Article

ADAPTIVE WATERSHED PLANNING AND CLIMATE CHANGE

Craig Anthony (Tony) Arnold[*]

I. INTRODUCTION

The likely hydrological effects of climate change will upset settled expectations and require water institutions to adapt. These effects will be felt in many different water environments

* Associate Dean for Academic Affairs and Faculty Development, Boehl Chair in Property and Land Use, Professor of Law, Affiliated Professor of Urban Planning, and Chair of the Center for Land Use and Environmental Responsibility, University of Louisville; Huber Hurst Visiting Eminent Scholar, University of Florida Levin College of Law, Fall 2009; Visiting Professor of Law and Symposium Visiting Professor, University of Houston Law Center, Spring 2010. The initial foundations of this research began while I was a Visiting Scholar at the School of Planning, College of Design, Architecture, Art, and Planning, University of Cincinnati, 2008–2009. In addition, I would like to thank Dustin Wallen and Carol Norton for collaboration on an EPA-funded project on comprehensive "wet growth" tools that also contributed to the conceptual foundations of this article.

from Texas aquifers, which are subject both to depletion under the rule-of-capture and conservation by groundwater management districts,[1] to the West's fully-allocated Colorado River,[2] to the conflict-ridden Apalachicola-Chattahoochee-Flint River system in the Southeast,[3] to the Florida Everglades, which have yet to be restored,[4] to the Great Lakes basin and its recent protective Compact,[5] to Fargo, North Dakota's flood control works on the Red River,[6] to the small Darby Creek watershed in developing rural-suburban Oldham County, Kentucky.[7] Water supply plans of major urban areas will likely prove inadequate, and water supplies for agriculture, instream flows and other uses are likely to be diminished in at least some regions.[8] The legal

---

1. *See generally* George H. Ward, *Water Resources and Water Supply, in* THE IMPACT OF GLOBAL WARMING ON TEXAS: A REPORT OF THE TASK FORCE ON CLIMATE CHANGE IN TEXAS (Jurgen Schmandt et al. eds., 2nd ed. 2009); Travis W. Witherspoon, Recent Development*, In the Well: Desired Future Conditions and the Emergence of Groundwater as the New Senior Water Right*, 5 ENERGY & ENVTL. L. & POL'Y J. 166 (2010); Chris Connelly, *The Inconvenience in Texas Groundwater*, 46 HOUS. L. REV. 1301 (2009).

2. *See generally* ROBERT W. ADLER, RESTORING COLORADO RIVER ECOSYSTEMS: A TROUBLED SENSE OF IMMENSITY (2007); Tim Barnett et al., *The Effects of Climate Change on Water Resources in the West: An Introduction and Overview*, 62 CLIMATIC CHANGE 1, 6–7 (2004).

3. *See generally* Joseph W. Dellapenna, *Interstate Struggles Over Rivers: The Southeastern States and the Struggle Over the 'Hooch*, 12 N.Y.U ENVTL. L. J. 828, 830–31 (2005) [hereinafter Dellapenna, *Interstate Struggles*]; J.B. Ruhl*, Water Wars, Eastern Style: Divvying Up the Apalachicola-Chattahoochee-Flint River Basin*, J. CONTEMP. WATER RES. & EDUC., June 2005, at 47.

4. *See generally* Alfred R. Light, *Beyond the Myth of Everglades Settlement: The Need for a Sustainability Jurisprudence*, 44 TULSA L. REV. 253 (2008); CYNTHIA BARNETT, MIRAGE: FLORIDA AND THE VANISHING WATER OF THE EASTERN U.S. 180–92 (2007).

5. *See generally* Noah D. Hall & Bret B. Stuntz, *Climate Change and Great Lakes Waters Resources: Avoiding Future Conflicts with Conservation*, 31 HAMLINE L. REV. 641 (2008); Noah D. Hall, *Toward a New Horizontal Federalism: Interstate Water Management in the Great Lakes Region*, 77 U. COLO. L. REV. 405 (2006).

6. DAN GUNDERSON, *Officials Seek Long-term Solutions for Red River Flood Control*, MINN. PUB. RADIO NEWS, *available at* http://minnesota.publicradio.org/display/web/2010/01/19/red-river-flood-plans; L. Li & S.P. Simonovic, *System Dynamics Model for Predicting Floods from Snowmelt in North American Prairie Watersheds*, 16 HYDROLOGICAL PROCESSES 2645 (2002); R.A. Pielke, Jr., *Flood Impacts on Society: Damaging Floods as a Framework for Assessment, in* FLOODS 133–55 (Dennis J. Parker ed., 2000).

7. *See generally* University of Louisville Land Use and Planning Law Service Learning Team for the Darby Creek Watershed, Darby Creek Legal Service-Learning Project, http://www.kwalliance.org/Portals/3/pdf/darby_creek_codes_and_ordinances.pdf (last visited March 1, 2008).

8. *See generally* Kathleen A. Miller*, Grappling with Uncertainty: Water Planning and Policy in a Changing Climate*, 5 ENVTL. & ENERGY L. & POL'Y J. 395 (2010); JOEL B. SMITH, PEW CENTER ON GLOBAL CLIMATE CHANGE, A SYNTHESIS OF POTENTIAL CLIMATE CHANGE IMPACTS ON THE U.S. iv–v, 11–12 (2004); U.S. GLOBAL CHANGE RESEARCH PROGRAM, GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES 41–42 (2009); SCIENTIFIC ASSESSMENT OF THE EFFECTS OF GLOBAL CHANGE ON THE UNITED STATES: A REPORT OF THE COMMITTEE ON ENVIRONMENT AND NATURAL RESOURCES, NATIONAL SCIENCE AND TECHNOLOGY COUNCIL 12–13 (2008) [hereinafter SCIENTIFIC ASSESSMENT]. For global perspectives on climate change's impacts on water resources, see Zbigniew W.

system will struggle to reconcile "secure" water rights and allocations, such as landowners' historic groundwater withdrawals, prior appropriation rights, interstate allocations, and even water use permits, with hydrological conditions, that will differ greatly from the assumptions on which those rights and allocations were granted.[9] Flood prevention, preparation, and response efforts will struggle to keep up with unanticipated flood disasters and changing ecological and social conditions.[10] Ecosystem conservation and restoration programs will strain under an overwhelming amount of change both in physical, chemical, and biological phenomena and in scientific knowledge.[11] The structure and functions of watersheds, at multiple levels, will likely experience significant change.[12]

Few phenomena make the case for both ecosystem management and adaptive management quite as well as climate change. The effects of climate change will be felt at multiple hydrological, geographic, and institutional scales that transcend

Kundzewicz et al., *Freshwater Resources and Their Management*, *in* ADAPTATION AND VULNERABILITY: CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 173–210 (Martin L. Parry et al. eds., 2007). For analysis of the inadequacies of California's Inland Empire Utility Agency's Regional Urban Water Management Plan in the face of climate change uncertainties, see DAVID G. GROVES ET AL., PREPARING FOR AN UNCERTAIN FUTURE CLIMATE IN THE INLAND EMPIRE: IDENTIFYING ROBUST WATER-MANAGEMENT STRATEGIES (2008), *available at* www.rand.org. The impacts of climate change will intersect with the vulnerabilities of existing water supply management institutions. For example, urban water supply plans can elicit substantial criticism, notwithstanding the uncertainties associated with climate change. For criticisms of Atlanta's water supply planning, see, for example, Stacy Shelton, *Metro Water Plan: What Level of Commitment?* ATLANTA J.-CONST., Jan. 18, 2009, *available at* http://www.ajc.com/services/content/printedition/2009/01/18/waterplan01183dot; PACIFIC INST. FOR STUDIES IN DEV., ENV'T & SECURITY, A REVIEW OF WATER CONSERVATION PLANNING FOR THE ATLANTA, GEORGIA REGION (2006), *available at* http://www.pacinst.org/ reports/atlanta/atlanta_analysis.pdf.

9. *See*, *e.g.,* Holly Doremus & Michael Hanemann, *The Challenges of Dynamic Water Management in the American West*, 26 UCLA J. ENVTL. L. & POL'Y 55 (2007).

10. SMITH, *supra* note 8, at iv, 11, 13; SCIENTIFIC ASSESSMENT OF THE EFFECTS OF GLOBAL CHANGE ON THE UNITED STATES: A REPORT OF THE COMMITTEE ON ENVIRONMENT AND NATURAL RESOURCES, NATIONAL SCIENCE AND TECHNOLOGY COUNCIL 13, 15 (2008).

11. SMITH, *supra* note 8, at 14–17; SCIENTIFIC ASSESSMENT OF THE EFFECTS OF GLOBAL CHANGE ON THE UNITED STATES: A REPORT OF THE COMMITTEE ON ENVIRONMENT AND NATURAL RESOURCES, NATIONAL SCIENCE AND TECHNOLOGY COUNCIL 8–11 (2008); On climate-related changes to ecosystems generally, see Andreas Fischlin et al., *Ecosystems, Their Properties, Goods and Services, in* ADAPTATION AND VULNERABILITY: CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 211–72 (Martin L. Parry et al. eds., 2007).

12. Climate and Land Use Change Effects on Ecological Resources in Three Watersheds: A Synthesis Report, 72 Fed. Reg. 45045 (Aug. 10, 2007); N. LEROY POFF ET AL., PEW CENTER ON GLOBAL CLIMATE CHANGE, AQUATIC ECOSYSTEMS AND GLOBAL CLIMATE CHANGE: POTENTIAL IMPACTS ON INLAND FRESHWATER AND COASTAL WETLAND ECOSYSTEMS IN THE UNITED STATES (2002); SMITH, *supra* note 8, at 16–17; Fischlin et al., *supra* note 11, at 233–34.

specific water sources or political and legal jurisdictions.[13] Moreover, the effects will be uncertain, complex, and frequently changing.[14] Thus, water resources should be managed at ecosystem scales, or at watershed scales, as watersheds are the ecological systems of water. This management should use the adaptive management methods of flexibility, experimentation, and learning through iterative processes of managing environmental conditions and programs.[15]

The combination of ecosystem management and adaptive management may be called "adaptive ecosystem management"[16] or "adaptive watershed management" in the case of aquatic ecosystems.[17] The adaptive ecosystem management concept has had the unfortunate effect of de-emphasizing or even rejecting the role of planning in shaping the relationships between human actions and ecological conditions. The very process of adapting to uncertain, complex, and dynamic phenomena eschews comprehensive, rational, prospective plans based on known, stable and predictable conditions and fixed, pre-established goals. The adaptive ecosystem management concept emphasizes uncertainty, complexity, the nonlinear dynamics of both ecological and social processes, and inherent limits to human knowledge, understanding, and behavioral capacity. Adaptive ecosystem management embraces ad hoc experimentalism that responds to changing conditions, emerging knowledge, and feedback processes. Institutions with responsibilities for natural resource allocation and environmental conservation,

---

13. SCIENTIFIC ASSESSMENT, *supra* note 8, at 2–3; Hari M. Osofsky, *Is Climate Change "International"? Litigation's Diagonal Regulatory Role*, 49 VA. J. INT'L L. 585 (2009); Robin Kundis Craig, *"Stationarity is Dead" – Long Live Transformation: Five Principles for Climate Change Adaptation Law*, 34 HARV. ENVTL. L. REV. 9, 54 (2010) [hereinafter Craig, *Stationarity*].

14. *See* SMITH, *supra* note 8, at 11–12; J.B. Ruhl, *Climate Change and the Endangered Species Act: Building Bridges to the No-Analog Future,* 88 B.U. L. REV. 1 (2008) [hereinafter Ruhl, *Climate Change*]; Alejandro E. Camacho, *Adapting Governance to Climate Change: Managing Uncertainty Through a Learning Infrastructure*, 59 EMORY L.J. 1, 10–15 (2009) [hereinafter Comacho, *Adapting Governance*].

15. *See infra* Parts II and III.

16. *See, e.g.,* Bradley C. Karkkainen, *Adaptive Ecosystem Management and Regulatory Penalty Defaults: Toward a Bounded Pragmatism*, 87 MINN. L. REV. 943 (2003) [hereinafter Karkkainen, *AEM*]; Bradley C. Karkkainen, *Collaborative Ecosystem Governance: Scale, Complexity, and Dynamism*, 21 VA. ENVTL. L.J. 189, 200–04 (2002) [hereinafter Karkkainen, *CEG*]; J.B. Ruhl, *Thinking of Environmental Law as a Complex Adaptive System: How to Clean Up the Environment By Making a Mess of Environmental Law*, 34 HOUS. L. REV. 933, 999 & n.267 (1997); Light, *supra* note 4, at 253–56.

17. *See, e.g.,* D.S. Pensley, *The Legalities of Stream Interventions: Accretive Changes to New York's Riparian Doctrine Ahead?,* 25 PACE ENVTL. L. REV. 105, 123, 143 (2008); Bruce P. Hooper & Christopher Land, *Integrated, Adaptive Watershed Management, in* INTEGRATED RESOURCES AND ENVIRONMENTAL MANAGEMENT: CONCEPTS AND PRACTICES 97 (D. Scott Slocombe & Kevin Stuart Hanna eds., 2007).

preservation, or restoration are to shift attention and resources from planning activities to management activities.[18]

Even though not all adaptive ecosystem management advocates have thrown out the proverbial planning "baby" with the predictive-control (or "rational-comprehensive"[19]) "bathwater,"[20] too little attention has been given to the role of planning in adaptation and ecosystem management. A concept of "adaptive planning" is not only consistent with adaptive ecosystem management, but could actually improve adaptive ecosystem management methods and the capacity of institutions to engage in adaptive ecosystem management effectively. Moreover, a growing number of watershed plans are exhibiting some characteristics of adaptive planning, particularly with respect to the effects of climate change on watersheds and water resources.[21]

This article explores the role of adaptive watershed planning in adapting to climate change. Adaptive watershed management requires the use of adaptive planning methods, not merely ad hoc, reactive experimentalism and incrementalism. Without some process of planning, Charles Lindblom's "science of muddling through"[22] – the public-policy and public-administration foundation of adaptive management – becomes "the science of drifting along." We run the risk of having no goals or sense of direction, no go-to plans ready to use when contingencies arise, no long-term investment of resources in conservation, no proactive efforts, and no agreed-upon criteria, values, and processes for evaluating possible alternative courses of action. In contrast, adaptive planning gives some direction and focus to adaptive ecosystem management activities by combining decisional structures, goal-setting processes, and resource availability with flexibility, adaptability, multi-criteria decision making, and iterative feedback loops with continual or periodic plan adjustments.[23]

Furthermore, adaptive watershed planning can improve not only adaptive watershed management methods, but also the

---

18. *See infra* Part III.

19. *See* Charles E. Lindblom, *The Science of "Muddling Through,"* 19 PUB. ADMIN. REV. 79 (1959).

20. *See, e.g.,* Fred Bosselman, *A Role for State Planning: Intergenerational Equity and Adaptive Management,* 12 U. FLA. J. L. & PUB. POL'Y 311 (2001) [hereinafter Bosselman, *A Role for State Planning*]; Robert L. Glicksman, *Ecosystem Resilience to Disruptions Linked to Global Climate Change: An Adaptive Approach to Federal Land Management*, 87 NEB. L. REV. 833, 866–71 (2009).

21. *See infra* Part IV.

22. Lindblom, *supra* note 19.

23. *See infra* Parts IV, V.

content and effectiveness of watershed plans themselves.[24] If watershed plans are to be useful, they must contemplate the uncertainties associated with climate change and its effects. Watershed planning groups or officials must plan for adaptation to the unexpected, multiple, complex, multi-scalar, and interconnected impacts of climate change on watershed and water resources.

Part II of this article discusses watershed management as a particular type of ecosystem management. Watersheds have become popular units for organizing water management activities. However, watersheds and their functions actually occur at multiple scales, and many different types of actions fall within the broad category of "watershed management." Part III of this article describes the characteristics and logic of adaptive management, as well as its limits. The concept of watershed management can be easily misunderstood or misapplied. Part IV introduces the principles of adaptive planning and compares them to conventional planning across six features: option, redundancy, rigidity, decisions, emergence, and criteria. Part V presents a number of reasons to engage in adaptive watershed planning. Part VI explores examples of watershed plans in the U.S. and Canada that have addressed climate change. They show several different ways of planning for climate change at watershed levels, which suggests that no uniform, comprehensive model of watershed planning for climate change exists. This variety may itself be an adaptive feature of watershed planning, or it may reflect that adaptive management is in an early or incomplete stage. However, Part VI also highlights some examples of watershed plans that give no meaningful attention to climate change or the potential that changing climate conditions could upset the plans' goals and efficacy. These examples suggest that adaptive planning has yet to be embraced in many watersheds. Finally, Part VII analyzes a number of issues in adaptive watershed planning, including barriers to, and opportunities for, the increased and improved use of adaptive watershed planning to improve the capacity of watershed institutions to adapt to climate change.

II. WATERSHED MANAGEMENT

One of the core premises of ecosystem management is that problems concerning human use and management of natural

24. *See infra* Parts IV, V.

resources and the environment should be addressed at the ecological scales at which they occur.[25] This concept contrasts with conventional management and public problem solving, which typically occur at political-legal scales. The jurisdiction and the scope of management missions, and authority of government agencies and other organizations are human constructs that do not match the scales at which ecological processes and functions occur, or the ways by which nature organizes itself. Even human activities and their effects transcend political boundaries and legal jurisdiction. Political-legal-social "geography" in the U.S. typically produces decisions and actions that are fragmented and disconnected, preventing natural resources and environmental management that is rational, efficient, effective, or ecologically responsible.[26]

The concept of an "ecosystem," which is short for "ecological system," is that we can observe and classify certain geographic areas and physical environments around which a community of biological organisms are organized and function.[27] Even though the labeling and delineation of any given "ecosystem" may be a human construct that attempts to approximate natural conditions (perhaps in the same way that a map approximates the physical landscape that it represents), ecosystem categories do a better job of organizing the activities of human institutions with respect to natural resources and the environment than do conventional categories of government jurisdiction, or agency and organizational jurisdiction.[28]

25. *See generally* Karkkainen, *CEG*, *supra* note 16; *See also* NATIONAL RESEARCH COUNCIL, NEW STRATEGIES FOR AMERICA'S WATERSHEDS 2–3 (1999) [hereinafter NATIONAL RESEARCH COUNCIL, NEW STRATEGIES]; DAVID LEWIS FELDMAN, WATER POLICY FOR SUSTAINABLE DEVELOPMENT 286–87 (2007); Charles P. Lord et al., *Natural Cities: Urban Ecology and the Restoration of Urban Ecosystems*, 21 VA. ENVTL. L.J. 317, 325–27 (2003); William Goldfarb, *Watershed Management: Slogan or Solution?,* 21 B.C. ENVTL. AFF. L. REV. 483, 484 (1994); A. Dan Tarlock, *Putting Rivers Back in the Landscape: The Revival of Watershed Management in the United States*, 14 HASTINGS W.-N.W. J. ENVTL. L. & POL'Y 1059, 1059–60, 1063–64, 1067 (2008) [hereinafter Tarlock, *Rivers*]; J.B. Ruhl et al., *Proposal for a Model State Watershed Management Act*, 33 ENVTL. L. 929, 930–32 (2003).

26. For a variety of sources on the mismatch between fragmented political-legal-social scales of decision making and management and the scales at which nature is organized, particularly watersheds, see STEWARDSHIP ACROSS BOUNDARIES (Richard L. Knight & Peter B. Landres eds., 1998); THOMAS E. DAVENPORT, THE WATERSHED PROJECT MANAGEMENT GUIDE 1–3 (2003); Craig Anthony (Tony) Arnold, *Is Wet Growth Smarter Than Smart Growth?: The Fragmentation and Integration of Land Use and Water*, 35 ENVTL. L. REP. 10152 (2005) [hereinafter Arnold, *Wet Growth*]; Tarlock, *Rivers*, *supra* note 25, at 1059–60, 1063–64, 1067; Lord et al., *supra* note 25, at 325–27; Goldfarb, *supra* note 25, at 484; Ruhl et al., *supra* note 25, at 930–32.

27. Karkkainen, *CEG*, *supra* note 16, at 207 & n.44; MILLENNIUM ECOSYSTEM ASSESSMENT, ECOSYSTEMS AND HUMAN WELL-BEING A SYNTHESIS v (2005).

28. Karkkainen, *CEG*, *supra* note 16, at 200–04; JOHN COPELAND NAGLE & J.B. RUHL, THE LAW OF BIODIVERSITY AND ECOSYSTEM MANAGEMENT 318–34 (2nd ed. 2006).

Ecosystems can be specific places (e.g., "the greater Yellowstone ecosystem"; "the Chesapeake Bay ecosystem"), particular types of systems (e.g., Southeastern pine forests; Pacific Northwest old-growth forests), or general types of systems, such as "coasts and oceans, farmlands, forests, fresh waters, grasslands and shrub-lands, and urban and suburban landscapes."[29]

Watersheds are the ecosystems at which surface water processes and functions occur.[30] A watershed is an area of land that drains to a common point on a surface body of water, such as a river, stream, or lake.[31] Watersheds have nested scale, which means that smaller units are nested within larger units, which are nested within even larger units.[32] A typical, although by no means definitive, classification of watersheds would be that small catchments are nested within sub-watersheds, which area nested within watersheds, which are nested within sub-basins, which are nested within basins.[33] Thus, watersheds are primarily defined by their hydrology with respect to geography: the flow of water over land. However, watersheds are characterized by multiple processes and functions: including drainage, storage, filtration, biotic support, sediment, evapotranspiration, and energy cycles.[34] Increasingly, the classification of aquatic ecosystems by hierarchical nested scales is being challenged by

29. THE H. JOHN HEINZ III CENTER FOR SCIENCE, ECONOMICS AND THE ENVIRONMENT, HIGHLIGHTS: THE STATE OF THE NATION'S ECOSYSTEMS 2008: MEASURING THE LANDS, WATERS, AND LIVING RESOURCES OF THE UNITED STATES 3 (2008); *See also* MILLENNIUM ECOSYSTEM ASSESSMENT, *supra* note 27.

