UNIVERSITY OF
COLORADO LAW REVIEW
Volume 83, Issue 1 *2011*

THE PROBLEM OF ENVIRONMENTAL MONITORING

ERIC BIBER*

Environmental law depends on the regular collection of accurate information about the state of the natural environment ("ambient monitoring") in order to assess the effectiveness of current regulatory and management policies and to develop new reforms. Despite the central role that ambient monitoring plays in environmental law and policy, the scholarly literature has almost ignored the question of whether and how effective ambient monitoring will take place—even though there is ample evidence that our current ambient monitoring data have extensive gaps and significant flaws. Moreover, the importance of ambient monitoring will only increase in the future with the shift to a new paradigm of adaptive management in which management and regulatory decision-making are kept purposefully flexible for future adjustment. This Article develops the ignored concept of ambient monitoring, explains why public agencies will predominantly have the task of ambient monitoring, and explores the fundamental characteristics of effective

* Assistant Professor of Law, UC Berkeley School of Law (Boalt Hall), Visiting Assistant Professor of Law, University of Chicago Law School, Fall 2011. Thanks to Brad Karkkainen, John Leshy, Albert Lin, J.B. Ruhl, Robin Kundis Craig, Jonathan Nash, Todd Aagaard, William Buzbee, David Sklansky, Cymie Payne, Katarina Linos, Eric Talley, Suzanne Scotchmer, Gillian Lester, Jodi Short, Wayne Brazil, Robert Bartlett, Michelle Wilde Anderson, Molly van Houweling, Lynn Huntsinger, Louise Fortmann, Justin Brashares, Michael Kang, Lance Gunderson, Kai Lee, Matthew Fladeland, Berry Brosi, David Skelly, Holly Doremus, Dan Farber, Joe Sax, Andrew Guzman, Ty Alper, Alex Camacho, Anne Joseph O'Connell, Melissa Murray, Matthew Stephenson, and Dave Owen and participants in workshops at Emory Law School; Vermont Law School's Colloquium on Environmental Scholarship; UC Berkeley Department of Environmental Science, Policy and Management; UC Berkeley Energy and Resources Group; and UC Berkeley School of Law for helpful comments. I am indebted to Jessica Cheng, Ryan Kelly, Jay Chayoung Kim, Tosh Sagar, and Heather Haney for invaluable research assistance. This paper is dedicated to the memory of Phil Frickey.

monitoring that make it so challenging. This Article then connects the scientific challenges of effective monitoring to the dynamics of public agencies to establish why those agencies might fail to conduct effective monitoring. Finally, it proposes possible solutions, with a focus on developing separate monitoring agencies.

INTRODUCTION

Last year, the *Washington Post* ran the headline: "[t]hat repulsive unflushed toilet? Better to swim in it than in the Chesapeake Bay."[1] Even though the cooperative federal and state program to clean up the Chesapeake Bay has spent millions on monitoring programs to evaluate its progress, critics contend (rightly) that the collected data are inadequate to evaluate whether and how management and regulatory programs are actually improving water quality.[2] The Chesapeake Bay is no anomaly. In California, for instance, the *Los Angeles Times* observed that "[h]ealth testing of California's beaches has slumped to its lowest level since ocean monitoring became law more than a decade ago, putting swimmers, surfers and divers at greater risk of exposure to contaminated water."[3]

1. Petula Dvorak, *Think the Bay's a Sewer? Don't Insult the Sewer*, WASH. POST, July 27, 2010, at B1.

2. *See infra* notes 120, 191 and accompanying text.

3. Tony Barboza, *Beach Water Testing at Ebb: Swimmers, Surfers and Divers Are at Greater Risk of Exposure to Harmful Bacteria, a* Times *Probe Shows*, L.A. TIMES, Aug. 30, 2010, at A1.

Water conditions that are sometimes sixfold dirtier than an unflushed toilet present possibly serious risks to human health.[4] But without proper and adequate monitoring of those conditions, how would we know a problem exists, let alone plan successful preventative and curative measures to address it?

These stories, and many others, highlight a central but neglected problem in environmental law: the surprising lack of reliable information about the conditions of the environment in which we live, i.e., ambient environmental conditions. There are tremendous gaps in our knowledge about a wide range of environmental resources, from water quality, to air quality, to endangered species, to wetlands.[5] Those gaps result not just from the absence of monitoring data but also from the ineffective nature of much of the monitoring data that is available.[6]

What might cause such gaps? To some extent, gaps are understandable: Monitoring is costly and difficult to do well.[7] Inadequate funding and infrequent collection of data were both important causes of the monitoring breakdowns in the Chesapeake Bay and in California.[8] But there are also significant political, legal, and institutional obstacles to the pursuit of effective monitoring by the public agencies that gather most of the data. One example is the failure to replace the aging U.S. satellites that monitor global environmental conditions, causing significant gaps for information crucial to understanding climate change.[9] Observers blame the problem

4. *See* Dvorak, *supra* note 1. One main risk is the potential for disease-causing bacteria and viruses from untreated human and animal waste; measurements for fecal coliform bacteria are used as a proxy for this risk. *See Fecal Bacteria*, ENVTL. PROTECTION AGENCY, http://water.epa.gov/type/rsl/monitoring/vms511.cfm (last visited June 30, 2011).

5. *See infra* notes 81–89 and accompanying text.

6. *See infra* notes 81–89 and accompanying text.

7. *See infra* Part I.C.

8. Barboza, *supra* note 3; Kate Yanchulis, *Is Your Swimming Spot Dirtier Than a Toilet?*, NEWS21 (July 26, 2010), http://chesapeake.news21.com/water/chesapeake-bay-swim-spots-bacteria (report from the organization that conducted Chesapeake Bay tests noting that some locations were not official public beaches and so were not monitored at all, despite being popular with the public for swimming; that other locations were monitored once a week; and that major storm events that caused pollution were sometimes missed by monitoring).

9. *See* Suzanne Bohan, *A Dimmer View of Earth*, CONTRA COSTA TIMES, Aug. 8, 2010, at A1 (discussing political dynamics that undermined the satellite monitoring program); U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-10-558, POLAR-ORBITING ENVIRONMENTAL SATELLITES: AGENCIES MUST ACT QUICKLY TO ADDRESS RISKS THAT JEOPARDIZE THE CONTINUITY OF WEATHER AND CLIMATE DATA (2010) [hereinafter POLAR-ORBITING ENVIRONMENTAL SATELLITES:

on inefficient inter agency coordination, indifferent management by the relevant agencies, and a change in White House priorities.[10]

Monitoring of environmental conditions matters for environmental law. It can provide essential information to regulators, legislators, industry, and the public about the cleanliness of our air and water and about the conditions of the ecosystems that human life depends upon. This is information that legislators use to hold regulators accountable, that regulators use to improve regulatory programs, and that the public uses to make decisions about the environmental risks of everyday activities like swimming at the beach.

Beyond its significance in current regulatory frameworks, monitoring is central to the future direction of environmental law. The new paradigm of adaptive management has been embraced by academics, regulators, and managers.[11] Indeed, adaptive management forms the basis of major ecological restoration projects in the Chesapeake Bay, Colorado River, and the Everglades, as well as a proposed planning process for the U.S. National Forest system.[12] These paradigms require that environmental policy be constantly updated to meet changing circumstances, especially a globally changing climate.[13] But a system that calls for constant adaptation requires the ongoing collection of information about changing circumstances. We can hardly adapt our policies if we do not know whether we need to adapt, why we need to adapt, or how we need to adapt.

Monitoring will also be crucial as environmental law relies more on the concept of ecosystem services, in which the benefits for humans from natural ecosystems are converted

---

AGENCIES MUST ACT QUICKLY] (discussing risks to an environmental program from a gap in satellite monitoring); U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-09-564, POLAR-ORBITING ENVIRONMENTAL SATELLITES: WITH COSTS INCREASING AND DATA CONTINUITY AT RISK, IMPROVEMENTS NEEDED IN TRI-AGENCY DECISION MAKING (2009) [hereinafter POLAR-ORBITING ENVIRONMENTAL SATELLITES: WITH COSTS INCREASING] (discussing problems in a multi-agency group that managed the satellite program).

10. *See* POLAR-ORBITING ENVIRONMENTAL SATELLITES: WITH COSTS INCREASING, *supra* note 9.

11. *See infra* notes 54–61 and accompanying text.

12. National Forest System Land Management Planning, 76 Fed. Reg. 8480 (Feb. 14, 2011) (to be codified at 36 C.F.R. pt. 219); *see infra* Part I.B.

13. *See infra* Part I.B.

into quasi-monetary form.[14] Ecosystem services can help justify protection of those ecosystems politically, increase the legal consideration given to those ecosystems under existing legal doctrines (such as nuisance), or provide the basis for markets that trade in the services and create economic incentives for the protection of the ecosystems.[15] The most aggressive use of ecosystem services being considered today is "carbon offsets" in carbon regulatory systems.[16] These would allow emitters of carbon dioxide and other greenhouse gasses to "offset" their emissions by contributing to the protection and restoration of ecosystems that absorb greenhouse gases from the atmosphere (or at least prevent the release of those gases into the atmosphere).[17] The credibility and effectiveness of the offset concept depends in large part on ensuring that the quantity and quality of the relevant ecosystems are both well understood and monitored.[18]

---

14. *See generally* J.B. Ruhl & James Salzman, *The Law and Policy Beginnings of Ecosystem Services*, 22 J. LAND USE & ENVTL. L. 157 (2007). These benefits might include the prevention of flooding that intact wetlands can provide by absorbing excess runoff or the sequestration of carbon by forests from the atmosphere.

15. *Id.*; *see also* J.B. Ruhl, *The "Background Principles" of Natural Capital and Ecosystems Services—Did* Lucas *Open Pandora's Box?*, 22 J. LAND USE & ENVTL. L. 525 (2007).

16. At the international level, climate change negotiations have developed the Reducing Emissions from Deforestation and Forest Degradation (REDD) program in which developing countries would receive funds to improve forest management and reduce or offset carbon emissions. *See UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD), FAO, UNDP, UNEP Framework Document*, UN-REDD PROGRAMME (June 20, 2008), http://www.un-redd.org/LinkClick.aspx?fileticket=gDmNyDdmEI0%3d&tabid=587&language=en-US [hereinafter UN-REDD PROGRAMME]. At the national level, the proposal for climate change regulation in the last U.S. Congress included a provision allowing for offsets. *See* H.R. REP. NO. 2454, at 678, 774 (2009). The state agency implementing California's carbon regulatory program (AB 32) has proposed including a similar offset program. *See* Mary D. Nichols, *Update Regarding the Proposed Offset Component of the California Cap-and-Trade Program*, CAL. AIR RESOURCES BOARD (July 29, 2010), http://www.arb.ca.gov/cc/capandtrade/meetings/062210/offset_program_-update.pdf.

17. *See* UN-REDD PROGRAMME*, supra* note 16.

18. For instance, the justification for granting particular offsets for the protection of tropical forests might depend on the argument that maintaining tropical forests in relatively undisturbed conditions will ensure that carbon is not emitted into the atmosphere. *See, e.g.*, William Boyd, *Ways of Seeing in Environmental Law: How Deforestation Became an Object of Climate Governance*, 37 ECOLOGY L.Q. 843, 867–69 (2010). Monitoring will be needed to (a) confirm that relatively undisturbed tropical forests continue to sequester carbon even in the face of future environmental change; (b) determine what "relatively

Nor is the importance of monitoring limited to environmental law. The concepts of flexibility and adaptability are increasingly relevant in administrative law. Under the rubrics of "new governance" or "democratic experimentalism," scholars have called for the regulatory system to move beyond rigid, inflexible legal mandates and instead to embrace legal structures in which agencies and stakeholders cooperate both to adjust legal standards to meet the particular needs of particular contexts and to use ongoing information collection to continually improve regulatory performance.[19] Again, these new paradigms require a broad understanding of the ambient conditions that the regulatory structure aims to improve. Even the recent financial crisis demonstrates the centrality of monitoring systemic conditions, given the importance of systemic risk for financial institutional health.[20] The just-passed financial reform statute creates a new agency to monitor systemic risks,[21] performing a role similar in nature to the monitoring of ambient environmental conditions in environmental law.

While ambient monitoring is important, there has been little investigation of whether and how it will occur. The literature to this point appears to assume that ambient monitoring is unproblematic, with little discussion of whether information gathering might constrain the adaptability and flexibility of regulatory standards.[22] To the extent that they have examined monitoring, environmental law scholars have focused on how government agencies can force private parties to produce more information about whether they are in compliance with relevant regulatory standards.[23] But when it comes to the monitoring of ambient environmental conditions,

---

undisturbed conditions" in tropical forests means; and (c) confirm that the forests have, in fact, been left in "relatively undisturbed conditions."

19. *See, e.g.*, Michael C. Dorf & Charles F. Sabel, *A Constitution of Democratic Experimentalism*, 98 COLUM. L. REV. 267 (1998) (developing the concept of "democratic experimentalism"); Orly Lobel, *The Renew Deal: The Fall of Regulation and the Rise of Governance in Contemporary Legal Thought*, 89 MINN. L. REV. 342 (2004) (explicating the concept of "new governance"); *see also* Kenneth A. Bamberger & Deirdre K. Mulligan, *Catalyzing Privacy: New Governance, Information Practices, and the Business Organization*, LAW & POL'Y (forthcoming 2011) (noting the rise of "new forms of governance that promote regulatory ambiguity, diversity, and revisability; that involve policy dynamism informed by experience and experimentation").

20. *See infra* notes 335–37 and accompanying text.

21. *See infra* notes 337 and accompanying text.

22. *See infra* notes 66–71 and accompanying text.

23. *See infra* notes 69–71 and accompanying text.

public agencies provide the majority of the data[24] because most private parties have limited incentives to provide complete and unfiltered data. Even if private parties provide more of this information, oversight will still fall to public agencies.[25]

This Article fills a gap in this literature by exploring the previously unasked but critical question: Can public environmental agencies do a good job of performing the challenging task of collecting over time the data we need to understand the state of our environment? Thoughtful answers to that question are central to the present and future of environmental law and other regulatory fields.

In order to answer this question, this Article begins in Part I with a comprehensive introduction to the importance, difficulty, and essentially public nature of environmental monitoring. Here, this Article develops the distinction between monitoring to determine whether private parties are in compliance with the law and ambient monitoring of environmental conditions. Drawing on the relevant scientific literature, this Article next explores the ways in which ambient monitoring can be challenging to perform: (1) it often requires relatively long-term, continuous measurements, and (2) it can be extremely difficult to design an effective monitoring program given the dynamic and complex nature of many natural systems.

This Article then builds on recent political science and administrative law scholarship to explore how the essential characteristics of environmental monitoring interact with the legal and institutional structures of public agencies. These interactions produce a range of constraints that can interfere with the ability of agencies to conduct effective monitoring. These constraints are the subject of Part II.

For instance, the low-profile nature of monitoring means that monitoring is particularly susceptible to public choice failures; no rallies in Washington D.C. are held to demand that Congress provide more funding for monitoring environmental conditions. But even when monitoring is funded, that funding is vulnerable to the charge that it is useless, wasteful government spending—red meat for the producer of a television newsmagazine program looking for a story about "government waste."

---

24. *See infra* notes 40–41 and accompanying text.
25. *See infra* note 33.

Constraints lie within agencies as well: Many agencies orient their activities around a particular "mission," yet collecting adequate monitoring data will often interfere with achieving that mission. An agency focused on timber production might be reluctant to collect adequate information about the status of wildlife populations because that information might produce political or legal pressures to cut back on logging.

If we can understand the vulnerabilities in public agency monitoring, then we can explore how to address the problem, which is the central aim of Part III. While there is a range of possible choices, the most promising separates agency monitoring from other administrative tasks. Separating tasks reduces the risk that a conflicting agency mission will interfere with an effective monitoring program and thus the risk that monitoring will be "traded-off" against other goals. In the end, effective practical solutions will depend on the particulars of individual regulatory and management programs, the resources at stake, and the political dynamics for any individual problem. While any solution will be challenging, environmental law in particular and administrative law more broadly will not be able to move forward unless we address the problem of environmental monitoring.

I. MONITORING IS NECESSARY, DIFFICULT, AND ESSENTIALLY PUBLIC

I begin by distinguishing ambient monitoring from the monitoring of compliance with existing rules, highlighting how ambient monitoring requires greater public involvement. I then explore ambient monitoring's importance for environmental law and the serious gaps in existing monitoring data. Next, I develop the challenges to conducting effective monitoring, specifically the need for continuity in monitoring and the difficulty of matching a monitoring program to the relevant management questions and to the complex ways in which environmental resources regularly vary across multiple scales.

A. Ambient Versus Compliance Monitoring

The monitoring of "ambient environmental conditions," i.e., the state of the environment at the local, regional, national, or global scale, contrasts with "compliance monitoring," which

focuses on compliance with a legal standard or regulation.[26] Ambient monitoring usually requires measurements over a larger temporal and geographic scale than compliance monitoring: compare the annual measurement of whether a particular end-of-the-smokestack pollution control device is functioning with the daily measurement of pollution levels across the entire Los Angeles Basin. Another useful example of ambient monitoring is the monitoring of river water quality, which might require measurements before the construction of any individual polluting factory, as well as measurements upstream of that factory's outfall and downstream measurements of where any impacts from that factory's outfall dissipate.

Ambient monitoring generally measures conditions that are affected by a combination of both human and natural causes, while compliance monitoring generally measures specific human causes. For example, contrast direct measurements of smokestack output with measurements of the impact of acid rain on the ecology of lakes in the Northeast United States.[27]

These two categories of monitoring are ends of a continuum, with various types of monitoring programs falling closer to one pole or another, or standing ambiguously in between. Ambient data might be used to measure compliance (depending on the regulatory standard). Some ambient monitoring programs might be small in absolute scale but still relatively large compared to the human activities that are the subject of regulation.[28] Thus, many types of monitoring—for instance, the "effects and effectiveness" monitoring conducted by the U.S. Fish and Wildlife Service (FWS) for permits issued under the Endangered Species Act (ESA)—might fall in both of these categories.[29]

---

26. *See* C.S. Russell, *Monitoring, Enforcement, and the Choice of Environmental Policy Instruments*, 2 REG. & ENVTL. CHANGE 73, 74 (2001) (drawing this distinction); Clifford S. Russell, *Monitoring and Enforcement*, *in* PUBLIC POLICIES FOR ENVIRONMENTAL PROTECTION 243, 244–45 (P.R. Portney ed. 1990) (same).

27. Acid rain result from a complicated mix of human and natural causes such as sulfur dioxide releases from power plants, soil conditions around the lakes, wind patterns, etc. *See* D.W. Schindler, *Effects of Acid Rain on Freshwater Ecosystems*, SCI., Jan. 8, 1988, at 149.

28. See *infra* Part I.C.2 for a discussion of the mobile air toxics program.

29. Alejandro E. Camacho, *Can Regulation Evolve? Lessons from a Study in Maladaptive Management*, 55 UCLA L. REV. 293, 325 (2007). This monitoring requires understanding the status and trends of a species in general (ambient

The dichotomy between relatively small-scale, human-oriented compliance monitoring and large-scale, more ecosystem-oriented ambient monitoring helps us understand important differences between the public and private sector roles in monitoring. The scholarly literature has emphasized how law can encourage the disclosure of compliance information by regulated parties,[30] including voluntary compliance monitoring by regulated industry in response to social and economic pressures for greater environmental performance.[31] Because government compliance monitoring may be comparatively inefficient given industry's better access to employees, records, or facilities, encouraging private compliance monitoring may be more effective.[32] A key trade-off

---

monitoring), *id.* at 320–21, as well as whether a particular project has adequately met its legal requirements under the ESA (compliance monitoring), *id.* at 317.

30. *See, e.g.*, John S. Applegate, *Bridging the Data Gap: Balancing the Supply and Demand for Chemical Information*, 86 TEX. L. REV. 1365, 1385–91 (2008); William W. Buzbee, *Adjudicatory Triggers of Enhanced Ambient Environment Information*, 83 IND. L.J. 583 (2008); Cary Coglianese et al., *Seeking Truth for Power: Informational Strategy and Regulatory Policymaking*, 89 MINN. L. REV. 277, 277–78 (2004); Daniel C. Esty, *Environmental Protection in the Information Age*, 79 N.Y.U. L. REV. 115, 124–28 (2004); Bradley C. Karkkainen, *Bottlenecks and Baselines: Tackling Information Deficits in Environmental Regulation*, 86 TEX. L. REV. 1409 (2008); Bradley C. Karkkainen, *Information as Environmental Regulation: TRI and Performance Benchmarking, Precursor to a New Paradigm?* 89 GEO. L.J. 257 (2001); Rena I. Steinzor, *Reinventing Environmental Regulation: The Dangerous Journey from Command to Self-Control*, 22 HARV. ENVTL. L. REV. 103, 150–83 (1998); Wendy E. Wagner, *Commons Ignorance: The Failure of Environmental Law to Produce Needed Information on Health and the Environment*, 53 DUKE L.J. 1619, 1717–36 (2004).

31. David W. Case, *Corporate Environmental Reporting As Informational Regulation: A Law and Economics Perspective,* 76 U. COLO. L. REV. 379, 386–401 (2005) (describing voluntary programs). Researchers have provided strong evidence that corporations will go beyond minimal statutory regulatory requirements in order to build public goodwill. *See, e.g.*, Neil Gunningham et al., *Social License and Environmental Protection: Why Businesses Go Beyond Compliance*, 29 LAW & SOC. INQUIRY 307 (2004).

32. *See* IAN AYRES & JOHN BRAITHWAITE, RESPONSIVE REGULATION: TRANSCENDING THE DEREGULATION DEBATE 104–05 (1995); KEITH HAWKINS, ENVIRONMENT AND ENFORCEMENT: REGULATION AND THE SOCIAL DEFINITION OF POLLUTION (1984); Jennifer Arlen, *The Potentially Perverse Effects of Corporate Criminal Liability*, 23 J. LEGAL STUD. 833, 835 & n.10 (1994); Jennifer Arlen & Reinier Kraakman, *Controlling Corporate Misconduct: An Analysis of Corporate Liability Regimes*, 72 N.Y.U. L. REV. 687, 707, 713 n.62 (1997); Louis Kaplow & Steven Shavell, *Optimal Law Enforcement with Self-Reporting of Behavior*, 102 J. POL. ECON. 583, 584, 602 (1994). There are also arguments that less confrontational inspection processes will encourage greater cooperation from regulated parties, again improving compliance monitoring. *See, e.g.*, EUGENE BARDACH & ROBERT A. KAGAN, GOING BY THE BOOK: THE PROBLEM OF REGULATORY UNREASONABLENESS 109–11 (1982).

here is ensuring complete and reliable compliance data while providing incentives to private parties to produce important compliance information.[33]

But there are two reasons why private entities may not be as central to successful ambient monitoring. First, ambient conditions are often measured at scales larger than any one unit of private property and/or in areas that are publicly owned (such as air or water). Thus, regulatory or management agencies often do not need access to private property or to private information in order to conduct effective monitoring.[34]

Second, private industry has strong incentives not to conduct ambient monitoring compared to compliance monitoring, in large part because it is *harder* to connect the results of ambient monitoring with the performance of individual actors. A primary rationale for voluntary compliance monitoring is that such monitoring might establish a company's environmental bona fides and produce market,

33. See, for example, AYRES & BRAITHWAITE, *supra* note 32, at 19–21, 25, 105–06, for a discussion of why some sort of government oversight is required; Neil Gunningham & James Prest, *Environmental Audit as a Regulatory Strategy: Prospects and Reform*, 15 SYDNEY L. REV. 492, 494 (1993); Cameron Holley, *Facilitating Monitoring, Subverting Self-Interest and Limiting Discretion: Learning from "New" Forms of Accountability in Practice*, 35 COLUM. J. ENVTL. L. 127, 162, 170–72 (2010) (finding empirical evidence from Australia of sham compliance in self-regulation and importance of regulatory checks to ensure validity of data); Paul R. Kleindorfer & Eric W. Orts, *Informational Regulation of Environmental Risks*, 18 RISK ANALYSIS 155, 162 (1998) ("[O]versight by regulators must continue to ensure the credibility of the information released to the public."); Kimberly D. Krawiec, *Cosmetic Compliance and the Failure of Negotiated Governance*, 81 WASH. U. L.Q. 487 (2003); Jodi L. Short & Michael W. Toffel, *Making Self-Regulation More than Merely Symbolic: The Critical Role of the Legal Environment*, ADMIN. SCI. Q. (forthcoming 2010) (empirical analysis finding that compliance with self-regulation and self-monitoring is higher where there is the possibility of regulatory surveillance). *See generally* John T. Scholz, *Cooperation, Deterrence, and the Ecology of Regulatory Enforcement*, 18 LAW & SOC'Y REV. 179 (1984); Matthew D. Zinn, *Policing Environmental Regulatory Enforcement: Cooperation, Capture, and Citizen Suits*, 21 STAN. ENVTL. L.J. 81, 96–106 (2002).

