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Camacho, Alejandro E.

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ADAPTING GOVERNANCE TO CLIMATE CHANGE: MANAGING UNCERTAINTY THROUGH A LEARNING INFRASTRUCTURE

Alejandro E. Camacho[*]

ABSTRACT

Though legislatures and agencies are considering how to prevent further climate change, some adverse effects from a warming climate are already inevitable. Adapting to these effects is essential, but regulators and scholars have largely neglected this need. This Article evaluates the capacity of natural resource governance to cope with the effects of climate change and provides a framework for Congress to help it do so.

This Article identifies unprecedented uncertainty as the paramount impediment raised by climate change and demonstrates how existing fragmented governance is poorly equipped to deal with this challenge. Drawing on lessons from prior regulatory experiments, it proposes a comprehensive strategy for managing uncertainty that promotes interagency information sharing. It also recommends that legislators adopt an "adaptive governance" framework that requires agencies to systematically monitor and adapt their decisions and programs. This learning infrastructure would promote agency learning and accountability, help manage uncertainty, and reduce the likelihood and magnitude of mistakes expected to come with facing such an exceptional problem with initially imprecise tools.

This Article operates on four levels. First, it uses case studies to illustrate valuable lessons about the challenges of creating effective natural resource management. Second, the Article is anchored in the specific implications of

[*] Associate Professor of Law, Notre Dame Law School. I would like to thank A.J. Bellia, Bill Buzbee, Robin Craig, Joe DiMento, Holly Doremus, Dan Farber, Rob Fischman, Nicole Garnett, Jessica Hellmann, Kathleen Marcus, Jason McLachlan, John Nagle, Mary Ellen O'Connell, J.B. Ruhl, Dan Tarlock, and Julian Velasco for their many helpful comments on earlier versions of this paper. I would also like to thank Dan Ashe, U.S. Fish and Wildlife Service; Chris Rose, U.S. Forest Service; Jeremy Martinich, U.S. Environmental Protection Agency; and Lisa Beever, Charlotte Harbor National Estuary Program, for their special insights on their respective programs. Dan Cory, Andrea Fowler, and Dan Podolner provided excellent research assistance.

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climate change, considering the value of interagency information sharing and adaptive governance in addressing climate effects. Third, it engages the growing theoretical literature on adaptive management and federalism. Finally, it provides insight on how agencies can manage uncertainty that has far-reaching implications for other areas of administrative regulation.

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INTRODUCTION

When a notoriously reticent but highly adaptive[1] organism like the polar bear (*Ursus maritimus*) is faced with a rapidly changing habitat due to global warming, it tries to do anything and everything to advance its survival. Well before modern industrial society released copious amounts of greenhouse gases into the atmosphere affecting the Arctic marine ecosystem, polar bears have been subject to a host of evolutionary pressures. However, like so many ecosystems throughout the globe,[2] the polar bear's ecosystem is facing a new flood of stressors that threaten its historic way-of-life—indeed, its existence. Other problems certainly exist,[3] but the most alarming obstacles to polar bear survival are strongly linked to the rapid decrease in sea ice caused by greenhouse gas-induced global warming. Polar bears depend on sea ice for feeding, travel, and shelter,[4] but ice is thinning rapidly, making food and denning less accessible and shortening the bears' hunting season.[5]

Unfortunately, even the polar bear's ability to adapt to these recent and rapid changes is limited. Reduced and thinning sea ice has led to increased drowning, starvation, weight loss, and cub mortality,[6] and some male polar

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[1] A few of the many polar bear adaptations include translucent fur for camouflage, an acute sense of smell for identifying distant food sources, a four-inch insulating fat layer, a streamlined body form for swimming, bow-legged front legs and furred paw pads for gripping sea ice, and flexible gestation periods to account for food variability. *See* U.S. Fish & Wildlife Serv., *The Polar Bear:* Ursus maritimus (2006), http://www.fws.gov/home/feature/2006/polarbear.pdf (last visited Aug. 2, 2009) (detailing traits of polar bears).

[2] *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: SYNTHESIS REPORT 31 (2007) ("Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes . . . .").

[3] *See, e.g.*, ARCTIC MONITORING & ASSESSMENT PROGRAMME, ARCTIC POLLUTION 2002: PERSISTENT ORGANIC POLLUTANTS; HEAVY METALS; RADIOACTIVITY; HUMAN HEALTH; CHANGING PATHWAYS 22 (2002) (detailing polychlorinated biphenyl contamination of polar bears).

[4] Andrew E. Derocher et al., *Polar Bears in a Warming Climate*, 44 INTEGRATIVE & COMP. BIOLOGY 163, 163 (2004).

[5] SCOTT SCHLIEBE ET AL., RANGE-WIDE STATUS REVIEW OF THE POLAR BEAR (*URSUS MARITIMUS*) 77–87 (2006).

[6] *See* ERIC V. REGEHR ET AL., POLAR BEAR POPULATION STATUS IN THE SOUTHERN BEAUFORT SEA (2006), *available at* http://pubs.usgs.gov/of/2006/1337/ (concluding that loss of sea ice off Alaska has increased the death rate for polar bear cubs); Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Polar Bear (*Ursus maritimus*) Throughout Its Range, 73 Fed. Reg. 28,212, 28,258, 28,270 (May 15, 2008) (to be codified at 50 C.F.R pt. 17) (discussing the impact of sea ice thinning on polar bears).

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bears are turning to cannibalism of females and cubs for sustenance.[7] As a result of these pressures, the U.S. Department of the Interior (DOI) designated polar bears as threatened[8] under the Endangered Species Act (ESA).[9] Similar detrimental effects are expected for a number of species throughout the Arctic marine food web.[10] Only through substantial and enduring human intervention—aggressive curbing of greenhouse gas emissions and measures that help species adapt—can the polar bear, and the ecosystem that it inhabits, continue to survive.

The perhaps well-intentioned but highly un-adaptive regulators that characteristically manage natural resources[11] in the United States are in a similarly precarious position. Like so many natural ecosystems, the network in which natural resource managers and regulators are a central constituent—environmental and natural resources law—is facing a wide array of stressors that threaten its continued (albeit far from flawless) operation. As it has since its inception, modern natural resource law is strained by myriad economic forces, situated in a polarized[12] political setting and unsettled by varying degrees of information uncertainty. This problem is exacerbated by a confounding array of regulatory fragmentation, with authority over each resource divided among many local, state, national, and international authorities.[13]

As a result of these many competing pressures, over the past several decades scholars have suggested[14]—and the U.S. Congress, the President, and

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[7] Steven C. Amstrup et al., *Recent Observations of Intraspecific Predation and Cannibalism Among Polar Bears in the Southern Beaufort Sea*, 29 POLAR BIOLOGY 997, 1001 (2006).

[8] Endangered and Threatened Wildlife and Plants, *supra* note 6, at 28,212. The World Conservation Union also designated polar bears as vulnerable. S. Schliebe et al., The IUCN Red List of Threatened Species: *Ursus maritimus* (2008), http://www.iucnredlist.org/details/22823.

[9] 16 U.S.C. §§ 1531–1544 (2008).

[10] SUSAN JOY HASSOL, IMPACTS OF A WARMING ARCTIC: ARCTIC CLIMATE IMPACT ASSESSMENT 58–60 (2004).

[11] "Natural resource" and "environmental resource" as used in this Article focus on biological resources and renewable resources on which biota depend (e.g., water and land), not extractive resources such as minerals and fossil fuels.

[12] For example, the listing of the polar bear as threatened, initiated in response to a lawsuit, has now been challenged in court. *See* Alaska v. Kempthorne, No. 1:08-cv-01352-EGS (D.D.C. filed Aug. 4, 2008).

[13] *See infra* Part III.A.

[14] *See, e.g.*, Alejandro E. Camacho, *Can Regulation Evolve? Lessons from a Study in Maladaptive Management*, 55 UCLA L. REV. 293 (2007) [hereinafter Camacho I] (assessing adaptive and collaborative governance reforms); Michael C. Dorf & Charles E. Sabel, *A Constitution of Democratic Experimentalism*, 98 COLUM. L. REV. 267, 283–84 (1998) (arguing for a "democratic experimentalism" model in which agencies determine and choose how to achieve their own goals); Jody Freeman, *Collaborative Governance in the Administrative State*, 45 UCLA L. REV. 1, 97–98 (1997) (discussing collaboration in agency decision making);

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administrative agencies have sporadically instituted[15]—a succession of regulatory reforms that have sought to adapt natural resource regulation. Because of the cacophony of pressures brought to bear on regulators, these changes have pulled natural resource governance in different directions. Some modifications may have been primarily motivated by an interest in reducing regulatory limitations on resource exploitation,[16] though many have been lauded as fostering a more effective approach to conservation.[17]

Yet because of a consistently weak commitment to regulator accountability and to improving resource management, these innovations have never been accompanied by any systematic attempt to determine whether agencies are working toward achieving conservation and other statutory goals.[18] Rather, numerous studies confirm that the most intense pressures on agencies have been political rather than scientific.[19] Existing evidence also reveals a concerted resistance to public accountability by both regulators and industry.[20]

Philip J. Harter, *Negotiating Regulations: A Cure for Malaise*, 71 GEO. L.J. 1, 112–13 (1982) (advocating negotiated rulemaking); Bradley C. Karkkainen, *Bottlenecks and Baselines: Tackling Information Deficits in Environmental Regulation*, 86 TEX. L. REV. 1409, 1439–42 (2008) [hereinafter Karkkainen I] (discussing ecosystem and place-based natural resource management); Richard H. Pildes & Cass R. Sunstein, *Reinventing the Regulatory State*, 62 U. CHI. L. REV. 1, 8–10 (1995) (detailing market-based, cost-benefit analysis and information disclosure reforms); Susan Rose-Ackerman, *Consensus Versus Incentives: A Skeptical Look at Regulatory Negotiation*, 43 DUKE L.J. 1206, 1212 (1994) (contrasting collaborative governance and market-based innovations).

[15] *See, e.g.*, Negotiated Rulemaking Procedure, 5 U.S.C. §§ 561–570 (2008) (requiring negotiation prior to official agency actions); 16 U.S.C. § 1539(a)(1)(B) (2000) (amending the ESA to allow habitat conservation plans); Regulatory Reinvention (XL) Pilot Projects, 60 Fed. Reg. 27,282 (May 23, 1995) (discussing flexibility in natural resource regulation); Pub. L. No. 106-554 § 515 app. C, 114 Stat. 2763A-153 (2000) (referred to variously as the "Data Quality Act" and the "Information Quality Act" and enacted as a two-paragraph provision in the December 21, 2001, consolidated appropriations bill, the measure requires that information disseminated by federal agencies meet "quality" standards); Exec. Order No. 12,866, 58 Fed. Reg. 51,735 (Oct. 4, 1993) (requiring regulatory impact analyses).

[16] *See, e.g.*, Holly Doremus, *Precaution, Science, and Learning While Doing in Natural Resource Management*, 82 WASH. L. REV. 547, 569 (2007) (stating adaptive management "has been used to emphasize the need to act while downplaying the role of learning").

[17] *See infra* Part III.A.2, III.B.2.

[18] *See infra* Part III.B.3.

[19] *See* OFFICE OF INSPECTOR GEN., DEP'T OF THE INTERIOR, INVESTIGATIVE REPORT ON ALLEGATIONS AGAINST JULIE MACDONALD, DEPUTY ASSISTANT SECRETARY, FISH, WILDLIFE AND PARKS (2007), *available at* http://www.doioig.gov/upload/Macdonald.pdf (finding that a DOI official edited scientific reports to discourage classification of endangered species); J.R. DeShazo & Jody Freeman, *The Congressional Competition to Control Delegated Power*, 81 TEX. L. REV. 1443, 1468 (2003) (finding political influence had a more significant effect on ESA listing and funding decisions than biological factors); Holly Doremus, *The Purposes, Effects, and Future of the Endangered Species Act's Best Available Science Mandate*, 34 ENVTL. L. 397, 402 n.21 (2004) (enumerating sources discussing how political pressures bear on listing decisions); Andrew Metrick & Martin L. Weitzman, *Patterns of Behavior in Endangered Species Preservation*, 72 LAND ECON. 1, 12 (1996) (concluding that more charismatic species receive more ESA funding); *see also* Terry M.

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Nonetheless, with varying degrees of success, natural resources and resource managers in the United States have subsisted in this disjointed environment. As for the polar bear, another wave of climatic stressors is pushing natural resource governance into unchartered territory. The best available evidence reveals that changes to almost all natural systems will be greater in orders of magnitude than those caused by any prior stressor that modern natural resource law has encountered.[21] Yet for natural resource governance, the exceptional uncertainty that arrives with global climate change is the largest challenge ever faced. In such an uncertain environment, and given the considerable expense likely to accompany any government effort to adapt to climate change, the possibility of both catastrophic damage and excessive and unproductive government regulation is very real.

Climate change necessitates a fundamental reformation of natural resource governance. The central challenge in fostering successful regulatory evolution is to cultivate the adaptive pressure on regulatory actors toward better program "fitness"—that is, achieving substantive conservation or other express[22] statutory goals rather than simply dampening or displacing political controversy. Drawing on insights from the academic literature on federalism and adaptive management, as well as lessons from existing experiments, this Article argues for the promotion of agency learning through *adaptive governance*—the systematic assessment and adaptation of management decisions and regulatory programs. In addition, legislators must establish and promote use of a shared information infrastructure that provides regulators opportunities to learn from the knowledge and experience of other regulators and respond to rapid changes in natural systems, scientific knowledge, and technology. By creating this *learning infrastructure*, legislators can

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Moe, *The Politics of Structural Choice: Toward a Theory of Public Bureaucracy*, *in* ORGANIZATION THEORY: FROM CHESTER BARNARD TO THE PRESENT AND BEYOND 116, 125–27 (Oliver E. Williamson ed., 1990) (describing a study of the Occupational Safety and Health Administration and finding that fluctuations in elected officials' preferences resulted in changes in agency policy making); Susan K. Snyder & Barry R. Weingast, *The American System of Shared Powers: The President, Congress and the NLRB*, 16 J.L. ECON. & ORG. 269, 269–70 (2000) (summarizing empirical literature on the political influence on regulation); Barry R. Weingast & Mark J. Moran, *Bureaucratic Discretion or Congressional Control? Regulatory Policymaking by the Federal Trade Commission*, 91 J. POL. ECON. 765, 792–93 (1983) (describing political influence on the implementation of policies by the FTC).

[20] *See* Camacho I, *supra* note 14, at 296.

[21] *See infra* Part I.

[22] *Cf.* Frank H. Easterbrook, *Text, History, and Structure in Statutory Interpretation*, 17 HARV. J.L. & PUB. POL'Y 61, 62–64 (1994) (providing a textualist critique of attempts to determine statutory intent or goals when not expressed by statutory text).

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significantly expand the adaptive capacity of regulatory programs to adjust to and manage unexpected and uncertain problems like climate change.

This Article proceeds in five parts. Part I briefly details the challenges raised by climate change both to natural resources and resource governance in the United States. Though existing data confirm that climate change is having and will continue to have substantial effects on a wide range of ecosystems, our knowledge of the extent and distribution of these effects is plagued with uncertainty for which there is no prior analog. This poses new problems for natural resource governance. Part II argues for the need to address these effects through comprehensive "adaptation" as a complement to climate change "mitigation."[23] It also offers a typology of adaptation strategies for addressing the effects of climate change. In particular, Part II explains the importance of managing uncertainty through "procedural" strategies that focus not on addressing the direct effects of climate change, but on adjusting *how* management decisions (and therefore adaptation decisions) are made.

Part III focuses on how two pervasive features of natural resource governance—regulatory fragmentation and inflexible decision making—hinder the capacity of agencies to respond coherently to the uncertainties of climate change. Relying on two case studies, this Part also demonstrates that the challenges of developing more effective regulation are greater than some advocates of past regulatory reforms have indicated. These proponents of adaptive and collaborative management experiments have ignored the challenges of sustained regulatory learning and shared decision making, seemingly expecting officials to confess mistakes, monitor and adapt strategies, and collaborate with other agencies despite few resources, incentives, or opportunities to do so. As a result, even recent experiments seeking to make governance more adaptive and collaborative have fallen well short of their promise. Though these limitations may have existed before the arrival of global warming, the uncertainty raised by climate change makes this

[23] An adaptation strategy "reduces the level of damages that might have otherwise occurred," while mitigation strategies act to prevent or reduce adverse climatic change, primarily through the abatement of greenhouse gas emissions. WILLIAM E. EASTERLING III ET AL., PEW CTR. ON GLOBAL CLIMATE CHANGE, COPING WITH GLOBAL CLIMATE CHANGE: THE ROLE OF ADAPTATION IN THE UNITED STATES iii (2004); *see also* WORKING GROUP II, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY 869 (M.L. Parry et al. eds., 2007) [hereinafter IPCC, ADAPTATION] (defining adaptation as the "[a]djustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (emphasis omitted)).

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disjointed and un-adaptive approach to resource management distressingly untenable.

Part IV details how very few strategies to adapt to climate change considered by legislatures and agencies in the United States really seek to reformulate regulatory processes themselves—how we choose among, and assess the effectiveness of, the many resource management alternatives. Relying on two case studies at the vanguard of natural resource governance, Part IV demonstrates how resource agencies largely continue to ignore the need for the systematic and coordinated collection and analysis of information about the performance of management decisions and regulatory programs in implementing regulatory missions.

Finally, Part V explains how the U.S. Congress and the President should alter domestic natural resources governance to manage the uncertainty of adapting to climate change.[24] This Part details the principal components of a learning infrastructure, including (1) an adaptive governance framework, which would require sustained monitoring and adjustment of regulatory decisions to assess whether such strategies further regulatory goals; and (2) an information-sharing infrastructure for collecting and circulating scientific data on natural systems and assessments of management strategies and programs. In addition, Part V considers ways to alter the incentives for agency officials to foster agency adaptability and more effective natural resource governance. Through this approach, the many promising substantive proposals adopted by resource managers for conserving and restoring natural resources can be assessed and modified by agencies, legislators, and the public to more directly advance resource management goals.[25] Just as importantly, such an infrastructure will help cultivate the adaptive capacity to manage the heretofore unknown upheavals that climate change will bring.

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[24] This Article's primary focus is on domestic natural resource governance in the United States. As such, it necessarily only briefly discusses the international dimensions of natural resource governance, such as in the context of case studies on Great Lakes and Colorado River governance. Though outside the scope of this Article, it bears mentioning that the learning infrastructure advocated herein—in particular the intergovernmental, information-sharing network—has clear implications for international governance as well.

[25] There are a variety of potential normative goals for resource management, such as resource preservation, restoration, or maximizing ecosystem services. Likewise, an adopted adaptation strategy may seek to resist or accept climate change, or seek to optimize human or ecological benefits. This Article does not advocate any particular substantive goal. Instead, it recognizes that such objectives indeed may (and should) change over time. As such, it contends that the learning infrastructure it proposes provides a superior process for establishing and promoting management goals compared to existing governance.

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I. THE UNCERTAIN EFFECTS OF CLIMATE CHANGE

Extensive evidence confirms that global climate change is already occurring and is very likely due to the increase in greenhouse gas concentrations from human activities.[26] The best data suggest that, across a wide array of future carbon emission scenarios, average global temperatures will rise between 2 and 11.5 degrees Fahrenheit over the next century,[27] though increases are expected to be even greater over land and closer to the North and South Poles.[28] Virtually all species and ecosystems will be affected by climate change. Yet the extent of these impending impacts and the exact future distribution of impacts globally and domestically are far from clear. This is the core dilemma that natural resource governance must confront if it is going to successfully manage the effects wrought by climate change.

A. Existing and Projected Effects on U.S. Ecosystems

Although difficult to distinguish from other natural and anthropogenic phenomena, the speed and severity of some climate change effects on natural systems can be identified and isolated.[29] An increasingly robust level of scientific data indicates that anthropogenic climate change is already having substantial detrimental effects on wildlife, vegetation, and ecological processes.[30] Direct effects on species "have been documented on every continent, in every ocean, and in most major taxonomic groups,"[31] and "changes in ice cover, salinity, oxygen levels[,] and circulation" have also been

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[26] *See* WORKING GROUP I, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS 10 (S. Solomon et al. eds., 2007) [hereinafter IPCC, PHYSICAL SCIENCE] (linking climate change to human activity).

[27] *See id.* at 13.

[28] *See id.* at 16.

[29] *Cf.* Camille Parmesan & Gary Yohe, *A Globally Coherent Fingerprint of Climate Change Impacts Across Natural Systems*, 421 NATURE 37, 37 (2003) ("Causal attribution of recent biological trends to climate change is complicated because non-climatic influences dominate local, short-term biological changes. Any underlying signal from climate change is likely to be revealed by analyses that seek systematic trends across diverse species and geographic regions . . . .").

[30] *See id.* (discussing the substantial detrimental effects of climate change); IPCC, PHYSICAL SCIENCE, *supra* note 26, at 3 (discussing the effects of climate change); *see generally* CAMILLE PARMESAN & HECTOR GALBRAITH, PEW CTR. ON GLOBAL CLIMATE CHANGE, OBSERVED IMPACTS OF CLIMATE CHANGE IN THE U.S. (2004) (reporting the effects of climate change in the United States).

[31] Camille Parmesan, *Ecological and Evolutionary Responses to Recent Climate Change*, 37 ANN. REV. ECOLOGY, EVOLUTION & SYSTEMATICS 637, 639 (2006); *see also* IPCC, ADAPTATION, *supra* note 23, at 8–9 (listing concerns of direct species effects); Boris Worm et al., *Impacts of Biodiversity Loss on Ocean Ecosystem Services*, 314 SCIENCE 787 (2006) (discussing the overall impact of biodiversity loss on ocean ecosystems).

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verified.[32] Ocean acidification has also been documented.[33] The best available evidence suggests that climate change is already disturbing natural systems in the United States.[34] Changes in U.S. air temperature, precipitation, snowpack,[35] water temperature, wildfire acreage, tree mortality, and water flow[36] are all consistent with climate change. Phenological changes have been observed in many species,[37] between species,[38] and throughout entire communities.[39] Species ranges have also shifted.[40]

Though these extant effects of climate change on ecosystems have been significant, they are relatively small compared to the speed and severity of projected effects. Warming of the U.S. climate will very likely continue for the next twenty-five to fifty years, irrespective of any reductions in future emissions.[41] Though the magnitude of temperature increases is expected to be

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[32] *See* IPCC, ADAPTATION, *supra* note 23, at 8.

[33] *See id.* at 9 (documenting ocean acidification but observing that "the effects of observed ocean acidification on the marine biosphere are as yet undocumented").

[34] *See generally* THOMAS R. KARL ET AL. EDS., U.S. GLOBAL CHANGE RESEARCH PROGRAM, GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES 9–12 (2009); H. JOHN HEINZ III CTR. FOR SCIENCE, ECON. AND THE ENV'T, THE STATE OF THE NATION'S ECOSYSTEMS 2008: FOCUS ON CLIMATE CHANGE 3–4 (2008) [hereinafter HEINZ CENTER].

[35] PETER BACKLUND ET AL., U.S. CLIMATE CHANGE SCI. PROGRAM, THE EFFECTS OF CLIMATE CHANGE ON AGRICULTURE, LAND RESOURCES, WATER RESOURCES, AND BIODIVERSITY; SYNTHESIS AND ASSESSMENT PRODUCT 4.3, 1, 5 (Margaret K. Walsh ed., 2008) [hereinafter USCCSP SAP 4.3].

