdf [hereinafter RIVERSMART REWARDS PROGRAM]; *RiverSmart Communities*, DIST. DEP'T OF THE ENV'T, http://ddoe.dc.gov/service/riversmart-communities (last visited Jan. 9, 2015).

279. Anacostia River Clean Up and Protection Act of 2009, D.C. CODE § 8-102.01 (2014).

Pollution cleanup efforts are improving environmental conditions in the basin. In an early effort, the Anacostia Watershed Society used embarrassing media coverage and the threat of litigation to get the District of Columbia to stop and cleanup pollution from leaking underground storage tanks and oil and other chemical runoff at a D.C. Metro bus maintenance yard.[280] The National Park Service is remediating hazardous waste at three sites.[281] The Anacostia Watershed Toxics Alliance (ATWA), a partnership of more than twenty-five public and private organizations, has developed a three-phase plan for studying and remediating toxic pollution in the Anacostia River, particularly its sediment.[282] Even though sediment study and community involvement plans have been developed only recently,[283] ATWA moved forward with early projects, having removed over 7,500 gallons of coal tar, 20,000 gallons of petroleum, and 25 pounds of mercury from sites within the watershed by the end of 2012.[284]

Green infrastructure would appear now to be the preferred means of controlling and reducing stormwater runoff and pollution in many Anacostia watershed jurisdictions: Not only do public plans and landowner incentive systems now call for green roofs, rain gardens, bioswales and other bioretention landscaping, wetland restoration, forest restoration, riparian buffer zones, and similar techniques that allow absorption or infiltration of stormwater,[285] but many such projects have already been installed on both public and private lands.[286] For example, as of 2010, approximately one million square feet of green roof have been either installed or approved for installation in the District.[287] In some cases green infrastructure is a more hydrologically and ecologically effective and cost-efficient way of managing stormwater than concrete-and-pipe grey infrastructure. Indeed, green infrastructure is being advanced as an alternative to some costly improvements to sewer and stormwater systems. [288]

However, grey infrastructure repairs, upgrades, and new construction (such as new underground tunnels to store more water and inflatable dams to prevent stormwater and sewer water from mixing) are being undertaken.[289] This is because

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280. MCCOOL, *supra* note 174, at 208.

281. *Anacostia Park Environmental Cleanup Projects*, NAT'L PARK SERV., http://www.nps.gov/nace/parkmgmt/apecp.htm (last visited Jan. 9, 2014).

282. EPA, *Stakeholder Efforts Earn Anacostia an Urban River Pilot Project*, PARTNERS IN PROGRESS: EPA UPDATE ON FEDERAL FACILITY CLEANUP AND REUSE, Nov. 2003, at 1, 3, *available at* http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1008ORM.TXT.

283. *Remedial Investigation Work Plan*, *supra* note 275; *see also For a Cleaner Anacostia River – The Anacostia River Sediment Project, Community Involvement Plan*, DIST. DEP'T OF THE ENV'T (Oct. 29, 2014), *available at* http://ddoe.dc.gov/anacostiasediment.

284. *Solid Waste and Emergency Response: Anacostia Watershed*, U.S. ENVT'L PROT. AGENCY, http://www.epa.gov/oswer/onecleanupprogram/anacostia.htm, (last visited Jan. 9, 2015).

285. *See generally* ARWRPR, *supra* note 59. Maryland has started to study its green infrastructure and identify key gaps and opportunities to convert available lands to green infrastructure in strategically needed locations. *See* TED WEBER ET AL., RESTORATION TARGETING IN MARYLAND'S GREEN INFRASTRUCTURE (2004), *available at* http://www.dnr.state.md.us/irc/docs/00015712.pdf.

286. *See, e.g.*, D.C. Water & Sewer Authority, *supra* note 270, at 3 (listing green-infrastructure installed by DC Water even before entering into the Green Infrastructure Partnership Agreement).

287. NOAH GARRISON & KAREN HOBBS, ROOFTOPS TO RIVERS II: GREEN STRATEGIES FOR CONTROLLING STORMWATER AND COMBINED SEWER OVERFLOWS 4 (2011), *available at* http://www.nrdc.org/water/pollution/rooftopsii/files/rooftopstoriversII.pdf.

[288] *See* CHEN & HOBBS, *supra* note 251, at 17.

289. *Id.*; RIVERTOWN, *supra* note 164, at 52–54, 57; NRDC, *supra* note 102.

green infrastructure cannot be a total substitute for a well-functioning grey infrastructure system for such a developed, highly paved, urban watershed. Moreover, redundancy provides resilience-enhancing backups in case either type of system fails or is overwhelmed by an unprecedented storm event.

Policies and plans also call for low-impact development (LID) or environmental site design (ESD). The term "green infrastructure" is often used interchangeably with LID/ESD, and LID/ESD includes green infrastructure techniques.[290] However, LID/ESD is focused on the design and construction of a development site, not the creation of biotic public infrastructure in the urban landscape, and includes non-biological methods of preventing or reducing stormwater runoff, such as decreased amounts of impervious cover, use of pervious pavement or materials, clustering buildings in a development project, installation of rain barrels, landscape watering systems that use recycled on-site water, controlled and targeted irrigation systems, and the like. The U.S. Navy, for example, adopted a Low Impact Development Policy in 2007, which applies to certain new construction and restoration projects, and has resulted in bioretention planter boxes, bioretention parking lot retrofits, permeable paver areas, and monitoring of these LID techniques for impact on runoff.[291]

Land conservation has received special attention in the Anacostia in the past few decades. Acquisition or dedication of lands for public parks became an important element of urban planning in Washington, D.C. and its Maryland suburbs in the early 20th century, and the creation or dedication of parks skyrocketed in the mid-20th century.[292] However, land and open space conservation as a major tool to improve the ecological resilience of the watershed is a relatively recent phenomenon: From 1996 to 2006, state and local governments in the Maryland portions of the Anacostia River basin acquired over 372 acres of new parkland with acquisition sites being targeted for the environmental benefits, such as protecting brown trout spawning and nursery waters.[293] As of 2003, conservation easements were held on 17,581 acres of private land in Montgomery County alone, and several conservation easement programs incentivized the protection of sensitive watershed lands, such as the Rural Legacy Program, the Legacy Open Space Program, forest conservation easements, and easements for riparian lands adjacent to development sites.[294] Moreover, Montgomery County has amended its zoning laws to protect certain watershed-sensitive lands from development, alteration, or pollution-generating land uses, including in the Upper Paint Branch Special Protection Area, the Environmental Overlay Zone, and forested lands.[295]

The greening of the Anacostia River Watershed can be seen in the public awareness of, engagement with, and commitment to the River, streams, and watershed features. For example, the National Park Service organizes the Anacostia Wa-

290. For descriptions of LID and ESD, see COMMENTS ON DRAFT, *supra* note 250, at 10–11; NRDC, *supra* note 102.

291 CHEN & HOBBS, *supra* note 251, at 3.

292. MWCOG, *supra* note 162162, at 12.

293. Craig Anthony (Tony) Arnold, *For the Sake of Water: Land Conservation and Watershed Protection*, 14 SUSTAIN 16, 23–24 (2006) [hereinafter Arnold, *For the Sake of Water*].

294. *Id.* at 25.

295. *Id.* at 22–23.

tershed Ambassador Youth Program, which involves local children in watershed education, remediation, and leadership opportunities.[296] The Anacostia Watershed Society is a major non-governmental organizer of programs to engage children, youth, and adults in watershed conservation, as described by one scholar:

> Public outreach has often been identified as the most critical task for public and private entities cooperating to protect the Anacostia River watershed. The various planning, regulatory, land management, restoration, and private conservation efforts to-date will not be enough to sustain the watershed without public awareness of the watershed, commitment to its vitality, and cooperation in preventing its degradation. Some efforts have had a narrow focus, such as an Environmental Education Compliance of Auto Repair Shops Program, which provided education and follow-up to reduce the amount of oil and grease in the Hickey Run from automotive repair shops.
>
> A somewhat broader, yet focused, project was the Small Habitat Improvement Program (SHIP), which was a pilot project started in 1990 to involve local residents in small-scale watershed restoration efforts. A project of numerous local government agencies, federal and state agencies, environmental groups, community groups, and schools, SHIP involved school children and local residents in a low-income, environmentally degraded subwatershed, Watts Branch, in cleaning up streams and neighborhood streets, planting approximately 1,500 native trees, establishing nearly two linear miles of riparian buffer, stenciling over 1,000 storm drains with the words "Don't Dump – Anacostia River Drainage," and educating both school children and area residents about the watershed and the importance of trees to watershed health. The focus of SHIP's projects was volunteer participation in the restoration efforts, engaging watershed residents in solving their own environmental problems and in developing experiential connections to the watershed.
>
> However, SHIP was only one of many efforts to increase people's understanding of, and commitment to protecting, the Anacostia River and its watershed. The Anacostia Watershed Society, a local non-profit, reports that over 30,000 volunteers, many of them urban children and youth, have participated in [a diverse range of activities, such as outdoor education programs, canoeing and kayaking on the river and its streams, tree planting, wetland restoration, environmental stewardship education, tree planting, wetland restoration, fish propagation, and trash cleanup] . . . .
>
> These many activities are not merely educational; they engage the local residents in experiencing, understanding, and developing relationships with the watershed in which they live, work, study, and play. Anthropological research among the local residents of the Anacostia River watershed shows that some residents have negative attitudes towards the river because of past negative experiences with the river and the surrounding

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296. *Anacostia Watershed Ambassador Youth Program*, NAT'L PARK SERVICE, http://www.nps.gov/nace/anacostia-watershed-ambassador-youth-program.htm (last updated Nov. 14, 2014).