30. *See generally* Robert W. Adler, *Addressing Barriers to Watershed Protection*, 25 ENVTL. L. 973 (1995) [hereinafter Adler, *Watershed Protection*]; U.S. ENVTL. PROT. AGENCY, PROTECTING AND RESTORING AMERICA'S WATERSHEDS: STATUS, TRENDS, AND INITIATIVES IN WATERSHED MANAGEMENT, EPA–840–R–00–001 (2001) (hereinafter EPA, PROTECTING AND RESTORING); U.S. ENVTL. PROT. AGENCY, THE WATERSHED APPROACH (1996) (hereinafter EPA, WATERSHED APPROACH); DAVENPORT, *supra* note 26, at 21–35; FELDMAN, *supra* note 25, at 2–3, 36.

31. NATIONAL RESEARCH COUNCIL, NEW STRATEGIES, *supra* note 25, at 14; DAVENPORT, *supra* note 26, at 21; FELDMAN, *supra* note 25, at 36; Goldfarb, *supra* note 25.

32. JOHN RANDOLPH, ENVIRONMENTAL LAND USE PLANNING AND MANAGEMENT 255–58 (2004); DAVENPORT, *supra* note 26, at 23–24; NATIONAL RESEARCH COUNCIL, NEW STRATEGIES, *supra* note 25, at 37–54; Adler, *Watershed Protection*, *supra* note 30, at 1091 & n.742.

33. *See* RANDOLPH, *supra* note 32, at 255–58 (citing *inter alia* Tom Schueler, *Basic Concepts of Watershed Planning*, *in* THE PRACTICE OF WATERSHED PROTECTION 145–61 (T. Schueler & H. Holland eds., 2000) *and* U.S. ENVTL. PROT. AGENCY, WATERSHED ANALYSIS AND MANAGEMENT: A GUIDE FOR TRIBES (2000)).

34. John M. Blair et al., *Ecosystems as Functional Units in Nature*, 14 NATURAL RES. & ENV'T 150 (2000); C.E. Griffith et al., *Ecoregions, Watersheds, Basins, and HUCs: How State and Federal Agencies Frame Water Quality*, 54 J. SOIL & WATER CONSERVATION 666 (1999); Sandra Postel & Stephen Carter, *Freshwater Ecosystem Services, in* NATURE'S SERVICES: SOCIETAL DEPENDENCE ON NATURAL ECOSYSTEMS 195 (Gretchen C. Daily ed., 1997); NATIONAL RESEARCH COUNCIL, NEW STRATEGIES, *supra* note 25, at 42–43; Adler, *Watershed Protection*, *supra* note 34, at 1093–94.

concepts of hierarchical patch dynamics, which emphasize discontinuities, disequilibrium, complexity, and the role of functional features, such as geomorphology, hydrology, riparian conditions, and climate in forming mosaics of dynamic patches.[35]

Watersheds have become popular geographic and ecological units around which to organize various planning, decision making, management, restoration, and problem solving activities with respect to water and/or land.[36] The human

---

35. JAMES H. THORP ET AL., THE RIVERINE ECOSYSTEM SYNTHESIS: TOWARDS CONCEPTUAL COHESIVENESS IN RIVER SCIENCE 1–7 (2008).

36. The large number and range of scholarship on watershed-based actions demonstrates both the popularity and variety of watershed-based initiatives. *See* SWIMMING UPSTREAM: COLLABORATIVE APPROACHES TO WATERSHED MANAGEMENT (Paul A. Sabatier ed., 2005) [hereinafter SWIMMING UPSTREAM]; THE PRACTICE OF WATERSHED PROTECTION (T. Schueler & H. Holland eds., 2000); LARGE-SCALE ECOSYSTEM RESTORATION: FIVE CASE STUDIES FROM THE UNITED STATES (Mary Doyle & Cynthia A. Drew eds., 2008); EDELLA SCHLAGER & WILLIAM BLOMQUIST, EMBRACING WATERSHED POLITICS (2008); DOUGLAS S. KENNEY ET AL., THE NEW WATERSHED SOURCE BOOK (2000); Jeffrey A. Ballweber, *A Critique of Watershed Management Efforts in the Lower Mississippi Alluvial Plain,* 35 J. AM. WATER RES. ASS'N 643 (1999); James M. Burson, *Middle Rio Grande Regional Water Resource Planning: The Pitfalls and the Promises*, 40 NAT. RES. J. 533 (2000); Jon Cannon, *Choices and Institutions in Watershed Management*, 25 WM. & MARY ENVTL. L. & POL'Y REV. 379 (2000); John Cobourn, *Integrated Watershed Management on the Truckee River in Nevada*, 35 J. AM WATER RES. ASS'N 623 (1999); Tenley Conway, *Getting Watershed Management to Work: A Framework for Understanding Interorganizational Relationships*, 35 MIDDLE STATES GEOGRAPHER 1 (2002); S.A.K. Derrickson et al., *Watershed Management and Policy in Hawaii: Coming Full Circle*, 38 J. AM. WATER RES. ASS'N 563 (2002); Brent Foster, *The Failure of Watershed Analysis Under the Northwest Forest Plan: A Case Study of the Gifford Pinchot National Forest*, 5 HASTINGS W.-N.W. J. ENVTL. L. & POL'Y 337 (1999); Kara Gillon, *Watershed Down?: The Ups and Downs of Watershed Management in the Southwest*, 5 U. DENV. WATER L. REV. 395 (2002); C.B. Griffin, *Watershed Councils: An Emerging Form of Public Participation in Natural Resources Management*, 35 J. AM. WATER RES. ASS'N 505 (1999); Dawn Hottenroth et al., *Effectiveness of Integrated Stormwater Management in a Portland, Oregon, Watershed*, 35 J. AM. WATER RES. ASS'N 633 (1999); Douglas S. Kenney, *Historical and Sociopolitical Context of Western Watersheds Movement*, 35 J. AM. WATER RES. ASS'N 493 (1999); Peter Lavigne, *Watershed Councils East and West: Advocacy, Consensus and Environmental Progress*, 22 UCLA J. ENVTL. L. & POL'Y 301 (2004); J. Letey, *Science and Policy in Integrated Watershed Management: A Case Study*, 35 J. AM. WATER RES. ASS'N 603 (1999); Mark Lubell et al., *Watershed Partnerships and the Emergence of Collective Action Institutions*, 46 AM. J. POL. SCI. 148 (2002); Mark Lubell & Allan Fulton, *Local Policy Networks and Agricultural Watershed Management*, 18 J. PUB. ADMIN. RESEARCH & THEORY 673 (2007); Sean T. McAllister, *The Confluence of a River and a Community: An Experiment with Community-based Watershed Management in Southwestern Colorado*, 3 U. DENV. WATER L. REV. 287 (2000); Michael Vincent McGinnis et al., *Bioregional Conflict Resolution: Rebuilding Community in Watershed Planning and Organizing*, 24 ENVTL. MGMT. 1 (1999); D.R. Montgomery et al., *Watershed Analysis as a Framework for Implementing Ecosystem Management,* 31 WATER RES. BULL. 369 (1995); Michael W. Mullen & Bruce E. Allison, *Stakeholder Involvement and Social Capital: Keys to Watershed Management Success in Alabama*, 35 J. AM. WATER RES. ASS'N 655 (1999); Dave Owen, *Urbanization, Water Quality, and the Regulated Landscape,* 81 U. COLO. L. REV. (forthcoming 2010) [hereinafter Owen, *Urbanization*]; J.B. Ruhl, *The (Political) Science of Watershed Management in the Ecosystem Age*, 35 J. AM. WATER RES. ASS'N 519 (1999); MICHAEL SCOZZAFAVA, U.S. ENVTL. PROT. AGENCY, THE BEST WATERSHED-BASED PLANS IN THE NATION (2006); A. Dan Tarlock, *The Potential Role of Local Governments in Watershed Management*, 20 PACE ENVTL. L. REV. 149 (2002); Jack E. Williams et al., *Understanding Watershed-Scale Restoration, in* WATERSHED RESTORATION: PRINCIPLES

consumption, use, and management of water supplies affect the functioning, health, and integrity of watersheds.[37] Runoff patterns and land use, development, and management also have effects on the functioning, health, and integrity of watersheds.[38] Thus, it is not surprising that we have seen a proliferation of groups, collaborative processes, inter-jurisdictional efforts, institutions, and projects organized around watersheds.[39] Dan Tarlock has described this phenomenon as "the revival of watershed management in the United States."[40] Nationwide, the power of watersheds as organizing units for water and land management activities can be seen in the proliferation of research, ideas, and methods published by the Center for Watershed Protection, a nonprofit organization,[41] and the U.S. Environmental Protection Agency's Division of Watersheds.[42]

The term "watershed management" can be misleadingly simple, though. The general principle that water and the aquatic effects of land use and development should be managed or addressed at watershed scales is relatively sound. However, watersheds and their functions actually occur at multiple scales, and many different types of actions fall within the broad category of "watershed management."

Decisions to address human activities at watershed scales involve choices about scale. Given the nested nature of watersheds, decision makers must select a level for action that could range anywhere from a large river basin with extensive drainage to a relatively small sub-watershed.[43] Decision makers must also wrestle with the fact that many of the geographic boundaries of watersheds under the United States Geological Survey's Hydrologic Unit Code ("HUC") classification system are artificial, created more for human convenience than for reflecting physical drainage patterns.[44] Likewise, watershed delineations

---

AND PRACTICES 1 (Jack E. Williams et al. eds., 1997); L.P. Wagenet et al., *Adult Education and Watershed Knowledge in Upstate New York,* 35 J. AM. WATER RES. ASS'N 609 (1999); John T. Woolley et al., *The California Watershed Movement: Science and the Politics of Place*, 42 NAT. RES. J. 133 (2002);

37. *See, e.g.*, CRAIG ANTHONY (TONY) ARNOLD ET AL., KENTUCKY WET GROWTH TOOLS FOR SUSTAINABLE DEVELOPMENT: A HANDBOOK ON LAND USE AND WATER FOR KENTUCKY COMMUNITIES 6–49 (2009), and sources cited therein.

38. *See, e.g.*, *id*.

39. *See* sources cited *supra* note 36.

40. Tarlock, *Rivers, supra* note 25.

41. *See generally* The Center for Watershed Protection, http://www.cwp.org/, and the various links on this site.

42. *See generally* The U.S. Environmental Protection Agency, Watersheds, http://www.epa.gov/owow/watershed/, and the various links on this site.

43. *See generally* Craig Anthony (Tony) Arnold, *Clean-Water Land Use: Connecting Scale and Function*, 23 PACE ENVTL. L. REV. 291 (2006) [hereinafter Arnold, *Clean-Water Land Use*].

44. *See* Griffith et al., *supra* note 34, at 667–68.

reflect surface water drainage that does not correspond precisely with interconnected groundwater flows and processes.[45] Aquifers and other groundwater supplies may be partially or mostly located under lands in one watershed, but have relatively significant hydrological relationships with surface waters that exist in another watershed.[46]

Decisions to address human activities at watershed scales also involve choices about the characteristics of the watershed that will be the focus of watershed-based management. A variety of hydrological and social phenomena occur within watersheds. Watershed functions and processes include water drainage, water storage, flood mediation and management, filtration of sediment and pollutants, support of biological life, sediment load, evapotranspiration, and energy generation and flows, among others.[47] A truly comprehensive effort to conserve and protect the health and integrity of all of a watershed's functions is a large and potentially overwhelming task. The range of human activities affecting watersheds is quite broad and includes: (1) the diversion, pumping, and consumptive uses of water; (2) water development projects and waterway alterations: (3) instream flow programs, including ecological and species protection, dredging for commercial navigation, fishing operations, and opportunities for recreational boating; (4) flood and runoff control; (5) land use and development patterns; (6) forestry, mining, and agricultural methods; and (7) introduction of pollutants into waterways, either direction or indirectly.[48] Likewise, natural events that can substantially alter a watershed's hydrology, perhaps in synergy with human-created effects, include floods, major storms, hurricanes, and drought.[49] Moreover, watershed characteristics selected for management may be defined, at least partly, with respect to social phenomena. These phenomena might include local culture and the ways by which a particular community defines itself with respect to waters; political objectives within or among particular units of government; and the available resources, expertise, or legal authority to address particular aspects of a watershed.[50]

Moreover, there are many different meanings to the "management" portion of watershed management. Many different types of actions are organized around and occur at

---

45. *See* NATIONAL RESEARCH COUNCIL, NEW STRATEGIES, *supra* note 25, at 41.

46. *Id.*

47. *See*, *e.g.*, Postel & Carter, *supra* note 47; Arnold, *Clean-Water Land Use*, *supra* note 43, at 318–20.

48. *See generally* ARNOLD ET AL., *supra* note 37, at 6–49, and sources cited therein.

49. *Id.*

50. *Id.*

watershed scales, depending on: (1) socio-cultural and political forces and demands; (2) the structures and functions of the relevant institutions; (3) the available resources, expertise, and legal authority; and (4) the ways by which individuals, groups, communities, and organizations frame problems regarding watersheds.[51] The following list, while likely not exhaustive, reflects the many different actions that might be included in a relatively inclusive category of "watershed management":

- water supply planning
- water supply allocations
- water supply storage and control
- water development and manipulation
- restoration of waterway conditions or particular watershed features
- flood control
- stormwater runoff control
- pollution control generally
- nonpoint source pollution control
- ambient water quality planning
- ambient water quality regulation and treatment
- public land management
- growth and development planning
- land use regulation
- study
- monitoring
- education and public engagement
- incentive programs
- advocacy
- dispute resolution
- collaboration and inter-entity cooperation.52

For example, each of the following could be characterized as "watershed management": large-scale ecosystem restoration projects, such as the Comprehensive Everglades Restoration Plan[53] or the Upper Mississippi River Basin ecosystem restoration project[54]; an interstate river commission created by interstate compact to control water diversions and uses, such as the Delaware River Basin Commission[55]; multi-participant

51. *See* sources cited *supra* note 36.
52. *See id.*
53. LARGE-SCALE ECOSYSTEM RESTORATION, *supra* note 36, at 1–53.; LAYZER, *supra* note 53, at 103–36; Light, *supra* note 4; Chrisine A. Klein, *On Integrity: Some Considerations for Water Law*, 56 ALA. L. REV. 1009, 1015–17 (2005).
54. LARGE-SCALE ECOSYSTEM RESTORATION, *supra* note 36, at 225–89.
55. Delaware River Basin Compact, Pub. L. No. 87–328, 75 Stat. 688 (1961); Dellapenna, *Interstate Struggles*, *supra* note 3, at 831, 840–49;

groups or councils created to plan, manage, or resolve disputes over competing uses of waters in a watershed, such as the Middle Rio Grande Water Assembly in New Mexico,[56] multi-participant cooperation and perhaps even the creation of a watershed-based management entity to protect water quality and control urban or agricultural runoff in the shadow of Clean Water Act requirements for Total Maximum Daily Loads ("TMDLs"), National Permit Discharge Elimination System ("NPDES") permits, and storm water ("MS4") permits or state regulation, as in the case of Long Creek in Maine[57] or the Sacramento Valley Water Quality Coalition in California[58]; comprehensive integrated multi-participant planning processes for watersheds, perhaps authorized or required by state law, such as the State of Washington's Water Resource Inventory Areas program[59]; federal agencies' management of public lands and resources by assessing and protecting watershed features, such as watershed analyses and management of the Gifford Pinchot National Forest under the Northwest Forest Plan[60]; the adoption of land use and development regulations to protect watershed features or applicable in certain sensitive watershed zones, such as the Chatham County (North Carolina) Watershed Protection Ordinance[61] or New York City's extraterritorial land-use regulatory and eminent domain powers in the source watershed for its drinking water supplies[62]; and watershed protection advocacy groups formed around particular watersheds, such as the Connecticut River Watershed Council and the Nashau River Watershed Association.[63] John Cobourn's study of integrated watershed management in the Truckee River basin in Nevada encompasses nine different watershed projects occurring within the basin: (1) the Truckee River Operating Agreement; (2) Steamboat Creek Restoration Plan; (3) Small Ranch Water Quality Program; (4) Storm Drain Stenciling Program; (5) Champions of the Truckee Program; (6) Truckee River Habitat Restoration Group; (7) Regional Water Management Plan; (8) Emergency Response Planning; and (9) Lower River Restoration.[64]

---

56. Burson, *supra* note 36, at 554–67.
57. Owen, *Urbanization*, *supra* note 36.
58. Lubell & Fulton, *supra* note 36, at 674, 678–79.
59. Watershed Planning Act, WASH. REV. CODE ANN. § 90.82 (2004).
60. *See generally* Foster, *supra* note 36.
61. Chatham County Watershed Protection Ordinance (1993, rev. 2009).
62. NATIONAL RESEARCH COUNCIL, WATERSHED MANAGEMENT FOR POTABLE WATER SUPPLY: ASSESSING THE NEW YORK CITY STRATEGY (2000).
63. Lavigne, *supra* note 36, at 307–08.
64. Cobourn, *supra* note 64, at 627–31.

Not surprisingly, few definitive conclusions can be made about the effectiveness of watershed management, because so many different activities and efforts could fall within this broad category. Some watershed-based efforts at resource management and conservation have enjoyed noteworthy success, and some have been noteworthy failures.[65] A number of different variables could account for the differences. In addition, evaluators do not agree on a number of different possible criteria to evaluate watershed management, which reflects differences in expectations about what watershed management should achieve.[66]

65. *Compare* the studies cited *supra* note 36 (evaluating the wide range of outcomes from watershed-base actions).

66. For example, compare the differing conclusions that commentators have reached about some large-scale and prominent watershed initiatives. On the Chesapeake Bay Program: Cannon, *supra* note 36, at 394–407 (generally successful); Erin Ryan, *New Orleans, The Chesapeake, and the Future of Environmental Assessment: Overcoming the Natural Resources Law of Unintended Consequences*, 40 U. RICH. L. REV. 981, 982–85, 1003–16 (2006) (wetland loss due to unintended consequences of well-intentioned wetlands protection policies); HOWARD R. ERNST, CHESAPEAKE BAY BLUES: SCIENCE, POLITICS, AND THE STRUGGLE TO SAVE THE BAY 130–52 (2003) (extensive analyses of history, successes, failures, and ongoing challenges, with overall favorable assessment but recommendations for specific improvements to the existing framework); U.S. GEN. ACCOUNTING OFFICE, GAO–06–96, CHESAPEAKE BAY PROGRAM: IMPROVED STRATEGIES ARE NEEDED TO BETTER ASSESS, REPORT, AND MANAGE RESTORATION PROGRESS 13–35 (2005) (analyzing underperformance and management problems). On the Comprehensive Everglades Restoration Plan CERP: JUDITH A. LAYZER, NATURAL EXPERIMENTS: ECOSYSTEM-BASED MANAGEMENT AND THE ENVIRONMENT 103–36 (2008) (few tangible gains from collaborative ecosystem restoration planning process); Klein, *supra* note 53, at 1031–32 (a promising opportunity); Sandra 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, 934–42 (2009) (too many compromises and bureaucratic inertia); J. Walter Milon et al., *Adaptive Ecosystem Management and the Florida Everglades: More Than Trial-and-Error?*, 113 WATER RES. UPDATE 37 (1998) (engineering biases in CERP); Light, *supra* note 4, at 256–58, 270–74 (restoration process lacks dispute resolution mechanisms and substantive sustainability rules); Salt et al., *supra* note 36, at 5, 27–31 (identifying ten success lessons from the creation of CERP); Christa L. Zweig & Wiley M. Kitchens, *The Semiglades: The Collision of Restoration, Social Values, and the Ecosystem Concept*, 18 RESTORATION ECOLOGY 138, 140–41 (2010) (concluding that the ecosystem restoration goals of CERP are impossible to achieve, because ecosystem changes prevent return to pre-disturbance conditions).
On the California Bay-Delta Accord (CALFED): FELDMAN, *supra* note 25, at 154–170 (a major achievement in introducing collaborative adaptive management to complex water conflicts in the Western U.S., somewhat successful in some particular respects, and too soon to tell if significant challenges can be overcome); LAYZER, *supra* note 66, at 137–71 (fails to prevent or reduce serious ecological stresses on Bay-Delta system due to primacy of gaining consensus); Jody Freeman & Daniel A. Farber, *Modular Environmental Regulation*, 54 DUKE L.J. 795, 837–76 (2005) (a model of modular environmental regulation that overcomes the constraints of inflexible approaches); Dave Owen, *Law, Environmental Dynamism, Reliability: The Rise and Fall of CALFED*, 37 ENVTL. L. 1145 (2007) (assessing CALFED as a failure); Elizabeth Ann Rieke, *The Bay-Delta Accord: A Stride Toward Sustainability*, 67 U. COLO. L. REV. 341 (1996) (assessing CALFED as a success); David E. Booher & Judith E. Innes, *Complexity and Adaptive Policy Systems: CALFED as an Emergent Form of Governance for Sustainable Management of Contested Resources*, IURD Working Paper Series, Institute of Urban and Regional Development, UC Berkeley (2006), *available at*

For example, Judith Layzer's excellent set of case studies of collaborative ecosystem-based management evaluated whether collaborative management at both aquatic and terrestrial ecosystem levels (including some watershed management efforts) achieved improved environmental conditions.[67] However, her study did not control for the degree of decline already underway or projected for the ecosystem conditions, thus ignoring the potential that some of the collaborative ecosystem-based management efforts were successful at avoiding or reducing likely harms. In addition, she acknowledges that her study is limited in time and space.[68] Thus, it possibly misses positive effects that emerge over time or across geographic scales, including the creation or strengthening of networks and institutions, evaluative feedback about what works and what does not work that can be applied in other circumstances, and long-term but gradual or delayed improvements in watershed conditions.

