ADAPTIVE MANAGEMENT AND THE FUTURE OF ENVIRONMENTAL LAW

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Adaptive management is the new paradigm in environmental law. It is omnipresent in scholarship and management documents and is even starting to appear in court opinions. There have been many calls for environmental law to adapt itself to adaptive management by becoming more flexible and dynamic. But does adaptive management really warrant a revolution in environmental law? Or is it adaptive management that might need to adapt to the world of environmental law?

There has been an abundance of scholarship on the strengths of adaptive management, making the case for changing environmental law to embrace adaptive management. But answering the two questions above also requires a close examination of the limits of adaptive management and whether it is important enough for environmental law that wholesale changes in the legal structure are required.[1] In this

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1. I agree with Holly Doremus that these questions have not been asked enough in the legal, scientific, or management literature. *See* Holly Doremus, *Adaptive Management as an Information Problem*, 89 N.C. L. REV. 1455, 1460 (2011) [hereinafter Doremus, *Adaptive Management as an Information Problem*] (noting that there is "not enough discussion about whether [adaptive management] ought to be used").

Article, I summarize the literature noting those limits, and my conclusion is that those limits are significant enough that we should be wary of wholesale revisions of environmental law to allow adaptive management to occur. Adaptive management has an important role to play, but there are many questions that it cannot answer. Moreover, the increased flexibility and dynamism that have been called for in environmental law would carry their own costs.

I. ADAPTIVE MANAGEMENT AS THE NEW PARADIGM OF ENVIRONMENTAL LAW

Adaptive management is based on the principle of "learning by doing"[2] and is frequently presented as a form of experimentation. Ideally, managers implement different management policies for a resource at different places at the same time, they monitor any differences in outcomes over time, and those differences in outcomes help answer questions about which management policies might be more or less successful for achieving management goals. For instance, a forest manager might be uncertain about whether harvesting standing dead timber after a fire increases or reduces forest regeneration. The manager might harvest timber at five sites that have had a fire, not harvest timber at another five sites, and then monitor whether there are any differences in regeneration at the ten sites.[3]

The concept of adaptive management has been expanded beyond this classic form (which came to be known as "active adaptive management").[4] One extension is that managers, instead of consciously or actively creating differences in management across multiple sites in order to produce information, might rely on historical data to produce rigorous models about how environmental systems function, use those models to identify a single best-practice for management, and implement that practice. Managers would also use monitoring to observe whether results diverge from predictions from the model, and use those divergences to update the model and the management system. This option gained the moniker of "passive adaptive management" because managers were not using active experimentation to reduce uncertainty.[5]

2. C.J. Walters & C.S. Holling, *Large-scale Management Experiments and Learning By Doing*, 71 ECOLOGY 2060 (1990).

3. *Id.*

4. *Id.*

5. *Id.* at 2061. A key problem of "passive adaptive management" is that it can "confound management and environmental effects." Because there is only one management model, it is impossible to determine whether a change in outcome is the result of a change in management or

Another option is to simply make initial management choices in a "haphazard" way without development of a rigorous model to generate predictions about what results management should produce; instead, managers would simply monitor results and adjust if results were not achieving management goals. This is appropriately called "trial and error,"[6] and many adaptive management scholars consider it, in fact, to be very different from adaptive management.[7]

Adaptive management has become a dominant theme in the scholarship and practice of environmental law, so dominant that many scholars and managers assert that the *only* feasible option for environmental law is adaptive management.[8] The dynamic nature of natural systems has provided a major rationale for the widespread embrace of adaptive management.[9] The looming inevitability of significant climate change provides another impetus for these calls for adaptive management, as scholars assert that the only way for environmental regulation and management to remain functional in the face of climate change is for those regulatory and management systems to become adaptive.[10]

concurrent changes in environmental conditions (e.g., climate or weather).

6. *Id.*

7. *See, e.g.*, Kai Lee, *Appraising Adaptive Management*, 3 ECOLOGY & SOC'Y NO. 2, ART. 3 (1999); Lance Gunderson & Stephen S. Light, *Adaptive Management and Adaptive Governance in the Everglades Ecosystem*, 39 POLICY SCI.'S 323, 326-27 (2006).

8. J.B. Ruhl & Robert L. Fischman, *Adaptive Management in the Courts*, 95 MINN. L. REV. 424, 424-25 (2010) ("Adaptive management has become the tonic of natural resources policy."); *id.* at 430 ("[T]here has been broad consensus among resource managers and academics that adaptive management is the only practical way to implement ecosystem management."); J.B. Ruhl, *Climate Change Adaptation and the Structural Transformation of Environmental Law*, 40 ENVTL. L. 363, 422 (2010); J.B. Ruhl, *Regulation by Adaptive Management: Is It Possible?*, 7 MINN. J. L. SCI. & TECH. 21, 25 n.7 (2005) ("As gloomy as the prospects for adaptive management appear today, regulation by adaptive management is *inevitable*."); Bradley C. Karkkainen, *Adaptive Ecosystem Management and Regulatory Penalty Defaults: Toward a Bounded Pragmatism*, 87 MINN. L. REV. 943, 943 (2003).

9. *See, e.g.*, A. Dan Tarlock, *The Nonequilibrium Paradigm in Ecology and the Partial Unraveling of Environmental Law*, 27 LOY. L.A.L. REV. 1121, 1139 (1994) ("The major institutional change necessitated by the nonequilibrium paradigm is the need to apply adaptive management to biodiversity protection."); J.B. Ruhl, *A Manifesto for the Radical Middle*, 38 IDAHO L. REV. 385, 394-95, 402-03 (2002); Julie Thrower, *Adaptive Management and NEPA: How a Nonequilibrium View of Ecosystems Mandates Flexible Regulation*, 33 ECOLOGY L.Q. 871 (2006).

10. *See, e.g.*, Alejandro Camacho, *Adapting Governance to Climate Change: Managing Uncertainty through a Learning Infrastructure*, 59 EMORY L.J. 1, 39-40 (2009); Joshua J. Lawler, *Climate Change Adaptation Strategies for Resource Management and Conservation Planning*, 1162 ANNALS OF THE N.Y. ACAD. OF SCI.'S 79, 85 (2009); Robert L. Glicksman, *Ecosystem Resilience to Disruptions Linked to Global Climate Change: An Adaptive Approach to Federal Land Management*, 87 NEB. L. REV. 833, 836-37 (2009); Robin Kundis Craig, *Stationarity is Dead—Long Live Transformation: Five Principles for Climate Change Adaptation Law*, 34 HARV. ENVTL.

Yet the calls for the widespread adoption of adaptive management have been matched by the observations that adaptive management has had few real-world successes to date.[11] A common response to this tension has been to argue that inflexible bureaucracies and laws are a primary obstacle to successful implementation of adaptive management,[12] and the legal system must give way and change to allow for adaptation to proceed.[13]

L. REV. 9, 17 (2010).

11. *See, e.g.*, Holly Doremus, *Adaptive Management, the Endangered Species Act, and the Institutional Challenges of "New Age" Environmental Protection*, 41 WASHBURN L.J. 50, 54 (2001) [herein after Doremus, *Adaptive Management, the Endangered Species Act*] (noting that "skepticism about adaptive management comes from the lack of success stories to date"); Carl J. Walters, *Is Adaptive Management Helping to Solve Fisheries Problems?*, 36 AMBIO 304 (2007) (arguing that adaptive management has "been radically less successful than one would expect from its intuitive appeal").

12. *See* Brian Walker et al., *Resilience, Adaptability, and Transformability in Social-ecological Systems*, 9(2) ECOLOGY & SOC'Y 5 (2004) ("Adaptive management, widely and deservedly promoted as a necessary basis for sustainable development, has frequently failed because the existing governance structures have not allowed it to function effectively."); C.S. Holling, *What Barriers? What Bridges?*, *in* BARRIERS AND BRIDGES TO THE RENEWABLE OF ECOSYSTEMS AND INSTITUTIONS 3, 9 (Lance H. Gunderson et al., eds. 1995) (arguing that agencies tend to focus on one target and short-term outputs and fail to test hypotheses or experiment and that the solution is "flexible, adaptive policies, not rigid, locked-in ones"); Ahjond S. Garemstani et al., *Panarchy, Adaptive Management, and Governance: Policy Options for Building Resilience*, 87 NEB. L. REV. 1036, 1036 (2009) (arguing that solving environmental problems "requires frequent recalibration of the policy used to address the environmental issue"); Craig R. Allen et al., *Adaptive Management For A Turbulent Future*, 92 J. ENVTL. MGMT. 1339, 1343 (2011) ("Legal certainty does not mesh well with environmental unpredictability. . . . The certainty of law and institutional rigidity often limit the experimentation that is necessary for adaptive management," and the "adversarial character of administrative law, combined with the need for certainty (e.g., procedural rules) in the larger realm of American law, is likely incompatible with adaptive management"). Surveys of federal environmental agency employees have revealed similar sentiments. Tomas M. Koontz & Jennifer Bodine, *Implementing Ecosystem Management in Public Agencies: Lessons from the U.S. Bureau of Land Management and the Forest Service*, 22 CONSERVATION BIOLOGY 60, 65 (2008) (BLM employees report lawsuits and appeals as most important legal barrier to adaptive management); George H. Stankey et al., *Adaptive Management and the Northwest Forest Plan: Rhetoric and Reality*, 101 J. OF FORESTRY 40 (Jan/Feb. 2003) (interview with primarily Forest Service employees finds that they believe that law is a significant constraint on adaptive management and that endangered species protection reduces risk taking); FORREST FLEISCHMAN, BUREAUCRACY, COLLABORATION, AND COPRODUCTION: A CASE STUDY OF THE IMPLEMENTATION OF ADAPTIVE MANAGEMENT IN THE USDA FOREST SERVICE 12 (2008), *available at* http://www.indiana.edu/~workshop/publications/materials/conference_papers/fleischman.pdf (noting survey that found that FS employees complained of constraints by legal system and risk-aversion within the agency that restricted adaptive management).