> social and physical environments of their neighborhoods. Residents with positive attitudes towards the river have had positive experiences with it. The above-described public outreach efforts are giving residents more positive experiences with, and a greater stake in, the river.[297]

Finally, the social forces that stratified Anacostia communities by race and socioeconomic class, including the legacy of slavery, have cast a long shadow over the region.[298] In Washington D.C., African Americans outnumber Caucasians; however, they live disproportionately in the Anacostia River's former industrial block (e.g., near the Washington Navy Yard and the Potomac Power and Electric Company facilities), whereas the Caucasians, historically possessing greater material and political resources, live near the Potomac, which is often called "The Nation's River" in contrast to the Anacostia's moniker "The Forgotten River."[299] Critically, the Potomac's environmental ills have received greater attention than the Anacostia's, despite their close proximity and comparable social and ecological significance.[300]

Moreover, several sources warn that restoration projects in Washington D.C. may actually be a continuation of earlier economic and environmental injustices thinly veiled behind the rhetoric of environmental sustainability. For example, citing critical sociopolitical analyses of the urban sustainability movement in the Anacostia and beyond,[301] Haynes argues that African American stakeholders continue to be marginalized and exploited under the guise of the Anacostia Riverfront Initiative.[302] For instance, instead of using the Initiative to directly confront systemic public health, housing, education, and employment problems, the D.C. Government earmarked historically impoverished African American areas for redevelopment as riverfront parks and commercial spaces (e.g., Yards Park, Nationals Park), which seem to primarily cater to tourists and affluent Caucasian stakeholders.[303]

Nevertheless, many residents want to see the area revitalized,[304] and though the overall sentiment towards the Anacostia's current condition is negative, some report a renewed sense of vitality from recent developments.[305] Moreover, several initiatives sponsored by federal and local government seek to involve area residents in watershed management, education, and restoration, indicating that social implications of urban renewal projects and broader restoration activities are nuanced and

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297. Arnold, *For the Sake of Water*, *supra* note 293, at 26–27.

298. *See generally* Kronthal, *supra* note 77; Williams, *supra* note 97; *see also* Brett Williams, *A River Runs Through Us*, 103 AM. ANTHROPOLOGIST 409, 412–14 (2001) [hereinafter Williams, *A River Runs Through Us*].

299. Haynes, *supra* note 77, at 7–8.

300. EPA, Anacostia Rebirth, *supra* note 78.

301. *See* Williams, *supra* note 97; Williams, *A River Runs Through Us*, *supra* note 298; Melissa Checker, *Wiped Out by the "Greenwave": Environmental Gentrification and the Paradoxical Politics of Urban Sustainability*, 23 CITY & SOC'Y 210 (2011).

302. *See generally* Haynes, *supra* note 77.

303. *Id.*

304. Kronthal, *supra* note 77.

305. *See* NAT'L WILDLIFE FED'N LAKE RESEARCH PARTNERS, RESTORING THE ANACOSTIA RIVER: DETERMINING THE BEST PATH FORWARD AND BUILDING PUBLIC WILL FOR ACTION 8 (2012), *available at* http://www.summitfdn.org/wp-content/uploads/downloads/2012/10/Anacostia-Report-Best-Path-Forward.pdf.

potentially not straightforward.[306] Finally, there is the question of timescale. The majority of potentially beneficial activities in the Anacostia were undertaken relatively recently (i.e., beginning in the 1980s), yet entrenched social and natural systems may take several decades to transform.[307] Interlinked institutional-social-ecological systems typically must evolve over multiple iterations before new policies become fully effective in addressing the systems' complex problems.[308]

III. ASSESSING RESILIENCE

A. Climate Change

A future likely driver of change in the Anacostia River watershed is *climate change*. Over two millennia ago, non-anthropogenic climate change transformed the Anacostia basin from a cold boreal forest system to a warmer system of hardwoods, anadromous and estuarine fish, and shellfish.[309] Assessing the near- and medium-term resilience of the Anacostia River basin now requires attention to human-influenced climate change.[310] Most analyses focus on coastal areas of the Mid-Atlantic or on the Chesapeake Bay.[311] Climate change is projected to have profound impacts on coastal regions of Maryland with sea level rise of 2.7 to 3.4 feet

306. *Id.*

307. Marten Scheffer et al., *Slow Response of Societies to New Problems: Causes and Costs*, 6 ECOSYSTEMS 493, 494–97 (2003); Lance H. Gunderson et al., *The Evolution of an Idea—The Past, Present, and Future of Ecological Resilience*, *in* FOUNDATIONS OF ECOLOGICAL RESILIENCE, *supra* note 28, at 423–44.

308. *See* Carl Folke et al., *Adaptive Governance of Social–Ecological Systems*, 30 ANN. REV. OF ENV'T & RES. 441, 442–45 (2005); Sara T. Borgström et al., *Scale Mismatches in Management of Urban Landscapes*, 11 ECOLOGY & SOC'Y, no. 2, art. 16 (2006), *available at* http://www.ecologyandsociety.org/vol11/iss2/art16/; Arnold, *supra* note 84, at 271–302.

309. WENNERSTEN, *supra* note 98, at 5–6.

310. On the importance of assessing watershed resilience for climate change, *see* Nemec et al., *supra* note 6. For calls to assess climate change impacts on aquatic ecosystems and water resources and to develop resilience-focused plans in the region of the Anacostia, *see* MD. COMM'N ON CLIMATE CHANGE ADAPTATION & RESPONSE & SCIENTIFIC & TECHNICAL WORKING GROUPS, COMPREHENSIVE STRATEGY FOR REDUCING MARYLAND'S VULNERABILITY TO CLIMATE CHANGE: PHASE II: BUILDING SOCIETY, ECONOMIC, AND ECOLOGICAL RESILIENCE 45–53 (2011), *available at* http://www.dnr.state.md.us/climatechange/climatechange_phase2_adaptation_strategy.pdf [hereinafter MARYLAND COMMISSION BUILDING RESILIENCE REPORT].

311. *See, e.g.*, Raymond G. Najjar et al., *The Potential Impacts of Climate Change on the Mid-Atlantic Coastal Region*, 14 CLIMATE RES. 219 (2000); *How Will Climate Change Affect the Mid-Atlantic Region?*, U.S. EVNT'L PROTECTION AGENCY (June 2001), http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=4011; CHESAPEAKE BAY PROGRAM SCIENCE & TECH. ADVISORY COMM., CLIMATE CHANGE AND THE CHESAPEAKE BAY: STATE-OF-THE-SCIENCE REVIEW AND RECOMMENDATIONS (2008), *available at* http://www.chesapeake.org/stac/Pubs/climchangereport.pdf; MARYLAND COMM'N ON CLIMATE CHANGE ADAPTATION & RESPONSE WORKING GRP., COMPREHENSIVE STRATEGY FOR REDUCING MARYLAND'S VULNERABILITY TO CLIMATE CHANGE: PHASE I: SEA LEVEL RISE AND COASTAL STORMS (2008), *available at* http://dnr.maryland.gov/coastsmart/pdfs/comprehensive_strategy.pdf [hereinafter MARYLAND COMMISSION SEA LEVEL RISE REPORT]; U.S. DEP'T OF AGRIC., CLIMATE CHANGE, AGRICULTURE, AND WATER RESOURCES IN THE MID-ATLANTIC: PROCEEDINGS FROM A REGIONAL SCIENCE WORKSHOP (2010); *The Impact of Climate Change on the Mid-Atlantic Region*, U.S. ENVT'L PROTECTION AGENCY, http://www.epa.gov/reg3artd/globclimate/ccimpact.html (last updated Sep. 3, 2014). For a more balanced assessment of climate change impacts on a range of Mid-Atlantic ecosystems, *see* Catriona E. Rogers & John P. McCarty, *Climate Change and the Ecosystems of the Mid-Atlantic Region*, 14 CLIMATE RESEARCH 235 (2000).

by the end of this century, and on the Chesapeake Bay, which is ranked as the third most climate vulnerable region in the United States, behind Louisiana and southern Florida.[312] Shore erosion, coastal flooding and inundation, salt water intrusion, and more frequent coastal storms are common projections for coastal Maryland.[313]

Unfortunately, too little is known about what kind of effects climate change will have in the Anacostia River basin. As a noncoastal watershed that is upstream of the Bay itself, the Anacostia is once again a "forgotten river." However, the increased incidence and magnitude of extreme storm events could produce more episodic flashy flooding and runoff.[314] If so, these events would likely increase erosion and runoff of sediment that will make the River shallower and clog it, create more CSOs, wash concentrations of pollutants into the streams and River, and scour stream/river beds and banks.[315] A few studies model the interactive impacts of both climate change and urbanization in the Anacostia River basin, predicting larger and more frequent storm flows (peak flows) and decreased durations of low flow conditions.[316] The studies predict that these conditions will increase sediment concentrations and movement in surface waters, erosion of streambeds, and more variation in fraction of exposed bedrock in the active layer of the streambed.[317]

Overall, greater variability in precipitation is predicted with episodes of drought likely at times during summer months.[318] With population increase, consumer demand, and periodic summer droughts, overall demand for water is likely to increase 30 to 40 percent, but public water systems in the Washington, D.C. area have more flexibility and capacity to adapt to new demands and temporary shortages than rural areas do.[319] Moreover, higher temperatures will increase river and stream evaporation during low-flow periods creating stresses on fish and other aquatic species.[320] The upper, especially northwestern, reaches of the watershed are more vulnerable to decreased recharge of groundwater aquifers than are the lower southeastern reaches, due to differences in geology and storage capacity.[321]

In addition, rising sea levels from climate change could push the tidal intrusion further into upper reaches of the Anacostia system and alter water flow patterns in the main river channel.[322] Increased heat in urban and suburban areas–

312. MARYLAND COMMISSION SEA LEVEL RISE REPORT, *supra* note 311, at 4.

313. *Id.* at 4–5.