Furthermore, the framing of the problem(s) and desired outcome(s) makes a difference. A watershed evaluator who is concerned with protecting water quality at watershed levels is likely to be disappointed with watershed management aimed primarily at water supplies and uses. A watershed-based public education campaign may seem modest when compared to statutory reforms that create regional water management districts with regulatory authority to mandate conservation, but may seem substantial when compared to previously unsuccessful locality-specific conservation education campaigns. In short, point of reference makes a great difference when evaluating whether watershed management is as successful as it is popular.

III. ADAPTIVE MANAGEMENT

Adaptive management is accepted today as the preferred method of ecosystem management, particularly by scholars and resource managers.[69] More particularly for watersheds,

---

http://www.csus.edu/ccp/publications/isss_complexity_and_adaptive_policy_systems.pdf (example of increasingly needed form of collaborative complex adaptive system governance); Holly Doremus, *CALFED and the Quest for Optimal Institutional Fragmentation*, 12 ENVTL. SCI. & POL'Y 729 (2009) (offering a nuanced assessment of CALFED's successes and failures) [hereinafter Doremus, *CALFED*].

67. *See* LAYZER., *supra* note 66.

68. *Id.* at 32–40, 267–92.

69. Karkkainen, *AEM*, *supra* note 16, at 945–48; NAGLE AND RUHL, *supra* note 28, at 350–56; NICK SALAFSKY ET AL., ADAPTIVE MANAGEMENT: A TOOL FOR CONSERVATION PRACTITIONERS (2001).

"adaptive management is the preferred policy approach for any watershed management."[70] Prominent conservation biologist Ed Grumbine summarizes adaptive ecosystem management: "Adaptive management assumes that scientific knowledge is provisional and focuses on management as a learning process or continuous experiment where incorporating the results of previous actions allows managers to remain flexible and adapt to uncertainty."[71] More specifically, Jack Ahern summarizes the essence of adaptive management of natural resources:

> Adaptive management re-conceives management actions as experiments that have testable hypotheses. Whereas traditional management hesitated to apply new policy decisions until proof of efficacy was obtained through long and short-term empirical studies, adaptive management is a proactive method under which projects and policy decisions are used as "experimental probes," to learn by doing. Data made available upon the outcome of each policy decision or model implemented are used to structure alternative and future choices, attempting to reduce the amount of uncertainty and improve ecological knowledge and understanding over time. Monitoring is the primary tool used to gauge the efficacy of decisions made, and is itself subject to a wide range of uncertainty. In the adaptive approach, uncertainty lies in determining appropriate systems or populations of study, spatial-temporal scales, and geographic extent.[72]

The central feature of adaptive management is "learning while doing."[73] It is by nature experimentalist, incrementalist, evolutionary, interdisciplinary, and iterative.[74] In the environmental and natural resources fields, this method was conceptualized by C.S. "Buzz" Holling in his classic book

---

70. Arnold, *Clean-Water Land Use*, *supra* note 43, at 322.

71. Edward Grumbine, *What Is Ecosystem Management?*, 8 CONSERV. BIOLOGY 27, 31 (1994).

72. Jack Ahern, *Theories, Methods and Strategies for Sustainable Landscape Planning*, *in* FROM LANDSCAPE RESEARCH TO LANDSCAPE PLANNING: ASPECTS OF INTEGRATION, EDUCATION, AND APPLICATION 119, 129 (Bärbel Tress et al. eds., 2006) (citations omitted).

73. Holly Doremus, *Precaution, Science, and Learning While Doing in Natural Resource Management*, 82 WASH. L. REV. 547, 550 (2007). *See also* Ahern, *supra* note 72, at 129.

74. *See generally* J.B. Ruhl, *Regulation by Adaptive Management – Is It Possible?*, 7 MINN. J. L. SCI. & TECH. 21, 28 (2005); Robert Fischman & J.B. Ruhl, *Adaptive Management in the Courts*, 95 MINN. L. REV. (forthcoming 2010); Nagle & Ruhl, *supra* note 28, at 350–56; Ahern, *supra* note 72, at 129; Karkkainen, *AEM*, *supra* note 16, at 943–53; Karkkainen, *CEG*, *supra* note 16, at 199–206.

Adaptive Environmental Assessment and Management.[75] However, its theoretical foundations have some history in an influential public-administration critique of comprehensive rational planning and proposal of an alternative incrementalist management method of addressing problems as they arise: Charles Lindblom's "The Science of 'Muddling Through.'"[76] More broadly, as Brad Karkkainen points out, its theoretical foundations rest in Deweyan pragmatism and John Dewey's concepts of each social policy as an experiment to be evaluated and revised and each legal rule or principle as a working hypothesis to be tested in concrete applications.[77]

The scientific, management, and policy foundations of adaptive management have combined a model of ecological systems with a model of human cognition and decision making. The lessons of science and ecology are that ecosystems are complex and dynamic, characterized by: (1) nonlinear and unpredictable change; (2) many interconnections that cross scales of time, space, natural processes, and societal dynamics and effects; (3) organization by nested scales, networks, mosaics, shifting patches, and nonlinear transition; (4) feedback effects; and (5) phenomena that may lack analogies in past experience, data, and models.[78] The lessons of psychology, management, public administration, and organizational and human behavior focus on the inherent limits to human cognition and decision making capacity.[79] They emphasize the limits to human capacity to grasp, know, model, and plan rationally and comprehensively.[80] They also emphasize the provisional and evolving nature of human knowledge and analytical methods.[81] Human actions with respect to the environment have complex, interconnected, dynamic, and multiscalar causes and effects, including often unexpected effects on the environment.[82]

75. C.S. HOLLING ET AL., ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (C.S. Holling ed., 1978). Another early conceptualization, particularly as applied to resource management, was CARL WALTERS, ADAPTIVE MANAGEMENT OF RENEWABLE RESOURCES (1986). *See also* Kai N. Lee & Jody Lawrence, *Adaptive Management: Learning from the Columbia River Basin Fish and Wildlife Program*, 16 ENVTL. L. 431 (1986).

76. Lindblom, *supra* note 19.

77. Karkkainen, *AEM*, *supra* note 16, at 945, 956–60.

78. *Id.* at 945–48; DISCONTINUITIES IN ECOSYSTEMS AND OTHER COMPLEX SYSTEMS (Craig R. Allen & C.S. Holling eds., 2008); HOLLING ET AL., *supra* note 75, at 25–26.

79. *See, e.g.*, JAMES G. MARCH & HERBERT A. SIMON, ORGANIZATIONS 203–10 (1958); Christine Jolls et al., *A Behavioral Approach to Law and Economics*, 50 STAN. L. REV. 1471 (1998).

80. For a discussion of bounded rationality, see MARCH & SIMON, *supra* note 79, at 203–10; Jolls et al., *supra* note 79, at 1477–79; Lindblom, *supra* note 19.

81. *See* Karkkainen, *AEM*, *supra* note 16, at 945–48.

82. On the uncertainties, complexities, and dynamics of complex adaptive social systems and complex adaptive ecological systems interacting with one another, see

Adaptive management and its foundations reject the efficacy of long-term, comprehensive, static plans, because they are based on: (1) a set of unjustified assumptions about relatively stable conditions; (2) inaccurate models of predictable linear patterns of change in both nature and society; and (3) misplaced faith in the cognitive, predictive, and performance capacities of humans and ecosystem management organizations.[83]

With respect to water management, in particular, experts have boldly proclaimed that "stationarity is dead."[84] Stationarity is "the idea that natural systems fluctuate within an unchanging envelope of variability."[85] These experts have called for replacing equilibrium models with dynamic models and for replacing static plans with a focus on adaptation and resilience in the face of uncertain change.[86] In environmental and natural resources more generally, experts have warned that we are facing the "no-analog future": a future of changing conditions, including climate change, for which we have no analogies to understand, model, or predict.[87]

Adaptive management has several limits, though, despite its theoretical foundations and popularity as the so-called "preferred" method of environmental and natural resource management. Not much adaptive management is actually occurring, particularly among federal agencies charged with managing natural resources and environmental conditions. A recent study by Rob Fischman and J.B. Ruhl shows that, at best, federal agencies are applying an "adaptive management lite," a kind of ad hoc contingency planning, but not the adaptive management methods envisioned by the scholarly and

---

generally PANARCHY: UNDERSTANDING TRANSFORMATIONS IN HUMAN AND NATURAL SYSTEMS (Lance H. Gunderson & C.S. Holling eds., 2002); LINKING SOCIAL AND ECOLOGICAL SYSTEMS: MANAGEMENT PRACTICES AND SOCIAL MECHANISMS FOR BUILDING RESILIENCE (Fikret Berkes et al. eds., 1998); SCHLAGER & BLOMQUIST, *supra* note 36; J.B. Ruhl & James Salzman, *Climate Change, Dead Zones, and Massive Problems in the Administrative State: A Guide for Whittling Away*, 98 CAL. L. REV. 59 (2010).

83. For adaptive management critiques of conventional planning, see, e.g., Camacho, *Adapting Governance, supra* note 14, at 37–38; J.B. Ruhl, *Taming the Suburban Amoeba in the Ecosystem Age: Some Do's and Don'ts*, 3 WIDENER L. SYMP. J. 61, 70–78 (1998). For planning critiques of conventional planning, see e.g., Paramjit S. Sachdeva, *Development Planning – An Adaptive Approach*, LONG RANGE PLANNING, Oct. 1984, at 96, 96; John Friedmann, *A Conceptual Model for the Analysis of Planning Behavior*, ADMIN. SCI. Q. Sept. 1967, at 225, 225–26.

84. P.C.D. Milly et al., *Stationarity is Dead: Whither Water Management*, 319 SCI. 573 (2008); Craig, *Stationarity*, *supra* note 13.

85. Milly et al., *supra* note 84, at 573.

86. *See generally* Milly et al., *supra* note 84; Craig, *Stationarity*, *supra* note 13.

87. J.B. Ruhl, *Climate Change and the Endangered Species Act: Building Bridges to the No-Analog Future*, 88 B.U. L. REV. 1, 11 (2008); Douglas Fox, *Back to the No-Analog Future?*, 316 SCI. 823 (2007).

professional literature on it.[88] Alex Camacho has studied several different collaborative ecosystem management initiatives, finding that each is inadequately adaptive and fails to completely incorporate core adaptive management features.[89] However, Mary Jane Angelo offers a different perspective on the St. Johns River Water Management District's restoration of Lake Apopka in Florida.[90] She views the failures and setbacks of the District's restoration project as part of the adaptive management process of institutional learning.[91] In a prior article, Angelo observed that adaptive management has proven effective in natural resource management, even though its use in traditional environmental law has been limited.[92]

Moreover, some advocates of environmental conservation worry that adaptive management is or will be a management method without standards, which accommodates environmental degradation with its incrementalist refusal to take bold protectionist measures. These criticisms, when probed carefully, reveal several different concerns with adaptive management. One concern is that adaptive management is based largely on anthropocentric assessments about environmental protection and resource management goals, instead of embodying ecocentric ethics.[93] However, this criticism can be made about all or nearly all aspects of environmental and natural resources law and policy in the United States.

Another concern is that adaptive management fails to implement fixed and specific environmental conservation goals, instead allowing for evolving definitions of vague terms like "ecological integrity" and "ecosystem resilience."[94] A similar

88. Fischman & Ruhl, *supra* note 74.

89. Camacho, *Adapting Governance, supra* note 14, at 36–50, 55–64 (critiquing ecosystem management of the Great Lakes, the Colorado River, the Climate Ready Estuaries Program, and the Charlotte Harbor Estuary); Alejandro E. Camacho, *Can Regulation Evolve?: Lessons From a Study in Maladaptive Management*, 55 UCLA L. REV. 293, 335–44 (2007) (determining that the Endangered Species Act's Habitat Conservation Plan program is maladaptive); Lawrence Susskind et al., *Collaborative Planning and Adaptive Management in Glen Canyon: A Cautionary Tale*, 35 COLUM. J. ENVTL. L. 1, 2–7 (2010) (co-authored study of the Glen Canyon Dam and the Colorado River).

90. Mary Jane Angelo, *Stumbling Toward Success: A Story of Adaptive Law and Ecological Resilience*, 87 NEB. L. REV. 950 (2009).

91. *Id.* at 1005–06.

92. Mary Jane Angelo, *Harnessing the Power of Science in Environmental Law: Why We Should, Why We Don't, and How We Can*, 86 TEX. L. REV. 1527, 1552 (2008).

93. *See, e.g.*, Bruce Pardy, *Changing Nature: The Myth of the Inevitability of Ecosystem Management*, 20 PACE ENVTL. L. REV. 675, 675–79 (2003); Thomas R. Stanley, Jr., *Ecosystem Management and the Arrogance of Humanism*, 9 CONSERV. BIOLOGY 255, 256 (1995); Walter Kuhlmann, *Making the Law More Ecocentric: Responding to Leopold and Conservation Biology*, 7 DUKE ENVTL. L. & POL'Y F. 133, 136 (1996).

94. Annecoos Wiersema, *A Train Without Tracks: Rethinking the Place of Law and Goals in Environmental and Natural Resources Law*, 38 ENVTL. L. 1239 (2008).

concern is that adaptive management efforts lack adequate centralized authority, resources, and accountability.[95] Both of these concerns, though, also apply to most alternative forms of environmental protection and natural resources management. Environmental conservation goals in U.S. legal, political, and other social institutions are ever evolving and contested, despite statements of goals in environmental statutes that turn out to be mutable, malleable, and under-implemented. Environmental law and natural resources management are notoriously fragmented, whether their form is command-and-control regulation, federal-agency management, judicial doctrines, government funding and incentives, and other types.[96] Likewise, all programs, policies, and agencies are underfunded; it would be rare to find an example of legal or policy scholarship making the case that a worthwhile endeavor has received adequate resources from Congress or other government funding sources. There is no unitary all-powerful actor that is going to force environmental law and natural resources management to become more adequately adaptive or fully accountable to environmental conservation goals. Power is shared among branches of government and social, political, legal, economic, and cultural institutions in society. Even the outputs of any one institution, such as Congress or the federal courts, are the result of a multitude of forces and decision makers, not the rational selection of an optimal policy by a single decision maker.[97] Thus, the many concerns about the inadequacies of adaptive management turn out to be versions of larger concerns about the inadequacies, complexities, and evolution of institutions in U.S. society.

However, two critiques of "standardless" adaptive management deserve a closer look. One is that much of the literature on adaptive management stresses collaborative

---

95. Camacho, *Adapting Governance, supra* note 14, at 37–39; Cameron Holley, *Facilitating Monitoring, Subverting Self-Interest and Limiting Discretion: Learning From "New" Forms of Accountability in Practice*, 35 COLUM. J. ENVTL. L. 127 (2010).

96. *See, e.g.*, RICHARD J. LAZARUS, THE MAKING OF ENVIRONMENTAL LAW 29–42 (2004); Jody A. Freeman & Daniel Farber, *Modular Environmental Regulation*, 54 DUKE L.J. 795, 806–813 (2005); Holly Doremus, C*rossing Boundaries: Commentary on "The Law at the Water's Edge," in* WET GROWTH: SHOULD WATER LAW CONTROL LAND USE? 271 (Craig Anthony (Tony) Arnold ed., 2005); William W. Buzbee, *Recognizing the Regulatory Commons: A Theory of Regulatory Gaps*, 89 IOWA L. REV. 1, 22–27 (2003); Camacho, *Adapting Governance*, *supra* note 14, at 25–28.

97. Zygmunt J.B. Plater, *Environmental Law in the Political Ecosystem – Coping with the Reality of Politics*, 19 PACE ENVTL L. REV. 423 (2002); Richard J. Lazarus, *Super Wicked Problems and Climate Change: Restraining the Present to Liberate the Future*, 94 CORNELL L. REV. 1153, 1179–84 (2009); Craig Anthony (Tony) Arnold, *Working Out an Environmental Ethic: Anniversary Lessons from Mono Lake*, 4 WYO L. REV. 1 (2004) [hereinafter Arnold, *Working Out*].

decision making and management as fundamental features of adaptive management,[98] which critics contend undermines serious environmental protection and favors the status quo.[99] To some degree, there may simply be a conflation of adaptive ecosystem management and collaborative ecosystem management: two different methods of resource management that do not have to be merged.[100]

The conflation seems relatively widespread in both theory and practice, though, and thus requires a more searching inquiry about what is meant by "collaboration."[101] To the extent that collaborative management processes require consensus among all affected parties with respect to decision making, goal setting, and choice of implementation and management actions,[102] the critics have legitimate concerns. Existing users of resources are likely

---

98. *See, e.g.*, JULIA M. WONDOLLECK & STEVEN L. YAFFEE, MAKING COLLABORATION WORK: LESSONS FROM INNOVATION IN NATURAL RESOURCE MANAGEMENT (2000); BIOLOGICAL DIVERSITY: BALANCING INTERESTS THROUGH ADAPTIVE COLLABORATIVE MANAGEMENT (Louise E. Buck et al. eds., 2001); ROBERT J. MASON, COLLABORATIVE LAND USE MANAGEMENT: THE QUIETER REVOLUTION IN PLACE-BASED PLANNING (2008); Karkkainen, *CEG*, *supra* note 14, at 193–94. Many watershed management processes involve collaboration. *See, e.g.*, SWIMMING UPSTREAM, *supra* note 36; SCHLAGER & BLOMQUIST, *supra* note 36, at 40–44, 64–65. Cannon, *Choices and Institutions*, *supra* note 36, at 379; Mark Lubell et al., *Watershed Partnerships and the Emergence of Collective Action Institutions*, 46 AM. J. POL. SCI. 148 (2002); Jason Thomas, *The Plan's the Thing: Linking Collaborative Watershed Planning Processes to Plan Contents and Implementation*, paper delivered at the Western Political Science Association Conference, March 2008. *But see* Lavigne, *supra* note 36, at 307–11 (contrasting advocacy-oriented watershed councils in the Eastern U.S. with collaborative multi-stakeholder watershed councils in the Western U.S.). Collaboration as a part of environmental and natural resources governance more broadly is a component of New Governance theories. *See, e.g.*, Jody Freeman, *Collaborative Governance in the Administrative State*, 45 UCLA L. REV. 1, 22–23, 33–34 (1997); Ruhl & Salzman, *supra* note 82, at 106–07; Bradley C. Karkkainen, *"New Governance" in Legal Thought and in the World: Some Splitting as Antidote to Overzealous Lumping*, 89 MINN. L. REV. 471 (2004).

99. LAYZER, *supra* note 66, at 30–31; George Cameron Coggins, *Of Californicators, Quislings, and Crazies: Some Perils of Devolved Collaboration*, *in* ACROSS THE GREAT DIVIDE: EXPLORATIONS IN COLLABORATIVE CONSERVATION AND THE AMERICAN WEST 163–71 (Philip Brick et al. eds., 2001); David J. Sousa & Christopher McGrory Klyza, *New Directions in Environmental Policy Making: An Emerging Collaborative Regime or Reinventing Interest Group Liberalism?*, 47 NAT. RES. J. 377, 440 (2007); Cary Coglianese, *The Limits of Consensus*, ENV'T Apr. 1999, at 28; Cary Coglianese, *Is Consenus an Appropriate Basis for Regulatory Policy?*, *in* ENVIRONMENTAL CONTRACTS 93–113 (Eric W. Orts & Kurt Deketelaere eds., 2001); Zellmer & Gunderson, *supra* note 66, at 929–34; Lavigne, *supra* note 36, at 316–17.

100. *See, e.g.,* Joseph M. Feller, *Collaborative Management of Glen Canyon Dam: The Elevation of Social Engineering Over Law*, 8 NEV. L.J. 896, 933–38 (2008).

101. For examples of inquiries into the multiple meanings of collaboration, see, e.g., Ann Marie Thomson et al., *Conceptualizing and Measuring Collaboration*, 19 J. PUB. ADMIN. RESEARCH & THEORY 23 (2007); Chris Ansell & Allison Gash, *Collaborative Governance in Theory*, 18 J. PUB. ADMIN. RESEARCH & THEORY 543 (2007).

102. For treatments of "collaboration" as meaning "consensus," see, e.g., SCHLAGER & BLOMQUIST, *supra* note 36, at 40–44, 64–65; Karkkainen, *CEG*, *supra* note 16, at 240 (noting, though, that there are both hard and soft consensus processes); Griffin, *supra* note 36, at 514 (comparing advantages and disadvantages of consensus decision making processes in watershed planning).

to resist reduction or elimination of their uses, thus precluding consensus. Agreement on vague, general, or non-implementable goals is more likely to be reached than hard and specific choices about trade-offs, costs, and constraints. The reaching of consensus agreement can be perceived as a major break-through, and the parties can largely stop there, failing to engage in the long and challenging work of actually implementing the agreement through experimentation, feedback loops, learning, and adjustment.

However, collaboration could mean something else. It could mean cooperative action, in contrast to adversarial, competitive, or uncooperative behaviors.[103] In this respect, collaboration may be a necessary component of iterative adaptive management processes that could also include conflict, litigation, political activism, advocacy, top-down regulation, and other such features.[104] Alternatively, it could simply mean multi-participant: all affected parties have some meaningful opportunity to have input into decision making and management activities, even if they do not all agree with the decisions made or actions taken.[105] Given the scope of adaptive management activities, widespread engagement of participants may be necessary. Moreover, collaboration may be more about the use of diverse and diffuse sources of knowledge and expertise to engage in learning and adaptation through networks, instead of relying solely on centralized and narrowly bounded expert managers.[106] Each of these three possible meanings of collaboration can actually contribute to adaptive management's capacity to achieve environmental protection or sound resource management goals,

---

103. *See e.g.*, SWIMMING UPSTREAM, *supra* note 36 (collection of studies that, while acknowledging some watershed processes seek consensus, generally treat "collaboration" as synonymous with "cooperation" that can appear in many different processes and forms).