[36] *See* HEINZ CENTER, *supra* note 34, at 2–5 (discussing changes in these environmental factors). *See also* CAL. ENVTL. PROT. AGENCY, INDICATORS OF CLIMATE CHANGE IN CALIFORNIA ii–iii (Linda Mazur & Carmen Milanes eds., 2009), *available at* http://www.oehha.ca.gov/multimedia/epic/pdf/ClimateChangeIndicatorsApril2009.pdf (reporting decreased spring snowmelt, rising sea levels, and increased frequency of wildfires in California).

[37] *See* Parmesan, *supra* note 31, at 643–44 (noting that bloom dates (phytoplankton), flowering dates (flowers), calling dates (frogs), and spring events (birds) have generally advanced for certain species); INDICATORS OF CLIMATE CHANGE IN CALIFORNIA, *supra* note 36, at 146–66 (reporting accelerated wine grape blooming and changes in bird, small mammal, and butterfly migration patterns in California).

[38] *See, e.g.*, David W. Inouye et al., *Climate Change is Affecting Altitudinal Migrants and Hibernating Species*, 97 PROC. OF THE NAT'L ACAD. OF SCI. 1630, 1632–33 (2000) (discussing climate changes reflected by Colorado's yellow-bellied marmots and their food plants); Monika Winder & Daniel E. Schindler, *Climate Change Uncouples Trophic Interactions in an Aquatic Ecosystem*, 85 ECOLOGY 2100, 2102–05 (2004) (discussing asynchrony between phytoplankton and zooplankton in the northeast United States).

[39] *See* Parmesan, *supra* note 31, at 643–44 (reviewing various studies of diatoms, freshwater invertebrates, and shrubs in the Arctic).

[40] *See* Lisa Crozier, *Warmer Winters Drive Butterfly Range Expansion by Increasing Survivorship*, 85 ECOLOGY 231, 239–40 (2004) (explaining northward movement of sachem skipper butterfly range); Alan T. Hitch & Paul L. Leberg, *Breeding Distributions of North American Bird Species Moving North as a Result of Climate Change*, 21 CONSERVATION BIOLOGY 534, 534 (2007) ("As predicted, the northern limit of birds with a southern distribution showed a significant shift northward (2.35 km/year).").

[41] *See* USCCSP SAP 4.3, *supra* note 35, at 5 ("Warming is very likely to continue in the United States during the next 25 to 50 years, regardless of reductions in greenhouse gas emissions . . . .").

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quite problematic,[42] it is the speed of such changes that is likely to be the most damaging to biodiversity.[43] U.S. forest, coastal, and freshwater resources are expected to be particularly impaired,[44] with cascading effects on human health,[45] resource production,[46] and ecosystem services.[47] In Alaska, the very stability of the land is likely to change.[48]

B. A Different Order of Uncertainty

Though the best available data strongly indicate progressively severe effects on natural systems, the primary challenge that climate change posits for natural resource governance is the extraordinary uncertainty surrounding the precise manifestation of these impacts. In certain respects, climate change is similar to other, more conventional natural resource issues. To be sure, environmental problems are rife with limited information; in fact, some consider uncertainty to be a fundamental feature of modern environmental risk.[49] Government regulators have long been tasked with addressing problems for which information as to the generation, transmission, impact, and probable

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[42] *See id.* (discussing problems expected to be caused by rising temperatures).

[43] *See* FRANK R. SPELLMAN, ECOLOGY FOR NONECOLOGISTS 305 (2008) ("[I]t is the predicted rate of temperature change that poses the greatest threat to biodiversity."); Marcel E. Visser, *Keeping Up with a Warming World; Assessing the Rate of Adaptation to Climate Change*, 275 PROC. ROYAL SOC'Y 649, 649 (2008) ("[T]he magnitude of the ecological consequences will strongly depend on the rate of adaptation of species to their changing environment . . . .").

[44] *See* USCCSP SAP 4.3, *supra* note 35, at 96–97 (projecting greater disturbance to forests from fire, pestilence, and disease); IPCC, ADAPTATION, *supra* note 23, at 10–12 (projecting with very high confidence increased harm to coastal and freshwater resources); PETER C. FRUMHOFF ET AL., CONFRONTING CLIMATE CHANGE IN THE U.S. NORTHEAST: SCIENCE, IMPACTS, AND SOLUTIONS 47 (2007) (estimating a 350 to 500 mile northward shift for northeastern U.S. trees by the late twenty-first century, threatening birds, lynx, hares, and other species).

[45] *See* IPCC, ADAPTATION, *supra* note 23, at 12 (projecting increased adverse health effects from heat waves).

[46] *See id.* (projecting harm to fishing industry); HEINZ CENTER, *supra* note 34, at 3–4 (predicting increased drought, heat, disease, and pests in some agricultural areas); USCCSP SAP 4.3, *supra* note 35, at 9 (projecting increased disease and failure in grain and oilseed crops).

[47] *See generally* NAT'L ASSESSMENT SYNTHESIS TEAM, U.S. GLOBAL CHANGE RESEARCH PROGRAM, CLIMATE CHANGE IMPACTS ON THE UNITED STATES: THE POTENTIAL CONSEQUENCES OF CLIMATE VARIABILITY AND CHANGE (2000) (discussing decreased carbon storage, erosion protection, and water and air purification due to climate change).

[48] *See* David M. Lawrence et al., *Accelerated Arctic Land Warming and Permafrost Degradation During Rapid Sea Ice Loss*, 35 GEOPHYSICAL RES. LETTERS L11506 (2008) (projecting that rapidly melting sea ice will lead to permafrost melting in arctic regions of Alaska).

[49] *See* Jonathan Remy Nash, *Standing and the Precautionary Principle*, 108 COLUM. L. REV. 494, 498–99 (2008) ("Environmental problems typically arise in settings of risk and uncertainty."); Talbot Page, *A Generic View of Toxic Chemicals and Similar Risks*, 7 ECOLOGY L.Q. 207, 208–09 (1978) ("Ignorance of mechanism is the first characteristic of environmental risk problems." (emphasis omitted)).

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occurrence of hazards is limited.[50] As with other environmental problems, there is imperfect information about many existing effects of climate change simply because they have yet to be studied.[51] Likewise, though knowledge of future impacts from climate change is as great as it has ever been,[52] attempts to assess future effects must rely on modeling based on a range of assumptions that are of limited accuracy and precision.

Two fundamental features of climate change set it apart from more conventional environmental stressors. The first is the nature of the anticipated disruption. Every ecosystem is subject to periodic disturbances such as drought, flood, and fire. Even though some of these disruptions may be quite substantial, they are core features of resilient and dynamic ecosystems.[53] In contrast, the projected scope and severity of global anthropogenic climate change threatens to compromise the fundamental resilience and existence of many ecosystems.[54] Furthermore, these effects are anticipated to occur at a speed many times faster than any climatic change human civilization has encountered.[55] The unprecedented speed and type of change make it at best challenging—if not impossible—to extrapolate from current ecological knowledge. This uncertainty about the implications for ecosystems globally raises the stakes to a level much higher than for other environmental problems.

Perhaps more significantly for natural resource governance is the exceptional uncertainty that arises from any effort toward climate change adaptation. The global scale and complexity of climate tells part of the story. Scientists have been relatively effective at predicting macro-trends in variables such as air temperature, and today's models are much more sophisticated than

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[50] *See* JAMES SALZMAN & BARTON H. THOMPSON, JR., ENVIRONMENTAL LAW AND POLICY 13 (2d ed. 2007) ("In many respects scientific uncertainty is *the* defining feature of environmental policy.").

[51] *See* IPCC, ADAPTATION, *supra* note 23, at 9 ("[A]vailable analyses are limited in the number of systems and locations considered.").

[52] *See id.* at 5 (detailing case studies); *see also id.* at 15 ("Magnitudes of impact can now be estimated more systematically for a range of possible increases in global average temperature.").

[53] *See* J.B. Ruhl, *Climate Change and the Endangered Species Act: Building Bridges to the No-Analog Future*, 88 B.U. L. REV. 1, 22 (2008) ("Although all ecosystems undergo disturbance regimes such as flood, fire, and drought, all of which we have some experience observing and predicting, ecologists understand that these forms of disturbance are part of the stable disequilibrium of resilient, dynamic ecosystems." (footnote omitted)).

[54] *See* IPCC, ADAPTATION, *supra* note 23, at 11 ("The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances . . . and other global change drivers . . . .").

[55] *See* Stephen H. Schneider et al., *Climate-Change Scenarios for Impact Assessment*, *in* GLOBAL WARMING AND BIOLOGICAL DIVERSITY 38, 42 (Robert L. Peters & Thomas E. Lovejoy eds., 1992).

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earlier ones.[56] Yet even some fairly recent models of surface temperature and sea level changes—areas of climate science with the best and most straightforward data—are already proving somewhat inaccurate.[57] This limited accuracy stems from the multivariate nature of climate. The exact course of various potentially confounding natural factors[58] is unknown; some factors may be synergistic and nonlinear (i.e., lead to a vicious cycle of warming);[59] and some factors become apparent only after additional climatic changes occur.[60] In short, various features of climate dynamics are not well understood by scientists.

Climate change adaptation raises two further uncertainties. Any efforts to adapt natural systems to manage the effects of climate change will be substantially influenced by mitigation activities that abate further climatic change.[61] However, mitigation activities raise their own uncertainties because they will be carried out by a host of regulatory actors and are likely to change over time.[62]

Finally, though modeling for global climate temperatures and sea levels is already daunting, projections localized to a scale needed to provide practical

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[56] *See* WORLD CONSERVATION UNION, CLIMATE CHANGE AND NATURE: ADAPTING FOR THE FUTURE 3 (2006) ("New modeling tools and techniques are becoming available that can project potential changes in species range and distribution on land and at sea.").

[57] *See* Stefan Rahmstorf et al., *Recent Climate Observations Compared to Projections*, 316 SCIENCE 709, 709 (2007) (finding global sea level rise is greater than model predictions, and mean surface temperature rise is in the far upper range of model predictions).

[58] For example, emitted aerosols may counteract warming by deflecting solar radiation, and there is some evidence that increased forest fires may reduce temperatures in the long-term because of increased surface reflectivity. *See* Richard A. Kerr, *Another Global Warming Icon Comes Under Attack*, 317 SCIENCE 28, 28 (2007); J.T. Randerson et al., *The Impact of Boreal Forest Fire on Climate Warming*, 314 SCIENCE 1130, 1130 (2006).

[59] For example, melting permafrost releases more greenhouse gases that will accelerate warming, leading to more permafrost melt. *See* Katey M. Walter et al., *Methane Bubbling from Northern Lakes: Present and Future Contributions to the Global Methane Budget*, 365 PHIL. TRANSACTIONS ROYAL SOC'Y A 1657, 1657 (2007).

[60] *Cf.* Ruhl, *supra* note 53, at 19 ("[E]ven as we learn more about the highly coupled, tightly interacting processes that comprise the climate, the likelihood is that we will realize with even greater clarity that it is inherently unpredictable.").

[61] *See* EASTERLING, *supra* note 23, at iii. For a discussion of the relationship between climate change mitigation and adaptation, see Part II.A.

[62] *Cf.* WORKING GROUP III, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: MITIGATION OF CLIMATE CHANGE 9 (2007) (noting that uncertainty concerning mitigation is reflected in "ranges of baselines, rates of technological change and other factors that are specific to . . . different [analytical] approaches," and from "the limited information for global coverage of countries, sectors and gases").

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aid for adaptation decisions[63] are even more troublesome. Localized impacts of climate change will vary greatly depending on the adaptability of each ecosystem[64] and many non-climate factors.[65] As modeling is downscaled to particular ecosystems, these various additional sources of uncertainty limit the ability to make projections,[66] and small changes in assumptions can lead to widely varying results.[67] These difficulties are made even more challenging because basic long-term data are lacking for many ecosystems.[68] As a result, existing local modeling is still rare and only provides limited reliable (and mostly qualitative) information about the effects of climate change on specific ecosystems.[69] So the global scale of the problem, the limited study of effects, the variety and complex interaction of variables, and the particular difficulties for localized ecosystem modeling combine to raise uncertainty to a level humans have never encountered and governments have never attempted to manage.[70]

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[63] *See* Climate and Land Use Change Effects on Ecological Resources in Three Watersheds: A Synthesis Report, 72 Fed. Reg. 45,045, 45,046 (Aug. 10, 2007) (stating the "[e]ffects of global change drivers differ by place and in scale, necessitating place-specific impacts information to enable stakeholders to respond appropriately").

[64] *See* IPCC, ADAPTATION, *supra* note 23, at 11.

[65] These include changes in population, income, technological development, land use, other pollution, and invasive species. *See id.* at 20 ("[L]arge differences in regional population, income and technological development . . . are often a strong determinant of the level of vulnerability to climate change." (citation omitted)).

[66] *See* IPCC, PHYSICAL SCIENCE, *supra* note 26, at 74 ("There remain a number of important sources of uncertainty limiting the ability to project regional climate change. . . . There are some important climate processes that have a significant effect on regional climate, but for which the climate change response is still poorly known."); IPCC, ADAPTATION, *supra* note 23, at 9 ("[T]emperature variability is larger at the regional than at the global scale . . . . [A]t the regional scale other factors (such as land-use change, pollution, and invasive species) are influential.").

[67] *See, e.g.*, U.S. CLIMATE CHANGE SCI. PROGRAM, CLIMATE MODELS: AN ASSESSMENT OF STRENGTHS AND LIMITATIONS 88 (2008) ("[M]aking different assumptions about the land biosphere within a single model gave markedly different feedback values."). For example, the suitability of habitat for many wetland plant species can be drastically altered by even minor variations in water availability. *See* SPELLMAN, *supra* note 43, at 305.

[68] *See, e.g.*, IPCC, PHYSICAL SCIENCE, *supra* note 26, at 74 ("For those regions that have strong topographical controls on their climatic patterns, there is often insufficient climate change information at the fine spatial resolution of the topography. In some regions there has been only very limited research on extreme weather events.").

[69] *See* Ruhl, *supra* note 53, at 21 (2008); *cf.* Jean-Philippe Vidal & Steven D. Wade, *Multimodel Projections of Catchment-Scale Precipitation Regime*, 353 J. HYDROLOGY 143, 143 (2008) ("Hydrologists and water resources planners make use of downscaled climate scenarios, often with little regard for the performance of scenario construction methods, for informing decisions on water resources and flood risk management policies and projects.").

[70] *See* Ruhl, *supra* note 53, at 22 ("[C]limate change does not present just another disturbance regime, the operations of which we can extrapolate from current ecological knowledge; rather, it will be the undoing of ecosystems as we know them." (footnote omitted)).

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II. ADAPTING TO CLIMATE CHANGE

Exceptional uncertainty is the core challenge that natural resource governance faces from climate change. Ecologists and other scientists are being forced to reconsider long-held assumptions and methodologies for studying natural systems, and agencies are being pressed to prepare for problems they have never faced before.[71] In short, adapting to climate change necessitates the coordination and mobilization of scientific and management information to a degree never attempted. To be sure, government institutions must develop a suite of strategies to both prevent further climatic change and foster suitable adaptations to its effects on natural and human systems. More importantly, natural resource governance must develop an infrastructure that enhances the capacity of public and private actors to assess and manage an uncertain regulatory environment.

A. The Need for Adaptation

Despite the sizeable uncertainty that accompanies any comprehensive effort to manage the effects of climate change, climate change adaptation is a vital complement to mitigation activities that seek to curb further climatic change. On the one hand, focusing more attention on adaptation should certainly not supplant vital efforts to abate greenhouse gas emissions. Extensive evidence compiled by thousands of independent scientists indicates that without swift, comprehensive efforts to substantially reduce emissions, the effects of climate change on natural systems will undoubtedly be more severe.[72] Indeed, the many uncertainties and challenges detailed in Part I.B counsel for very robust abatement restrictions. Emissions reduction through efforts, such as the currently pending Waxman-Markey American Clean Energy and Security Act of 2009,[73] that seek a cap-and-trade or emission tax system to mitigate greenhouse gas emissions should not be merely an afterthought, but rather a vital part of any sensible response to climate change.[74]

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[71] *See id.*; *cf.* Jonathan Lash & Fred Wellington, *Competitive Advantage on a Warming Planet*, 85 HARV. BUS. REV. 95, 96 (2007) ("[C]limate change presents business risks that are different in kind because the impact is global, the problem is long-term, and the harm is essentially irreversible.").

[72] COMM. ON ENV'T & NATURAL RES., NAT'L SCI. & TECH. COUNCIL, SCIENTIFIC ASSESSMENT OF THE EFFECTS OF GLOBAL CHANGE ON THE UNITED STATES 77–79 (2008).

[73] American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong. (Agreed to on June 26, 2009, placed on Senate Legislative Calendar July 7, 2009), *available at* http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:h2454eh.txt.pdf.

[74] *See* EASTERLING ET AL., *supra* note 23, at iii.

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On the other hand, no amount of abatement, even if enacted tomorrow, is likely to diminish the effects of climate change for several decades. Evidence suggests that the effects of global warming are already being experienced in the United States, and climate change is likely to continue for decades, even in the event of significant reduction of emissions.[75] Countless people and ecosystems are and will continue to be threatened by the effects of climate change, at least until abatement measures show results.[76]

Climate change thus will increasingly place considerable stress on the perpetually limited resources allocated to manage natural resources. Government institutions must be tactical in trying to expand the capacity to address existing regulatory vulnerabilities while anticipating and averting severe climate change effects. Unfortunately, legislators and regulators in the United States and elsewhere have only begun to consider the role of adaptation in combating climate change.

B. A Typology of Government Adaptation Strategies

Greater attention must be given to reducing the existing and future adverse effects of climate change on natural resources. To advance this endeavor, this section proposes a framework for classifying government adaptation measures according to three particularly relevant parameters: (1) whether the adaptation primarily anticipates or reacts to effects from climate change; (2) whether the strategy focuses exclusively, partially, or only indirectly on projected climate change effects; and (3) whether the strategy is a "substantive" response to the direct effects of climate change, or an indirect "procedural" adaptation of a process for deciding among substantive adaptations. All of these government strategies likely have a role to play in any comprehensive approach to climate change adaptation. However, as detailed here, the uncertainty attributable to climate change, and the inevitable scarcity of resources allocated for natural resource governance, counsel for an emphasis on proactive, procedural strategies directed at addressing existing key regulatory vulnerabilities likely to be exacerbated by climate change. Such strategies can provide a basis for

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[75] *See* USCCSP SAP 4.3, *supra* note 35, at 3.

[76] This is likely to be especially true for particularly vulnerable persons or nations, including low-income communities or developing regions of the world. *See* NICHOLAS STERN, STERN REVIEW: THE ECONOMICS OF CLIMATE CHANGE 92 (2006).

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government regulators to manage uncertainty and reduce the risk of regulatory waste.[77]

1. Proactive and Reactive Strategies

The timing of an adaptation's implementation is likely to have significant repercussions on the cost and success of the strategy.[78] A *proactive* adaptation "takes place before impacts of climate change are observed."[79] Such strategies seek to formulate long-term strategies for infrastructure, education, outreach, and improving collective capacities to adapt, as well as create incentives to change behaviors suited to the shifting climate.[80] However, such strategies are susceptible to the considerable uncertainty inherent in predictive modeling. Therefore, to be successful, proactive strategies must be designed to adapt to a range of possible effects and must be nimble enough to respond to new information obtained during implementation.[81]

In contrast, a *reactive* adaptation is "a deliberate response to a climatic shock or impact, in order to recover and prevent similar impacts in the

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[77] Though not the focus of this Article, it should be noted that not all adaptations must be governmental. Certainly, private actors are already adapting to climate change. *See* IPCC, ADAPTATION, *supra* note 23, at 636 (noting ski resorts building lifts to accommodate higher altitudes and discussing farmers and timber companies adjusting crop varieties). In addition, private markets can increase adaptive capacity by creating incentives to adapt, with private insurance as a prominent example. *See* STERN, *supra* note 76, at 412 ("[B]etter developed insurance markets would help to create clear price signals . . . about the risks associated with climate change."). Indeed, some insurers have already adjusted prices to encourage climate change loss and hazard prevention. *See* IPCC, ADAPTATION, *supra* note 23, at 636. Nonetheless, private markets are limited in their ability to foster efficient adaptations because (1) they are also subject to the uncertainties of climate change; (2) markets may be missing or misaligned; and (3) participants in markets must deal with financial constraints. *See* STERN, *supra* note 76, at 411–12 ("Uncertainty in climate change projections could therefore act as a significant impediment to [private] adaptation."). As such, the role of public governance can be understood as not only to enhance the adaptive capacity of private markets (cultivating the informational, regulatory, institutional, and managerial conditions needed to support private adaptation) but also to implement government adaptation strategies for reducing vulnerability where market responses are likely to be insufficient. *See generally id.* at 404–47 (discussing the role of government adaptation responses in addressing the effects of climate change).

[78] EASTERLING ET AL., *supra* note 23, at vi, 14.

[79] IPCC, ADAPTATION, *supra* note 23, at 869 (emphasis omitted); *see also* JILL S. BARON ET AL., U.S. CLIMATE CHANGE SCI. PROGRAM, PRELIMINARY REVIEW OF ADAPTATION OPTIONS FOR CLIMATE-SENSITIVE ECOSYSTEMS AND RESOURCES glossary at 1 (Susan Herrod Julius & Jordan M. West eds., 2008) [hereinafter USCCSP, ADAPTATION OPTIONS] (defining "anticipatory adaptation" as "that [which] takes place before impacts of climate change are observed").

[80] *See* EASTERLING ET AL., *supra* note 23, at vi.

[81] *See, e.g.*, *id.* at 24.

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future."[82] Such strategies have the key inherent advantage of being subject to less uncertainty, as they are only implemented in response to actualized risks.[83] However, various intrinsic problems exist with reactive approaches. Because they are only implemented after-the-fact, "a high degree of ecosystem and infrastructure damage is likely to occur before reactive measures are taken."[84] Due to "inefficiencies in the response when it is needed, wasted investments made in ignorance of future conditions, or potentially even greater damages because precautionary actions were not taken,"[85] reactive adaptations may be more vulnerable to higher long-term administrative costs and damages.[86] The limitations of reactive strategies are particularly problematic when addressing high-cost or irreversible impacts of long-term and expensive investments., or when otherwise important to prevent (and not merely respond to) climate effects.[87] Unfortunately, such circumstances are quite common in the context of climate change, particularly in the context of threats to certain biological resources.[88]

Thus, in adapting to the effects of climate change on ecological resources it is better to prevent negative consequences by employing proactive adaptations based on the precautionary principle.[89] Reactive adaptations should be left to circumstances in which proactive strategies were unsuccessful in identifying and preventing a hazard from occurring.[90] Establishing a systematic approach for cultivating successful proactive adaptations is thus crucial to developing effective adaptation strategies.

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[82] JANET ABRAMOVITZ ET AL., WORLD CONSERVATION UNION ET AL., ADAPTING TO CLIMATE CHANGE: NATURAL RESOURCE MANAGEMENT AND VULNERABILITY REDUCTION 10 (2001).

[83] *See* Linda A. Joyce et al., *National Forests*, *in* USCCSP, ADAPTATION OPTIONS, *supra* note 79, at 40.

[84] *See* Margaret A. Palmer et al., *Wild and Scenic Rivers*, *in* USCCSP, ADAPTATION OPTIONS, *supra* note 79, at 33.

[85] *See* Joyce et al., *supra* note 83, at 40.

[86] *See* EASTERLING ET AL., *supra* note 23, at ii. For example, reactive strategies such as ecosystem restoration to pre-event conditions can be wasteful if they do not integrate proactive planning for future conditions. *See id*. at 5.

[87] *See id*. at 24.