314. MARYLAND COMMISSION BUILDING RESILIENCE REPORT, *supra* note 310, at 46, 48.

315. *Id.* at 38.

316. Mohammad I. Hejazi & Glenn E. Moglen, *Regression-Based Approach to Low Flow Prediction in the Maryland Piedmont Region Under Joint Climate and Land Use Change*, 21 HYDROLOGICAL PROCESSES 1793 (2007); Jim Pizzuto et al., *Two Model Scenarios Illustrating the Effects of Land Use and Climate Change on Gravel Riverbeds of Suburban Maryland, U.S.A.*, 11 DEV. EARTH SURFACE PROCESSES 359 (2007); Mohammad I. Hejazi & Glenn E. Moglen, *The Effect of Climate and Land Use Change on Flow Duration in the Maryland Piedmont Region*, 22 HYDROLOGICAL PROCESSES 4710 (2008). A study of sixty watersheds, including the Anacostia's Northeast Branch, shows that urbanization increases streamflow beyond the effects of climate change on streamflow. David R. DeWalle et al., *Potential Effects of Climate Change and Urbanization on Mean Annual Streamflow in the United States*, 36 WATER RES. RES. 2655 (2000).

317. Pizzuto et al., *supra* note 316.

318. MARYLAND COMMISSION BUILDING RESILIENCE REPORT, *supra* note 310, at 46–48.

319. *Id.* at 46–47.

320. *Id.*

321. *Id.* at 45–46.

322. *Id.* at 36–37.

perhaps exacerbated by heat island effect–could affect human health, commitment to conservation of the waterway for recreational and aesthetic enjoyment, and the vitality of trees, plants, grasses, and the like that are important to the health and functioning of the watershed.[323] Changing climate conditions could affect wetland health and function, alter forest composition as maples, beeches, and birches are replaced by oaks, hickories, and pines, and facilitate the spread of warm-weather invasive species.[324] Existing degraded and stressed conditions of the Anacostia's aquatic systems and biotic communities have weakened their resilience to climate change.[325] Stormwater drainage systems may be inadequately designed for higher quantities, velocities, or frequencies of stormwater runoff flows from climate change.[326] Green infrastructure strategies could fail if heat, disease, pests, changes in precipitation patterns, or other effects of climate change cause vegetation to die, dry up wetlands, or create more runoff than swales, rain gardens, and other biodetention/bioretention features can handle on a regular basis.[327]

Unfortunately, there are too few systematic analyses of climate change's likely effects on the Anacostia River basin, thus leaving the watershed and its governance vulnerable to unexpected, substantial, and perhaps even rapid changes. As a result, climate change and the element of surprise are likely to combine with one another to create difficult-to-prevent or difficult-to-adapt-to transformations in the ecological, social, and institutional conditions of the watershed.

B. Three Alternative Futures of the Anacostia River Watershed

As a highly manipulated and degraded watershed, the Anacostia will require large efforts to cross ecological thresholds back into highly functional and diverse ecosystems. Major initiatives are underway and provide a variety of alternative regimes to examine. The Anacostia River Watershed Restoration Plan identifies eleven major ecological problems[328] and eight restoration strategies[329] that have

323. *Id.* at 5–10, 26–28, 36–38. On the health effects of urban heat island effect and climate change, see Jonathan A. Patz et al., *Impact of Regional Climate Change on Human Health*, 438 NATURE 310 *passim* (2005), *available at* http://www.nature.com/nature/journal/v438/n7066/pdf/nature04188.pdf.

324. *How Will Climate Change Affect the Mid-Atlantic Region?*, *supra* note 311, at 2; Rogers & McCarty, *supra* note 311, at 237, 239–41.

325. *See generally* Rogers & McCarty, *supra* note 311; *see also* MARYLAND COMMISSION BUILDING RESILIENCE REPORT, *supra* note 310, at 36–39. For example, climate change will likely necessitate the migration of fish, other species, and even entire systems like wetlands, at which point the effects of existing stream channel alterations, migration barriers, and land development patterns will be felt more keenly. *Id.* at 38.

326. Dae-Hyun Koo, *Sustainability Applications for Storm Drainage Systems Minimizing Adverse Impacts of Global Climate Change*, 2012 ICPTT 36, 37 (2012), *available at* http://ascelibrary.org/doi/pdf/10.1061/9780784412619.005; MARYLAND COMMISSION BUILDING RESILIENCE REPORT, *supra* note 310, at 48.

327. For example, New York City's post-Sandy resilience plan expressly addresses the vulnerabilities and resilience of various types of green infrastructure to climate change throughout the plan, and found that most green infrastructure performed quite well overall under the conditions of Hurricane Sandy. *See generally* CITY OF NEW YORK, PLANYC: A STRONGER, MORE RESILIENT NEW YORK (2013), *available at* http://s-media.nyc.gov/agencies/sirr/SIRR_singles_Lo_res.pdf.

328. Reduction of tidal wetlands; reduction of non-tidal wetlands; reduction of riparian and upland resources; trash; sediment and nutrients; toxics; combined and sanitary sewer overflows; stream channel degradation; invasive and nonnative species; flooding; and blockage of fish passage. *Id.*

329. Stormwater management; stream restoration; wetland restoration; fish passage blockage removal; riparian restoration; litter reduction; toxic remediation; parkland acquisition. *Id.*

been given special attention for cross-scale interactions to address multiple ecological stressors with multi-pronged restoration efforts. For example, stormwater management has the potential to address sediment, nutrient, and stream degradation stressors.

Restoration planning efforts have identified three stormwater related restoration scenarios—minimal, moderate, and aggressive—and projected these scenarios out ten years to assess potential reductions in pollutant loads by treating (i.e., controlling) impervious area. The most aggressive restoration scenario has been projected out into the long-term (2030, 2040, and 2050). Each scenario (i.e., "plausible trajectory"[330]) is addressed below for its potential contribution to the resilience of the Anacostia watershed.

Under the minimal restoration scenario, no additional restoration occurs other than what currently exists, with minimal involvement of the private sector. The ten year projection of this minimal scenario approximates control of 1 to 2 percent impervious area of the watershed, mostly through treating transportation related impervious area (e.g., street sweeping, green streets), with reduced nutrient and sediment loads by 1 percent.[331] In our view, the minimal restoration scenario will continue the trajectory of adverse impacts of land development, urbanization, impervious cover, and other alterations of watershed features and will lead to the *collapse of the watershed's hydrology*.

The moderate implementation scenario projects increased stormwater controls but is limited to only 5 to 10 percent of impervious surfaces that are, like the minimal scenario, restricted mostly to the transportation sector. The ten year projections estimate an additional 23 percent[332] of the watershed's impervious area controlled over the minimal scenario and reductions of nutrients and sediments of 8 to 11 percent.[333] In our view, given potential climate change impacts, demographic and land-use changes, and other uncontrolled disturbances to the watershed, this scenario merely maintains the status quo in overall effect: *continued deteriorated and vulnerable conditions*.

The aggressive restoration scenario includes participation from the private sector, both commercial[334] and residential.[335] For federal, state, and commercial properties, new construction and redevelopment activities must comply with current, more restrictive stormwater regulations, so significant redevelopment projects have the potential to improve the overall water quality of the Anacostia river basin by installing green retrofits for onsite stormwater management.[336] For example, the average age of shopping malls in the area is thirty-two years old, making them

330. RESILIENCE I, *supra* note 14, at 19.
331. ARWRPR, *supra* note 59, at 102 (figure 5-14).
332. *Id.* at 81.
333. *Id.* at 102.
334. Includes commercial, industrial, and multi-family residential properties.
335. Includes single family residences only.
336. MD. DEPT. ENV'T, MARYLAND STORMWATER MANAGEMENT GUIDELINES FOR STATE AND FEDERAL PROJECTS 7–23 (2010), *available at* http://www.mde.state.md.us/assets/document/State%20and%20Federal%20SWM%20Guidelines%20final.pdf. *See generally* LOIEDERMAN SOLTESZ ASSOC.S, INC., STORMWATER MANAGEMENT MANUAL AND REGULATIONS IN THE STATE OF MARYLAND (2010), *available at* http://www.solteszco.com/sites/default/files/article-pdf/Stormwater%20Management%20Whitepaper.pdf.

prime targets for major renovations as the economy recovers from the great recession.[337] In our view, this aggressive restoration scenario has potential for significant enhancement of the ecological health and functions of the watershed, even if it is not a "return" to a prior state, as well as transformation in the ongoing ways that the watershed is governed and managed. In other words, the aggressive restoration scenario would advance the social-ecological-institutional trajectory of the watershed towards a *greening of the watershed and its institutions*.

The likely outcome of these three possible trajectories is difficult to predict and will depend on both institutional change and institutional adaptive capacity. Currently all methods of engaging single family residential properties are voluntary and are typically encouraged through economic incentives for "citizen stormwater management."[338] Through rebates and stormwater fee credit programs, like D.C.'s Riversmart Homes program, municipal governments provide financial incentives, resources, and outreach materials for homeowners to install green infrastructure retrofits.[339] Not only will this approach move the ecological system nearer a restored regime, but it will also improve the social dynamics of the system by connecting residents to their environment and making environmental protection part of their everyday lives.[340]

The aggressive scenario projected out ten years estimates control of an additional 27 percent of the watershed's impervious area[341] and nutrient and sediment load reductions of approximately 25 to 34 percent.[342] Restoration planners projected this scenario out to 2050 and found the potential to control 112 percent of the watershed's impervious area (some acreage would be double treated, such as a street that has been greened which would also be treated by improved street sweeping)[343] and reduce nutrient and sediment loads by 48 to 58 percent.[344]

Adaptive urban design has the potential for mitigating climate change impacts in megapolitan regions as well.[345] Models by Georgescu et al. indicate that green roofs, in combination with cool roofs (i.e., highly reflective roofs), may "entirely offset[] urban-induced warming."[346] In the Mid-Atlantic region, green roofs alone may induce cooling of about 1.19 degrees Celsius.[347] Metropolitan D.C. has been

337. ARWRPR, *supra* note 59, at 41. For an assessment of the market demand for redevelopment for retail and commercial properties, see GREEN DOOR ADVISORS, INC., ANACOSTIA COMMERCIAL MARKET ANALYSIS 3–13 (2011), *available at* http://www.peopleplandc.org/wp-content/uploads/2011/10/Final-Anacostia-Commercial-Market-Analysis1.pdf.