13. Kundis Craig, *supra* note 10, at 65-67 ("Legislatures and policymakers should thus incorporate comprehensive and pervasive adaptive management requirements and procedures into natural resource management statutes."); 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, 949 (2009) ("Legal vehicles should enhance flexibility, learning, and adaptive approaches, rather than reinforce pathologically resilient institutions and

In terms of the current legal structure, scholars and managers have articulated two major ways that law might deter adaptive management. First, the legal system imposes significant costs on active management efforts through front-end analytic and public participation requirements under statutes such as the National Environmental Policy Act ("NEPA") and the Administrative Procedure Act ("APA");[14] the costs of doing environmental review analysis and allowing for public participation, and the associated costs and risks of judicial review, deter agencies from making decisions.[15] This undermines adaptive management, which

ecosystems."); Craig R. Allen et al., *supra* note 12, at 1343 ("[E]nvironmental law must be 'adapted' to fit with adaptive management."). *But see* Ruhl, *Regulation by Adaptive Management*, *supra* note 8, at 54-56 (arguing that implementation of adaptive management requires restrictions on volatility and drift in agency decision-making).

A related claim is that adaptive management requires agencies to embrace "organizational instability." K. Jeffrey Danter et al., *Organizational Change as a Component of Ecosystem Management*, 13 SOC'Y & NAT. RES. 537, 538 (2000); Steven L. Yaffee, *Ecosystem Management in Practice: The Importance of Human Institutions*, 6 ECOLOGICAL APPLICATIONS 724, 726 (1996); Stephen S. Light et al., *The Everglades: Evolution of Management in a Turbulent Ecosystem*, *in* BARRIERS AND BRIDGES TO THE RENEWABLE OF ECOSYSTEMS AND INSTITUTIONS 103, 158 (Lance H. Gunderson et al., eds. 1995); George H. Stankey et al., U.S. DEP'T OF AGRICULTURE, ADAPTIVE MANAGEMENT OF NATURAL RESOURCES: THEORY, CONCEPTS, AND MANAGEMENT INSTITUTIONS 50-51 (2005). The two concepts (legal flexibility and organizational instability) are often connected in the adaptive management literature, but they can be distinguished. One could imagine a creative, dynamic agency that nonetheless operates within a legal framework that is fairly stringent. In this paper, I only focus on the questions related to legal flexibility.

14. Mark J. Wieringa & Anthony G. Morton, *Hydropower, Adaptive Management, and Biodiversity*, 20 ENVTL. MGMT. 831, 839 (1996); Thrower, *supra* note 9, at 886-87; Ruhl, *Regulation by Adaptive Management*, *supra* note 8, at 36; Craig R. Allen et al., *supra* note 12; Melinda Harm Benson, *Integrating Adaptive Management and Oil and Gas Development: Existing Obstacles and Opportunities for Reform*, 39 E.L.R. 10962, 10972-73 (2009).

15. Bradley C. Karkkainen, *Panarchy and Adaptive Change: Around the Loop and Back Again*, 7 MINN. J. L. SCI. & TECH. 59, 74-75 (2005) [hereinafter Karkkainen, *Panarchy*] ("[T]he adversarial and litigious character of contemporary administrative law coupled with its overall tendency toward nitpicking enforcement of fixed "command-and-control" rules—especially procedural rules, which are singularly easy for courts to enforce—and its reluctance to countenance uncertainty and lack of information as the basis for agency decision-making are all profoundly at odds with the very concept of adaptive management."); Kundis Craig, *supra* note 10, at 66; Mary Jane Angelo, *Stumbling Toward Success: A Story of Adaptive Law and Ecological Resilience*, 87 NEB. L. REV. 950, 1001-02 (2009) ("Another challenge of adaptive management is that it may be difficult to incorporate substantial public participation. . . . If we need to wait to convene all stakeholders and achieve consensus or near consensus before every action, we simply will not be able to have the quick reaction time necessary for adaptive management."); Ruhl, *Regulation by Adaptive Management*, *supra* note 8, at 31 ("Quite simply, there is good reason to doubt whether regulation by adaptive management is possible without substantial change in administrative law."). Some of these scholars also note, however, that despite the obstacles that NEPA and the APA might impose on adaptive management, agencies can nonetheless successfully pursue adaptive management in the right circumstances. *See* Ruhl & Fischman, *supra* note 8, at 441 ("[T]he impression in agencies that lawsuits and appeals present a barrier to implementing adaptive management is unfounded."); *id.* at 475 ("Despite fundamentally different assumptions about

requires the repeated reconsideration and reevaluation of decisions over time in response to new information and, in the context of active adaptive management, the ability to make more complicated decisions when setting up an experimental system in the first place.

Second, substantive restrictions on the kinds of managerial actions that management and regulatory agencies can take might foreclose a range of important adaptive management options from implementation. For example, the Endangered Species Act's ("ESA") prohibition on agency action that will jeopardize the existence of listed species might prevent adaptive management experiments that carry risks for listed species, but that might also produce significant improvements in knowledge about how to protect those listed species or other natural resources.[16]

Particular ideas to respond to these problems include: placing adaptive management authority or mandates directly into environmental statutes or regulations;[17] reducing or changing judicial review of agency decisions (whether in general, or in the specific context of adaptive management);[18] eliminating the finality of at least some kinds of agency decisions and requiring regular or even constant reevaluation of those decisions;[19] reducing or altering NEPA requirements for agency

knowledge and decision-making, adaptive management is compatible with NEPA.")

16. Zellmer & Gunderson, *supra* note 13, at 946-47; Stankey et al., *supra* note 13, at 29; Angelo, *supra* note 15, at 1001; JAMES PIPKIN, THE NORTHWEST FOREST PLAN REVISITED 49-50 (1998) (arguing that adaptive management in the Northwest Forest Plan was stifled by ESA constraints); Lance Gunderson, *Resilience, Flexibility and Adaptive Management—Antidotes for Spurious Certitude?*, 3 ECOLOGY & SOC'Y NO. 1, ART. 7 (1999) (arguing that adaptive management in Everglades was obstructed by concerns about whether experiments might harm a listed species); Thomas T. Ankersen & Richard Hamann, *Ecosystem Management and the Everglades: A Legal and Institutional Analysis*, 11 J. LAND USE & ENVTL. L. 473, 496-501 (1996) (arguing that Clean Water Act and ESA restrictions threatened experimental methods of managing water to restore the Everglades).

17. J.B. Ruhl, *Adaptive Management for Natural Resources—Inevitable, Impossible or Both?*, 54 ROCKY MOUNTAIN MINERAL L. FOUND. PROCEEDINGS 11, 11-33 (2008) ("Ideally, however, Congress and state legislatures will fund and empower agencies to implement adaptive management."); Thrower, *supra* note 9, at 894-95 (calling for incorporation of adaptive management principles into NEPA through regulations); Kundis Craig, *supra* note 10, at 65-67.

18. Ruhl, *A Manifesto for the Radical Middle*, supra note 9, at 406-407 (calling for greater discretion and more deferential and reduced judicial review for agencies involved in adaptive management); Karkkainen, *Panarchy*, *supra* note 15, at 75 (proposing a "two-track" system in which adaptive management projects would receive different treatment under administrative law); Kundis Craig, *supra* note 10, at 66-67.

19. Tarlock, *supra* note 9, at 1140-44; Thrower, *supra* note 9, at 885-87; Ruhl & Fischman, *supra* note 8, at, 437-38 (critique of one-shot, predictive, "front-end" model of administrative law as inconsistent with iterative, repeated model of adaptive management and realities of natural resources management, especially climate change); J.B. Ruhl, *Taking Adaptive Management Seriously: A Case Study of the Endangered Species Act*, 52 U. KANSAS L. REV. 1249, 1251-52

decisionmaking;[20] reducing or altering public participation requirements for agency decision-making;[21] reducing or altering other procedural requirements for agency activities such as plan development or management decision-making;[22] and altering substantive restrictions that statutes such as the ESA might place on adaptive management.[23]

These are not just ideas being batted around by scholars. Management and regulatory agencies have adopted the rhetoric of adaptive management. The U.S. Forest Service repeatedly relied upon the concept of adaptive management to justify proposed revisions of its planning regulations that would eliminate mandates to maintain minimum viable populations of certain wildlife species and would reduce judicial review, environmental analysis, and public participation for the development of plans for National Forest lands.[24]

II. THE LIMITS OF ADAPTIVE MANAGEMENT

Should we be altering the structure and substance of environmental law to advance the concept of adaptive management? Is adaptive management in fact so important that environmental law should be

(2004); Kundis Craig, *supra* note 10, at 66-67.

20. Melinda Harm Benson & Ahjond S. Garmestani, *Embracing Panarchy, Building Resilience, and Integrating Adaptive Management Through a Rebirth of the National Environmental Policy Act*, 92 J. OF ENVTL. MGMT. 1420 (2011).

21. Ruhl, *A Manifesto for the Radical Middle*, *supra* note 9, at 405-06 ("Adaptive management cannot work if citizens can challenge every recalibration decision with this full range of public participation tools. There must be some insulation of the adaptive management process from the debilitating participation of every interest group demanding a "seat at the table" and right to challenge each and every move the agency makes."); Angelo, *supra* note 15, at 1002-03; Karkkainen, *Panarchy*, *supra* note 15, at 74-75.

22. Kundis Craig, *supra* note 10, at 65-67 ("For example, public lands managers may need some form of general planning requirements coupled with abbreviated administrative procedures for specific implementation decisions, periodic rather than continual judicial review for rationality, the ability to rely on postdecisional evaluations rather than predecisional justifications, or increased emergency authorities in order to achieve true capacity for adaptive management in the face of climate change impacts to resources and ecosystems."); *cf.* Glicksman, *supra* note 10, at 836-37 (arguing that cumbersome planning process gets in the way of adaptation to climate change pressures);

23. Angelo, *supra* note 15, at 1002 (arguing for lower ESA standards when "the primary purpose of the proposed action is to maintain or restore ecological resilience to an ecosystem"); ROBERT W. ADLER, RESTORING COLORADO RIVER ECOSYSTEMS: A TROUBLING SENSE OF IMMENSITY 168, 269 (2007) (call for exemptions from environmental laws (like ESA) to allow for more experiments); NATIONAL RESEARCH COUNCIL, UPSTREAM: SALMON AND SOCIETY IN THE PACIFIC NORTHWEST 342-43 (1996).