34. There are exceptions, of course—for instance, monitoring of the conditions of certain kinds of endangered species with highly restricted ranges that are found predominantly on private property will exhibit more similarities with compliance monitoring. *Cf.* Stephen Polasky & Holly Doremus, *When the Truth Hurts: Endangered Species Policy on Private Land with Imperfect Information*, 35 J. ENVTL. ECON. & MGMT. 22 (1998); Wendy Wagner, *Stormy Regulation: The Problems that Result when Stormwater (and Other) Regulatory Programs Neglect to Account for Limitations in Scientific and Technical Information,* 9 CHAP. L. REV. 191, 195–96 (2006) (noting the advantage that landowners might have in monitoring stormwater runoff).

social, or political benefits.[35] But a company can only gain those benefits if the geographic and temporal scale of ambient environmental information matches closely with the geographic and temporal scale of the impacts of the company's operations. For instance, a company that has the only industrial facility on a lake will gain a substantial benefit in terms of public relations if it can show that the water around its facility is in good shape, because those positive conditions are more obviously the result of the company's activities. However, if there are ten other facilities on the lake, then positive ambient conditions will also show the good management activities of the other facilities, giving them the same benefits without the costs of ambient monitoring.[36] Conversely, the company may rightfully believe that its environmental performance is strong, but that the presence of other, poorly-performing facilities on the lake might obscure the strength of its own environmental performance. If there is a risk that the data will be positive or negative because of the activities of others, the company will have less incentive to invest in the collection of ambient environmental data (as opposed to measures of its own environmental performance, such as end-of-the-wastepipe pollution).[37]

Moreover, there is also the non-trivial risk that ambient outcomes will not directly relate to the performance of the facility because of complex interactions within natural systems that make causation difficult to establish. If there are significant feedback effects (positive or negative), raising or lowering emissions may not translate directly into improvements in ambient conditions. Again, ambient measures are not the best way for a facility to show that *its own* environmental performance is strong.

In fact, few corporate environmental reports contain any information about ambient environmental conditions.[38] There is also little evidence that private parties that receive permits

35. *See supra* note 31.

36. *Cf.* Richard R. Nelson, *The Simple Economics of Basic Scientific Research*, 67 J. POL. ECON. 297, 302–04 (1959) (noting the problems of underinvestment by private companies in basic scientific research because of positive externalities).

37. *Cf. id.* (noting that high uncertainty in investment in basic research will deter risk-averse companies from investment in the area).

38. Douglas J. Lober et al., *The 100 Plus Corporate Environmental Report Study: A Survey of an Evolving Environmental Management Tool*, 6 BUS. STRATEGY & ENV'T 57, 68 (1997) ("[A]lmost all companies have stopped with reporting releases, rather than their impact on the environment.").

under the ESA are conducting any monitoring on the status of the species at issue, even when required by the relevant permits.[39]

In practice, much of the ambient monitoring in this country is publicly funded or undertaken.[40] Moreover, publicly owned and managed natural resources, including hundreds of millions of acres of public lands, play a significant role in environmental management; given the scale of the resources and public ownership, monitoring of those resources will also usually be public.[41] Finally, major ecological restoration projects in the United States often include ambient monitoring, such as those in the Chesapeake Bay, the Everglades, and the Pacific Northwest; monitoring is public because of the large scale of the restoration projects.

B. The Importance of Ambient Monitoring for Environmental Law and the Lack of Monitoring Data

Ambient monitoring is important to environmental law because it can help set overall policy, it can be an integral part of an existing regulatory or management system, and it is a key component of the primary reforms that academics and policymakers have suggested for environmental law. Yet, despite its importance and the many existing public monitoring programs, there are major inadequacies in our existing ambient monitoring data.

In general, monitoring can help identify previously unknown environmental harms that require the development of a new regulatory system or the adjustment of an existing one, serving as a "meta" tool that helps us choose whether and how to regulate.[42] Within any regulatory program, monitoring

39. *See* Camacho, *supra* note 29, at 316, 325–27.

40. *See* Wagner, *supra* note 30, at 1676; *see also* Esty, *supra* note 30, at 198; Richard B. Stewart, *A New Generation of Environmental Regulation?,* 29 CAP. U. L. REV. 21, 103 n.313 (2001).

41. *See* Eric Biber et al., *Restoring Public Trust in Public Lands: An Agenda for the New Administration*, 36 ECOLOGY L. CURRENTS 159, 159–60 (2009) (outlining the importance of federally-managed public lands for environmental protection). Those lands will be even more important as both a resource for renewable energy to help reduce climate change and for adaptation in response to climate change. *See* John D. Leshy, *Federal Lands in the Twenty-First Century*, 50 NAT. RESOURCES J. 111 (2010).

42. *See* IAN F. SPELLERBERG, MONITORING ECOLOGICAL CHANGE 5 (2d ed. 2005) (long-term studies "can be a basis for early detection of potentially harmful effects on components of ecosystems"); John M. Hellawell, *Development of a*

can help determine whether regulatory standards should be strengthened or relaxed for known harms.[43] And finally, it can be used to determine whether individual activities are in compliance with existing standards, even if the regulatory standard does not depend on ambient measures of environmental quality, by, for example, revealing significant amounts of cheating.[44]

Therefore, monitoring may be used to either support additional regulation or relax regulatory standards, which will affect whether monitoring is politically viable or not.[45] And, it might be used either to support a change in the legal or regulatory status quo or to oppose such a change, raising legal questions.[46] The distinction between these two dichotomies is important: Not all changes in the legal or regulatory status quo will lead to greater regulation, for instance.[47]

Ambient monitoring may be embedded into existing regulatory programs. Many environmental statutes use "quality-based" approaches that depend on ambient measures.[48] The Clean Air Act sets the level of required state air pollution regulation based on whether air quality meets minimum federal standards.[49] Likewise, the Clean Water Act's Total Maximum Daily Load (TMDL) program requires states to identify which rivers and lakes have water quality below minimum standards and then requires regulations to improve

---

Rationale for Monitoring, *in* MONITORING FOR CONSERVATION AND ECOLOGY 1, 3, 5 (Barrie Goldsmith ed., 1991) (monitoring used for "detecting incipient change"); J.J. Messer, *Monitoring, Assessment, and Environmental Policy*, *in* ENVIRONMENTAL MONITORING 499, 502 (G. Bruce Wiersma ed., 2004) (noting importance of monitoring data for identifying the problem of acid rain for forests and lakes in the Eastern United States).

43. *See* Hellawell, *supra* note 42, at 4; *see also* Messer, *supra* note 42, at 504–05 (monitoring data accelerated the phase-out of ozone-depleting chemicals under the Montreal Protocol); *id.* at 508 (monitoring inspired stricter lead air emissions standards).

44. *See* BARBARA J. DOWNES ET AL., MONITORING ECOLOGICAL IMPACTS: CONCEPTS AND PRACTICE IN FLOWING WATERS 39 (2002); Hellawell, *supra* note 42, at 3–4.

45. *See infra* Part II.A.1 for further exploration of this topic.

46. The issue of whether monitoring is a prerequisite for proposed government action can play an important role in the attitude courts take towards enforcing legal monitoring requirements. *See infra* Part III.B.3.

47. *See* Eric Biber, *The Importance of Resource Allocation in Administrative Law*, 60 ADMIN. L. REV. 1, 57–58 (2008).

48. Carol Rose, *Environmental Law Grows Up (More or Less), and What Science Can Do to Help*, 9 LEWIS & CLARK L. REV. 273, 275–78 (2005).

49. 42 U.S.C. §§ 7409–7410 (2006).

water quality.[50] These regulatory programs force "regulators to figure out the state of the relevant environment . . . and then in an ongoing way to keep such information current, further adjusting regulatory requirements," necessitating "ongoing vigilance and regulatory zeal of sorts that are seldom observed in studies of regulatory behavior."[51] For instance, the TMDL program has been notoriously slow and unsuccessful, in large part because of a lack of information about ambient conditions.[52]

Monitoring is crucial to the future of environmental law as well. In the past ten years, the paradigm in environmental law has shifted to "ecosystem management" and "adaptive management."[53] Ecosystem management emphasizes a holistic approach, recognizing the connections between different resources even where those connections cross traditional jurisdictional lines.[54] Ecosystem management incorporates adaptive management, consciously structured to produce useful new information that can improve future decision making.[55] A

50. 33 U.S.C. § 1313(d) (2006).

51. *See* Buzbee, *supra* note 30, at 600.

52. *Id.* at 600–01. Similarly, "baselines" are often used to establish regulatory standards in environmental law, and those baselines are often based on historic environmental conditions and will require ongoing monitoring of those conditions for enforcement. *See generally* J.B. Ruhl & James Salzman, *Gaming the Past: The Theory and Practice of Historic Baselines in the Administrative State*, 64 VAND. L. REV. 1 (2011).

53. *See, e.g.*, Mary Jane Angelo, *Harnessing the Power of Science in Environmental Law: Why We Should, Why We Don't, and How We Can*, 86 TEX. L. REV. 1527, 1546–52 (2008); Alejandro E. Camacho, *Adapting Governance to Climate Change: Managing Uncertainty Through a Learning Infrastructure*, 59 EMORY L.J. 1 (2009); Holly Doremus, *Adaptive Management, the Endangered Species Act, and the Institutional Challenges of "New Age" Environmental Protection*, 41 WASHBURN L.J. 50, 54 (2001); C.S. Holling & Gary K. Meffe, *Command and Control and the Pathology of Natural Resource Management*, 10 CONSERVATION BIOLOGY 328, 332 (1996) ("Ecosystems are moving targets, with multiple potential futures that are uncertain and unpredictable. Therefore management has to be flexible [and] adaptive . . . ."); J.B. Ruhl, *Regulation by Adaptive Management—Is It Possible?* 7 MINN. J. L. SCI. & TECH. 21 (2005); J.B. Ruhl, *Taking Adaptive Management Seriously: A Case Study of the Endangered Species Act*, 52 U. KAN. L. REV. 1249, 1249–50 (2004); J.B. Ruhl, *Thinking of Environmental Law as a Complex Adaptive System: How to Clean Up the Environment by Making a Mess of Environmental Law*, 34 HOUS. L. REV. 933, 996–97 (1997); A. Dan Tarlock, *The Nonequilibrium Paradigm in Ecology and the Partial Unraveling of Environmental Law*, 27 LOY. L.A. L. REV. 1121, 1139–41 (1994); John M. Volkman, *How Do You Learn From a River? Managing Uncertainty in Species Conservation Policy*, 74 WASH. L. REV. 719, 738–62 (1999).

54. *See, e.g.*, R. Edward Grumbine, *What is Ecosystem Management?,* 8 CONSERVATION BIOLOGY 27, 29–31 (1994).

55. *See infra* note 66 and accompanying text.

main driver of these proposals has been the inevitable need for environmental law to be flexible in the face of climate change.[56]

One example of adaptive management-based proposals is a "rolling rule regime" that draws heavily on "new governance" principles. It asks central regulators to devolve management and regulatory powers to local entities. Those local entities in turn provide "reports on proposals and outcomes" from their efforts. Those reports in turn are then used to "periodically reformulate minimum performance standards, desirable targets, and paths for moving from the former to the latter" to achieve "continuous improvements in both regulatory rules and environmental performance."[57]

Environmental agencies have widely adopted these new paradigms.[58] Management of the Columbia River Basin in the Pacific Northwest, where multiple dams provide much of the electricity for the region but also have had devastating impacts on wild salmon runs, is based on ecosystem and adaptive management.[59] Managers attempt to balance multiple goals (such as electricity production and salmon production) through a wide range of resource decisions (such as water flow, fisheries restrictions, and land-use management) by operating facilities and designing regulations in ways that will produce new information.[60] The results of different management choices are, in theory, supposed to inform decision makers for future decision making; for instance, it might be determined that one management choice to protect salmon from the impacts of hydroelectric dams may be less effective than another.[61]

Yet many have been disappointed with the results so far.[62] For instance, habitat conservation plans (HCPs) under the ESA—plans intended to protect endangered species while also allowing development to proceed—are based on ecosystem and adaptive management, yet fail to meet many of the relevant

---

56. *See, e.g.*, Camacho, *supra* note 53.

57. Charles Sabel et al., *Beyond Backyard Environmentalism*, BOSTON REV., Oct.–Nov. 1999, at 4.

58. *See generally* NATHAN F. SAYRE ET AL., MONITORING AS A SOCIAL PROCESS: A CASE STUDY OF NATIONAL FOREST GRAZING ALLOTMENTS, 1927–2007 (2010) (surveying examples).

59. *See* John M. Volkman & Willis E. McConnaha, *Through a Glass, Darkly: Columbia River Salmon, the Endangered Species Act, and Adaptive Management*, 23 ENVTL. L. 1249, 1250, 1254–58 (1993).

60. *Id.* at 1254–58.

61. *See generally id.*

62. *See* Doremus, *supra* note 53, at 54 (noting that "skepticism about adaptive management comes from the lack of success stories to date").

regulatory standards and goals set to prevent the extinction of hundreds of rare species.[63] Legal scholars have identified a range of obstacles to ecosystem and adaptive management. For instance, artificial geographic or institutional divides might interfere with the ability to adaptively manage entire ecosystems.[64] In addition, the upfront costs to develop new agency regulations or management approaches deter agencies from experimenting.[65]

While there is much truth in these critiques, there is another key, understudied issue. Ecosystem and adaptive management need tremendous amounts of ambient data.[66] "[A]daptive governance" requires "regular monitoring" as well as regular "assessment[ ] and adjustment of all agency decision making."[67] Without monitoring, it will be impossible to determine whether management or regulation is achieving the relevant goals and therefore whether (and what type of) adaptation is required.

Despite the importance of ambient monitoring, the environmental law scholarship has not focused much on the

63. Camacho, *supra* note 29, at 297, 323–24, 330.

64. *See, e.g.*, Camacho, *supra* note 53, at 26–30; Jamison E. Colburn, *Habitat and Humanity: Public Lands Law in the Age of Ecology*, 39 ARIZ. ST. L. J. 145, 163–69, 195 (2007); Jeffrey W. Jacobs, *Broadening U.S. Water Resources Project Planning and Evaluation*, 42 NAT. RESOURCES J. 21, 28 (2002); Karkkainen, *Bottlenecks and Baselines, supra* note 30, at 1439–43.

65. *See, e.g.*, Camacho, *supra* note 53, at 37–38; Karkkainen, *Bottlenecks and Baselines*, *supra* note 30, at 1443–44; Ruhl, *Regulation by Adaptive Management*, *supra* note 53.

66. *See* KAI N. LEE, COMPASS AND GYROSCOPE: INTEGRATING SCIENCE AND POLITICS FOR THE ENVIRONMENT 58–59 (1993); Camacho, *supra* note 53, at 38; Norman L. Christensen et al., *The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management*, 6 ECOLOGICAL APPLICATIONS 665, 669–70 (1996); Holly Doremus, *Data Gaps in Natural Resource Management: Sniffing for Leaks Along the Information Pipeline*, 83 IND. L.J. 407, 409 (2008); Grumbine, *supra* note 54, at 31 (monitoring is usually part of the definition of ecosystem management used by scholars and management agencies); Bradley C. Karkkainen, *Toward a Smarter NEPA: Monitoring and Managing Government's Environmental Performance*, 102 COLUM. L. REV. 903, 939–40, 966 (2002); Jan G. Laitos & Thomas A. Carr, *The Transformation on Public Lands*, 26 ECOLOGY L.Q. 140, 219–20 (1999). Charles Sabel and his coauthors also recognize the importance of monitoring for accountability under their "rolling rule" proposal. Sabel et al., *supra* note 57 (noting that in the "absence of rigorous monitoring" their proposal would "lead to self-deluding celebrations of expert powers" and a lack of political accountability).

67. Camacho, *supra* note 53, at 49; *accord* Holling & Meffe, *supra* note 53, at 332; Ruhl, *Taking Adaptive Management Seriously*, *supra* note 53, at 1264; *see* NAT'L RESEARCH COUNCIL, ADAPTIVE MANAGEMENT FOR WATER RESOURCES PROJECT PLANNING 26 (2004).

issue.[68] It has explored in some detail how public agencies might create stronger incentives for private parties to produce more environmental information (for compliance purposes),[69] and there has been some discussion of how environmental law might be structured to reduce the need for monitoring data.[70] But there has been little exploration of whether and how public agencies will undertake effective monitoring programs.[71]

---

68. C. S. Russell, *Monitoring, Enforcement, and the Choice of Environmental Policy Instruments*, 2 REG. & ENVTL. CHANGE 73 (2001) ("[A]ll too often the monitoring problem has been assumed away" in environmental law.). *But see* Dave Owen, *Probabilities, Planning Failures, and Environmental Law*, 84 TUL. L. REV. 265, 333 (2009) (noting possible problems with monitoring under adaptive management).

69. *See supra* note 30 and accompanying text.

70. *See, e.g.*, John S. Applegate & Robert L. Fischman, *Missing Information: The Scientific Data Gap in Conservation and Chemical Regulation*, 83 IND. L.J. 399, 400–01 (2008); Howard Latin, *Ideal Versus Real Regulatory Efficiency: Implementation of Uniform Standards and "Fine-Tuning" Regulatory Reforms*, 37 STAN. L. REV. 1267 (1985).

71. *See* Alejandro E. Camacho, *Beyond Conjecture: Learning About Ecosystem Management from the Glen Canyon Dam Experiment*, 8 NEV. L.J. 942, 953–54 (2008) (noting the "persistent failure of regulatory institutions to engage in systematic monitoring and assessment of regulatory programs" that is "all too often overlooked or neglected by both governmental regulators and scholars"); Holly Doremus, *Precaution, Science, and Learning While Doing in Natural Resource Management*, 82 WASH. L. REV. 547, 569 (2007) (noting that adaptive management as a term has "been used to emphasize the need to act while downplaying the role of learning," justifying management decisions "without any enforceable requirements for learning or incorporating new knowledge").

There are a few important exceptions in which scholars have examined the role that environmental law might play in structuring how agencies obtain information. Brad Karkkainen has shown how the NEPA does not create incentives to develop long-term information. Karkkainen, *supra* note 66, at 932; *see also* Buzbee, *supra* note 30, at 598–600 (exploring incentives for government agencies to collect ambient environmental information). Wendy Wagner has explored how administrative law and judicial review create an incentive for the production of too much information. Wendy E. Wagner, *Administrative Law, Filter Failure, and Information Capture*, 59 DUKE L.J. 1321, 1353–65, 1371 (2010). Holly Doremus notes the importance of changing institutional systems to make them more flexible to respond to changing information. *See generally* Doremus, *supra* note 53. *See also* Esty, *supra* note 30, at 142–49 (exploring how institutional structures might be relevant to the development of environmental information). Bruce Ackerman led a group of scholars who investigated the development of technical information to support water quality regulation along the Delaware River in the 1970s, although his research focused more on the modeling rather than on the data collection. BRUCE A. ACKERMAN ET AL., THE UNCERTAIN SEARCH FOR ENVIRONMENTAL QUALITY 9–16 (1974). There has been one study of "new environmental governance" in Australia that covered, among other issues, monitoring. Holley, *supra* note 33, at 178–84, 195–202 (finding serious problems with monitoring in a collaborative, neighborhood environmental program in Australia). While these are important beginning points for an analysis of how institutions might be relevant for environmental information policy, they do not closely examine how institutional structures and incentives, particularly

There are many existing federal and state environmental monitoring programs. Federal programs with national scope include the National Oceanic and Atmospheric Administration's (NOAA) programs focusing on ocean and coastal resources (such as its Center for Coastal Monitoring and Assessment),[72] the U.S. Forest Service's Forest Inventory and Analysis,[73] and FWS's National Wetlands Inventory.[74] There are also multiple federal monitoring programs that are regional or local, including the Glen Canyon Monitoring and Research Center (GCMRC), which monitors the effectiveness of the restoration of the Colorado River below Glen Canyon Dam,[75] and RECOVER, the monitoring and research program for the restoration effort in the Florida Everglades.[76] The U.S. Geological Survey (USGS) conducts perhaps the largest collection of environmental monitoring programs. It runs a range of national programs (such as a Status and Trends monitoring program for biological diversity)[77] and regional or local programs such as the GCMRC. At the state level, many states have their own substantial monitoring programs. Some are part of a larger state-federal "cooperative federalism" regulatory framework (such as state water-quality monitoring programs under the federal Clean Water Act);[78] others were developed by states on their own initiative, such as California's efforts to establish its own environmental indicators program[79] or the network of state "natural heritage" programs that

---

those of public institutions, might help or hinder the collection of environmental information.

72. *About Us: An Overview of COAST*, CENTER FOR COASTAL MONITORING & ASSESSMENT, http://ccma.nos.noaa.gov/about/coast/overview.aspx (last visited June 22, 2011).

73. *Forest Inventory and Analysis National Program*, USDA FOREST SERVICE, http://fia.fs.fed.us (last visited June 22, 2011).

74. *National Wetlands Inventory*, U.S. FISH & WILDLIFE SERVICE, http://www.fws.gov/nwi (last visited June 22, 2011).

75. *Grand Canyon Monitoring and Research Center*, U.S. GEOLOGICAL SURV., http://www.gcmrc.gov (last visited June 22, 2011).

76. *RECOVER: Restoration Coordination & Verification*, COMPREHENSIVE EVERGLADES RESTORATION PLAN, http://www.evergladesplan.org/pm/recover/recover.aspx (last visited June 22, 2011).

77. *Status and Trends of Biological Resources Program*, U.S. GEOLOGICAL SURV., http://biology.usgs.gov/status_trends (last visited June 22, 2011).

78. *See, e.g.*, 33 U.S.C. § 1315 (2006).

79. *See Environmental Protection Indicators for California*, OFFICE ENVTL. HEALTH HAZARD ASSESSMENT, http://www.oehha.ca.gov/multimedia/epic/index.html (last visited June 22, 2011).

provide data about rare and endangered species around the country.[80]

These existing monitoring programs collect a tremendous amount of information. But nonetheless, the consensus is that the remaining gaps are large,[81] whether it is information about the level of exposures to chemical risks for the public at large,[82] water quality,[83] wildlife,[84] rangeland health,[85] or forest health.[86] Current efforts by a leading environmental foundation to develop indicators on the quality of the environment in the United States have been limited by data gaps that prevent any assessment of about forty percent of

80. *See About Us*, NATURESERVE, http://www.natureserve.org/about Us/index.jsp (last visited June 22, 2011). NatureServe is a public-private partnership of (primarily public) "natural heritage" organizations in all fifty states that was created over the past fifteen to twenty years and has been very successful in creating a national monitoring and data management program for information about endangered species. *Id.*

81. U.S. GEN. ACCOUNTING OFFICE, GAO/OCG-99-17, MAJOR MANAGEMENT CHALLENGES AND PROGRAM RISKS: ENVIRONMENTAL PROTECTION AGENCY 15–16 (1999) (identifying major gaps in the EPA's environmental data); *see, e.g.*, Lori Snyder Bennear & Cary Coglianese, *Measuring Progress: Program Evaluation of Environmental Policies*, ENV'T, Mar. 2005, at 22, 32; Christensen et al., *supra* note 66, at 681; Robert L. Fischman, *The Divides of Environmental Law and the Problem of Harm in the Endangered Species Act*, 83 IND. L.J. 661 (2008); Robin O'Malley et al., *Closing the Environmental Data Gap*, ISSUES SCI. & TECH., Spring 2009, at 69; Wagner, *supra* note 30, at 1625–31.

82. Applegate, *supra* note 30, at 1380–83 (noting the lack of any toxicity information for over half of the 100 highest production chemicals).