[88] *See id*. at 4 ("A 'wait-and-see' approach would be particularly unsuccessful in coping with . . . [i]rreversible impacts, such as species extinction or unrecoverable ecosystem changes [and] . . . [u]nacceptably high costs and damages, such as inappropriate coastal zone development that exposes lives and property to intense storm damages . . . .").

[89] *See* IPCC, ADAPTATION, *supra* note 23, at 246.

[90] *Cf.* Palmer et al., *supra* note 84, at 33 ("[A] reactive approach is not the most desirable response strategy to climate change . . . .").

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2. Exclusive, Co-benefit, or No-Regret Strategies

Another variable for distinguishing among adaptation strategies emphasizes the orientation of the adaptation in terms of the benefit provided. *Exclusive* adaptations are directed exclusively at reducing the effects of climate change. A *co-benefit* strategy is in part directed at reducing vulnerabilities related to climate change but is also expected to produce other public benefits.[91] *No-regrets* adaptations are directed at providing net benefits irrespective of the effects of climate change.[92]

Due to existing uncertainties about such effects, prudent regulators should seek to maximize the use of no-regrets adaptations.[93] No-regrets strategies reduce the risks of regulatory waste from uncertainty because they are a net benefit to their particular natural and/or regulatory system regardless of whether (or to what extent) the projected effects of climate change occur. However, given the magnitude and speed of impacts anticipated by climate change, it is doubtful that reliance on no-regrets strategies alone could forestall all the heretofore unknown effects of climate change.[94] Because the exact effects of climate change remain uncertain, regulators also should seek to adopt partial or co-benefit adaptations that maximize supplementary public benefits in order to minimize the risks from costly adaptations. Only as a precaution against particularly large or catastrophic risks should regulators consider employing exclusive adaptations that lack other public benefits.

3. Substantive and Procedural Strategies

In classifying potential adaptation strategies, perhaps the most important distinction is one that has not been identified in the scientific or legal literature: whether the adaptation is primarily a substantive or procedural strategy. This

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[91] ABRAMOVITZ ET AL., *supra* note 82, at 10–11. One example might be the conservation of natural buffer systems to minimize the effects of climate change, which some claim would have the additional benefits of enhancing biodiversity conservation and economic productivity, as well as alleviating poverty more effectively. *See id.* at 28.

[92] *See id.* at 10 (describing decreasing "vulnerability to current climate-related variability and extremes, such as through flood-control structures, most likely also reducing vulnerability to shifts in risk due to climate change" (footnote omitted)).

[93] *See* IPCC, ADAPTATION, *supra* note 23, at 246.

[94] *See, e.g.*, Harriet Bulkeley, *No Regrets? Economy and Environment in Australia's Domestic Climate Change Policy Process*, 11 GLOBAL ENVTL. CHANGE 155, 167 (2001) (concluding with regard to Australia's experience implementing no-regrets climate change adaptations that "while following the path of no-regrets may provide short-term compromises, in itself it does not offer an escape route from fundamental conflicts between economic goals and environmental objectives . . . .").

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distinction considers whether the strategy principally seeks to address the direct effects of climate change (*substantive*), or to change a process for deciding among substantive adaptations (*procedural*).

a. Substantive Governmental Strategies

Most of the strategies mentioned by natural resource managers and discussed in the growing scholarly literature on climate change adaptation are substantive. For example, many proposed adaptations focus on altering the environment to minimize the direct effects of sea level rise and severe weather events such as storm intensity, floods, and droughts.[95] These sorts of direct, discrete adaptations, such as physical removal of invasive species or construction of breakwaters, rock sills, levees, or dams,[96] tend to be reactive.[97]

Other substantive adaptations seek to alter the way private actors interact with the immediate environment to reduce the effect of climate change, often through the disclosure of information or changes to regulations that encourage or mandate particular private conduct. For example, regulatory adaptations that address increased risks to coastal resources could include (1) public information disclosure or education initiatives regarding flood risk;[98] (2) early warning systems;[99] (3) changes to government flood insurance;[100] (4) subsidies[101] or changes to zoning or building codes[102] to increase the capacity

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[95] *See* Susan Herrod Julius et al., *Introduction*, *in* USCCSP, ADAPTATION OPTIONS, *supra* note 79, at 7–10; IPCC, ADAPTATION, *supra* note 23, at 247.

[96] *See* Jill S. Baron et al., *National Parks*, *in* USCCSP, ADAPTATION OPTIONS, *supra* note 79, at 14; J. Michael Scott et al., *National Wildlife Refuges*, *in* USCCSP, ADAPTATION OPTIONS, *supra* note 79, at 42; Palmer et al., *supra* note 84, at 14–15, 31; Charles H. Peterson et al., *National Estuaries*, *in* USCCSP, ADAPTATION OPTIONS, *supra* note 79, at 40. Other examples include shore land conservation, erosion controls, and lower-level tear-away walls on structures. *See* EASTERLING ET AL., *supra* note 23, at 27–28.

[97] *See* IPCC, ADAPTATION, *supra* note 23, at 636. For example, the State of Alaska, where coastal villages are falling into the ocean as protective sea ice melts, has pledged $11 million for coastal village protection primarily through strengthening sea walls. Tom Kizzia, *State Puts Erosion on Priority List—COASTAL VILLAGES: The Goal Is to Attract Additional Federal Aid by Allocating Control-Project Money*, ANCHORAGE DAILY NEWS, May 12, 2008, at A1.

[98] IPCC, ADAPTATION, *supra* note 23, at 636.

[99] CONG. BUDGET OFFICE, UNCERTAINTY IN ANALYZING CLIMATE CHANGE: POLICY IMPLICATIONS 36 (2005).

[100] *See* IPCC, ADAPTATION, *supra* note 23, at 636 ("The U.S. National Flood Insurance Program is changing its policy to reduce the risk of multiple flood claims, which cost the programme more than US $200 million/yr. Households with two flood-related claims are now required to elevate their structure 2.5 cm above the 100-year flood level, or relocate." (citation omitted)).

[101] Robert Knox, *Mass. Urges Owners on Coast to Elevate Homes: Storms and Rising Seas Pose Threat to Properties*, BOSTON GLOBE, May 24, 2008, at B1 (noting that the Federal Emergency Management Agency will partially subsidize elevation of private homes).

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of private property to withstand climate events;[103] (5) modifications to permit programs to reduce coastal erosion, such as prohibitions on private seawalls;[104] or (6) relocations of private structures from flood-prone areas through government acquisition.[105]

On a larger scale, substantive adaptations also include agency management planning, varying from site-specific to program-wide plans. An example of a program-wide plan is EPA's new National Water Strategy, which seeks to modify EPA's water programs to address climate change effects.[106] As adaptation strategies necessarily are specific to their application, the list of potential discrete or concrete strategies for any particular plan may be extensive.[107] Management planning strategies being considered include the creation of additional protected areas,[108] wildlife corridors,[109] and replicate ecosystems;[110] increased protection of vulnerable genotypes, species, and communities;[111] ecosystem restoration;[112] and "assisted migration" of species.[113]

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[102] EASTERLING ET AL., *supra* note 23, at 26.

[103] AJAY MATHUR ET AL., WORLD BANK, AN ADAPTATION MOSAIC: A SAMPLE OF THE EMERGING WORLD BANK IN CLIMATE CHANGE ADAPTATION 12 (2004).

[104] *See* James G. Titus, *Rising Seas, Coastal Erosion, and the Takings Clause: How to Save Wetlands and Beaches Without Hurting Property Owners*, 57 MD. L. REV. 1279, 1313 (1998).

[105] EASTERLING ET AL., *supra* note 23, at 27 (explaining New Jersey's coastal land acquisition program, Rhode Island's prohibition on seawalls, and Texas' rolling easements).

[106] *See generally* U.S. EPA, OFFICE OF WATER, NATIONAL WATER PROGRAM STRATEGY: RESPONSE TO CLIMATE CHANGE (2008).

[107] For example, a single management plan for a National Wildlife Refuge may involve, among other strategies, prescribed burning to manage wildfires, removal of dispersal barriers to promote species range expansion and migration, habitat restoration, and sustaining migrant organisms struggling in their new habitat. Scott et al., *supra* note 96, at 30–31.

[108] *See, e.g.*, Lee Hannah et al., *Protected Area Needs in a Changing Climate*, 5 FRONTIERS ECOLOGY & ENV'T 131, 135 (2007) (finding that "protected areas are a useful conservation response to climate change").

[109] *See, e.g.*, Paul Williams et al., *Planning for Climate Change: Identifying Minimum-Dispersal Corridors for the Cape Proteaceae*, 19 CONSERVATION BIOLOGY 1063, 1064 (2005) (devising a quantitative method for identifying conservation corridors that allow species the flexibility needed to adapt to shifting habitats as a result of climate change).

[110] *See, e.g.*, Julius et al., *supra* note 95, at 2 ("Replication centers on maintaining more than one example of each ecosystem or population such that if one area is affected by a disturbance, replicates in another area provide insurance against extinction and a source for recolonization of affected areas." (emphasis omitted)).

[111] *See, e.g.*, Peter Kareiva et al., *Synthesis and Conclusions*, *in* USCCSP, ADAPTATION OPTIONS, *supra* note 79, at 2 (recommending an increased representation of different genotypes, species, and communities under protection).

[112] *Id.* at 20–21.

[113] *See, e.g.*, Jason S. McLachlan et al., *A Framework for Debate of Assisted Migration in an Era of Climate Change*, 21 CONSERVATION BIOLOGY 297 (2007) (discussing deliberate relocation of organisms to new habitats as climate changes).

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b. Procedural Governmental Strategies

Though most commenters have focused on substantive strategies that seek to minimize or reverse the adverse effects of climate change on natural systems, the most crucial adaptations may take the more indirect form of procedural governmental strategies. Rather than focusing on directly managing the effects of climate change—or the natural systems or human conduct that may exacerbate such effects—this category is intended to encompass strategies that manage the regulatory programs and processes that develop more direct strategies. Such approaches might seek to change the decision-making process officials use to select direct adaptation strategies. At their broadest level, such approaches might also seek a more fundamental transformation of the government institutions society relies on to manage natural resources. For example, procedural adaptation strategies should be created to flexibly manage the considerable uncertainty surrounding climate change to avert and minimize the harm from mistakes throughout the regulatory process.

The concept of "adaptive management" was originally proposed by scientists in the 1970s who sought a more effective approach to natural resource management in response to the significant uncertainty that regularly exists in ecosystems.[114] This increasingly influential model seeks to address information gaps in management plans that surface during plan formation by including systematic monitoring procedures for obtaining more data to adjust the management strategies during implementation.[115]

At the broadest level, procedural adaptation strategies may also include large-scale modifications to governance—that is, how regulators manage the programs that govern natural systems and how societies manage these regulators. Such approaches might include wholesale changes to existing statutory regimes or programs, the creation of new programs or agencies, or other fundamental changes to decision-making processes for regulating or managing natural resources.[116] A few observers have discussed the need to

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[114] *See* C.S. HOLLING, *The Spruce Budworm/Forest-Management Problem*, *in* ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT 143, 156 (C.S. Holling ed., 1978); CARL WALTERS, ADAPTIVE MANAGEMENT OF RENEWABLE RESOURCES (1986).

[115] *See* Camacho I, *supra* note 14, at 330–31.

[116] For example, one scholar claims that the protection of individual species could be better facilitated by incorporating biological and long-term planning considerations more directly in decision-making processes under the ESA. *See* Carol A. Bloomgarden, *Protecting Endangered Species Under Future Climate Change: From Single-Species Preservation to an Anticipatory Policy Approach*, 19 ENVTL. MGMT. 641, 645 (1995).

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make systemic or large-scale governance changes to respond to climate change.[117] Yet, as detailed in Part IV, few recognize the need to increase the adaptive capacity of natural resource programs and governance to manage the uncertainty that climate change brings.

C. The Value of Procedural Strategies

Though the value of direct substantive adaptations may be more apparent in comprehensive attempts to address the effects of climate change, a central assertion of this Article is that procedural strategies that transform existing approaches to natural resource governance are even more vital given the uncertainties that exist for addressing the impacts of a warming climate. For all the reasons that apply regarding the effects from climate change,[118] substantive government adaptations—and in particular those seeking to regulate or manage ecosystems—are subject to the uncertainties of climate change as impact models are downscaled to specific locations.[119] This uncertainty is compounded by the limited information that exists regarding the suitability and efficacy of possible adaptation strategies. For example, captive breeding and assisted migration strategies are less likely to work if climate change effects are rapid[120] or substantial,[121] yet the speed and magnitude of change are largely unknown for particular ecosystems. This uncertainty is again amplified because analyses of such strategies are rare, particularly in response to climate change, and protocols identifying when such strategies may be appropriate often do not exist.[122] Additionally, some strategies are likely to conflict with other conservation methods or resource uses,[123] and the optimal reconciliation of such conflicts is debatable.

However, uncertainty over the exact future consequences and optimal substantive strategies should not lead to the conclusion that regulators and the public can afford to neglect adaptation. As is often the case when inexorable uncertainty exists in assessing long-term environmental harms,[124] the key question is not whether something should be done. Indeed, the United States is

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117 *See infra* note 286 and accompanying text.

118 *See supra* Part I.B.

119 *See* Kareiva et al., *supra* note 111, at 13.

120 IPCC, ADAPTATION, *supra* note 23, at 247.

121 INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE AND BIODIVERSITY 41 (Habiba Gitay et al. eds., 2002).

122 *See* McLachlan et al., *supra* note 113, at 297.

123 *See id*.

124 *See supra* note 49.

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already investing enormously in climate change adaptation, though most of these costs are not counted as such because they are treated as facets of more conventional management activities, such as drought relief or storm damage recovery,[125] and are aimed at problems such as water resource planning for which climate change is only one stressor.[126] The key question is, based on the best available data, what strategies are likely to be most effective and cost efficient at averting or minimizing potential damage from climate change.[127]

Procedural strategies can serve as the crucial bridge between uncertainty and the need for adaptation. Designed properly, such strategies are crucial for helping managers and regulators manage the substantial uncertainty about both the effects of climate change and the efficacy and side effects of substantive adaptation responses. Furthermore, larger-scale governance strategies can be cultivated that seek to create and disseminate information to regulatory actors, stakeholders, and the public to minimize uncertainty about climate change effects, substantive adaptations, and smaller-scale procedural adaptations.[128] Procedural strategies can thus serve to strengthen the adaptability of existing processes and help avoid and adjust over- and under-regulation in response to climate change.

III. THE POOR ADAPTIVE CAPACITY OF EXISTING GOVERNANCE

A baseline assessment of the state of natural resource governance is essential for understanding the range of adaptation strategies that may be both necessary and effective for addressing the effects of climate change. Do existing programs exert sufficient pressure on regulators and managers to systematically assess management approaches and manage uncertainty? If not, do emerging adaptation strategies seek to alter the existing regulatory infrastructure to provide private and public actors the capacity and incentive to respond adeptly to climate change?

Unfortunately, existing governance in the United States is fragmented, poorly informed, and un-adaptive; thus, it is inadequately suited to deal with

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[125] For example, funding or management of water, coastal, or forest resources as responses to drought, storm, or fire events, respectively, may in fact be climate change adaptations. *See, e.g.*, Kareiva et al., *supra* note 111, at 2–4 ("Many adaptation approaches . . . are already being used to address a variety of other environmental stressors . . . .").

[126] *See* IPCC, ADAPTATION, *supra* note 23, at 719.

[127] *See* EASTERLING ET AL., *supra* note 23, at iii.

[128] *See infra* Part V.

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the effects of climate change. As a result, climate change has been neglected, and most existing state and federal regulatory programs are ill-prepared to adapt to the direct effects of climate change. Agency reforms that seek to make the regulatory process more collaborative and adaptive have fallen short of their potential. Such experiments neither adopt a shared, adaptive infrastructure for managing and regulating agency actions nor provide agency officials or stakeholders sufficient incentives to learn from and adapt management decisions. To illustrate these contentions, this Part relies on two case studies of ecosystem governance in the United States. Though by no means exhaustive, these case studies demonstrate that without fundamental realignment, existing regulatory regimes appear ill-equipped to address the strain and uncertainty accompanying climate change.

A. Natural Resource Governance Is Fragmented

As U.S. environmental law has ripened over the past few decades, most ecological communities have become subject to a clutter of government programs with limited jurisdiction and information and thus limited capacity to learn and adapt. Even more recent collaborative experiments have very poorly developed frameworks for collecting and sharing information. Though there may be advantages to fragmented and concurrent authority, so far such fragmentation has not facilitated either inter-governmental learning or the development of responses to large-scale problems. As a result of these shortcomings, natural resource regulators and managers have been slow to respond to the need for comprehensive adaptation to climate change.

1. Existing Fragmentation Impedes Adaptation

Though natural resource agencies are often created with limited authority to regulate or manage a particular resource problem, over time natural systems in the United States have become subject to a patchwork of piecemeal regulation. In fact, Professor William Buzbee has catalogued the regulatory fragmentation that pervades governmental resource management using taxonomic classifications such as vertical,[129] horizontal,[130] institutional,[131] and

[129] William W. Buzbee, *The Regulatory Fragmentation Continuum, Westway and the Challenges of Regional Growth*, 21 J.L. & POL. 323, 344 (2005) [hereinafter Buzbee I] ("Vertical fragmentation refers to the division of regulatory turf among layers of political actors and regulators. . . . [I]n most complex regulatory settings, federal, state and local officials play roles, with each further handing authority down to administrative agencies and sometimes citizens." (emphasis omitted)).

[130] *Id*. at 347 (describing horizontal fragmentation as "each actor having a different subject matter turf").

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temporal.[132] Even individual agencies are regularly fragmented into fairly autonomous divisions or regional offices.[133] This broad fragmentation has both impeded concerted agency action for adapting to climate change and created significant barriers for agency learning.

While some scholars have delineated the benefits of a regulatory system with decentralized and redundant regulatory authority,[134] various weaknesses have also been identified,[135] including how fragmentation can lead to a failure by regulators to effectively address broadly dispersed resource issues such as global climate change.[136] Professor Buzbee has detailed this often overlooked "regulatory commons"[137] problem:

> Even where a social ill is widely recognized, the existence of multiple potential regulators will create predictable incentives for regulatory inattention. Especially where the causes of an ill cross jurisdictional borders, the harms themselves cross borders, and there is vertical or horizontal fragmentation of potential regulatory turfs, incentives for regulatory inattention are strong.[138]

Adaptation to climate change serves as a prime example of such a regulatory commons.[139] Though the considerable effects of climate change are widely recognized, its causes and harms cross jurisdictional borders, and there

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131 *Id.* at 348 ("Institutional fragmentation relates to how different types of legal or regulatory institutions play roles. . . . [D]iverse institutions such as legislatures, agencies, courts and legally empowered citizens all typically can play key roles in major regulatory actions." (emphasis omitted)).

132 *Id.* at 342 ("Temporal fragmentation refers to how regulatory procedures and decisions are spread in a sequence over a lengthy period of time." (emphasis omitted)).

133 *See* Elizabeth Glass Geltman & Andrew E. Skroback, *Reinventing the EPA to Conform with the New American Environmentality*, 23 COLUM. J. ENVTL. L. 1, 11–12 (1998) (describing intra-agency fragmentation at EPA and state environmental agencies).

134 For more detailed discussion of the disadvantages and opportunities of fragmented governance, see *infra* notes 375–83 and accompanying text.

135 For example, various scholars have focused on the potential for overregulation in situations where "numerous regulators are confronted with a more particularized project or proposal with localized and discernible effects . . . ." Buzbee I, *supra* note 129, at 349. *See also* James M. Buchanan & Yong J. Yoon, *Symmetric Tragedies: Commons and Anticommons*, 43 J.L. & ECON. 1, 11–12 (2000); WILLIAM A. FISCHEL, REGULATORY TAKINGS: LAW, ECONOMICS, AND POLITICS 251–52 (1995).

136 *See* J.B. Ruhl & James Salzman, *Massive Problems in the Administrative State: Strategies for Whittling Away*, 98 CAL. L. REV. (forthcoming 2010), *available at* http://ssrn.com/abstract=1280896 (discussing agency reticence to address complex problems, which, by their nature, cannot be completely addressed under the jurisdiction of a single agency).

137 William W. Buzbee, *Recognizing the Regulatory Commons: A Theory of Regulatory Gaps*, 89 IOWA L. REV. 1, 5–6 (2003) [hereinafter Buzbee II].

138 Buzbee I, *supra* note 129, at 356 (citations omitted).

139 *Cf.* Buzbee II, *supra* note 137, at 11–14 (explaining how mitigating global climate change presents regulatory commons challenges).

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is widespread regulatory fragmentation.[140] In such a splintered regulatory setting, private demands for government action are split among various potential regulators. Regulators who act early are likely to receive diluted credit as other regulators free ride on their efforts while status quo biases and risk aversion create additional incentives for regulatory inaction.[141] Regulators thus have little incentive to devote resources to gather information on—or regulate the risks of—global climate change.

Consequently, it is unsurprising that various observers have concluded that the U.S. and its regulatory programs are unprepared for the effects of climate change.[142] Thorough analyses of possible adaptations are growing in number but are still scarce and limited.[143] Some natural resource regulators claim to be in the process of considering strategies for adapting to climate change, but few agencies have adopted any adaptations.[144] Even in recent regulatory actions, many agencies simply ignore climate change,[145] with at least some agency officials claiming that, because of their limited jurisdiction, they have insufficient information or capacity to respond.[146]

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[140] *See* CONG. BUDGET OFFICE, *supra* note 99, at 36 (noting that adaptation policies are more difficult to implement than mitigation strategies at the federal level because they involve multiple policies and areas of government); Robin Kundis Craig, *Climate Change, Regulatory Fragmentation, and Water Triage*, 79 U. COLO. L. REV. 825, 861 (2008) (stating that due to fragmented water resource management, "problems such as . . . climate change are arising that no entity has sufficient regulatory authority to comprehensively or coherently address").

[141] *See* Buzbee II, *supra* note 137, at 30–36.

[142] *See, e.g.*, IPCC, ADAPTATION, *supra* note 23, at 15 (finding that current capacity for adaptation in the United States is uneven and readiness for increased exposure is low); U.S. GOV'T ACCOUNTABILITY OFFICE, CLIMATE CHANGE, AGENCIES SHOULD DEVELOP GUIDANCE FOR ADDRESSING THE EFFECTS ON FEDERAL LAND AND WATER RESOURCES 156 (2007) [hereinafter GAO REPORT] (noting that budget cuts and loss of research stations pose "challenges to conducting the research necessary for appropriate decision making relating to climate change issues"); STERN, *supra* note 76, at 92 ("[L]ittle can now be done to change the likely adverse effects that some developing countries will face in the next few decades, and so some adaptation will be essential.").

[143] IPCC, ADAPTATION, *supra* note 23, at 719. *See also* Bruce Stutz, *Adaptation Emerges as Key Part of Any Climate Change Plan*, YALE ENVIRONMENT360 (May 26, 2009), available at http://e360.yale.edu/content/feature.msp?id=2156 ("[A]daptation strategies are only beginning to be developed, mainly because there's precious little science on adaptation and few working models.").

[144] See *infra* Part IV.A for a more detailed discussion of government adaptation strategies.

[145] *See, e.g.*, Policy on Wilderness Stewardship, 73 Fed. Reg. 67,876 (Nov. 17, 2008) (failing to mention climate change in new FWS guidance for recommending additional wilderness designations to Congress).