338. OLIVIA ODOM GREEN ET AL., UPSCALING NATURAL AND SOCIAL CAPITALS FOR DECENTRALIZED URBAN STORMWATER MANAGEMENT 3 (2013), *available at* http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1208&context=usepapapers.

339. *See generally* RIVERSMART REWARDS PROGRAM *supra*, note 278.

340. Olivia Odom Green et al., *Identification and Induction of Human, Social, and Cultural Capitals Through an Experimental Approach to Stormwater Management*, 4 SUSTAINABILITY 1669 (2012), *available at* http://www.mdpi.com/2071-1050/4/8/1669/htm.

341. ARWRPR, *supra* note 59, at 81.

342. *Id.* at 102.

343. *Id.* at 81.

344. *Id.* at 102.

345. Matei Georgescu et al., *Urban Adaptation Can Roll Back Warming of Emerging Megapolitan Regions*, 111 PROCEEDINGS NAT'L ACAD. SCI. 2909 *passim* (2014).

346. *Id.* at 2911.

347. *Id.* at 2913 tbl. 2.

aggressively promoting green roofs on commercial buildings since 2003.[348] The District provides subsidies for privately financed green roofs and grants for non-profit and community groups.[349]

Restoration and retrofit scenarios have the potential to reduce and perhaps reverse the impact of negative ecological drivers such as urbanization and anthropocentric climate change. However, alternative yet plausible scenarios could play out in which the current trend toward green infrastructure and adaptive urban design is simply a fad or political winds shift away from restoration and toward increased urban development without concern for the environment. In such a scenario, the social and ecological drivers that have pushed the Anacostia to the brink of ecological collapse would again track toward that threshold.

Likewise, as the regional and national economies—as well as real estate lending and investment—improve following the recession and financial and foreclosure crises that began in late 2007, it is plausible to project renewed interest in urban development and suburban sprawl into the Anacostia headwaters. A major land-development boom would diminish the net effects of the current restoration and green-infrastructure efforts at improving the hydrological and ecological processes of the watershed.

Changes in federal law, such as the application of Phase II Stormwater Rules, are not likely to be reversed, thus engraining some level of onsite stormwater control for new development or significant redevelopment. However, political, legal, economic, and social-cultural forces can alter existing regulatory and legal regimes in unexpected ways, as evidenced by the periodic attacks on the Endangered Species Act[350] or the current uncertainties about the scope of federal jurisdiction over waters and wetlands in the shadow of the *Rapanos* case.[351] Political pushback against federal stormwater regulations, particularly under conditions of urban fiscal stress or adverse economic impacts, could result in congressional weakening of the laws or pervasive agency under-enforcement. Judicial hostility to the regulatory scheme could weaken key aspects of it. In the absence of these kinds of changes, though, the current regulatory system will keep pressure on federal, state, and local agencies and watershed governance stakeholders to develop and implement green-infrastructure techniques in the watershed.

IV. ASSESSING THE ADAPTIVE CAPACITY OF THE ANACOSTIA RIVER

348. *See* CHESAPEAKE BAY FOUND., GREEN ROOF DEMONSTRATION PROJECT FINAL REPORT: OCTOBER 2003-SEPTEMBER 2008 1–2 (2008), *available at* http://green.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/Green%20Roofs%20Report%2003-08.pdf; *see also*, U.S. DEP'T OF ENERGY, GREEN ROOFS 12, 21 (2004), *available at* https://www1.eere.energy.gov/femp/pdfs/fta_green_roofs.pdf; *see also* GARRISON & HOBBS, *supra* note 287, at Washington, D.C. 1–Washington, D.C. 6.

349. The subsidies are currently $5 to $10 per square foot, up to a cap of $2,500. *Green Roofs in the District of Columbia*, DIST. DEPT. ENV'T, http://green.dc.gov/greenroofs (last visited Jan. 9, 2015); *see also* PRINCE GEORGE'S CNTY. DEPT. ENVTL. RESOURCES GUIDELINES FOR GREEN ROOFS 2 (2014), *available at* http://www.princegeorgescountymd.gov/sites/StormwaterManagement/Resources/BMP/Documents/2_Guidelines%20for%20Green%20Roofs.pdf.

350. Arnold & Gunderson, *supra* note 3, at 10429–31.

351. *Id.* at 10439–49.

WATERSHED

A. Institutional-Social-Ecological Dynamics and Adaptive Capacity

The social-ecological resilience of the watershed will depend on the adaptive capacity of its governance institutions. The ISED framework points our analysis towards a consideration of how institutions, society, and ecosystems have changed over time in relationship to one another and whether they have the capacity to co-evolve towards more adaptive, resilient systems.

1. Institutional Change

Change within institutions is an important component of systemic adaptation to disturbance and changes. Watershed governance, as it becomes institutionalized, tends to change incrementally with respect to the goals pursued, the problems addressed, methods and strategies used, stakeholders involved, and processes followed in the governance system.[352] It is possible that cycles of rigidity, collapse, and reorganization in systems might appear in watershed institutions over a longer period of time than most current watershed governance institutions have existed,[353] or might be more likely in large-scale watershed systems like the California Bay-Delta system[354] than in smaller scale systems like the Anacostia River Basin.

The institutionalization of watershed governance in the Anacostia is too new to evaluate evidence of its flexibility, adaptive capacity, and evolutionary trajectory. However, certain features of adaptive watershed governance systems that contribute to their plasticity and incremental changes over time are present in the Anacostia watershed governance system. Watershed governance in the Anacostia has a polycentric structure with loosely, but not tightly, linked networks of diverse and engaged stakeholders and government agencies.[355] Multiple modes or methods of watershed governance are being used in moderately integrated ways to achieve multiple goals for the long-term ecological and social functioning of the watershed.[356] Governance processes are participatory, engaging multiple stakeholders and many area residents. Moreover, cooperation among stakeholders is relatively high, yet conflict, litigation, and formal legislative and regulatory processes are

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352. *Framing Watersheds*, *supra* note 84; *Adaptive Water Law*, *supra* note 4.

353. For analyses of the rigidity of water institutions generally, see Denise Lach et al., *Maintaining the Status Quo: How Institutional Norms and Practices Create Conservative Water Organizations*, 83 TEX. L. REV. 2027 (2005); *see also* Sandi Zellmer & Lance Gunderson, *Why Resilience May Not Always Be a Good Thing: Lessons in Ecosystem Restoration from Glen Canyon and the Everglades*, 87 NEB. L. REV. 893 (2009).

354. The collapse of the CALFED governance system of the California Bay-Delta system, replaced by the Bay Delta Conservation Plan and the Delta Stewardship Council, is an example of large-system rigidity, collapse, and reorganization. *See generally* David E. Booher & Judith E. Innes, *Governance for Resilience: CALFED as a Complex Adaptive Network for Resource Management*, 15 ECOLOGY & SOC'Y, no. 3, art. 35 (2010), *available at* http://www.ecologyandsociety.org/vol15/iss3/art35/; Holly Doremus, *CALFED and the Quest for Optimal Institutional Fragmentation*, 12 ENV'T SCIENCE & POL'Y 729 (2009), *available at* http://www.sciencedirect.com/science/article/pii/S1462901109000793. *See generally* JAY R. LUND ET AL., COMPARING FUTURES FOR THE SACRAMENTO-SAN JOAQUIN DELTA (2010), *available at* http://www.ppic.org/content/pubs/report/R_708EHR.pdf.

355. *See, e.g.*, WALKER & SALT, *supra* note 1; Garmestani et al., *supra* note 29.

356. Arnold & Gunderson, *supra* note 3; *Fourth Generation Environmental Law*, *supra* note 3.

used to hold both government agencies and resource users accountable to watershed-conservation standards or to break down entrenchment of interests that resist collective problem-solving.[357] Litigation and political activism lead to collaboration, not merely escalation of the conflict.[358] Some formal monitoring mechanisms and feedback loops have been built into plans and projects and other informal feedback loops have emerged; there is capacity for both expert and public learning from implementation of governance decisions and actions.[359] The basic foundations of an evolving adaptive governance system appear to exist in the Anacostia River watershed.

Changes within federal environmental regulatory institutions have already played important roles in the current transition to a focus on watershed restoration and green infrastructure. Changes in one institution can contribute to changes in other institutions. For example, the Clean Water Act went from being an institutionalized point-source pollution control system aimed at industry and wastewater treatment plants to having a much more diverse array of objectives, including control of nonpoint source pollution and runoff through stormwater system permitting, TMDLs, funding for watershed planning under Section 319 of the CWA, and promotion of green infrastructure as an alternative to engineered controls.[360] Both top-down command-and-control regulation and rule-enforcing litigation have forced government agencies and polluters to address watershed problems, such as runoff, CSOs, and toxic pollutants. However, as these legal tools have been put to use in the watershed, they have not been cure-all solutions. Instead, they have stimulated innovation, cooperation, and problem-solving among many stakeholders at several different scales. Watershed institutions have arisen out of the dynamic and interwoven successes and failures of more formal legal and regulatory regimes. Elements of federal administrative agencies and federal environmental law are inflexible and maladaptive,[361] but not monolithically so. Changes within and between the institutions of federal governance of waters and waterways have played and will continue to play important roles in efforts to improve the social-ecological resilience of the Anacostia River watershed.