24. *See* 73 Fed. Reg. 21,468 (Apr. 21, 2008); 70 Fed. Reg. 1023 (Jan. 5, 2005); *see also* Martin Nie, *Whatever Happened to Ecosystem Management and Federal Lands Planning*, *in* THE LAWS OF NATURE: REFLECTIONS ON THE EVOLUTION OF ECOSYSTEM MANAGEMENT LAW AND POLICY (Kalyani Robbins, ed. 2013).

overhauled in response?

There are reasons to question whether adaptive management will be so central to the future of environmental law. There are limits to the ability of adaptive management to reduce uncertainty (the primary argument for adaptive management), costs to the use of adaptive management, and limits to the ability of adaptive management to improve management and regulatory outcomes.

A. Limits to the Ability of Adaptive Management to Reduce Uncertainty

1. Problems of Scale

Active adaptive management implies the use of at least one control and one treatment option for management, and ideally many more for statistical analysis purposes. But for environmental problems that are large-scale getting even two replicates may be extremely costly, or even impossible.[25] At the extreme, we cannot develop two replicate Earths to conduct an adaptive management experiment for possible efforts to use geoengineering to offset the impacts of greenhouse gases.[26] For a system like the Florida Everglades, which has been the focus of ecological restoration efforts for decades, replication also may not be feasible. The Everglades function as one large, interconnected ecological system; one purpose of the Everglades restoration program is to reconnect the hydrology of the system as a whole so that it functions better. It is therefore difficult, if not impossible, to envision how we might undertake replicates of the major management choices we need to pursue for the entire Everglades system.

Of course, not all adaptive management need be active. Passive adaptive management might be feasible at large scales because it does not require replication. However, note that, as a result, we may reduce

25. R. Gregory et al., *Deconstructing Adaptive Management: Criteria for Applications to Environmental Management*, 16 ECOLOGICAL APPLICATIONS 2411, 2423 (2006) (active adaptive management not useful for "large-scale and long-term" problems because can't develop experimental system at that level).

26. Geoengineering involves the active human manipulation of the global climate or atmosphere to offset the effects of greenhouse gases on the climate, either through the reduction of greenhouse gas concentrations in the atmosphere, or through reduction of the gasses' effects on global temperatures. One of the most commonly suggested options is the injection of sulfur aerosols into the upper atmosphere; the aerosols would increase the reflection of solar radiation and therefore reduce the heating of the Earth from the sun. In principle, this could offset the increased insulation caused by greenhouse gases. However, there are tremendous uncertainties about possible side effects from such efforts.

the ability to learn from our management and regulatory choices—precisely the point of adaptive management in the first place.

Likewise, we might develop ways to conduct adaptive management at subsets of larger units.[27] This concept, to some extent, is how the adaptive management program in the Everglades has tried to address the problem of doing replication for large-scale management of an overall system. Managers have developed smaller-scale pilot projects that identify key uncertainties in how the larger system operates and attempt to reduce that uncertainty through experimentation.[28] For instance, there is uncertainty about how successful different methods to backfill drainage canals and restore natural water flow to the northern Everglades might be and what risks each method might entail. The agency has implemented a pilot project of different backfilling efforts for a limited number of canals to reduce that uncertainty.[29] This can help reduce uncertainty, but it is limited by the need to extrapolate from the smaller-scale experiments to the larger-scale system that is of management interest.

2. Problems of Time

Adaptive management necessarily requires time: time for the adaptive management program to be designed; time for replicates to be established; and time for management to occur, monitoring to be conducted, results to be collected, and data to be analyzed.[30] However, some environmental problems are pressing enough that we might not be able to wait for the production of information from the adaptive management process to reduce uncertainty. A final decision must be made now.[31]

27. Gregory et al., *supra* note 25; Murdoch K. McAllister & Randall M. Peterman, *Experimental Design in the Management of Fisheries: A Review*, 12 N. AM. J. OF FISH. MGMT. 1 (1992); Doremus, *Adaptive Management as an Information Problem*, *supra* note 1, at 1487-88.

28. *See, e.g.*, NAT'L RESEARCH COUNCIL, PROGRESS TOWARD RESTORING THE EVERGLADES: THE FIRST BIENNIAL REVIEW–2006, 6-12 (providing overview of these efforts and call for increasing their use).

29. *See* NAT'L RESEARCH COUNCIL, PROGRESS TOWARD RESTORING THE EVERGLADES: THE FOURTH BIENNIAL REVIEW 70-71 (2012).

30. *See* W.H. Moir & W.M. Block, *Adaptive Management on Public Lands in the United States: Commitment or Rhetoric?*, 28 ENVTL. MGMT. 141, 144 (2001); Byron K. Williams et al., U.S. DEP'T OF THE INTERIOR, ADAPTIVE MANAGEMENT: THE U.S. DEPARTMENT OF THE INTERIOR TECHNICAL GUIDE 10 (2009 ed.) [hereinafter Williams et al., U.S. DEPARTMENT OF THE INTERIOR TECHNICAL GUIDE].

31. *See, e.g.*, Doremus, *Adaptive Management as an Information Problem*, *supra* note 1, at 1471 (noting that a key question is whether learning will happen quickly enough under adaptive management to make a difference for management).

This is certainly not a fatal problem for many adaptive management efforts.[32] One advantage of adaptive management is that it allows for information production to be produced concurrently with management choices, since it is management that produces the relevant information. But when a diversity of management choices cannot be taken, when decisions are irreversible, and when they must be made now, then neither active nor passive adaptive management is feasible. A paradigmatic example of this is the decision about whether to take a small population of an endangered species into captivity for breeding (as with the California condor in the 1980s).[33] The population is small enough that replication is not feasible (foreclosing active adaptive management), the decision about which approach to use may well be irreversible (foreclosing passive adaptive management), and delay might simply allow the species to vanish into extinction.

3. Problems of Information Production

Active and passive adaptive management both require high-quality monitoring to be successful. However, there are several reasons to question whether regulatory and management agencies will, in fact, undertake the high-quality monitoring needed to reduce uncertainty.

High-quality monitoring requires extended periods of time and often must be continuous in that time frame, it must be well-matched in time and space to the scale of the questions it seeks to answer, and it is usually extremely costly.[34] It is often difficult for outsiders, particularly non-experts, to assess the quality of monitoring.[35]

The need for continuity, and the opacity of monitoring to outside supervision, make monitoring particularly susceptible to asymmetric

32. Political pressures to make management decisions happen sooner rather than later might likewise prevent effective use of adaptive management. As BLM developed oil and gas in Wyoming's Powder River Basin, the agency claimed that it did not have the authority to slow down development to allow for the results of monitoring to be collected, analyzed, and used to adapt management decisions; accordingly, an adaptive management option was rejected by the agency. *See* Melinda Harm Benson, *Adaptive Management Approaches by Resource Management Agencies in the United States: Implications for Energy Development in the Interior West*, 28 J. ENERGY & NAT. RESOURCES L. 87, 107 (2010); Benson, *Integrating Adaptive Management and Oil and Gas Development*, *supra* note 14, at 10974-75 (noting that political pressure on BLM to quickly approve oil and gas leases in Pinedale, Wyoming region lead to massive expansion of drilling before any monitoring data could be brought to bear on the decision-making process).

33. For an overview of the relevant facts, *see* National Audubon Society v. Hester, 801 F.2d 405 (D.C. Cir. 1986).

34. Eric Biber, *The Problem of Environmental Monitoring*, 83 U. COLO. L. REV. 1, 22-34 (2011).

35. *Id.* at 27-34.

pressures in the political process.[36] Myopia makes it difficult for agencies and legislatures to commit to long-term monitoring programs. [37] Courts often defer to the information produced by agencies, further weakening incentives to produce high-quality information.[38] Agencies with multiple objectives might be wary of pursuing monitoring when the resulting data might result in conflicts with other objectives. [39] Even when a direct conflict does not exist, actual monitoring data might constrain an agency's freedom of maneuver and autonomy in the future in unpredictable ways.[40] Finally, agency institutional culture might not be amenable to pursuing monitoring. For instance, scientists in agencies might have few professional incentives to conduct long-term monitoring projects. [41]

4. Problems of Institutional Continuity

Institutional continuity is not just important for the collection of data, but also for the overall maintenance of adaptive management programs. Often the results of different experiments may take many years to bear the fruit of reduced uncertainty, in part because of the long time frames at which many ecological processes operate, or alternatively the long time frames required to detect the signal of meaningful information in the noise of ecological variation. Thus, tremendous patience may be needed by agencies, legislators, interest groups, and the public to determine whether different management options will produce different results. Many adaptive management advocates frame adaptive management as a long-term investment in improved information, often at the short-term cost of foregone resource exploitation or increased risk to environmental benefits.[42]

36. *Id.* at 35-39. I discuss these asymmetries *infra* Part II.B.2.
37. *Id.* at 39-40.
38. *Id.* at 41-43.
39. *Id.* at 43-48.
40. *Id.* at 48-51.
41. *Id.* at 51-53.
42. *See, e.g.*, Tracy M. Rout et al., *Optimal Adaptive Management For The Translocation of a Threatened Species*, 19 ECOLOGICAL APPLICATIONS 515, 520 (2009); Carl Walters, *Challenges in adaptive Management of Riparian and Coastal Ecosystems*, 1 ECOLOGY & SOC'Y ART. 1 (1997); Andrew N. Gray, *Adaptive Ecosystem Management in the Pacific Northwest: A Case Study from Coastal Oregon*, CONSERVATION ECOLOGY (Nov. 23, 2000), *available at* http://www.ecologyandsociety.org/vol4/iss2/art6/; Lance H. Gunderson, *Adaptive Dancing: Interactions Between Social Resilience and Ecological Crises*, *in* NAVIGATING SOCIAL-ECOLOGICAL SYSTEMS: BUILDING RESILIENCE FOR COMPLEXITY AND CHANGE 33, 44 (Fikret Berkes & Johan Colding, eds. 2003) ("Learning is a long-term proposition, which requires a ballast against short-term politics and objectives."); *see also* Doremus, *Adaptive Management as an Information*

However, if myopia is a significant factor in environmental decision-making, this patience might be hard to come by. Building strong institutions that are resilient to political pressures would seem to be a plausible response, but many adaptive management advocates also call for organizational instability as necessary for adaptive management to succeed.[43]

5. Problems of Learning

If the dynamism of an environmental resource is high enough, there are questions about whether learning and therefore the reduction of uncertainty is even feasible. In a number of areas, environmental conditions change quickly enough, and are unpredictable enough, that data are useless for management or regulatory purposes soon after they are collected. For instance, water quality in beaches can change in a matter of minutes, far more quickly than the twenty-four to forty-eight-hour timeframes required for current monitoring techniques, and water quality can change for reasons that are still only partially understood.[44] The population dynamics of certain fish species (such as sardines, anchovies, and perhaps cod) are highly variable and still poorly

Problem, *supra* note 1, at 1461 (Adaptive management "requires striking a balance between short-term management objectives and long-term learning, between devoting resources to management and to monitoring.").