[146] *See, e.g.*, GAO REPORT, *supra* note 142, at 156, 159, 163, 167 (conveying comments by various officials regarding their agencies' limited capacity to respond to climate change); Constance I. Millar et al., *Tahoe National Forest, in* USCCSP, ADAPTATION OPTIONS, *supra* note 79, at 9 ("Fragmentation and inflexibility result from partitioning [Tahoe National Forest] into small management units; small unit sizes also restrict the capacity for full understanding of ongoing dynamics and process."); Kareiva et al., *supra* note 111, at 30 ("National wildlife refuges and wild and scenic rivers are subject to water regulation by other agencies or

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2. Existing Fragmentation Impedes Agency Learning

Though these delays undoubtedly can be attributed in part to a lack of political will, agency inaction is also fundamentally a consequence of the significant barriers to agency learning created by fragmented governance that aggravates the enormous uncertainty with which such agencies must cope. Agency officials do not have the systemic capacity to learn readily from analyses of potential effects or management strategies employed by other agencies, or even those strategies employed by other offices or divisions in the same agency.[147] Because most agencies lack sufficient information about the localized effects of climate change and potential adaptation strategies—or even the resources and technical capacity to generate such data—it is unsurprising that most agencies believe they do not have the capacity for long-term comprehensive adaptation.[148] Faced with more obtrusive, short-range threats and limited information about the effects and relative benefits of different approaches, managers ignore climate change adaptation completely or adopt piecemeal adaptations only in response to concrete risks while calling for more information before acting comprehensively.

In response to these incentives and effects of regulatory fragmentation, increasing numbers of scholars and regulatory actors are calling for substantial changes in natural resource governance. Though eliminating fragmentation may often be implausible and undesirable,[149] numerous scholars have emphasized the need for agencies to create linkages with other regulators to reduce the effects of fragmentation.[150] In recognizing that resource

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entities. This fragmented jurisdiction means that collaboration among agencies is required so that they are all working toward common goals using common management approaches . . . [but] formal co-management remains the exception, not the rule.").

147 *See, e.g.*, Camacho I, *supra* note 14, at 341 ("[T]here is no comprehensive network to facilitate the dissemination of . . . information in other than a haphazard, and likely inefficient, way. . . . [N]egotiation and implementation are conducted by regional and field offices without any centralized or even decentralized coordination. Moreover, the high turnover of [FWS] staff exacerbates this fragmentation problem by further limiting the ability to draw on prior experience. As such, there is at best limited cross-pollination of data . . . and certainly far less than could occur." (citations omitted)); Bradley Karkkainen, *"New Governance" in Legal Thought and in the World: Some Splitting as Antidote to Overzealous Lumping*, 89 MINN. L. REV. 471, 495 (2004) [hereinafter Karkkainen II] ("[R]esponsibility for negotiating HCPs and enforcing their terms was a responsibility assigned to regional and field offices, each operating largely by its own lights.").

148 *See supra* note 146 and accompanying text.

149 See *infra* notes 375–383 and accompanying text for more detailed discussion of the advantages of fragmented governance.

150 *See, e.g.*, EUGENE BARDACH, GETTING AGENCIES TO WORK TOGETHER: THE PRACTICE AND THEORY OF MANAGERIAL CRAFTSMANSHIP (1998) (providing recommendations for fostering interagency

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management inevitably requires consideration of connected ecosystem components, some scholars and agencies[151] have called for the development of networks of regulatory programs and ultimately management that is focused on particular ecosystems or landscapes.[152] Though collaborative management is still the exception and not the rule,[153] a number of inter-jurisdictional governance regimes have been created.[154] Properly structured, innovations that promote information pooling and inter-jurisdictional communication might enrich agency decision making and decrease incentives for regulatory inaction.

3. Lessons from the Great Lakes

Unfortunately, existing experiments have failed to develop and support a system for interaction and information sharing that facilitates inter-agency learning. The following case study on Great Lakes governance serves as an archetypical illustration of the fragmentation that exists in natural resource regulation. It demonstrates the impediments to climate change adaptation caused by divided authority and the failure to develop useful inter-jurisdictional networks despite longstanding recognition of the negative effects of fragmented governance.

With ninety percent of the U.S. and eighteen percent of the global freshwater supply, the Great Lakes are the largest surface freshwater system on the planet,[155] and they support considerable economic activity.[156] The Great

collaboration); Ruhl & Salzman, *supra* note 136, at 41–45 (discussing a system of "weak ties" for alleviating the effects of fragmentation).

[151] *See, e.g.*, U.S. EPA, Ecosystem Protection Workgroup, Toward a Place-Driven Approach: The Edgewater Consensus on an EPA Strategy for Ecosystem Protection (March 15, 1994), *in* JOHN COPELAND NAGLE & J.B. RUHL, THE LAW OF BIODIVERSITY AND ECOSYSTEM MANAGEMENT 384, 384–85 (2d ed. 2006); Peterson et al., *supra* note 96, at 51 (explaining that ecosystem-based management "is designed to bring . . . disparate groups together to achieve the integration and coordination of efforts").

[152] *See, e.g.*, 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 (1996); R. Edward Grumbine, *What Is Ecosystem Management?*, 8 CONSERVATION BIOLOGY 27 (1994); Karkkainen I, *supra* note 14, at 1439–42 (explaining "ecosystem management" and "place-based" integrated management).

[153] *See* Kareiva et al., *supra* note 111, at 30 ("Although such collaboration does occur, formal co-management remains the exception, not the rule.").

[154] For notable examples, see Natural Community Conservation Planning Act, CAL. FISH & GAME CODE §§ 2800-2835 (West 2009); California Bay-Delta Authority (CBDA), http://calwater.ca.gov/calfed/oversight/CBDA/index.html (last visited July 3, 2009); Chesapeake Bay Program, http://www.chesapeakebay.net/index.aspx (last visited July 3, 2009). For additional examples, see Bradley C. Karkkainen, *Collaborative Ecosystem Governance: Scale, Complexity, and Dynamism*, 21 VA. ENVTL. L.J. 189, 217–18 (2002) [hereinafter Karkkainen III].

[155] *See* Great Lakes Envtl. Research Lab., Nat'l Oceanic & Atmospheric Admin., About Our Great Lakes: Great Lakes Basin Facts, http://www.glerl.noaa.gov/pr/ourlakes/facts.html (last visited Feb. 18, 2009).

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Lakes are currently impaired by a number of environmental stressors,[157] and climate change will likely exacerbate these considerable threats. The region is especially vulnerable to climate change because of long water retention times and the relatively small drainage basin.[158] Scientists project appreciable increases in air and water temperature and evaporation;[159] decreases in water levels,[160] water quality,[161] wetland number and function,[162] and forest area;[163] and substantial increases in demand for water nationally.[164] Species ranges and the timing of biological events are also expected to change substantially.[165]

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[156] *See id.* (reporting the $4 billion fishing industry, 1,270 miles of commercial shipping routes, and 90% of iron ore and 58% of automobile production in the United States and Canada associated with the Great Lakes); GEORGE W. KLING ET AL., UNION OF CONCERNED SCIENTISTS & ECOLOGICAL SOC'Y OF AM., CONFRONTING CLIMATE CHANGE IN THE GREAT LAKES REGION 8 (2003) (reporting almost $2 trillion in regional production in 2000).

[157] These include water pollution, invasive species, changing precipitation and evapotranspiration levels, and rising water temperature. GOV'T OF CAN. & U.S. EPA, *The Great Lakes Today: Concerns*, *in* THE GREAT LAKES: AN ENVIRONMENTAL ATLAS AND RESOURCE BOOK (3d ed. 2008), *available at* http://www.epa.gov/glnpo/atlas/glat-ch4.html#4; NOAH D. HALL ET AL., NAT'L WILDLIFE FED'N, CLIMATE CHANGE AND GREAT LAKES WATER RESOURCES 7 (2007) (detailing precipitation and evapotranspiration projections); LINDA MORTSCH ET AL., GREAT LAKES WATER QUALITY BD. OF THE INT'L JOINT COMM'N, CLIMATE CHANGE AND WATER QUALITY IN THE GREAT LAKES REGION: RISKS, OPPORTUNITIES, AND RESPONSES 5 (2003) (describing water temperature increase from 1895 to 1999 of nearly double the national average). Water and wetland levels are also declining. GREAT LAKES COMM'N, WETLANDS RESTORATION: REGIONAL PRIORITIES FOR THE GREAT LAKES 1 (2007) (noting that well over half the Basin's historic wetlands have disappeared); Cynthia E. Sellinger et al., *Recent Water Level Declines in the Lake Michigan-Huron System*, 42 ENVTL. SCI. TECH. 367, 367 (2008) (finding Lakes Michigan and Huron have fallen approximately 3.6 feet since 1997). The Basin is also home to a number of endangered species. *See* U.S. EPA ET AL., *Case Study—Great Lakes and Upper Midwest*, *in* CLIMATE CHANGE, WILDLIFE, AND WILDLANDS 2, http://www.epa.gov/climatechange/wycd/downloads/CS_glum.pdf (last visited May 9, 2009) (discussing the endangered lynx, gray wolf, and peregrine falcon).

[158] *See* E. McBean & H. Motiee, *Assessment of Impact of Climate Change on Water Resources: A Long Term Analysis of the Great Lakes of North America*, 12 HYDROLOGY & EARTH SYS. SCI. 239, 239–40 (2008).

[159] *See, e.g.*, MORTSCH ET AL., *supra* note 157, at 5, 34, 38 (projecting air temperature increase as high as 9º F and mean annual lake surface evaporation increase of 39%).

[160] *See, e.g.*, Brent M. Lofgren et al., *Evaluation of Potential Impacts on Great Lakes Water Resources Based on Climate Scenarios of Two GCMs*, 28 J. GREAT LAKES RES. 537, 537 (2002) (projecting water level drop in Lakes Michigan and Huron of up to 4.5 feet).

[161] *See* MORTSCH ET AL., *supra* note 157, at 51–64 (expecting disappearance of small lakes and increase in summer algae, waterborne diseases, and water quality violations).

[162] *See id.* at 64–65 (stating changing climate will alter wetland flushing, sedimentation, nutrient input, and ice cover duration).

[163] *See* U.S. EPA, *supra* note 157, at 6 (noting projections of as much as a 70% decline in Great Lakes forests in the next four decades).

[164] *See* IPCC, ADAPTATION, *supra* note 23, at 14 (stating mountains in the western United States will experience "decreased snowpack, more winter flooding, and reduced summer flows, exacerbating competition for over-allocated water resources").

[165] *See, e.g.*, KLING ET AL., *supra* note 156, at 45 (stating conservative projections indicate 19–39% decline in ducks and 29% net loss in forest bird diversity by 2030s).

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Yet most scientists concede there is tremendous uncertainty about the precise location, type, and extent of these local effects.[166] Without a regulatory system that manages uncertainty effectively, such abrupt climate change could prove catastrophic.

a. A Fragmented Regulatory Patchwork

An astonishing number of government programs have been created to address these stressors on the natural resources of the Great Lakes, but this broad assortment of institutions lacks the infrastructure for managing the uncertainties of climate change. In addition to the many local, state, and provincial programs that address water use and environmental protection,[167] efforts by the governments of Canada and the United States are staggeringly numerous and fragmented. In the United States alone, more than 148 different federal programs involving ten federal agencies manage natural resources in the Great Lakes Basin.[168]

Due in large part to this piecemeal regulatory approach, various regional and international regimes of limited jurisdiction have arisen. The International Joint Commission (IJC) created by the Boundary Waters Treaty[169] has narrow authority to monitor and research air quality, water quality, and water levels and recently began analyzing the effects of climate change.[170] Subsequent amendments to the Boundary Waters Treaty also empower the IJC to review lake-wide management plans created by state and federal water quality agencies.[171] In a similarly fragmented fashion, the 1955 Convention on Great Lakes Fisheries[172] established the Great Lakes Fisheries Commission to

166 *See, e.g.*, *id.* at 16 (noting that uncertainty in models increases as the considered area grows smaller).

167 *See* HALL & STUNTZ, *supra* note 157, at 30–31 ("The scope and standards of the Great Lakes states' water management laws vary greatly, resulting in much inconsistency and little certainty in water resource protection."). In addition, the U.S. Supreme Court has weighed in on numerous water diversions by the State of Illinois from Lake Michigan. *See, e.g.*, Wisconsin v. Illinois, 449 U.S. 48 (1980).

168 U.S. GEN. ACCOUNTING OFFICE, GREAT LAKES, AN OVERALL STRATEGY AND INDICATORS FOR MEASURING PROGRESS ARE NEEDED TO BETTER ACHIEVE RESTORATION GOALS 4 (2003); U.S. EPA, *Great Lakes Federal Programs*, http://epa.gov/greatlakes/fedprograms.html (last visited May 9, 2009).

169 Treaty Between the United States and Great Britain Relating to Boundary Waters Between the United States and Canada, U.S.-Gr. Brit., Jan. 11, 1909, 36 Stat. 2448.

170 *See* MORTSCH ET AL., *supra* note 157, at 5.

171 Agreement Between the United States of America and Canada on Great Lakes Water Quality, U.S.-Can., Apr. 15, 1972, 23 U.S.T. 301, superseded in 1978 by 30 U.S.T. 1383, amended in 1983 by 35 U.S.T. 2371, amended in 1987 by Protocol Amending the 1978 Agreement Between the United States of America and Canada on Great Lakes Water Quality, U.S.-Can., Nov. 18, 1987, T.I.A.S. No. 11551, at Annex II.

172 Convention on Great Lakes Fisheries Between the United States of America and Canada, U.S.-Can., Sept. 10, 1954, 6 U.S.T. 2836.

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coordinate research and control efforts on fisheries—most notably curtailing the invasive sea lamprey.[173]

The states and provinces in the Great Lakes Basin have also developed a series of regional programs focusing on water use, including the Great Lakes Commission (to gather data and make non-binding recommendations on water use)[174] and a Council of Great Lakes Governors (to coordinate data gathering, consultation, and the development of a process for regulating new water uses and diversions).[175] As a result, the Great Lakes-St. Lawrence River Basin Water Resources Compact (Compact)[176] was adopted in 2008.[177] The Compact prohibits almost any new diversion of water out of the Basin area[178] and requires all signatories to apply the same approval standard for new withdrawals inside the Basin.[179] In addition, it establishes a regional inventory of large water uses[180] and requires a review every five years of cumulative impacts that might consider the effects of climate change.[181]

Finally, President George W. Bush issued an executive order in 2004, creating the Great Lakes Interagency Task Force (ITF) in an effort to coordinate the many federal programs governing the Great Lakes and to lead a Great Lakes Regional Collaboration (GLRC).[182] The GLRC includes the ITF, the Great Lakes Governors' Council, the Great Lakes and St. Lawrence Cities

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173 *See* Great Lakes Fisheries Comm'n, *About the Great Lakes Fishery Commission*, http://www.glfc.org/aboutus/brief.php (last visited May 9, 2009).

174 Great Lakes Basin Compact, Pub. L. No. 90-419, 82 Stat. 414, 415–17 (1968).

175 *See* COUNCIL OF GREAT LAKES GOVERNORS, THE GREAT LAKES CHARTER: PRINCIPLES FOR THE MANAGEMENT OF GREAT LAKES WATER RESOURCES (1985); COUNCIL OF GREAT LAKES GOVERNORS, THE GREAT LAKES CHARTER ANNEX: A SUPPLEMENTARY AGREEMENT TO THE GREAT LAKES CHARTER (2001).

176 COUNCIL OF GREAT LAKES GOVERNORS, GREAT LAKES-ST. LAWRENCE RIVER BASIN WATER RESOURCES COMPACT (2005) [hereinafter COMPACT], *available at* http://www.cglg.org/projects/water/docs/12-13-05/Great_Lakes-St_Lawrence_River_Basin_Water_Resources_Compact.pdf. An associated non-binding agreement incorporates Quebec and Ontario. *See* COUNCIL OF GREAT LAKES GOVERNORS, GREAT LAKES-ST. LAWRENCE RIVER BASIN SUSTAINABLE WATER RESOURCES AGREEMENT (2005), *available at* http://www.cglg.org/projects/water/docs/12-13-05/Great_LakesSt_Lawrence_River_Basin_Sustainable_Water_Resources_Agreement.pdf.

177 *See* Great Lakes-St. Lawrence River Basin Water Resources Compact, Pub. L. No. 110-342, 122 Stat. 3739 (2008).

178 COMPACT, *supra* note 176, at § 4.8.

179 *Id*. at § 4.11.

180 *Id*. at § 4.1.

181 *Id*. at § 4.2.

182 Exec. Order No. 13,340, 69 Fed. Reg. 29,043 (May 20, 2004).

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Initiative,[183] American Indian tribes, and a task force of members of Congress from the region. The GLRC's chief product to date has been a proposal for protecting and restoring the Great Lakes.[184] The Obama administration proposed funding to implement much of this strategy,[185] which the House of Representatives approved (and the Senate is considering) as part of the 2010 budget.[186]

b. Flawed Collaborative Innovations

These various collaborative attempts to reduce the effects of fragmentation have at best only modestly increased the adaptive capacity of the regulatory programs that govern and manage the resources in the Great Lakes Basin. Despite the variety of regional and international entities with a hand in the Great Lakes, governance is still very fragmented by jurisdiction and by resource, with few opportunities for regulators and managers to collaborate and learn from each other and fellow officials. Though the IJC and Great Lakes Fisheries Commission increased available information and coordination opportunities for resource managers and regulators for particular Great Lakes resources, these entities have also created horizontal fragmentation by focusing on narrow segments of Great Lakes resources. Their influence on Great Lakes resource management thus has been mixed.[187]

Similarly, though the regional Compact is an unprecedented step toward more coordinated and flexible regional water use management, it remains quite narrow. The Compact largely ignores other resource matters such as water

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183 The Great Lakes and St. Lawrence Cities Initiative is a binational coalition of local officials for advancing conservation and restoration in the Great Lakes and St. Lawrence River. *See generally* Great Lakes and St. Lawrence Cities Initiative, http://www.glslcities.org/ (last visited May 9, 2009).

184 *See* GREAT LAKES REG'L COLLABORATION, GREAT LAKES REGIONAL COLLABORATION STRATEGY TO RESTORE AND PROTECT THE GREAT LAKES (2005) [hereinafter GLRC STRATEGY].

185 *See* Great Lakes Restoration Initiative, http://www.epa.gov/greatlakes/glri/ (last visited July 14, 2009).

186 *See* H.R. 2996, 111th Cong., at 66 (as passed by House, June 26, 2009). The Senate is scheduled to vote on 2010 funding for this strategy in September 2009. *See* Stephanie Veale, *Schumer Promotes Great Lakes Initiative*, DEMOCRAT & CHRONICLE (Rochester, N.Y.), Aug. 25, 2009, available at http://www.democratandchronicle.com/article/20090825/NEWS01/908250329/1002/NEWS/Schumer-promotes-Great-Lakes-initiative

187 *See, e.g.*, Joseph W. Dellapenna, *Interstate Struggles over Rivers: The Southeastern States and the Struggle over the 'Hooch'*, 12 N.Y.U. ENVTL. L.J. 828, 858 (2005) ("[T]he Commission [has] made remarkably few regulatory decisions or even recommendations to the two governments given the enormous development in water use and abuse . . . ." (footnote omitted)). *See also id.* at 858–59 ("The [IJC] . . . has been less successful in dealing with pollution than in dealing with the more strictly engineering aspects of its charge." (footnote omitted)).

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quality and biological resources,[188] and does little to address water use except restrict new water exports and uses. As a result, the Compact has been criticized for failing to fulfill even its declared water use management goals.[189] Climate change is likely to make these structural inadequacies worse.[190]

Perhaps more troubling is the fact that each of the national, regional, and international attempts to address Great Lakes resource management have failed to focus on a key consequence of fragmented governance—the limited capacity for intergovernmental learning. Even though the GLRC represents the most ambitious attempt to harmonize resource management and restoration funding efforts, it still suffers from a weak commitment to intergovernmental learning. The GLRC has made some progress drafting reports on invasive species, toxic pollution, wetland restoration, and beach contamination.[191] It also ambitiously states that it aspires to coordinate data gathering by the multitude of agencies with jurisdiction over the Great Lakes,[192] which has the potential to serve as a useful tool for monitoring and adjusting management strategies (including climate adaptations).

Though perhaps an improvement on previous governance, the GLRC still does not provide systematic opportunities for cross-jurisdictional information sharing on essential resource management concerns. The GLRC does propose the creation of a number of projects designed to generate scientific information and increase public access to such information.[193] The GLRC also fails to integrate Canadian regulators and consider water management issues, and to date it has largely ignored climate change as a stressor on Great Lakes resources. More importantly, though the ambitions of the GLRC for coordinating scientific data are an improvement on conventional fragmented

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188 *See* COMPACT, *supra* note 176, at § 4.11 (contemplating only piecemeal consideration of water quality or biological resources in permit applications for future water withdrawal).

189 *See* Joseph W. Dellapenna, *International Law's Lessons for the Law of the Lakes*, 40 U. MICH. J.L. REFORM 747, 797 (2007).

190 *See id.* at 793–94.

191 *See* GREAT LAKES REG'L COLLABORATION, AQUATIC INVASIVE SPECIES RAPID RESPONSE INITIATIVE: PROGRESS REPORT–JUNE 2008 (2008); GREAT LAKES REG'L COLLABORATION, GLRC TOXIC POLLUTANTS INITIATIVE: PROGRESS REPORT–NOVEMBER 2008 (2008); GREAT LAKES REG'L COLLABORATION, GREAT LAKES REGIONAL COLLABORATION HABITAT/WETLANDS INITIATIVE: A PROGRESS REPORT AND CALL TO ACTION (2008); GREAT LAKES REG'L COLLABORATION, BEACH PROJECT INITIATIVE: PROGRESS REPORT–NOVEMBER 2008 (2008).

192 *See* GLRC STRATEGY, *supra* note 184, at 53–58.

193 *See* U.S. EPA, *2010 Great Lakes Restoration Initiative Summary of Proposed Programs and Projects* 2–6 (2009), *available at* http://www.epa.gov/glnpo/glri/2010GLRIProgramsProjects.pdf (proposing scientific observing systems, watershed modeling, forest resource analysis, and an information management program for scientific information as part of the Great Lakes Restoration Initiative).

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governance, the GLRC does not even consider collecting, generating, or disseminating information evaluating management strategies by participating agencies that would facilitate intergovernmental learning. Moreover, although the GLRC stipulates the importance of increased coordination and integration of monitoring data, it concedes that existing resources for such activities are wholly insufficient and that, without additional investment, monitoring activities will decline.[194]

This limited and erratic commitment to collaboration is representative of natural resource management in the U.S. and raises serious questions about the ability of existing governance to address the effects of climate change. The fact that climate change effects on the Great Lakes have been largely ignored by this vast array of regulators, including those tasked with reducing the effects of fragmentation, is telling. Only recently have there been efforts even to consider integrating the effects of climate change into management activities.[195] Even the IJC—the one institution that has analyzed the possible effects of climate change on Great Lakes resources under its jurisdiction[196]—has yet to even propose adaptation strategies for the Great Lakes Basin. The absence of an infrastructure for generating and disseminating information to regulators and managers on regulatory tools and management strategies represents a failure to harness collectively available information and experience. This leaves the Great Lakes Basin susceptible to regulatory gaps, and ultimately reduces prospects for managing the large-scale effects and considerable uncertainty that is expected to follow from climate change. Because such experiments fail to provide incentives for regulators and managers to work with and learn from their counterparts, existing collaborative efforts have added yet another layer of fragmentation to the already disjointed regulatory landscape.

B. Natural Resource Governance Is Not Adaptive

In addition to characteristic fragmentation, natural resource governance in the United States is quite un-adaptive. Existing programs are not designed to

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194 *See* GREAT LAKES REG'L COLLABORATION, *Appendix for the Information and Indicators Strategy Team*, *in* GREAT LAKES REGIONAL COLLABORATION (2005).