Institutional emergence and evolution has occurred in the context of ecological and social change. Ecosystem and social system changes can create strong feedbacks to institutions. For example, from the late eighteen century to the early twentieth century, changes to flow regimes, sediment loading, and streambed levels in the Anacostia River interacted with changes in the area's economy, social structure, and technology (e.g., the advent of railroads and industries) to weaken the

357. *See generally* SWIMMING UPSTREAM: COLLABORATIVE APPROACHES TO WATERSHED MANAGEMENT (Paul A. Sabatier et al. eds., 2005). *See also* Dave Huitema et al., *supra* note 6.

358. *See* Bradley C. Karkkainen, *Getting to "Let's Talk": Legal and Natural Destabilizations and the Future of Regional Collaboration*, 8 NEV. L. J. 811, 811 (2008); *see also Working Out an Environmental Ethic*, *supra* note 83, at 33–39, 44–48.

359. *See generally* ADAPTIVE GOVERNANCE AND WATER CONFLICT: NEW INSTITUTIONS FOR COLLABORATIVE PLANNING (John T. Scholz & Bruce Stiftel eds., 2005).

360. Innovative Stormwater Infrastructure Act, S. 1677, 112th Cong. (2013); H.R. 3449, 111th Cong. (2013); EPA's Expanded Interpretation of its Permit Veto Authority under the Clean Water Act before the House Comm. on the Transportation and Infrastructure, Subcomm. on Water Resources and Environment, 113th Cong. (2014).

361. Arnold & Gunderson, *supra* note 3, at 10434–38.

institutions of commercial navigation in the Anacostia. More recently, the watershed's poorly functioning hydrology and poor water quality, when combined with a rise in environmentalist attitudes and political activism in society, have contributed strongly to the rise and development of new watershed institutions to address these problems.

Furthermore, not all institutions change; institutional resilience can undermine larger institutional-social-ecological resilience. In particular, the resistance of some institutions to change is a barrier to watershed resilience in the Anacostia basin. The institution of private property rights is one example. Admittedly, on a micro-level, property rules in the United States have changed (e.g., increased protection of tenants in landlord-tenant law, changes in water law doctrines).[362] From a macro-level of effects on the functioning of the Anacostia River watershed, though, private property rights, takings doctrine protections of landowners, and land-development institutions remain strong and resistant to watershed-protecting changes.[363] Even where the law of private property rights has changed with changing conditions, the culture of private property rights affects regulators' decisions and the social and political climate in which land use policies are decided.[364] As land use regulatory institutions have changed from the highly rigid Euclidean zoning system to a more mixed and flexible system with negotiated development approvals, conditional permits, mixed-use projects, and smart-growth policies, social norms and institutional structures favor continued land development and alteration of natural systems for human use and consumption.[365] Moreover, Maryland has a distinctive legal doctrine—the "change-or-mistake rule"—that prohibits localities from changing existing zoning unless it was a mistake or conditions have changed.[366] This rule is highly inflexible and could create barriers to watershed-regarding zoning changes unless advocates develop a clear record to support how land-use conditions have changed since the existing zoning was adopted or why the zoning was a mistake. Overall, the resilience of institutions favoring land development and land-cover change poses substantial risks to the linked social-ecological-institutional resilience of the Anacostia River watershed.

362. *See, e.g.*, Marini v. Ireland, 265 A.2d 526, 535 (N.J. 1970) (adopting the implied warranty of habitability in leaseholds); State v. Michels Pipeline Constr., Inc., 217 N.W.2d 339, 349–50 (Wis. 1974) (overruling the rule of capture for groundwater and replacing it with a combination of the reasonable use doctrine and the correlative rights doctrines).

363. *See* Holly Doremus, *Takings and Transitions*, 19 J. LAND USE & ENVTL. L. 1 (2003); *see also* Holly Doremus, *Climate Change and the Evolution of Property Rights*, 1 U.C. IRVINE L. REV. 97 (2012). For concerns about how judicial takings doctrines will prevent state courts from changing property institutions, see generally Craig Anthony (Tony) Arnold, *Legal Castles in the Sand: The Evolution of Property Law, Culture, and Ecology in Coastal Lands,* 61 SYRACUSE L. REV. 213 (2011).

364. Craig Anthony (Tony) Arnold, *The Structure of the Land Use Regulatory System in the United States,* 22 J. LAND USE & ENVTL. L. 441, 486–91 (2007), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1020305.

365. *Id.* at 505–06.

366. *See* Nw. Merchants Terminal, Inc. v. O'Rourke, 60 A.2d 743, 753 (Md. 1948); Kracke v. Weinberg, 79 A.2d 387, 391 (Md. 1951); MacDonald v. Bd. of Cnty. Comm'rs, 210 A.2d 325, 328 (Md. 1965).

2. Social Change

Social change is also a major component of ecological, social, and institutional resilience. The rise of watershed institutions in the Anacostia has been possible in the context of a society in which grassroots political (and legal) movements have developed and grown. These movements include bottom-up, citizen-initiated, community-based activism for environmental protection, pollution cleanup and accountability, civil rights, social justice, environmental justice, and neighborhood preservation.[367] Another major social change has been in how watershed lands, waters, and vegetation are valued. Once viewed as easily exploitable and alterable (even dispensable) raw materials for farming, navigation, industry, and urban development, they are increasingly being used for their aesthetic, recreational, environment-moderating, and natural functions. An economy for green infrastructure and watershed restoration is developing. Tragically, it is only when forests and wetlands are rare, waters are polluted, and landscapes and waterscapes are grey with human-constructed features that we value natural features and systems enough to manage and conserve them for their ecological functions. Resilience science warns us that this brinkmanship approach to the economic and social valuation of nature is dangerous; we may have passed key tipping points to irreversible losses.

Systems within society co-evolve. For example, agriculture in the Anacostia watershed developed alongside the commercial-navigation economy, but land-clearing and soil-degrading farming practices ended up creating sediment buildup and lower flows in the Anacostia River and its tributaries, ultimately decreasing their capacity to support navigation. In another example, the political and economic forces that spurred pollution-generating and riverfront-altering industrial and urban development in the watershed harmed the health, safety, and vitality of African American communities. As new political and economic forces for urban renewal and redevelopment emerged, the health and vitality of these communities' social-cultural networks and economies were threatened or destroyed through neighborhood clearance and gentrification.

These examples instruct us to pay particular attention to the effects of political, economic, and socio-cultural forces on one another, some of which tend to have amplifying and reinforcing dynamics (e.g., the economics of land development and the politics of land development). If, for example, societal preferences for and attitudes towards green infrastructure were to become negative, its economic value would likely drop quickly, followed very soon (or perhaps even concurrently) by a precipitous drop in political support for green infrastructure. This kind of cascade effect could ultimately lead to new land cover patterns altering the watershed's ecology and hydrology and flipping the basin into the collapse scenario previously described.

3. Ecological Change

Ecosystems are dynamic; resilience science is based on the premise that ecosystems can exist in multiple stable states and either adapt or reorganize as they

367. Here, we use the term "citizen" to mean one who is a member of the public or a local community, not necessarily someone who has official United States citizenship.

undergo disturbances.[368] Ecological change results from natural forces. Nature-driven ecosystem change might occur within the ecosystem itself, such as forest succession, prairie and savanna succession, barrier island migration (if one sees the island-ocean dynamic as part of a single system), variable streamflow regimes, or variability and diversification in tropical lowlands.[369] It might occur from the ecosystem's interaction with other natural systems. A river may suddenly change course due to a major storm or flood event; wetlands may transition from one dominant state to another as a result of fires, drought, or freezes that change water flows and soil content; and species' natural ranges may shift in response to changes in climate, food sources, or habitat type or health.[370]

In the Anacostia River basin, for example, forest succession dynamics are producing reforestation and overall increase in watershed tree canopy after more than two centuries of human-caused deforestation. Evidence of major systemic changes in the Anacostia's aquatic and forest ecosystems before significant human impact also indicate that ecosystems undergo natural change internally and in interaction with one another.[371] Historically, tidal freshwater wetlands in the Anacostia region underwent a variety of natural disturbances from linked riverine and climatic systems, including inundation, drought, and salinity change.[372] These dynamics have proven important to understand when restoring tidal freshwater marshes along the Anacostia River; soil elevations and inundation patterns make a difference as to whether native or non-native invasive vegetation thrives in restored wetlands.[373] However, restoration projects must also account for irreversible effects of urbanization and altered hydrology and not attempt merely to mimic historic natural conditions.[374]

More significantly for the Anacostia today, changes in social systems and institutions dramatically affect ecosystem functions, structure, and resilience, as illustrated by the impossibilities of restoring the Anacostia's tidal freshwater wetlands to pre-altered natural states when the watershed's hydrology and landscapes remain human-dominated. More generally, the linked economic-political-social systems in the Anacostia drove the watershed's dominant land uses to agriculture, then to industry, and then to urban development. These changes were supported by evolving institutions of private property, government authority, labor, race relations, and economic regulation. Each stage brought new and more deforestation, soil erosion,

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368. *See generally* FOUNDATIONS OF ECOLOGICAL RESILIENCE, *supra* note 28.

369. For examples of regime shifts from natural disturbances (as well as human disturbances), see Carl Folke et al., *Regime Shifts, Resilience, and Biodiversity in Ecosystem Management*, *in* FOUNDATIONS OF ECOLOGICAL RESILIENCE, *supra* note 28; C.S. Holling, *The Resilience of Terrestrial Ecosystems: Local Surprise and Global Change*, *in* FOUNDATIONS OF ECOLOGICAL RESILIENCE, *supra* note 28.