83. U.S. GEN. ACCOUNTING OFFICE, GAO/RCED-00-54, WATER QUALITY: KEY EPA AND STATE DECISIONS LIMITED BY INCONSISTENT AND INCOMPLETE DATA 25–35 (2000) (detailing that much state water quality data is unreliable); Sidney A. Shapiro & Rena Steinzor, *Capture, Accountability, and Regulatory Metrics*, 86 TEX. L. REV. 1741, 1771 (2008) (citing EPA figures, which show that only nineteen percent of river and stream miles and thirty-seven percent of lake, pond, and reservoir acres have water quality assessments).

84. U.S. GEOLOGICAL SURVEY, U.S. DEP'T OF INTERIOR, STATUS AND TRENDS OF THE NATION'S BIOLOGICAL RESOURCES 4 (Michael J. Mac et. al. eds., 1998), *available at* http://www.nwrc.usgs.gov/sandt/SNT.pdf [hereinafter STATUS AND TRENDS] ("[T]he information available to describe the status and trends of many organisms is extremely limited."); *see also* O'Malley et al., *supra* note 81, at 72 ("[I]nformation on short-term population trends was available for only about half of the vertebrate species at risk of extinction and only about a quarter of invertebrates.").

85. SUSTAINABLE RANGELANDS ROUNDTABLE, CRITERIA AND INDICATORS FOR SUSTAINABLE RANGELANDS 9–10 (2009) (describing how the national effort to develop indicators of rangeland health ran into obstacles because of a lack of data); *see also id.* at app. 2-1 (providing an overview of proposed indicators for which data are lacking).

86. *See* U.S. FOREST SERV., NATIONAL REPORT ON SUSTAINABLE FORESTS 2010, at 2-140 to 2-143 (2008) (providing a table with an overview of data quality for indicators of forest health showing substantial numbers without good data).

proposed indicators and limit the quality of the assessment for many more.[87] These failures exist at both the federal[88] and the state levels.[89]

C. The Challenges of Effective Ambient Environmental Monitoring

The gaps in our ambient monitoring programs are not surprising considering the difficulty of effective ambient monitoring. That difficulty stems from the tremendous variability in environmental resources and the uncertainty of our knowledge about that variability. Environmental processes function at radically different rates and at "spatial and temporal scales covering several orders of magnitude," and variations are not linear, making extrapolation over time and space difficult.[90] Indeed, this complexity and uncertainty has been a major rationale for ecosystem and adaptive management.[91]

---

87. H. JOHN HEINZ III CTR. FOR SCI., ECON., & THE ENV'T, ENVIRONMENTAL INFORMATION: A ROAD MAP TO THE FUTURE 8 (2008) [hereinafter A ROAD MAP TO THE FUTURE]; *see also* H. JOHN HEINZ III CTR. FOR SCI, ECON., & THE ENV'T, FILLING THE GAPS: PRIORITY DATA NEEDS AND KEY MANAGEMENT CHALLENGES FOR NATIONAL REPORTING ON ECOSYSTEM CONDITION 13–14 & fig.1, 22, app. A (2006) [hereinafter FILLING THE GAPS]; H. JOHN HEINZ III CTR. FOR SCI., ECON., & THE ENV'T, HIGHLIGHTS, THE STATE OF THE NATION'S ECOSYSTEMS 2008, at 6–7 tbl.1 (2008).

88. *See supra* notes 85–86 (weaknesses in federal land management agency data).

89. *See supra* notes 1–3, 83 (failures in state water quality monitoring programs). The California Environmental Indicators program has released only one report since 2005, apparently a casualty of the state's budget crisis. *See Environmental Protection Indicators for California*, *supra* note 79 (listing reports provided by program, limited to a 2004 general report and 2005 update, and a 2009 report focused on climate change indicators); OFFICE OF ENVTL. HEALTH HAZARD ASSESSMENT, CAL. ENVTL. PROT. AGENCY, INDICATORS OF CLIMATE CHANGE IN CALIFORNIA (2009) (focusing on indicators that provide evidence of climate change and its impacts in California); CAL. RES. AGENCY, CAL. ENVTL. PROT. AGENCY, ENVIRONMENTAL PROTECTION INDICATORS FOR CALIFORNIA 2004 UPDATE add. 1, at 1 (2005), http://www.oehha.ca.gov/multimedia/epic/pdf/ADDENDUM-June2005complete.pdf (noting that fiscal constraints prevented the expansion of the program to cover needed indicators for which current data were insufficient).

90. Holling & Meffe, *supra* note 53, at 335.

91. Ruhl, *Taking Adaptive Management Seriously*, *supra* note 53, at 1260, 1263. *See generally* Ruhl, *Thinking of Environmental Law as a Complex Adaptive System*, *supra* note 53.

In this section, I talk about the monitoring of environmental resources, variables, or indicators. By resources, I mean the actual physical environmental qualities in which we are interested (e.g., how clean is the water, how plentiful is

Complexity and uncertainty mean that effective monitoring must be extended over considerable periods of time, that designing monitoring programs to effectively answer specific questions will be difficult and require significant expertise, and that monitoring will often be such a costly endeavor that managers and regulators might regularly rely on shortcuts. In this section, I develop all of these obstacles in detail; this provides a foundation for my analysis of the legal and institutional challenges that face agencies seeking to conduct effective monitoring.

1. Measurement over Time: Continuity and Longevity

A key part of monitoring, and a key challenge, is measuring variables over an extended period of time.[92] There are two aspects to this problem: continuity—how regularly measurements are made (i.e., whether there are gaps in the collection of measurements over time), and longevity—how long over time measurements are made (i.e., how many days, weeks, months, years, or decades the series of measurements covers).

Continuous monitoring is important because data gaps reduce the ability to assess the full scope of variability in environmental resources. Infrequent but significant events are often crucial to the status of environmental resources.[93] If, for

---

an endangered species). By variables, I mean the physical characteristics that we measure in order to evaluate the environmental resource (e.g., we might measure the levels of a particular toxic pollutant in order to understand how clean the water is). By indicators, I mean the measurement or analysis of variables that are intended to serve as a proxy for other environmental variables, often because those other variables are too expensive or difficult to measure directly.

92. Leslie M. Reid, *The Epidemiology of Monitoring*, 37 J. AM. WATER RESOURCES ASS'N 815, 817 (2001) (noting that one-quarter of flawed monitoring programs studied "were not of sufficient duration to answer the questions posed"); LEE, *supra* note 66, at 175 ("The most foreseeable risk to ecosystem management is that the overall picture of the system will be damaged by interruption of data collection as some measurements are discontinued and by loss of existing data."). For definitions of monitoring that emphasize the temporal aspect, see, for example, T. Brydges, *Basic Concepts and Applications of Environmental Monitoring*, *in* ENVIRONMENTAL MONITORING 83, 84 (G. Bruce Wiersma ed., 2004); SPELLERBERG, *supra* note 42, at 2; CARYL L. ELZINGA ET AL., MONITORING PLANT AND ANIMAL POPULATIONS 2 (2001); Martin Kent, Book Note, *The Enigma of Ecosystem and Conservation Monitoring*, 30 J. BIOGEOGRAPHY 312, 313 (2003).

93. *See* Craig E. Williamson et al., *Lakes and Streams as Sentinels of Environmental Change in Terrestrial and Atmospheric Processes*, 6 FRONTIERS ECOLOGY & ENV'T 247, 248 (2008); *see also* Gary E. Davis, *Design Elements of Monitoring Programs: The Necessary Ingredients for Success*, 26 ENVTL.

example, one collects data over a twenty-year period, but with one year of that data missing, one might lose the ability to assess the frequency and intensity of events that could occur less frequently than every twenty years—and the missing data might be the one year when that rare event occurred. The higher, the more unpredictable, and the more unknown the variability of the system, the more important continuous data collection will be. Moreover, data may be missing for a reason, biasing the results of the monitoring program.[94] And because there is always something special or unique about any given individual time period, critics can use missing data to challenge the quality of the monitoring data and any management recommendations based on that data.

Continuity refers not just to the actual taking of measurements but also to making sure that data collection protocols are consistent over time (or at least compatible), so that data can be analyzed over the entire time period of the monitoring program.[95] Changes in monitoring methodologies can make it impossible to draw comparisons of data over time.

MONITORING & ASSESSMENT 99, 100–01 (1993); Jerry F. Franklin et al., *Contributions of the Long-Term Ecological Research Program*, 40 BIOSCIENCE 509, 509 (1990) (noting the importance of "infrequent (rare or episodic) events, including such disturbances as floods, hurricanes, wildfires, or volcanic eruptions" in ecology and that "[l]ong-term studies are essential to understand[ing] such phenomena"); Jerry F. Franklin, *Importance and Justification of Long-Term Studies in Ecology*, *in* LONG-TERM STUDIES IN ECOLOGY: APPROACHES AND ALTERNATIVES 3, 5–6 (Gene E. Likens ed., 1989); L. Roy Taylor, *Objective and Experiment in Long-Term Research*, *in* LONG-TERM STUDIES IN ECOLOGY: APPROACHES AND ALTERNATIVES, *supra*.

94. For instance, flood gauge data might be missing because a particularly large flood event destroyed the gauges, creating bias that systematically underestimates the importance and likelihood of large flood events. Lance H. Gunderson, *Foreword, Learning to Monitoring or Monitoring to Learn?*, *in* MONITORING ECOSYSTEMS: INTERDISCIPLINARY APPROACHES FOR EVALUATING ECOREGIONAL INITIATIVES xi, xiii (David E. Busch & Joel C. Trexler eds., 2003) ("[C]ases when monitoring was eliminated because of budget restrictions have proved to be ecologically critical years. It was during these critical periods when the system underwent a major transformation, yet those years became missing points on time-series plots."); NAT'L RESEARCH COUNCIL, A BIOLOGICAL SURVEY FOR THE NATION 8 (1993); *see also, e.g.*, Donald B. Rubin, *Inference and Missing Data*, 63 BIOMETRIKA 581, 581 (1976) (ignoring the processes that cause missing data is only appropriate if those processes are random).

95. SPELLERBERG, *supra* note 42, at 231; Michael B. Usher, *Scientific Requirements of a Monitoring Programme*, *in* MONITORING FOR CONSERVATION AND ECOLOGY 15, 27 (Barrie Goldsmith ed., 1991); Paul L. Ringold et al., *Design of an Ecological Monitoring Strategy for the Forest Plan in the Pacific Northwest*, *in* MONITORING ECOSYSTEMS, *supra* note 94, at 73, 82–83.

Longevity is important for several reasons. Many environmental resources change at a slow rate,[96] and if trends are subtle, then significant time may be needed to identify the trend.[97] It can be extremely time-consuming to identify declines in the populations of wildlife species, where even the sharpest declines are often measured by just a few percentage points annually.[98]

Long-term monitoring is also important for understanding whether changes in a set of variables or indicators are the product of an underlying change in the resource instead of temporary fluctuations, a particularly important issue given the high and uncertain variability of most environmental resources.[99] Without long-term data, it may be impossible to separate year-to-year variations from long-term trends that are of greater management interest.[100] For instance, measures of atmospheric levels of carbon dioxide had to continue for several years before seasonal patterns of changes could be detected and an overall increase in carbon dioxide levels over time could be differentiated from those seasonal patterns.[101] Satellite measurements of global environmental variables often require decades to identify long-term cycles and distinguish those cycles from potentially human-caused impacts due to increases

96. SPELLERBERG, *supra* note 42, at 22; Franklin, *supra* note 93, at 4; Gene E. Likens, *Preface*, *in* LONG-TERM STUDIES IN ECOLOGY: APPROACHES AND ALTERNATIVES ix, x–xi (Gene E. Likens ed., 1989).

97. *See* DAVID STRAYER ET AL., LONG-TERM ECOLOGICAL STUDIES: AN ILLUSTRATED ACCOUNT OF THEIR DESIGN, OPERATION, AND IMPORTANCE TO ECOLOGY 7–8 (1986); Franklin et al., *supra* note 93, at 509; A. Wolfe et al., *Long-Term Biological Data Sets: Their Role in Research, Monitoring, and Management of Estuarine and Coastal Marine Systems*, 10 ESTAURIES 181, 183 (1987) ("Long-term data sets are essential for field verification when subtle changes or long-term effects are involved.").

98. Teresa Woods & Steve Morey, *Uncertainty and the Endangered Species Act*, 83 IND. L.J. 529, 532 (2008).

99. NAT'L RESEARCH COUNCIL, A BIOLOGICAL SURVEY FOR THE NATION 4 (1993); SPELLERBERG, *supra* note 42, at 22; Brydges, *supra* note 92, at 84; Hellawell, *supra* note 42, at 13, 13 fig.1.6; Wolfe et al., *supra* note 97, at 185–86; Kent, *supra* note 92, at 313 (noting the challenge for monitoring of "isolating human impact/management effects from underlying 'natural' variability in species populations and environmental variables").

100. According to one study, about five years are required to develop a reasonable estimate of the variance of an ecological variable. *See* Timothy K. Kratz et al., *Temporal and Spatial Variability as Neglected Ecosystem Properties: Lessons Learned from 12 North American Ecosystems*, *in* EVALUATING AND MONITORING THE HEALTH OF LARGE-SCALE ECOSYSTEMS 359, 367 (David J. Rapport et al. eds., 1995).

101. Charles D. Keeling, *Rewards and Penalties of Monitoring the Earth*, 23 ANN. REV. ENERGY ENV'T 25, 39–42, 47 (1998).

in global temperatures.[102] Other examples abound, such as ice records on lakes that extend 130 years, providing evidence of general warming trends that are otherwise invisible.[103]

In addition, understanding causal linkages often requires data collection over long periods of time. For instance, long-term data can reveal the response of environmental resources to infrequent disturbances, allowing a determination of not just whether changes are occurring, but also why.[104]

Finally, monitoring may need to be long-term simply because it takes time for the relevant data to accumulate: Salmon runs occur at most a few times a year, and so obtaining significant data may require many years of observation;[105] collecting adequate data on the presence of an endangered bat species near a proposed wind farm in West Virginia required three years of surveys.[106] And just as with continuous monitoring, one might need long-term monitoring to respond to political arguments that the data do not extend long enough to cover the full range of variability for a resource. [107]

---

102. NAT'L RESEARCH COUNCIL, EARTH SCIENCE AND APPLICATIONS FROM SPACE: NATIONAL IMPERATIVES FOR THE NEXT DECADE AND BEYOND 62–66 (2007); NAT'L RESEARCH COUNCIL, OPTIONS TO ENSURE THE CLIMATE RECORD FROM NPOESS AND GOES-R SPACECRAFT 2–3, 18–20 (2008).

103. John J. Magnuson, *Long-Term Ecological Research and the Invisible Present*, 40 BIOSCIENCE 495, 495 (1990).

104. SPELLERBERG, *supra* note 42, at 22; Brydges, *supra* note 92, at 88 (noting the importance of long term, multimedia "integrated monitoring" for identification of both "what changes are occurring and why they are happening"); Magnuson, *supra* note 103, at 497–98.

105. Kai Lee, *Appraising Adaptive Management*, 3 CONSERVATION ECOLOGY 3 (1999) ("Most natural indicators yield one data point a year; even a simple trend takes patience . . . ."); *see also* Ray Hilborn, *Can Fisheries Agencies Learn from Experience?*, 17 FISHERIES 6, 8–10 (1992).

106. *See* Animal Welfare Inst. v. Beech Ridge Energy LLC, 675 F. Supp. 2d 540 (D. Md. 2009).

107. "Long-term" can mean significant periods of time, extending to decades or longer. Brydges, *supra* note 92, at 88. A leading reference in the field recommends at least five years of data to detect trends in plant and animal populations. ELZINGA ET AL., *supra* note 92, at 191. "[D]ata for reporting on change in carbon . . . in forest soils, forest floors, and down woody debris" will take about ten years to result in "adequate data to report changes." FILLING THE GAPS, *supra* note 87, at 77; NAT'L RESEARCH COUNCIL, DOWNSTREAM: ADAPTIVE MANAGEMENT OF GLEN CANYON DAM AND THE COLORADO RIVER ECOSYSTEMS 45 (1999) (noting the need for "decades of data collection" to understand the "multidecadal life span and population dynamics" of long-lived fish species); Scott A. Hatch, *Statistical Power for Detecting Trends with Applications to Seabird Monitoring*, 111 BIOLOGICAL CONSERVATION 217 (2003) (reporting that to identify declines in wildlife populations, monitoring programs may have to operate from eleven to sixty-nine years); Gene E. Likens, *A Priority for Ecological Research*, 64 BULL. ECOLOGICAL SOC'Y AM. 234, 234–39 (1983).

2. Designing Monitoring Programs to Answer the Relevant Questions

Effective monitoring requires collecting enough of the right kind of data to answer effectively the questions the monitoring program was established to address.[108] There are at least three important issues here: measuring the right variables, measuring those variables at the right scale, and measuring those variables at sufficient levels.

First, a monitoring program may measure variables that are not actually connected to the underlying resources that are of management interest.[109] Choosing wrong or misleading variables or indicators can cause serious management problems if it leads the agency to ignore important environmental problems that are not adequately represented in its measurements.[110] For instance, wetlands managers and regulators have been criticized for overemphasizing a simplistic focus on total acreage of wetlands available instead of considering the quality of the wetlands being protected or restored.[111]

Second, if an environmental resource varies at a different scale from the monitoring program (larger or smaller geographically, or shorter or longer temporally), then monitoring will be ineffective.[112] A mismatch in scale can drown any signal with large variability in the monitoring data, greatly undermining the effectiveness of the monitoring program. It can also cause the reverse problem, where the monitoring program is unable to detect important variations that are happening at a finer resolution than the scale of the monitoring program.

---

108. Reid, *supra* note 92, at 815 (finding that thirty percent of flawed monitoring programs studied could not provide the kind of information that "was needed to meet the project objectives").

109. Barry R. Noon, *Conceptual Issues in Monitoring Ecological Resources*, *in* MONITORING ECOSYSTEMS, *supra* note 94, at 27, 42–43.

110. *See generally* ACKERMAN ET AL., *supra* note 71 (noting how the existence of data on biological oxygen demand in the Delaware River caused policymakers and technocrats to focus on that variable to the exclusion of other, possibly more relevant variables such as turbidity).

111. *See* Lisa Dale & Andrea K. Gerlak, *It's All in the Numbers: Acreage Tallies and Environmental Program Evaluation*, 39 ENV'T MGMT. 246 (2007).

112. *See* Hellawell, *supra* note 42, at 9–13; Usher, *supra* note 95, at 18–19; Noon, *supra* note 109, at 50, 60–61; Robert J. Livingston, *Field Sampling in Estuaries: The Relationship of Scale to Variability*, 10 ESTUARIES 193 (1987); NAT'L RESEARCH COUNCIL, ECOLOGICAL INDICATORS FOR THE NATION 153–54 (2000); DOWNES ET AL., *supra* note 44, at 197–248.

For instance, if a resource only varies at a global scale and at a pace of months or years (such as concentrations of carbon dioxide in the atmosphere), more frequent measurements or many local measurement stations will be a waste of resources. On the other hand, if a resource varies at a level of meters and at a pace of days or even hours, then infrequent measurements or highly dispersed measurement stations will be highly misleading. Matching scale is particularly difficult because the appropriate scale will vary depending on the resource being monitored and the questions being asked.[113] A study of the same resource but asking different questions (e.g., how does water quality in a small urban stream change after large rain events, compared to understanding whether the average water quality has gotten consistently worse in that urban waterway) will require very different scales for monitoring.[114] The problem is further complicated by a common trade-off between frequent temporal coverage and widespread geographic coverage—in other words, it will usually be prohibitively expensive to conduct over the same area and time frame many more frequent measurements at many closely spaced monitoring stations.[115] For some variables with high spatial and temporal variability, "which include many of the critical environmental conditions," good information "is almost never available" to help understand status and trends of environmental conditions.[116]

One example of the problem of scale is demonstrated by temporary releases of hazardous air pollutants by industrial facilities (often from equipment malfunctions) that adjoin residential neighborhoods—releases that are a major health risk.[117] Initial identification of these harms can be done most effectively through the use of mobile monitoring stations, rather than long-term, fixed monitoring sites, which are often

113. STATUS AND TRENDS, *supra* note 84, at 5 (noting how the scale for monitoring can vary tremendously from one wildlife species to another); ENVTL. MONITORING TEAM, NAT'L SCI. & TECH. COUNCIL, INTEGRATING THE NATION'S ENVIRONMENTAL MONITORING AND RESEARCH NETWORKS AND PROGRAMS: A PROPOSED FRAMEWORK 35 (1997) ("Environmental issues that must be addressed by [monitoring] inevitably will have different properties of spatial and temporal variability and, thus, require different sampling designs.").

114. *See generally* Wagner, *supra* note 34.

115. ENVTL. MONITORING TEAM, *supra* note 113, at 5–6.

116. *Id.*

117. *See* Thomas O. McGarity, *Hazardous Air Pollutants, Migrating Hot Spots, and the Prospect of Data-Driven Regulation of Complex Industrial Complexes*, 86 TEX. L. REV. 1445, 1452 (2008).

ineffective because sample collection is infrequent in time and space.[118] Likewise, beach water-quality measurement programs are often only conducted weekly—even though water quality can vary tremendously over a few hours in response to rain storms.[119] The lack of frequent testing means that spikes in water pollution that might adversely affect swimmers can go undetected. And the Chesapeake Bay restoration program has been conducting water-quality monitoring for decades on the aggregate level of the principal pollutants entering the Bay from the major watersheds (such as the total level of pollutants entering from the Potomac River watershed).[120] The problem is that this monitoring program was unable to pinpoint where major pollution sources were located within a large watershed, nor was it able to identify the effectiveness of various management or regulatory efforts within a watershed (e.g., the effectiveness of efforts to control pollution from farms along a particular tributary to the Potomac River).[121] Yet it is the second set of data that is essential to the pursuit of adaptive management, since it will inform decision makers about the utility of various management or regulatory strategies.[122]

Because of the interaction of technical and budgetary limitations, the nature of the research or management question being asked, and the variability of the resource being

118. *See id.* at 1479 (noting that the stationary monitor for air pollution only collects data every sixth day); Dara O'Rourke & Gregg P. Macey, *Community Environmental Policing: Assessing New Strategies of Public Participation in Environmental Regulation*, 22 J. POL'Y ANALYSIS & MGMT., 383, 383–84, 395 (2003).

119. *See* sources cited *supra* note 8.

120. *See* HOWARD R. ERNST, CHESAPEAKE BAY BLUES: SCIENCE, POLITICS, AND THE STRUGGLE TO SAVE THE BAY 134–36 (2003). *See generally* CHESAPEAKE BAY PROGRAM SCIENTIFIC & TECHNICAL ADVISORY COMM. & CHESAPEAKE BAY PROGRAM WATERSHED PARTNERS SENIOR MANAGERS, DEVELOPMENT AND IMPLEMENTATION OF A PROCESS FOR ESTABLISHING CHESAPEAKE BAY PROGRAM'S MONITORING PROGRAM PRIORITIES AND OBJECTIVES (2009); TASK FORCE ON ANALYSIS OF NON-TIDAL WATER QUALITY MODELING RESULTS, SCIENTIFIC & TECHNICAL ADVISORY COMM. OF THE CHESAPEAKE BAY PROGRAM, ASSESSING PROGRESS AND EFFECTIVENESS THROUGH MONITORING RIVERS AND STREAMS (2005) [hereinafter ASSESSING PROGRESS AND EFFECTIVENESS]; TASK FORCE ON NON-TIDAL WATER QUALITY MONITORING NETWORK DESIGN, SCIENTIFIC & TECHNICAL ADVISORY COMM. OF THE CHESAPEAKE BAY PROGRAM, RECOMMENDATIONS FOR REFINEMENT OF A SPATIALLY REPRESENTATIVE NON-TIDAL WATER QUALITY MONITORING NETWORK FOR THE CHESAPEAKE BAY WATERSHED (2005).

121. *See* sources cited *supra* note 120.

122. *See* ASSESSING PROGRESS AND EFFECTIVENESS, *supra* note 120, at 17–19; sources cited *supra* note 120.

measured, the question of the appropriate scale for measurement of a resource is typically extremely difficult to answer. Moreover, because of the tremendous uncertainty about the variability of many environmental resources, answering these questions will involve high levels of uncertainty as well. As a result, it will be extremely difficult for outsiders not steeped in the details of any one monitoring program to assess its validity on this point.