195 The Obama administration's proposed Great Lakes Restoration Initiative anticipates convening Federal agencies "to coordinate efforts to identify key priorities for climate change impacts modeling/prediction for Great Lakes ecosystems." U.S. EPA, *supra* note 193, at 2.

196 *See* MORTSCH ET AL., *supra* note 157 (reporting IJC projections on the effects of climate change on water quality in the Great Lakes region).

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manage uncertainty or reduce the likelihood and magnitude of mistakes that often result from facing uncertain problems with imprecise tools. Many natural resource agencies have declared allegiance to changes in management to make it more adaptive, leading to the creation of various management experiments. Unfortunately, as exemplified by a prominent regulatory effort along the Colorado River, such attempts have not been effective at promoting adaptive decision making due to poor regulatory design and a failure to attend to resource manager incentives.

1. Existing Governance Impedes Adaptive Adaptation

Traditionally, the legitimacy of natural resource agency decision making—including promulgating regulations, preparing and implementing management plans, and permitting or licensing activities—has been fundamentally premised on agency expertise[197] buttressed by interest representation.[198] Agencies have been expected to rely heavily on their presumed expertise at forecasting detailed, long-range management plans, with public input on proposed actions—typically a late addendum through a standardized public notice-and-comment process.[199] Upon adoption of the plan, agency responsibilities were presumed to be straightforward—to implement and enforce the plan.[200]

Yet, this theoretical model of natural resource governance does not match the reality of substantial uncertainty that agency officials regularly face. With inevitably limited information regarding natural systems and the effects of proposed actions, agencies often adopt a plan or course of action that

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[197] *See* Richard B. Stewart, *Administrative Law in the Twenty-First Century*, 78 N.Y.U. L. REV. 437, 440–41, 443 (2003) (detailing the "new deal" and "analytic management" models of regulatory management that trust in agency expertise for legitimacy).

[198] *See id.* at 441–42 (detailing the "interest representation" model of regulatory management that depends on interest group representation for legitimacy).

[199] *See* Karkkainen III, *supra* note 154, at 200 ("We are accustomed to thinking of environmental protection in terms of centralized, top-down prescription of fixed, enforceable, uniform rules. The unstated background assumption is that an expert regulator . . . will know enough to be able to identify and isolate the most important problems, and gather sufficient information about them to prescribe effective solutions with sufficient specificity to translate into legally enforceable commands." (footnote omitted)); Alejandro E. Camacho, *Beyond Conjecture: Learning About Ecosystem Management from the Glen Canyon Dam Experiment*, 8 NEV. L.J. 942, 954 (2008) [hereinafter Camacho II].

[200] *See* Karkkainen III, *supra* note 154, at 200 ("This approach assumes . . . that the challenge for the regulator is to study the problem until she decides she has enough information to prescribe a fixed rule, and then make it stick." (footnote omitted)).

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subsequent information frequently demonstrates is incomplete or incorrect.[201] The dynamic nature of natural systems belies the ability of agencies to rely on static, long-range planning. As circumstances change, even plans based on rigorous data can quickly become obsolete.[202]

Aggravating the problem is the fact that, whether due to a lack of agency incentives or resources, subsequent monitoring and adjustment of agency decisions are persistently deficient. Regular monitoring and revision can help foster agency accountability and legitimacy by pushing regulators to account for the evolving character of complex systems, particularly when there are significant uncertainties regarding the initial regulatory decision.[203] Though monitoring of agency decisions is routinely required by statutes and regulations, and though agencies expressly acknowledge the importance of accountability,[204] agency attention to such directives is notoriously poor.[205] As a result, agencies rarely ensure that their actions are actually achieving regulatory goals, let alone adjust these decisions when new information is learned or circumstances change.[206]

In addition to being inefficient, such an approach leaves natural systems vulnerable to a host of foreseeable and unforeseeable risks, as agencies are not aware of whether initial projections were correct, initial strategies were effective, or new conditions or information have arisen to warrant making adjustments to such strategies. Equally important, when combined with the limited public oversight of agency implementation and restricted judicial

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[201] *See id.* at 201 ("[W]e inescapably operate under a chronic information deficit with respect to a variety of factors relevant to environmental decision making. Under the circumstances, the conventional strategy . . . is a prescription for inaction and ineffectiveness, or policy failure.").

[202] *See, e.g.*, Kareiva et al., *supra* note 111, at 30 ("If a plan is not updated regularly, or a planning horizon is too short-sighted in view of climate change, a plan's management goals may become outdated or inappropriate.").

[203] *See* Alejandro Esteban Camacho, *Mustering the Missing Voices: A Collaborative Model for Fostering Equality, Community Involvement and Adaptive Planning in Land Use Decisions; Installment Two*, 24 STAN. ENVTL. L.J. 269, 296 (2005) [hereinafter Camacho III].

[204] *See, e.g.*, Camacho I, *supra* note 14, at 324–25.

[205] *See* Freeman, *supra* note 14, at 16–17; Camacho I, *supra* note 14, at 328; MGMT. SYS. INT'L, AN INDEPENDENT EVALUATION OF THE EFFECTIVENESS OF THE U.S. FISH AND WILDLIFE SERVICE'S NATIONAL WILDLIFE REFUGE SYSTEM 20 (2008) ("[O]nly 11% of refuge managers surveyed described the current level of inventory and monitoring work as being mostly or fully sufficient."). *Cf.* E.S. Bernhardt et al., *Synthesizing U.S. River Restoration Efforts*, 308 SCI. 636, 637 (2005) (finding only 10% of the 37,099 stream and river restorations in the United States between 1990 and 2004 that were conducted or authorized by agencies incorporated any form of monitoring or assessment, and most of those assessments were not designed to share collected information).

[206] Camacho I, *supra* note 14, at 332–35.

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review,[207] the limitations of agency expertise and the absence of true accountability raise fundamental questions regarding the legitimacy of resource agency decision making.

In this context, various legal scholars have asserted the importance of cultivating programs that allow for flexibility and learning in agency decisions.[208] These assertions have paralleled the mounting appeals in the scientific literature to integrate adaptive management in resource regulation.[209] Based on a pragmatic model of decision making as an iterative process of design, implementation, and evaluation,[210] scholars promote refashioning agency regulation and management through ongoing monitoring and adaptation.[211] Such monitoring and adaptation can promote accountability and more effective resource management by allowing decisions to be tailored if conditions change or new information is acquired.[212] As I have argued elsewhere, through systematic "regulatory learning," agencies can better manage uncertainty by treating natural resource regulation and management as long-term processes of provisional decisions followed by monitoring, evaluation, and adaptation.[213]

Adaptive management is a particularly useful strategy for managing the uncertainty of climate change as it increases the ability of a natural system to absorb and respond to multiple climate change scenarios.[214] While operating in an entirely transparent system where all effects are foreseeable would be ideal, waiting for the effects of climate change to become completely clear could result in irreparable losses to ecosystems.[215] Adaptive management strategies have the capacity to incorporate confidence estimates, rather than strictly black-and-white scenarios.[216] Thus, managers can use the imperfect

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[207] *See* JAN G. LAITOS, NATURAL RESOURCES LAW 34–35 (2002).

[208] *See, e.g.*, Dorf & Sabel, *supra* note 14, at 285; Karkkainen II, *supra* note 147, at 496; Freeman, *supra* note 14, at 28–29.

[209] *See* J.B. Ruhl, *Regulation by Adaptive Management—Is It Possible?*, 7 MINN. J. L. SCI. & TECH. 21, 28 n.12 (2005). For an overview of the scientific literature on adaptive management, see notes 114–115 and accompanying text; GEORGE H. STANKEY ET AL., USDA, FOREST SERV., ADAPTIVE MANAGEMENT OF NATURAL RESOURCES: THEORY, CONCEPTS, AND MANAGEMENT INSTITUTIONS 31–33 (2005).

[210] *See* Dorf & Sabel, *supra* note 14, at 285.

[211] *See* Freeman, *supra* note 14, at 28.

[212] *See* Camacho III, *supra* note 203, at 295–97; Freeman, *supra* note 14, at 28.

[213] *See* Camacho I, *supra* note 14, at 342–44, 351.

[214] Emma L. Tompkins & W. Neil Adger, *Does Adaptive Management of Natural Resources Enhance Resilience to Climate Change?*, 9 ECOLOGY & SOC'Y 1, 1–2 (2004).

[215] *See, e.g.*, Scott et al., *supra* note 96, at 2 ("[D]elaying action could result in irreversible losses to the integrity, diversity, and health of the [National Wildlife Refuge System].").

[216] *See* Kareiva et al., *supra* note 111, at 23–25.

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information they possess at any particular time, rather than waiting to act until the scientific information is clear, knowing that the strategy can be changed as more information becomes available.[217] Adaptive management strategies can also be used to evaluate basic assumptions of current management plans—for example, reliance on historic conditions as points of comparison for future trends.[218] Because of these features, many have promoted adaptive management as the most promising approach for addressing uncertainty in the face of climate change.[219]

2. Recent Adaptive Experiments Are also Deficient

Because of the limitations of conventional approaches, many agencies have declared varying levels of interest in making their regulatory regimes more adaptive, and some even have experimented with adaptive management. Regrettably, even some well-regarded attempts at adaptive management have not sufficiently attended to the design of their experiments or the incentives of officials and stakeholders to facilitate adaptive regulation.

Numerous federal natural resource agencies have claimed to integrate adaptive management into decision making. The U.S. Fish and Wildlife Service (USFWS) adopted one of the first official statements regarding adaptive management in 2000; it promulgated guidance requiring adaptive management strategies under the Endangered Species Act for habitat conservation plans (HCPs) "that would otherwise pose a significant risk to the species due to significant data or information gaps."[220] It also recently adopted in principle a "Strategic Habitat Conservation" policy framework,[221] which claims to promote the use of adaptive management for entire landscapes.[222] In

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[217] *See* Joseph Arvai et al., *Adaptive Management of the Global Climate Problem: Bridging the Gap Between Climate Research and Climate Policy*, 78 CLIMATIC CHANGE 217, 219 (2006).

[218] *See* Joyce et al., *supra* note 83, at 47.

[219] *See* Scott et al., *supra* note 96, at 37.

[220] U.S. Fish & Wildlife Serv. & National Oceanic & Atmospheric Admin., *Addendum to the HCP Handbook*: Questions & Answers, 2 (2000), http://www.fws.gov/endangered/pdfs/HCP/Final_Addendum_QandA.pdf (last visited July 4, 2009); Notice of Availability of a Final Addendum to the Handbook for Habitat Conservation Planning and Incidental Take Permitting Process, 65 Fed. Reg. 35,242, 35,252 (June 1, 2000).

[221] *See* Memorandum from Kenneth Stansell, Acting Dir., U.S. Fish & Wildlife Serv., to Service Directorate (Mar. 20, 2007) (on file with author) (discussing Strategic Habitat Conservation).

[222] U.S. Fish & Wildlife Serv., *Strategic Habitat Conservation*: *The USFWS Framework for Landscape Conservation*, http://www.fws.gov/science/doc/SHCFactSheet1008pdf.pdf (last visited Aug. 3, 2009) ("[SHC] is an adaptive management framework that informs decisions about where and how to expend resources for wildlife species, or groups of species, in identified priority areas or regions with particular biological importance—often referred to as landscapes.").

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2007, the DOI adopted a technical guide[223] and policy guidance seeking incorporation of adaptive management "into pertinent internal programmatic guidance" to be considered for use in certain situations.[224] Both the DOI and the U.S. Forest Service (USFS) have proposed incorporating adaptive management into rules implementing the National Environmental Policy Act,[225] and in 2008, the USFS claimed to promote the use of adaptive management in its National Forest System Land Management Planning Rule.[226] The Environmental Protection Agency (EPA) has yet to rely on adaptive management for any major regulatory program,[227] and actual use by any agency is still rare in practice.[228]

In the few circumstances in which federal agencies have claimed to implement or regulate adaptive ecosystem management strategies, significant flaws are apparent. For example, as I have detailed elsewhere, the HCP program has failed to provide sufficient agency incentives or resources to implement monitoring and adaptive management effectively.[229] Though monitoring is required in the HCP program, it is usually deficient and even absent.[230] Additionally, regulating agencies only require applicants to use adaptive management when there are severe data gaps, and even then the

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223 BYRON K. WILLIAMS ET AL., ADAPTIVE MANAGEMENT WORKING GROUP, ADAPTIVE MANAGEMENT: THE U.S. DEPARTMENT OF THE INTERIOR TECHNICAL GUIDE (2007).

224 Secretary of the Interior Order No. 3270, (Mar. 9, 2007), available at http://elips.doi.gov/elips/SO_word/so3270.doc. ("Consideration of [adaptive management] is warranted when: (a) there are consequential decisions to be made; (b) there is an opportunity to apply learning; (c) the objectives of management are clear; (d) the value of reducing certainty is high; (e) uncertainty can be expressed as a set of competing, testable models; and (f) an experimental design and monitoring system can be put in place with a reasonable expectation of reducing uncertainty.").

225 *See* 36 C.F.R. § 220.5 (2009) (noting in the context of an environmental impact statement that "[a]n adaptive management proposal or alternative must clearly identify the adjustment(s) that may be made when monitoring during project implementation indicates that the action is not having its intended effect, or is causing unintended and undesirable effects."); 43 C.F.R. § 46.145 (2009) ("Bureaus should use adaptive management, as appropriate, particularly in circumstances where long-term impacts may be uncertain and future monitoring will be needed to make adjustments in subsequent implementation decisions.").

226 36 C.F.R. § 219.3 (2009) ("Land management planning is an adaptive management process that includes social, economic, and ecological evaluation; plan development, plan amendment, and plan revision; and monitoring.").

227 Carl Bruch, *Adaptation Law and the Future of Environmental Law: How Climate Change Will Reshape Environmental Governance*, CLIMATE CHANGE, SUSTAINABLE DEV. & ECOSYSTEMS COMM. NEWSL. (Am. Bar Ass'n, Chicago, Ill.), May 2008, at 13, 15.

228 *See, e.g.*, Camacho I, *supra* note 14, at 298 (stating that though the FWS has "repeatedly acknowledged that adaptive management and contingency planning are valuable characteristics . . . empirical evidence shows an aversion to implementing them").

229 *See* Camacho I, *supra* note 14, at 323–35.

230 *See id.* at 324–28.

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agencies agree that any adaptations in response to unforeseen events must be funded by the agency.[231] Because agency resources for monitoring and adaptation are paltry, adaptive management is rarely required in HCPs and subsequent modification of initial strategies is even less common.[232] Most importantly, USFWS does not systematically collect or assess information about HCPs to allow or direct agency personnel to learn about the relative value of different negotiating, monitoring, and management strategies.[233]

Others have detailed similar limitations in other adaptive management experiments.[234] Some have even observed that certain agencies have sought to use the adaptive management label as a screen for approving action when they are faced with uncertain effects but have little interest in subsequent monitoring and adaptation.[235] Although leading prototypes of the use of adaptive management are better than conventional resource governance, as exemplified by the following case study, they can fall short of the ideal.

3. The Colorado River's Flawed Adaptive Management Experiment

Despite a recent high-profile experiment to integrate adaptive management into governance for a portion of the Colorado River, the current matrix of regulatory programs still remains remarkably un-adaptive—a problem likely to be exacerbated by the substantial uncertainty associated with climate change. Though the river has been popularized as a volatile torrent with the legendary power to carve out the Grand Canyon, the current flow for "the most regulated

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231 *See id*. at 329–32.

232 *See id*. at 332–35.

233 *See id*. at 336–42.

234 *See, e.g.*, Dave Owen, *Law, Environmental Dynamism, Reliability: The Rise and Fall of CALFED*, 37 ENVTL. L. 1145 (2007); R. Gregory et al., *Deconstructing Adaptive Management: Criteria for Applications to Environmental Management*, 16 ECOLOGICAL APPLICATIONS 2411, 2413 (2006) (noting that a program's scale, levels of uncertainty and risk, and lack of institutional support can make applying adaptive management very difficult); Scott et al., *supra* note 96, at 29 ("[F]ew resources are available to support post-adoption implementation, including monitoring, experimentation, and iterative revisions.").

235 *See* Doremus, *supra* note 16, at 569 ("Promises of adaptive management have become excuses to act in the face of uncertainty, providing empty assurances of environmental protection without any enforceable requirements for learning or incorporating new knowledge." (footnote omitted)). *Cf.* Holly Doremus, *Adaptive Management, the Endangered Species Act, and the Institutional Challenges of "New Age" Environmental Protection*, 41 WASHBURN L.J. 50, 53 (2001) [hereinafter Doremus, *Adaptive Management*] ("Agencies can use claims of adaptive management as a ploy to placate demands for environmental protection without actually imposing any enforceable constraints on themselves.").

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and over allocated river in the world"[236] is much more labored and controlled. Numerous dams provide power for thirteen million households[237] and water for more than thirty million people.[238] They also support robust recreation industries,[239] but these dams have completely transformed the river.[240] In addition, accelerating consumption[241] and drought[242] have depleted water levels. Already, the river often runs dry before reaching the Gulf of California,[243] and even non-climate change projections indicate that live storage[244] in Lakes Mead and Powell will be *gone* by 2021.[245] Unsurprisingly, controlling and siphoning off water, in concert with other stressors, has taken a heavy toll on the river's ecosystems.[246] Today, various native fish, plant, and bird species are endangered or extirpated in certain river segments,[247] and the once-fertile Colorado River Delta ecosystem has degraded and shrunk eighty percent in the last century.[248]

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236 N.S. Christensen & D.P. Lettenmaier, *A Multimodel Ensemble Approach to Assessment of Climate Change Impacts on the Hydrology and Water Resources of the Colorado River Basin*, 11 HYDROLOGY & EARTH SYS. SCI. 1417, 1418 (2007).

237 *See* ROBERT W. ADLER, RESTORING COLORADO RIVER ECOSYSTEMS: A TROUBLED SENSE OF IMMENSITY 5 (2007).

238 *See id.*; MARK T. ANDERSON & LLOYD H. WOOSLEY, JR., WATER AVAILABILITY FOR THE WESTERN UNITED STATES—KEY SCIENTIFIC CHALLENGES 15 (2005).

239 *See* ADLER, *supra* note 237, at 253, 256.

240 *See* Cristensen & Lettenmaier, *supra* note 236, at 1418.

241 *See* ANDERSON & WOOSLEY, *supra* note 238, at 26, 28 (stating that approximately 300 million gallons of water *per day* is consumed in the lower Colorado River Basin beyond the renewable water supply).

242 *See id.* at 3, 15, 49.

243 *See* Jennifer J. Follstad Shah et al., *River and Riparian Restoration in the Southwest: Results of the National River Restoration Science Synthesis Project*, 15 RESTORATION ECOLOGY 550, 551 (2007) (interpreting C. Nilsson et al., *Fragmentation and Flow Regulation of the World's Large River Systems*, 308 SCIENCE 405–08 (2005)).

244 Live storage is "the reservoir space from which water can be evacuated by gravity." *See* Tim P. Barnett & David W. Pierce, *When Will Lake Mead Go Dry?*, 44 WATER RESOURCES RES. W03201 (2008).

245 *See id.*

246 Dam construction stabilized and lowered water flow and temperature, reduced nutrient content, and reduced vital sediments, which hindered reproduction and replenishment of beach and sandbar habitat for certain native species. *See* ADLER, *supra* note 237, at 6, 42–45. Introductions of exotic fish and intentional poisoning of certain native fish by government agencies further altered ecosystems. *See id.* at 2, 108–09.

247 *See* U.S. Fish & Wildlife Serv., *The Upper Colorado River Basin and Endangered Fish*, http://www.fws.gov/coloradoriverrecovery/Crovervu.htm (last visited Feb. 18, 2009) (stating four of fourteen native species of fish are endangered); Joseph M. Feller, *Collaborative Management of Glen Canyon Dam: The Elevation of Social Engineering over Law*, 8 NEV. L.J. 896 (2008); Nat'l Parks Serv., Glen Canyon National Recreation Area: Plants, http://www.nps.gov/glca/naturescience/plants.htm (last visited Feb. 18, 2009) (discussing twenty rare plants and other endemic plant species); ADLER, *supra* note 237, at 6 (discussing endangered bird species in the Colorado River Basin).

248 *See* Barbara J. Morehouse et al., *Science and Socio-Ecological Resilience: Examples from the Arizona-Sonora Border*, 11 ENVTL. SCI. & POL'Y 272, 276 (2008).

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Climate change is expected to further threaten the Colorado River's ability to serve as a productive resource for the southwestern United States and northwestern Mexico. The river's watershed is particularly susceptible to climate change because the region is arid, and discharge is highly responsive to the effects of temperature and precipitation changes on snow accumulation, melt, and evapotranspiration.[249] By mid-century, reservoirs are expected to hold one-third less water than current levels, and hydropower generation could decrease by nearly forty percent.[250] Recent studies also indicate that the area will become drier, woodland vegetation will be replaced (if at all) by desert species, and wildfires will be more intense and frequent.[251] Few projections of localized effects exist,[252] and there is considerable variability in these projections.[253] Yet even under conservative temperature predictions and a no-population-growth scenario, the Colorado River will be unable to maintain existing water allocations.[254] Because almost all of the river's water is consumed, any reduction would be highly disruptive to the ecosystem and water allocation demands.[255] As stated by one recent study, "the fully allocated Colorado system [is] at the brink of failure, wherein virtually any reduction in precipitation over the Basin, either natural or anthropogenic, will lead to the failure of mandated allocations."[256]

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249 *See* Christensen & Lettenmaier, *supra* note 236, at 1418.

250 *See* Tim Barnett et al., *The Effects of Climate Change on Water Resources in the West: Introduction and Overview*, 62 CLIMATIC CHANGE 1, 6, 7 (2004). Another leading study projects that discharge at the river's rough midpoint may decrease by twenty percent by mid-century. *See* P.C.D. Milly et al., Letters, *Global Pattern of Trends in Streamflow and Water Availability in a Changing Climate*, 438 NATURE 347 (2005).

251 *See* Nat'l Parks Serv., Grand Canyon Nat'l Park, *Research on Wildfire Hazard Reduction in Ponderosa Pine Ecosystems at Grand Canyon National Park: Executive Summary*, http://www.nps.gov/archive/grca/forest/execsum.htm (last visited July 5, 2009).

252 In fact, many recent agency analyses do not even consider the local effects of climate change. *See* Nat'l Parks Serv., Grand Canyon Nat'l Park, *Science Research—Current Projects*, http://www.nps.gov/grca/naturescience/research_current_projects.htm (last visited July 5, 2009); Nat'l Parks Serv., Glen Canyon National Recreation Area, *Research at Glen Canyon* (2008), http://www.nps.gov/glca/naturescience/upload/CURRENT%20RESEARCH%20AT%20GLEN%20CANYON%20NATIONAL%20RECREATION%20AREA.pdf (last visited Feb. 18, 2009).

253 *See, e.g.*, Christensen & Lettenmaier, *supra* note 236, at 1428 ("While all models agree with respect to the direction of temperature changes, there is considerable variability in the magnitude, direction, and seasonality of projected precipitation changes.").

254 *See* Barnett et al., *supra* note 250, at 6.

255 *See* Christensen & Lettenmaier, *supra* note 236, at 1419.