370. Folke et al., *supra* note 2; Holling et al., *supra* note 30.

371. *See, e.g.*, Grace S. Brush, *Forests Before and After the Colonial Encounter*, *in* THE HISTORY OF AN ECOSYSTEM: DISCOVERING THE CHESAPEAKE 40 (Philip D. Curtin et al. eds., 2001); T.M. Cronin et al., *Rapid Sea Level Rise and Ice Sheet Response to the 8,200-Year Climate Event*, 34 GEOPHYSICAL RES. LETTERS L20603 (2007); WENNERSTEN, *supra* note 98, at 4–6.

372. James E. Perry et al., *Tidal Freshwater Wetlands of the Mid-Atlantic and Southeastern United States*, *in* TIDAL FRESHWATER WETLANDS 157 (Aat Barendregt et al. eds., 2009).

373. *See* Peter Ian May, Alternate State Theory and Tidal Freshwater Mudflat Experimental Ecology on Anacostia River, Washington, Part 3 (2007) (unpublished Ph.D. dissertation, University of Maryland) (on file with Digital Repository, University of Maryland).

374. *See* Andrew H. Baldwin, *Restoring Complex Vegetation in Urban Settings: The Case of Tidal Freshwater Marshes*, 7 URBAN ECOSYSTEMS 125 *passim* (2004).

wetland loss, erosive and pollutant-carrying runoff, and sedimentation of streams and the river. Already prone by its nature to be somewhat sluggish, the downstream tidal portions of the river became more heavily silted, slower, and shallower, which in turn has trapped sediment laden with toxic and organic chemicals from industrial and urban/suburban pollution. Even if all pollution could now be prevented from entering the Anacostia's waters, the streambed would remain contaminated for at least decades. Moreover, the vast amount of impervious cover and land-development in the watershed, when combined with the loss of runoff-moderating forests and wetlands, threatens the hydrological functioning of the watershed.

Major changes in social systems, institutions, and human behavior are needed to prevent further decline and perhaps even collapse of the watershed altogether. Nonetheless, some of the laws, policies, and conservation activities of the past three decades have led to promising improvements in certain ecological conditions.

B. Adaptive Governance of the Anacostia River Basin for Social-Ecological Resilience

The history of the Anacostia River watershed, viewed in light of the ISED framework, suggests some important lessons about how the watershed can be governed adaptively for social-ecological resilience. Overall, governance decisions should aim to strengthen the adaptive capacity of the watershed as an ecosystem, the human communities in the watershed, and the watershed's governance institutions.

1. Watershed Governance

Geography matters to how watershed governance systems emerged and evolved in the Anacostia River watershed. The relatively small scale of the basin means that polycentric, multimodal, modular governance systems and citizen-based organizations can flourish relatively effectively in loosely interconnected networks without becoming unwieldy and collapsing from their volume and complexity. The Anacostia basin crosses only one state boundary, not several, and no international boundaries. The status and role of Native American tribes and their reservations are not significant issues in the Anacostia. However, the relatively small size of the basin mean that there are no major management levers to effect major changes in the watershed's management. There is no major dam to breach that will quickly restore natural streamflows. Water transfers from farmers and ranchers to cities are not relevant policy options here. There are no endangered species that can be the focal point of a lawsuit forcing multiple stakeholders to the bargaining table to find ways to achieve improved biotic conditions. Instead, the Clean Water Act has to be the federal regulatory hammer that gets the relevant stakeholders and governance entities working together to innovate solutions and change degradation trajectories.

The location of the Anacostia in and near the nation's capital is a distinctive geographic factor affecting the watershed's resilience and adaptive governance capacity. The federal government is a major landowner, polluter, and governance partner in the watershed. Its power over land use governance in the District of Columbia for almost two decades created ecological, social, and racial harms from development and redevelopment practices. However, many of its agencies are now important partners with other major public and private partners to clean up pollution, restore wetlands, implement green infrastructure, and conserve undeveloped lands. The types of federal land ownership in the Anacostia are different than in the West, where national parks and forests, federal rangelands, federal fish and wildlife management, and major dams and reservoirs dominate.

Emergent watershed governance institutions in the Anacostia River basin should be continued and strengthened, because they show adaptive features and capacity. They are organized around the watershed and thus are scaled to govern ecological and hydrological problems at the ecosystem scale. Yet, they have smaller-scale components, such as plans organized around each subwatershed, and watershed protection in the Anacostia is also part of larger-scale basin management and governance activities in the Chesapeake Bay basin. Thus, Anacostia River watershed governance is multiscalar with governance activities appropriately scaled to the relevant problems.

The watershed governance system is polycentric. There was no single centralized authority that mandated watershed protection. Instead, numerous watershed governance institutions, partnerships, and structures emerged among various federal, state, and local government agencies, citizen-based organizations, and multistakeholder collaborations. Land conservation decisions in a Maryland upstream subwatershed are not being made by the same decision makers who are developing green-infrastructure policies in Washington, D.C., and vice-versa. There are several different major basin-focused plans, many subwatershed plans, various restoration projects, several major pollution remediation efforts underway, and tens of thousands of green-infrastructure management actions being undertaken. Many decision-making and even implementation processes are highly participatory, thus improving perceived legitimacy, public support, and diversity of information and learning.

This polycentric structure produces the use of many different strategies and policy instruments (multi-modality), diversity in innovation, redundancy of efforts and resources, and the capacity to separate and reconnect various policies and governance frameworks from or to one another (modularity). All of this helps the overall governance system in the basin be more resilient to disturbances, because a single policy failure does not necessarily cascade through the whole system, thus allowing other policies and resources to continue to be employed for watershed governance.

Nonetheless, adaptive linkages among these governance modules have developed, allowing for loose, but not tight, integration. Many entities (e.g., government agencies, citizen groups) participate, often substantially, in more than one governance partnership or framework. Informal networks have developed to share information and cooperate on specific actions. In fact, both formal and informal cooperation have flourished in the basin across agency silos, political jurisdictions, social differences, and public-private divides, often driven by a common interest in improving the overall ecological and social functioning of the watershed and addressing its interconnected problems.

Moreover, litigation, political advocacy, and other conflict-based processes have been used effectively to move parties towards cooperative problem-solving, not to escalate conflict or create distrust. While there is certainly no lack of conflict or distrust, the relative level of social capital in the watershed appears from the level of actual cooperation that is occurring to be rather high, especially given urban-suburban, white-black, rich-poor, public-private, and federal-state/local tensions historically.

Watershed governance processes in the Anacostia seem to have cycled through several different iterations in the past two to three decades, with incremental but meaningful changes being made to governance structure and functions (e.g., issues being addressed and solutions being developed). This evolutionary characteristic is adaptive, in contrast to rigidity and entrenchment in some governance systems. Certainly watershed governance in the Anacostia River basin can be improved, but the system's characteristics allow for experimentation in governance reforms with minimal risk of systemic collapse from mistakes or unanticipated outcomes. In general, the Anacostia River watershed governance system should be continued, supported, and strengthened.

2. Restoration and Green Infrastructure

The hydrology and ecology of the Anacostia River watershed affects the opportunities for adaptive governance. While episodic droughts in the Anacostia River basin are likely to become greater stresses on both natural and human systems under conditions of climate change, the primary stressors under both current highly urbanized conditions and under predicted climate change conditions (especially in interaction with urbanized conditions) have to do with too much water, not too little water. Peak storm events, which are likely to increase in frequency and intensity as the climate changes, and stormwater runoff from impervious surfaces combine to scour streambeds and stream banks, erode soils, and carry sediment and pollutants into waterways. The slow-flowing, shallow downstream tidal portions of the Anacostia have become more sluggish and shallow due to anthropogenic land and waterway alterations, and are traps where pollutant-laden sediment collects and remains toxic. Natural forests and wetlands have been eliminated from much of the watershed, now replaced with built structures, a fact that limits the options of governance systems. Merely improving the ecological management of natural resources—often at least one policy option in large Western river basins—will not do much to improve the ecological resilience of a watershed where most of those natural resources no longer exist.

The Anacostia's history suggests that policy makers, restoration project managers, and the public may be tempted to oversimplify the potential for watershed restoration but should resist doing so. By detailing the several threshold transitions that the Anacostia River watershed has undergone, we have developed a deeper understanding of the impossibility of returning the watershed to pre-development conditions, even with a massive investment of resources in restoration projects and green infrastructure. Pseudo-nostalgia for a watershed of clear flowing waters and abundant verdant forests can influence public perceptions and policy choices, ultimately resulting in disappointment, disillusionment, and governance failure when the historic conditions cannot be achieved. Even if some ecosystems might be flipped back to a pre-disturbance regime by eliminating or controlling a single primary type of disturbance, the Anacostia's history illustrates that it has had so many different and substantial disturbances over time and has transitioned through several different states that it just is not possible under conceivable near-term conditions to flip it back to a pre-development regime.[375] Thus, policy makers, scientists, and the public must identify characteristics or indicia of a healthy, well-functioning, and resilient watershed that are achievable and appropriate given its history and current human-altered conditions. Plans that focus on the river's fish-ability and swim-ability suggest an effort to select goals and measures of progress towards these goals that interconnect both the social and ecological characteristics of the watershed in the context of its human-dominated landscape.

The current trend in the Anacostia River watershed towards cleanup of pollution, restoration of watershed features (e.g., wetlands, forests, riparian lands), and use of green infrastructure should continue and increase. Given the vulnerabilities and current trends in watershed conditions, the aggressive restoration scenario is the only plausible scenario that will strengthen the social-ecological resilience of the watershed. However, we have three specific recommendations, in addition to support for the existing features of this scenario described elsewhere in the article and in various plans and project documents cited herein.