43. *See supra* note 13 at accompanying text.

44. *See* Molly K. Leecaster & Stephen B. Weisberg, *Effect of Sampling Frequency on Shoreline Microbiology Assessments*, 42 MARINE POLLUTION BULL. 1150 (2001); Kellogg J. Schwab, *Are Existing Bacterial Indicators Adequate for Determining Recreational Water Illness in Waters Impacted by Nonpoint Pollution?*, 18 EPIDEMIOLOGY 21 (2007); Timothy J. Wade et al., *Rapidly Measured Indicators of Recreational Water Quality Are Predictive of Swimming-Associated Gastrointestinal Illness*, 114 ENVTL. HEALTH PERSPECTIVES 24 (2006); Linwood Pendleton, *The Economics of Using Ocean Observing Systems to Improve Beach Closure Policy*, 36 COASTAL MGMT. 165, 167-68 (2008); A.B. Boehm et al., *Decadal and Shorter Period Variability of Surf Zone Water Quality at Huntington Beach, California*, 36 ENVTL. SCI. & TECH. 3885 (2002) ("The concentration of fecal indicator bacteria in the surf zone at Huntington Beach, CA, varies over time scales that span at least 7 orders of magnitude, from minutes to decades. . . . These results demonstrate that coastal water quality is forced by a complex combination of local and external processes and raise questions about the efficacy of existing marine bathing water monitoring and reporting programs."); Joon Ha Kim & Stanley B. Grant, *Public Mis-Notification of Coastal Water Quality: A Probabilistic Evaluation of Posting Errors at Huntington Beach, California*, 38 ENVTL. SCI. & TECH. 2497, 2501 (2004) (time delays in analysis, high variability of contamination, and infrequent sampling mean that posting water-contamination notices are prone to large amounts of error (both under- and overprotective) with up to forty-percent error rate) ("An analysis of . . . data at Huntington Beach reveals that posting decisions would have to be updated every forty minutes (or more frequently) to significantly reduce posting errors."); Alexandria D. Boehm & Stephen B. Weisberg, *Tidal Forcing of Enterococci at Marine Recreational Beaches at Fortnightly and Semidiurnal Frequencies*, 39 ENVTL. SCI. & TECH. 5575, 5578 (2005).

understood, such that it might not be possible to predict whether a population is about to collapse ahead of time.[45] Dynamism and complexity can be manageable and be the basis for useful learning if they fall within certain limits, but not if dynamism and complexity result in unpredictable changes that produce either new, unprecedented states for natural systems, or otherwise result in uncertain limits to the status of important environmental resources.

The challenge is that if past performance is no indication at all of the future, then there is little possibility that the results of past adaptive management will be of use for future management choices. Advocates of adaptive management have pointed to the dynamism and complexity of natural systems as a reason to embrace the concept, but if dynamism and complexity are high and unpredictable enough, it is hard to see how any form of experimentation or monitoring could reduce uncertainty to a degree sufficient to help guide decisions.

B. The Costs of Adaptive Management

1. Direct Costs of Adaptive Management

Adaptive management is costly in terms of resources and foregone opportunities.[46] Active and passive adaptive management both impose

45. *See* W.G. Clark, THE LESSONS OF THE PERUVIAN ANCHOVETA FISHERY, 19 CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATIONS REPORTS 57, 60-61 (1975-76); Daniel Lluch-Belda et al., *The Recovery of the California Sardine as Related to Global Change*, 33 CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATIONS REPORTS 50, 50, 58 (1992); Kevin Hill & Tim Baumgartner, *Pacific Sardine: Past, Present, and Future, Symposium Introduction*, 46 CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATIONS REPORTS 73, 73 (2005); Arthur F. McEvoy & Harry N. Scheiber, *Scientists, Entrepreneurs, and the Policy Process: A Study of the post-1945 California Sardine Depletion*, 44 J. ECON. HISTORY 393, 398 (1984); R.J.H. Beverton, *Small Marine Pelagic Fish and the Threat of Fishing; Are They Endangered*, 37 J. FISH BIOLOGY (Supp. A.) 5 (1990).

46. *See, e.g.*, Gregory et al., *supra* note 25, at 2411 (arguing that biological scientists are "attracted to AM because it provides a tenable mechanism for applying the scientific method to challenging problems facing complex ecosystems, often resulting in the design of costly experiments that tend to ignore impacts on other important environmental, social, or economic objectives"); Craig R. Allen & Lance H. Gunderson, *Pathology and Failure in the Design and Implementation of Adaptive Management*, 92 J. ENVTL. MGMT. 1379, 1381 (2011); *see also* Gretchen J.A. Hansen, *The Value of Information in Fishery Management*, 33 FISHERIES 340 (2008) (noting tradeoff between obtaining new information and getting additional production from the resource); HOLLY DOREMUS ET AL., CENTER FOR PROGRESSIVE REFORM, MAKING GOOD USE OF ADAPTIVE MANAGEMENT 9 (2011) [hereinafter HOLLY DOREMUS ET AL., CENTER FOR PROGRESSIVE REFORM]; Doremus, *Adaptive Management as an Information Problem*, *supra* note 1, at 1459; Marcia Barinaga, *A recipe for river recovery?*, 273 SCI. 1648, 1650 (1996); KAI LEE, COMPASS AND GYROSCOPE 53, 66 (1992); Carl J. Walters & Roger Green, *Valuation of Experimental Management Options for Ecological Systems*, 61 J. WILDLIFE MGMT. 987, 993

costs for monitoring and analyzing the results of management decisions; active adaptive management imposes the additional costs of establishing multiple management strategies (which often may be more costly than simply managing pursuant to a single prescription). All of these costs may be significant.[47]

There are also additional costs. In active adaptive management, by definition, we are choosing to use a diverse strategy of management techniques. Some of those techniques will likely or certainly be less effective at achieving particular goals than others, so the choice of a diverse strategy will result in less output of those goals, at least in the near term.[48] For instance, the decision to close some areas of a fishing ground in order to determine whether closures will improve the status of a fish stock will necessarily result in less catch of fish in the near term.[49]

Of course, the cost of adaptive management does not mean that it should not be pursued. The key question is whether the cost is outweighed by the benefit of new information or reduced uncertainty that adaptive management can provide.[50] An example of how a cost-benefit analysis might weigh against adaptive management comes from efforts to control the sea lamprey, an invasive aquatic species that significantly harms fisheries in the Great Lakes. There are existing, proven mechanisms to control the lamprey, but also additional possible tools that might be more effective. Researchers concluded, however, that the additional knowledge from an adaptive management program was outweighed by the benefits of pursuing existing control methods for the lampreys. Thus, the funds that would be needed to be spent on testing new methods and monitoring the results would be better spent on current management choices.[51]

(1997).

47. HOLLY DOREMUS, ET AL., CENTER FOR PROGRESSIVE REFORM, *supra* note 46, at 5 (adaptive management "requires more resources than conventional management, because doing it right requires taking the time to carefully analyze the system at the outset, monitor the results, and periodically reassess and revise").

48. Cindy L. Halbert, *How Adaptive is Adaptive Management? Implementing Adaptive Management in Washington State and British Columbia*, 1 REVIEWS IN FISHERY SCI. NO. 3, 261, 274 (1993); Donald T. Hornstein, *Complexity Theory, Adaptation, and Administrative Law*, 54 DUKE L.J. 913, 942-43 (2005) (noting tradeoff between "exploration" (i.e., learning) and "exploitation" (i.e., production or achieving the underlying goals) is inherent in flexibility, and a mixed strategy that is only partly flexible and adaptive may be superior).

49. Donald Ludwig et al., *Uncertainty, Resource Exploitation, and Conservation: Lessons from History*, 260 SCI. 17, 17-18 (1993).

50. Doremus, *Adaptive Management as an Information Problem*, *supra* note 1, at 1479.

51. Eli P. Fenichel & Gretchen J.A. Hansen, *The Opportunity Cost of Information: An Economic Framework For Understanding the Balance Between Assessment and Control in Sea Lamprey (Petromyzon marinus) Management*, 67 CANADIAN J. FISHERIES & AQUATIC SCI. 209, 210

Cost will not simply be economic. Experimentation in management of endangered species can provide important information and reduced uncertainty, but it can also create risks of harm to the species, even the possibility of extinction. Consider a proposal to allow logging in selected riparian zones (normally protected from logging) that are breeding habitat for an endangered salmon run to test the hypothesis that logging does not affect the species, or might even help it. There is a risk that the change to the status quo will harm the species significantly, but that risk may result in the production of useful information or reduced uncertainty.[52] Again, the question is whether the short-term risk of increased environmental harm is worth the benefits of long-term information production, particularly where the risk is of irreversible harm.[53]

This tradeoff is particularly challenging because the most information might be produced by management options that are the most extreme, and, therefore, the most costly or the most risky.[54] Small manipulations or changes in management strategies are less likely to produce significant changes in outcomes that can be detected using statistical techniques.

All of these costs will mean that adaptive management will not always (or perhaps often) be a useful management strategy for a wide range of environmental problems. Where reduction in uncertainty is not a high priority for managers and regulators—perhaps because uncertainty does not matter a lot to decisionmakers,[55] or because there isn't a lot of uncertainty to begin with[56]—then the costs of adaptive

(2010).