256 Barnett et al., *supra* note 250, at 7.

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a. From Conflicting Mandates to an Attempt at Adaptive Management

Colorado River governance incorporates a well-known regulatory innovation purporting to promote adaptive and collaborative decision making. However, this experiment has only added a modest level of adaptability to the river's arcane regulatory machinery. Allocation of the river's water is governed by the "Law of the River," a motley assemblage of statutes, court decisions, treaties, contracts, decrees, and regulatory guidelines[257] that has been the subject of political debate and litigation for decades.[258] The Basin is also subject to a suite of federal and state environmental and natural resource laws,[259] including the Endangered Species Act, which was activated by the listing of four endangered fish that inhabit the river.[260] The resulting protections for these species and their ecosystems have produced persistent conflict with the water-allocation and secondary hydropower-generation goals advanced by the Law of the River.[261] Limited scientific knowledge of these sensitive resources and uncertainty about the effects of dam operations have exacerbated this tension.[262]

Nowhere is this resource conflict between consumptive, power generation, ecological, and recreational uses more prominent than in the operation of Glen Canyon Dam and its effects on the Glen Canyon National Recreation Area and Grand Canyon National Park. Ostensibly to resolve this tension, Congress

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[257] The Law of the River most notably includes the following: Colorado River Storage Project Act, 43 U.S.C. § 620 (2008) (enacted 1956); Colorado River Basin Project Act, 43 U.S.C. §§ 1501–1556 (2008) (enacted 1968); Upper Colorado River Basin Compact, ch. 48, 63 Stat. 31 (1949); Treaty Respecting Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, U.S.-Mex., Feb. 3, 1944, 59 Stat. 1219; Arizona v. California, 547 U.S. 150 (2006) (consolidated Supreme Court decree incorporating *Arizona v. California*, 376 U.S. 340 (1964), and subsequent amendments). For a complete list of the Law of the River, see U.S. Dep't of the Interior, Bureau of Reclamation, Lower Colo. Region, *The Law of the River*, http://www.usbr.gov/lc/region/g1000/lawofrvr.html (last visited July 5, 2009).

[258] *See* ADLER, *supra* note 237, at 19, 141–54 (detailing recurring interstate litigation and conflict between environmental, hydropower, agriculture, and recreation interests).

[259] *See* Camacho II, *supra* note 199, at 946.

[260] Native Fish and Wildlife: Endangered Species, 32 Fed. Reg. 4001 (Mar. 11, 1967); Endangered and Threatened Wildlife and Plants; Determination of Critical Habitat for the Colorado River Endangered Fishes: Razorback Sucker, Colorado Squawfish, Humpback Chub, and Bonytail Chub, 59 Fed. Reg. 13,374 (Mar. 21, 1994) (to be codified at 50 C.F.R. pt. 17).

[261] *See, e.g.*, Grand Canyon Trust v. U.S. Bureau of Reclamation, No. CV-07-8164-PHX-DGC, 2008 WL 1458784, at *1 (D. Ariz. May 26, 2009) (holding that FWS opinion on Colorado River dam project violated ESA, Bureau of Reclamation experimental plan did not violate Grand Canyon Protection Act, and environmental assessment for dam project did consider appropriate and reasonable alternatives under NEPA); *see also* Camacho II, *supra* note 199, at 947.

[262] *See* Camacho II, *supra* note 199, at 948.

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passed the Grand Canyon Protection Act of 1992 (GCPA),[263] but in fact, Congress merely evaded responsibility by tasking the Secretary of the Interior to design a process for reconciling the conflicting legal mandates.[264] Pursuant to congressional authority provided in the GCPA,[265] in 1997 the Secretary of the Interior established the Glen Canyon Dam Adaptive Management Program (AMP) as an experimental effort at collaborative adaptive management involving various federal agencies, the Colorado River Basin states,[266] American Indian tribes, academics, environmental organizations, the recreation industry, and power users.[267] The AMP notably includes: (1) the Grand Canyon Monitoring and Research Center (GCMRC), a scientific research program proposed as one of the first government institutions to rely on adaptive management for long-term monitoring and research; (2) the Adaptive Management Working Group (AMWG), a twenty-five member federal advisory committee intended to improve regulatory decision making by engaging a range of affected stakeholders in management decisions; (3) a Technical Work Group tasked with liaising between the AMWG and GCMRC; and (4) an independent science advisory committee. [268]

The AMP is often identified by agencies and observers as one of the most successful examples of adaptive management in regulatory decision making.[269] To be sure, the AMP has a number of promising elements. The GCMRC integrates a well-funded information gathering and assessment apparatus charged with scientific monitoring and research and relies on robust independent peer review panels "to assess the quality of research, monitoring, or science being conducted."[270] Admirers of the AMP identify a number of high-profile experimental flood releases from Glen Canyon Dam that have

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263 Pub. L. No. 102-575, 106 Stat. 4669 (1992).

264 *See* Camacho II, *supra* note 199, at 948.

265 Grand Canyon Protection Act, *supra* note 263, at §§ 1803(b), 1804(c)(3), 1805(a), (c).

266 These include Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming. *See* Colorado River Compact of 1922, art. III(d), 70 CONG. REC. 324 (1928).

267 *See* BUREAU OF RECLAMATION, DEP'T OF THE INTERIOR, STRATEGIC PLAN: GLEN CANYON DAM ADAPTIVE MANAGEMENT. PROGRAM 4, 9 (2001), *available at* http://www.usbr.gov/uc/rm/amp/pdfs/sp_final.pdf.

268 *See id*. at 2–3; Glen Canyon Dam Adaptive Management Program, Purpose and Goals, http://www.gcdamp.gov/aboutamp/pg.html (last visited July 13, 2009).

269 *See, e.g.*, Secretary of the Interior, *supra* note 224 (stating adaptive management "has proved to be a useful approach in cases such as the Bureau of Reclamation's management of Glen Canyon Dam"); Dirk Kempthorne, *Message from the Secretary*, *in* WILLIAMS ET AL., *supra* note 223, at i; *see also* Camacho II, *supra* note 199, at 956–57.

270 BUREAU OF RECLAMATION, *supra* note 267, at 6.

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provided valuable scientific information about the downstream ecosystem.[271] Such management experimentation, monitoring, and assessment are vital steps in any attempt to cope with uncertainty in resource management and are indeed a considerable improvement on conventional resource governance.

b. The Flaws of an Acclaimed Experiment

Yet, despite these enhancements, the Glen Canyon Dam AMP (Glen Canyon AMP) exemplifies the unfulfilled promise of recent experiments seeking to increase government capacity to manage uncertainty adaptively. The AMP is plagued by a weak and uncertain mandate and provides insufficient incentives for collaborative and adaptive decision making. This is in part because there is substantial uncertainty regarding what the function of the AMP—and the AMWG in particular—should be in managing the conflicting mandates of the GCPA.[272] The relationship of the AMWG to any decisions made regarding Glen Canyon Dam management by the Secretary of Interior is very unclear, as the Secretary is free to disregard AMWG recommendations without explanation. Without a clear and direct role in resource management decisions, the AMP acts as nothing more than a costly "accessory to the regulatory process."[273]

Furthermore, the AMP lacks any standards for assessing and ensuring the program's progress toward regulatory goals.[274] As a result, though important scientific information has been gained through GCMRC experiments, the AMP provides no concrete thresholds delineating when any such data must be used to adjust management of the dam.[275] Although the GCMRC engages in experiments, monitoring, and assessment of the results, it has no standard or deadline for making adjustments to operations to account for new information obtained through such experiments. It is telling that over the twelve years of the AMP's existence, not a single modification to long-term operations of the dam has been made,[276] and the AMP has failed to reliably improve the quality

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[271] *See, e.g.*, Doremus, *Adaptive Management*, *supra* note 235, at 78–79; Vicky J. Meretsky et al., *Balancing Endangered Species and Ecosystems: A Case Study of Adaptive Management in Grand Canyon*, 25 ENVTL. MGMT. 579 (2000).

[272] *See* Camacho II, *supra* note 199, at 949–50.

[273] *See id.* at 951.

[274] *See id.* at 957.

[275] *See id.*

[276] *See id.*

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of the fragile downstream ecosystem.[277] Though perhaps interesting as academic exercises, the AMP's research experiments are not adaptive management because they have never been used to adapt resource management decisions.

Most problematic, however, is the lost opportunity to gather information about adopted management strategies and the Glen Canyon AMP itself.[278] The GCMRC does gather considerable scientific data about the natural systems and resources in the AMP area. But, like virtually every other natural resource program, nobody in the AMP is required to gather, analyze, or distribute any information on the efficacy of adopted resource management strategies or decision-making processes. Without clear requirements or incentives to monitor and adjust the AMP, the AMP's managers simply do not consider in any systematic way whether adopted management strategies or the AMP have been effective at achieving the program's goals. Because systematic monitoring and adjustment of management strategies is not required, Congress, the Secretary of the Interior, and the AMWG have little capacity to adapt the AMP or its management strategies to make them more effective.[279]

In short, like all other natural resource programs, the AMP has not developed an infrastructure for reducing uncertainty or improving the efficacy of management strategies currently in use. The lack of systematic information on the past performance of such strategies compounds the uncertainty that agencies confront in managing the natural systems under their jurisdiction—uncertainty, of course, that is magnified with the ascendancy of climate change. As a result, programs such as the AMP are sandwiched between management uncertainties and uncertainties about natural systems, with little incentive to reduce either.[280] A key lesson from management efforts like the Glen Canyon AMP, then, is that even programs adopted to adaptively manage natural resources need a comprehensive framework for managing not only uncertainty about changing natural systems but also information gaps regarding the efficacy of their resource management strategies and resource programs.

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[277] *See* Memorandum from Field Supervisor, U.S. Fish & Wildlife Serv. to Deputy Reg'l Dir., Bureau of Reclamation, Upper Colo. Region, Salt Lake City, Utah (Feb. 27, 2008), *available at* http://www.usbr.gov/uc/envdocs/bo/FinalGCDBO2-26-08.pdf.

[278] *See* Camacho II, *supra* note 199, at 955–56.

[279] *See id.* at 957.

[280] Indeed, like most other natural resource programs, the AMP has not publicly considered or adopted any strategies to account for, or respond to, the acute climate effects projected for the Colorado River Basin.

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C. Lessons for Managing Uncertainty: A Learning Infrastructure

The various regulatory experiments introduced to promote collaborative and adaptive management provide valuable lessons for building the capacity of natural resource governance to manage uncertainty associated with climate change. Unfortunately, as exemplified by Great Lakes governance, attempts to reduce the effects of fragmentation have provided at best weak opportunities and incentives for cross-jurisdictional information sharing and collaboration. Furthermore, as illustrated by the Glen Canyon AMP, even adaptive management innovations have not been structured to require or otherwise promote adaptive decision making. As a result, despite these experimental efforts, most natural resource programs still lack the tools and incentives to learn systematically from their own management experience. They also remain isolated and unable to harness the broader knowledge of other natural resource managers.

In essence, these experiments demonstrate that natural resource governance has failed to develop the systemic capacity to manage uncertainty. What is needed is an infrastructure that proliferates opportunities for information sharing and that cultivates learning. As further detailed in Part V, such an infrastructure should include the development of a shared, easily accessible clearinghouse for the collection and dissemination of scientific data and evaluations of management decisions among government programs.[281] Such an effort would serve to reduce the negative consequences of regulatory fragmentation by harnessing the collective experience of natural resource agencies and facilitating collaborative learning among jurisdictions.

In addition, such a learning infrastructure should emphasize adaptive governance—regular monitoring, assessment, and adjustment of all agency decision making as judged against stated statutory goals.[282] Adaptive governance seeks to go beyond adaptive management, which focuses on assessing and adjusting individual agency regulatory or management choices for particular resource problems. Adaptive governance is the systematic evaluation and adaptation of all agency decisions (including rulemaking and planning activities) in furtherance of stated program goals. It even includes the assessment of agency personnel and of the agencies themselves against statutory goals. The development of such an adaptive infrastructure that induces agencies and stakeholders to learn throughout the governance process

[281] *See infra* Part V.A.
[282] *See infra* Part V.B.

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is vital for managing and reducing the uncertainty accompanying climate change.

IV. THE INADEQUACY OF EXISTING CLIMATE ADAPTATIONS

Global climate change has accelerated the necessity of developing systematic adaptive regulation and inter-jurisdictional information sharing. Given the substantial shortcomings of existing governance—and the pressing need to address the effects of climate change—a vital path for addressing the additional stress from climate change is clear. Legislators and agencies must adopt, fund, and encourage comprehensive procedural adaptation strategies that cultivate the development of monitoring, information gathering, and adaptation protocols in natural resource governance. Information generation, collection, and dissemination must be coordinated among jurisdictions in order to diminish the negative effects of regulatory fragmentation that discourage adaptation and learning by regulators and managers..

Unfortunately, effective implementation of adaptation measures is often neglected by decision-makers. Agencies have focused primarily on substantive adaptations, neglecting the need to change natural resource governance to manage the uncertainty of climate change. It is encouraging that a few programs propose to foster information sharing and adaptive management in resource management. However, even these programs and the agencies involved ignore the need to adopt procedural adaptations that promote agency learning about the regulatory process itself. By doing so, agencies are repeating mistakes in addressing uncertainty from recent regulatory experiments, with potentially crippling effects for natural systems in the face of climate change.

A. Few Adopt or Propose Adaptive or Collaborative Adaptations

As detailed earlier, as a paradigmatic regulatory commons, few regulators have adopted any strategies for adapting to climate change.[283] Managers continue to rely on strategies premised on historically normal conditions that even agency officials concede are not likely to apply under projected climate change scenarios.[284] As of August 2009, Congress has not adopted any

[283] *See supra* notes 142–46 and accompanying text.

[284] *See* GAO REPORT, *supra* note 142, at 8, 37 (describing how a lack of new guidance from agency officials impairs managers' ability to address climate change issues). *See also* IPCC, ADAPTATION, *supra* note

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strategies expressly directed at climate change adaptation, and few federal bills even proposing adaptation have focused on adaptive management and interagency information sharing.[285]

Similarly, despite growing calls for the use of adaptive management,[286] the few agencies considering adaptation neglect adaptive and collaborative procedural strategies. Department of Interior agencies have developed remarkably few adaptation strategies despite a 2001 order from the Secretary requiring programs to account for climate change in all long-range planning and major management decisions.[287] Virtually all National Park management plans ignore climate change or reject consideration of any proactive adaptation.[288] Even the certified "Climate Friendly" National Parks[289]

23, at 637 ("In general, decision makers lack the tools and perspectives to integrate future climate, particularly events that exceed historic norms." (citation omitted)).

[285] *See, e.g.*, Lieberman-Warner Climate Security Act of 2008, S. 3036, 110th Cong. §§ 4701–02, 4801, 7005 (2008) (proposing adaptation fund, review of national adaptation needs and costs, international climate change adaptation program, and periodic update of adaptation strategies); Coastal State Climate Change Planning Act of 2008, H.R. 5453, 110th Cong. (2008) (seeking funding of state coastal adaptation planning); Climate Change Drinking Water Adaptation Research Act, S. 2970, 110th Cong. (2008) (seeking drinking water adaptation study); Climate Change Adaptation Act, S. 2355, 110th Cong. (as reported with amendments and an amendment to the title, June 5, 2008) (requiring the President to create a national adaptation plan and directing the Secretary of Commerce to oversee regional vulnerability assessments and plans).

One exception is the American Clean Energy and Security Act of 2009, passed by the U.S. House of Representatives and placed on calendar in the U.S. Senate. *See* American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong. (as passed by House, June 26, 2009, placed on Senate Legislative Calendar, July 7, 2009), *available at* http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:h2454eh.txt.pdf (proposing, among other things, the creation of a National Climate Service, at § 452, as "a collaborative, interagency research and operational program . . . for reliable, timely, and relevant information related to climate variability and change," as well as a Natural Resources Adaptation Science and Information program in the U.S. Geological Survey (USGS), at § 477, "for developing and providing science and information needed to assess and address the impacts of climate change and ocean acidification on natural resources"). *See also* Omnibus Public Land Management Act of 2009, S. 22, 111th Cong. (2009) (proposing information exchange in conjunction with strategic plan for research on ocean acidification adaptation).

[286] *See, e.g.*, NAT'L WILDLIFE FED'N, A LETTER FROM SCIENTISTS TO THE UNITED STATES CONGRESS URGING ACTION TO ADDRESS THE THREATS OF GLOBAL WARMING TO WILDLIFE AND ECOSYSTEMS (2008); WORLD CONSERVATION UNION, *supra* note 56, at 2.

[287] *See* Secretary of the Interior Order No. 3226, Amendment No. 1 (Jan. 16, 2009), *available at* http://www.blm.gov/pgdata/etc/medialib/blm/wy/programs/science.Par.46189.File.dat/SO_3226A1.pdf (replacing Secretary of the Interior Order No. 3226 (Jan. 19, 2001)).

[288] *See, e.g.*, NAT'L PARKS SERV., SAGUARO NATIONAL PARK: ABBREVIATED FINAL GENERAL MANAGEMENT PLAN/ENVIRONMENTAL IMPACT STATEMENT 3 (2008), *available at* http://planning.nps.gov/document/SAGU%20Abbrev_WEB_part1.pdf ("Because the issue of global climate change is an emerging scientific field, the *General Management Plan* did not address this topic specifically. As part of NPS inventorying and monitoring efforts the park staff will establish a program to track associated effects on park resources as a result of climate change. If and when effects are identified through this program, the park staff would then recommend necessary changes in management policies . . . .").

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typically fail to mention adaptation in their "Climate Friendly Parks Action Plans," focusing only on mitigation of the climate footprint of any particular park.[290]

The USFWS response to climate change is primarily limited to researching its effects and considering how to incorporate these findings into future management.[291] One minor exception is the Habitat Conservation program, which USFWS claims is attempting to accelerate coordination and collaboration with other agencies and private parties to conserve habitat due to climate change.[292] In addition, though not yet an adopted adaptation strategy, encouragingly in September 2009 the USFWS produced a draft plan for public comment that proposes the development over the next five years of a national adaptation strategy for fish and wildlife that would employ "Strategic Habitat Conservation,"[293] which if adopted would help promote the use of adaptive management and inter-agency collaboration.[294] Other Interior agencies like the Bureau of Land Management have not adopted any adaptations.[295]

It is encouraging that USFS published a strategic adaptation plan in October 2008 that briefly mentions the need for better data management, collaboration, and agency learning.[296] However, virtually the entire plan is

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289 Nat'l Parks Serv., *Climate* Friendly *Parks*, http://www.nps.gov/climatefriendlyparks/ (last visited Feb. 18, 2009) ("The Climate Friendly Parks program is a joint partnership between the [EPA] and the [NPS]. Climate Friendly Parks from around the country are leading the way in the effort to protect our parks' natural and cultural resources and ensure their preservation for future generations.").

290 *See, e.g.*, NAT'L PARKS SERV. ENVTL. LEADERSHIP PROGRAM, CLIMATE FRIENDLY PARKS: YOSEMITE NATIONAL PARK ACTION PLAN (2006). Two parks do refer to adaptive management in their "Climate Friendly Parks Action Plans," albeit only in passing. *See* NAT'L PARKS SERV. ENVTL. LEADERSHIP PROGRAM, CLIMATE FRIENDLY PARKS: HAWAII VOLCANOES NATIONAL PARK BECOMES A CLIMATE FRIENDLY PARK 7 (2007); NAT'L PARKS SERV. ENVTL. LEADERSHIP PROGRAM, CLIMATE FRIENDLY PARKS: ROCKY MOUNTAIN NATIONAL PARK ACTION PLAN 8 (2007).

291 *See* U.S. Fish & Wildlife Serv., *Climate Change:* What We're Doing, http://www.fws.gov/home/climatechange/ouractions.html (last visited July 14, 2009) (describing several research programs).

292 *See id.*

293 *See supra* note 222 and accompanying text.

294 *See* U.S. FISH & WILDLIFE SERV., RISING TO THE CHALLENGE: STRATEGIC PLAN FOR RESPONDING TO ACCELERATING CLIMATE CHANGE 10, 18-20 (2009) (public comment draft).

295 Personal communication with E. Dwight Fielder, Bureau of Land Management, Division Chief, Fish, Wildlife and Plant Conservation (Aug. 1, 2008) (noting that BLM has not adopted any official climate adaptations).

296 *See* U.S. FOREST SERV., FOREST SERVICE STRATEGIC FRAMEWORK FOR RESPONDING TO CLIMATE CHANGE 7 (2008) (mentioning the "need to work collaboratively" with federal, state, tribal, and local authorities); *id.* at 8 (discussing the need for "improved, coordinated, and enhanced monitoring systems, predictive models, decision support tools, and databases"); *id.* at 11 ("Addressing climate change will depend on reducing institutional barriers and increasing adaptive learning through experimentation."). As provided for in this strategy, USFS did recently create guidance documents on incorporating climate change into NEPA

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dedicated to substantive responses,[297] as are all existing USFS adaptation strategies.[298] Furthermore, only 15 of 121 USFS forest plans even reference climate change as a risk factor.[299]

Other federal agencies ignore the need for adaptive regulation but have advocated limited steps toward better interagency cooperation. With one important exception,[300] EPA's planned adaptation strategy is limited to a recently published "National Water Program Strategy" that concentrates on mitigation and specific, un-adaptive adaptations.[301] Its discussion of adaptation chiefly focuses on substantive strategies that adjust existing water programs to account for the direct effects of climate change.[302] However, the Water Program Strategy does describe a watershed-based "coordinating framework" that contemplates some interagency cooperation.[303] Similarly, though ignoring adaptive management, NOAA has begun coordinating the collection of certain scientific data with Canadian agencies[304] and has suggested a National Climate Service to coordinate climate information and services across the federal government.[305]

Generally, state governments have not fared any better at developing adaptation strategies that promote adaptive decision making or information sharing. Only a small minority of states even considered adaptation in their Climate Action Plans (CAPs), and even a smaller number discuss it with any specificity, or are preparing plans that will detail proposed adaptation efforts.[306] The few state CAPs to discuss adaptation primarily focus on

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planning that briefly mention adaptive management. *See* U.S. FOREST SERV., CLIMATE CHANGE CONSIDERATIONS IN PROJECT LEVEL NEPA ANALYSIS (2009), *available at* http://www.fs.fed.us/emc/nepa/climate_change/includes/cc_nepa_guidance.pdf; U.S. FOREST SERV., CLIMATE CHANGE CONSIDERATIONS IN LAND MANAGEMENT PLAN REVISIONS (2009), *available at* http://www.fs.fed.us/emc/nepa/climate_change/includes/cc_land_mgmt_plan_rev.pdf.

297 *See, e.g.*, U.S. FOREST SERV., FOREST SERVICE STRATEGIC FRAMEWORK FOR RESPONDING TO CLIMATE CHANGE 9 (2008) (noting thinning of forest stands and prescribed fire).

298 *See, e.g.*, Joyce et al., *supra* note 83, at 21.

299 *Id.* at 45.

300 *See also infra* Part IV.B.1 (evaluating EPA's Climate Ready Estuaries pilot program).

301 U.S. EPA, *supra* note 106, at 61.

302 *See id.* at iv.

303 *See id.* at 40.

304 News Release, Nat'l Oceanic & Atmospheric Admin., United States, Canada Begin New Climate Data-Sharing Agreement (Nov. 14, 2008), http://www.noaanews.noaa.gov/stories2008/20081114_canadaclimate.html.

305 *See* NAT'L OCEANIC & ATMOSPHERIC ADMIN., TOWARDS A NATIONAL CLIMATE SERVICE (2008), *available at* http://www.dco.noaa.gov/transition/corporatestrategy/climate_service_2pg.pdf.