First, the restoration and green-infrastructure plans and projects must actually be implemented fully. The often large gaps between any watershed plan's goals and strategies, on one hand, and its actual implementation and outcomes, on the other hand, typically threaten the resilience of linked social-ecological systems. Regulated parties seek exemptions and variances, exploit loopholes and enforcement gaps, and lobby and litigate against regulations. Costs of implementation can grow and available resources often shrink or fail to materialize. The mere act of developing plans and policies can create a false sense of accomplishment that deters leaders and participants from engaging in the hard work and making the hard choices that have to occur during implementation. As new problems arise and changing conditions (e.g., climate change) create disappointing results or unexpectedly adverse effects, the public becomes disillusioned, distracted, and/or disinterested, and support for watershed restoration and conservation wanes. Outcomes can fall short of optimistic and even mistaken projections. Climate change, population growth, continued and increasing land-development pressures, invasive species, and other changing conditions threaten to offset or even undermine efforts to control runoff and restore key watershed features. Given the various barriers to full and effective implementation, the aggressive restoration[376] scenario is the bare minimum needed to adaptively manage the watershed's vulnerabilities and to strengthen the watershed's ecological, social, and institutional resilience.

Second, the restoration and green-infrastructure plans and projects must be implemented adaptively. Both restoration projects and new or conserved green infrastructure are vulnerable to sudden, unexpected disturbances. They are also vulnerable to changing conditions that are interconnected often across scales and that can cross thresholds to an undesirable state, causing the projects and plans to fail. The existing watershed is already vastly altered from its pre-development state and subject to many interacting human disturbances. As monitoring of initial wetlands restoration projects showed, changes had to be made to soil levels and other wet-

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375. We do not think that total or near-total human abandonment of the watershed is likely in any foreseeable time horizon, so we do not consider what would happen to the watershed if human disturbance were greatly reduced or eliminated altogether.

376. *See* ARWRPR, *supra* note 59, at 107–09.

land design features in order to counter the adverse effects of non-native invasive vegetation and wildlife disturbances.[377] The implementation of aggressive restoration strategies will have to be experimental, and methods—and perhaps even goals—will have to be adjusted as lessons are learned from monitoring implementation actions.

Third, aggressive restoration approach will have to use many different methods by many different actors to achieve many different goals. Multiple strategies and tools to control and reduce stormwater runoff as a major driver of ecological and hydrological degradation in the Anacostia River basin are needed given the long and multi-faceted history of eliminating nature's runoff moderators while increasing society's runoff generators. The control of stormwater runoff and CSOs is a critically important goal for the resilience of the Anacostia River watershed. However, overall watershed resilience also depends on other goals: reduction of urban heat island effects, remediation of contaminated lands and waters, socially and racially just land-use and green-infrastructure policies, land conservation, reforestation, engaging the public in watershed conservation, strengthening but also adapting watershed governance institutions to changing conditions and needs, and others. Moreover, history tells us that conservation of undeveloped lands in the upper areas of the watershed must accompany restoration projects in the lower areas of the watershed, because those undeveloped lands will likely experience continued development pressures.

Multi-modal strategies spread risk over many methods, instruments, and tools. Shared-risk strategies spread risk and costs over many participants or stakeholders. Both spreading risk and creating systemic redundancies decrease vulnerabilities to contagion and cascade effects which can cause systemic collapse from disturbances to "lynchpin" elements of the system. Thus, while green roofs and installed bioinfiltration systems, such as rain gardens and bioswales, do much to control runoff and have other co-benefits, leaders and participants in Anacostia River watershed governance should also invest in other biotic strategies. For example, urban and suburban trees absorb runoff, prevent soil erosion, protect human health by absorbing air pollution and moderating urban heat-island effects, sequester carbon, improve the walkability of streetscapes, increase property values, and improve mental and emotional health.[378]

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377. Baldwin, *supra* note 374, at 130–32.

378. David J. Nowak et al., *Tree and Forest Effects on Air Quality and Human Health in the United States*, 193 ENVTL. POLLUTION 119, 119–20 (2014); MARGARET M. CARREIRO ET AL., ECOLOGY, PLANNING, AND MANAGEMENT OF URBAN FORESTS: INTERNATIONAL PERSPECTIVES (2008); MIAMI-DADE COUNTY UDB AND THE CITY OF MIAMI, FLORIDA, URBAN ECOSYSTEM ANALYSIS 5 (2008), *available at* http://www.systemecology.com/4_Past_Projects/Amfor%20ReportMiamiUEA_V4%20final_lowres.pdf; C.Y Jim & Wendy Y. Chen, *Ecosystem Services and Valuation of Urban Forests in China*, 26 CITIES 187, Washington, D.C. 4 (2009); Cynnamon Dobbs et al., *A Framework for Developing Urban Ecosystem Forest Services and Goods Indicators*, 99 LANDSCAPE & URB. PLAN. 196, 198 (2011); Francisco J. Escobedo et al., *Urban Forests and Pollution Mitigation: Analyzing Ecosystem Services and Disservices*, 159 ENVTL. POLLUTION 2078 (2011); Francesc C. Baró et al., *Contribution of Ecosystem Services to Air Quality and Climate Change Mitigation Policies: The Case of Urban Forests in Barcelona, Spain*, 43 AMBIO 466 (2014), *available at* http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3989519/.

3. Land Use Regulation

The intense concentration of resilience-threatening land uses in the Anacostia River basin is a critical aspect of its geography. In this highly urbanized watershed, every one of countless commercial retail centers, parking lots, residential developments, streets and freeways, industrial sites, stormwater and sewer conduits, filled or drained wetlands, cleared forest lands, and other urban-suburban land uses has a magnified effect. In general, land use strongly affects stream ecosystems in interaction with other forces like climate change and invasive species and in nonlinear ways with threshold effects.[379] Impervious cover, in particular, has significant threshold effects: at ten percent of a catchment or subwatershed under impervious cover, stream health for biological life is significantly impaired, and at twenty-five percent impervious cover, the stream loses its capacity to support biological life and experiences irreversible harms.[380]

Substantial changes in land cover and land use have been the primary driver of the decline in watershed conditions throughout the watershed's agricultural, navigational, industrial, and urban transformations. Even now, continued urban and suburban land-development pressures affect watershed functions and processes and threaten to undermine new efforts to green the watershed with biotic infrastructure and restoration of wetlands, riparian lands, and parks. The aggressive restoration scenario will fail unless it includes significant regulation of new and existing land uses, not only in the District of Columbia but also in the Maryland suburbs and semi-rural areas. A resilience strategy cannot depend solely on publicly provided green infrastructure and public restoration activities in major urban areas, because new sources of impervious cover and new disturbances to soils, trees, vegetation, and stream features can quickly produce adverse effects on watershed conditions and functions that exceed benefits from green infrastructure and restoration projects.

Thus, requiring all new and existing land uses to retain and manage all post-development stormwater runoff on-site, including retrofitting already developed sites, is an important regulatory element of a multi-modal strategy to enhance the watershed's resilience and health. Land use regulations should also restrict the percentage of land that is covered in impervious material and require all development projects to be designed and constructed to preserve existing trees and other natural features of the land that provide valuable support to watershed processes. Comprehensive land use plans should expressly identify future land uses, development patterns, and infrastructure development that enhance, not hurt, watershed function and resilience. Each element of a land use plan should be evaluated by both local planners and watershed governance partners for its effect on the watershed.

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379. J. David Allan, *Landscapes and Riverscapes: The Influence of Land Use on Stream Ecosystems*, 35 ANN. REV. ECOL. EVOL. SYST. 257, 272–77 (2004), *available at* http://www-personal.umich.edu/~dallan/pdfs/Annurev.pdf.

380. U.S. ENVTL. PROTECTION AGENCY, NATIONAL MANAGEMENT MEASURES TO CONTROL NONPOINT SOURCE POLLUTION FROM URBAN AREAS 1–20 (2005), *available at* http://water.epa.gov/polwaste/nps/urban/upload/urban_guidance.pdf; JOHN RANDOLPH, ENVIRONMENTAL LAND USE PLANNING AND MANAGEMENT 405 (2004).

Land development should be strictly restricted or even prohibited altogether in riparian buffer zones, wetland conservation zones, and overlay zones protecting sensitive watershed lands. Public conservation of undeveloped lands such as open space, parks, or watershed-service lands should continue and increase. Upstream jurisdictions in Maryland should devote special attention to watershed-regarding land use regulation, planning, and conservation in proactive, preventative ways. Watershed resilience is much harder to achieve after an area has undergone substantial development and increase in impervious cover; the pattern of destruction-regret-restoration must be broken, even if it requires land use regulators to exercise the courage and expend the political and financial resources to restrict and prohibit new land development.

4. Public Engagement

One of the most important features of an adaptive and resilient watershed governance system is a high level of public engagement in watershed governance and conservation. Watershed governance,[381] stormwater management,[382] and environmental conservation[383] are inherently and inescapably political, regardless of legal and scientific imperatives. Environmental protection and natural-resource management laws include statutes that can be amended or repealed by elected legislators, regulations that are developed and implemented by government officials subject to political pressures, new policy directives, politics-dependent funding, and judicial decisions by judges who are either elected by the voters or appointed and confirmed by elected officials. Even landmark ecosystem-protecting judicial decisions are not self-enforcing; they require widespread public engagement and political activism in order to develop the public and political will and resources to change policies and behaviors.[384]

Watershed resilience depends on adaptive watershed-regarding governance institutions, which in turn depend on public values and attitudes and political forces. Public engagement with the watershed and its functions (e.g., tree planting, canoeing, volunteer work on restoration projects) and public participation in watershed governance (including planning, decision making, monitoring, and enforcement) do much to build people's care for and commitment to the watershed and its resilience.[385] The long-term resilience of the Anacostia and its institutions requires ways to keep participants involved when the sense of urgent crisis is over and other issues vie for their attention, ways to involve new and more participants, and ways to engage suburban and rural Maryland participants as much as urban D.C. participants.