52. PIPKIN, *supra* note 16, at 49-50 (1998) (describing this conflict in the context of managing riparian areas of forest in the Pacific Northwest).

53. Where the environmental risks from adaptive management involve irreversible harms to resources that society values highly, risks might greatly outweigh any possible benefits from adaptive management. *See* Gregory et al., *supra* note 25, at 2419 (noting possibility of "taboo tradeoffs" that will effectively prevent adaptive management).

54. *See* Donald Ludwig & Carl J. Walters, *Fitting Population Viability Analysis into Adaptive Management*, *in* POPULATION VIABILITY ANALYSIS 511, 515 (Steven R. Beissinger & Dale R. McCullough eds., 2002).

55. *See* Gregory et al., *supra* note 25, at 2419 (differences that adaptive management is intended to identify must be large enough to matter for decisionmakers); Williams et al., U.S. DEPARTMENT OF THE INTERIOR TECHNICAL GUIDE, *supra* note 30, at 11 (Adaptive management should only be done when the "value of information for decisionmaking is high.").

56. Doremus, *Adaptive Management as an Information Problem*, *supra* note 1, at 1467-68 (adaptive management is "only useful if learning is needed" because "information gaps" limit management); Rout et al., *supra* note 42, at 520; Michael A. McCarthy & Hugh P. Possingham, *Active Adaptive Management for Conservation*, 21 CONSERVATION BIOLOGY 957, 957 (2007).

management will rarely be worth it.[57]

2. The Costs of Flexibility

Adaptive management, whether active or passive, necessarily requires flexibility in future management or regulatory choices. That flexibility creates uncertainty for human actors—such as developers who might wish to know exactly what kinds of mitigation burdens they will have to accept as they determine whether a project is economically feasible or not. That uncertainty creates significant costs—economic, social, psychological—for the human communities in which adaptive management is occurring.[58]

There are additional costs from flexibility—the costs that flexibility might pose to environmental law in general. Holly Doremus and others have pointed out that the flexibility and discretion adaptive management requires may be abused by management and regulatory agencies. Indeed, agencies might use the cover of adaptive management, without the substance, to pursue other agendas.[59]

There is ample literature in environmental legal scholarship that points out the asymmetries in implementation of environmental regulatory and management standards: In general, because the benefits of environmental law are dispersed and the costs concentrated, regulated parties will have stronger incentives and abilities to organize, monitor,

57. *See* Michael J. Conroy et al., *Application of Decision Theory To Conservation Management: Recovery of Hector's Dolphin*, 35 WILDLIFE RESEARCH 93, 99-100 (2008) (should only pay for additional information up to "expected value of perfect information" in order to do more research that is worthwhile (and usually less, given statistical noise).
Many advocates for adaptive management argue that society systematically underestimates the benefits of learning from adaptive management and overestimates the costs of adaptive management. *See, e.g.*, John M. Volkman & Willis E. McConnaha, *Through a Glass Darkly: Columbia River Salmon, the Endangered Species Act, and Adaptive Management*, 23 ENVTL. L. 1239, 1256-57 (1993); Walters & Holling, *supra* note 2, at 2062; Stankey et al., *supra* note 13, at 7 ("the costs of lost learning are seldom accounted for when experimentation is restricted or prohibited").

58. *See* David A. Super, *Against Flexibility*, 96 CORNELL L. REV. 1375, 1406-07, 1413-14 (2011).

59. *See* Holly Doremus, *Precaution, Science, and Learning While Doing in Natural Resource Management*, 82 WASH. L. REV. 547, 569 (2007) [hereinafter Doremus, *Precaution, Science, and Learning*]; Doremus, *Adaptive Management, the Endangered Species Act, supra* note 11, at 53; Holly Doremus, *Adapting to Climate Change with Law that Bends without Breaking*, 2 SAN DIEGO J. CLIMATE & ENERGY L. 45, 80 (2010) [hereinafter Doremus, *Adapting to Climate Change*]; Daniel J. Rohlf, *Integrating Science, Law, and Policy in Managing Natural Resources: Towards a Sound Mix Rather than a Sound Bite*, *in* FOREST FUTURES 127, 129 (Karen Arabas & Joe Bowersox, eds., 2004).

and influence the passage and implementation of environmental laws.[60] As Dan Farber and others have noted, the result of these public choice dynamics can be significant slippage in the implementation of environmental laws compared to the standards on the books, and outside enforcement of relatively stringent, inflexible standards can be an important tool to constrain that slippage.[61]

Relatively inflexible standards can also be important pre-commitment devices. Richard Lazarus has described how pre-commitment devices can help address harms that are distributed over time and space, as many environment problems are.[62] Given the long-term nature of many environmental harms, such as climate change, pre-commitment may be important to constrain myopic decision-making by implementing agencies or myopic pressure by interest groups.[63] Pre-commitment may be especially important when decision-makers and the public might become used to deteriorated environmental conditions and therefore sequentially and repeatedly accept more and more environmental harm over time (what has been called the "shifting baselines" problem);[64] inflexible standards can constrain this kind of subtle degradation in standards.[65]

Flexibility, to the extent that it requires reductions in procedural requirements for environmental decision-making, can also impose costs in terms of reduced public participation. Flexibility might directly reduce participation by allowing for fewer opportunities for public participation. But even if the proposed changes maintain the same opportunities for public participation, and instead only reduce (for instance) judicial review of agency compliance with those procedural requirements, or judicial review of whether agencies have fully

60. *See, e.g.*, Matthew D. Zinn, *Policing Environmental Regulatory Enforcement: Cooperation, Capture, and Citizen Suits*, 21 STAN. ENVTL. L. J. 81, 126–31 (2002); Eric Biber, *The Importance of Resource Allocation in Administrative Law*, 60 ADMIN. L. REV. 1, 40–49 (2008); Daniel A. Farber, *Taking Slippage Seriously: Noncompliance and Creative Compliance in Environmental Law*, 23 HARV. ENVTL. L. REV. 297, 307–08 (1999).

61. *See* Farber, *supra* note 60, at 298-99; Richard J. Lazarus, *Super Wicked Problems and Climate Change: Restraining the Present to Liberate the Future*, 94 CORNELL L. REV. 1153, 1156 (2009).

62. Lazarus, *supra* note 61, at 1197; Eric Biber, *Which Science? Whose Science? How Scientific Disciplines Can Shape Environmental Law*, 79 U. CHI. L. REV. 471, 514-21 (2012); Doremus, *Adapting to Climate Change*, *supra* note 59, at 48-59.

63. Lazarus, *supra* note 61, at 1174; Biber, *Which Science?*, *supra* note 62, at 516.

64. Eric Biber, *Climate Change and Backlash*, 17 N.Y.U. ENVTL. L.J. 1295, 1330 (2009).

65. Of course, this argument presumes the normative undesireability of allowing such shifts to occur over time. For an argument that shifting baselines might be an appropriate response in certain circumstances to climate change, see Kundis Craig, *supra* note 10, at 35, 64.

considered comments submitted by the public, there may still be negative impacts on public participation. Members of the public may be less willing to undertake costly efforts to participate in the decision-making process if they believe that their contributions are more likely to be ignored by the agency. Judicial review can be seen as a credible commitment by the government to ensure that the agency will take public participation seriously, and therefore encourage greater investments by the public in participation. Reduced public participation will have costs for environmental law and policy. One risk is that reduced public participation may reduce buy-in by various interest groups in the ultimate decision, making implementation more difficult. It may also reduce the quality of the information available to the agency for decision-making.[66]

There is one final potential cost to flexibility. Flexibility can be seen as delaying decision-making over time, and indeed, this is precisely how adaptive management is supposed to work, as decision-making is spread out over time so that additional, useful information can be drawn upon. But decision-making requires resources: the attention, time, and consideration of decision-makers (whether administrative, legislative, or judicial). There is no guarantee that when we delay decisions to the future that we will have the resources to adequately make decisions then, as opposed to now.[67]

Moreover, if we increase the number of decisions to be made—which the flexibility of adaptive management specifically requires—we increase the demands on our decisional resources, perhaps beyond their limits. We might have particular concerns about increasing the number of decisions when decisions involve value conflicts and high uncertainty, and therefore the decisions might be particularly costly.[68] Those two characteristics are, of course, very true of environmental law.[69]

66. For instance, citizen participation appears to improve the decision-making process by which species are identified as threatened or endangered and listed for protection under the Endangered Species Act. *See* Eric Biber & Berry Brosi, *Officious Intermeddlers or Citizen Experts? Petitions and Public Production of Information in Environmental Law*, 58 UCLA L. REV. 321 (2010); Berry Brosi & Eric Biber, *Citizen Involvement in the U.S. Endangered Species Act*, 337 SCI. 802 (2012).

67. Super, *supra* note 58, at 1406-07, 1435-36.

68. *Id.*

69. Increasing the number of decisions, and spreading them out over time, might also exacerbate the possibility of slippage, as representatives of diffuse interests may have greater difficulty monitoring and influencing decisions that are spread out over time. *See* Super, *supra* note 58, at 1423.

3. Limits to the Ability of Adaptive Management to Improve Management, or Problems of Uncertainty

As noted above, monitoring is essential to evaluating the results of adaptive management and to provide the impetus for adaptation in response to experiments or even trial and error. There will almost inevitably be uncertainty around monitoring data, because of the dynamism of so many environmental resources[70] and the limitations that the large spatial and temporal scales for many ecological questions pose for data collection.[71] Indeed, because there can be multiple methods for analyzing monitoring data, and there is no consensus on which methods are superior in many situations,[72] even disputes over how best to analyze monitoring data may not be resolvable. Monitoring and adaptive management might not be able to resolve disputes over the state of a resource or which management or regulatory options are performing best.[73]

Powerful political actors that are opposed to major management changes can rely on this nearly inevitable, residual uncertainty to argue that the results of an adaptive management program do not, in fact, require changes in management.[74] A helpful example of this phenomenon is the history of the adaptive management program for the Glen Canyon Dam. The dam itself has significant impacts on downstream natural resources in Grand Canyon National Park.