The third problem is that many monitoring programs require the identification of a statistically significant difference or correlation in order to justify management changes.[123] However, if the monitoring program is not collecting enough data to be able to detect statistically significant differences at a level that is important for the management program (i.e., if the resolution of the monitoring program is too low), the monitoring program will be ineffective.[124] For instance, Congress required NOAA to determine whether a certain form of tuna fishing was harming dolphin populations.[125] The study that NOAA developed did not examine enough dolphins in order to obtain results that could answer the congressionally mandated questions.[126] This problem is also highly technical because for many resources we do not know the resource's full range of variability—a necessary precondition for a determination of how many measurements are needed to reduce uncertainty to an acceptable level. And again, because these questions require detailed understanding of the monitoring program, statistics, and the resource, it will be

123. ELZINGA ET AL., *supra* note 92, at 186 (noting general practice for trend detection is that if a regression does not find a slope that is statistically significant from zero, "then a population is assumed to be stable"); Doremus, *supra* note 53, at 74 (noting that the plan required monitoring to show a "statistically significant shortfall between performance expectations and actual results" to trigger mandatory management changes); James D. Nichols & Byron K. Williams, *Monitoring for Conservation*, 21 TRENDS ECOLOGY & EVOLUTION 668, 670 (2006) (noting that in general practice "population declines are identified by means of a statistical test of a null hypothesis of no decline versus a decline" triggering a decision to change management or conduct more intense monitoring).

124. ELZINGA ET AL., *supra* note 92, at 265–70; SPELLERBERG, *supra* note 42, at 234; Nichols & Williams, *supra* note 123, at 670–71; Noon, *supra* note 109, at 43–44; Usher, *supra* note 95, at 16–18.

125. *See* Earth Island Inst. v. Hogarth, 494 F.3d 757, 760 (9th Cir. 2007).

126. *Id.* at 764–65 ("The NOAA determined that a minimum sample size of 300 dolphins per species was necessary to make scientifically valid conclusions regarding fishery-related effects. . . . Instead, the NOAA studied a meager total of 56 dolphins . . . .").

difficult for outsiders to evaluate the quality of monitoring programs.

3. The Costliness of Monitoring, and Its Implications

Given all of the above, it is not surprising that effective monitoring is costly.[127] Monitoring the restoration of a riparian habitat in one small creek costs "as much as actual construction of the habitat improvements and [requires] three years of data for statistically reliable confirmation."[128] The most recent, best estimate of how much money we spend on monitoring is about $600 million a year at the federal level alone.[129] Often, expensive monitoring only produces a limited amount of data of limited utility.[130] The high cost of monitoring raises two obvious questions: Are there ways to reduce the costs? And how much do we really need to spend on monitoring?

a. Lowering the Cost of Monitoring

One option to address the high cost of monitoring might be technological advances, such as remote sensing of resources from satellites that can reduce the cost of monitoring; however, they are no panacea. For instance, satellite monitoring often requires significant measurements on the ground ("ground-truthing") to ensure accuracy, and a wide range of important resources and variables are not amenable to satellite monitoring.[131] But even a significant reduction in the cost of monitoring still will not eliminate the challenges of monitoring: One cannot monitor everything everywhere, so managers and regulators have to make choices about when to measure, how to measure, and what to measure. Even for low-cost monitoring

127. Doremus, *supra* note 66, at 447–49; Kai N. Lee & Jody Lawrence, *Adaptive Management: Learning from the Columbia River Basin Fish and Wildlife Program*, 16 ENVTL. L. 431, 455 (1986) ("[M]onitoring and evaluation can cost substantially more than all the rest of the implementation process."); Volkman & McConnaha, *supra* note 59, at 1261.

128. Lee & Lawrence, *supra* note 127, at 447.

129. A ROAD MAP TO THE FUTURE, *supra* note 87, at 18 n.3.

130. Kai N. Lee, *Deliberately Seeking Sustainability in the Columbia River Basin*, *in* BARRIERS AND BRIDGES TO THE RENEWAL OF ECOSYSTEMS AND INSTITUTIONS 214, 224–26 (Lance H. Gunderson et al. eds., 1995).

131. *See* NAT'L RESEARCH COUNCIL, ECOLOGICAL INDICATORS FOR THE NATION 60 (2000). See Esty, *supra* note 30, at 158–67, for a thorough overview of the possibilities that new technology might create for monitoring.

systems, continuity will be important, and the choices about when, how, and what to measure will be technical and often opaque to non-experts, contributing to the obstacles I develop in Part II.

There is also a range of analytic tools that can reduce the costs of monitoring. Variables used to measure one resource can be used as indicators to estimate the values of another resource that is more expensive or difficult to monitor ("proxies").[132] Models can reduce the need for monitoring data by allowing the extrapolation of results from one place or time to another.[133] Both proxies and models are widely used in environmental decision-making because of the "logistical and financial constraints associated with not being able to measur[e] everything everywhere."[134] But both proxies and scientific models are built upon assumptions, which are often based on value judgments and therefore tend to be contested.[135] The technical and complicated nature of many models makes it easy for an analyst to hide important assumptions from outside observers.[136]

b. The Inherently Political Question of How Much Monitoring Is Enough

The high cost of monitoring raises the question of how to prioritize among various monitoring programs and how to ensure that monitoring is cost-effective.[137] Answering these

132. Robert L. Glicksman, *Bridging Data Gaps Through Modeling and Evaluation of Surrogates: Use of the Best Available Science to Protect Biodiversity Under the National Forest Management Act*, 83 IND. L.J. 465, 467 (2008).

133. *See id.* at 474–79; *see also* DOWNES ET AL., *supra* note 44, at 164–94 (describing the range of models relevant for monitoring).

134. ENVTL. MONITORING TEAM, *supra* note 113, at 17.

135. James D. Fine & Dave Owen, *Technocracy and Democracy: Conflicts Between Models and Participation in Environmental Law and Planning*, 56 HASTINGS L.J. 901, 922–24, 926–29 (2005); Glicksman, *supra* note 132, at 467, 480–81; Thomas O. McGarity & Wendy E. Wagner, *Legal Aspects of the Regulatory Use of Environmental Modeling*, 33 ENVTL. L. REP. 10751 (2003); Wendy Wagner et al., *Misunderstanding Models in Environmental and Public Health Regulation*, 18 N.Y.U. ENVTL. L.J. 293, 295, 304 (2010).

136. Fine & Owen, *supra* note 135, at 926, 932; Glicksman, *supra* note 132, at 481–82 (discussing claims that natural resource management agencies, "intentionally or not, have masked their value judgments in the language of technical determinations," making it extremely difficult for outsiders to effectively judge how the agency is using the available data and the extent to which assumptions and the value judgments underlying those judgments affect the agency's decision); *see generally* Wagner et al., *supra* note 135.

137. *See* Doremus, *supra* note 66, at 447–51.

questions requires an understanding of how effectively our existing monitoring programs are functioning and how effectively any new investments will pay off.

But that understanding in turn requires significant time and expertise to obtain estimates that will still be highly uncertain. Because monitoring programs are extremely opaque for outsiders to assess, assessments of how much to monitor are very difficult. This raises an "infinite regress" problem—if monitoring is hard to assess, then monitoring of monitoring is therefore also hard to assess, and so on.

That does not mean we cannot draw any conclusions whatsoever about monitoring. It is relatively easy to determine when you have no monitoring data *at all*, and as noted earlier, that is all too frequent in environmental policy making today in the United States. The challenge is assessing, once a monitoring program is in place, whether it is providing effective answers to the relevant regulatory and management questions or whether it is (by design or by accident) providing the illusion of monitoring.[138]

The questions of how much and how well to monitor are therefore probably not questions that easily or readily lend themselves to fine-grained assessments. Instead, we will often have to rely on relatively crude assessments on the nature, quality, and worth of our monitoring programs. One shortcut is to ignore the "technical" questions of the statistical power, scale, and frequency of monitoring data collection and instead focus on the institutional and legal structures that implement a monitoring program. If we trust those structures to create positive incentives for effective monitoring, then we might have much more confidence that the outputs of our monitoring program are indeed effective.[139] Legal scholars have highlighted the importance of trust in making environmental programs operate effectively, in part because of the tremendous uncertainties that permeate decision-making in environmental law and policy.[140] The opacity of assessing whether monitoring

138. The effectiveness of monitoring can be seen as an extreme example of the hard-to-measure outputs of public agencies, a characteristic that has significant implications for how public agency management functions. *See infra* Part II.B.

139. *See* Rebecca M. Bratspies, *Regulatory Trust*, 51 ARIZ. L. REV. 575, 594, 603–05, 619 (2009).

140. *See id.* at 601 ("[U]ncertainty is a hallmark of situations requiring trust."); Richard J. Lazarus, *The Tragedy of Distrust in the Implementation of Federal Environmental Law*, 54 LAW & CONTEMP. PROBS. 311 (1991).

programs are effective or not also creates significant uncertainty, and thus a need to establish trust.

The importance of establishing trust for monitoring programs means that monitoring is inherently a political question.[141] Yet monitoring is often seen as one of the most technical and non-political parts of the implementation of environmental law—the monitoring literature almost exclusively focuses on technical questions, such as which variables best reflect changes in the resources of interest.[142] The assumption that monitoring is a technical, apolitical question probably also explains why so much of the existing environmental law and policy literature has elided the political, institutional, and legal obstacles to effective monitoring and instead assumed that monitoring will occur as a matter of course, at least for public agencies. But identifying those obstacles to trust is key to solving environmental law's monitoring problem.

II. OBSTACLES TO AGENCY MONITORING

Environmental monitoring requires continuity, consistency and significant expertise and effort to be successful. These characteristics create two main legal or institutional challenges for the achievement of effective environmental monitoring: the need for institutional continuity, and the relative opacity of assessing whether monitoring is effective. These challenges produce significant constraints on the public agencies seeking to conduct effective environmental monitoring.[143]

The need for continuity in monitoring leads to two major problems: myopic legislatures and agencies that cut monitoring

141. *See* SAMUEL P. HAYS, EXPLORATIONS IN ENVIRONMENTAL HISTORY 54–55 (1998) ("If the agency believes that it can work out a monitoring system by itself based upon a 'scientific' determination of the inherent qualities of the [resource] that will resolve disputes, then I think that it is sorely mistaken.").

142. *See, e.g.*, SAYRE ET AL., *supra* note 58.

143. Of course, there are many reasons why agencies might want to conduct monitoring. Monitoring may be seen as providing crucial information that is relevant for the agency's accomplishment of a necessary task. For instance, engineers constructing a dam may want a good sense of the variability of water flows in a river system so that they can properly design the dam and its storage capacity to handle flood events. Policymakers may be genuinely interested in determining whether environmental conditions are improving, declining, or stable to make decisions about whether and how to change environmental policy. Scientists may be genuinely interested in obtaining long-term information about a resource in order to investigate its characteristics and gain new information.

budgets in order to fund activities with more short-term payoffs; and the long-term nature of monitoring makes it unappealing professionally for the agency scientists who are often key figures in monitoring programs.

Likewise, opacity leads to two main problems: the difficulty of evaluating whether monitoring is effective leads agencies to underinvest in environmental monitoring in comparison to other activities that are more easily assessed; and the difficulty of evaluating monitoring data is one of the factors that leads courts to grant significant deference to agencies in judicial review, reducing the incentives for agencies to collect additional data.

And both continuity and opacity combine to cause two problems: together they make the political dynamics very difficult for monitoring because both factors produce significant advantages for regulated industry in overseeing the implementation of monitoring programs by environmental agencies; and both factors create uncertainty for agencies as to the results of monitoring, creating risks for the institutional autonomy that agencies value.

For purposes of this Part's analysis, these problems are split into two overarching categories: those that are the result of external constraints on the agency; and those that are the result of internal forces within the agency.

A. External Constraints on Agency Monitoring Programs

Actors external to the agency—Congress, the President, interest groups, the media, the public, or the courts—might constrain an agency's ability or willingness to develop and maintain an effective monitoring program in a variety of ways.

1. Political Constraints

The National Biological Survey (NBS) was intended to provide early warnings about declining species or ecosystems.[144] It was created through the transfer of scientists from other existing agencies within the Department of the Interior to a new, stand-alone research agency within the

144. Richard Stone, *Babbitt Shakes Up Science at Interior*, 261 SCI. 967, 967 (1993).

department.[145] The goal was to "distance the science from the political fray that is sometimes associated with contentious regulatory issues."[146]

But the proposal simply fanned political flames. Conservative fears over potential impacts of the NBS on property rights forced the new agency's disappearance as a separate entity.[147] NBS's personnel were merged into the USGS, forming the new Biological Resources Division.[148] With NBS "hidden" in USGS, the political controversy died down—and USGS has continued to develop monitoring programs for biological research.[149]

As the NBS example shows, information is political, and therefore politics influences the collection and dissemination of information.[150] The politics of environmental law are fundamentally influenced by the differential organizational capacities of those who benefit and those who pay for most environmental regulation. The costs of most environmental regulation tend to fall heaviest on a relatively small group of individuals or corporations, whereas the benefits of environmental regulation, usually a public good, tend to be spread widely among a large number of individuals, often the entire public.[151] Because the benefits are so dispersed, the challenges of organizing individuals to lobby for stronger environmental regulation are significantly harder compared to the opponents of stronger regulation.[152] Of course, lobbying for

145. *Id.*; Establishment of the National Biological Survey, 58 Fed. Reg. 63,387 (Dec. 1, 1993) (secretarial order creating NBS).

146. H. Ronald Pulliam, *The Political Education of a Biologist: Part II*, 26 WILDLIFE SOC'Y BULL. 499, 499 (1998).

147. Critics asserted that the information gathered by NBS would be used to justify a massive expansion of land-use regulation by the federal government under the ESA. Stone, *supra* note 144; Frederic H. Wagner, *Whatever Happened to the National Biological Survey?*, 49 BIOSCIENCE 219, 220 (1999). *See also* Pulliam, *supra* note 146, at 499–501 (describing campaign by property rights groups to eliminate NBS and quoting a property-rights activist who wrote that "[politicians] can use the information provided by [NBS] to control and regulate people.").

148. Colin Macilwain, *US Geological Survey Picks up the NBS Pieces*, 382 NATURE 658, 658 (1996); Wagner, *supra* note 147, at 220.

149. Pulliam, *supra* note 146, at 502.

150. Wagner, *supra* note 30, at 1641 ("Actors will invest as much in obstructing research as they expect to lose if the information is made publicly available.").

151. *See* Steven P. Croley, *Public Interested Regulation*, 28 FLA. ST. U. L. REV. 7, 35–38 (2000); Matthew D. Zinn, *Policing Environmental Regulatory Enforcement: Cooperation, Capture, and Citizen Suits*, 21 STAN. ENVTL. L.J. 81, 126–31 (2002).

152. Biber, *supra* note 47, at 43.

stronger environmental regulation will sometimes succeed, as shown by the passage of numerous environmental statutes.[153] But it does mean that those that seek to benefit from environmental regulation will often be at a political disadvantage compared to those that pay the costs.[154] That disadvantage may be easier to overcome in the push to enact high-profile and short-term legislation because the beneficiaries of regulation may be able to rally around significant events, such as environmental crises.[155] But the imbalance is more stubborn in the context of lower-profile, ongoing activities such as the implementation of environmental statutes by agencies.[156]

Monitoring can be seen as the ultimate example of low-profile implementation of environmental law.[157] While it may be relatively easy to determine whether monitoring is taking place at all (e.g., has an agency even issued a report?), it is often extremely difficult for non-experts (and even experts) to determine whether an existing monitoring program is effective. For the Chesapeake Bay restoration effort, it took years to determine that there were gaps between the models used to evaluate the program and the monitoring data, or that the monitoring data was not providing an adequate evaluation of the effectiveness of management techniques.[158]

Moreover, because good monitoring programs depend on continuity, outside parties need to conduct expert and *ongoing* supervision of agency monitoring programs—an even more demanding task. And because most environmental statutes place the burden of demonstrating the need for additional regulation on the agency, the lack of effective monitoring will usually benefit regulated industry.[159] In short, monitoring is

153. Christopher C. DeMuth & Douglas H. Ginsburg, *Rationalism in Regulation*, 108 MICH. L. REV. 877, 910 (2010); Biber, *supra* note 47, at 41–42 n.141.

154. *See* Biber, *supra* note 47, at 40–49.

155. *See* Anthony Downs, *Up and Down with Ecology—The "Issue-Attention" Cycle*, 28 PUB. INT. 38 (1972); Daniel A. Farber, *Politics and Procedure in Environmental Law*, 8 J.L. ECON. & ORG. 59, 66–67 (1992).

156. *See* Biber, *supra* note 47, at 42–44.

157. *See id.* at 45–46.

158. *See* sources cited *supra* note 120.

159. Wendy E. Wagner, *Congress, Science, and Environmental Policy*, 1999 U. ILL. L. REV. 181, 229–31.

uniquely vulnerable to the "slippage" often present in the implementation of environmental law.[160]

For instance, the fight against the NBS was part of a campaign led by organizations, such as the American Farm Bureau and the National Cattlemen's Association, that represented industries that bore some of the regulatory costs under the ESA; these organizations might not have succeeded in changing the language of the ESA itself, but they were much more successful in eliminating data collection by the NBS that would have supported ESA implementation.[161] The Fish Passage Center (a small agency that monitored Pacific Northwest salmon populations) was targeted by a senator who considered a staff memo that supported court-ordered changes to dam management as "political advocacy"; the senator, who represented Idaho (where industry benefitted from the dams), tried to eliminate the agency through an appropriations rider, although in the end a federal appeals court concluded that the agency could continue operations.[162]

Politics will not always cut against the development and implementation of monitoring programs; in fact, it might inspire them. First, as noted earlier, monitoring might either be used to justify increased regulation or decreased regulation: There might be a range of situations where the parties subject to regulation might support monitoring because it might lead to lighter regulation.[163] Second, an agency might seek monitoring information in order to provide it with political support to accomplish a key agency goal. When the U.S. Forest Service sought to reduce grazing on its lands by politically powerful private leaseholders, it concluded that the development of quantitative data about the conditions of its rangelands over time through a monitoring program would be a powerful political tool in its favor.[164] As a result, the agency

160. *See, e.g.*, Doremus, *supra* note 71, at 573; McGarity, *supra* note 117, at 1485; Barton H. Thompson, Jr., *The Continuing Innovation of Citizen Enforcement*, 2000 U. ILL. L. REV. 185, 216; *see also* Daniel A. Farber, *Taking Slippage Seriously: Noncompliance and Creative Compliance in Environmental Law*, 23 HARV. ENVTL. L. REV. 297 (1999).

161. *See* H. Ronald Pulliam, *The Political Education of a Biologist: Part I*, 26 WILDLIFE SOC'Y BULL. 199, 200 (1998); Pulliam, *supra* note 146, at 501.

162. *Random Samples: People*, 310 SCI. 1613 (Yudhijit Bhattacharjee ed., 2005); Nw. Envtl. Def. Ctr. v. Bonneville Power Admin., 477 F.3d 668, 677 (9th Cir. 2007).

163. Davis, *supra* note 93, at 99–100; STATUS AND TRENDS, *supra* note 84, at 5–6.

164. *See generally* SAYRE ET AL., *supra* note 58.

developed a comprehensive monitoring program and maintained it through the late 1970s.[165]

Finally, those in favor of the current legal or regulatory status quo might see additional monitoring as a way to delay (or perhaps even defeat) changes to the legal or regulatory landscape. For instance, observers of the adaptive management program for Glen Canyon Dam have noted that powerful water and power interests have repeatedly called for more monitoring in order to avoid major changes to the operations of the dam to protect endangered species.[166] Of course, the pressure for additional monitoring as a way to delay action will not necessarily translate into *effective* monitoring. Indeed, it might be that ineffective monitoring, by never providing adequate answers to the relevant management questions, is the most effective way of achieving delay.

2. Budget Constraints

Monitoring programs are regularly constrained by budgets.[167] While budgeting is a political question, this

---

165. *Id.*

166. Joseph M. Feller, *Collaborative Management of Glen Canyon Dam: The Elevation of Social Engineering over Law*, 8 NEV. L.J. 896, 927–28 (2008); Lawrence Susskind et al., *Collaborative Planning and Adaptive Management in Glen Canyon: A Cautionary Tale*, 35 COLUM. J. ENVTL. L. 1, 23, 46 (2010); *see also* Juliet Eilperin, *Interior Ignored Science When Limiting Water to Grand Canyon*, WASH. POST, Jan. 28, 2009, at A6 (describing history of political pressure from water and power interests to restrict changes to operation of dam).

167. SPELLERBERG, *supra* note 42, at 231 ("From my experience, I would estimate that approximately 80-90% of monitoring programmes fail or are abandoned because of lack of resources."); *see also* A ROAD MAP TO THE FUTURE, *supra* note 87, at 8 ("It is well known among environmental professionals that information collection and related activities are among the lowest priorities when it comes to budgets and other resources."); Holley, *supra* note 33, at 197–98. Funding constraints apparently doomed EPA's ambitious Environmental Monitoring and Assessment Program (EMAP) that was originally intended in the late 1980s to "monitor and report on status and trends in the condition of the Nation's ecological resources" both terretrial and aquatic. Laura E. Jackson & Steven G. Paulsen, *Preface to Special Issue: The Eighth Symposium of the Environmental Monitoring and Assessment Program (EMAP)—Research and Partnerships for Accountability*, 150 ENVTL. MONITORING & ASSESSMENT 1 (2009); *see also* FRESHWATER ECOLOGY BRANCH, U.S. ENVTL. PROT. AGENCY, METHODS FOR AQUATIC RESOURCE ASSESSMENT (MARA) FY 2008–2012, at 6–8 (2007) (detailing the decline in funding for EMAP over time); NAT'L HEALTH & ENVTL. EFFECTS RESEARCH LAB., U.S. ENVTL. PROT. AGENCY, RESEARCH STRATEGY: ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM II-1 to -2 (2002) (describing limits of EMAP monitoring because of funding constraints); *id.* at I-1 to -2 (describing the scaling down of the EMAP program).

subsection discusses the possibility that budget cuts for monitoring programs might not be a result of the political inconvenience of monitoring, but instead a result of the perception that monitoring is not important at all.

Monitoring can easily be portrayed as wasteful information collection without any payoff in terms of improved decision-making.[168] For instance, during his presidential campaign, Senator John McCain regularly identified studies of grizzly bear population levels as wasteful government spending.[169] Myopia is a problem not just for the legislature that funds the agencies,[170] but also the agencies themselves that might respond to a cut in their overall budget by disproportionately cutting monitoring because the impacts of those cuts might not be felt for years.[171]

The U.S. environmental satellite program produces climate data that may take decades to provide policy-useful information.[172] When the overall U.S. earth observation satellite program ran into cost overruns and delays, Congress and the relevant agencies cut the climate data collection portion of the satellite programs first in order to protect the weather programs that provide information more relevant in the short-term.[173] These cuts were part of an overall decline in

168. *See, e.g.*, Doremus, *supra* note 66, at 429 ("Monitoring drains scarce agency resources without providing the political benefits of action."); Gunderson, *supra* note 94, at xiv.

169. *See* Coco Ballantyne, *McCain's Beef with Bears?—Pork*, SCI. AM. (Feb. 8, 2008), http://www.scientificamerican.com/article.cfm?id=mccains-beef-with-bears.

170. *See* Doremus, *supra* note 71, at 572–73 ("Legislatures . . . seem systematically inclined to target funding towards action to the exclusion of learning.").

171. Erica Fleishman et al., *Conservation in Practice: Overcoming Obstacles to Implementation*, 13 CONSERVATION BIOLOGY 450, 451 (1999) ("[T]he planning horizons for many organizations are considerably shorter than those needed for effective adaptive management or monitoring programs."); Robert C. Szaro et al., *The Ecosystem Approach: Science and Information Management Issues, Gaps, and Needs*, 40 LANDSCAPE & URB. PLAN. 89, 98 (1998) ("Federal, state, private, and academic institutions undervalue long-term monitoring . . . ."); Steven L. Yaffee, *Ecosystem Management in Practice: The Importance of Human Institutions*, 6 ECOLOGICAL APPLICATIONS 724, 725 (1996) ("While public agencies would seemingly have the greatest ability to look out for the long term, their traditions and permanent workforces make them very protective of the status quo, and their short-term perspective is reinforced by short-term budget and political cycles.").

172. *See supra* Part I.C.1.