306 *See* U.S. EPA, State Climate Action Plans Database, http://yosemite.epa.gov/gw/StatePolicyActions.nsf/webpages/index.html (last visited Feb. 18, 2009) (compiling state Climate Action Plans). Montana

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substantive strategies[307] or only quickly mention the value of adaptive management[308] or coordinating information,[309] without providing the necessary detail about how this should and could be accomplished effectively. Similarly, many state "Wildlife Action Plans"[310] fail to even mention climate change, and those that do so fail to discuss adaptation or do so only briefly.[311] Because federal and state governments have neglected adaptation activities, those local governments interested in developing adaptation strategies lack vital localized scientific data and funding necessary to prepare for the effects of climate change.[312]

B. The Limitations of the Few Promising Adaptation Strategies

In a positive development, two government programs have been created that endorse adaptive management and agency collaboration in the context of climate change adaptation. Though the U.S. Climate Change Science Program and EPA's Climate Ready Estuaries program are certainly improvements on

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specifically rejected adaptation, regarding it as a low priority. GOVERNOR'S CLIMATE CHANGE ADVISORY COMM., MONTANA CLIMATE CHANGE ACTION PLAN 7-3 (2007).

[307] *See, e.g.*, ARIZ. CLIMATE CHANGE ADVISORY GROUP, CLIMATE CHANGE ACTION PLAN 43 (2006) ("recommend[ing] that a comprehensive state climate change adaptation strategy be developed and implemented").

[308] *See, e.g.*, WASH. CLIMATE ADVISORY TEAM, 2008 CLIMATE CHANGE INTERIM REPORT: LEADING THE WAY ON CLIMATE CHANGE; THE CHALLENGE OF OUR TIME 154 (2008) ("Laws, regulations and decision-making systems may need to . . . accept risk for the sake of learning and adaptive management."); GOVERNOR'S CLIMATE CHANGE INTEGRATION GROUP, FINAL REPORT TO THE GOVERNOR: A FRAMEWORK FOR ADDRESSING RAPID CLIMATE CHANGE 22 (2008) (urging Oregon state authorities to "[u]se and continually improve adaptive management processes and contingency planning").

[309] *See* GOVERNOR'S CLIMATE CHANGE INTEGRATION GROUP, *supra* note 308, at 22 (recommending Oregon "[c]oordinate research agendas across states and regions"); GOVERNOR'S COMM'N ON CLIMATE CHANGE, FINAL REPORT: A CLIMATE CHANGE ACTION PLAN 33–38 (2008) (recommending collaboration on regional adaptations); GOVERNOR'S ACTION TEAM ON ENERGY & CLIMATE CHANGE, FLORIDA'S ENERGY AND CLIMATE CHANGE ACTION PLAN 8-5 (2008) (recommending coordination with federal agencies, other states, and countries). Maryland's CAP mentions the need for "intergovernmental coordination on coastal adaptation," but leaves it for the federal government to create. *See* Md. Comm'n on Climate Change, *Building a Federal-State Partnership*, *in* MARYLAND CLIMATE ACTION PLAN ch. 6, at 10 (2008).

[310] A Wildlife Action Plan assessing the condition of a state's wildlife and outlining necessary conservation actions is required of any state seeking funds through the federal State Wildlife Grants Program or Wildlife Conservation and Restoration Program. Pittman-Robertson Wildlife Restoration Act, 16 U.S.C. § 669c(d)(1)(D) (2008).

[311] *See, e.g.*, JEFF LERNER ET AL., DEFENDERS OF WILDLIFE, CONSERVATION ACROSS THE LANDSCAPE: A REVIEW OF THE STATE WILDLIFE ACTION PLANS 13 (2006).

[312] *See* Ashley Lowe et al., Ctr. for Clean Air Policy, *Ask the Climate Question: Adapting to Climate Change Impacts in Urban Regions* 4–6 (2009), *available at* http://www.ccap.org/docs/resources/674/Urban_Climate_Adaptation-FINAL_CCAP%206-9-09.pdf (stating local governments need more funding and more localized climate data to engage in adaptation activities).

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conventional natural resource governance, the former has no regulatory authority, and the latter is small with little funding. More fundamentally, neither program seeks to set up a systematic infrastructure for developing and sharing information on the past and future performance of potential strategies for managing natural resources.[313]

1. The Climate Ready Estuaries Program and Charlotte Harbor Estuary

The EPA's recently created Climate Ready Estuaries pilot program promises to supplement the agency's existing regional collaboration program for estuaries, the National Estuaries Program, by providing additional federal information gathering and coordination. This rare and promising program has elements that could promote valuable information sharing and adaptive decision making. Unfortunately, it also seems poised to repeat the mistakes made by recent innovations in adaptive and collaborative governance.

a. The National Estuaries Program and Charlotte Harbor Estuary

Though estuaries[314] are managed by numerous government programs[315] under various statutes,[316] the EPA's National Estuaries Program (NEP)[317] is a core estuary protection program that fundamentally relies on intergovernmental collaboration. The NEP includes twenty-eight estuaries,

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[313] Similarly, the U.S. Geological Survey (USGS) has initiated a National Climate Change and Wildlife Science Center, which funds limited scientific research and has identified priority research needs, including data assessment and model interpretation, downscaling, decision-support tools, and the "[d]evelopment of clearinghouse and network capacity for standardized data and synthesis sharing." USGS, National Climate Change and Wildlife Science Center, http://nccw.usgs.gov/ (last visited May 8, 2009). Though in early development, like the Climate Ready Estuaries program, this Center does not appear to contemplate developing and incorporating systematic information on the performance of management strategies and agencies.

[314] Estuaries are "semi-enclosed bod[ies] of water on the seacoast in which fresh and salt water mix," thus serving as rich sources of biological productivity and ecosystem services. Peterson et al., *supra* note 96, at 4 (citation omitted).

[315] These include the National Oceanic and Atmospheric Administration's National Estuarine Research Reserve System and its Restoration Center, EPA's National Estuary Program, and state and local governments. *See* NOAA, Estuaries & You, http://www.estuaries.gov/estuaries101/About/Default.aspx?ID=251 (last visited May 5, 2009) (providing a list of governmental programs that protect and study estuaries).

[316] These include the Coastal Zone Management Act, the Estuary Restoration Act, the Endangered Species Act, the Clean Water Act, and the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act. *See* Peterson et al., *supra* note 96, at 12–17 (discussing statutes that serve to protect estuaries).

[317] The NEP was established in 1987 under the Clean Water Act § 320 and was amended by the Estuaries and Clean Waters Act. *See* 33 U.S.C. § 1330 (1994); Estuaries and Clean Waters Act, 33 U.S.C. § 2903 (2000).

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each of which has completed a Comprehensive Conservation and Management Plan (CCMP).[318] While focusing on water quality, each CCMP seeks to coordinate management of a variety of estuarine resources.[319] Like many collaborative innovations, NEP estuaries lack direct regulatory authority, relying on coordination, voluntary commitments, and providing incentives to regulators with jurisdiction.[320]

The Charlotte Harbor National Estuary Program (Charlotte Harbor), encompassing 4,700 square miles in western Florida, exemplifies the promise of NEP estuaries. Charlotte Harbor was named an "estuary of national significance" and included in the NEP in 1995.[321] Incredibly, Charlotte Harbor seeks to integrate eight federal agencies, twenty-six state agency divisions, seven counties, twenty-four cities, two water management districts, three regional planning councils, and at least eighty other special districts.[322] Despite this fragmentation, Charlotte Harbor developed its original CCMP through a collaborative "management conference" composed of government authorities, academics, stakeholders, and interested citizens, with EPA approving the CCMP in 2001.[323]

Like the Glen Canyon AMP, some have lauded the NEP as a successful experiment in collaborative ecosystem-based management.[324] Relying on

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[318] *See* U.S. EPA, Nat'l Estuary Program, Comprehensive Conservation and Management Plans, http://www.epa.gov/nep/ccmp/index.html (last visited Aug. 21, 2009).

[319] *See* Peterson et al., *supra* note 96, at 1 (stating the CCMPs have management goals of maintaining water quality, sustaining fish and wildlife populations, preserving habitats, protecting human values, and fulfilling water quality needs).

[320] *Id.* at 7. However, once approved, any federal action must be consistent with the CCMP. *See* Hope M. Babcock, *Dual Regulation, Collaborative Management, or Layered Federalism: Can Cooperative Federalism Models from Other Laws Save Our Public Lands?*, 14 HASTINGS W.-NW. J. ENVTL. L. & POL'Y 449, 473 (2008) ("Once approved, any federal action must be consistent with the plan." (footnote omitted)).

[321] CHARLOTTE HARBOR NAT'L ESTUARY PROGRAM, COMMITTING TO OUR FUTURE, A COMPREHENSIVE CONSERVATION AND MANAGEMENT PLAN FOR THE GREATER CHARLOTTE HARBOR WATERSHED FROM VENICE TO BONITA SPRINGS TO WINTER HAVEN 2 (2008) [hereinafter CHARLOTTE CCMP].

[322] *Id.* at 11–12.

[323] *See* Charlotte Harbor Nat'l Estuary Program, Who's Who in the Charlotte Harbor National Estuary Program Management Conference, http://www.chnep.org/NEP/committees/MgtConf.htm#Legislative%20Subcommittee (last visited May 5, 2009) (describing policy, management, technical advisory, and citizen advisory committees).

[324] *See* Richard H. Pierce et al., *Charlotte Harbor Initiative: Assessing the Ecological Health of Southwest Florida's Charlotte Harbor Estuary*, 13 ECOTOXICOLOGY 275, 276 (2004) ("Rarely do opportunities arise that facilitate the creation of scientific ventures with a broadly interdisciplinary approach. Where such opportunities have existed in the past (e.g., the National Estuary Program), the insights and benefits have been remarkable."); U.S. EPA, National Estuary Program, Implementing a Community-Based Watershed Approach, http://www.epa.gov/neplessons/ (last visited May 5, 2009) (detailing the "Keys to Success" of NEPs); *see*

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collaborative decision making to develop management efforts,[325] the NEP serves as a facilitator and capacity builder that helps provide the momentum for overcoming the incentives to under-regulate that are created by regulatory fragmentation.[326] NEP estuaries are relatively well-funded,[327] and some are making progress toward their stated goals.[328]

Evidence suggests, however, that the NEP may be more of a qualified achievement. For at least some estuaries, once the CCMP is approved, the collaborative "management conference" has no function, leaving plan implementation to voluntary compliance by each government entity.[329] Moreover, the NEP's manual for community-based watershed management never mentions adaptive management or seeks to implement procedures for systematic plan adjustment.[330] Unsurprisingly, the NEP also does not create any program-wide method for estuaries and their constituent agencies to systematically share information or otherwise learn from the experiences of other estuaries.

Even if the NEP could be deemed a partial success to date, climate change is likely to cripple estuarine resources and management. Most NEP estuaries remain substantially impaired by invasive species, fishing, pollution, waterfront construction, and habitat degradation.[331] Yet estuaries are likely to experience some of the most severe effects of climate change, including changing temperature, rising sea levels, changing precipitation that affects

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generally Mark Lubell, *Resolving Conflict and Building Cooperation in the National Estuary Program*, 33 ENVTL. MGMT. 677 (2004) ("[T]he NEP does a better job of resolving conflict and building project-level cooperation than similar estuaries without the NEP.").

325 *See* COASTAL MGMT. BRANCH, U.S. EPA, COMMUNITY-BASED WATERSHED MANAGEMENT: LESSONS FROM THE NATIONAL ESTUARY PROGRAM 4–5 (2005) [hereinafter U.S. EPA, LESSONS] ("By ensuring that stakeholders responsible for and interested in the management and use of the estuary are involved in the process, the NEPs have achieved successful collaboration.").

326 *See* Babcock, *supra* note 320, at 473 (describing the facilitator role of the federal government under the "collaborative management" model).

327 *See* U.S. EPA, Nat'l Estuary Program, Sustainable Financing Strategies, http://www.epa.gov/nep/fund.html (last visited Aug. 21, 2009).

328 For example, Charlotte Harbor claimed that by 2006, "progress ha[d] been made on all of the original 15 quantifiable objectives, with 2 of the 15 (13%) objectives and 13 of the 48 (27%) original priority actions having been accomplished." CHARLOTTE CCMP, *supra* note 321, at 2.

329 *See* Babcock, *supra* note 320, at 474 ("The management conference has no continuing function once the plan is approved."). *But see* CHARLOTTE CCMP, *supra* note 321, at 7–10 (discussing subsequent activities of management conference subcommittees).

330 *See* U.S. EPA, LESSONS, *supra* note 325, at 43–44, 62–63 (discussing only conventional monitoring options).

331 *See* Peterson et al., *supra* note 96, at 8–9 (outlining various environmental stressors on biological communities).

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runoff, and altered wind and storm patterns.[332] Collateral effects of human adaptations to protect private property (such as shoreline armoring) are likely to further impair estuarine resources in unknown ways.[333] In fact, the U.S. Climate Change Science Program alarmingly concluded that "[m]aintaining the status quo of estuarine management would guarantee growing failures in meeting all . . . management goals under progressive climate change."[334]

The absence of a programmatic infrastructure for agency learning makes it unsurprising that most existing CCMPs by and large have failed to adopt any climate change adaptations. Charlotte Harbor is one of the most advanced NEP estuaries on climate change planning, yet its 2008 CCMP only included two pages on climate change..[335] The only mention of adaptation is a brief list of preliminary strategies that either seek information and outside support[336] or that are only tangentially related to estuarine resources.[337] Though Charlotte Harbor has obtained funding from EPA to develop a vulnerability assessment[338] and adaptation plan[339] for a portion of the estuary, it only appears to be considering adopting various direct, substantive adaptations.[340]

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[332] *See* VICTOR S. KENNEDY ET AL., COASTAL AND MARINE ECOSYSTEMS AND GLOBAL CLIMATE CHANGE: POTENTIAL EFFECTS ON U.S. RESOURCES 7 (2002).

[333] *See* Peterson et al., *supra* note 96, at 3 ("[C]urrent policies allowing shoreline armoring to protect private property from damaging erosion imply escalating losses of public tidewater lands . . . .").

[334] *Id.* at 1.

[335] *See* CHARLOTTE CCMP, *supra* note 321, at 137–38. Some estuaries, such as the Massachusetts Bays Program, may include adaptation strategies as they update their plans. *See, e.g.*, Mass. Bays Program, State of the Bays, Special Topic: Climate Change and the Massachusetts Bays Program, http://www.mass.gov/envir/massbays/climate.htm (last visited May 5, 2009) (discussing updates to the Massachusetts Bay Program to reflect "emerging challenges that climate change presents").

[336] These include identifying "potentially critical areas to be addressed related to adaptation," developing a greenhouse gas emissions and carbon sequestration inventory, and working with the EPA. CHARLOTTE CCMP, *supra* note 321, at 137.

[337] These include considering support for a governor's executive order, encouraging "reduce, reuse and recycl[ing]" policies, increasing remote communications, and encouraging the hotel industry to gain a green lodging certification. *Id.*

[338] *See* CHARLOTTE HARBOR NAT'L ESTUARY PROGRAM, SCOPE OF WORK FOR THE EPA REGION 4 VULNERABILITY ASSESSMENT GRANT (040108 CRE REG 4 CRE), AN ANALYSIS OF CLIMATE CHANGE EFFECTS ON ECOSYSTEMS AND INFRASTRUCTURE SURROUNDING THE CHARLOTTE HARBOR ESTUARY (2008).

[339] *See* CHARLOTTE HARBOR NAT'L ESTUARY PROGRAM, ADAPTATION PLAN: DEVELOPMENT OF CLIMATE CHANGE ADAPTATION PLAN FOR A SOUTHWEST FLORIDA COASTAL CITY, SCOPE OF WORK (2008).

[340] *See id.* at 3 (listing substantive adaptation options: "[a]void importation of new exotic plants," "[p]rotect waterway buffers," and "[p]rotect coastal habitats through land acquisition and conservation easements"); Charlotte Harbor Nat'l Estuary Program, Charlotte Harbor Climate Ready Estuaries April 9, 2009 Workshop, http://www.chnep.org/projects/CRE/4-9-09_vulnerabilityadapations.pdf (listing ninety-two possible adaptation options, with "[m]ore rigorous agency review of development," "[u]se flexible planning," and "[b]etter distribution of information" as the only potentially procedural adaptations considered).

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b. The Climate Ready Estuaries Program

To aid estuaries in identifying climate change vulnerabilities and developing adaptation plans, in June 2008, the EPA inaugurated a Climate Ready Estuaries (CRE) program as part of the NEP.[341] Though still new, the CRE program is a rare procedural adaptation strategy that, in a limited sense, seeks to increase the adaptive capacity of agencies to address climate change despite the substantial uncertainties regarding localized effects. EPA created a publicly accessible "Coastal Toolkit" that essentially serves as an annotated bibliography of internet links "for estuaries and coastal programs interested in learning more about climate impacts and adaptation."[342] The portal organizes links to information (including examples) on climate change monitoring, coastal vulnerability tools, smart growth, data sources, adaptation planning, and financing opportunities.[343]

Additionally, the pilot program designates six NEP estuaries—including Charlotte Harbor—to which EPA intends to provide targeted support to "1) assess climate change vulnerabilities, 2) develop and implement adaptation strategies, 3) engage and educate stakeholders, and 4) share the lessons learned with other coastal managers."[344] Furthermore, an EPA white paper created by the CRE program recommends to individual estuaries that they incorporate monitoring and evaluation in adaptation planning "in the style of adaptive management."[345] The EPA thus plans to increase the capacities of individual

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[341] *See* U.S. EPA, Climate Ready Estuaries, http://www.epa.gov/cre/ (last visited Aug. 21, 2009) (stating that the CRE program works with NEPs to assess climate change vulnerabilities, develop and implement adaptation strategies, engage and educate stakeholders, and share the lessons learned with other coastal managers).

[342] U.S. EPA, Climate Ready Estuaries, Coastal Toolkit, http://www.epa.gov/cre/toolkit.html (last visited May 5, 2009).

[343] *Id.*

[344] *See* U.S. EPA, *supra* note 341. The other five estuaries currently involved in the program are the Albemarle-Pamlico Sounds National Estuary Program, Massachusetts Bays Program, New Hampshire Estuaries Project, Partnership for Delaware Estuary, and San Francisco Estuary Project. *See also* U.S. EPA, Climate Ready Estuaries, http://nerrs08.elkhornslough.org/content/Sector%20Materials/Managers/Materials/Managers'Foldercontents_EPAClimateReadyEstuariesInformation.pdf (last visited July 7, 2009) (listing the six NEPs included in the CRE program).

[345] U.S. EPA, ADAPTATION PLANNING FOR THE NATIONAL ESTUARY PROGRAM, WHITE PAPER 1 (2009), *available at* http://www.epa.gov/CRE/downloads/CREAdaptationPlanning-Final.pdf. *See also id.* at 6 ("Adaptation plans should include an outline of the process that will be used to periodically monitor and evaluate: (1) climate-driven changes in the estuary, and (2) the effectiveness of adaptation actions in lessening the negative impacts of those climate-driven changes. . . . Ideally, an adaptation plan will reflect the need for regular evaluation of adaptation effectiveness and incorporation of new or better information on climate effects. Rather than a static plan, authors of an estuary's climate change adaptation plan must consider the dynamic nature of information and climate interactions, and build in a regular process to revisit the plan's

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estuaries to address climate change by providing them with information on the relative value of various strategies.

Unfortunately, the CRE program is repeating mistakes from prior adaptive regulatory experiments. The CRE's Coastal Toolkit is certainly an upgrade on conventional information infrastructures, assembling publicly available scientific data from disparate sources, decision-support tools, and reports relevant to estuarine adaptation to climate change. As such, it facilitates agency information sharing and has the potential to foster intergovernmental learning, at least at the front-end during creation of adaptation plans.

However, as with prior experimental programs, EPA has not demonstrated any intent to treat the CRE program like an ongoing management experiment. The program is quite limited in funding and does not have nor does it promise long-term funding to local estuary programs.[346] More importantly, though the scientific information and models included in the Coastal Toolkit are likely to be useful, the toolkit lacks systematic information evaluating the past performance of estuarine management strategies or CCMPs on which EPA or Congress could rely for adapting the NEP program to better address conventional resource stressors, let alone climate change. Because systematic assessments of the performance of CCMPs have never occurred, little information on the effectiveness of potential adaptation strategies can be included in the toolkit.

Moreover, EPA appears not to have developed any systematic framework for modifying adaptation strategies or the CRE program over time. It is certainly a positive step that the CRE program suggests that estuaries periodically monitor and evaluate their adaptation plans.[347] Nonetheless, the lessons of prior adaptive management experiments indicate that estuaries are not likely to engage in adaptive management of their adaptation plans unless required to do so. Furthermore, if the CRE program itself were adaptive, it would impose rigorous monitoring and systematic assessments of the CRE's activities to evaluate whether adopted strategies are effective and to modify them when they are not. Instead, the CRE seems poised to employ the far less rigorous, highly problematic, but altogether common approach used by natural

specified priorities and actions. This may require a standing or ad hoc workgroup consisting of stakeholders and decision makers, or some other ongoing structure or practice, to ensure that the plan stays up-to-date and effective.").

346 Telephone interview with Jeremy Martinich, U.S. EPA, Climate Change Division (July 18, 2008).

347 *See supra* note 345 and accompanying text.

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resource regulators—relying on anecdotal evidence rather than rigorous analyses anchored in regulatory experimentation.[348]

2. The Climate Change Science Program

The only other federal program to provide more detailed consideration of adaptations that foster adaptive or collaborative governance is the U.S. Climate Change Science Program (CCSP), a federally funded research effort on climate change sponsored by thirteen federal agencies.[349] Though it is encouraging that the CCSP acknowledges the need for adaptive management and agency collaboration, it neither has the capacity to implement such strategies nor addresses a number of the important limitations of prior attempts at collaborative and adaptive governance.

In its 2008 *Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources: Synthesis and Assessment Product 4.4* (SAP 4.4), the authors described adaptive management as a key adaptation tool for climate-sensitive ecosystems and resources.[350] The report suggests that, given the complexity of climate change, adaptive management "may be the only way to take management action today while allowing for increased understanding and refinement tomorrow."[351] It also mentions the need for intergovernmental collaboration, stating that making sure that "management is done at appropriate scales, and not necessarily simply the scales of convenience or tradition," and stating that increasing "collaboration among agencies" will "aid in achieving adaptation to climate change."[352]

In fact, in some respects, the CCSP is itself a partial step toward a coordinating body for responding to climate change. The CCSP was established as a method for assembling federal research on climate change.[353]

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[348] *See* Camacho I, *supra* note 14, at 342.

[349] *See* U.S. Climate Change Sci. Program, U.S. Climate Change Science Program: Participating Agencies, http://www.climatescience.gov/about/agencies.htm (last visited May 5, 2009).

[350] *See* USCCSP, ADAPTATION OPTIONS, *supra* note 79, at 1.

[351] Kareiva et al., *supra* note 111, at 27.

[352] *Id.* at 36. *See also id.* at 37 ("Although a single national park or national forest may have limited capacity for adaptation, the entire system of parks and forests and refuges in a region may have the capacity for adaptation."). However, the CCSP's analysis focuses primarily on federally managed lands, virtually ignoring resources on private, state, and local property.

[353] *See* U.S. CLIMATE CHANGE SCI. PROGRAM & SUBCOMM. ON GLOBAL CHANGE RESEARCH, THE U.S. CLIMATE CHANGE SCIENCE PROGRAM: VISION FOR THE PROGRAM AND HIGHLIGHTS OF THE SCIENTIFIC STRATEGIC PLAN 29 (2003) ("The strategy seeks to optimize the benefits of research that is conducted, sponsored, or applied by 13 agencies and departments of the U.S. Government.").