70. Moir & Block, *supra* note 30, at 144 ("Research seldom has clear answers to contested management issues."); LEE, *supra* note 46, at 46-48, 57-58; Byron K. Williams & Fred A. Johnson, *Adaptive Management and the Regulation of Waterfowl Harvests*, 23 WILDLIFE SOC'Y BULLETIN 430, 434 (1995); Conroy et al., *supra* note 57, at 93-94; Bernard T. Bormann & A. Ross Kiester, *Options Forestry: Acting on Uncertainty*, 102 J. OF FORESTRY 22, 22 (June 2004) ("Unknowable uncertainties arise when things change faster than they can be measured: Collecting more data does not help.").

71. Ray Hilborn and Donald Ludwig, *The Limits of Applied Ecological Research*, 3 ECOLOGICAL APPLICATIONS 550 (1993); Gregory et al., *supra* note 25; Doremus, *Adaptive Management as an Information Problem*, *supra* note 1, at 1484-88.

72. Len Thomas, *Monitoring Long-Term Population Change: Why Are There So Many Analysis Methods?*, 77 ECOLOGY 49 (1996). Figure one in the article highlights how very different trend lines can be identified using different analytic tools with the same data.

73. Bormann & Kiester, *supra* note 70, at 22-23 ("the true confidence intervals surrounding many policies overlap, to the extent that choosing one over another is based on something other than what is known"); Emery Roe, *Why Ecosystem Management Can't Work Without Social Science: An Example from the California Northern Spotted Owl Controversy*, 20 ENVTL. MGMT. 667, 670-71 (1996) (adaptive management "will leave behind as many, if not more, research and management uncertainties as it resolves").

74. This is true in the context of a relatively open, public, and democratic political system like in the United States. In a more authoritarian system, the ability of stakeholders to use uncertainty to derail adaptive management will be reduced because the role that stakeholders play in decisionmaking will be reduced.

Controversy over those impacts, along with legal constraints (such as the Endangered Species Act) and Congressional action (the Grand Canyon Preservation Act ("GCPA")) forced the Bureau of Reclamation (which operates the Dam) to develop an adaptive management program for the Dam. A series of experimental floods beginning in 1996 were designed to test whether significant changes to the operations of the Dam might improve the conditions of a range of downstream natural resources. The consensus in the scientific and policy literature was that the experimental floods were a resounding success, and provided strong and actionable monitoring data that supported significant changes in Dam operations. Yet it is only recently, about fifteen years after the process began, that major changes have occurred in the Dam's operations.[75] Critics argue that this is because of the decision-making structure for the Dam: power and water interests who would be hurt most by Dam reoperation have an effective veto over changes to Dam operation.[76] These powerful interests have pointed to residual uncertainty about the results of various experimental flooding to argue that there is no basis for significant changes in Dam operations.[77] They also have drawn on burden of proof. In an early article on adaptive management for the Dam, staff members for the Western Area Power Administration (one of the major power interests associated with the Dam) called for setting a high burden of proof for any changes from the status quo for Dam operations.[78]

Political pressure in this context may well be asymmetric; it might regularly weigh more on the side of increasing exploitation of natural resources for human use in the face of uncertain data about the status of those resources. In the fisheries context, there is evidence that when fisheries scientists give policymakers a range of possible figures for the status of a fishery (highlighting the uncertainty present in the data),[79]

75. *See* Felicity Barringer, *Dam's Flow Limit Loosened to Feed Grand Canyon*, N.Y. TIMES, May 23, 2012, *available at* http://www.nytimes.com/2012/05/24/science/earth/dam-limits-loosened-to-feed-grand-canyon.html (reporting proposal by government to allow for high-flow releases from Glen Canyon Dam, a significant change from prior dam management).

76. Joseph M. Feller, *Collaborative Management of Glen Canyon Dam: The Elevation of Social Engineering Over Law*, 8 NEV. L.J. 897, 921-29 (2008); Alejandro E. Camacho, *Beyond Conjecture: Learning About Ecosystem Management from the Glen Canyon Dam Experiment*, 8 NEV. L.J. 942, 947-53 (2008); Lawrence Susskind et al., *Collaborative Planning and Adaptive Management in Glen Canyon: A Cautionary Tale*, 35 COLUM. J. ENVTL. L. 1, 6 (2010).

77. Susskind et al., *supra* note 76, at 46-49; Feller, *supra* note 76, at 921-29.

78. Mark J. Wieringa and Anthony G. Morton, *Hydropower, Adaptive Management, and Biodiversity*, 20 ENVTL. MGMT. 831, 832-33 (1996) ("Operational modifications should have measurable and beneficial effects that clearly outweigh the adverse effects on other resources.").

79. Many leading adaptive management scholars regularly call for agencies and scientists to "embrace uncertainty" by being open about uncertainty in their communications with the public and

policymakers consistently choose the estimates that will allow the most fishing activity, and therefore increase the risk of collapse for a fishery.[80] Indeed, fisheries scientists have argued that this is precisely what happened in the run-up to the collapse of the Canada Atlantic cod fishery—a fishery that once was one of the largest in the world and has been defunct since the mid-1990s. According to these assessments, both scientists and policymakers consistently drew the most optimistic conclusions about the status of the cod fishery from the relevant data, until the collapse was so obvious that there was no choice but to completely end fishing.[81]

Even where there is not disproportionate political power among the various interest groups involved in an environmental dispute, uncertainty may nonetheless allow various stakeholders to continue fights over policy even after the adaptive management program has been established. Most natural resource debates involve fundamental conflicts over goals and objectives.[82] As such they are examples of "wicked

in the development of management and regulatory decisions. *See generally* Walters, *supra* note 42; Williams et al., U.S. DEPARTMENT OF THE INTERIOR TECHNICAL GUIDE, *supra* note 30, at 3-4; Stankey et al., *supra* note 13, at 29; LEE, *supra* note 46, at 63; Gunderson, *Adaptive Dancing*, *supra* note 42, at 37-38; Ray Hilborn et al., *Current Trends in Including Risk and Uncertainty in Stock Assessment and Harvest Decisions*, 50 CANADIAN J. FISHERIES & AQUATIC SCI. 874 (1993) (call for fisheries biologists to be more explicit about risk and uncertainty when presenting stock assessments to decision-makers).

80. *See* Josh Eagle & Barton H. Thompson, Jr., *Answering Lord Perry's Question: Dissecting Regulatory Overfishing*, 46 OCEAN & COASTAL MGMT. 649 (2003).

81. *See* Jeffrey A. Hutchings & Ransom A. Myers, *What Can Be Learned from the Collapse of a Renewable Resource? Atlantic Cod, Gadus morhua, of Newfoundland and Labrador*, 51 CANADIAN J. FISHERIES & AQUATIC SCI. 2126, 2144 (1994); Jeffrey A. Hutchings et al., *Is Scientific Inquiry Incompatible With Government Information Control?*, 54 CANADIAN J. FISHERIES & AQUATIC SCI. 1198, 1198-99, 1202-03 (1997); Lennox O'Reilly Hinds, *Crisis in Canada's Atlantic Sea Fisheries*, 19 MARINE POL'Y 271, 281 (1995); Quinn Schiermeier, *How Many More Fish in the Sea?*, 419 NATURE 662, 662-63 (2002); Ransom A. Myers et al., *Hypotheses for the Decline of Cod in the North Atlantic*, 138 MARINE ECOLOGY PROGRESS SERIES 293 (1996); *The Cod that Disappeared*, NEW SCIENTIST, 16 Sept. 1995, at 24, 28; D.H. Steele et al., *The Managed Commercial Annihilation of Northern Cod*, 8 NEWFOUNDLAND STUDIES 34, 48 (1992); Barbara Neis, *Fishers' Ecological Knowledge and Stock Assessment in Newfoundland*, 8 NEWFOUNDLAND STUDIES 155, 171-72 (1992); Cabot Martin, *The Collapse of the Northern Cod Stocks: Whatever Happened to 86/25?*, 20 FISHERIES No. 5, p. 6, 7 (May 1995).

82. R. Edward Grumbine, *Reflections on "What is Ecosystem Management?"*, 11 CONSERVATION BIOLOGY 41, 47 (1997) ("All resource allocation decisions are matters of political struggle rather than technical facts."); Rebecca J. McLain & Robert G. Lee, *Adaptive Management: Promises and Pitfalls*, 20 ENVTL. MGMT. 437, 439 (1996); Conroy et al., *supra* note 57, at 93 ("decisions in conservation biology commonly involve conflicts over objectives"); LEE, *supra* note 46, at 87; R. McGreggor Cawley & John Freemuth, *Tree Farms, Mother Earth, and Other Dilemmas: The Politics of Ecosystem Management in Greater Yellowstone*, 6 SOC'Y & NAT. RES. 41 (1993); W. Bruce Shepard, *Seeing the Forest for the Trees: New Perspectives' in the Forest Service*, RENEWABLE RES. J. 8 (1990).

problems" for which "there are no true or false answers." In these problems "many parties are equally equipped, interested, and/or entitled to judge the solutions, although none has the power to set formal decision rules to determine correctness. Their judgments are likely to differ widely to accord with their group or personal interests, their special value-sets, and their ideological predilections."[83]

In the environmental context there are a wide range of goals that stakeholders pursue, and many of those goals are seen as permissible politically and legally.[84] For instance, adaptive management is often pursued as part of the broader concept of ecosystem management. But goals in ecosystem management tend to be vague.[85] They are frequently too broad to be of use to structure outcomes or constrain the level of debate among stakeholders about what goals should be.[86]

Yet there is a widespread agreement in the adaptive management literature that, at least in the beginning of the adaptive management process, there needs to be a clear articulation among participants/managers/stakeholders as to the objectives or the goals for the regulatory or management program in question.[87] Clear goals are

83. Horst W.J. Rittel & Melvin M. Webber, *Dilemmas in a General Theory of Planning*, 4 POL'Y SCI. 155, 163 (1973); Holly Doremus, *Data Gaps in Natural Resource Management: Sniffing for Leaks Along the Information Pipeline*, 83 IND. L. J. 407, 433-34 (2008).