173. *See* NAT'L RESEARCH COUNCIL, EARTH SCIENCE AND APPLICATIONS FROM SPACE: NATIONAL IMPERATIVES FOR THE NEXT DECADE AND BEYOND, *supra* note 102, at 1 (noting that cost overruns led Congress and the agencies to cut "secondary" measurements in climate data in order to protect "core" measurements in weather forecasting).

the number of missions and funding for space-based environmental data collection at NOAA and the National Aeronautics and Space Administration (NASA).[174]

Of course, one could make monitoring more appealing by increasing its relevance for short-term management and regulatory policy decision-making.[175] But if monitoring is seen as relevant for short-term management and regulatory decisions, it might become dangerous to politically powerful parties, and funding might be cut precisely because it is too relevant.[176] Agencies seeking to fund and maintain a monitoring program face a dilemma: making monitoring seem worthwhile enough for politicians to invest in, but not so important that it becomes politically risky.[177]

3. Judicial Review

A significant constraint on agencies is the possibility of judicial review. But judicial deference to agencies based on the relative technical expertise of agencies may actually discourage agency collection of monitoring data, both because it reduces the incentives for anyone but the agency to collect any data at all, and because it reduces the incentives of the agency itself to collect any more data than is minimally necessary for the agency to get its decision upheld by the court.

First, the "record review" rule requires that courts only consider the material the agency itself considered at the time it made its decision.[178] That rule has the practical impact of

174. *See* NAT'L RESEARCH COUNCIL, EARTH SCIENCE AND APPLICATIONS FROM SPACE: NATIONAL IMPERATIVES FOR THE NEXT DECADE AND BEYOND, *supra* note 102, at 32–35 (noting the decline in total number of Earth-observation space missions, the large decline in NASA funding for such missions, and the increase in NOAA funding that is offset by large cost overruns).

175. LEE, *supra* note 66, at 175 ("[M]onitoring is too expensive to be defended solely on the basis of its contribution to learning . . . ."); *see also* Noon, *supra* note 109, at 32–33 (noting that when monitoring is "discussed in abstract terms," has "vague objectives," and has "no institutionalized connections to the decision-making process" then it will be given low priority and will be politically unpopular).

176. An example is Senator Craig of Idaho's efforts to eliminate the Fish Passage Center. *See Random Samples: People*, *supra* note 162 and accompanying text.

177. LEE, *supra* note 66, at 83 ("Research that has consequences is research that actors will try to tamper with or keep from occurring. Adaptive management is research that must have consequences if it is to be worth the high costs of doing it.").

178. *See* 3 CHARLES H. KOCH, JR., ADMINISTRATIVE LAW AND PRACTICE § 8.27 (3d ed. 2010).

giving the agency the dominant role in developing the information that courts rely upon. While it is theoretically possible for outside groups to put monitoring or other information into the record to be considered by the agency or a reviewing court, in practice there are serious limits to the amount and quality of information that can be contributed this way. The public often is not able to participate until near the end of the decision-making process, when it may be too late to collect data or conduct significant analyses, let alone develop long-term monitoring data.[179] Thus, most monitoring data will be collected by the decision-making agency itself, or sometimes by another government agency with an interest in the issue. In addition, courts, wary of getting caught in a "battle of experts" over technical information, generally give much more weight to the information provided by either the decision-making agency or other government agencies compared to any information collected by outside groups.[180] Overall, judicial review generally discourages the production and collection of useful monitoring data by outside groups.[181]

Moreover, intimidated by the technical nature of many agency activities, when courts do evaluate the agency's decision, they generally show strong deference, with higher deference for more technical decisions.[182] This discourages information production by the agency itself, "endors[ing] deliberate (and convenient) ignorance on the part of" government agencies.[183] The highly deferential standard of

179. *See* William F. Pedersen, Jr., *Formal Records and Informal Rulemaking*, 85 YALE L.J. 38, 79–80 n.150 (1975) (noting the need for advance notice and significant amounts of preparation to provide useful comments on technical matters); Stephanie Tai, *Three Asymmetries of Informed Environmental Decisionmaking*, 78 TEMP. L. REV. 659, 686 (2005).

180. *See* Michael C. Blumm & Stephen R. Brown, *Pluralism and the Environment: The Role of Comment Agencies in NEPA Litigation*, 14 HARV. ENVTL. L. REV. 277, 302 (1990).

181. Wendy Wagner notes that record review provides few constraints on the relevance of the information that can be put into the administrative record, and therefore encourages parties (particularly regulated industry) to add large amounts of trivial or irrelevant information into the record in an effort to overwhelm the agency. Wagner, *supra* note 71, at 1329–34, 1353–65. While Wagner shows how administrative law encourages the inclusion of existing, but mostly irrelevant information, my analysis shows how administrative law discourages the production of new, potentially highly-relevant information.

182. *See, e.g.*, Balt. Gas & Elec. Co. v. Natural Res. Def. Council, Inc., 462 U.S. 87, 103 (1983) (noting that where an agency "is making predictions, within its area of special expertise, at the frontiers of science," then judicial review "must generally be at its most deferential").

183. Doremus, *supra* note 71, at 574–77.

review implies that an agency that produces the minimum amount of information to meet judicial scrutiny will have its decision upheld. But because courts want to impose some accountability on agencies, the standard is not toothless. If a court can deduce a major problem in the record, the agency's decision might be overturned.[184] In these circumstances, the agency is essentially being punished for developing additional information above the minimum needed for judicial deference.[185]

B. Internal Forces Shaping Agency Monitoring Programs

A range of forces within an agency might also affect the willingness and ability of that agency to conduct an effective monitoring program. Effective monitoring might conflict with other important goals that an agency seeks to pursue. An agency might be unwilling to conduct long-term monitoring because of the possibility that it might reduce the agency's autonomy, and monitoring might be in tension with the dominant professional culture in an agency.

1. Conflicts with Other Agency Goals, Particularly an Agency's "Mission"

Monitoring might conflict with other agency goals in several ways, all of which can deter the agency from conducting monitoring: First, an agency might be reluctant to implement monitoring because it might make it easier for outsiders to hold the agency accountable for performance on environmental goals that the agency has been legally tasked with but has historically disfavored. Second, environmental performance in general, and ambient monitoring in particular, are the kinds of goals that an agency may often underperform on, in part because they are so hard to evaluate in terms of performance. Third, a public agency frequently organizes itself around a central mission in order to motivate employees, so an agency

184. *See, e.g.*, Motor Vehicle Mfrs. Ass'n of U.S., Inc. v. State Farm Mut. Auto. Ins. Co., 463 U.S. 29, 43 (1983) (stating that a court will overturn an agency decision that "is so implausible that it could not be ascribed to a difference in view or the product of agency expertise").

185. *See* Matthew C. Stephenson, *Evidentiary Standards and Information Acquisition in Public Law*, 10 AM. L. & ECON. REV. 351, 363, 365 (2008).

will be reluctant to conduct monitoring to the extent that it might interfere with that mission.

Advocates for adaptive management call for an "adaptive governance" system in which there would be "systematic evaluation and adaptation of all agency decisions . . . in furtherance of stated program goals," including "the assessment of agency personnel and of the agencies themselves against statutory goals."[186] Systematic evaluation necessarily implies monitoring, but getting an agency to rigorously and critically examine itself on an ongoing basis may be a significant challenge. Agency leadership might discourage collection of monitoring data that might show flaws in the existing management of environmental resources by the agency.[187]

The Government Performance and Results Act requires federal agencies to develop quantitative performance metrics.[188] Because these metrics can be used to cut agency budgets, an agency does not have an incentive to make them meaningful—instead, an agency purposefully may make metrics unambitious (and therefore easy to achieve) and technically obscure (therefore reducing their political salience), rendering them more or less useless.[189]

---

186. Camacho, *supra* note 53, at 49.

187. *See* LEE, *supra* note 66, at 77 ("There is accordingly a moral hazard for adaptive management: that managers will cook the books. . . . [S]kewed science can be beneficial to the trapped administrator, giving the appearance of rigorous evaluation and testing but providing a predetermined positive result."); JEFFREY L. PRESSMAN & AARON WILDAVSKY, IMPLEMENTATION: HOW GREAT EXPECTATIONS IN WASHINGTON ARE DASHED IN OAKLAND 183, 203–04 (3d ed. 1984) (noting the risks of fudging or self-serving data if agencies evaluate themselves); Doremus, *supra* note 53, at 55–56 ("[Decision makers] may even avoid collecting information that might shake [their] beliefs."); Doremus, *Precaution, Science, and Learning While Doing in Natural Resource Management*, *supra* note 71, at 571 (noting that "[i]nternal [agency] incentives are likely to run the other way" from the collection of information that allows for review of agency management decisions); Archon Fung & Dara O'Rourke, *Reinventing Environmental Regulation from the Grassroots Up: Explaining and Expanding the Success of the Toxic Release Inventory*, 25 ENVTL. MGMT. 115, 123 (2000); *cf.* Canice Prendergast, *A Theory of "Yes Men,"* 83 AM. ECON. REV. 757 (1993) (formal modeling showing that agents may manipulate information to mimic the preferences of the principal where the principal relies on incentive contracts to encourage information production).

188. Shapiro & Steinzor, *supra* note 83, at 1743.

189. *Id.* at 1759–69; s*ee also* THOMAS O. MCGARITY, REINVENTING RATIONALITY: THE ROLE OF REGULATORY ANALYSIS IN THE FEDERAL BUREAUCRACY 137–38 (1991) (noting the general problem).

Critics of the Chesapeake Bay restoration program argued that it consistently overemphasized information from models at the expense of monitoring, not just because the models were cheaper, but because the results from the models made the overall progress of the restoration program appear much better than the monitoring results did.[190] Public reports by the agency managing the Chesapeake Bay recovery program provided positive progress assessments that were based on models without making the source of the information clear.[191]

An agency's reluctance to monitor its performance effectively can be even greater when it is called upon to measure goals that it has previously disregarded or underemphasized, because monitoring would only highlight its lack of performance on those goals. And there are good reasons to expect that environmental goals are likely to be systematically underemphasized by many agencies. When an agency is tasked with multiple goals that might conflict, it must necessarily make a decision about how to trade off between those goals, and the more measurable goals will usually receive more attention from the agency.[192] Historically, environmental outcomes have been poorly measured because of the lack of monitoring;[193] thus, environmental performance has often been hard to evaluate. Consequently, environmental performance has been underemphasized compared to other goals. For instance, the Army Corps of Engineers might be less considerate of environmental values when making decisions about dam construction compared to other values (e.g., overall cost, flood control effectiveness).[194]

Moreover, an agency might systematically underperform in managing environmental monitoring programs, not just in the achievement of environmental goals themselves. Monitoring

190. *See* ERNST, *supra* note 120.

191. *See* David A. Fahrenthold, *Cleanup Estimate for Bay Lacking*, WASH. POST, Dec. 24, 2007, at B1; Peter Whoriskey, *Bay Pollution Progress Overstated*, WASH. POST, July 18, 2004, at A1.

192. Eric Biber, *Too Many Things to Do: How to Deal with the Dysfunctions of Multiple-Goal Agencies*, 33 HARV. ENVTL. L. REV. 1, 9–13 (2009).

193. *See supra* notes 81–89 and accompanying text.

194. As discussed above, environmental goals are often hard to measure as a technical matter, making them more vulnerable to this dynamic. *See supra* Part I.C.2. But environmental goals may often involve extremely vague, general exhortations to provide for a healthy environment. *See, e.g.*, 43 U.S.C. § 1732(b) (2006) (provision requiring the Bureau of Land Management to prevent "unnecessary or undue degradation" of federal public lands). Such vague provisions make measuring the success of goals even more difficult.

itself is hard to measure in terms of quality,[195] and improvement in environmental monitoring may be in conflict with other agency goals. Investment in improving monitoring necessarily means resources cannot be invested in other tasks, and improved environmental monitoring might produce political or legal pressure to perform better on underemphasized, underperforming environmental goals at the expense of other goals.

The environmental satellite monitoring program historically has been run by three agencies: NOAA, NASA, and the Department of Defense. For at least two of these agencies—NASA and the Department of Defense—environmental data collection is probably not a very high-priority goal. Unsurprisingly, the environmental satellite program has been plagued by incompetent and indifferent management[196]: The Defense Department official in charge of contract management and procurement for the program could not even be bothered to attend interagency program meetings.[197]

The problem might be ameliorated if an agency is able to break this loop, perhaps through leadership that invests in monitoring that in turn makes environmental goals easier to measure and therefore less disadvantaged relative to other goals. But for many government organizations, there is an additional barrier to overcome: the agency's sense of mission.

Many public agencies are assigned a range of hard-to-measure, vague goals.[198] Because of those vague goals, it is difficult or impossible to use strong performance-based incentives to motivate agency employees.[199] Public agency managers therefore might motivate employees by orienting the agency around a "mission" that employees are committed to

195. *See supra* Part I.C.2.

196. *See* POLAR-ORBITING ENVIRONMENTAL SATELLITES: WITH COSTS INCREASING, *supra* note 9, at 21–27.

197. *Id.*

198. HERBERT A. SIMON, ADMINISTRATIVE BEHAVIOR: A STUDY OF DECISION-MAKING PROCESSES IN ADMINISTRATIVE ORGANIZATIONS 176–77 (3d ed. 1976); DONALD P. WARWICK, A THEORY OF PUBLIC BUREAUCRACY: POLITICS, PERSONALITY, AND ORGANIZATION IN THE STATE DEPARTMENT 63 (1975); JAMES Q. WILSON, BUREAUCRACY: WHAT GOVERNMENT AGENCIES DO AND WHY THEY DO IT 26 (1989).

199. Oliver E. Williamson, *Public and Private Bureaucracies: A Transaction Cost Economics Perspective*, 15 J.L. ECON. & ORG. 306, 322, 324 (1999); *see also* Mathias Dewatripont et al., *The Economics of Career Concerns, Part II: Application to Missions and Accountability of Government Agencies*, 66 REV. ECON. STUD. 183, 198 (1999).

achieving without strong pecuniary incentives.[200] The mission will often align with one of the agency's goals, but there will be inconsistencies.[201]

If improved monitoring of environmental resources will result in information that might conflict with achievement of the agency's mission or is seen as a waste of resources that does not help accomplish the mission, then an agency will be even more likely to underinvest in monitoring. For instance, Alyson Flournoy argues that the Army Corps of Engineers' historic mission of developing water resources is in significant conflict with a conservation mission of implementing its wetlands protection program, limiting information production about wetlands protection.[202]

Public land management agencies provide multiple examples of this dynamic. The Bureau of Land Management (BLM) manages over 200 million acres of federal land in the western United States and has historically been focused on developing its land for mining, oil and gas, logging, and even grazing, but not on protecting non-consumptive uses such as scenic quality, wildlife, or water quality.[203] Unsurprisingly, the agency has systematically underinvested in monitoring of its wildlife resources. A GAO report in the early 2000s noted that the BLM had systematically shifted funds appropriated for wildlife monitoring toward permitting oil and gas drilling, leading to a dearth of adequate data on wildlife status or the impacts of oil and gas drilling on wildlife.[204]

---

200. *See* SIMON, *supra* note 198, at 112–15, 198; WILSON, *supra* note 198, at 26, 95; Timothy Besley & Maitreesh Ghatak, *Competition and Incentives with Motivated Agents*, 95 AM. ECON. REV. 616 (2005); Biber, *supra* note 192, at 16. Among the non-pecuniary rewards that government agencies might use to attract and retain qualified personnel is the opportunity to "make a difference" in the accomplishment of a particular agency mission by ensuring that agency employees have significant discretion to achieve the mission. Sean Gailmard & John W. Patty, *Slackers and Zealots: Civil Service, Policy Discretion, and Bureaucratic Expertise*, 51 AM. J. POL. SCI. 873 (2007). Non-pecuniary goals, particularly a desire to achieve public service goals, are a major factor in motivating bureaucrats. *See, e.g.*, JOHN BREHM & SCOTT GATES, WORKING, SHIRKING, AND SABOTAGE: BUREAUCRATIC RESPONSE TO A DEMOCRATIC PUBLIC 194–95 (1997); MARISSA MARTINO GOLDEN, WHAT MOTIVATES BUREAUCRATS?: POLITICS AND ADMINISTRATION DURING THE REAGAN YEARS 23 (2000).

201. SIMON, *supra* note 198, at 210–11; Biber, *supra* note 192, at 16–17.

202. Alyson C. Flournoy, *Supply, Demand, and Consequences: The Impact of Information Flow on Individual Permitting Decisions Under Section 404 of the Clean Water Act*, 83 IND. L.J. 537, 579–80 (2008).

203. *See* Stewart, *supra* note 40, at 36.

204. *See* Blaine Harden, *Federal Wildlife Monitors Oversee a Boom in Drilling*, WASH. POST, Feb. 22, 2006; *see also* U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-

Similarly, the U.S. Forest Service in the Coronado National Forest (CNF) in Arizona and New Mexico for decades had monitored the condition of its rangelands with inspections that occurred every year or two.[205] In the late 1970s, that regular monitoring program abruptly ceased and did not resume until the late 1990s; during the gap, only limited monitoring occurred.[206] The monitoring was not terminated because of any fundamental changes in the science or technology of rangeland management.[207] One likely explanation for why monitoring terminated is conflict with the agency's mission: The range conservation staff decided that to achieve its mission (ensuring that grazing was within the ecological limits of the rangeland), its time was better spent in developing relationships with ranchers rather than conducting detailed monitoring of rangeland conditions.[208]

2. Impingement on an Agency's Autonomy or Discretion

An agency might be reluctant to monitor not because it creates a specific, clear conflict with a current project, but because monitoring data might prove troublesome in the future. Monitoring programs are initiated to obtain information about an inadequately understood resource. Monitoring data are to some extent unpredictable or uncontrollable and might undermine an agency's decision in the future.

The lack of information, on the other hand, generally gives an agency a tremendous amount of political or legal leeway. An agency can use various tools to "stretch" incomplete or ineffective monitoring data instead of conducting additional

---

05-418, OIL AND GAS DEVELOPMENT: INCREASED PERMITTING ACTIVITY HAS LESSENED BLM'S ABILITY TO MEET ITS ENVIRONMENTAL PROTECTION RESPONSIBILITIES 14–15, 17 n.28, 22–24, 31–32 (2005) (noting that BLM's problems with monitoring are long-standing, and that they have led to significant monitoring gaps due to shifting resources away from monitoring to development activities).

205. *See* SAYRE ET AL., *supra* note 58, at 9.

206. *See id.*

207. *See id.* at 10.

208. *See id.* at 10–11. Was the loss of monitoring a problem if the mission of environmental conservation of rangelands was advanced? The loss of decades of monitoring data about rangeland status harmed endangered species management in the CNF. *See id.* In other words, by focusing on their mission, the agency officials neglected the utility of their data for other important environmental goals, emphasizing how this dynamic can also result in harmful conflicts among environmental goals.

monitoring: indicators, proxies, extrapolation, and modeling.[209] All of these tools require underlying assumptions—assumptions that allow an agency (if it wants to) to bury important policy conclusions, making it extremely difficult for outsiders to detect and contest them.[210] Moreover, courts provide significant deference to all of these tools,[211] so their use by an agency provides both political and legal room to maneuver. While additional data might make models more accurate, they also create the possibility of constraining the conclusions that the agency can reach based on its models, restricting its legal and political discretion. That discretion may be a very valuable commodity for a public agency. [212]

Indeed, there are relatively few examples of an agency consciously imposing rigorous monitoring requirements upon itself.[213] A 1982 Forest Service regulation (the "MIS regulation") required the Service to monitor important indicator wildlife species populations in order to ensure that management activities were protecting overall species diversity and ecosystem health.[214] However, over time, the agency adapted and changed the regulatory requirements to maximize its own discretion. For instance, the Service interpreted those regulations as allowing it to measure suitable habitat for the relevant wildlife species and then extrapolate from habitat to the status of the species themselves (the "proxy-on-proxy"

209. *See supra* Part I.C.3.a.

210. Peter H. Schuck, *Legal Complexity: Some Causes, Consequences, and Cures*, 42 DUKE L.J. 1, 31 (1992) (Agencies seek to conceal what they do in technical jargon because it promotes "agency autonomy," making them "more opaque to the generalist institutions like Congress and the media" and "more difficult to control and help obscure their pursuit of controversial policies."); Wagner, *supra* note 159, at 253 n.255; Wagner et al., *supra* note 135; Wendy E. Wagner, *The Science Charade in Toxic Risk Regulation*, 95 COLUM. L. REV. 1613, 1650–72 (1995).

211. *See* Wagner et al., *supra* note 135, at 319–45.

212. Agency managers will often seek to "acquire sufficient freedom of action and external political support" in order to pursue the agency's mission. *See* WILSON, *supra* note 198, at 26. That autonomy may also be essential for the agency if it wants to provide significant policy discretion to its own employees as part of its efforts to attract and retain them. Gailmard & Patty, *supra* note 200. Agency managers may even be willing to trade off budgetary resources for greater autonomy. *See* WILSON, *supra* note 198, at 28, 179–81.

213. *See, e.g.*, Robert B. Keiter, *Ecological Concepts, Legal Standards, and Public Land Law: An Analysis and Assessment*, 44 NAT. RESOURCES J. 943, 975–77 (2004).

214. Glicksman, *supra* note 132, at 494–95; Greg D. Corbin, Comment, *The United States Forest Service's Response to Biodiversity Science*, 29 ENVTL. L. 377, 389–91 (1999).

approach). These steps gave it significantly more leeway to interpret population trends and reduce the potential constraints that the data might impose on management decisions.[215] Similarly, the agency avoided monitoring those species that might be most sensitive to management decisions.[216] Even so, after a series of court cases implied that the agency might be required to conduct significant monitoring as a result of the regulation (and in some cases rejected the "proxy-on-proxy" approach), the Service moved to eliminate the MIS regulations.[217]

A desire to avoid external constraints might be another explanation for the ending of monitoring in the Coronado National Forest. The monitoring terminated in the late 1970s, right as three major legal changes in the legal environment coalesced—the rise of more active judicial review of agency decision-making (particularly environmental decision-making), a greater willingness of courts to hear claims raised by environmental groups (through the expansion of standing to sue), and the passage of environmental statutes such as the National Environmental Policy Act (NEPA) that created causes of action for environmental groups to challenge agency decisions.[218] Those changes combined to create a powerful new legal force in grazing monitoring: environmental groups.[219] Information that the Forest Service collected about rangeland conditions was no longer just a weapon that it could use against grazing lessees—it was also a weapon that might potentially be used against the Service by outside environmental groups to challenge a range of agency decisions (from grazing permits to grazing improvements to road construction).[220]

---

215. *See* ELZINGA ET AL., *supra* note 92, at 7 (proxy-on-proxy method necessarily "introduces the additional source of uncertainty in the assumed relationships between the indicator [habitat] and the species"); Corbin, *supra* note 214, at 399, 401; *supra* Part I.C.3.

216. *See* Gerald J. Niemi et al., *A Critical Analysis on the Use of Indicator Species in Management*, 61 J. WILDLIFE MGMT. 1240 (1997); Corbin, *supra* note 214, at 404.

217. *See* Keiter, *supra* note 213, at 950–52, 977 (noting the George W. Bush Administration's revisions to regulations to eliminate monitoring requirements and the transfer of any monitoring obligations to agency handbooks and manuals, which are less likely to be judicially enforceable); *see also* Glicksman, *supra* note 132, at 500–18 (noting similar regulation revisions made by the Clinton Administration).

218. *See* SAYRE ET AL., *supra* note 58, at 17–21.

219. *See generally id.*

220. *See id.*

Finally, the long-term commitment necessary for maintaining the effectiveness of many monitoring programs will necessarily require long-term planning and budgets. That commitment can tie the hands of the agency, constraining its flexibility with respect to internal budgeting, assignment of personnel and technical equipment, and so forth. An agency accustomed to planning for short-term horizons may feel great discomfort in trying to plan for the maintenance of a ten- or twenty-year monitoring program.[221]

3. Conflicts with Agency Culture, Particularly the Preferences of Scientists

A final internal constraint on agency monitoring might be that an agency's culture is simply not hospitable to monitoring. Here, the focus is the disdain or reluctance of scientists to conduct what is perceived to be "routine monitoring."