104. *See, e.g.*, Arnold, *Working Out, supra* note 97 (collaboration as one critical but insufficient element of multiple forces needed for environmental conservation outcome to water-resource conflict, with other forces including litigation, political advocacy and leadership, public education and engagement, scientific research, and the psychology of place).

105. For works treating collaboration as more as participatory and multi-participant than as necessarily consensual, see, e.g., ADAPTIVE CO-MANAGEMENT: COLLABORATION, LEARNING, AND MULTI-LEVEL GOVERNANCE (Derek Armitage et al. eds., 2007); MASON, *supra* note 98, at 43–46; William D. Leach, *Is Devolution Democratic?: Assessing Collaborative Environmental Management* (Cal. State Univ., Sacramento – Dep't of Pub. Policy & Admin., Ctr. for Collaborative Policy Working Paper Series, 2004), *available at* http://ssrn.com/abstract=628122**.** .

106. *See, e.g.*, BRIDGING SCALES AND KNOWLEDGE SYSTEMS: CONCEPTS AND APPLICATIONS IN ECOSYSTEM ASSESSMENT (Walter V. Reid et al. eds., 2006); ADAPTIVE CO-MANAGEMENT, *supra* note 105, at 87–89; David Feldman & Helen Ingram, *Making Science Useful to Decision Makers: Climate Forecasts, Water Management, and Knowledge Networks*, 1 WEATHER, CLIMATE, & SOC'Y 9 (2009); Lubell & Fulton, *supra* note 36, at 693.

provided that neither collaboration or flexibility become the primary goals in themselves.

More generally, though, adaptive management may be morphing into a form that misunderstands or misapplies its conceptual foundations. Adaptive management runs the risk of being an anti-planning, ad hoc, reactive experimentalism that has given up on goal-setting and on prediction and modeling altogether.[107] Legitimate concerns about the efficacy of comprehensive, static plans and predictive models based on historic data and equilibriums can slide into a rejection of all planning and deep cynicism about the benefits of prediction and modeling efforts at all. Moreover, adaptive management in practice can focus primarily on small-scale, immediate, reactive, or passive management activities.[108] All of these developments together deter ecosystem managers from robust levels of learning, evaluation, improvement of knowledge and models, goal-setting, and re-evaluation of objective and criteria.[109] The roles of adaptive management in improving scientific knowledge, decision making, and management methods can remain unfulfilled, while responses to uncertainty and change become "do nothing," "do business as usual," or "do whatever you want."[110] The "science of muddling through" becomes the "science of drifting along." This is not what adaptive management is meant to be, but a misunderstood or misapplied concept of adaptive management could couple with post-modern influences on public policy and law – there is no objective science, common knowledge, or agreed-upon goals and values – to undermine ecosystem conservation and rational science-based resource management.[111]

---

107. *See, e.g.*, Sachdeva, *supra* note 83, at 96 (calling attention to differences between adaptive management methods integrated with adaptive planning, and an anti-planning "muddling-through incrementalism"); Nina-Marie E. Lister & James J. Kay, *Celebrating Diversity: Adaptive Planning and Biodiversity Conservation*, *in* BIODIVERSITY IN CANADA: ECOLOGY, IDEAS, AND ACTION 189 (Stephen Bocking ed., 2000) (noting the need for goals and values to be integrated with the scientific experimentation of adaptive management in order to produce decisions).

108. Doremus, *supra* note 61, at 568–71; Karkkainen, *AEM*, *supra* note 16, at 950 (contrasting active, passive, and trial-and-error versions of adaptive management).

109. Doremus, *supra* note 61, at 568–71.

110. Doremus, *supra* note 61, at 568–71; Glicksman, *supra* note 20, at 873.

111. For a discussion of post-modern thinking as eroding trust in the efficacy and legitimacy of the regulatory state and social structures generally, particularly because of decisions made under uncertainty, see Rebecca M. Bratspies, *Regulatory Trust*, 51 ARIZ. L. REV. 575, 580–83 (2008). On post-modernism generally, see STANLEY J. GRENZ, A PRIMER ON POSTMODERNISM (1996); MICHEL FOUCAULT, POWER/KNOWLEDGE: SELECTED INTERVIEWS AND OTHER WRITINGS, 1972–1977 (1980); RICHARD RORTY, PHILOSOPHY AND THE MIRROR OF NATURE (1979); JACQUES DERRIDA, OF GRAMMATOLOGY (1976); MICHEL FOUCAULT, THE ARCHAEOLOGY OF KNOWLEDGE AND THE DISCOURSE ON LANGUAGE (1972). Classic works applying postmodern deconstructionism to law are ROBERTO MANGABEIRA

Finally, at the very least, adaptive management is in its infancy or toddler years of conceptual and as-applied development. We still have much to learn about how to set goals, plan actions, apply resources, manage, evaluate, and learn adaptively in light of uncertainty and ecological and social dynamics. The theory and practice of adaptive management will continue to evolve and hopefully improve.

IV. ADAPTIVE PLANNING

Adaptive planning merges the adaptability of adaptive ecosystem management with the roles and benefits of planning processes, thus arguably improving both planning and management functions. Adaptive planning is an iterative and evolving process of identifying goals and making decisions for future action that are flexible, contemplate uncertainty and multiple possible scenarios, include feedback loops for frequent modification to plans and their implementation, and build planning and management capacity to adapt to change.[112] It is planning that seeks to adapt to the complexity of systems and actors, conditions of uncertainty and unpredictability, and the dynamism of environments characterized by instability and rapid nonlinear changes.[113] The need for adaptive planning arises out of the following conditions: "[T]he ecological, social, political, cultural and economic environments within which we live and work increase in *complexity*. This process is irreversible and manifests itself in a higher *diversity* of emergent structures and activities and in an increased *uncertainty* of outcomes."[114] The features of adaptive planning include:

- flexibility and expectations of difficult-to-predict change (i.e., tolerance for ambiguity and uncertainty);
- the use of multiple scenarios, multiple hypotheses, data replication and pseudoreplication, data analogues, testable and revisable thresholds, and similar scientific methods for reducing or accounting for uncertainty;

UNGER, WHAT SHOULD LEGAL ANALYSIS BECOME? (1996); ROBERTO MANGABEIRA UNGER, THE CRITICAL LEGAL STUDIES MOVEMENT (1986); MARK KELMAN, A GUIDE TO CRITICAL LEGAL STUDIES (1987).

112. *See generally* sources throughout this section.

113. *See generally* Sachdeva, *supra* note 83; Dmitry Ivanov et al., *A Multi-structural Framework for Adaptive Supply Chain Planning and Operations Control with Structure Dynamics Considerations*, 200 EUROPEAN J. OPERATIONAL RESEARCH 409 (2010).

114. George Rzevski, Keynote Address to the Russian Academy of Science: Planning Under Conditions of Uncertainty (June 2007).

- continuous learning, monitoring, and feedback loops that affect plans (including maintaining a commitment to these processes);
- ongoing and iterative changes to plans (including some plan development during implementation);
- holistic and flexible design, including the embedding of options within the plan (e.g., in the forms of menus, branches, or sequels);
- integrated and interdisciplinary or transdisciplinary planning that addresses a range of interrelated scales, problems, and disciplinary insights;
- management or coordination of interdependent conditions;
- consideration of social, political, economic, cultural, institutional, and organizational complexities, as well scientific, natural, and technical complexities when developing plans and management actions;
- participatory social interaction among multiple participants at various levels of organizational structure and through multi-organization networks (including scaling up and down and using dynamic decision making processes);
- planning of process (planning of planning) as well as planning of management activities.[115]

George Rzevski has identified six characteristics of adaptive planning, which he contrasts with the accompanying characteristics of conventional planning.[116] They are:

Planned Options - When operating conditions are stable the best planning practise is to work out and implement the optimal plan for these conditions. Under frequent and unpredictable

---

115. *See, e.g.*, Sachdeva, *supra* note 83; Ahern, *supra* note 72, at 128-29; Jules N. Pretty & Ian Scoones, *Institutionalizing Adaptive Planning and Local-Level Concerns: Looking to the Future*, *in* POWER AND PARTICIPATORY DEVELOPMENT: THEORY AND PRACTICE 157 (Nici Nelson & Susan Wright eds., 1995); Helen Briassoulis, *Theoretical Orientations in Environmental Planning: An Inquiry into Alternative Approaches*, 13 ENVTL. MGMT. 381, 386–87 (1989); Lister & Kay, *supra* note 107; K. Matthias Weber, *Foresight and Adaptive Planning as Complementary Elements in Anticipatory Policy-making: A Conceptual and Methodological Approach*, *in* REFLEXIVE GOVERNANCE FOR SUSTAINABLE DEVELOPMENT 189 (Jan-Peter Voß et al. eds., 2006). The U.S. military's development of an adaptive planning process in 2007 included the following features:

- clear strategic guidance and iterative dialogue
- integrated interagency and coalition planning
- integrated intelligence planning
- embedded options
- living plans
- parallel planning in a network-centric, collaborative environment.

Robert M. Klein, *Adaptive Planning: Not Your Great Grandfather's Schlieffen Plan*, 45 JOINT FORCES Q. 84, 86 (2007).

116. Rzevski, *supra* note 114.

changes in operating conditions the concept of optimality does not make sense; planners are advised to consider and work out in some detail a large number of optional ways of fulfilling the plan. Some of these options may never be required; however, due to uncertainty there is no way of predicting which ones will be needed. Using multi-agent technology options can be generated in real time.

Planned Redundancy - Planned options require planned redundancy of resources. In contrast to rigid planning, where redundant resources are considered as a waste and the key notion is a slim process, adaptive planning requires additional resources that are not needed for normal operation and which may be required only in case of the necessity of employing optional solutions.

Event-Driven Continuous Planning - In contrast to rigid planning which specifies what will be done within certain time periods (one-year plan, five-year plan), adaptive planning is a continuous process. As events affecting operation occur, the current plan is modified to accommodate the changes in operating conditions and modifications are immediately implemented. The process of perpetual modifications of the plan continues as long as the operation that is being planned is active.

Selforganisation in Planning - Under stable operating conditions (relative to the planning span) it is rational to conduct centralised planning; therefore if there is a high probability that economic conditions will be stable during the next five years it is rational to have a series of five-year plans. In complex operational environments, that is, when there is high level dynamics and uncertainty, there is a need for a different planning strategy. When changes in operating conditions occur on the hourly or daily basis, there is simply no time for reports on disruptive events to reach the central planning body, for planners to decide what modifications are required and send instructions to executives and for executives to implement the specified modifications. Therefore, under conditions of complexity the best planning strategy is selforganisation, which in a nutshell means that constituent units of the operational system are empowered to make all planning decisions through a process of negotiation with each other. The degree of delegation of decision making depends on specific conditions, although there is a rule acquired through experience, which stipulates that the deeper the delegation the more effective the selforganisation.

Emergence in Planning - By definition, planning by selforganisation means that the plan emerges from the interaction of constituent decision makers and is never imposed on them from higher levels of the hierarchy.

Multiple-Criteria Planning - Conventional planning is optimised using one criterion such as maximum profit, minimum costs or similar, which is applied uniformly to all resources. New methods have been developed for adaptive planning to use multiple criteria for every planning decision and to enable different balance of criteria to be used for different resources.[117]

Adaptive planning contemplates that adaptation is not merely a matter of technical and scientific management but also a highly social phenomenon. The dynamic uncertainty and complexity to which adaptive planning seeks to adapt exist not only in external environments (e.g., ecosystems, interrelationships between society and nature) but also in the internal structures of planning and management institutions, organizations, and networks.[118] Broad-based participation in adaptive planning – typically decentralized and multiscalar – serves several purposes: (1) improving the diversity of information and ideas and their sources (e.g., local knowledge; multidisciplinary insights); (2) connecting plans to implementation by empowering managers and constituent decision makers to alter plans or management actions in response to changes or new information; (3) building adaptive capacity generally in multi-participant institutions, organizations, and networks, including the creation of "shared schema" among those responsible for management activities through multi-participant networks that share information; and (4) effectuating the principles of deliberative participatory democracy.[119]

Adaptive planning gives as much attention to planning the process of planning and adaptive implementation as it does

117. *Id.* at 2–3 (emphasis added).

118. *See generally* Sachdeva, *supra* note 83, at 97; Ivanov et al., *supra* note 113, at 4–5.

119. Pretty & Scoones, *supra* note 115, at 157; Jack D. Kartz & Michael K. Lindell, *Adaptive Planning for Community Disaster Response*, *in* CITIES AND DISASTER: NORTH AMERICAN STUDIES IN EMERGENCY MANAGEMENT 5, 10 (Richard T. Sylves & William W. Waugh eds., 1990); Sachdeva, *supra* note 83, at 97, 100–02; Lister & Kay, *supra* note 107; Weber, *supra* note 115. *But see* Friedmann, *supra* note 83, at 230–32 (describing adaptive planning as hierarchical, political, and opportunistic).

to developing flexible plan content.[120] Planners can choose among different ways of building adaptation into planning and implementation, such as: (1) making explicitly conditional decisions that await future information and conditions in order to be completed or finalized; (2) creating formal multi-stage decision making processes with frequent or periodic planned revisions to decisions in accordance with specified experiments and feedback loops; and (3) creating informal, decentralized, and evolving decision making processes.[121]

Adaptive planning has been applied in many settings. These settings include environmental planning and natural resources management,[122] the development of military strategies,[123] cattle ranching,[124] artificial intelligence and computer-driven planning programs,[125] innovation systems in science and technology,[126] development strategies,[127] corporate management,[128] supply-chain management,[129] and disaster response.[130]

Adaptive planning may or may not differ significantly from adaptive management, depending on the theory and practice of adaptive management employed. On one end of the spectrum, Fred Bosselman defines adaptive management as an adaptive form of planning and insists that long-range planning is essential

---

120. Sachdeva, *supra* note 83, at 101. For an analysis of process-based adaptive land-use planning based on the theories of architect Christopher Alexander, see Braham Boyce Ketcham, *The Alexandrian Planning Process: An Alternative to Traditional Zoning and Smart Growth*, 41 URB. LAW. 339 (2009).

121. *See generally* Per Strangert, *Adaptive Planning and Uncertainty Resolution*, 9 FUTURES 32 (1977). Kartz and Lindell found that in the context of disaster response, more formal adaptive planning activities, such as frequent plan updates and reviews and updates of procedures are less effective at improving adaptability than less formal information-sharing activities, such as task forces, training, advisory councils, and reviews with elected officials, even though these less formal methods are less easily monitored and evaluated. Kartz & Lindell, *supra* note 119, at 25–27.

122. Brissoulis, *supra* note 115, at 386–87 (environmental planning); Ahern, *supra* note 72, at 128–29 (adaptive methods applied to sustainable landscape planning); Lara Whitely Binder, *Preparing for Climate Change in the U.S. Pacific Northwest*, 15 HASTINGS W.-N.W. J. ENVTL. L. & POL'Y 183, 189–95 (2009) (planning and adaptation to climate change's impacts on natural resources and the environment in the Pacific Northwest).

123. Klein, *supra* note 115.

124. Ernest Bentley & C. Richard Shumway, *Adaptive Planning over the Cattle Price Cycle*, 13 SO. J. AGRIC. ECON. 139 (1981).

125. DIMITRIS VRAKAS ET AL., AM. ASS'N FOR ARTIFICIAL INTELLIGENCE, LEARNING RULES FOR ADAPTIVE PLANNING, ICAPS–03 PROCEEDINGS 82 (2003).

126. Weber, *supra* note 115.

127. Sachdeva, *supra* note 83; Pretty & Scoones, *supra* note 115, at 157.

128. Russell Ackoff, *A Concept of Corporate Planning*, LONG RANGE PLANNING, Sept. 1970, at 2.

129. Ivanov et al., *supra* note 113.

130. Kartz & Lindell, *supra* note 119, at 5–31.

to adaptive management.[131] With respect to watershed planning, in particular, I have noted the interrelationship between planning and adaptive management in enhancing overall institutional adaptive capacity:

> One must be careful not to assume that the process of planning necessarily means that we can presume to create a workable static plan that anticipates all forces, changes, or processes working on a particular watershed, water supply, water system, or socio-ecological dynamic. Instead, watershed planning and management institutions must engage in adaptive management. However, the process of engaging in long-range, place-based planning contributes to the development of institutions and their capacities to engage in healthy adaptive management and stewardship of water.[132]

Others, such as Dan Tarlock, refer to "adaptive planning and management" as if they are complementary and linked concepts.[133] Likewise, Rob Glicksman calls for adaptive planning for federal land management and urges that adaptive management concepts can make land and resource planning more adaptive while still actually engaging in long-term planning.[134] However, Glicksman recognizes that agencies are tempted to use adaptive management concepts to defer real planning with the idea that management officials will just make ad hoc decisions as problems or issues arise, or as he writes, "a 'don't-worry-about-it-now-because-we'll-figure-out-what-we-need-to-do-when-it-happens' approach."[135] Furthermore, Judith Layzer's important analysis of several major collaborative and adaptive ecosystem management case studies nationwide demonstrates that the setting of goals and direction for ecosystem management can rather easily be separated from flexible management methods and that calls for adaptability in

131. Bosselman, *A Role for State Planning*, *supra* note 20. Another example of integrating adaptive planning with adaptive management principles is Lister & Kay, *supra* note 107.

132. Craig Anthony (Tony) Arnold, *Water Privatization Trends in the United States: Human Rights, National Security, and Public Stewardship*, 33 WM. & MARY ENVTL. L. & POL'Y REV. 785, 848 (2009) [hereinafter Arnold, *Water Privatization*].

133. A. Dan Tarlock, *The Nonequilibrium Paradigm in Ecology and the Partial Unraveling of Environmental Law*, 27 LOY. L.A. L. REV. 1121, 1140 (1994) (quoting a National Research Council-National Academy of Sciences report); Tarlock, *Rivers*, *supra* note 25, at 1097 n.207 (same). *See also* Fred Bosselman, *Swamp Swaps: The "Second Nature" of Wetlands*, 39 ENVTL. L. 577, 628 (2009); Alex Williamson, *Seeing the Forest and the Trees: The Natural Capital Approach to Forest Service Reform*, 80 TUL. L. REV. 683, 706 (2005).

134. Glicksman, *supra* note 20, at 866–71.

135. *Id.* at 871.

plan implementation can mask the lack of clear and comprehensive ecosystem-conservation goals in order to achieve consensus and accommodate established interests.[136] Adaptive management critics have pointed that without attention to planning and institutional design, adaptive management too easily breaks down into incrementalist avoidance of hard choices and necessary changes to the status quo, evasion of environmental stewardship duties, and very little real learning and use of feedback in recalibrating management.[137] Adaptive planning has been characterized as using the "learning-by-doing" and "adaptation through social experimentation" methods of adaptive management without "succumb[ing] to the anti-planning stance implied by muddling-through incrementalism."[138]

Likewise, whether adaptive planning differs from the type of planning typically employed or critiqued depends on the circumstances. In theory, adaptive planning is contrasted with a much more rigid form of conventional planning. Paramjit Sachdeva argues that adaptive planning is a preferable alternative to a planning model that is alternatively referred to as "synoptic rationalistic planning," "comprehensive blueprint planning," and "preactive planning, in the sense of anticipatory decision making of the predict-and-prepare variety."[139] Sachdeva states that "[the] emphasis on adaptation [in adaptive planning] contrasts sharply with the earlier blueprint approach in which deviations from the master plan were considered errors to be curtailed rather than opportunities for redesign."[140] Rzevski observes the following contrasts:

> (1) conventional planning seeks to form only the optimal plan, whereas adaptive planning includes as many options as practical in the plan;
> (2) conventional planning seeks to avoid redundancy of resources, whereas redundancy of resources is planned in adaptive planning;
> (3) conventional planning mandates that the plan be followed for a specified time, whereas adaptive planning provides for the continuous modification of the plan to accommodate changes in the operational environment;

136. LAYZER, *supra* note 67, at 267–92.
137. *Id.* at 31–32 (citing eleven works).
138. Sachdeva, *supra* note 83, at 96.
139. *Id.*
140. *Id.*; *see also* Pretty & Scoones, *supra* note 115, at 158–159 (contrasting adaptive planning with conventional and technical "blueprint" planning).

> (4) conventional planning has centralized decision making, whereas adaptive planning occurs by decentralized self-organization;
> (5) conventional planning requires that the activities contemplated by the plan be executed within a specified period, whereas adaptive planning allows for executable activities to emerge from negotiations between constituent decision- makers; and
> (6) conventional planning typically applies a single criterion to all activities, whereas adaptive planning allows for the balancing of or selection from among multiple decision criteria, against which to evaluate each activity.[141]

The contrast between adaptive planning and conventional planning bears out in the legal requirements governing planning and in the effects of plans. Statutes governing water supplies, public infrastructure projects, public lands and resources, wildlife and endangered species, and land uses and growth, among other topics, require the preparation of formal, comprehensive, rational plans based on thorough and objective scientific evidence and the implementation of these plans for all management activities encompassed by the plans' content for a set or even indefinite period of time.[142] These conventional types of plans can create static legal obligations. For example, the Ninth Circuit invalidated the Bureau of Land Management's ("BLM") allegedly adaptive timber sales practices that were inconsistent with its timber management plan because the BLM did not formally amend its plan.[143] Likewise, the U.S. Forest Service did not comply with an adopted land and resource management plan when it proposed an "iterative process" for the development and implementation of a monitoring plan.[144] Moreover, the federal government was held liable for a compensable taking of private property when it sought to reduce water supplies to county water supply districts, which in turn served farm irrigators, due to changed or unanticipated conditions concerning instream flows needed to support endangered species.[145] The federal government's basis of liability was a set of contractual obligations

141. Rzevski, *supra* note 114, at 4.

142. *See, e.g.*, National Forest Management Act of 1976, 16 U.S.C. § 1604(g)(3) (2006) (national forest land-use and management plans); TEX. WATER CODE ANN. §§ 16.051–16.060 (Vernon 2008) (state, regional, and local water plans); CAL. GOV'T. CODE §§ 65300 et seq. (West 2003) (local government comprehensive plans for the jurisdiction's long-term physical development).