84. *See* AARON WILDAVSKY, SPEAKING TRUTH TO POWER: THE ART AND CRAFT OF POLICY ANALYSIS 215 (1979) ("To know whether objectives are being achieved, one must first know what they are supposed to be. Yet, the assumption that objectives are known, clear, and consistent is at variance with all experience. We know that objectives invariably may be distinguished by three outstanding qualities: they are multiple, conflicting, and vague. . . . The classic case is the multiple-use concept in natural resources that posits equal value for both preservation and use.'").

85. *See, e.g.*, Thomas A. More, *Forestry's Fuzzy Concepts: An Examination of Ecosystem Management*, 94 J. OF FORESTRY 8, 19 (Aug. 1996); Allan K. Fitzsimmons, *Sound Policy or Smoke and Mirrors: Does Ecosystem Management Make Sense?*, 32 WATER RESOURCES BULLETIN 217 (1996); Oliver Houck, *On the Law of Biodiversity and Ecosystem Management*, 81 MINN. L. REV. 869, 938 (1997); Steven L. Yaffee, *Three Faces of Ecosystem Management*, 13 CONSERVATION BIOLOGY 713 (1999).

86. Annecoos Wiersema, *A Train Without Tracks: Rethinking the Place of Law and Goals in Environmental and Natural Resources Law*, 38 ENVTL. L. 1239, 1261 (2008); Roger A Sedjo, *Toward an Operational Approach to Public Forest Management*, 94 J. OF FORESTRY 8, 24 (Aug. 1996) (noting vagueness of the concept and that it is "least intelligible when determining objectives").

87. Byron K. Williams, *Adaptive Management of Natural Resources — Framework and Issues*, 92 J. ENVTL. MGMT. 1346, 1348 (2011); Jamie E. McFadden et al., *Evalauting the Efficacy of Adaptive Management Approaches: Is There a Formula For Success?*, 92 J. ENVTL. MGMT. 1354, 1356 (2011); Byron K. Williams, *Passive and Active Adaptive Management: Approaches and an Example*, 92 J. ENVTL. MGMT. 1371, 1178 (2011); Clinton T. Moore et al., *Adaptive Management in the U.S. National Wildlife Refuge System: Science-Management Partnerships for Conservation Delivery*, 92 J. ENVTL. MGMT. 1395 1396 (2011); Gregory et al., *supra* note 25, at 2418; James E. Lyons et al., *Monitoring in the Context of Structured Decision-Making and Adaptive*

important for an adaptive management program for three reasons. First, goals help determine what the important management or regulatory questions are, and therefore what information an adaptive management program can provide and how to design monitoring or experiments to reduce the relevant uncertainty.[88] Second, goals help determine what kinds of tradeoffs are present in making decisions about whether and how to pursue adaptive management (i.e., what costs will be necessarily entailed by an adaptive management program, and whether those costs are worth paying).[89] Finally, goals are required so that the adaptive management program can evaluate success or failure for various management options.[90]

Given all this, it is no surprise that a failure to resolve underlying controversy has been identified as a reason why adaptive management has failed. Stakeholders that are still in conflict over underlying goals for a regulatory or management program may continually point to residual uncertainty to support their differing positions and resist unfavorable regulatory or management action, even in the face of apparently successful experiments and monitoring programs.[91] The Glen Canyon Dam adaptive management program again provides an example of this dynamic: Congress has never provided clear guidance among conflicting goals for management of the Dam (water storage, power generation, recreational use, protection of downstream Grand Canyon resources, and protection of endangered species), and due to this, it is difficult to resolve underlying uncertainty by determining what

Management, 77 J. WILDLIFE MGMT. 1683, 1684 (2008); Craig R. Allen et al., *supra* note 12, at 1339; N. SALUFSKY ET AL., BIODIVERSITY SUPPORT PROGRAM, ADAPTIVE MANAGEMENT: A TOOL FOR CONSERVATION PURPOSES 34-36 (2001); Stankey et al., *supra* note 13, at 47 fig. 7.

88. Doremus, *Adaptive Management as an Information Problem*, *supra* note 1, at 1469 (noting "the need for clear goals" for adaptive management to succeed, because "[w]ithout identified management goals, it is impossible to understand what relevant information is missing").

89. For instance, an adaptive harvest management for North American waterfowl was limited in terms of management choices and experimentation because of fundamental disagreements about what goals of management should be, and how to prioritize among those goals (harvest size, population size, simplicity of regulatory system, among others in developing and implementing experiments). Fred A. Johnson, *Learning and Adaptation in the Management of Waterfowl Harvests*, 92 J. ENVTL. MGMT. 1385, 1391-92 (2011).

90. Gordon L. Baskerville, *The Forestry Problem: Adaptive Lurches of Renewal*, *in* BARRIERS AND BRIDGES TO THE RENEWABLE OF ECOSYSTEMS AND INSTITUTIONS 37, 88 (Lance H. Gunderson et al., eds. 1995).

91. McLain & Lee, *supra* note 82, at 261, 279; Courtland L. Smith et al. *Sailing the Shoals of Adaptive Management: The Case of Salmon in the Pacific Northwest*, 22 ENVTL. MGMT. 671 (1998) (noting how significant uncertainty in scientific understanding of why salmon runs are decreasing is drawn upon by different interest groups to advance their own positions about appropriate salmon policy).

risks are more important and what risks are less important to consider in making management changes.[92] As a result, all stakeholders can point to the uncertainty that surrounds the management or regulatory choices they oppose, and effectively stalemate any changes in management or regulation in an ongoing proxy fight over the goals.[93]

Thus, disputes over values or conflicts may not be resolved by an adaptive management process, but instead simply exist below the surface, manifesting themselves in ongoing contests over whether the adaptive management program has really "proven" anything. In contrast to disputes where there is a shared understanding of common goals, adaptive management is constrained in its ability to solve disputes with underlying value conflicts.[94]

III. CONCLUSION

My focus here has been on the question of whether adaptive management should be the justification for major changes in the structure and process of environmental law, and my conclusion is a skeptical one. There may well be other reasons that we want to increase flexibility and dynamism in environmental law, perhaps because of changes in climate,[95] but those should be based on other arguments in addition to, or instead of, adaptive management.

Nonetheless, while adaptive management is not a panacea, I also believe that it will play a useful, even important, role in environmental decision-making, within significant limits. Those limits include:

92. Zellmer & Gunderson, *supra* note 13, at 930-31; *see also* HOLLY DOREMUS ET AL., CENTER FOR PROGRESSIVE REFORM, *supra* note 46, at 4 (arguing that lack of clear goals doomed the adaptive management program in the Everglades).

93. Gregory et al., *supra* note 25, at 2418 ("A skilled participant can nearly always spin issues of uncertainty management in creative and self-serving ways."); *see also* Robert H. Socolow, *Failures of Discourse: Obstacles to the Integration of Environmental Values Into Natural Resource Policy*, *in* WHEN VALUES CONFLICT: ESSAYS ON ENVIRONMENTAL ANALYSIS, DISCOURSE, AND DECISION 1-2 (Laurence H. Tribe et al., eds. 1976); Andrew J. Tyre & Sarah Michaels, *Confronting Socially Generated Uncertainty in Adaptive Management*, 92 J. ENVTL. MGMT. 1365, 1366-67 (2011) (describing how, when subjective expert probabilities are used to parameterize biological models, stakeholders will contest those probabilities that conflict with their goals).

94. Fred Johnson & Ken Williams, *Protocol and Practice in the Adaptive Management of Waterfowl Harvests*, 3 ECOLOGY & SOC'Y ART. 8 (1999), *available at* http://www.consecol.org/vol3/iss1/art8; FLEISCHMAN, *supra* note 12, at 16; Koontz & Bodine, *supra* note 12, at 65 (BLM employees report that unresolved conflict is a major reason why ecosystem management fails); Stankey et al., *supra* note 13, at 34 (framing problems "as technical in nature when often they involve value-based issues" has lead to problems with many adaptive management projects).

95. Kundis Craig, *supra* note 10.

- A geographic and temporal scale that makes either multiple management and regulatory options, or at least monitoring of ongoing management and regulatory decisions, feasible;[96]
- Time that is sufficient for adaptive management to provide useful information before decisions expected to have system-transforming results need to be made;
- Institutional and legal structures that will ensure the production of high-quality monitoring data and that are stable enough to maintain monitoring and adaptive management programs over extended periods of time;
- Benefits of adaptive management (in terms of improved information and reduced uncertainty) that exceed the costs (not just the direct costs of setting up management options and monitoring the results, but also the indirect costs of foregone benefits from exploitation of the resource and increased short-term risks of harm to valuable resources);
- Flexibility that does not present unacceptable levels of uncertainty for society or undermine management or regulation because of political pressures;[97]
- Sufficient agreement on underlying management and regulatory goals that makes it plausible that additional information will improve the decision-making process;
- Dynamism and uncertainty that are high enough to justify the need for adaptive management, but not so high that they make it difficult or impossible to reduce uncertainty through adaptive management.

These limits apply to both active and passive adaptive management, though they may more seriously limit active adaptive management.

It is unclear whether many of these criteria are actually satisfied in many of the areas of environmental law where adaptive management is currently being pursued. For instance, adaptive management might not be appropriate for fisheries where the relevant species population dynamics are so complex and unpredictable that additional data may not be useful for management.[98] Adaptive management faces serious

96. *See generally* Gregory et al., *supra* note 25.

97. For an effort to develop a proposal that achieves this, see Kundis Craig, *supra* note 10, at 17, arguing for principled flexibility in which flexibility is allowed with respect to the means of achieving environmental goals, but not as to which goals are pursued or whether action should be taken to achieve those goals. *See also* Doremus, *Adapting to Climate Change*, *supra* note 59.