Attention must also be given to the characteristics of public norms that develop around the watershed and its restoration. For example, watershed residents and

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381. SCHLAGER & BLOMQUIST, *supra* note 82, at 151–82.

382. KARVONEN, *supra* note 82, at 159–86.

383. *See generally* RICHARD LAZARUS, THE MAKING OF ENVIRONMENTAL LAW (2004); Craig Anthony Arnold, *supra* note 83, at 39–48.

384. *Id.*

385. Daniel A. DeCaro & Michael K. Stokes, *Public Participation and Institutional Fit: A Social–Psychological Perspective*, 18(4) ECOL. & SOC'Y 40 (2013), *available at* http://www.ecologyandsociety.org/vol18/iss4/art40/.

their institutions have framed and valued the watershed in several different ways over the past three centuries: for the tobacco plantation economy, for commercial navigation, for industrial and sewer waste discharge, for urban and suburban development, and for environmental amenities in the urbanized landscape. The changes in value are both promising and disturbing. They suggest a trend towards recognizing the many benefits that healthy, well-functioning ecosystems provide to human society and the importance of ecosystem resilience. On the other hand, they reflect a persistent framing of the watershed as a commodity or exploitable economic resource for human consumption with the type of consumption changing about every century as social, economic, and physical conditions change. The current "green" values and attitudes towards the Anacostia may be temporary. Restoration of degraded urban watersheds and riverfronts is an important phenomenon nationally.[386] However, careful study of the history of these watersheds raises questions about whether this is a trend towards improved social-ecological resilience or merely a different form of watershed exploitation and consumption.

5. Social Justice

Race, class, and social justice are important factors in the social-ecological resilience of urban watersheds. In many ways, ecologically harmful exploitation of watershed lands and waters have been intertwined with humanly and socially harmful exploitation of people of color and low- and moderate-income communities throughout the Anacostia's post-colonization history. C.S. Lewis famously wrote, "Man's power over Nature means the power of some men over other men with Nature as the instrument."[387]

The Anacostia Watershed Society and other watershed-focused organizations have helped to develop adaptive governance institutions and processes by engaging the participation and voice of low-income people and neighborhoods of color, including children, neighborhood organizations, and social-justice groups. However, concerns about gentrification threaten the legitimacy and efficacy of watershed restoration actions and governance systems.

The watershed will not be resilient unless governance decisions and actions address past injustices, are fair in their processes and their distribution of environmental harms and benefits, and strengthen, not weaken, the health and resilience of low-income and minority communities, including neighborhoods in the Anacostia River area. Some plans and actions in the Anacostia River basin seem to involve robust participation by low-income and minority groups, but others seem to be dominated by elites and experts, which is troubling. Adaptive watershed governance institutions need to address directly the risk of resident-displacing gentrification and framing of the river and its watershed as environmental amenities for those with the power or money to enjoy. Assessments of urban watershed resilience and adaptive governance capacity must give thoughtful and thorough attention to the histories of racism, class discrimination, segregation, and environmental injustices

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386. *See generally* RIVERTOWN, *supra* note 164.
387. C.S. LEWIS, THAT HIDEOUS STRENGTH 178 (1946).

that continue to have influence over the linked ecological, social, and institutional conditions of the watershed.

6. Monitoring and Feedback Loops

Adaptive watershed governance requires extensive monitoring and feedback loops in which lessons learned from monitoring the effects of actions and decisions end up shaping and reshaping future decisions and actions. This is a fundamental element of adaptive management, such as the adaptive management of restoration projects and the installation and maintenance of green infrastructure.[388] However, it is also a fundamental element of adaptive governance in which governance decisions and actions are ongoing experiments from which officials and the public can learn and governance decisions can be improved.[389]

Considerable informal feedback loops exist among various government agencies, nongovernmental organizations, and other participants in many of the Anacostia River watershed partnerships and projects. Information and ideas are shared through informal networks, as well as formal and semi-formal networks. In addition, some restoration and green-infrastructure projects have monitoring activities built-in and have produced some important lessons to guide decision-makers or managers. However, like most examples of adaptive management or adaptive governance,[390] there has been very little systematic attention to designing and imbedding feedback loops into governance processes in order to ensure monitoring, assessment, learning, and appropriate revisions of plans, policies, and actions. It will be difficult to determine whether the watershed governance system in the Anacostia River basin is improving its social-ecological resilience and how governance decisions should adapt if rigorous feedback loops are not built into plans and governance structures. Like many legal regimes,[391] the legal frameworks and rules in this watershed, such as the Clean Water Act, TMDLs, MS4 permits, CSO consent decrees, and individual water discharge or land-development permits, have no automatic mechanisms for modifications based on lessons learned or changed conditions and, indeed, may be difficult to revise.

Nonetheless, watershed governance systems in the Anacostia may be flexible enough to provide the space for revisions to rules, policies, plans, and actions if the

388. For classic works on adaptive management and feedback loops, see generally ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (C.S. Holling ed. 1978); Kai N. Lee & Jody Lawrence, *Adaptive Management: Learning from the Columbia River Basin Fish and Wildlife Program*, 16 ENVTL. L. 431 (1986).

389. Craig Anthony (Tony) Arnold, *Adaptive Watershed Planning and Climate Change*, 5 ENVTL. & ENERGY L. & POL'Y J. 417, 432 (2010); Cosens & Williams, *supra* note 6. *See also* ADAPTIVE GOVERNANCE & WATER CONFLICT: NEW INSTITUTIONS FOR COLLABORATIVE PLANNING 8 (John T. Scholz & Bruce Stiftel eds., 2005) (evaluating mechanisms for both scientific and social/public learning in adaptive water governance institutions). Pragmatist John Dewey envisioned democracy as a continual experiment from which the public would learn and progress; each policy or rule could be considered its own experiment subject to revision based on the results of the experiment. Bradley C. Karkkainen, *Adaptive Ecosystem Management and Regulatory Penalty Defaults: Toward a Bounded Pragmatism*, 87 MINN. L. REV. 943, 945, 955–60 (2003).

390. Alejandro E. Camacho, *Adapting Governance to Climate Change: Managing Uncertainty Through a Learning Infrastructure*, 59 EMORY L.J. 1, 10–15 (2009); Alejandro E. Camacho, *Can Regulation Evolve?: Lessons From a Study in Maladaptive Management*, 55 UCLA L. REV. 293, 335–44 (2007).

391. *See generally* Arnold, *Adaptive Water Law*, *supra* note 4.

right variables are carefully and persistently monitored and if the monitoring data are analyzed for lessons that could inform governance institutions. Based on this resilience assessment of the Anacostia River basin, we conclude that seven key variables should be studied, monitored in an ongoing, systematic, and thorough manner, and managed adaptively for the overall social-ecological-institutional resilience of the watershed. These variables are: (1) land cover and land use; (2) the quantity, velocity, and quality of stormwater runoff; (3) streamflow;[392] (4) pollutant loading, adjusted for changing ecological conditions, not merely a measure of compliance with TMDLs; (5) performance of green infrastructure; (6) the interactions between social values/norms and political forces, including not only measures of public attitudes and values towards the Anacostia and the environment but also trends and patterns in environmental, natural-resource, and land-use politics at various governance scales;[393] and (7) institutional capacity and change.

V. CONCLUSION

The history of the Anacostia River watershed offers several important lessons about adaptive watershed governance and social-ecological resilience in small, Eastern, urban-suburban watersheds generally. Neither resilience assessments nor frameworks of adaptive watershed governance are relevant solely to large Western river basins. However, the distinctive characteristics of watersheds like the Anacostia require particular attention in assessing their social-ecological resilience and in developing and supporting adaptive watershed governance systems.

Institutions matter. Throughout this case study of the Anacostia River watershed, we have identified the strong and pervasive roles of institutions in the watershed's declining ecological resilience and potential for improved social-ecological resilience.

However, institutions change, often in complex inter-relationships with social change and ecological change. We have developed and used a new analytical tool, the ISED framework, to focus our resilience assessment of the Anacostia River basin on the role of institutional change in the context of ecological and social change. The institutional-social-ecological dynamics of the Anacostia River basin over time give us both concerns and optimism about its potential for improved social-ecological resilience.

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392. In some respects, streamflow could be considered just a post-terrestrial measure of stormwater runoff, at least for watershed resilience monitoring purposes. However, measuring streamflow separately is important for two reasons. First, it would be too costly and impractical to measure stormwater runoff from every possible location or source before it enters streams and rivers. Streamflow allows monitors to detect runoff trends that might not be detected by on-site or storm-sewer monitoring devices. Second, we do not know exactly how changes in stormwater runoff, climate change, riparian and riverine restoration projects, and other changes to the watershed will affect the baseline flow regime of the Anacostia River and its feeder streams. Assumptions about this regime and the relationships between runoff rates and streamflows used in existing models might have to be modified if actual streamflow and runoff data do not match the models. Gathering both types of data can help us to better understand the changes that the river and streams are undergoing as policy and management decisions are implemented.

393. For studies emphasizing the critically important role of politics in how watershed governance and stormwater management change over time, see SCHLAGER & BLOMQUIST, *supra* note 82, and KARVONEN, *supra* note 82. These studies can point researchers in the direction of aspects of politics and public values that require monitoring.

Resilience assessments must give attention to the major drivers of systemic change that can strengthen or weaken systemic resilience. Analyzing the major drivers of land cover change and alterations of watershed structural features, we have concluded that the greatest opportunities for a more resilient, climate-adaptive Anacostia River watershed require continued and improved changes in watershed governance, restoration and green infrastructure initiatives, land use regulation, public engagement, integration of social justice into watershed decision making, and monitoring and feedback loops.