143. Klamath-Siskiyou Wildlands Ctr. v. Boody, 468 F.3d 549 (9th Cir. 2006).

144. Western Watersheds Project v. U.S. Forest Serv., 2006 WL 292010 (D. Idaho 2006).

145. Tulare Lake Basin Water Storage Dist. v. United States, 49 Fed. Cl. 313 (2001).

that were in turn based on static and outdated water management planning.[146]

The contrast between adaptive planning and conventional planning is deceptively simple, though. Other taxonomies of planning concepts exist. One taxonomy contrasts adaptive planning with developmental, allocative, and innovative planning models.[147] Another taxonomy contrasts adaptive planning with comprehensive/rational, incremental, contingency, advocacy, and participatory/consensual models of planning.[148] Adaptive planning methods can be applied to subject-specific models of planning, such as Steiner's Ecological Planning Model, Steinitz' Framework Method for Landscape Planning, and the Framework Method for Sustainable Landscape Ecological Planning.[149] It can be related to any of four planning theories developed as responses to the conceptual inadequacies of the rationalist planning model: pragmatism, socio-ecological idealism, political-economic mobilization, and communications and collaboration.[150] In addition, adaptive planning has been treated as a mere component of broader social and strategic cognition processes according to a rather vague model of "adaptive foresight."[151] Thus, several planning methods and concepts are available to ecosystem managers and decision makers and various combinations might be used.

Moreover, even when government agencies and resource managers are expected or thought to use more conventional planning, they may be using at least some adaptive planning techniques in fact. One possible example of adaptive planning may be the practice of local governments to make frequent small-scale amendments to their comprehensive plans. Typically a local government will amend its comprehensive plan when officials wish to approve a rezoning or a land development permit that is inconsistent with the then-applicable content of the comprehensive plan.[152] A doctrine known as the "consistency requirement" legally mandates that all zoning and land use

146. *Id.*

147. *See generally* Friedmann, *supra* note 83.

148. *See generally* Briassoulis, *supra* note 122.

149. Ahern, *supra* note 72, at 125–29.

150. *See generally* David P. Lawrence, *Planning Theories and Environmental Impact Assessment*, 20 ENVTL. IMPACT REV. 607 (2000).

151. E. Anders Eriksson & K. Matthias Weber, *Adaptive Foresight: Navigating the Complex Landscape of Policy Strategies*, 75 TECH. FORECASTING & SOC. CHANGE 462, 464, 468 (2008).

152. Carol M. Rose, *Planning and Dealing: Piecemeal Land Use Controls as a Problem of Local Legitimacy*, 71 CAL. L. REV. 839 (1983); Charles L. Siemon, *The Paradox of "In Accordance with a Comprehensive Plan" and Post Hoc Rationalizations: The Need for Efficient and Effective Judicial Review of Land Use Regulations*, 16 STETSON L. REV. 603 (1987). *See*, *e.g.*, Martin County v. Yusem, 690 So. 2d 1288, 1293–95 (Fla. 1997).

approvals be consistent with the locality's comprehensive plan.[153] The practice of many frequent small-scale adjustments to the comprehensive plan in order to accommodate particular development proposals has been criticized as undermining comprehensive rational planning, which is arguably the foundation of zoning and local land use regulation, and facilitating piecemeal, incoherent, negotiated land development approvals.[154] In fact, public concern over this practice has led to a proposed voter amendment to the Florida Constitution – Amendment 4, also known by the name of the group proposing it, "Florida Hometown Democracy" – which would prohibit local governments from amending their comprehensive plans without voter approval.[155] However, conditions change, the range of possible rational development proposals can be difficult for planners to foresee fully, and local goals and values regarding land development may change, particularly with respect to specific areas and projects.[156] These plan amendments may be the infusion of adaptability into local land use planning processes, enabling local officials to adapt incrementally to change over time, instead of having to wait for a full-scale overhaul of the comprehensive plan every several years. While it is quite likely that some small-scale plan amendments in response to development proposals result from politically expedient accommodation of development pressures and interests, it is also quite likely that some of them serve the public interest and the principles of good adaptive planning in light of changing circumstances.

153. ARIZ. REV. STAT. ANN. § 9–462.01(F) (2010); CAL. GOV'T. CODE § 65860 (West 2003); FLA. STAT. ANN. § 163.3194 (West 2006); KY. REV. STAT. ANN. § 100.213 (West 1970). *See generally* Charles M. Haar, *In Accordance with a Comprehensive Plan*, 68 HARV. L. REV. 1154 (1955).

154. *See* Rose, *supra* note 52; Siemon, *supra* note 152; Arnold, *Wet Growth*, *supra* note 26, at 10172.

155. *See* Florida Hometown Democracy, http://www.floridahometowndemocracy.com; Florida Secretary of State, Division of Elections, Referenda Required for Adoption and Amendment of Local Government Comprehensive Land Use Plans, http://election.dos.state.fl.us/initiatives/initdetail.asp?account=37681&seqnum=2 (official State of Florida constitutional amendment website with link to PDF of language of Amendment 4 ballot measure). For commentary on the proposed amendment, see, e.g., Brian Goldberg, *New Reactions to Old Growth: Land Use Law Reform in Florida*, 34 COLUM. J. ENVTL. L. 191 (2009); Michael S. Davis & Nicole C. Armstrong, *Hometown Democracy - The St. Pete Beach Experience*, 38 STETSON L. REV. 491 (2009).

156. *See generally* Craig Anthony (Tony) Arnold, *The Structure of the Land Use Regulatory System in the United States*, 22 J. LAND USE & ENVTL. L. 441, 466–67, 479–81, 493–95, 498–99 (2007) [hereinafter Arnold, *Structure of Land Use*].

V. ADAPTIVE WATERSHED PLANNING

A. Features

Adaptive watershed planning combines adaptive methods, ecosystem scale, and planning processes. This combination enables water institutions and other institutions in society to improve adaptive capacity to the multi-faceted interactions of climate dynamics, watershed dynamics, and human, social, and institutional dynamics. Undoubtedly, the uncertain and complex potential for decreased water supplies, increased flooding and runoff, altered watershed composition and processes, changing water consumption practices, and increased conflict over water necessitates experimental and responsive management methods. Nonetheless, this potential also demands multi-criteria goals, decisional and conflict-resolution structures, identification of the likely set of possible conditions and relationships at issue, tentative decisions about actions to be taken or the type and characteristics of adaptive management experiments to be pursued, and iterative ongoing processes for reviewing and modifying plans as conditions change or new information is obtained. This Part describes several core features of adaptive watershed planning and then identifies several reasons to engage in adaptive watershed planning.[157]

Scale. Water resources and aquatic conditions should be planned and managed at watershed scales, because watersheds are the geographic organizing units of surface-water processes and functions.[158] Certain groundwater resources might better be

---

157. For a very good resource detailing watershed planning and management processes generally, see DAVENPORT, *supra* note 26. Adaptive watershed planning shares a number of features with a concept known as "Integrated Water Resource Management" ("IWRM"), but has a broader set of concerns than water-resource demand management and can be considerably more polycentric than many formulations of IWRM. For discussions of IWRM, see, e.g., John Butterworth et al., *Finding Practical Approaches to Integrated Water Resources Management*, 3 WATER ALTERNATIVES 68 (2010); Bruce Lankford & Nick Hepworth, *The Cathedral and the Bazaar: Monocentric and Polycentric River Basin Management*, 3 WATER ALTERNATIVES 82 (2010); Jeffry S. Wade, *Privatization and the Future of Water Services*, 20 FLA. J. INT'L. L. 179, 192–96 (2008); William Blomquist et al., *Comparison of Institutional Arrangements for River Basin Management in Eight Basins* (World Bank Policy Research Working Paper No. 36, 2005). In her article in this symposium issue, Dr. Kathleen Miller describes the benefits of IWRM multi-factor models of water flows throughout the watershed, including the climate-sensitive Water Evaluation and Planning Version 21 ("WEAP") tool. Miller, *supra* note 8

158. The watershed is "an optimal unit for management and planning of water resources because it is a complete hydrologic unit and an appropriate scale for the consideration of sustainability of water resource use." REBECCA RUSH ET AL., GUELPH WATER MANAGEMENT GROUP, ADAPTING TO CLIMATE CHANGE IN THE OLDMAN RIVER WATERSHED, ALBERTA: A DISCUSSION PAPER FOR WATERSHED STAKEHOLDERS 4 (2004). *See also* ARNOLD ET AL., *supra* note 37, at 59; FELDMAN, *supra* note 25, at 285–88.

planned and managed by geographic regions corresponding to underground aquifers. Given that surface waters and groundwater are usually interconnected, watershed planning might be adjusted to include or be linked to groundwater planning. Moreover, watersheds are interconnected with one another across multiple nested scales, necessitating choices about which level of watershed to select for planning purposes.[159] Ideally, watershed planning scale would match hydrological function, with nested scales of plans from small catchments up to large basins and plans that contemplate that variable patch dynamics of aquatic ecosystems.[160] Adaptive planning, particularly for multiscalar ecological problems, should involve both scaling up for integration and coordination across levels of scale and scaling down for decentralization, localization, and attention to micro-scale effects.[161] However, this degree of planning may simply be too large, complex, and unwieldy to be practical. After all, water resources and watersheds are affected not only by ecological and hydrological dynamics but also by political, legal, economic, socio-cultural, and institutional dynamics. Thus, the choice of geographic scale for watershed planning should consider the problems that have been framed for planning and management and the scale at which the effects of those problems occur.[162] In addition, pragmatic considerations of social system capacity, such as legal authority, inter-jurisdictional cooperation, and resource availability, should be considered in selecting a level of watershed for planning.[163]

In addition to geographic scale, temporal scale should be considered. A solely short-term plan, while arguably more flexible and changeable, gives too little consideration to conservation goals, the needs and interests of future generations, stewardship principles, preparation for future change, and the long-term ecology of watersheds. On the other hand, a solely long-term plan, while arguably more consistent with planning's historic foundations, is of little use, because uncertainty about future conditions increases with the planning time horizon, necessary adaptations and adjustments will likely take management actions far from projected long-term goals,

---

159. Arnold, *Clean-Water Land Use*, *supra* note 43; Adler, *Watershed Protection*, *supra* note 30; ARNOLD ET AL., *supra* note 37, at 59–60; FELDMAN, *supra* note 25, at 285–88.

160. Arnold, *Clean-Water Land Use*, *supra* note 43; RANDOLPH, *supra* note 32; THORP ET AL., *supra* note 35; ARNOLD ET AL, *supra* note 37, at 59.

161. *See, e.g.*, Pretty & Scoones, *supra* note 115, at 161–63; Craig, *Stationarity*, *supra* note 13, at 54–55

162. Adler, *Watershed Protection*, *supra* note 30.

163. ARNOLD ET AL., *supra* note 37, at 60; FELDMAN, *supra* note 25, at 285–88

collective goals may change as conditions change, and there is a potential disconnect between long-term goals and short-term management actions. Thus, adaptive watershed planning should contain short-term, medium-term, and long-term goals, with increasing generality and flexibility in goals along the time continuum.[164] With respect to both geography and time, adaptive watershed planning should be multiscalar or at least multiscale-regarding (i.e., attentive to multiple scales) to the extent practical.

Scope. In addition to multiscalar planning focused on watershed scales over time, adaptive watershed planning takes an integrated or holistic approach to the many aspects of watershed conditions and phenomena that affect water resources.[165] The holistic approach to watershed planning has been described as follows:

> A holistic approach helps to address all beneficial uses of a water resource, the criteria necessary to protect those uses, and the strategies required for water resource protection and restoration. It encourages collaborative, integrated water resource planning and effective implementation of management strategies, thus helping to achieve water resource goals. A holistic approach means that watershed planning encompasses both human and natural environments, both land resources and water resources, both water quality and water use/supply, both surface waters and groundwater, both public sector policies/programs and private sector choices/actions, the physical, chemical, and biological characteristics and processes of watersheds, and the variety of different impacts of land use, development, and growth on watersheds . . . .[166]

In particular, adaptive watershed planning should attempt to integrate water supply planning and management (including public water supply practices, irrigation practices, instream flows and uses, and water infrastructure development and management), water quality planning and protection (including both point and nonpoint sources, stormwater runoff, and watershed landscape features that affect water quality), land use planning and policies, energy use management, planning for disaster avoidance and response (including flood control, evacuation plans, public health emergency plans, wildfire

164. *See, e.g.*, Craig, *Stationarity*, *supra* note 13, at 54.
165. FELDMAN, *supra* note 25, at 286–88.
166. ARNOLD ET AL., *supra* note 37, at 60.

management and control, among many other disaster-related issues), biodiversity and species' habitat conservation, economic development policies, forestry planning and management, agriculture policies and practices, and other related phenomena affecting watershed conditions. For example, watershed planning plays a significant role in growing efforts to integrate water supply management, water quality protection, and land-use and development planning and regulation, a phenomenon or trend known as "wet growth."[167]

In general, adaptive watershed planning should focus on the overall health, integrity, and functioning of the watershed and the sustainability of water resources in society and nature.[168] It also should give attention to issues of social equity and environmental justice.[169] Interdisciplinary and transdisciplinary approaches to watershed planning are also critical aspects of the adaptive method of watershed planning.[170] The planning process should give attention to the development of both broad goals and narrow goals.[171]

Care should be taken, though, to consider what may be meant by integration and the limits to an integrated approach. It does not necessarily mean a comprehensive planning process

167. *See id.*, at 57–101. On wet growth generally, see ARNOLD ET AL., *supra* note 37 (U.S. EPA-funded comprehensive report on wet growth principles and methods, aimed at communities in Kentucky, but drawing on nationwide examples and applicable to communities nationwide); WET GROWTH: SHOULD WATER LAW CONTROL LAND USE?, *supra* note 96; Arnold, *Wet Growth*, supra note 26; Michael Allan Wolf, *Supreme Guidance for Wet Growth: Lessons from the High Court on the Powers and Responsibilities of Local Governments*, 9 CHAPMAN L. REV. 233 (2006). *See also* Owen, *Urbanization*, *supra* note 36; 10,000 FRIENDS OF PENNSYLVANIA, WATER AND GROWTH: TOWARD A STRONGER CONNECTION BETWEEN WATER SUPPLY AND LAND USE IN SOUTHEASTERN PENNSYLVANIA (2007), *available at* http://10000friends.org/sites/10000friends.org/files/water_report_07_final_with_covers.pdf .; CITY OF OLYMPIA, WASHINGTON, LOW-IMPACT DEVELOPMENT STRATEGY FOR GREEN COVE BASIN: A CASE STUDY IN REGULATORY PROTECTION OF AQUATIC HABITAT IN URBANIZING WATERSHEDS (2002), *available at* http://www.psparchives.com/publications/our_work/stormwater/lid/ordinances/Green_Cove.pdf..

168. ARNOLD ET AL., *supra* note 37, at 50, 75; FELDMAN, *supra* note 25, at 2–5, 286–88.

169. *See* Eileen Gauna, *Environmental Justice in a Dryland Democracy: A Comment on Water Basin Institutions*, *in* WET GROWTH, *supra* note 167, at 171–201.

170. *See, e.g.*, Helena Sousa Ferreira & André Botequilha Leitão, *Integrated Landscape and Water-Resources Planning with Focus on Sustainability*, *in* FROM LANDSCAPE RESEARCH TO LANDSCAPE PLANNING, *supra* note 72, at 143–59; Ahern, *supra* note 72, at 122; Weber, *supra* note 115, at 215–16; Feldman & Ingram, *supra* note 106. *See also* Holly Doremus, Data Gaps in Natural Resources Management: Sniffing for Leaks Along the Information Pipeline (UC Davis Legal Studies Research Paper No. 83) [hereinafter Doremus, *Data Gaps*], *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=919000##) (discussing the importance of interdisciplinary and transdisciplinary knowledge and data in natural resources management generally).

171. Thomas, *supra* note 98.

that attempts to centralize control over all aspects of human activity and choice that could affect watershed conditions. In many cases, adaptive watershed planning may simply be about reforming existing watershed planning processes to be more adaptive or reforming existing watershed management processes to improve their planning dimensions. Moreover, a truly comprehensive and holistic approach to watershed planning could encompass so many different issues, affected parties, and possible policies and implementation actions as to be impractical, unmanageable, incomprehensible, and too lengthy for responding to current or even emerging needs. Some commentators observe that the most successful watershed planning efforts are essentially ad hoc, pragmatic problem-solving efforts aimed at rather particular watershed problems and thus are not truly comprehensive or integrated.[172]

However, watershed plans that first seem to be successful may turn out to have substantial adverse unintended consequences due to the failure to consider multidimensional effects across time, space, media, watershed features, and spheres of human activity.[173] Attempts to address a particular watershed problem can be "integrated" in the sense of considering the effects of multiple conditions, forces, policies, and behaviors on the problem at issue and coordinating the plan and its policies with other plans and policies. Moreover, one of the primary benefits of most watershed planning in general is that it features coordination, collaboration, and networking across the traditional policy "silos" that can characterize issues of natural resources and the environment.

For example, a watershed-based water supply planning initiative focused on improving water storage options will need to consider the possible effects of climate change (e.g., evaporation rates, precipitation variability in quantities and timing, the run-off effects of changing vegetation patterns), relationships to land use policies, possible alternate population and development-pattern projections, aquatic species protection laws and policies, structural functions of watershed features and flows, stormwater runoff controls and management (e.g., affecting available runoff into water bodies and water supplies), flood potential and disaster-avoidance goals, surface-water based economic and social sectors (e.g., fishing, boating, tourism), the mosaic of applicable water law, and the potential effectiveness and relative costs of alternate demand-management strategies. A relatively

172. SCHLAGER & BLOMQUIST, *supra* note 36, at 43.
173. *See generally* Ryan, *supra* note 66.

integrated analysis might lead planners to select a mix of options, not relying solely or primarily on increasing water storage to achieve water supply planning objectives, and might even offer the potential to try, test, and evaluate several different methods. In another example, water conservation planning, stormwater management methods (including on-site best management practices), and sustainable land-development standards all would benefit from coordination among these three areas of potentially distinct and separate planning efforts. In other words, the concept of an "integrated" scope to adaptive watershed planning is a flexible, pragmatic (non-purist), context-specific, and issue-specific concept.

Process. The process of adaptive watershed planning[174] is first and foremost adaptable or flexible, which means that: (1) the process itself is not static or rigid; and (2) the plan, which results from the planning process, incorporates features that facilitate the plan's ongoing adjustment, revision, and even continuing development. Thus, the process is iterative and emergent; the plan's content arises out of the interplay of numerous forces and conditions, including: (a) multi-factor decisions about initial goals, policies, options, and criteria in the plan; (b) self-organization features that allow constituent participants of the planning process to shape plan content; (c) planning decisions made during implementation itself; (d) continuous, event-driven modification of the plan and its implementation strategies and methods in response to evolving conditions, data, knowledge, and other feedback from implementation, monitoring, or other indicia of conditions and effects; and (e) plan modification based on changing needs and goals in the watershed, in watershed institutions, and in society. Adaptive watershed planning gives considerable attention to the process itself and to both the design and the emergence of the process. Experts in both water planning and watershed planning have noted disfavor with static plans and favor for open, flexible, multi-goal, iterative, and adaptive planning processes.[175]

174. This discussion of adaptive watershed planning process draws on the theory of adaptive planning, discussed in Section IV.

175. *See, e.g.*, A. Dan Tarlock, *A First Look at a Modern Legal Regime for a "Post-Modern: United States Army Corps of Engineers*, 52 U. KAN. L. REV. 1285, 1287 n.16, 1298–99 (2004); A. Dan Tarlock, *Water Law Reform in West Virginia: The Broader Context* 106 W. VA. L. REV. 495, 505–06 (2004); Robert W. Adler, *Toward Comprehensive Watershed-Based Restoration and Protection for Great Salt Lake*, 1999 UTAH L. REV. 99, 199 [hereinafter Adler, *Great Salt Lake*]. *But see* Diane K. Brownlee, *The Public Vote in the Game of Water Wars: An Unquenchable Thirst to Define and Implement "Public Values" in Western Water Laws*, 70 UMKC L. REV. 647, 669 (2002) ("If water planning is to truly improve and serve the new public demands on water, water officials must have a static and all-encompassing plan.")

Adaptive watershed planning expressly addresses uncertainties and unpredictability by making use of multiple data, models, and predictive tools with the recognition of their limits, by focusing on robustness instead of optimization, and by identifying multiple options and criteria for selection among those options as conditions develop or emerge. However, the planning process must select goals and policies. It must identify strategies, options, and implementation action items. It must establish standards, criteria, and metrics for evaluation. And it must provide for regular monitoring, assessment, feedback loops, improvement of data and models, and adjustments to the plan (e.g., periodic review and updates). The plan must be implemented. Moreover, both scientific learning and social learning must occur through the iterations of the process, and they must inform the plan and the ongoing planning process.[176] Adaptive watershed planning is not a mere license-to-experiment for on-the-ground (or in-the-water?) managers. Nor is it a timid resignation to the status quo or a deferral of tough choices with the hope that answers will emerge from institutions that are "muddling through" or "drifting along" looming crises.

Nonetheless, adaptive watershed planning should not force change just for the sake of change. It should not include standards and processes that push decision makers into making frequent changes that are based on inadequate data, insufficient reasons for change, or an insufficiently lengthy implementation period to gather reliable feedback on the plan's effects. For example, Mary Doyle concludes that adaptive management has not worked with respect to the Comprehensive Everglades Restoration Plan ("CERP") because it "has not yet mandated a major course correction in planning, budget, or implementation," even though "project managers are continuously adjusting their actions according to scientific inputs."[177] While the CERP should be adjusted because scientific research shows that the Everglades cannot be restored to historic ecosystem conditions due to irreversible changes in ecosystems' structures and processes[178] and thus Doyle is correct that the CERP should undergo plan adjustment, the implication of her statement seems to be that adaptive management works only if plans are changed. This presumes, as a matter of theory, that no plan whatsoever should

176. On the importance of both scientific learning and social (or public) learning for adaptive governance of water resources, see John T. Scholz & Bruce Stiftel, *The Challenges of Adaptive Governance*, *in* ADAPTIVE GOVERNANCE AND WATER CONFLICT: NEW INSTITUTIONS FOR COLLABORATIVE PLANNING 1, 8–9 (John T. Scholz & Bruce Stiftel eds., 2005).