98. *See supra* notes 42-45 and accompanying text.

challenges when used for the protection of endangered species, both because there may not be sufficient time to develop additional information before major, irreversible, high-stakes decisions have to be made, and because the risks of short-term irreversible harm for endangered species from experimentation might outweigh the benefits of improved information.[99] As for climate change adaptation, for changes that are happening at a large temporal and geographic scale, pursuing active adaptive management might be infeasible and too costly.[100]

Of course, any assessment of the merits and demerits of adaptive management as a policy tool has to be relative: how effective is adaptive management compared to other possible options? The current primary option is what J.B. Ruhl has called "front-end" decision-making,[101] in which decision-makers attempt to fully predict possible outcomes based on different alternatives, weigh the pros and cons of those different alternatives, and implement the best alternative, without significant follow-up monitoring or adjustment in response to that monitoring.[102] On some of the issues discussed in this paper, both adaptive management and "front-end" analysis have their pros and cons: front-end analysis will be more useful where dynamism and complexity are limited and adaptive management where dynamism and complexity are more significant, but still allow for learning. But where dynamism and complexity might be so high that learning is impossible, we might again be better off with relatively rigid, inflexible standards based on front-end analysis.[103]

For other factors, "front-end" analysis at first blush appears superior. Rigid, up-front standards avoid the risks and costs of flexibility described in this paper. For still others, adaptive management might be the best of a bad set of choices. For instance, it seems clear that adaptive management will, in general, be better in producing information in the face of uncertainty than "front-end" analysis, even where scale imposes significant limits on adaptive management.[104] The

99. *But see* Ruhl, *Taking Adaptive Management Seriously*, *supra* note 19, at 1265 ("the one spot on the spectrum of species decline we ought to hope and expect to find adaptive management at work is at the point when we think a species might very well become extinct. If we do not practice adaptive management at that stage, what is the point of doing anything?").

100. Gregory et al., *supra* note 25, at 2423.

101. Ruhl, *Climate Change Adaptation*, *supra* note 8.

102. This model describes how environmental analysis under NEPA more or less currently proceeds. *See e.g.*, Bradley Karkkainen, *Toward a Smarter NEPA: Monitoring and Managing Government's Environmental Performance*, 102 COLUM. L. REV. 903 (2002).

103. *See, e.g.*, Ronald A. Heiner, *The Origin of Predictable Behavior*, 73 AM. ECON. REV. 560 (1983).

104. See *supra* Section II.A.1.

flexibility of adaptive management, if implemented right, might also make decision-making more responsive to rapid (but not-too-rapid) changes in environmental conditions.

A full examination of the relative pros and cons of adaptive management and the other, main alternatives is beyond the scope of this paper. I think one of the most important lessons of this paper is that such a relative analysis is necessary, and not just on the turf that is most favorable to adaptive management.

There are two other major lessons that I draw from the limits of adaptive management. First, instead of attempting to adopt wholesale the concept of adaptive management into environmental law and concomitantly force major changes on environmental law to make the fit work,[105] we might instead look to see how the concept of adaptive management might be "adapted" so it works better with environmental law. While scholars have criticized agencies for pursuing passive adaptive management or trial and error, rather than active adaptive management, and have argued for legal and structural changes in response, my assessment indicates that perhaps we should be more sympathetic to the agencies and the law. There might be good reasons that large-scale experiments are not feasible for many of the regulatory and management problems we face. It is for these reasons Holly Doremus has suggested the phrase "learning while doing" instead of adaptive management because the former phrase broadens the focus beyond large-scale experiments.[106] I think this is an important first step in making the discussions over the interaction between adaptive management and environmental law into a two-way conversation between legal scholars and environmental managers and scientists about how both adaptive management and environmental law might need to be adjusted to work better together.

Second, we might question whether the adaptation that adaptive management requires in environmental law means that the legal system must necessarily become more flexible. Indeed, it may be that stringently applied standards in environmental law could help us better achieve the underlying goals of learning while doing or adaptive management. Tough standards can both inspire the efforts needed to establish adaptive management programs that might increase information—for example, ESA restrictions threaten significant

105. *See, e.g.*, Karkkainen, *Panarchy*, *supra* note 15, at 77.
106. *See* Doremus, *Precaution, Science, and Learning*, *supra* note 59, at 568-70.

economic impacts unless a better management solution is found[107]— and also provide outer limits on the experiments and changes that are part of adaptive management, providing important protection to valuable resources.[108]

An example of how standards might be usefully applied to adaptive management is the concept of triggers: ex ante standards that, if met, automatically cause significant management or regulatory responses.[109] Triggers can be used to force adaptation in response to monitoring results; they can also be used to provide underlying guarantees that important resources will be protected from serious, irreversible impacts from adaptive management experiments.[110]

Triggers have limits: triggers cannot produce agreements where none are to be found.[111] Sophisticated stakeholders who understand uncertainty and the relevant resources that are relevant for the dispute

107. *See, e.g.*, FLEISCHMAN, *supra* note 12, at 16; Joy B. Zedler, *Adaptive Management of Coastal Ecosystems to Support Endangered Species*, 24 ECOLOGY L.Q. 735 (1997); Yaffee, *supra* note 13, at 726 (arguing that ESA is "needed to encourage development interests and agencies to engage in the multiparty discussions critical to achieving effective eco- system management"); Volkman & McConnaha, *supra* note 57, at 1263-64 (arguing ESA helped force environmental protection and change the political burden of proof for ecological restoration).

108. *See, e.g.*, Rohlf, *Integrating Science, Law, and Policy in Managing Natural Resources*, *supra* note 59; Ruhl, *Taking Adaptive Management Seriously*, *supra* note 19, at 1249 (noting need for "inflexible commands" as part of overall process); Carl Walters, *Designing Fisheries Management Systems That Do Not Depend Upon Accurate Stock Assessment*, 280, *in* REINVENTING FISHERIES MANAGEMENT (Tony J. Pitcher et al., eds. 1998) (in light of fundamental uncertainty in fisheries, calling for using a coarse, fixed standard in which we "treat the seas as closed to fishing with small exceptions"); Doremus, *Adaptive Management as an Information Problem*, *supra* note 1, at 1485; Ruhl, *Regulation by Adaptive Management*, *supra* note 8, at 54-56 (arguing that implementation of adaptive management requires restrictions on volatility and drift in agency decision-making).

109. Moir & Block, *supra* note 30, at 146; HOLLY DOREMUS ET AL., CENTER FOR PROGRESSIVE REFORM, *supra* note 46, at 11 ("In order to ensure that adaptation occurs, management plans should set forth clear benchmarks for adapting to new information or changing circumstances."); SALUFSKY ET AL., *supra* note 87, at 59-60; Doremus, *Adaptive Management, the Endangered Species Act*, *supra* note 11, at 85-86; Julien Martin, et al., *Structured Decision Making As A Conceptual Framework To Identify Thresholds For Conservation And Management*, 19 ECOLOGICAL APPLICATIONS 1079, 1080-81 (2009). For a thorough overview of triggers and how they have been used, see Martin Nie & Courtney Schultz, *Decision Making Triggers in Adaptive Management*, REPORT TO USDA PACIFIC NORTHWEST RESEARCH STATION, NEPA FOR THE 21ST CENTURY (Nov. 1, 2011).

110. Another advantage is that by requiring stakeholders or agency staff to articulate what levels of uncertainty are acceptable for a monitoring program, triggers can produce a constructive dialogue about uncertainty and the role it might play in decision-making—much the way that initial modeling in adaptive management programs can produce a constructive dialogue about underlying assumptions and goals in environmental disputes.

111. *See* Nie & Schultz, *Decision Making Triggers in Adaptive Management*, *supra* note 109 (noting how triggers have not resolved disputes over the management of the Tongass National Forest).

will know how to manipulate the setting of triggers and won't agree to triggers that might undermine their goals.[112] If ex ante uncertainty is high enough to preclude this kind of strategy, sophisticated stakeholders may simply refuse to agree to triggers. Moreover, it is impossible to predict and plan for all contingencies in environmental regulation and management. Thus, there is an inevitable possibility that surprises will be turned up in the adaptive management program that haven't been planned for in the trigger system.[113] Finally, there is a risk that the trigger system might have an "expiration date." If the monitoring program and trigger system require a long enough time to operate, the political, economic, and social landscape may have changed significantly in the interim, such that any trigger might not be enforceable.[114]

There are other possibilities. For instance, statutes that authorize or even require agencies to use adaptive management do not necessarily need to give the agencies more flexibility. Simply granting the authority or even mandating adaptive management might be done without making other changes to the various procedural or substantive structures in environmental law.[115]

Even changes to existing procedural or substantive requirements to help advance adaptive management need not result in overall reductions in flexibility. Indeed, if properly structured, such changes might reduce the risk that agencies attempt to use adaptive management to augment their discretion at the expense of other important goals. Statutory reforms might require that an agency make certain findings before pursuing adaptive management (e.g., that adaptive management will in fact be useful for the problems the agency is attempting to address), and

112. WILDAVSKY, *supra* note 84, at 216 ("Strategically located participants often refuse to accept definitions of objectives that would put them at a disadvantage or in a straightjacket should they wish to change their designation of what they do in the future."). There are a range of ways in which triggers can be adjusted or manipulated: the baseline from which the triggers is measured, the actual level for the trigger, or the level of uncertainty required to be satisfied for determining whether that level has been met; and the mandatory nature of the specific management or regulatory responses that will be imposed if the trigger is met. All of these points are often the focus of significant dispute among stakeholders. *See* Nie & Schultz, *Decision Making Triggers in Adaptive Management*, *supra* note 109.

113. Such situations may nonetheless be useful, as they produce very important information about the world, helpfully revising our scientific understandings. LEE, *supra* note 46, at 148-49.

114. *See* SALUFSKY ET AL., *supra* note 87, at 60 (unclear "whether people would make decisions based on a discussion that had been held years ago").

115. Of course, if adaptive management really does require substantial changes in procedural or substantive requirements in environmental law, authorizing or requiring its use by agencies without making those changes simply sets those agencies up for failure.

it might impose significant requirements on an agency that seeks to pursue adaptive management (e.g., mandatory, enforceable monitoring or reporting requirements), in return for some revisions to existing procedural or substantive requirements. The goal here would be to make adaptive management useful for an agency when adaptive management is, in fact, a useful tool for reducing uncertainty, rather than a standardless loophole from otherwise applicable legal requirements. The result of such a balance might be fewer claims by agencies that they are using adaptive management (because such claims now come with real, but useful, costs), but more real use of adaptive management. What adaptive management might need, ultimately, is not more flexibility than traditional environmental law, but different kinds of constraints.