Scientists such as biologists, geologists, chemists, and epidemiologists are key components of the functioning of agencies such as EPA, FWS, the Forest Service, the Park Service, and USGS.[222] The problem is that there is a widespread attitude that scientists should not spend too much time monitoring because it is not good for professional advancement, as long-term monitoring projects do not easily turn into the kinds of research projects that lead to publication, grants, tenure, and improved professional reputation. The time frames are just not right because of the long-term nature of monitoring: Decades-long (or even multi-year) monitoring projects are longer than the relevant cycles for individual professional advancement in science. As a result, "[m]onitoring is science's Cinderella, unloved and poorly paid. . . . Monitoring does not win glittering prizes. Publication is difficult, infrequent, and unread. . . . [L]ong-term measurement is

221. *See, e.g.*, NAT'L RESEARCH COUNCIL, *supra* note 107, at 82–85 (criticizing monitoring program for Glen Canyon Dam management as too short-term, where the relevant strategic plan only applied for five years, while the resources in question likely required decades-long monitoring programs).

222. The federal government employs over 73,000 scientists, with significant numbers in environmental agencies. The Forest Service has over 7,000; NOAA has over 5,000; USGS and FWS each have over 4,000; and the EPA has about 5,000. Spreadsheet Compiled by Author, Summary of Employment Data from the United States Office of Personnel Management Website (July 2010), http://www.fedscope.opm.gov/ (on file with author).

simply not valued as 'discovery' science."[223] These negative attitudes matter, even for those scientists who might otherwise be interested in monitoring. Political scientists have identified peers as a major influence on agency employees' attitudes and motivation,[224] and if peer scientists do not respect monitoring, employees are less likely to pursue it in an effective way.

These attitudes can also have real impacts on the funding and institutional support for monitoring within agencies. For example, long-term measurements of carbon dioxide levels in the atmosphere were regularly threatened with funding cuts because funding agencies such as the National Science Foundation did not see long-term monitoring as a "scientific" endeavor.[225]

The scientific skepticism towards monitoring might be offset by more favorable attitudes toward monitoring from other major professional groups within environmental agencies. For instance, foresters are an important component of federal and state forestry agencies.[226] Professions that have been more focused on resource management might be more inclined toward monitoring of the resources as well. However, monitoring may not be seen as an end in itself, but as a way to achieve the dominant professional managerial goal. For instance, foresters might be far more enthusiastic about monitoring how quickly timber is growing, and less interested in monitoring the status of wildlife that might interfere with active forest management.[227] In these contexts, the problem of conflicts with other agency goals and missions might be exacerbated.

---

223. Euan Nisbet, *Cinderella Science*, 450 NATURE 789, 789–90 (2007); *see also* Franklin, *Importance and Justification of Long-Term Studies in Ecology*, *supra* note 93, at 12 (noting that "the ecological community" has a "phobia of 'monitoring' "); Doremus, *supra* note 66, at 452–53; Likens, *supra* note 107, at 240; Reed F. Noss, *Indicators for Monitoring Biodiversity: A Hierarchical Approach*, 4 CONSERVATION BIOLOGY 355, 361 (1990) ("Monitoring has not been a glamorous activity in science . . . ."); Taylor, *supra* note 93, at 21.

224. *See* BREHM & GATES, *supra* note 200, at 196; GOLDEN, *supra* note 200, at 27.

225. *See* Keeling, *supra* note 101, at 51, 56–58.

226. Biber, *supra* note 192, at 24–27; Louise Fortmann, *The Role of Professional Norms and Beliefs in the Agency-Client Relations of Natural Resource Bureaucracies*, 30 NAT. RESOURCES J. 361 (1990).

227. Biber, *supra* note 192, at 14–17. Attitudes have shifted recently among foresters, however. *Id.* at 27–28.

III. EXPLORING SOLUTIONS

How might we try to solve the problems of ambient monitoring in environmental law? Solutions require addressing the problems that continuity and opacity pose for monitoring programs. Continuity requires establishing commitment and reliability on the part of the institutional actors that conduct or supervise monitoring.[228] Moreover, because of continuity, forcing reluctant institutional actors to monitor effectively is very difficult. Absent incentives for agencies to conduct adequate monitoring, supervision must be ongoing and continuous, which is a tall order.

Opacity also means that it is quite difficult for outsiders to force an actor to conduct effective monitoring. The supervision required to ensure that monitoring is effective demands significant technical expertise and resources. Moreover, the uncertainty that opacity creates means that at some point there needs to be underlying trust that the actor conducting or supervising the monitoring wants to achieve effective monitoring.

There are a range of possible solutions, each with their own strengths and weaknesses. We could try to encourage greater collaboration among agencies to conduct monitoring, an option that would encourage the efficient use of resources but that cannot not address situations where external constraints and internal forces mean that no agency has an incentive to conduct the relevant monitoring. We could try to rely more on resources outside agencies, particularly citizen groups; these organizations may have a great deal of passion and incentives to monitor, but they may lack both the expertise and the continuity to tackle many monitoring problems.

As Part III.C will develop in more detail, one of the more promising solutions to deal with both continuity and opacity is to rely on public agencies that are primarily focused on monitoring. Public agencies are more likely than other alternatives to have the institutional continuity either to undertake effective long-term monitoring or to supervise its performance. Public agencies that primarily focus on monitoring can also develop the expertise needed to deal with the technically difficult tasks of monitoring, and their focus on

228. *See* Todd R. La Porte, *High Reliability Organizations: Unlikely, Demanding, and at Risk*, 4 J. CONTINGENCIES AND CRISIS MGMT. 60 (1996).

monitoring can also create strong institutional incentives for them to do a good job in either conducting or supervising effective monitoring. These separate agencies need not conduct the monitoring themselves; they might instead provide regular, expert, and effective audits of monitoring data that can provide sufficient incentives for management or regulatory agencies to conduct their own effective monitoring programs.

Before solutions are discussed, a skeptical reader might ask whether Congress and the President, when they enact environmental laws that require significant monitoring, know that the monitoring is likely to be ineffective and will undermine implementation.[229] If that is the case, and one believes that Congress and the President are electorally accountable, is there a problem to solve? But ineffective monitoring undermines the transparency and accountability of the political process: There are often significant asymmetries in the understanding of the effectiveness of monitoring, asymmetries that tend to favor regulated parties.[230] In other words, the public probably does not understand the problems with monitoring and would not accept ineffective monitoring if they did understand them. Moreover, it is quite plausible that not even legislators or other elected officials fully understand the possibility of dysfunction in setting up monitoring programs—in which case, a fuller understanding of those concerns might lead to better institutional and legal design for environmental policymaking.

Part III.A begins by discussing how we might work with existing agencies, buttressed by better leadership, better funding, or better collaboration among these agencies. The best of these options (better collaboration) has potential to address problems of coordination and redundancy where agencies already have incentives to address monitoring problems. Part III.B then turns to exploring whether we could rely on groups that exist outside of agencies to encourage or conduct better monitoring; most of these options, however, have problems with continuity, although citizen groups provide a relatively overlooked option for improving monitoring. Finally, Part III.C discusses how we might restructure agencies themselves to encourage more and better monitoring, a solution with a great deal of promise, although it is not a panacea.

---

229. *See, e.g.*, Daniel A. Farber, *Politics and Procedure in Environmental Law*, 8 J.L. ECON. & ORG. 59, 68–69 (1992) (noting this possibility).

230. *See supra* Part II.A.1.

A. Working with Existing Agencies: Better Leadership, Better Funding, Better Collaboration

Perhaps the most obvious solutions are better leadership, better funding, and better coordination and collaboration across agencies. While some of these options might be relatively inexpensive and politically feasible, all are limited by their failure to address the underlying incentives that make agencies reluctant to conduct effective monitoring.

There have been claims that "leadership" in key positions in agencies will lead to better monitoring.[231] But pinning all of our hopes on individual leaders is an inadequate response—great leaders are a highly contingent and uncertain solution. The contingent nature of this solution is particularly problematic given the importance of long-term continuity to successful monitoring. If great leaders come and go, then the monitoring programs they support may come and go too. In the end, even if strong leadership can be found, the structure and function of agencies is also crucial to the monitoring programs' success or failure.[232]

Another frequently suggested solution is providing more funding for monitoring,[233] such as dedicated funding streams that are more resistant to political whims.[234] While there is no question that more funding is required, the problem is how to overcome the political resistance to additional funding, including the creation of new funding streams. And even if dedicated, reliable funding is provided for agency monitoring, an agency might not use that funding to implement *effective* monitoring, given internal agency conflicts.

Improved collaboration among the various environmental agencies that currently do conduct monitoring would allow for better sharing and use of the information that does exist across the various agencies. Usually some sort of central information

231. *See* Bohan, *supra* note 9 (scientists decrying the "dearth of leadership" in the satellite monitoring program).

232. Alan L. Dean, *General Propositions of Organizational Design*, 131, 139, *in* FEDERAL REORGANIZATION: WHAT HAVE WE LEARNED? (Peter Szanton ed., 1981) ("Significant defects in organization cannot be overcome solely by the efforts of a leader . . . .").

233. Camacho, *supra* note 53, at 72; Doremus, *supra* note 66, at 457–59.

234. *See* Leshy, *supra* note 41, at 131, 134 (proposing the allocation of energy royalties from public lands for a monitoring and management fund).

clearinghouse or coordinating committee is proposed, with only advisory or facilitating powers.[235]

One key problem that collaboration might address is the compatibility of monitoring data and protocols across multiple agencies conducting similar monitoring programs.[236] Compatibility of data across monitoring programs could allow for the aggregation of data across those monitoring programs, which in turn could produce useful information at different (larger or smaller) temporal and spatial scales than the individual monitoring programs cover.[237] Aggregation of data might also allow different programs to complement each other and offset each others' weaknesses—for instance, programs that are large in geographic scale (e.g., remote sensing from satellites) can be paired with small-scale, intensive studies of particular locations (e.g., long-term ecological studies at biological research sites). The small-scale studies can be used to interpret and analyze the large-scale data and make it more effective and useful.[238] The advisory functions of a central body might also provide some additional impetus for agencies that are already interested in conducting good monitoring to extend or improve their efforts to address important gaps.

The problem is that collaborative efforts face an uphill battle if they are truly to address the hardest challenges in improving environmental monitoring—the reluctance (whether conscious or not) of agency officials to pursue effective monitoring programs that might threaten an agency's other goals, mission, or autonomy. If an agency was reluctant to pursue effective monitoring on its own, it is hard to see how a collaborative, voluntary process will matter. Participation in the collaborative venture might be pro forma.[239] And indeed,

235. A ROAD MAP TO THE FUTURE, *supra* note 87, at 10–12; NAT'L RESEARCH COUNCIL, A BIOLOGICAL SURVEY FOR THE NATION vii–viii (1993); ENVTL. MONITORING TEAM, *supra* note 113, at 3–4, 63–64; Camacho, *supra* note 53, at 68.

236. Data compatibility has been a serious issue in the United States. FILLING THE GAPS, *supra* note 87, at 39–40.

237. See KAREN E. SETTY ET AL., EVOLUTION OF MONITORING PROGRAM DESIGN FOR MARINE OUTFALLS IN THE SOUTHERN CALIFORNIA BIGHT (2010), ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/AnnualReports/2010AnnualReport/ar10_001_013.pdf, for an example of a successful cooperative effort pooling monitoring from multiple industrial sources to estimate the impacts of discharges on the ambient environment of the coastal waters of Southern California.

238. ENVTL. MONITORING TEAM, *supra* note 113, at 9–12.

239. JEFFREY L. PRESSMAN & AARON WILDAVSKY, IMPLEMENTATION 133–34 (3d ed. 1984) (making same points); WILSON, *supra* note 198, at 190–91 (noting that agencies will generally attempt to preserve their autonomy in cooperative

the history of formal collaborative efforts across agencies makes fairly clear that, unless collaboration is in the interests of all of the participating agencies, success is unlikely.[240] The U.S. environmental satellite program's problems are in part the result of an ineffective inter-agency collaboration, with different agency protocols and procedures for contracting and procurement, different agency goals and standards for the program, and different institutional cultures.[241] In response, the Obama Administration terminated the interagency collaboration and divided the satellite program among the component agencies.[242]

All this is not to say that collaboration is not an important potential solution. It can be done with relatively low cost and with politically feasible inter-agency agreements. It is the solution that might work best when agencies do not have institutional reasons to oppose or resist monitoring and there is not likely to be significant political resistance to monitoring.

B. Outsourcing: Relying More on Actors Outside the Bureaucracy

If the problem is the incentives against monitoring that continuity and opacity create within agencies, we might look outside those agencies to try and resolve the problem, to institutions such as regulated parties, citizen groups, courts, or Congress. However, relying on industry leads us back to the same problem of agency incentives; citizen groups, courts, and Congress often lack either the continuity or the expertise to effectively conduct or supervise monitoring.

---

agreements); *id.* at 268–69 (contending that most cooperative agreements are useless).

240. DONALD CHISHOLM, COORDINATION WITHOUT HIERARCHY: INFORMAL STRUCTURES IN MULTIORGANIZATIONAL SYSTEMS 146–49 (1989); WILSON, *supra* note 198, at 192 ("[I]t is extraordinarily difficult to coordinate the work of different agencies."); Allen Schick, *The Coordination Option* 85, 97–98, *in* FEDERAL REORGANIZATION: WHAT HAVE WE LEARNED? (Peter Szanton ed., 1981).

241. *See* POLAR-ORBITING ENVIRONMENTAL SATELLITES: WITH COSTS INCREASING, *supra* note 9, at 21–27.

242. *See* POLAR-ORBITING ENVIRONMENTAL SATELLITES: AGENCIES MUST ACT QUICKLY, *supra* note 9, at 15.

1. Industry Monitoring

While industry may have fewer incentives to conduct ambient environmental monitoring,[243] one could envision rigorous legal requirements that private industry conduct ambient monitoring.[244] Nonetheless, public oversight of the private monitoring programs would be required, leaving the question of when and how government agencies will be able to ensure that private parties conduct effective ambient environmental monitoring programs,[245] more or less the same question. For instance, a developer of a proposed wind farm in West Virginia conducted surveys inadequate to detect the presence of an endangered species in the area.[246] Despite the inadequate monitoring, the local government with permitting authority signed off on the survey and the project.[247]

2. Citizen Group Monitoring

Individual citizens in "bucket brigades" use inexpensive technology to measure air quality in their community, often with a particular focus on toxic air pollutants that nearby industrial facilities might release.[248] This monitoring can be a potent media and political tool that influences regulators or regulated industry. In the National Audubon Society's Christmas Bird Count (CBC), volunteer bird-watchers have reported counts of birds observed from thousands of locations across the country every Christmas for over 100 years.[249] These

243. *See supra* Part I.A.

244. Case, *supra* note 31, at 438–42; Coglianese et al., *supra* note 30; Donald T. Hornstein, *Complexity Theory, Adaptation, and Administrative Law*, 54 DUKE L.J. 913, 958 (2005).

245. EPA recognizes that its oversight of private data collection and reporting is a form of public monitoring. *See* JAMES H. FINGER, U.S. ENVTL. PROT. AGENCY, REGION IV, MEMO RE: ENVIRONMENTAL PROTECTION AGENCY QUALITY ASSURANCE POLICY STATEMENT (July 6, 1979). Scholars have called public supervision of private monitoring efforts "meta-monitoring." *See* Peter N. Grabosky, *Using Non-Governmental Resources to Foster Regulatory Compliance*, 8 GOVERNANCE 527, 543 (1995).

246. *See* Animal Welfare Inst. v. Beech Ridge Energy LLC, 675 F. Supp. 2d 540 (D. Md. 2009).

247. Ultimately, the farm was blocked by litigation in federal court. *See id.*

248. *See* Christine Overdevest & Brian Mayer, *Harnessing the Power of Information Through Community Monitoring: Insights from Social Science*, 86 TEX. L. REV. 1493, 1510–11 (2008).

249. Erica H. Dunn et al., *Enhancing the Scientific Value of the Christmas Bird Count*, 122 THE AUK 338, 338 (2005).

are only two examples of a wide range of citizen monitoring efforts for environmental quality across the United States.[250]

But many monitoring technologies may be financially out of the reach of most volunteer groups.[251] Even where the technology is feasible, the data protocols may be implemented in a flawed way.[252] And even if volunteer monitoring is methodologically correct, it may nonetheless be suspect in the eyes of the public or the regulator because of claims that the information was collected by groups with a hidden agenda.[253] Finally, there are serious questions about the ability of volunteer organizations to maintain long-term commitments to collect monitoring information continuously, rigorously, and effectively over an extended period of time.[254] Many community organizations are unlikely to have the kind of institutional lifespan necessary for effective monitoring.[255]

Volunteer monitoring seems most plausible when: (a) the monitoring techniques are relatively inexpensive and simple; (b) the effectiveness of the volunteer monitoring program is relatively simple for auditors or outsiders to assess (to reduce the perception of bias); and (c) the continuity of the monitoring program over time is less important. For instance, the CBC uses extremely simple methodologies, occurs only once a year, and involves an activity (bird-watching) that many people do for fun on their own.[256] Likewise, the "bucket brigade" measurements focus on transient and temporary outbursts of air pollution in local communities, although more technical expertise for performing and analyzing the data may be required.[257] Even with these caveats, there are areas in which volunteer monitoring can be quite useful, like monitoring of water quality in small- to medium-sized bodies of water, where the techniques are cheap and easy to use and where long-term measurements may not be as critical. In contrast, volunteer monitoring may not be feasible for the monitoring of trace

250. *See* Christine Overdevest, Cailin Huyck Orr & Kristine Stepenuck, *Volunteer Stream Monitoring and Local Participation in Natural Resource Issues*, 11 HUM. ECOLOGY REV. 177, 177–78 (2004); Thompson, *supra* note 160, at 187, 218–29.

251. *See* Overdevest & Mayer, *supra* note 248, at 1521–22.

252. *See id.* at 1519–20; O'Rourke & Macey, *supra* note 118, at 403, 407–08.

253. *See* sources cited *supra* note 252.

254. *See* O'Rourke & Macey, *supra* note 118, at 384, 407–09.

255. *See generally id.*

256. *See* Dunn et al., *supra* note 249 (describing the limits of CBC).

257. *See* O'Rourke & Macey, *supra* note 118; Overdevest & Mayer, *supra* note 248, at 1521.

pollutants in waterways or air (because of the challenge of avoiding contamination and the need for high-precision analysis). Finally, while the CBC program shows that some volunteer programs can be sustained over the long-term, we might be skeptical of relying upon citizen groups for the bulk of long-term monitoring.

3. Enlisting Courts? Imposing Mandatory Monitoring Duties on Agencies with Judicial Enforcement

While courts generally cannot conduct monitoring themselves, courts might compel agencies to conduct more effective monitoring through the enforcement of statutory provisions that require monitoring.[258]

But many prominent environmental statutes, such as NEPA, do not have explicit mandates for monitoring.[259] While these statutes do require agencies to provide analyses and reports of the information they already have, courts have rarely interpreted these statutes as imposing additional information collection duties on agencies.[260] Absent such a judicial interpretation, statutes like the NEPA generally do not support long-term monitoring because they are tied to individual projects.[261] Once information is gathered to justify a particular project, the agency moves on to the next one, with little ex post

258. For proposals to this effect, see, for example, Alyson C. Flournoy, et al., *Harnessing the Power of Information to Protect Our Public Natural Resource Legacy*, 86 TEX. L. REV. 1575, 1587–89 (2008) (proposing a National Environmental Legacy Act that would require agencies to monitor environmental conditions); *see also* Camacho, *supra* note 53, at 72–73; Doremus, *supra* note 53, at 83–84 ("Clear, enforceable information collection and disclosure mandates must be part of any adaptive management requirement or authority.").

259. 42 U.S.C. §§ 4321–4370(f) (2006).

260. *Compare* Colo. Envt'l Coal. v. Dombeck, 185 F.3d 1162, 1170–72 (10th Cir. 1999) (holding that the Forest Service did not violate NEPA when it did not collect quantitative population data about the distribution of rare species that might be affected by timber project), *with* Nat'l Parks & Conservation Ass'n v. Babbitt, 241 F.3d 722, 732–33 (9th Cir. 2001) (requiring collection of data about potential impacts of additional cruise ships on marine mammals in a national park), *abrogated on other grounds by* Monsanto Co. v. Geertson Seed Farms, 130 S. Ct 2743 (2010). *See also* 40 C.F.R. § 1502.22 (2010) (regulation interpreting NEPA that requires an agency to state whether there are significant uncertainties about any analysis of environmental impacts, but only requires additional information collection when such information is both essential "and the overall costs of obtaining it are not exorbitant.").

261. Buzbee, *supra* note 30, at 603; Karkkainen, *supra* note 66, at 939–40, 965–66.

data collection for the approved project and little or no baseline data collection for future projects.[262]

Some statutes and regulations do explicitly impose mandatory monitoring duties on agencies.[263] However, many of these programs have not been effectively implemented by agencies absent judicial intervention.[264] And that judicial intervention is quite rare, as even with explicit mandatory statutory or regulatory requirements, courts often simply refuse to order agencies to conduct monitoring. There are three main doctrinal rationales for the judicial reluctance to compel monitoring: (1) an agency monitoring program is neither a "final" nor specific agency "action" that a court can review or mandate under the APA;[265] (2) the level of compliance by an agency with a mandatory duty is not for the court to review, as long as at least some compliance exists;[266] or (3) the apparently

262. Buzbee, *supra* note 30, at 603; Karkkainen, *supra* note 66, at 939–40.

263. For instance, BLM and Forest Service regulations currently require the monitoring of federal lands for adverse impacts from off-highway vehicle (OHV) use. *See* 43 C.F.R. § 8342.3 (2010) (BLM regulation); 36 C.F.R. § 212.57 (2010), *available at* http://www.gpoaccess.gov/cfr/retrieve.html (Forest Service regulation).

264. Regular GAO reports have found the level of OHV monitoring by the BLM and the Forest Service to be inadequate. *See* U.S. GOV'T ACCOUNTABILITY OFFICE, GAO/RCED-95-209, FEDERAL LANDS: INFORMATION ON THE USE AND IMPACT OF OFF-HIGHWAY VEHICLES 4 (1995); U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-09-509, ENHANCED PLANNING COULD ASSIST AGENCIES IN MANAGING INCREASED USE OF OFF-HIGHWAY VEHICLES (2009).

In theory, the ESA requires regular monitoring and reevaluation of major management decisions, such as status reviews for listed species and reports on the recovery progress for listed species. Ruhl, *Taking Adaptive Management Seriously: A Case Study of the Endangered Species Act*, *supra* note 53, at 1266–68. However, in practice the agencies that implement the ESA "regularly fail to conduct status monitoring and adjustment" for listed species, *id.* at 1267, and the recovery reports have been cursory, *id.* at 1268. The ESA section 7 consultation requirement, which requires a federal agency proposing an action that might harm endangered species to consult with FWS, does impose some obligation to collect information about the current status of relevant listed species and the potential impact of the action on the species. Buzbee, *supra* note 30, at 596–97. However, that requirement generally produces only intermittent information gathering. *See* Ruhl, *Taking Adaptive Management Seriously: A Case Study of the Endangered Species Act*, *supra* note 53, at 1264–71. The exception is repeated ESA consultation or permitting for an ongoing activity, such as in the context of the grazing program on the CNF. *See infra* notes 285–91 and accompanying text.

265. *See* Ecology Ctr., Inc. v. U.S. Forest Service, 192 F.3d 922, 925–26 (9th Cir. 1999) (concluding that monitoring obligation is not a final agency action which can be compelled by courts); Sierra Club v. Peterson, 228 F.3d 559, 565–68, 571 n.8 (5th Cir. 2000) (rejecting challenges to Forest Service monitoring because plaintiffs were not attacking a specific agency decision).

266. *See, e.g.*, Mont. Snowmobile Ass'n v. Wildes, 26 F. App'x 762, 764 (9th Cir. 2002); Friends of the Earth v. U.S. Dep't of the Interior, 478 F. Supp. 2d 11, 26

mandatory language in the statute, regulation, or plan is in fact only hortatory.[267] But underlying these rationales is likely a concern about judicial attempts to micromanage agencies by constantly supervising whether they are conducting what is, in essence, an ongoing, day-to-day operational program, rather than a particular task that can be completed within a set period of time.[268] Whatever the merits of those judicial concerns might be, they present a substantial obstacle to those who seek to reform environmental monitoring absent a fundamental reorientation of how courts view their relationship vis-à-vis administrative agencies.