177. LARGE-SCALE ECOSYSTEM RESTORATION, *supra* note 36, at ix, xiii–xiv.

178. *See* Zweig & Kitchen, *supra* note 66.

be implemented "as is." However, whether a plan needs to change depends on whether additional knowledge, changed conditions, and evolving social and ecological needs show the need for the plan to change.

Whether adaptive watershed planning must be collaborative depends on what we mean by collaborative, as discussed previously in this article's analysis of adaptive management concepts. On one end of the spectrum, adaptive watershed planning does not require consensus-based decision making. On the other end of the spectrum, adaptive watershed planning principles are not consistent with a sharp divide between policy makers who form plans and managers who implement plans. Plan content or revisions to plan content arise out of implementation, monitoring, evaluation, and ongoing planning. Thus, adaptive planning needs continuous interactions among policy makers, planners, scientists, managers, and affected parties.[179] These interactions are necessary for learning and adaptation to occur: for mistakes to be identified, for impacts and results to be measured and evaluated, for analysis and deliberation to occur among those involved in making and implementing watershed plans, for new knowledge and ideas to develop and disperse throughout the networks that characterize watershed-based activities, and for changes to be made and implemented.

In between the consensus model and the interactive-feedback model, though, is the multi-participant model.[180] While it is certainly possible for a single organization to engage in adaptive watershed planning as a means to improve its planning and management of water resources or related watershed features that are within its jurisdiction or control, most watershed planning and management involve multiple government agencies and non-government organizations, groups, and persons. In these circumstances, widespread participation in adaptive watershed planning is desirable for at least five

179. Briassoulis, *supra* note 122, at 386.

180. I am purposefully not using the term "multi-stakeholder" for two reasons. First, all of us have a stake in the health and integrity of watersheds, not just those persons and entities that participate in watershed planning and management activities. Second, the term "stakeholder" can sometimes connote a person or entity with a rather narrowly defined economic self-interest in the outcome of watershed planning and management decisions, thus suggesting that the process is meant to be something like a multi-party business transaction. I prefer the term "multi-participant" to mean the participation of multiple persons or entities who may be affected by watershed planning and management decisions. I especially thank Donna Christie for noticing my use of the term and asking about it during a distinguished visiting lecture at Florida State University College of Law, which in turn has prompted me to be more explicit about my choice of terminology.

reasons: (1) no single entity has decision making authority or control over all the aspects of human activity that would or should be addressed in a given adaptive watershed plan; (2) a diverse array of participants will improve the knowledge base of the watershed planning process and perhaps contribute or spread innovative ideas; (3) the development of social capital, trust, resource contributions, expertise, and engagement is usually necessary to the effective implementation of the plan; (4) all, many, or some of the planning participants will play key roles in the plan's implementation, monitoring, assessment, and revision, all critical features of iterative adaptive planning; and (5) multi-participant adaptive watershed planning is a manifestation or pursuit of deliberative participatory democracy in action.

Nonetheless, multi-participant planning does not mean conflict-free planning. While some level of cooperation will be necessary to produce and implement a plan, some level of conflict is likely to occur and may even be necessary. Water resource decisions and watershed policies involve competing interests and contested values. In the iterations of adaptive watershed planning, conflict-based methods of litigation, political advocacy, opposition and resistance, and other forms of conflict may function as disturbances, uncertain social conditions, and feedback loops that inform and shape the planning process over time.

Moreover, in grasping the iterative nature of adaptive watershed planning processes, we need to understand that any particular "snapshot" of the state of such planning efforts at a given point in time is of limited utility at best, because these processes will continue to evolve and develop through many iterations and machinations.[181] For example, it may be that the San Francisco Bay-Delta's CALFED process is "dead"[182] or that the Comprehensive Everglades Restoration Plan is hopelessly mired in bureaucracy and impossible to accomplish,[183] but I would not bet the farm on any such assessment. These watershed-based planning processes, despite their flaws, may emerge again in altered, mutated, or evolved forms to play important roles in problem-solving and management of their respective watersheds. It is quite possible that this will never happen, but my point is that we simply cannot tell now what

181. *See, e.g.*, Adler, *Great Salt Lake*, *supra* note 175, at 199 (noting that support for initially limited watershed planning efforts can lead to "the beginning of a much longer, more iterative and adaptive process").

182. *See* Doremus, *CALFED*, *supra* note 66.

183. Zellmer & Gunderson, *supra* note 66, at 934–42; Layzer, *supra* note 67, at 104; Zweig & Kitchens, *supra* note 66.

twists and turns any particular water-resource and watershed planning and management process will take in the coming decades.

Data, Models, and Predictions. Adaptive watershed planning requires the continual use, improvement, refinement, adjustment, and development of data, models, and predictions related to a variety of watershed and water resource conditions. These conditions include temperature and climate patterns, storm events, precipitation (quantities, rates, timing, form, etc.), water demands, stream flows, stormwater runoff (quantities, rates, and quality), stream bed and riparian structure, the health of aquatic species' populations and their habitats, groundwater storage capacity, population growth, land development patterns, vegetation conditions, energy-water interrelationships, and a number of other factors affecting watersheds and water resources.[184] The various uses of such data and models include: climate change scenarios for the watershed; hydrological scenarios for the watershed; water supply and demand scenarios; land use pattern scenarios (e.g., population growth, build-out); consideration of compound, cumulative, and synergistic impacts; adaptation options; costs and benefits of various options; vulnerability analyses; and improvement of institutional adaptive capacity.[185]

However, given the uncertainties and nonlinear spatial and temporal dynamics of climate change, there is no single model of climate change.[186] Instead, watershed planners will need to consider the range of results (or predictions) from a variety of plausible, scientifically accepted models of changes in climate and their hydrological and aquatic effects.[187] For example, the Rand Corporation analyzed the vulnerabilities of Inland Empire Utilities Agency's 2005 Regional Urban Water Management Plan and the potential performance of different management options under a wide range of climate-change scenarios.[188] Unfortunately, though, most watersheds currently do not have climate-and-water models at the watershed scale;

---

184. For a study of the impacts of multiple stresses on water demand and supply in the U.S. Southeast, using various individual and combined scenarios of climate change, land use/land cover change, and population change, see *Multiple Stresses on Water Demand and Supply Across the Southeastern United States*, 44 J. AM. WATER RES. ASS'N 1441 (2008).

185. SHARON CLARK ET AL., STATE OF THE ROARING FORK WATERSHED REPORT ch. 3, § 5, 19–20 (2008); Miller, *supra* note 8; ASSOCIATION OF METROPOLITAN WATER AGENCIES, IMPLICATIONS OF CLIMATE CHANGE FOR URBAN WATER UTILITIES 11–15 (2007).

186. Miller, *supra note* 8, at 219–224, 232–233; GROVES ET AL., *supra* note 8, at 4–14

187. Watershed planners will need to use probabilistic models, instead of basing plans on historic data and past variability envelopes. Milly et al., *supra* note 84.

188. GROVES ET AL., *supra* note 8.

most of the currently accepted modeling is at larger regional, continental, or global scales.[189] Thus, adaptive watershed planning will create the demand for watershed-level climate-change models, will play a role in the development of such models, and will require continual reevaluation and potential adjustment in light of new models or improvements to the models on which plans are based. Furthermore, the uncertainties associated with climate change modeling should encourage watershed planners to adopt precautionary or no-regrets plans, avoiding irreversible stresses on watersheds and water supplies that could prove unsustainable, even disastrous, if the effects of climate change are more extreme than planners expected.[190]

At the same time, though, existing watershed planning efforts could improve their adaptability if they were only to use existing, evolving, increasingly sophisticated, and more accurate data and models of such phenomena as flood risk geography[191] and water supply projections.[192] This fact suggests that one of the reasons for watershed vulnerabilities and maladaptive watershed plans currently is not only the effects of climate change uncertainties but simply the failure to use available data and models. However, even for effects that are less complex and uncertain than climate change, there can be unintended consequences and lateral effects that upset the predictions of

189. For example, watershed planners in Washington indicated that the lack of watershed-level climate change and hydrology models pose significant barriers to incorporation of climate change considerations into watershed plans. Lara C. Whitely Binder, *Climate Change and Watershed Planning in Washington State*, 42 J. AM. WATER RES. ASS'N 915, 924–25 (2006) [hereinafter Binder article]. Likewise, the need for "global climate model downscaling" to watershed levels and higher spatial resolution in climate-and-hydrology data has been identified as important to adaption of Far West Texas regional watershed plans to the effects of climate change. TEXAS WATER DEVELOPMENT BOARD, FAR WEST TEXAS CLIMATE CHANGE CONFERENCE: STUDY FINDINGS AND CONFERENCE PROCEEDINGS 1, 16–17 (2008), *available at* www.twdb.state.tx.us/publications/reports/climatechange.pdf. Planners in Canada's Roaring Fork watershed note that "regional climate change modeling is in its early stages" and that there are considerable data and knowledge gaps for watershed planning. CLARK ET AL., *supra* note 185, at ch. 3, § 5, 19–21.

190. FELDMAN, *supra* note 25, at 275; Miller, *supra* note 8, at 232–233; Craig, *Stationarity*, supra note 13, at 67; Rasmus Heltberg et al., *Addressing Human Vulnerability to Climate Change: Toward a "No Regrets" Approach*, 19 GLOBAL ENVTL. CHANGE 89 (2009).

191. NATIONAL RESEARCH COUNCIL, MAPPING THE ZONE: IMPROVING FLOOD MAP ACCURACY (2009) (urging the use of currently available flood data, models, and mapping methods to improve understanding and communication of flood risk).

192. MANASQUAN WATERSHED MANAGEMENT GROUP, MANASQUAN RIVER WATERSHED MANAGEMENT PLAN 17 (2000) (adopting watershed plan strategy to "[d]evelop water supply projections based on more reliable computer modeling," with eight action items that include updating data for improved accuracy, evaluating data sources, and engaging in computer simulation models of growth build-out and related water demand estimates; also suggesting that some current hydrological conditions are incompletely understood).

linear cause-and-effect models. Based on studies on Louisiana's coastal wetlands and the Chesapeake Bay, Erin Ryan recommends that analysts:

> [Analysts] run the linear causal assessment backward as well as forward, asking not only what external factors might be upset by a proposed resource management strategy, but also what external factors might upset the strategy itself . . . . [and to use a] network approach to assessment . . . . [that] trace[s] potential causal connections along the circuitous routes that bridge the proposed management strategy to the external environment in which it would play a role . . . . [and give] more facile consideration of impacts that arise over attenuated branches of a complex ecosystem.[193]

David Feldman and Helen Ingram have discovered that one of the primary barriers to adaptation to climate change's impacts on water resources and management is that improvements in probabilistic climate forecasts are driven by the scientists producing them, instead of by the water planners and managers using them.[194] They argue that for climate forecasts to have good value and utility, they should arise in collaborative and adaptive knowledge networks, aided by boundary organizations that cross disciplinary and organizational divides to link networks, knowledge, and policy ideas.[195] They list watershed-based planning groups as boundary organizations, which facilitate these networks that co-produce knowledge and diffuse innovation.[196] Adaptive planning, in particular, aids in developing shared knowledge and collective cognitive pathways among multi-participant networks.[197]

Options, Alternatives, and Criteria. As has been discussed previously, watershed planning inherently involves the pursuit of multiple goals. Feldman and Ingram refer to "watershed-based entities designed to comprehensively manage and coordinate several management objectives simultaneously" as facing "the usual challenge of trying to harmonize competing objectives."[198] Moreover, multi-goal plans may result not only from the multiple

193. Ryan, *supra* note 66, at 1017, 1022.
194. Feldman & Ingram, *supra* note 106.
195. *Id.*
196. *Id.* at 16, Table 1.
197. Kartz & Lindell, *supra* note 119, at 9–10.
198. Feldman & Ingram, *supra* note 106, at 13–14.

values and interests in water but also from the many different issues that affect watersheds and water supplies.

An adaptive approach both to the multiple goals for watershed planning and to the uncertainties and complexities of watershed conditions and phenomena like climate change is for watershed plans to include a range of options and alternatives for obtaining certain desired conditions or meeting certain plan criteria. [199] Thus, instead of selecting a single optimal goal or solution to stresses on water resources and watersheds, adaptive watershed planning ideally identifies a range of options that are robust under any number of models of climate change (i.e., "decisions that are likely to perform adequately, no matter what realization of the deeply uncertain variables actually transpires."[200]).

Several features ideally characterize options and alternatives in adaptive watershed plans. First, they are proactive to the extent possible and practical in an environment of uncertainty. The plan should not be a wait-and-see reactive approach to adaptation, but instead make use of active adaptive methods to explore possible ways to improve the resilience and healthy functioning of water institutions and the watershed itself.

Second, plans should be based not only on science but also on public values and norms. Science alone cannot make value choices or ensure public buy-in to plan content. Data, scientific models, and improved knowledge using adaptive methods will not be enough for successful adaptive watershed planning. The planning process will require soft methods for translating social values and risk choices into policies and plans for a desired future or set of possible futures that are desired or acceptable. There are many such methods. Two are addressed here as examples: visioning and adaptive foresight. Lister and Kay describe visioning:

> One way to begin integrating values into planning is through the use of visioning. Visioning is a planning tool, one of several now being used to generate consensus through shared perceptions of a desirable future . . . . Adaptive planning, that integrates values and science (through visioning or another collaborative forum), is essentially a design process, through which we collectively evaluate and decide which of many futures we wish to steer ourselves towards, though

199. *See supra* Part IV on adaptive planning, and sources cited therein.
200. Miller, *supra* note 8, at 228.

> choices, trade-offs, trial and error, learning by doing, and flexible management.[201]

Weber describes adaptive foresight:

> Generally speaking, foresight processes represent a mechanism with which to deal systematically with future risks, opportunities and options by drawing on a broad range of future expectations and by involving an equally broad range of actors in a participatory process. . . . Exploratory approaches tend to be used to identify new emerging developments and resulting risks and opportunities that open up new issues and agendas for action. They start form the present and 'explore' the range of possible development paths. In contrast to forecasting, however, exploratory foresight emphasises the multitude of possible development paths resulting from the interaction between society and scientific-technological opportunities. . . . Normative approaches start with one or several images of the future in order to assess them along different dimensions and to identify the steps and requirements to realise them. . . . . [N]ormative foresight processes serve to negotiate societal goals and visions related to science, technology and society. . . . In practice, most foresight processes that have been realised over the past years combine both exploratory and normative elements, using a range of more or less formalised methodologies.[202]

Foresight methods of adaptive planning have been recognized, even by their advocates, as lacking rigorous and systematic evidence of their contribution to sustainable outcomes, as being more impressionistic than scientifically grounded, and as lacking sophisticated methods of implementation through strategic planning.[203] However, both visioning and adaptive foresight, among other possible methods,[204] may be useful in engaging multiple participants in

201. Lister & Kay, *supra* note 107, at 198.

202. Weber, *supra* note 115, at 197–98.

203. *Id.*, at 199–200.

204. Another method that can be used in connection with a number of other approaches is geovisualization. Experts in ways to improve planning participants' understanding of complex environmental processes and geospatial data in ways that will be useful to reaching collaborative decisions focus on a method called collaborative geovisualization, in which various methods and tools for representing geospatial data visually are used in collaborative creation of knowledge and making of decisions. *See, e.g.*, ISAAC BREWER ET AL., COLLABORATIVE GEOGRAPHIC VISUALIZATION: ENABLING SHARED UNDERSTANDING OF ENVIRONMENTAL PROCESSES, *available at* HTTP://www.geovista.psu.edu/publications/IBAMivis/IBAMivis.pdf; ALAN M. MACEACHREN, GEOVISUALIZATION TO MEDIATE COLLABORATIVE WORK: TOOLS TO SUPPORT

adaptive watershed planning with values-based and policy-based thinking about possible, yet uncertain, future watershed and water resource conditions.

Third, options and alternatives must be accompanied by criteria for evaluating them and selecting among them as the plan develops and is implemented. This is a particularly challenging aspect of adaptive watershed planning. If the criteria are too specific, narrow, rigorous, and scientific, they may undermine the flexibility and adaptive capacity of the plan. If they are too general, broad, flexible, and policy-based, they may leave almost limitless discretion to managers and future decision makers in ways that ultimately undermine the sustainability and adaptation-enhancing features of the plan. Planning participants should give considerable attention and thought to criteria to guide the plan's implementation and continued development and assessment.

Fourth, the plan should include multiple strategies and methods for achieving broad policy goals – planned redundancies – as ways of hedging against the failure of some strategies and methods and against unexpected conditions that may render "efficient, optimal" strategies and methods inadequate. The types of strategies and methods that might be considered in adaptive watershed planning include:

- drought planning
- development of new water supplies
- demand-management methods instead of supply augmentation
- conservation incentives and pricing
- conjunctive management of surface water and groundwater
- recharge of aquifers seasonally or based on groundwater levels or based on groundwater mining practices
- reuse of wastewater
- green infrastructure
- watershed-protectionist zoning
- low-impact-development design standards
- flexible water sharing arrangements
- water rights transfers or sales
- conjunctive management of surface water and groundwater
- increased water storage and/or improved water storage capacity
- decreased reliance on imported water

DIFFERENT-PLACE KNOWLEDGE CONSTRUCTION AND DECISION-MAKING, *available at* http://www.icaci.org/documents/ICC_proceedings/ICC2001/icc2001/file/f16009.doc.

- residential water conservation measures
- commercial and industrial water conservation measures
- improved irrigation efficiencies and agricultural water conservation measures
- water use restrictions
- improved technologies
- objectives for maximum daily per capita water use
- water-quality best management practices
- stormwater runoff management and control
- water treatment technology
- revised water quality standards
- riparian buffer zones
- forestry practices and conservation
- wetland conservation and restoration
- landscape/terrain micro-storage
- water-use efficiency best management practices
- increased energy efficiency of water and wastewater treatment operations
- streamflow criteria or benchmarks
- aquatic habitat condition criteria or benchmarks
- water quality conditions criteria or benchmarks
- floodplain redefinition
- increased floodplain development restrictions
- incentives for new or improved technology
- investment in research and data collection
- improved data and modeling (including regional and local modeling at watershed level and finer spatial resolution)
- creation of research consortia or networks
- public education and awareness.

The adaptive planning process involves selection of multiple means for achieving desired goals, but in ways that are appropriate to the needs and conditions of the watershed. For example, David Feldman states that water conservation methods are complex to achieve and typically require multiple strategies implemented in phases,[205] thus requiring multi-strategy flexible plans.

Institutional Adaptive Capacity. Adaptive watershed planning is not only about the adaptive characteristics of the plan and its implementation but also about the adaptive capacity and resilience of watershed institutions and organizations. "Adaptivity is not just a matter of specific policy measures and

205. FELDMAN, *supra* note 25, at 298–306.

portfolios, but also of institutional and structural settings."[206] Several features have been identified as contributing to systemic resilience in ecosystem planning and management, including a diverse range of actors and social roles within the system, social capital and trust, flexible multiscalar networks of organizations, institutions, and actors, institutional redundancy, collective schema and memory, knowledge and understanding of the dynamics of ecosystems and social systems, collaboration, and multi-level governance.[207]

However, some adaptive characteristics may not be enough if systemic or comprehensive adoption of adaptive methods does not occur. For example, water supply planning in Texas has improved in adaptive capacity over the years by providing for planning at state, regional, and local levels and by requiring that plans be continually reviewed and updated every five years. Texas water supply planning fails to be sufficiently adaptive to climate change, because predictions of shortages are based on the drought of record, instream and environmental flows planning are not incorporated into drought planning, surface rights and flow requirements are not integrated with groundwater rights and management, data and models on water availability are incomplete and still developing, regional planning units do not entirely match watershed scales, and climate change effects have largely been ignored in water planning thus far.[208] Nonetheless, an incomplete and limited watershed planning effort may lead to "a much longer, more iterative and adaptive process."[209]

Finally, a characteristic of adaptive watershed planning that is critical to long-term system adaptive capacity is learning: both scientific and social (public) learning.[210] As discussed previously, feedback from an adaptive watershed plan's implementation contributes to revisions to the plan and to existing data and models and generates new actions, data, and models. However, it also ideally shapes and reshapes watershed institutional and

206. Weber, *supra* note 115, at 217. *See also* RUSH ET AL., *supra* note 158, at 6 (asserting that adaptive capacity of watershed planning depends on the structure of institutional arrangements).

207. Firket Birkes & Carl Folke, *Linking Social and Ecological Systems for Resilience and Sustainability*, *in* LINKING SOCIAL AND ECOLOGICAL SYSTEMS: MANAGEMENT PRACTICES AND SOCIAL MECHANISMS FOR BUILDING RESILIENCE 1, 5-6 (Fikret Birkes & Carl Folke eds. 1998); Feldman & Ingram, *supra* note 106.

208. TEX. WATER CODE ANN. §§ 16.051–16.060 (Vernon 2009) (state, regional, and local water plans); ANDREW SANSOM, WATER IN TEXAS: AN INTRODUCTION 7, 9, 203–12 (2008); Witherspoon, *supra* note 1.

209. Adler, *Great Salt Lake*, *supra* note 175, at 199.

210. Scholz & Stiftel, *supra* note 176; Feldman & Ingram, *supra* note 106, at 9; Freeman & Farber, *supra* note 66, at 883–88; Kartz & Lindell, *supra* note 119, at 8.

organizational structure, culture, and understanding in ways that enhance institutional and organizational adaptive capacity. As Mary Jane Angelo points out, ecological resilience may turn on the resilience of ecosystem-based institutions and organizations to learn from and adapt to their mistakes.[211] She observes that this learning might include incremental learning from incremental ecological or social change, spasmodic or episodic learning from abrupt ecological or social change, and transformational learning from transformational change.[212]

B. Benefits

Adaptive watershed planning offers a number of benefits to the planning and management of water resources. First, it provides a process for goal identification to guide management activities, but in a way that incorporates adaptability and uncertainty into goals from the outset.[213] Adaptive management is not enough if the goal-setting processes and initial decisions about actions are also not adaptive. Given that adaptive planning does not require optimization of a single goal, plans can reflect multiple goals and decisional processes for resolving conflicting values. Identification of goals and goal-resolution can aid water managers, who may wrestle with the many different values that waters and watersheds serve in society; their assumptions about goals are often disrupted by political conflict, legal conflict, and human behaviors that do not match stated static goals. Incrementalist experimentation will not be effective if managers' only feedback involves ecological effects and processes, without attention to changing socio-political conditions and policy goals.

Second, adaptive planning is a means to incorporate adaptive management principles into required or expected planning processes. Statutes often require that government agencies with responsibility for natural resources or ecosystem conditions engage in planning and adopt formal plans that are to govern their management activities.[214] Moreover, courts may

211. Angelo, *Stumbling*, *supra* note 90, at 1004–7.

212. *Id.* at 994–95.

213. For a discussion of the role that adaptive planning can play in setting goals and incorporating values into decisions that cannot be based purely on the scientific considerations of adaptive management, see Lister & Kay, *supra* note 107.

214. *See, e.g.*, National Forest Management Act, 16 U.S.C. § 1604(g)(3) (2010) (national forest land use and management plans); TEX. WATER CODE §§ 16.051–16.060 (Vernon 2010) (state, regional, and local water plans); CAL. GOVT. CODE §§ 65300 et seq. (West 2010) (local government comprehensive plans for the jurisdiction's long-term physical development).

question officials' use of adaptive management methods to avoid planning.[215] Even where planning is not legally required, public expectations or organizational culture may functionally necessitate planning. To the extent legally permissible, features of adaptive planning may serve to meet planning requirements but in ways that enable agency officials to adapt to changing or unexpected conditions.

Third, adaptive watershed planning can integrate—or at least build connections between—water resources and other areas of planning and management, such as land use, disaster preparation and response, public health, pollution control and prevention, public lands, biodiversity and species protection, and energy policy. In general, watershed planning and management have been recognized as using networks that transcend narrow, organizational, jurisdictional, and disciplinary silos that often constrain more formal and subject-specific allocation of governance and management authority.[216] Adaptation to uncertain conditions requires attention to the many, complex interrelationships among various ecological and social phenomena. For example, planners and decision makers can explore and compare different growth scenarios or assumptions, drawing on data and models from many different disciplines, professions, and entities, instead of relying solely on data and models specific to water resource management.

Fourth, the process of adaptive watershed planning can improve information and understanding, thus contributing to the scientific and social learning sought in adaptive management. Perhaps most importantly, planning under conditions of uncertainty itself creates demand for better data, information, models, and understanding. Watershed-based collectivities – watershed groups, networks, organizations, or institutions – both demand and generate data, information, models, and understanding, often as part of planning processes.[217] Watershed-based planning processes are network pathways for the diffusion of innovation, information, and methods.[218]

215. *See, e.g.*, Klamath-Siskiyou Widlands Ctr. v. Boody, 468 F.3d 549, 554 (9th Cir. 2006); Western Watersheds Project v. U.S. Forest Service, 2006 WL 292010 (D. Idaho 2006).

216. Feldman & Ingram, *supra* note 106; SWIMMING UPSTREAM, *supra* note 36; Karkkainen, *CEG*, *supra* note 16.

217. *See, e.g.*, DAVENPORT, *supra* note 26 (describing watershed management's information demand and generation throughout multiple phases of watershed planning, implementation, and evaluation); Holly Doremus, *Data Gaps*, *supra* note 170.

218. *See, e.g.*, Lubell & Fulton, *supra* note 36; Feldman & Ingram, *supra* note 106. For a discussion of adaptive planning as creating a "shared schema" among those responsible for management activities, developed through multi-participant networks, *see* Kartz & Lindell, *supra* note 119, at 10.

Watershed planning processes expand the scope and variety of expertise and knowledge beyond water management specialists to other professionals, agencies, and interested parties, including members of the public.[219] Local knowledge – often particularly relevant to grassroots place-based planning and collaborative processes – supplements and sometimes challenges expert scientific knowledge and assumptions.[220] Adaptive watershed planning also provides decision makers and managers with information about and consideration of the uncertainties and complexities of human and social systems, not just ecological systems.[221]

Fifth, adaptive watershed planning functions as a tool of integrationist multimodality. We currently see the evolution of environmental, natural resources, land use, and water law towards the use of multiple modes or methods of conservation and management, but in integrated ways.[222] This development – called integrationist multimodality – is an adaptive response to complexity and uncertainty.[223] Watershed-based governance, management, collaboration, and planning activities have been identified as examples of emergent integrationist multimodality: connecting multiple modes of aquatic protection and stewardship around watershed-based actions and plans.[224] However, if adaptive planning methods are not used in these activities, the watershed-based plans, programs, policies, regulations, management activities, processes, and institutions run the risk of either unraveling or collapsing under unexpected stressors and static rigidity. Neither integration nor multimodality are

219. Feldman & Ingram, *supra* note 106; FELDMAN, *supra* note 25, at 278–85.

220. *See, e.g.*, BRIDGING SCALES AND KNOWLEDGE SYSTEMS, *supra* note 106; FIKRET BERKES, SACRED ECOLOGY: TRADITIONAL ECOLOGICAL KNOWLEDGE AND MANAGEMENT (1999); Fikret Berkes, *Rethinking Community-Based Conservation*, 18 CONSERVATION BIOLOGY 621 (2004); FELDMAN, *supra* note 25, at 278–85. On the concept of local knowledge generally, see CLIFFORD GEERTZ, LOCAL KNOWLEDGE: FURTHER ESSAYS IN INTERPRETATIVE ANTHROPOLOGY (1983); Lea S. VanderVelde, *Local Knowledge, Legal Knowledge, and Zoning Law*, 75 IOWA L. REV. 1057 (1990).

221. *See, e.g.,* PANARCHY, *supra* note 82; LINKING SOCIAL AND ECOLOGICAL SYSTEMS, *supra* note 82; FELDMAN, *supra* note 25, at 278–93 (addressing both various sources of knowledge about social conditions and the need for watershed planning to incorporate social concerns, as well as ecological concerns); Griffin, *supra* note 36; McAllister, *supra* note 36; McGinnis et al., *supra* note 36; Wooley et. al., *supra* note 36, at 135; Peter H. Gleick, *Global Freshwater Resources: Soft-Path Solutions for the 21st Century*, 302 SCI. 1524, 1526–27 (2003) (calling for "soft path" methods of water planning that seeks to improve the productive use of water by identifying the evolving human and social water usage goals and developing new methods to satisfy various human and ecological needs for water that focus on end-goals and not on physical infrastructure itself).

222. Craig Anthony (Tony) Arnold, *Fourth-Generation Environmental Law: Integrationist and Multimodal*, 35(3) WM. & MARY ENVTL. L. & POL'Y REV. (forthcoming 2010).

223. *Id.*

224. *Id.*

adaptive per se and require adaptive planning mechanisms to facilitate scientific and social learning and periodic adjustment.

Sixth, adaptive watershed planning presumes some element of public governance and planning in water management, even if these governance and planning features could be multi-participant, could use informal, decentralized, or collaborative processes, or could select market-based mechanisms and economic incentives as methods to implement plans and to add adaptive flexibility to existing water allocations and uses. Some believe that the best way to increase the capacity of water institutions to adapt to climate change is to rely primarily on the reallocative power of private free markets in water.[225] However, many have pointed out that water is a public good, serving many essential functions in society and nature, and that private markets in water do not work in practice in the United States as well as free-market theory would suggest.[226] Despite the limits of public governance and planning, they are necessary elements of water management in the United States.

Seventh, adaptive watershed planning improves the capacity, resilience, and adaptability of existing watershed management organizations and institutions.[227] It introduces methods for balancing or integrating multiple goals. Adaptive watershed plans link principles and context, moving beyond abstract principles uninformed by context and beyond unprincipled ad hoc responses. They include plans for the redundancy of resources. They provide for feedback loops that shape not only specific management decisions but also plans and goals themselves. Adaptive watershed planning ideally creates methods for rapid decentralized decision making in response to changing conditions. The process of multi-participant adaptive watershed planning informs and educates multiple actors, builds social capital in existing institutions, creates a means for the

---

225. Jonathan H. Adler, *Water Marketing as an Adaptive Response to the Threat of Climate Change*, 31 HAMLINE L. REV. 730 (2008); Miller, *supra* note 8, at 20–21. *See generally* TERRY L. ANDERSON & PAMELA SNYDER, WATER MARKETS: PRIMING THE INVISIBLE PUMP (1997); Andrew P. Morriss, *Lessons from the Development of Western Water Law for Emerging Water Markets: Common Law vs. Central Planning*, 80 OR. L. REV. 861, 883 (2001). Joe Dellapenna criticizes this market primacy perspective, which he labels the "Washington Consensus." Joseph W. Dellapenna, *Climate Disruption, The Washington Consensus, and Water Law Reform*, 81 TEMP. L. REV. 383, 386, 390–401 (2008) [hereinafter Dellapenna, *Climate Disruption*].

226 *See, e.g.*, Dellapenna, *Climate Disruption*, *supra* note 225; Robert Glennon, *Water Scarcity, Marketing, and Privatization*, 83 TEX. L. REV. 1873, 1889 (2005); Joseph W. Dellapenna, *The Importance of Getting Names Right: The Myth of Markets for Water*, 25 WM. & MARY ENVTL. L. & POL'Y REV. 317 (2000); Arnold, *Water Privatization*, *supra* note 132, at 789; Sandra B. Zellmer & Jessica Harder, *Unbundling Property in Water*, 59 ALA. L. REV. 679 (2008).

227. *See supra* Section V.A.

diffusion of innovation, and aids in supporting the evolution of culture to adapt to changing conditions and uncertainties. As discussed previously, adaptive watershed planning links planning with adaptive management, thus improving the capacity of water resource management institutions to make better use of adaptive management methods.

Finally, adaptive watershed planning processes create opportunities to create new planning and management processes, networks, and institutions that improve society's ability to respond adaptively to changing conditions on uncertainties in water resources. These new developments aim to overcome the current fragmentation of authority and action and to support local and grassroots responses to watershed problems when centralized pre-existing organizations or institutions fail to act. Adaptive watershed planning can create networks for future action and problem-solving. Adaptive watershed planning is a systemic innovation that is an adaptive evolution in environmental and natural resources management.

VI. WATERSHED PLANS AND CLIMATE CHANGE

The potential impacts of climate change are increasingly receiving attention in watershed plans, suggesting that watershed planning may becoming more adaptive. For example, in California, the Santa Ana Watershed Project Authority's 2009 Santa Ana Integrated Watershed Plan gives substantial attention to the impacts of climate change on water resources in the Santa Ana River Watershed.[228] This plan recognizes the scientific agreement that climate change is occurring, the existing evidence of climate change and its impacts in the watershed, and the variety of quantitatively different climate change models and projections that simultaneously undermine the value of relying on past data, yet fail to provide a definitive prediction of future conditions.[229] However, the plan applies a range of plausible models of future temperatures, precipitation, and sea level rise to address likely impacts in the watershed: increased evaporation and transpiration; increased water demands; longer, hotter, and more frequent heat waves; wildfire risks; summer peak energy demands; diminished air quality;

---

228. SANTA ANA WATERSHED PROJECT AUTHORITY, ONE WATER, ONE WATERSHED, 2009 SANTA ANA INTEGRATED WATERSHED PLAN: AN INTEGRATED REGIONAL WATER MANAGEMENT PLAN 2, 389–400 (2009), *available at* http://www.sawpa.org/documents/owow/irwmp/2009SantaAnaIRWMP.pdf.

229. *Id.* at 389–92.

water body temperatures; decreased water quality and related biotic stresses; the effects of decreased precipitation on supplies of imported water; increased flood risks; decreased groundwater replenishment; and risks to the reliability of local water supplies.[230] The plan sets forth several climate-change management strategies for water resource managers in the watershed:

- Understand that the past is not the future;
- Develop watershed-wide programs;
- Incorporate climate considerations into land use planning;
- Factor in flood and fire management in planning decisions;
- Protect and restore aquatic ecosystems;
- Make water use efficiency and local water supply development a top priority;
- Promote investment in renewable energy, building efficiency, and vehicle efficiency;
- Recognize the energy intensity of water supplies;
- Increase public education; and
- Perform carbon footprint assessment and use the tool to identify additional opportunities for reducing carbon emissions.[231]

These strategies are rather general, providing very little specific guidance to water resource managers about how to adapt to climate change's impacts on the watershed. However, they serve to focus attention on relevant issues and concerns for adaptive management of the watershed and its water supplies. Moreover, the watershed planners considered climate change analyses in connection with other sources of uncertainty and change, including Colorado River drought conditions, San Joaquin Delta vulnerability, and population growth and development, to develop a set of integrated goals and strategies to guide water resource management and watershed conservation efforts.[232] The plan's working goals and objectives are:

- Provide reliable water supply;
- Preserve and enhance the environment;
- Promote sustainable water solutions;
- Ensure high quality water;
- Provide economically efficient solutions;

230. *Id.* at 392–96.
231. *Id.* at 397–99.
232. *Id.* at 2, 15–19.

- Improve regional integration and coordination;
- Use rainfall as a resource;
- Provide recreational opportunities; and
- Maintain quality of life.[233]

Again, these goals are general, vague, and reflect a multitude of values and policy objectives. In some sense, every water manager and watershed community would aspire to these goals. However, they serve to focus overall watershed-based actions on a vision of "a sustainable Watershed that is drought proofed, salt-balanced, and supports economic and environmental viability."[234]

More specific ideas about how to achieve these general goals are discussed with respect to ten different "pillar" areas: water supply reliability; water quality improvement; water recycling; water use efficiency; water and land use; flood risk management; environment and habitat enhancement; parks, recreation, and open space; climate change; and environmental justice. Some examples of these specifics include developing additional storage for recycled water, developing new pathogen indicators and new residual chlorine standards, reconsidering whether flood risk management should continue to be based on the 100-year flood probabilities created from historic data, and changing landscape design elements to increase pervious hard surfaces, pavers, bio-swales, new irrigation technology, and water-efficient gardens in comprehensive landscape planning and consumer packages.[235]

Moreover, the Santa Ana Integrated Watershed Plan adopts twelve "next step" strategies to guide water resource adaptability to changing conditions:

- Increase storage;
- Reduce demand;
- Value water differently;
- Desalt groundwater;
- Develop risk-based water quality improvement programs;
- Incorporate integrated water planning into General Plans;
- Maximize preservation and use of native plants;
- Manage public property for more than one use;
- Recycle water;
- Consider stormwater as water supply;

233. SANTA ANA WATERSHED PROJECT AUTHORITY, *supra* note 228, at 15.
234. *Id.* at 1.
235. *Id.* at 5–10.

- Create watershed governance; and
- Implement watershed-wide education programs.[236]

Each of these strategies has specific content beyond its general strategy description. The plan will need to be implemented, though, with specific, concrete actions that may involve experimentation, assessment, and adjustment. Moreover, the plan does little to establish performance measures or standards for evaluating the implementation actions and progress towards the plan's goals, or to create feedback loops and accountability mechanisms to ensure that the plan's objectives are achieved. These limitations may be due to the fact that the plan expressly envisions watershed governance to be a multi-stakeholder bottom-up collaborative process involving all "the local agencies, organizations, and other interested parties within the Watershed."[237] The Santa Ana Watershed Project Authority's goal of achieving greater plan implementation by achieving widespread buy-in by affected entities and parties will depend on the degree to which the relevant actors within the watershed develop their own plans and actions that reflect the plan's goals. Nonetheless, getting these actors to focus on the unreliability of past water conditions, the potential impacts of climate change, and the range of policy and management changes that could improve capacity to adapt to these changing conditions is a major step forward from conventional planning or ad hoc management practices.

A 2002 study examines the incorporation of climate change considerations into voluntary watershed management plans under the State of Washington's Watershed Planning Program, which provides for locally-based multi-participant watershed planning efforts in state-delineated Water Resource Inventory Areas.[238] Overall, the study shows that a significant portion of watershed planning units, about two-thirds, are considering climate change in some respects in their development of watershed plans, but most of these considerations remain at fairly general or superficial levels of identification and are hampered by lack of technical tools and studies, the relative newness and uncertainties of climate-change hydrological modeling, and lack of leadership or initiative.[239] The study's

236. *Id.* at 18.

237. *Id.* at 2.

238. Binder article, *supra* note 189; Lara C. Whitley Binder, Watershed Planning, Climate Variability, and Climate Change: Bringing a Global Scale Issue to the Local Level (2002) (unpublished M. Pub. Admin. Thesis, University of Washington) (on file with Environmental, Energy Law & Policy Journal) [hereinafter Binder thesis].

239. *See generally*, Binder article, *supra* note 189; Binder thesis, *supra* note 239 .

author, Lara Whitely Binder, emphasizes the benefits of awareness of climate change's watershed impacts and planning units' initial, even if general or superficial, attention to climate change in their watershed plans; she believes that these developments are creating demand for improved and greater use of climate-change hydrology studies in watershed planning and management, the initial establishment of network-based knowledge about climate change and water among watershed planning unit participants, and the potential for more detailed planning for climate change variability in future plan updates.[240] Interestingly, the Washington State Department of Ecology has involved the University of Washington's Climate Impacts Group in supporting the efforts of WRIA watershed planning groups to address climate change impacts on their watersheds.[241]

Adaptive watershed planning can stimulate further planning efforts that address climate change impacts, even if the watershed plan itself did not initially address climate change in any meaningful way. For example, the Pomperaug River Watershed Coalition and various governmental entities prepared a draft Pomperaug Watershed Management Plan in 2006, which called for the U.S. Geological Survey to model various river-flow effects under extreme climate conditions but did not contain specific climate-change adaptation plans.[242] In 2009, though, the Coalition sponsored a multi-participant exercise over hypothetical extreme drought conditions from which an action plan was drafted.[243] In another example, the Association of Bay Area Governments is attempting to incorporate climate change data into its regional San Francisco Bay watershed maps and data and to develop drought planning and other climate change adaptation strategies.[244]

Some watershed institutions are merely in the phase of identifying the likely effects that climate change may have on water resources and watershed functions, the need for additional data and modeling, and the importance of altering their watershed plans for adaptation to these impacts. Examples

---

240. Binder article, *supra* note 189, at 921–25.

241. Washington State Watershed Plan, http://cses.washington.edu/cig/fpt/fptarchive/watershedplan.shtml (last visited September 13, 2010).

242. Draft, Pomperaug Watershed Management Plan (Oct. 22, 2006) (on file with author).

243. Pomperaug Watershed Coalition Completes Draft Action Report After Drought Simulation (Feb. 25, 2009), *available at* http://www.voicesnews.com.

244. Kathleen Van Velsor, Climate Change and Planning Implications for San Francisco Bay: Regional Watershed Management and a Flood of Ideas about How to Anticipate and Capture Rainfall for Prolonged Droughts (Jan. 19, 2010) (abstract, on file with the Environmental, Energy Law & Policy Journal).

include Colorado's November 2008 State of the Roaring Fork Watershed Report, sponsored by the Ruedi Water and Power Authority with the Roaring Fork Conservancy,[245] and the RAND Corporation's assessment of California's Inland Empire Utilities Agency's 2005 Regional Urban Water Management Plan and various possible changes to it under a range of climate change models.[246] The Vashon-Maury Island Watershed Plan in King County, Washington, calls for improved research and modeling of climate change's watershed impacts and assessments of these impacts for adaptation and conservation purposes.[247] Another example was the Far West Texas Climate Change Conference, held by the Texas Water Development Board in El Paso in 2008, pursuant to a statutory mandate from legislation authored by Texas State Senator Eliot Shapleigh,[248] who was the keynote luncheon speaker at the Symposium from which this issue of the *Environmental and Energy Law and Policy Journal* derives. The conference convened experts, state water planners, and members of the Far West Texas Regional Water Planning Group to develop and consider "recommendations for incorporating potential impacts of climate change into the Far West Regional Water Plan, including potential impacts to the Rio Grande in Texas subject to the Rio Grande Compact, and identifying feasible water management strategies to offset any potential impacts."[249] The participants made several recommendations for water supply and infrastructure management, water conservation, further research, data, and modeling of climate change impacts on water, continued regional planning and assessments, and reconsideration of planning benchmarks based on the drought of record.[250]

Canadian watershed and water resources experts have given quite a bit of attention to the watershed impacts of climate change. These developments include:

- The 1999 Symposium on Climate Change and Watershed Management at Black Creek Pioneer Village, Toronto;[251]

245. SHARON CLARK ET AL., *supra* note 185, at 5.
246. GROVES ET AL., *supra* note 8.
247. KING COUNTY (WA) DEP'T OF NATURAL RES. & LAND RES. DIV., VASHON-MAURY ISLAND WATERSHED PLAN (JUNE 6, 2005).
248. TEXAS WATER DEVELOPMENT BOARD, FAR WEST TEXAS CLIMATE CHANGE CONFERENCE: STUDY FINDINGS AND CONFERENCE PROCEEDINGS (2008), *available at* http://www.twdb.state.tx.us/publications/reports/climatechange.pdf.
249. *Id.*
250. *Id.* at 35–36.
251. ENVIRONMENT CANADA ET AL., CLIMATE CHANGE AND WATERSHED MANAGEMENT: PROCEEDINGS OF A SYMPOSIUM HELD NOVEMBER 10, 1999, AT BLACK CREEK PIONEER VILLAGE, TORONTO (1999).