There are a few areas where courts have tried to enforce statutory monitoring requirements. Usually, courts are more willing to step in when a monitoring duty can be framed as a precondition to the agency being able to pursue some other activity that it seeks to accomplish (such as a timber sale or road construction).[269] This allows courts to avoid the agency

(D.D.C. 2007) (citing Norton v. S. Utah Wilderness Alliance, 542 U.S. 55, 63 (2004)); Natural Res. Def. Council, Inc. v. U.S. Forest Serv., 634 F. Supp. 2d 1045, 1062 (E.D. Cal. 2007); Gardner v. U.S. Bureau of Land Mgmt., 633 F. Supp. 2d 1212, 1230 (D. Or. 2009); Friends of the Kalmiopsis v. U.S. Forest Serv., No. 98-35793, 1999 WL 893631 (9th Cir. Oct. 15, 1999); *Ecology Center*, 192 F.3d at 926.

267. *See* Norton v. S. Utah Wilderness Alliance, 542 U.S. 55, 71 (2004) (concluding that the agency's land management plan's requirement that monitoring of OHV requirements be conducted was only hortatory and not judicially enforceable); *see also* ONRC Action v. Bureau of Land Mgmt., 150 F.3d 1132, 1139–40 (9th Cir. 1998) (similar interpretation of similar provisions in management plan); Lands Council v. Vaught, 198 F. Supp. 2d 1211, 1229–33 (E.D. Wash. 2002) (same); Audubon Naturalist Soc'y of the Cent. Atl. States, Inc. v. U.S. Dep't of Transp., 524 F. Supp. 2d 642 (D. Md. 2007) (narrowly interpreting monitoring requirements under Clean Air Act); Mass. Audubon Soc'y, Inc. v. Daley, 31 F. Supp. 2d 189 (D. Mass. 1998) (same for Atlantic Tunas Convention Act).

268. *See* Lujan v. Nat'l Wildlife Fed'n, 497 U.S. 871 (1990) (requiring that an agency decision be a specific agency action for judicial review to apply, in part to avoid the risk that courts will be drawn into managing the "day-to-day" operations of an agency); Norton v. S. Utah Wilderness Alliance, 542 U.S. 55 (2004) (applying *Lujan v. Nat'l Wildlife Fed'n* to conclude that courts can only compel "specific" mandatory agency action and that plan language requiring monitoring was only hortatory for similar reasons); *Ecology Center*, 192 F.3d at 925–26 (citing Lujan v. Nat'l Wildlife Fed'n, 497 U.S. at 899) (applying the *Lujan* court's injunction against judicial intervention in "day-to-day" operations of agencies).

269. For instance, in the West Virginia wind farm case, the court was willing to conclude that the monitoring was inadequate in the context of a case where plaintiffs sought to enjoin the construction of a particular wind project. Animal Welfare Inst. v. Beech Ridge Energy LLC, 675 F. Supp. 2d 540 (D. Md. 2009). Caselaw in which plaintiffs have sought to enforce the Forest Service's MIS regulations usually involved a plaintiff seeking to stop a separate, specific Forest Service activity, such as a logging project, on the grounds of inadequate monitoring, rather than trying to seek direct review of the inadequate monitoring

action problem because they are merely enjoining a specific agency action (such as the timber sale or the road construction) until the agency has compiled an adequate monitoring record.[270] But even here, the result is often litigation trench warfare between plaintiffs seeking to force agency monitoring of a certain level or kind, and an agency that is determined to avoid what it sees as the unnecessary and unrealistic costs of proposed monitoring.

For instance, the Ninth Circuit has held that the Forest Service can use "proxy-on-proxy" estimates of habitat quantity and quality as a substitute for actual measures of MIS population numbers only if the Forest Service shows that the habitat estimates are an effective and adequate proxy.[271] However, the court's efforts to closely examine the Forest Service's proxy-on-proxy methodology have led the court into a long series of cases that require factually intense examination and produce difficult-to-reconcile outcomes.[272]

---

itself. *See infra* notes 271–72; *see also Ecology Center*, 192 F.3d at 925 n.6 (drawing this distinction); Neighbors of Cuddy Mountain v. Alexander, 303 F.3d 1059, 1066–68, 171 (9th Cir. 2002) (allowing challenge to logging proposal based on claim of inadequate monitoring); J.B. Ruhl and Robert L. Fischman, *Adaptive Management in the Courts*, 95 MINN. L. REV. 424, 449–451 (2010) (describing how monitoring failures were successfully used to challenge proposed timber sales under the Northwest Forest Plan).

270. This approach is similar to the "destabilization right" concept that Brad Karkkainen has advocated as a way of forcing industry and regulatory agencies to produce more information about environmental harms. *See generally* Bradley C. Karkkainen, *Getting to "Let's Talk": Legal and Natural Destablizations and the Future of Regional Collaboration*, 8 NEV. L.J. 811 (2008); Bradley C. Karkkainen, *Information-Forcing Environmental Regulation*, 33 FLA. ST. U. L. REV. 861 (2006). It can also be seen as a tool by which Congress might make an agency's preferred action more difficult until and unless the agency meets minimum evidentiary standards or makes a showing of minimum effort in conducting monitoring activities, and in doing so, increases the incentives to conduct monitoring. *See generally* Matthew C. Stephenson, *Information Acquisition and Institutional Design*, 124 HARV. L. REV. 1422 (2011); Dezsö Szalay, *The Economics of Clear Advice and Extreme Options*, 72 REV. OF ECON. STUD. 1173 (2005) (formal modeling developing this analysis).

271. Lands Council v. McNair, 537 F.3d 981, 997–98 & n.10 (9th Cir. 2008), *overruled in part by* Winter v. Natural Res. Def. Council, Inc., 555 U.S. 7 (2008) (correcting the standard for a preliminary injunction), *as recognized in* Am. Trucking Ass'n v. Los Angeles, 559 F.3d 1046, 1052 (9th Cir. 2009).

272. *Compare Lands Council*, 537 F.3d at 997–98 (upholding use of proxy-on-proxy methodology), *and* Native Ecosystems Council v. U.S. Forest Serv., 428 F.3d 1233, 1251 (9th Cir. 2005) (same), *with* Native Ecosystems Council v. Tidwell, 599 F.3d 926, 933–34 (9th Cir. 2010) (rejecting use of proxy-on-proxy methodology), *and* Earth Island Inst. v. U.S. Forest Serv., 442 F.3d 1147, 1175–76 (9th Cir. 2006) (same), *abrogated by* Winter v. Natural Res. Def. Council, Inc., 555 U.S. 7 (2008). Other circuits have either prohibited the Forest Service from conducting proxy-on-proxy monitoring entirely, or have generally allowed it, without the close

The problem is that it is very difficult for courts to analyze whether an agency truly has done all it can in developing an effective monitoring program. Judicial enforcement appears to be a relatively costly and inefficient way of achieving better monitoring, with uncertain outcomes and the risk of exacerbating the "ossification" of agency action.[273] Even when judicial intervention occurs, it is a long and slow process for individual court cases to turn into effective monitoring programs, given the intermittent nature of judicial review. A more modest option might be to reduce the disincentives for information production, by allowing plaintiffs to introduce more extra-record evidence when challenging agency decisions, in order to force agencies to conduct better monitoring.[274] The risk is that outside parties will swamp courts with superfluous and irrelevant information, in the hope of either overturning the agency decision, or at least delaying adverse agency decisions.[275]

---

analysis the Ninth Circuit has provided. *Compare* Sierra Club v. Martin, 168 F.3d 1, 6 (11th Cir. 1999) (rejecting Forest Service use of proxy-on-proxy methodology), *with* Ind. Forest Alliance, Inc. v. U.S. Forest Serv., 325 F.3d 851, 863 (7th Cir. 2003) (allowing use of proxy-on-proxy methodology). Nonetheless, even in these circumstances the difficult question of adequacy of monitoring arises, since a court that requires quantitative population measures to satisfy the MIS requirements must determine how much data is adequate. *See, e.g.*, Utah Envtl. Congress v. Bosworth, 372 F.3d 1219, 1227 (10th Cir. 2004) (rejecting proxy-on-proxy methodology, but upholding the Forest Service's reliance on "cursory" data on population levels of a species that had been collected from a single location); *see generally* Utah Envtl. Congress v. Troyer, 479 F.3d 1269 (10th Cir. 2007) (upholding Forest Service compliance with MIS regulations despite serious problems with underlying data).

273. *See, e.g.*, Thomas O. McGarity, *Some Thoughts on "Deossifying" the Rulemaking Process*, 41 DUKE L.J. 1385 (1992) (developing concept of rulemaking "ossification" in which significant procedural requirements and judicial review deter agencies from productive action). This is not to say that statutory monitoring requirements might not be useful to the extent they have political power to encourage agencies to conduct more monitoring by highlighting the importance of the task. And judicial enforcement of those monitoring requirements may be a "second-best" alternative if other solutions are not available. *See* Stephenson, *supra* note 185, at 360–71 (showing that where a court requires an agency to collect research in order to undertake an action the agency seeks to pursue, the incentives for the agency to collect information increase substantially).

274. *See* Jeffrey Rudd, *The Forest Service's Epistemic Judgments: Enhancing Transparency to Ensure "New Knowledge Informs" Agency Decision-Making Processes*, 23 TEMP. ENVTL. L. & TECH. J. 145, 216–21 (2004).

275. *Cf.* Wagner, *supra* note 71, at 1325 (discussing the excessive use of information and related information costs as a means of gaining control over regulatory decision making in informal rule makings).

Alternatively, one could require near absolute deference by courts to agency decisions, such that additional information will not increase the risk of a court overturning the agency decision.[276] The problem here is that the risk of judicial review is not the only factor that leads agencies to be reluctant to pursue effective monitoring—there may be other reasons agencies avoid monitoring.[277] Moreover, complete deference for agency decisions may have other costs that outweigh any benefits from improved monitoring programs.

4. Congress

Another possibility is that closer congressional supervision of agency monitoring might help improve an agency's incentives to monitor. GAO reports have provided important information about the weaknesses of individual agency monitoring programs.[278] However, Congress faces somewhat similar institutional capacity problems as the courts. There are limits on the type and amount of oversight Congress can do for monitoring programs and that oversight tends to focus on more glamorous activities than ambient monitoring:[279] GAO reports

276. *See* Stephenson, *supra* note 185, at 375–77.

277. *See supra* Part II.B.

278. *See* sources cited *supra* note 83.

279. After all, there are only 535 members of Congress, all with the entire federal bureaucracy to oversee, and a wide range of other activities to undertake besides oversight. *See* CHRISTOPHER H. FOREMAN, JR., SIGNALS FROM THE HILL 18–19 (1988) (noting the necessity of selectivity in Congressional oversight activities given the scale of bureaucracy and the size of Congress). It is for these reasons that scholars have contended that the dominant methodology by which Congress oversees the bureaucracy is reacting to complaints from constituents (responding to "fire alarms"), as it is far more cost-effective than regular "police patrols." *See, e.g.*, Mathew D. McCubbins & Thomas Schwartz, *Congressional Oversight Overlooked: Police Patrols Versus Fire Alarms*, 28 AM. J. POL. SCI. 165 (1984). Since monitoring is difficult for outsiders to evaluate in terms of effectiveness and is a low-profile activity, there may be little ability or willingness for outsiders to identify problems with monitoring programs and bring them to the attention of Congress; this would systematically skew oversight against finding problems with monitoring. *See generally* Hugo Hopenhayn & Susanne Lohmann, *Fire-Alarm Signals and the Political Oversight of Regulatory Agencies*, 12 J.L. ECON. & ORG. 196 (1996) (describing how asymmetric information may skew the political oversight of agencies). Thus, even with evidence that Congress does do substantial oversight, *see generally* JOEL ABERBACH, KEEPING A WATCHFUL EYE (1990), there is good reason to believe that this oversight would not focus on ambient monitoring and would not be effective in doing so, *see id.* at 109–12, 120–21, 199–201 (noting how Congressional oversight tends to focus on activities that provide political rewards for Congressmen, such as scandals or policy disputes with the agency).

on the topic, for instance, are intermittent.[280] While Congress may have access to more expertise than courts, it is nonetheless unlikely that Congress will ever be able to build up sufficient expertise in a wide range of technical areas related to monitoring to serve as an effective overseer. And finally, to the extent that Congress is a major source of the political and budgetary constraints for monitoring, it seems unlikely that Congress can be counted on to make the problem better, as opposed to worse.[281]

C. Restructuring Agencies to Create Incentives for Monitoring

Instead of trying to work with agencies as they are, or relying on other institutions instead of agencies, we might try to fundamentally restructure agencies in order to increase the incentives for monitoring. Agencies may have greater continuity than citizen groups, courts, or Congress, and greater expertise than all three as well. The most promising option here would be to consider the creation of separate agencies whose primary goal is monitoring.

1. The Advantages of Creating New Monitoring Agencies

If a main challenge is the potential conflict between monitoring and an agency's other goals, an agency focused primarily on monitoring might be an improvement.[282] A separate monitoring agency might have been less susceptible than the BLM to cutting wildlife monitoring in order to pursue oil and gas development, since that kind of development would have been outside the scope of the agency's mandate. While there are few examples of a pure monitoring stand-alone agency in the environmental context, there are a number of agencies where monitoring is a primary goal, and where monitoring has relatively little conflict with other goals. For

280. Since August 1, 1995, only thirteen of the last 150 GAO reports that discuss the BLM touch upon the question of ambient environmental monitoring. U.S. GOVERNMENT ACCOUNTABILITY OFFICE, http://www.gao.gov (follow "Reports & Testimonies" hyperlink; then search for reports that discuss BLM).

281. *See supra* Part II.A.1.

282. Others have made similar proposals. *See* ACKERMAN ET AL., *supra* note 71, at 156–61; Doremus, *supra* note 53, at 81; Doremus, *supra* note 66, at 458; Shapiro & Steinzor, *supra* note 83, at 1775–77.

instance, USGS contains a substantial amount of the environmental monitoring activity within the federal government, and its other tasks (primarily conducting scientific research for the federal government on a range of natural resource issues)[283] do not directly conflict with that monitoring role. Separation or institutional independence is not determined by the organizational chart: Agencies that are formally separate may in practice be closely intertwined and subunits within a larger agency may, in effect, be quite independent because of internal politics, budgeting, agency culture, or other factors. [284]

A separate agency need not conduct the monitoring itself in order to improve monitoring. For instance, the FWS's role in the ESA consultation process can substantially improve monitoring by other federal agencies. In the consultation process, other federal agencies have to develop an analysis of proposed federal actions to ensure that those actions will not seriously harm endangered species.[285] FWS reviews that analysis and then produces a biological opinion that agrees or disagrees with the acting agency's analysis.[286] That opinion is, for all practical purposes, determinative because of the potential for judicial review.[287] FWS's separate analysis plus judicial enforcement create strong incentives for the action agency to produce substantial data to ensure that consultation will reach a positive result.[288] For example, ESA litigation in the late 1990s over the impacts of Forest Service grazing activities in the Coronado National Forest (CNF) on endangered species forced consul-tation with FWS, which in turn demanded more monitoring data to ensure that listed species were not harmed.[289] As a result, the Forest Service restarted its monitoring program.[290] Unlike judicial review of agency monitoring, a supervising agency such as FWS has a significant expertise advantage in overcoming the opacity of monitoring, and, so long as the consultation or review is for a

283. *See* U.S. GEOLOGICAL SURVEY, U.S. DEP'T OF THE INTERIOR, FACING TOMORROW'S CHALLENGES—U.S. GEOLOGICAL SURVEY SCIENCE IN THE DECADE 2007–2017 (2007).

284. *Cf.* WILSON, *supra* note 198, at 92.

285. *See* 16 U.S.C. § 1536(a) (2006).

286. *Id.*

287. *See* Bennett v. Spear, 520 U.S. 154, 169–70 (1997).

288. *See* Buzbee, *supra* note 30, at 596–97.

289. *See generally* SAYRE ET AL., *supra* note 58.

290. *See id.*

repeated or ongoing activity (as with the grazing monitoring in the CNF), it can address the problems with continuity much better than courts can because review is built into the administrative process, rather than being dependent on a separate lawsuit.[291]

With a separate agency, we have the advantages of continuity (because we have a public institution, which is usually fairly long-lived);[292] we have the advantages of expertise (because the agency primarily focuses on monitoring); and we have an institution with an incentive to conduct effective monitoring (because of administrative separation from other potentially conflicting activities).[293]

There are also potential political benefits of a separate monitoring agency. A large organization that combines monitoring with other tasks might, if budget cuts come, cut monitoring budgets disproportionately in order protect other, higher-profile or preferred jobs.[294] And, of course, cuts may be worse to the extent that monitoring is disfavored within an agency (perhaps because of potential conflicts with the agency's mission).[295] For instance, the federal agencies responsible for Earth observation satellites have a wide range of activities they pursue besides monitoring, and therefore, did not have the

291. Unfortunately, many activities that go through ESA consultation are not repeated or ongoing, and, in these cases, consultation may not provide significant advantages for monitoring. *See* sources cited *supra* note 263.

292. There is some disagreement over exactly how long public agencies actually stay around. *Compare* HERBERT KAUFMAN, ARE GOVERNMENT ORGANIZATIONS IMMORTAL? 34 (1976) (finding that from the mid-1920s to the mid-1970s, 85% of government agencies continued to exist in some form and 62% had existed in virtually the same form), *with* David E. Lewis, *The Politics of Agency Termination: Confronting the Myth of Agency Immortality*, 64 J. POL. 89, 89 (2002) (finding that 62% of agencies created since 1946 have been terminated). Even with the lower numbers, however, public agencies likely have a much greater life expectancy than private organizations.

293. In envisioning using agencies to fill specific roles in a larger, integrated administrative structure, rather than as the primary locus of the decisionmaking process, the proposal is similar to the "modular regulation" concept developed by Jody Freeman and Dan Farber. *See generally* Jody Freeman & Daniel A. Farber, *Modular Environmental Regulation*, 54 DUKE L.J. 795 (2005). Freeman and Farber emphasize how modularity can improve information acquisition and use. *See id.* at 824–25, 846 (citing an example from joint federal-state management of the California Delta).

294. *See* Peter Szanton, *So You Want to Reorganize the Government?*, *in* FEDERAL REORGANIZATION 1, 13 (Peter Szanton ed., 1981); *supra* Part II.A.2.

295. JONATHAN B. BENDOR, PARALLEL SYSTEMS: REDUNDANCY IN GOVERNMENT 254–56 (1985); *supra* Part II.B.2.

same institutional incentives to avoid budget cuts to monitoring.[296]

But if the only activity the agency pursues is monitoring, then there is no such possibility for a trade-off. In order to ensure its institutional survival, the agency has to maintain its monitoring budget. And government agencies tend to fight hard for institutional survival.[297] A separate monitoring agency might fight for more consistent funding over time, and resist some of the short-term efforts to cut monitoring budgets.

Finally, there is one additional potential political benefit from the creation of a separate monitoring agency—it might be able to develop a reputation as an "unbiased" provider of information that is untainted by institutional connections to a regulatory or management agency. In other words, its data might be more credible, and its funding might be more secure, precisely because the staff who conduct monitoring do not have an institutional stake in regulatory or management decisions.[298]

2. The Disadvantages of a Separate Monitoring Agency

Perhaps the largest disadvantage of separating monitoring activities is the institutional distance it might create between the regulatory or management decision-makers and those conducting monitoring. Monitoring is often more effective and efficient if it is closely coordinated with the decisions that monitoring is supposed to inform.[299] For instance, a major

296. *See* Bohan, *supra* note 9 (noting that Earth observation satellites are managed by NASA, the Department of Defense, and NOAA).

297. *See* WILSON, *supra* note 198, at 58 (noting that members of an organization "will try to defend and advance the interests of their parent organization[s]" and that organizations will look to solve "organizational maintenance problem[s]" by finding roles for the organization to fulfill).

298. Regulated industry might be more suspicious of monitoring conducted by a regulatory agency that is perceived to be seeking data to justify more regulation; environmental groups might be more suspicious of monitoring conducted by a management agency that is perceived to be seeking data to justify new development projects.

299. *See, e.g.*, Davis, *supra* note 93, at 101 (noting that monitoring is "best managed by site managers and conducted by resource specialists"); David B. Lindenmayer & Gene E. Likens, *Adaptive Monitoring: A New Paradigm for Long-Term Research and Monitoring*, 24 TRENDS IN ECOLOGY & EVOLUTION 482, 482–83 (2009); Nichols & Williams, *supra* note 123, at 668, 672 (arguing that targeted (or focused) monitoring that is directly connected to management questions is much more effective and efficient than "omnibus surveillance monitoring" without

concern agency managers and scientists expressed about NBS's creation was the potential disconnect between scientists and resource managers, such that the questions of interest to managers would not be addressed by scientists, and managers would not be aware of the information that scientists were producing.[300] Close consultation can avoid waste that might arise if the monitoring is either too precise (with unnecessary measurements) or not precise enough (such that the monitoring program cannot help answer the relevant management question).[301]

There are two political problems with separation. First, it may be politically easier to fund monitoring programs if their relevance is clear. And that relevance may be more obvious to the extent that the agency that will use the information is conducting the monitoring.

Second, a larger agency just may be better able to get its way in terms of total funding, and this might help the funding of monitoring despite the risk that the agency might disproportionately cut monitoring.[302] Isolated, small agencies might have more of a challenge making their case heard for funding in the budgetary process, particularly if they do not

---

a clear management connection); David G. Silsbee & David L. Peterson, *Planning for Implementation of Long-Term Resources Monitoring Programs*, 26 ENVTL. MONITORING & ASSESSMENT 177, 179 (1993).

300. Stone, *supra* note 144, at 976; Wagner, *supra* note 147, at 221. Similar criticisms have been made of the GCMRC. *See* Susskind et al., *supra* note 166, at 23, 45–46. Another example is the dysfunction created by the separation of the monitoring and research functions of the National Institute for Occupational Safety and Health from the regulatory functions of the Occupational Safety and Health Administration. *See* TED GREENWOOD, KNOWLEDGE AND DISCRETION IN GOVERNMENT REGULATION 116–18 (1984).

301. LEE, *supra* note 66, at 179; Kevin A. Roberts, *Field Monitoring: Confessions of an Addict*, *in* MONITORING FOR CONSERVATION AND ECOLOGY 179, 180 (F.B. Goldsmith ed., 1991).

302. A larger agency might have more stability in terms of overall funding but more volatility in terms of funding for monitoring specifically, and a smaller agency might have the reverse problem. For instance, a larger agency's overall budget might be $100 billion plus or minus $1 billion (a 1% variance) while the smaller agency's overall budget might be $5 billion plus or minus $500 million (a 10% variance). Reciprocally, the larger agency's monitoring budget might vary from .5% to 5% of its overall budget (from $500 million to $5 billion) while the smaller agency's monitoring budget might be consistently 20%. Whether monitoring will be better provided for in the larger or smaller agency will depend on which factor is more important for monitoring budgets: variance in the overall budge or variance in the monitoring budget (e.g., the larger agency's monitoring budget ranges from $500 million to $5 billion because of the variance in monitoring budgets, while the smaller agency's monitoring budget ranges from $900 million to $1.1 billion (20% of $4.5 to $5.5 billion)).

have strong outside clients who support the agency's mission.[303] The larger the number, or the more politically powerful the clients of an agency are, the more support there will be for the program as a whole, including monitoring. The Fish Passage Center might have been so politically vulnerable to retaliation by a single senator through the appropriations process precisely because the area of its work was so narrow, and the number and power of its clients so limited.[304]

3. Synthesis

a. Coordination vs. Independence

We must make a trade-off between the relative importance of coordination versus the reduction of conflicts between monitoring and management. Resolving that trade-off will depend on the particular context of the resources being monitored and the interaction between monitoring and other management or regulatory goals.

One tentative hypothesis is that regulatory agencies might have fewer conflicts between most kinds of monitoring and other goals than management agencies. Regulatory agencies are more likely to be organized around an agency mission of identifying environmental problems that require regulatory

303. Harold Seidman, *A Typology of Government*, *in* FEDERAL REORGANIZATION: WHAT HAVE WE LEARNED? 33, 41–43 (Peter Szanton ed., 1981) (noting that independent agencies can be isolated and weak); *see* Fortmann, *supra* note 226, at 362–64 (summarizing literature on how supporting and developing clients may increase agency's political power).