- The update of the Rouge River Watershed Plan by the Toronto and Region Conservation Authority to model future conditions on the basis of two different climate change scenarios to allow for planning under uncertainty;[252]
- The Union of Nova Scotia Municipalities' model of Integrated Community Sustainability Plans, which involves long-term sustainability planning, including source water protection planning that addressed the impacts and volatilities associated with climate change;[253]
- The development of a toolkit for community land use planners to adapt to climate change, using the Pereau River watershed in southwestern Nova Scotia as a test case;[254]
- Watershed stakeholder discussion on adaptation to climate change in the Oldman River Watershed, Alberta;[255]
- The Grand River Conservation Authority's adoption of conservation practices to build watershed resilience to climate change in the Grand River Watershed in Ontario;[256]
- The Humber River Watershed Plan's express consideration of climate change and the unsustainability of current land use and environmental management practices for this Ontario watershed's future health under a number of scenarios;[257]
- A comprehensive regional assessment of climate change impacts on water resources & stakeholder identification of adaptation strategies in the Okanagan Basin of British Columbia;[258] and
- The Guelph (University of Guelph) Water Management Group's 2007 report on water allocation and security in Canada.[259]

---

252. Toronto & Region Conservation Authority, Integration of Climate Change Impacts and Adaptation into Municipal Policy and Programs: A Focus on Water Management, PPT presentation (Nov. 3, 2005); Glenn Farmer and Sonya Meek, Water Balance Component of TRCA's Watershed Planning Studies, PPT Presentation, CMCH On-line Teleconference (Sept. 22, 2005).

253. Debbie Nielsen & Britt Roscoe, Preparing for Change: Watershed Planning as a Sustainability Tool, PPT presentation, Union of Nova Scotia Municipalities ("UNSM") (undated).

254. Summary Project A1209: Climate Change Adaptation for Land Use Planners, *available at* http://adaptation.nrcan.gc.ca/projdb/pdf/178a_e.pdf.

255. REBECCA RUSH ET AL., *supra* note 158.

256. JOE FARWELL ET AL., MAKING WATERSHEDS MORE RESILIENT TO CLIMATE CHANGE: A RESPONSE IN THE GRAND RIVER WATERSHED, ONTARIO, CANADA, *available at* www.grandriver.ca/AboutGrand/ClimateChange08.pdf

257. TORONTO AND REGION CONSERVATION, HUMBER RIVER WATERSHED PLAN: PATHWAYS TO A HEALTHY HUMBER (2008).

258. COHEN & T. NEALE, VANCOUVER: ENVIRONMENT CANADA AND UNIVERSITY OF BRITISH COLUMBIA, PARTICIPATORY INTEGRATED ASSESSMENT OF WATER MANAGEMENT AND CLIMATE CHANGE IN THE OKANAGAN BASIN, BRITISH COLUMBIA (2006).

259. ROB DE LOË ET AL., WATER ALLOCATION AND WATER SECURITY IN CANADA: INITIATING A POLICY DIALOGUE FOR THE 21ST CENTURY 33–36 (2007).

In a number of respects, the Canadians seem to be more proactive about incorporating climate change adaptation into watershed planning than the Americans, although there are not hard data and definitive measures to compare the two nations and the trend towards increased watershed planning for climate change seems to be evolving in both nations. Nonetheless, it is worth noting that a substantial number of watershed plans in the U.S. make no mention or give no real attention to the uncertainties in future conditions posed by climate change or the possible impacts of climate change on water resources and watershed sustainability. These include the Armand Bayou Watershed Plan (Texas),[260] the Clayton County Watershed Management Plan (Georgia),[261] the Manasquan River Watershed Management Plan (New Jersey),[262] the Spring Creek Watershed Plan (Pennsylvania),[263] the Upper Colorado River Watershed Restoration and Management Plan (Texas),[264] and the Yellow Bank Creek Watershed Management Plan (Alabama).[265]

Thus, the overall picture in the United States is that the potential for adaptive watershed planning for climate change is far from being realized. Nonetheless, the potential is real, and a number of watershed planning groups and institutions are moving towards greater consideration of climate change and the need to include adaptive, proactive, and resilience-building actions in their watershed plans. As they do so, these groups and institutions will likely encounter a number of issues, obstacles, and challenges.

VII. ISSUES AND OBSTACLES

A number of inherent characteristics and external barriers may constrain the capacity of watershed planning to become sufficiently adaptive to climate change uncertainties and impacts. While adaptive watershed planning offers real benefits

---

260. ARMAND BAYOU WATERSHED PARTNERSHIP AND COASTAL COORDINATION COUNCIL, ARMAND BAYOU WATERSHED PLAN (2004).

261. CH2M HILL, [CLAYTON COUNTY, GA] WATERSHED ASSESSMENT AND MANAGEMENT PLAN, SECTION 6, WATERSHED MANAGEMENT PLAN (2001).

262. MANASQUAN WATERSHED MANAGEMENT GROUP, MANASQUAN RIVER WATERSHED MANAGEMENT PLAN (2000).

263. CLEARWATER CONSERVANCY, THE SPRING CREEK WATERSHED PLAN PHASE 1 FINAL REPORT: OUR CHALLENGES AND A DIRECTION FOR THE FUTURE (undated).

264. COLORADO RIVER MUNICIPAL WATER DISTRICT, UPPER COLORADO RIVER WATERSHED RESTORATION AND MANAGEMENT PLAN (2006).

265. MADISON COUNTY SOIL AND WATER CONSERVATION DISTRICT, YELLOW BANK CREEK WATERSHED MANAGEMENT PLAN (2004, rev. 2005).

and has real potential, it will not be easy to achieve, and it will not be a panacea to water resource management problems or watershed sustainability issues under complex, uncertain, and changing conditions.[266]

Legal authority. The legal authority for and constraints on watershed planning – or the lack of legal authority or constraints – can create both opportunities and obstacles to engage in adaptive watershed planning.[267] In some cases, watershed planning and management is authorized by statute or largely driven by government agency's choices about resource management or program implementation.[268] In these cases, adaptive watershed plans may be less vulnerable to legal challenges or reliance on voluntary implementation measures than situations in which the role of watershed planning is considerably more informal or decentralized. However, the adaptive features of watershed planning may be constrained or precluded by the legal requirements of the statutes authorizing or mandating watershed planning or an agency's resource management activities.

In other cases, watershed planning and management arise out of voluntary cooperation among multiple organizations and participants (sometimes through informal or semi-formal networks), grassroots initiatives, or the responses to particular institutions or entities to particular needs. In these cases, the planning processes and outcomes can be designed, or can emerge, with greater flexibility and various adaptive features than if they had been formally required or created. However, they may be challenged as unauthorized by law, may fail to be implemented effectively or even at all, or may lack necessary accountability and assessment measures.[269] In addition, they occur in the shadow of, or share legal, policy, and management space with other areas of law governing water resources and watershed features, such as assured supply laws,[270] the primacy of local control over land use,[271] state water law,[272] and a patchwork but possibly growing set of federal controls over water resources.[273]

266. For a very good case that there are no panaceas for water management problems, see Ruth Meinzen-Dick, *Beyond Panaceas in Water Institutions*, 104 PROCEEDINGS OF THE NAT'L ACAD. OF SCI. OF THE U.S. 15200 (2007).

267. Tarlock, *Rivers, supra* note 25, at 1098–1102.

268. *See, e.g.,* Watershed Planning Act, WASH. REV. CODE ANN. § 90.82 (West 2004); Foster, *supra* note 36.

269. *See* Tarlock, *Rivers, supra* note 25, at 1098–1102. *See also* sources of critiques of standardless adaptive management *supra* note 93.

270. *See, e.g.,* Lincoln L. Davies, *Just a Big, "Hot Fuss"?: Assessing the Value of Connecting Suburban Sprawl, Land Use, and Water Rights Through Assured Supply Laws*, 34 ECOLOGY L.Q. 1217 (2008).

271. *See, e.g.*, Arnold, *Structure of Land Use*, *supra* note 156.

The basic conundrum of too much law or too little law has no simple or clear answer, despite strong advocates and critics on both ends of the spectrum. However, the state of the law and the relative formality or informality of watershed institutions, and the emergence of new watershed-based initiatives and institutions, are not static; they continue to evolve. Perhaps the diversity of substantive law, processes, degree of formality/informality, and role of government agencies, among other factors, contributes to overall system resilience. This is not to say that particular watershed planning efforts could not be improved. Many could be improved. However, a uniform method or structural arrangement for adaptive watershed planning may be more vulnerable to the many potential mistakes that humans can make and to the potentially widespread impacts of policy failures than a more diverse and organic, albeit imperfect and messy, variety of watershed planning arrangements.

Hard choices. Several different features of adaptive planning may deter decision makers from making hard choices – in the sense of involving both specifics and trade-offs – about the sustainable conservation, management, and use of water resources: the contingent and changeable nature of all plans and decisions; the potential to push decisions into the future as conditions evolve; the multi-goal content of plans; the inclusion of multiple options or methods for achieving goals; the decentralization of decision making authority; and the multi-participant and often collaborative nature of adaptive watershed planning. Participants in watershed institutions and planning processes may use adaptation to uncertainty as a justification – an excuse – for adopting only vague and general goals, avoiding conflicts over limited resources and threats to existing water allocations, or even failing to make any choices at all. The lack of mechanisms for making trade-offs and hard choices about scarce resources and competing values may be a central cause of failure in adaptive watershed planning initiatives, as Holly Doremus asserts in the case of the CALFED process.[274] While adaptive watershed planning may be designed to accomplish multiple goals, consider multiple options, and remain flexible to adapt to changing conditions, it cannot aid watershed planners and water

272. *See, e.g.*, Robert W. Adler, *Climate Change and the Hegemony of State Water Law*, 29 STAN. ENVTL. L.J. 1 (2010).

273. *See, e.g.*, Robin Kundis Craig, *Adapting Water Federalism to Climate Change Impacts: Energy Policy, Food Security, and the Allocation of Water Resources*, 5 ENVTL. & ENERGY L. & POL'Y J. 183 (2010)

274. Doremus, *CALFED*, *supra* note 66, at 731.

resource managers to adapt to climate change if it is used to avoid hard policy choices.

The culture of certainty, security, and risk-denial. The very idea that watershed plans should be ever changing to unknown and uncertain future conditions such as previously unexperienced climate change effects is antithetical to the tendency of Americans – perhaps all humans – to crave certainty in their affairs and conditions, demand security in their water resources, and deny the existence of risks for which they have no prior experience.[275] This culture is embedded in the hard-to-change law of water rights, which favors the certainty, stability, and security of entitlements to use water, even if these allocations threaten the sustainability of water supplies and watersheds.[276] Adaptive watershed planning for climate change faces significant obstacles from the combination of risk-aversion and change-aversion psychology, culture, and law. Planning participants may tend to downplay the potential of severe climate change effects on water supplies and watershed conditions. They may have difficulty conceptualizing or understanding the nature, magnitude, and effects of potential climate change conditions and changing hydrological conditions. They may base plans, actions, and decisions on what Sandi Zellmer and Lance Gunderson call "spurious certitude."[277] They may seek to defer hard choices and painful adaptation actions until the effects are actually experienced, taking a reactive approach instead of a proactive approach. The combination of scientific uncertainty about precise effects, policy paralysis, and contingent nature of adaptive management and planning approaches is likely to contribute to a wait-and-see approach, even though evidence may show that deferring adaptation changes to water plans could make water management more vulnerable to climate change than adopting a set of robust adaptation policies proactively.[278] Adaptive watershed planning may become something more of a crisis response and management method than an adaptive crisis avoidance and minimization method. Moreover, reallocation of water resources and costly conservation and long-term sustainability policies will almost certainly be necessary in many watersheds, but the legal system's favoring or entitling of current water allocations will produce resistance to these changes and

275. *See* Doremus & Hanemann, *supra* note 9, at 56, 61–64, 70–75; Holly Doremus, *Takings and Transitions*, 19 J. LAND USE & ENVTL. L. 1, 4, 22–23 (2003); Kartz & Lindell, *supra* note 119, at 7, 10.

276. Doremus & Hanemann, *supra* note 9, at 61–69.

277. Zellmer & Gunderson, *supra* note 66, at 942.

278. GROVES ET AL., *supra* note 8.

costly conflict over them. Adaptive watershed planning may serve as a flexible, participatory, problem-solving process for finding ways of achieving needed reallocations or alternative conservation and sustainability policies, but it will be subject to forces that resist change and reject the need for it.

Implementation and feedback loops. A common, basic problem for any planning process is that all the resources, effort, social capital, and collective commitment can go into formulating the plan, which then is never implemented.[279] Adaptive watershed planning not only has this risk that is inherent in planning generally but also has the risk that the challenges of adaptive processes, with flexible implementation, continuous monitoring and evaluation, and periodic plan adjustments and changes, will make implementation all the more difficult. Much thought and care must go into the implementation of adaptive watershed plans; it is not merely a matter of executing a set of discrete and certain commands.

Designing and using feedback loops is a particularly difficult aspect of adaptive planning. Alex Camacho's studies of adaptive management implementation in various federal environmental programs, including the National Estuary Program's efforts to incorporate climate change adaptation in local and regional estuary planning and management efforts, conclude that adaptive methods are not accompanied by mandatory, systematic, or rigorous methods for evaluating the ecological or adaptive effects of policies and management actions and for using this evaluative information in adjusting policies and management actions.[280] He does not identify any examples of adaptive planning and management systems with effective feedback loop elements, and his analysis is particularly discouraging because it is relatively unlikely that Congress will adopt the comprehensive "learning infrastructure" reforms that he proposes.[281] In some respects, adaptive watershed planning may offer a more conducive governance environment in which to design feedback loops that result in scientific, social, and institutional learning, because they are decentralized, focused on particular water-resource and watershed problems that will require adaptation, and already starting to experiment with

279. Despite this concern, a study of watershed planning processes in Ohio revealed that watershed groups completed or made substantial progress towards all of their narrow policy recommendations and all but one of their broad policy recommendations. Thomas, *supra* note 98, at 17. This study was limited to only six watersheds, and thus many not be adequate to draw large-scale conclusions, but it is encouraging evidence that watershed plans can result in actual implementation.

280. Camacho, *Adapting Governance*, *supra* note 14, at 26–64.

281. *Id.* at 64–77.

adaptive planning methods. Even so, it is relatively likely that only some watershed planning efforts in the U.S. will incorporate systematic and rigorous feedback-loop elements, given the wide variety of such efforts and the various competing forces that are at work on watershed planning and management institutions. Moreover, given that many watershed plans are developed by multi-participant, informal, and even ad hoc collective action, it is questionable how many adaptive watershed planning processes will have the resources, personnel, and institutional and organizational structures to sustain monitoring, evaluation, learning, and plan revision activities on continuous and long-term bases.

Sustaining adaptive planning processes and institutions. The concern about the sustainability of feedback loop elements of adaptive watershed planning leads us to a broader concern about the sustainability of adaptive watershed planning processes and institutions generally. One evaluator of watershed councils notes that while government agencies managing natural resources will likely exist long into the future, multi-participant watershed councils may have difficulty engaging in long-term planning because they may last only a short time, experience burnout among participants, lose key members or leadership that provide critical institutional memory and implementation roles, or not be able to meet as regularly as needed for long-term plan implementation.[282] Moreover, there is some research to suggest that watershed-based groups are most likely to arise or be effective when they are responses to immediate, severe, and particular problems that lack adequate regulatory controls.[283] Given that many watershed plans are developed by multi-participant, informal, and even ad hoc collective action, it is questionable how many adaptive watershed planning processes will have the resources, personnel, and institutional and organizational structures to sustain monitoring, evaluation, learning, and plan revision activities on continuous and long-term bases. However, attempts to create formal institutional and organizational arrangements into a strong coordinating entity may undermine the viability and effectiveness of watershed-based planning and management efforts.[284]

More generally, it is not clear whether the public will accept adaptive planning on an ongoing basis. Helen Briassoulis raises this concern:

282. Griffin, *supra* note 36, at 515.
283. Lubell et al., *supra* note 36; SCHLAGER & BLOMQUIST, *supra* note 36, at 43.
284. Ruhl & Salzman, *supra* note 82, at 114–15.

> Despite the theoretical appeal of adaptive planning in a fluid natural and social world, at the operational level, the political realism of this approach can be questioned on two fronts: first, how much is modern society willing to make sacrifices in the present to secure the future and, second, how well is society prepared for the kind of adaptive learning and experimentation implied by this approach.[285]

Briassoulis quotes C.S. Holling to observe that we must become "a 'forgiving society'" in order to embrace adaptive planning.[286] This means that we must be willing to live with mistakes, changes, and the lack of certainty in our policies and plans as they unfold over time and that we must be willing to accept up-front that we must select precautionary approaches, limiting our use and exploitation of water resources or alteration of watersheds, even if the need for such sacrifices is not imminent or dire or if there is not strong certainty that these precautionary approaches will necessarily achieve the desired results.

Standardless planning and adaptation. As discussed previously in the section on adaptive management, critics of adaptive management worry that it is standardless ad hoc "muddling through" or "drifting along." As we look at adaptive watershed planning, we can see that there are actually three layers of activity that are at risk of lacking standards or principles to guide and constrain them. The first layer is composed of the standards that govern the identification of watershed institutions' goals and the formulation of watershed plans. The second layer is composed of the standards that govern the implementation of the plan and the actions taken pursuant to the plan. The third layer is composed of the standards that govern the evaluation of the plan and its implementation, including feedback-assessment, learning, and adjustment activities.

At each level, the standards have both normative dimensions, which include values, principles, ethics, and norms, and cognitive-objective dimensions, which include methodologies, mental schema, knowledge, and predictions. The two dimensions overlap and affect one another; thus, I am not trying to create a clean conceptual distinction between "subjective values" and "objective knowledge," to suggest a clear line between politics and science, or even to preclude the possibility of objective values and

---

285. Briassoulis, *supra* note 115, at 387.
286. *Id.*

subjective knowledge or science. However, we do need to recognize that there may be a variety of standards implicated in adaptive watershed planning that span a range and mix of normative and cognitive elements. For example, watershed planning and management may involve both standards for determining the degree of protection that should be provided to freshwater species and standards for determining how to measure the impacts of different water uses and management activities on freshwater species and various of their functions and conditions.

The first level poses particular challenges to identify and apply standards to the planning process itself. While legal requirements, particularly statutes, could mandate that certain criteria, policy goals, procedures, data, or assessment methods be considered or applied in watershed planning, there is no escaping that the very process of planning and goal setting for a critical public resource, such as water, involves considerable discretion. Inevitably, a wide range of forces and influences will shape watershed plans, including politics, interest group pressures, cognitive biases, social processes, culture, and a plurality of social norms and values. To the extent that laws regularly contradict strong political, social, cultural, and economic forces, the laws will be changed or ignored. Thus, the "standards" guiding and constraining planning and goal setting for watersheds and water resources will come from many different sources. Moreover, to the extent that the possible outcomes of watershed planning and goal setting are narrowed and limited, the plans lose adaptability to changing conditions and future uncertain risks. However, if there are no limits or standard-based framing of watershed planning and goal setting, the entire process could result in a non-implementable accommodation of too many different and competing values and goals or even in the failure to be able to form a plan or set of goals.

The second level is a bit less challenging but nonetheless poses potential problems. Watershed plans should contain standards to guide and constrain their implementation. However, plans are adaptive to the extent that they contain multiple options for their implementation, multiple criteria for decision making and the use of resources, and continuous, iterative, and event-driven modification.[287] As a result, the standards governing actions to effectuate the plan may be so flexible, and even shifting, as to render the plan largely standardless in effect.

287. Rzevski, *supra* note 114, at 1.

The third level, oddly enough, may turn out to be the level most susceptible to lack of standards. Each adaptive watershed plan should contain not only processes for the regular and ongoing evaluation of the plan and its implementation and consideration of this feedback information in adjusting the plan and its implementation, but the plan should also identify standards for this evaluation. However, as discussed above, the lack of meaningful and rigorous feedback loops is a common current problem in the incomplete use or misuse of adaptive management methods. In short, there is a high potential that supposedly adaptive watershed plans will not contain feedback loops or at least feedback loops effective at shaping scientific and social learning that in turn allows the plan to adapt to changing conditions and knowledge. With respect to some aspects of aquatic conditions or the watershed plan's implementation, useful feedback can be obtained through a combination of observant and analytical participants, networks, and iterative deliberative processes. This phenomenon can be rather hit-or-miss though, and there will be certain aquatic conditions or effects of watershed and water resource management that will require rigorous, systematic, and scientific analyses. If planners have not given in-depth and sustained attention to the standards governing these analyses and the standards by which the effects of watershed and water resource management activities will be judged, the feedback-loop aspect of adaptive planning will not function and therefore the entire method will be compromised. It is one thing to adjust the evaluative standards as new knowledge is obtained (e.g., new knowledge about the watershed's conditions and functions), but it is another thing altogether to provide no standards for evaluating the plan's effects.

VIII. CONCLUSION

Adaptive watershed planning is a valuable tool to U.S. water institutions and watershed management organizations as they seek to adapt to uncertain, complex, multiscalar, and nonlinear effects of climate change on water resources and watershed. Different than merely adaptive management methods, watershed management, or conventional planning, adaptive watershed planning combines iterative, experimental, adaptive processes, watershed focus and scale, and the functions and benefits of planning. Watershed institutions may be starting to use at least some features of adaptive planning to address climate change impacts, but there are numerous obstacles to doing so and inherent tensions within adaptive watershed planning. Nonetheless, watershed institutions and organizations will prove resilient and adaptive if they use the iterative, experimental, and adaptive processes of adaptive watershed planning to study, assess, and improve the process of adaptive watershed planning itself.