304. Another possible example of the weaknesses of small, stand-alone monitoring agencies is the Agency for Toxic Substances and Disease Registry (ATSDR), a part of the Department of Health and Human Services (HHS) that was created, in part, to monitor health impacts at hazardous waste sites around the country; its other primary roles are to conduct research and produce reports on the potential health impacts of toxic substances. *See* Rebecca Renner, *Health Agency Accused of Overlooking Environmental Threats to Public*, 2009 ENVTL. SCI. & TECH. 3989. Despite its relative independence, the ATSDR has been criticized as being too friendly to industry in its work and conducting sloppy monitoring and research programs. *Id.*; *see also* STAFF OF H. SUBCOMM. ON INVESTIGATIONS AND OVERSIGHT OF THE COMM. ON SCI. AND TECH., 111TH CONG., REP. ON THE AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY (ATSDR): PROBLEMS IN THE PAST, POTENTIAL FOR THE FUTURE? (Comm. Print Mar. 10, 2009). The problem in the case of the ATSDR is that its small size may have left it vulnerable to budget pressures and administrative indifference within HHS. *Id.* at 2–3 (describing how other agencies sought to subvert ATSDR's work).

solutions[305] and would more likely need monitoring data in order to justify new regulations against legal or political challenges. Management agencies are more likely to be focused around missions that involve development projects rather than environmental goals,[306] and, therefore, monitoring data are more likely to raise the risk of identifying new or emerging environmental problems that might interfere with proposed development activities.[307]

Another tentative hypothesis is that certain activities require less coordination between monitoring and management, and therefore might be more amenable to separation—for instance, the imposition of strict environmental standards. There is no need to tailor the monitoring program to the particulars of the individual management decisions since the standards must be met regardless.[308] On the other hand, if the object is to measure whether a particular management option has achieved environmental quality goals, then it may be crucial to calibrate the monitoring program to the specifics of the management option selected and the goals to be achieved.[309]

At least tentative evidence from some large ecological restoration projects in the United States indicates that more independence improves monitoring as long as minimal coordination exists. For instance, the restoration efforts for both the Colorado River in the Grand Canyon below Glen

305. An example is the federal Environmental Protection Agency, which has a reputation of pushing for environmental regulation. *See* Biber, *supra* note 192, at 46–50 (describing battles between the EPA and economists in the Office of Management and Budget over the cost-effectiveness of proposed EPA regulations).

306. For example, the Bureau of Land Management has a reputation of encouraging development. *See supra* notes 203–04 and accompanying text.

307. There may be regulatory agencies that might be wary of imposing additional regulation or that might see additional monitoring data as potentially threatening to their efforts to impose new regulation. Likewise, there may be management agencies that are committed to environmental conservation as a primary mission (such as, arguably, the National Park Service) and therefore might seek more monitoring data.

308. The ESA consultation process can be seen as an example of strict outside constraints (do not jeopardize the existence of listed species) that are imposed on management agencies (e.g., federal land management agencies).

309. For instance, in the Chesapeake Bay restoration program, coordination between management efforts to improve water quality through various "best management practices" and the monitoring program was essential. Without knowing where the management efforts might occur, and what the goals of those projects were, the design of effective monitoring programs would have been impossible. *See* sources cited *supra* note 120; *see also supra* text accompanying note 122.

Canyon Dam and for the Everglades have received praise for the quality of the monitoring work that they have conducted.[310] Both have relatively independent monitoring organizations.[311] By contrast, the monitoring for the Chesapeake Bay Program has been strongly criticized, and its monitoring group is integrated into the overall hierarchy of the program.[312]

b. Political Feasibility

But is it politically feasible to create stand-alone monitoring agencies in the first place? There is the benefit of the perception (if not reality) of an "unbiased" monitoring-only agency that can assure more funding and less political interference, but that benefit might often be outweighed by the twin risks of the agency being portrayed as either focusing on highly abstract, irrelevant studies that have no connection to reality, or providing politically dangerous information. The experience of the NBS—being eliminated by a hostile Congress that perceived it as a tool to increase regulation—highlights that second risk. It might be that the opponents of the NBS knew all too well how successful a stand-alone monitoring

310. *See* NAT'L RESEARCH COUNCIL, PROGRESS TOWARD RESTORING THE EVERGLADES: THE SECOND BIENNIAL REVIEW 194–212 (2008); NAT'L RESEARCH COUNCIL, ADAPTIVE MANAGEMENT FOR WATER RESOURCES PROJECT PLANNING 78–80 (2004).

311. *See* NAT'L RESEARCH COUNCIL, PROGRESS TOWARD RESTORING THE EVERGLADES: THE SECOND BIENNIAL REVIEW, *supra* note 310, at 72 (overview of structure of Everglades restoration program); Programmatic Regulations for the Comprehensive Everglades Restoration Plan, 67 Fed. Reg. 50,540, 50,543 (Aug. 2, 2002) (description of Everglades monitoring program); Restoration Coordination and Verification ("RECOVER"), 33 C.F.R. § 385.20 (2010) (federal regulations creating an Everglades monitoring program); *see* sources cited *supra* notes 75, 300 (describing the GCMRC); *see also* NAT'L RESEARCH COUNCIL, ADAPTIVE MANAGEMENT FOR WATER RESOURCES PROJECT PLANNING, *supra* note 310, at 66–68 (positive description of monitoring program for Upper Mississippi River restoration, also run by a relatively independent organization that is part of USGS). The monitoring programs for the Glen Canyon and the Upper Mississippi are relatively more independent, while the program for the Everglades is still overseen by the state and federal agencies conducting the restoration. However, the fact that the Everglades monitoring program has a separate mandate and authorization in federal regulations might give it more institutional autonomy than an agency that is an administrative component of a larger organization without any separate legal basis, as in the Chesapeake Bay restoration program.

312. *See* U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-06-96, CHESAPEAKE BAY PROGRAM: IMPROVED STRATEGIES ARE NEEDED TO BETTER ASSESS, REPORT, AND MANAGE RESTORATION PROGRESS 11–12, fig.3 (2005) (the monitoring program at the time was a subcommittee of the implementation committee of the overall CBP); *see also supra* notes 122, 191.

agency might be in developing better information about endangered species and therefore justifying expanded ESA protections for habitat and wildlife.

There are separate organizations that have survived the political gauntlet, such as the monitoring programs for the Grand Canyon and Everglades restoration efforts. The difference might be that these organizations were created as part of a larger ecological restoration project that was itself politically popular and did not have nearly the same high-profile posture as the NBS. For instance, the Glen Canyon Monitoring and Research Center is part of USGS.[313] Another possibility is that a monitoring agency created slowly over time is less politically vulnerable. For instance, Natureserve developed its network of biodiversity monitoring programs around the United States over a period of years, rather than through a major legislative effort in Congress (as with the NBS).[314]

To address the risk that small, isolated monitoring agencies might not have significant political clout, one could combine a range of monitoring activities into one single agency, rather than having a number of separate monitoring agencies conducting different monitoring activities.

Another solution might be to change the perception of how monitoring might benefit various interest groups. To the extent that the results of monitoring information are seen as not necessarily helping or hurting particular political actors ex ante, there might be less resistance. For instance, improved monitoring might lead to less regulation by reducing uncertainty about the status of an environmental resource or by providing evidence of improving conditions for the resource.[315]

Finally, broad participation of actors in deciding what resources to measure and how to measure them may help build trust in the monitoring program and reduce political opposition. These community-based or collaborative monitoring programs might increase support by reassuring the various

313. *See* Susskind et al. *supra* note 166, at 23.

314. *See supra* note 80.

315. *See, e.g.*, Leah R. Gerber et al. *Gray Whales and the Value of Monitoring Data in Implementing the U.S. Endangered Species Act*, 13 CONSERVATION BIOLOGY 1215 (1999) (showing the importance of monitoring data in demonstrating improved status of species and justifying a reduction of regulatory protection); *see also* Davis, *supra* note 93, at 99–100; Doremus, *supra* note 66, at 458–59.

stakeholders that the questions they believe are relevant for management decisions are being explored.[316]

c. Collaboration and Redundancy

One way to reduce coordination problems would be to provide some formal or informal connections between the monitoring agency and the relevant management or regulatory agencies. Of course, all the problems with collaboration outlined above would apply here. The management or regulatory agency might be more willing to cooperate if some sort of approval from the monitoring agency is required for the management or regulatory agency to initiate certain actions, similar to the ESA.[317]

Another option would be to allow the management or regulatory agency to conduct its own monitoring. If a management or regulatory agency concluded that the monitoring program implemented by the separate agency was not adequately answering the relevant questions, it could initiate its own monitoring program. The result would be redundant monitoring, and while redundancy may be a waste of resources,[318] it can also provide benefits. Redundancy can create resilience in an organizational system. For instance, we might be concerned that ineffective monitoring programs might miss important, emerging environmental problems. Multiple programs can reduce that risk, assuming that each program is relatively independent of the other.[319] If we set up multiple, redundant monitoring programs across different agencies, and

316. *See* Finn Danelsen et al., *Local Participation in Natural Resource Monitoring: A Characterization of Approaches*, 23 CONSERVATION BIOLOGY 31, 38 (2008); Ross Johnson, *What Does It All Mean?*, 26 ENVTL. MONITORING & ASSESSMENT 307, 311 (1993).

317. *See* 16 U.S.C. § 1536(a)(2) (2006) (requiring FWS approval for federal agency actions that might jeopardize species protected under the ESA).

318. BENDOR, *supra* note 295, at 29–32; Anne Joseph O'Connell, *The Architecture of Smart Intelligence: Structuring and Overseeing Agencies in the Post-9/11 World*, 94 CAL. L. REV. 1655, 1679–80 (2006). Analysis of collected information—along the lines of FWS participation in the ESA consultation process—might be the area most suited for redundancy, given relatively low costs for redundant analysis and the risk of missing important insights. *See* O'Connell, *supra*, at 1689–90.

319. BENDOR, *supra* note 295, at 44–54, 248 tbl.5. The creation of multiple monitoring programs in different agencies would increase their independence from one other.

if any one monitoring program detected a potential problem, then further action could be taken.[320]

Potentially offsetting these benefits is the risk that with multiple actors responsible for the same problem, each agency seeks to free ride on the efforts of the other agencies, resulting in less overall effort.[321] That risk can be reduced if a separate monitoring agency is given clear authority to monitor (making it at least partially accountable for any monitoring failure) and if other agencies that might have an interest in conducting monitoring (such as a management or regulatory agency) perceive themselves as competing to provide more accurate information than the monitoring agency.[322] For instance, if the regulatory agency is dissatisfied with the information being produced by the monitoring agency, then it will have an incentive to produce its own information to protect itself in the judicial or political process.

4. An Intriguing Example: USGS

As a way of tying these different points together, I turn to an emerging example in the federal government of an independent monitoring agency—USGS. Historically, USGS was an agency focused on mapping and geological research and had a strong reputation.[323] Over the decades, USGS has expanded into research on water quantity and quality, land-use changes, and, since the absorption of NBS in the 1990s,

320. O'Connell, *supra* note 318, at 1678–79. This is one of the key characteristics scholars have identified in successful "high reliability organizations." *See* La Porte, *supra* note 228, at 63–64. One problem with this solution is that it might increase the risk that non-existent problems are "identified" by various monitoring programs—the management and monitoring responses to such warnings must take into account the increased probability of such errors. O'Connell, *supra* note 318, at 1682.

321. O'Connell, *supra* note 318, at 1679–80; Michael M. Ting, *A Strategic Theory of Bureaucratic Redundancy*, 47 AM. J. POL. SCI. 274, 275 (2003); *see generally* William W. Buzbee, *Recognizing the Regulatory Commons: A Theory of Regulatory Gaps*, 89 IOWA L. REV. 1 (2003).

322. *See* Stephenson, *supra* note 270, at 1461–82 (noting that free-rider problems may be less severe in contexts where agencies are in competition with each other); *see generally* Mathias Dewatripont & Jean Tirole, *Advocates*, 107 J. POL. ECON. 1 (1999) (same); Sean Gailmard & John Patty, *Stove Pipes: A Theory of Internal Design* (2010) (unpublished paper on file with author) (developing a model that shows, under certain circumstances, that competition among multiple agencies can result in increased production of information).

323. Preston Cloud, *The Improbable Bureaucracy: The United States Geological Survey, 1879–1979*, *in* 124 PROCEEDINGS AMERICAN PHIL. SOC'Y 155 (1980).

biological resources.[324] In the past ten to fifteen years, USGS has conducted more monitoring activities and has pitched itself to Congress and the public as, in part, a leading provider of environmental monitoring services.[325] The prominence of monitoring in USGS's portfolio of activities might give it an institutional incentive to protect monitoring budgets to a greater degree than other agencies for whom monitoring is less important.[326]

Politically, USGS does not have any significant management or regulatory responsibilities and consequently markets itself as impartial.[327] As an agency that provides an array of services to private and public entities,[328] it has developed a large and growing clientele within and outside government that has benefited from its research, survey, and monitoring activities, such as the mining and oil and gas industries.[329] With a wide range of monitoring activities and

---

324. *See* U.S. GEOLOGICAL SURVEY, FACING TOMORROW'S CHALLENGES—U.S. GEOLOGICAL SURVEY SCIENCE IN THE DECADE 2007–2017: U.S. GEOLOGICAL SURVEY CIRCULAR 1309 (2007).

325. *See* PAUL V. DRESLER ET AL., U.S. GEOLOGICAL SURVEY, STRATEGIC PLAN FOR THE U.S. GEOLOGICAL SURVEY STATUS AND TRENDS OF BIOLOGICAL RESOURCES PROGRAM: 2004–2009—U.S. GEOLOGICAL SURVEY, BIOLOGICAL RESOURCES DIVISION, CIRCULAR 1277 iv (2004) (goal is to create "an integrated and focused effort to address identified monitoring information needs"); *id.* at vii ("At the heart of [the USGS Status and Trends of Biological Resources Program] are its existing monitoring activities.").

326. For instance, USGS's overall budget (primarily for research and monitoring) appears to vary to a smaller degree than the comparable research and monitoring budget for EPA. *Compare U.S. Geological Survey and Environmental Protection Agency FY 2008 Budget Request: Hearings Before the Subcomm. on Interior, Environment, and Related Agencies of the S. Comm. on Appropriations*, 110th Cong. fig.1 (2007) (testimony of Craig M. Schiffries, Senior Scientist, National Council for Science and the Environment) (USGS budget from 1996 to 2008 ranging between $ 1.1 billion and $950 million) *with id.* fig.2 (EPA budget from 1996 to 2008 ranging between $550 million and $800 million). Of course, even these variations pose challenges to USGS. For instance, its National Water Quality Assessment Program (NAWQA) had to reduce the number of study units in 2001 and reorient its research approach in response to funding cuts. U.S. GEOLOGICAL SURVEY, THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM—ENTERING A NEW DECADE OF INVESTIGATIONS: USGS FACT SHEET 071-01 (2001).

327. STATUS AND TRENDS, *supra* note 84, at v (USGS's biological research and monitoring program provides "unbiased, independent, integrated information about plants and animals"); U.S. GEOLOGICAL SURVEY, *supra* note 324, at 1 ("The USGS does not have regulatory or land-management responsibility and has a worldwide reputation for objective, unbiased science.").

328. *See* U.S. GEOLOGICAL SURVEY, *supra* note 324.

329. *See, e.g.*, Paul A. David & Gavin Wright, *Increasing Returns and the Genesis of American Resource Abundance*, 6 INDUSTRIAL & CORPORATE CHANGE 203, 223–29 (1997). The incentives discussed *supra* Part II that might cut against an agency's desire to conduct monitoring appear to be outweighed in the context of

clients, USGS might reduce the risk of political isolation. Finally, USGS's gradual growth has reduced the political risks associated with the full-blown creation of a new monitoring agency (as with NBS).

A possible challenge is that USGS does conduct other activities besides monitoring, primarily scientific research. It is fair to say that one of USGS's primary self-conceptions is as a science agency.[330] Scientific research does not usually result in direct conflicts with monitoring activities. But, as noted above, there is a risk that scientists might see monitoring as "not scientific" and not leading to professional recognition or advancement. USGS scientists generally are more closely tied to their respective disciplinary organizations than their compatriots in other government agencies and seem to believe that USGS emphasizes scientific professional engagement, recognition, and advancement.[331]

The risk, then, is that USGS will underperform in conducting effective monitoring because the scientists within the agency do not value it professionally. To its credit, USGS has itself acknowledged that USGS scientists may be reluctant to undertake monitoring programs and has emphasized that "these perceptions" that monitoring is not suitable for scientists "should change."[332] Time will tell the success of those efforts.[333]

---

the USGS by the political benefits of expanding its political support by building client relationships with a wide range of public and private entities with monitoring data. That does raise the risk that USGS might be tempted to skew its monitoring data to continue to keep those clients happy, but the wide and diverse range of clients that USGS serves might reduce that risk.

330. U.S. GEOLOGICAL SURVEY, *supra* note 324, at 1 (describing the agency as "world's leading natural science and information agency" with "nearly 9,000 scientists and support staff"). Output measures for many USGS programs include the number of peer-reviewed publications. *See, e.g.*, U.S. GEOLOGICAL SURVEY, WILDLIFE: TERRESTRIAL AND ENDANGERED RESOURCES PROGRAM, 5-YEAR PROGRAM PLAN FISCAL YEARS 2005–2009, at 13–20 (2004).

331. A survey of USGS and FWS biologists found that USGS biologists were more likely to be members of relevant scientific professional organizations, and this was in part a result of the greater support in USGS for professional orientation and a greater focus among USGS biologists on maintaining research skills. T. Bruce Lauber et al., *Factors Influencing Membership of Federal Wildlife Biologists in the Wildlife Society*, 73 J. WILDLIFE MGMT. 980, 986 (2009) ("The USGS is a research agency, whereas USFWS is a management and regulatory agency.").

332. *See* DRESLER ET AL., *supra* note 325, at 6.

333. Another risk is the possibility that USGS will become isolated from the management agencies that are the prime clients for its monitoring programs, reducing the effectiveness of those programs. USGS has emphasized collaborations with management agencies, perhaps in an effort to reduce this risk.

The discussion in this Part is only tentative, and there is a great deal of room for additional research here: Has USGS been and will it be successful in conducting effective monitoring? What kinds of cross-institutional comparisons could we make among the various large-scale ecosystem restoration programs in the Everglades, Chesapeake Bay, Grand Canyon, and elsewhere to learn more about whether and why effective monitoring can be successfully pursued? Are separate monitoring agencies really more effective or not? Moreover, there is also a great deal of work to be done to apply the general principles in this paper to the tremendously diverse range of environmental resource management problems, each with their own ecological, economic, and political context. The monitoring problems and solutions will be very different in the context of clean air versus range management. But, to this point, there has been almost no research on these kinds of questions, questions that are essential to a successful transition to a new world of adaptive ecosystem management.

CONCLUSION

The term "environment" can refer to the natural environment, and that is the usual meaning in environmental law. But it has a broader meaning—the context in which any activity takes place. Thus, the problem of environmental monitoring—of monitoring ambient, systemic conditions—is not just a problem for environmental law. It is a problem for any field of regulatory law.

The immediate trigger of the recent financial crisis was a series of dramatic changes in the global financial environment,[334] changes potentially caused by the problems of "systemic risk," (the possibility that the interconnections among different financial actors allow for the transmission and amplification of risk across institutional and international boundaries).[335] The analogy with ambient environmental

Id. at vi (stating that the strategic plan looks to "increas[e] communication, cooperation, and collaboration . . . in biological resource monitoring").

334. See ANDREW ROSS SORKIN, TOO BIG TO FAIL: THE INSIDE STORY OF HOW WALL STREET AND WASHINGTON FOUGHT TO SAVE THE FINANCIAL SYSTEM FROM CRISIS—AND THEMSELVES (2009), for an entertaining description of how those changes triggered the crisis.

335. See Olivier de Bandt & Philipp Hartmann, *Systemic Risk: A Survey*, (European Cent. Bank Working Paper Series, Working Paper No. 35, 2000), for an overview of the concept.

conditions is strong. In both cases, the focus is on systemic problems at a scale larger than that of an individual actor. Both problems require the gathering of tremendous amounts of data from large numbers of actors or locations (data about biotic and abiotic conditions in the natural environment in one case, data about a tremendous number of financial transactions in the other case).[336] And, in both cases, analysis and prediction will be complicated by the potential for interaction with exogenous changes or shocks (interaction of human pollution with biotic and abiotic systems in one case, the possibility of changes in underlying economic, political, or social conditions that affect the values of assets in the other case).

As with environmental law, ongoing, continuous monitoring of the financial environment will be important, if only because no one can know when a rapid rise in systemic risk might occur. The complexity and difficulty of assessing the effectiveness of systemic risk monitoring mimics the same challenges in environmental law; the uncertainty of any assessments as to the quality of the monitoring data parallel the same uncertainties in environmental law. Thus, the principles developed in this Article in the context of environmental law—the need to develop trust in the institutions that conduct the monitoring, the importance of creating institutions that are motivated to conduct effective monitoring, the difficulty of forcing effective monitoring to occur—can apply in the context of finance as well. Given the conclusions of this Article about the potentially important role that independent monitoring agencies can play, Congress's decision in the recent financial reform bill to give the task of collecting and analyzing the monitoring data on systemic risk to a new agency that has at least some institutional independence seems promising.[337]

---

336. The problems of collecting monitoring data in finance might be more manageable than in the context of environmental law because the relevant financial data (e.g., transactions with other parties) are collected by individual actors in the course of doing business, while it is the rare business actor who is interested enough in the natural world to collect data (except actors reliant on the exploitation of natural resources).

337. The 2010 Dodd-Frank financial regulation statute in the United States creates a new Office of Financial Research to collect information on systemic risk; the newly created Financial Stability Oversight Council can require almost any company in the United States to provide data to the Office and will use the information and analysis of the Office to fulfill its role as the systemic risk regulator of the U.S. economy. *See* Dodd-Frank Wall Street Reform and Consumer

Whatever the regulatory field, monitoring of ambient conditions will be central to the present and future of successful regulation and management. After this Article's review of how challenging it can be to conduct effective monitoring, a reader might conclude that the law should focus more on developing legal and institutional design structures that do not depend so heavily on monitoring. For instance, in areas where monitoring is inordinately expensive (such as environmental resources where there is high variability at both small temporal and geographic scales), perhaps we should manage based on the assumption that we will not be able to act based on timely, accurate information.[338] But this might require abandoning the possibility of adaptive, flexible, or experimental regulation and returning to "rigid, inflexible, dictated" regulatory standards inconsistent with the paradigm of new governance.[339]

But we cannot know if experimentation and adaptation are successful if we cannot monitor whether management choices have improved outcomes or not. The new governance literature has argued that whatever we may lose in terms of accountability with more flexible legal standards, we can gain back with greater monitoring that can provide a foundation by which we can judge whether regulatory and management programs are succeeding.[340] Yet that literature has paid little attention to how this monitoring will occur, whether it will be successful, and whether it can fill the accountability gap that would otherwise be created by the legal flexibility that the new, dynamic, experimentalist forms of governance demand.[341] The analysis in this Article makes clear that the answers to these

---

Protection Act, Pub. L. No. 111-203, §§ 112–15, 152–53, 124 Stat. 1376, 1394–1406, 1413–16 (2010).

338. *See, e.g.*, M. Estellie Smith, *Public Policy, Sciencing, and Managing the Future*, *in* NAKED SCIENCE: ANTHROPOLOGICAL INQUIRY INTO BOUNDARIES, POWER, AND KNOWLEDGE 201 (Laura Nader ed., 1996) (questioning the feasibility of monitoring fisheries); Wagner, *supra* note 34 (arguing for reshaping EPA's stormwater regulatory program to take into account the difficulty of conducting adequate monitoring of stormwater runoff).

339. *See* Holley, *supra* note 33, at 131–34 (noting "new environmental governance" in which new governance concepts are applied to environmental law); *see also* sources cited *supra* note 19.

340. *See* sources cited *supra* notes 19, 66.

341. *See*, *e.g.*, Holley, *supra* note 33, at 143–44 (noting the importance of monitoring for accountability in new governance); Rena I. Steinzor, *The Corruption of Civic Environmentalism*, 30 ENVTL. L. REP. 10909 (2000) (criticizing advocates of "rolling rule" regulation for failing to seriously consider need for accountability).

questions are not given, that monitoring may well not fill the breach caused by the retreat of law in new governance systems.

Every substantive regulatory area will have its own unique features that will make solving the problem of environmental monitoring different. But all have this in common: Addressing monitoring is a necessary feature of successful governance, whether of the old or new variety, and policymakers will need to thoughtfully consider how to answer what is an essentially political question as they make important legal and institutional design choices. To do otherwise is to court failure.