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The primary research output of the CCSP, the Synthesis and Assessment Products, are intended to provide "current assessments of climate change science to inform public debate, policy, and operational decisions" and to "help the CCSP develop future program research priorities."[354] In this sense, the CCSP could be a welcome beginning to an infrastructure for information gathering and dissemination that could assist natural resource managers across jurisdictions in addressing climate change.

Unfortunately, the CCSP has no regulatory or management authority over natural resources.[355] Consequently, though various federal natural resource agencies may have contributed to a report that notes the potential of adaptive management and the need for interagency collaboration, these same agencies also acknowledge that they have not developed any way to integrate the research into the management process.[356] Much like the Glen Canyon AMP, the CCSP may be an interesting research exercise, but it provides limited value if it is not a part of a comprehensive management effort for adapting agency decisions.

More substantively, though SAP 4.4 identifies a number of key problems with existing governance, it nonetheless ignores essential lessons from prior regulatory experiments for addressing these shortcomings. To its credit, SAP 4.4 does acknowledge that monitoring is essential, that managers lack resources for identifying the optimal strategy for a specific situation,[357] and that the risk of failure and weak rewards discourage regulators from engaging

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[354] Carlos M. Gutierrez et al., *Letter to Members of Congress*, *in* USCCSP, ADAPTATION OPTIONS, *supra* note 79.

[355] *See* ROBERT L. PETERS, DEFENDERS OF WILDLIFE, BEYOND CUTTING EMISSIONS: PROTECTING WILDLIFE AND ECOSYSTEMS IN A WARMING WORLD 16 (2008) ("The [CCSP] lacks authority to allocate or prioritize funding in the agencies it works with, and the members of the interagency working group often have little budgetary authority to implement the research directions that they define." (footnote omitted)). Though several federal agencies contribute, so do non-governmental actors, and the CCSP is considered solely a research program with no direct link to the regulatory process. *See* Kareiva et al., *supra* note 111, at 39 (observing that the CCSP only coordinates climate change research and suggesting the possibility of expanding the CCSP to include management research and coordination).

[356] *See, e.g.*, Allen M. Solomon, U.S. Forest Serv., Global Change and the US Forest Service: The Nature of the Climate Threats We Face, http://www.fs.fed.us/rmrs/docs/climate-change/national-briefing-papers.pdf (last visited July 5, 2009) ("The U.S. Forest Service has a basic global change research program now 15 years old, and a research infrastructure ready to support a focused effort. . . . There is no FS-wide global change strategy to apply that research or create new information needed to manage with uncertainty.").

[357] These tools include the ways of interpreting models, prioritizing actions, and identifying tradeoffs. *See* Kareiva et al., *supra* note 111, at 33–35 (discussing perceived barriers to effective implementation of adaptation).

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in adaptive management.[358] The report also mentions other challenges in implementing adaptive management, including the absence of intra-agency coordination.[359] Finally, in SAP 4.4, the CCSP perceptively concedes that "minimal institutional capacity exists to capture experience and expand learning," so that "many agency personnel do not have adequate training, expertise, or understanding to effectively address emerging issues."[360] These are rare observations by a government-sponsored authority about the limited adaptive capacity of government institutions to address climate change.[361]

Nonetheless, the CCSP ignores some flaws in existing governance and fails to provide solutions for some deficiencies it does identify. For example, though recognizing the importance of monitoring, SAP 4.4 overlooks that poor monitoring and enforcement are endemic to natural resource programs[362] and fails to suggest strategies for improvement (such as encouraging stakeholder involvement in monitoring).[363] Instead, the CCSP suggests that current monitoring indicators for climate change—even those based on historical conditions—are usually satisfactory.[364] Similarly, in attempting to address the challenges of implementing adaptive management, the CCSP asks agencies to include "hypotheses, monitoring, periodic re-evaluations, and flexibility" when using adaptive management.[365] The CCSP thus ignores the lessons of regulatory experiments like the Glen Canyon AMP and the Habitat

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358 *See id.* at 31–33 (stating that some agencies rely on a reward system that "provides few incentives for creative project development and implementation[,]" and that there is a "[l]ack of incentive to take risks").

359 *See, e.g.*, Joyce et al., *supra* note 83, at 43–44 ("[Adaptive management] would need to involve managers at various levels to[:] monitor changes in the ecosystem[;] . . . coordinate and make appropriate changes in policies, regulations, plans, and programs at all relevant scales; and modify the on-the-ground practices needed to implement these higher-level policies. This degree of cross-scale integration is not typically achieved at present . . . ."). *See also* Kareiva et al., *supra* note 111, at 26 ("Recent examinations of the difficulty of actually using adaptive management have emphasized that the temporal and spatial scale, dimension of uncertainty, risks, and institutional support can create major difficulties . . . .").

360 *Id.* at 32 (citations omitted).

361 Similarly, the Government Accountability Office (GAO) recently affirmed that resource managers do not have the direction they need to design new adaptive management systems. *See* GAO REPORT, *supra* note 142, at 9–10 (outlining the limited guidance that resource managers receive to address climate change).

362 *See supra* note 205 and accompanying text.

363 Instead, the CCSP appears to be skeptical of public participation. Kareiva et al., *supra* note 111, at 35 ("Stakeholders often do not have full information, sufficient expertise, or a long-term perspective that allows them to evaluate the relative merit of adaptation options. Therefore, they may act to inhibit or even block the use of adaptation in management planning.").

364 *See id.* at 26 (discussing current monitoring indicators). *But see* Joyce et al., *supra* note 83, at 56 ("[H]istorical targets, traditionally used as references for restoration, are often inappropriate in the face of changing climates . . . ."); Scott et al., *supra* note 96, at 49 ("[H]istorical conditions . . . are unlikely to be reasonable management goals in the face of climate change.").

365 Kareiva et al., *supra* note 111, at 26.

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Conservation Plan program that demonstrate the perils of leaving design of adaptive management to agencies and not requiring agency monitoring and re-evaluation. Instead, the report merely hopes that the uncertainty of climate change "may galvanize managers to embrace adaptive management as an essential strategy."[366]

Most notably, though it acknowledges that existing agencies lack the capacity to capture experience and learn, SAP 4.4 fails to propose or identify any systemic strategies for cultivating regulatory learning. On the positive side, the CCSP proposes changes to manager and regulator incentives to promote learning.[367] Yet it ignores the need for fundamental changes to the governance structure to induce regulators and managers to learn from past performance and each other. Ultimately, though the non-binding recommendations of the CCSP, if adopted, would be a considerable improvement on existing approaches to resource management, they nonetheless fail to provide sufficiently comprehensive guidance to government institutions on how to better adapt to climate change.

V. TOWARD ADAPTIVE NATURAL RESOURCE GOVERNANCE

As detailed in Part III, existing natural resource programs are not adaptive and fail to sufficiently encourage managers and regulators to learn how to methodically manage uncertainty and make resource management more effective at achieving program goals. The few governmental efforts described in Part IV that attempt to adapt natural resource regulation and management to climate change fail to address these problems, leaving natural resource governance vulnerable to the exceptional uncertainty that climate change brings. To expand the collective capacity for managing this uncertainty, Congress must establish a proactive, no-regrets infrastructure that helps resource managers learn from previous resource management strategies and decision-making processes.

The two core components of this learning infrastructure are a collaborative network for fostering information sharing and an adaptive methodology for assessing and adjusting government decision making over time. With clear

366 *Id.*

367 *See* Baron et al., *supra* note 96, at 2 ("Learning is further enhanced by providing training opportunities, supporting continuous inquiry, promoting an atmosphere of respect, rewarding personal initiative, and . . . allowing for unintentional failure."); Kareiva et al., *supra* note 111, at 31–32 (explaining the need to shift agency reward systems to promote creative project development and implementation).

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legislative directives and sufficient resources, and by experimenting with incentives for regulators and stakeholders, legislators can encourage agency learning about the effectiveness of adaptation strategies and decision-making processes. These measures would work to increase the effectiveness of government decision making and foster agency accountability to federal and state legislatures, stakeholders, and the public.

A. Fostering Intergovernmental Information Sharing

Due to the long-term and large-scale nature of climate change effects, the unprecedented uncertainty regarding such effects on particular resources, and the limited authority of regulators and managers to address resource problems, it is not surprising that the de facto response by most regulators is to ignore climate change. In such an uncertain regulatory environment, mistakes may be inevitable, and adaptation mistakes that require restoration of seriously threatened habitats or the creation of new habitats could lead to unanticipated threats to ecosystem health and high—possibly immeasurable—costs.[368] As such, it is predictable (and perhaps even understandable) that many regulators and managers prefer to neglect such a complex and exceptional problem.

Yet the uncertainties and risks of error associated with climate change must be managed, not ignored. The funding and development by Congress of a large-scale procedural adaptation that fosters information sharing is crucial for reducing the negative effects of regulatory fragmentation and managing the uncertainty from climate change. Beyond establishing regional venues that provide opportunities for collaborating on decision making,[369] such a network should include a publicly accessible clearinghouse for information sharing. Affording regulators opportunities to work with similarly situated authorities and access information systematically integrated from the diverse research and experience of other agencies would help reduce uncertainty by allowing regulators to tap into a broader set of scientific data and management experiences. Doing so would reduce the impediments to adaptation and agency learning that result from regulatory fragmentation.

Such an information clearinghouse could be housed and administered by any number of government institutions, including the Library of Congress

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368 IPCC, ADAPTATION, *supra* note 23, at 247.

369 *Cf.* PETERS, *supra* note 355, at 20, 22 (recommending a national strategy that includes "a high level of coordination among agencies" and that facilitates "agencies working together to develop strategic plans and internal guidance, conduct and share biological research, and develop and adopt effective management tools").

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(akin to its "Thomas"[370] web portal), the White House Council on Environmental Quality (CEQ),[371] or the embryonic USGS's National Climate Change and Wildlife Science Center.[372] The clearinghouse should incorporate scientific data on projected effects of climate change and other stressors, decision-support tools, and models for analyzing localized effects, as well as information on the advantages and disadvantages of potential management strategies in a variety of contexts. Undoubtedly, the generation of these types of additional data is sorely needed. However, as illustrated by the efforts of the Climate Ready Estuaries (CRE) program,[373] much data already exists but is widely dispersed among an assortment of private and public institutions and is often inaccessible electronically. As EPA has done with its CRE program, agencies could begin by developing databases and portals that collect and organize such information in one electronic location. Beyond EPA's efforts, agencies must regularly supplement and revise such records over time. Information currently gathered by international, intergovernmental, and foreign institutions, such as the United Nations Environment Programme, the Intergovernmental Panel on Climate Change, and the European Environment Agency could also be readily accessible through the clearinghouse.

Yet to truly promote intergovernmental learning on resource management, such a clearinghouse would have to include information that today is rarely generated by any natural resource agency—systematic reports on the past performance of resource management strategies toward accomplishing regulatory goals.[374] By providing regulators access to information on the achievements and limitations of past management strategies, Congress would help reduce uncertainty by allowing regulators considering adaptations to draw from other management experiences. Furthermore, making such information publicly available would increase the transparency of agency decision making and promote agency accountability to legislatures and the public.

Though there may be a superficial appeal to the consolidation of resource management to address the shortcomings of regulatory fragmentation, the

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370 *See* THOMAS, http://www.thomas.gov/ (last visited May 15, 2009).

371 *See* White House Council on Environmental Quality, http://www.whitehouse.gov/administration/eop/ceq/ (last visited May 15, 2009).

372 *See* USGS, *supra* note 313. In fact, the American Clean Energy and Security Act of 2009, does propose creating an adaptation science and information program at USGS to assess existing forecasting capabilities, develop tools for forecasting, monitoring, and managing climate change effects, and promoting data sharing. *See* American Clean Energy and Security Act, *supra* note 285, at § 477(d).

373 *See* CLIMATE READY ESTUARIES, *supra* notes 342–43 and accompanying text.

374 *See infra* Part V.B.

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creation of a national network that cultivates information sharing while maintaining concurrent management better accommodates the benefits of decentralized governance. Because fragmented governance can produce disincentives for agencies to learn and encourage inaction regarding problems like climate change, there may be a strong temptation to centralize regulatory authority and provide one answer to preempt all others. However, while there may be benefits to eliminating redundancy in certain circumstances,[375] there are considerable advantages to a decentralized and overlapping regulatory system.[376] Elaborating on long-asserted benefits of decentralized governance and federalism,[377] numerous scholars have pointed out some of the strategic advantages of a "dynamic,"[378] "adaptive,"[379] "interactive"[380] or "polyphonic"[381] federal system that relies on fragmented governance. Designed correctly, such a system may allow for a diversity of tailored approaches and help cultivate an array of laboratories of innovation for collective learning about the benefits and detriments of particular management strategies.[382] Furthermore, overlapping jurisdiction can allow various

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[375] For example, William Buzbee has argued that reducing the number of potential regulators and/or increasing the regulatory authority of particular regulators could lessen the incentives for regulatory inaction, though such cases are inevitably context-specific. Buzbee II, *supra* note 137, at 51; Buzbee I, *supra* note 129, at 362.

[376] *See generally* Buzbee I, *supra* note 129, at 324–25, 359–61 (describing potential advantages to "regulatory fragmentation").

[377] *See, e.g.*, Michael W. McConnell, *Federalism: Evaluating the Founders' Design*, 54 U. CHI. L. REV. 1484 (1987) (detailing the historical objectives and benefits of a "dual sovereignty" federal system). *But see* Edward L. Rubin & Malcolm Feeley, *Federalism: Some Notes on a National Neurosis*, 41 UCLA L. REV. 903 (1994) (contesting many of the asserted benefits of federalism).

[378] Ruhl & Salzman, *supra* note 136, at 40–43 (summarizing the current scholarly commentary surrounding "dynamic federalism").

[379] David E. Adelman & Kirsten H. Engel, *Adaptive Federalism: The Case Against Reallocating Environmental Regulatory Authority*, 92 MINN. L. REV. 1796, 1813–31 (2007) (discussing the strengths of adaptive systems as applied to environmental federalism).

[380] Robert A. Schapiro, *Toward a Theory of Interactive Federalism*, 91 IOWA L. REV. 243, 296–99 (2005) (arguing that polyphonic federalism advances goals of dualist federalism and gives greater scope to state power).

[381] Robert A. Schapiro, *Polyphonic Federalism: State Constitutions in the Federal Courts*, 87 CAL. L. REV. 1409, 1411 (1999).

[382] *See* Adelman & Engel, *supra* note 379, at 1819 ("[A]daptive systems [such as dynamic federalism] protect diversity against the winnowing effects of optimizing processes through a fragmented structure and disruptive events."); *id.* at 1847–48 (noting that state and local initiatives function as "laboratories of democracy"); David E. Adelman & Kirsten H. Engel, *Adaptive Environmental Federalism*, *in* PREEMPTION CHOICE: THE THEORY, LAW, AND REALITY OF FEDERALISM'S CORE QUESTION 277, 290 (William W. Buzbee ed., 2009) ("Adaptive federalism simultaneously sustains competitive legislation and administrative processes that promote the refinement of policies . . . and processes that produce a diverse range of policy options."). *Cf.* Ann Joseph O'Connell, *The Architecture of Smart Intelligence: Structuring and Overseeing Agencies in the Post-9/11 World*, 94 CAL. L. REV. 1655, 1676–77 (2006) (stating agency redundancy can prevent "group

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specialized knowledge sets (municipal local experience or agency subject-matter expertise) to be brought to bear on a particular problem.[383] Concurrent authority can also provide opportunities for inter-agency accountability.[384]

The challenge, then, is balancing the efficiency benefits of centralized decision making with the diversity benefits of decentralized governance.[385] Developing a shared information infrastructure is an effective way to lessen the collective-action problem and minimize the impediments to collaborative learning of a decentralized system while maintaining its benefits.[386] To maintain the diversity benefits of divided government, such a clearinghouse and coordination effort would neither require agency consolidation nor agreement on a particular strategy. However, it would require information flow and dialogue among regulators. This could be accomplished by mandating that each regulator's strategy is monitored and periodically evaluated against stated regulatory goals and that such assessments are made available to all regulators with jurisdiction through a shared, publicly accessible information clearinghouse. Through such a framework, agencies could better learn from the successes and mistakes of other regulators in their management of natural resources.[387] Such agencies would also serve as sources of external pressure on other regulators to engage in monitoring, reporting, and adjustment of adopted strategies.

Like most other regional collaborations, the Great Lakes Regional Collaboration (GLRC) could be viewed as an attempt at an information-sharing regime, but if so it is a very weak one. Though the GLRC has provided agencies opportunities for dialogue and collaboration on decision making, it never established a comprehensive information infrastructure that would facilitate inter-agency learning. The GLRC has not created a repository for pooling data or analyses on management strategies; indeed, regulators have

think" and agency capture, and promote agency competition that may yield better outcomes than coordination).

383 *Cf.* Camacho III, *supra* note 203, at 321–23 (discussing the subject matter expertise of agencies and the localized knowledge of local government authorities).

384 *See infra* notes 416–417 and accompanying text.

385 *See* Adelman & Engel, *supra* note 382, at 285 ("The challenge is to maintain a process of optimization, which leads to specialization and efficiencies, while cultivating a diversity of backup options in the wings.").

386 *Cf.* William W. Buzbee, *Interaction's Promise: Preemption Policy Shifts, Risk Regulation, and Experimentalism Lessons*, 57 EMORY L.J. 145, 164 (2007) ("[L]earning-by-monitoring regimes . . . can provide huge benefits . . . perhaps in provision of government services.").

387 *Cf.* Ruhl & Salzman, *supra* note 136, at 51 (suggesting that agency collaborations that do not mandate agreement may be more effective at solving complex problems if they preserve agency autonomy and accountability and if each agency clearly understands its responsibilities and range of discretion).

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not even conducted such analyses. Other evaluations of collaborative governance experiments have similarly found that scarce information about ecological processes, management strategies, and agency performance contributes greatly to failure by collaborative experiments.[388]

Undoubtedly, creating and maintaining a user-friendly and comprehensive clearinghouse of information is challenging. Others have recommended analogous data repositories for environmental assessment data,[389] where the potential to apply modern information technology has been similarly under-utilized, but existing databases are far from complete.[390] An administering agency would have to balance the need for an interface and databases that are publicly accessible and easily searchable[391] with the need to ensure that such tools are also comprehensive[392] and adaptable.[393]

As the lessons of natural resource governance make clear, establishing a flawless infrastructure at the outset may be impossible, so the clearinghouse itself can and should be monitored and adjusted over time to improve its utility and accessibility. Only by establishing and refining a network that promotes the creation, collection, and dissemination of information on the effects of climate change and the value of different strategies can we both reduce the barriers to effective action and cultivate a diverse range of management options that facilitates collective learning. Combined with the adaptive approach to governance delineated in the next section, establishing such a

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388 *See* Karkkainen I, *supra* note 14, at 1442 ("[A]n equally important factor is information, or rather, its scarcity.").

389 *See* Daniel A. Farber, *Bringing Environmental Assessment into the Digital Age*, *in* TAKING STOCK OF ENVIRONMENTAL ASSESSMENT: LAW, POLICY AND PRACTICE 219, 219 (Jane Holder & Donald McGillivray eds., 2007) (lamenting the difficulty of accessing environmental assessment data); Joseph F.C. DiMento & Helen Ingram, *Science and Environmental Decision Making: The Potential Role of Environmental Impact Assessment in the Pursuit of Appropriate Information*, 45 NAT. RESOURCES J. 283, 300 (2005) ("The federal government and the states should work together to create regional institutes to collect project and program environmental analyses. The institutes should also be repositories of environmental intelligence on the regions from other data-generating institutions."(footnote omitted)).

390 *See infra* note 406 and accompanying text. Both the State of California and Canada's Environmental Assessment Agency have created prototypical online aggregations of environmental assessment data, but neither contains even links to the full reports. Farber, *supra* note 389, at 235–37.

391 *See* Farber, *supra* note 389, at 235, 242. Farber suggests that though a general search engine such as Google might be effective, a tailored search engine is preferable. *See id*. at 242. Integrating geographic information system (GIS) technology, which would allow environmental data to be organized in a series of layers, could enhance comprehensiveness. *See id*. at 221, 243–47; DiMento & Ingram, *supra* note 389, at 302–03. However, this might hinder public accessibility.

392 *See* Farber, *supra* note 389, at 237–38.

393 For example, the database should be able to incorporate follow-up information such as monitoring data. *See id.* at 238–40.

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network would initiate the infrastructure needed for regulators to assess and manage the effects of climate change more effectively.

B. Cultivating Adaptive Management and Governance

As detailed earlier,[394] recent adaptive management experiments provide key lessons for future governance that can help legislators build on the insights of the adaptive management theoretical literature. Governance processes should be structured to induce agencies and stakeholders to learn—not only about the merits of particular resource decisions, but also more broadly about regulatory strategies and processes. Congress should establish this adaptive governance infrastructure through cross-cutting legislation that requires federal agencies to monitor and adaptively manage their decisions and programs, and provide funding and incentives for agencies to do so. When combined with a cross-jurisdictional information network, the development of such an infrastructure would promote agency accountability and help manage the uncertainty that comes with climate change.

One potentially fruitful legislative avenue that would help create an adaptive governance process is a sweeping amendment to the National Environmental Policy Act of 1969 (NEPA).[395] By requiring federal agencies to prepare environmental impact statements that disclose the effects of—and alternatives to—any proposed "major Federal actions significantly affecting the quality of the human environment,"[396] NEPA does provide a baseline regulatory framework for generating and releasing information. About half the states have analogous statutes applicable to state and local agencies.[397] As a result, most federal, state, and local agencies already are accustomed to some form of procedural framework for generating information for proposed agency activities.

However, NEPA would have to be fundamentally re-fashioned for it to serve as a comprehensive adaptive governance framework. Others have chronicled the limitations of NEPA as a structure for generating quality

394 *See supra* Part III.C.

395 42 U.S.C. §§ 4321–4375 (2000).

396 *See id.* § 4332(2)(C).

397 *See* Bradley C. Karkkainen, *Toward a Smarter NEPA: Monitoring and Managing Government's Environmental Performance*, 102 COLUM. L. REV. 903, 905 n.7 (2002) [hereinafter Karkkainen IV] (noting that more than 25 states have emulated NEPA).

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information and promoting dynamic learning.[398] Environmental analyses under NEPA are characteristically static, one-time assessments assembled when the agency provides public notice of its proposed action.[399] As such, not only does NEPA allow agencies to conduct such analyses too late in the decision-making process to influence agency decisions,[400] it also does not require agencies to review an analysis after an action is adopted through follow-up monitoring.[401] Additionally, NEPA does not specifically require adaptive management.[402] As a result, agencies rarely revisit prior NEPA analyses to ascertain if they were accurate[403] or review previously adopted mitigation measures to determine if they were effective.[404] In short, NEPA does not require agencies to learn.[405]

Moreover, as with other statutes, little information sharing occurs through existing NEPA programs. Neither Congress nor the relevant federal agencies have created a comprehensive infrastructure to collect and facilitate the broad dissemination of the information that has been generated through NEPA analyses to other agencies and the broader public. The NEPA data that does exist is compiled by various institutions, and many NEPA analyses are not tracked, compiled, or otherwise accessible to the public, other agencies, or even different officials in the same agency.[406]

To establish the learning infrastructure necessary to promote adaptive governance and intergovernmental information sharing, NEPA would have to be fundamentally transformed. Congress would have to amend NEPA to

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398 *See, e.g.*, *id.* at 905 (describing the shortcomings of the NEPA process); Daniel A. Farber, *Adaptation Planning and Climate Impact Assessments: Learning from NEPA's Flaws*, 39 ENVTL L. REP.: NEWS & ANALYSIS 1065 (2009); DiMento & Ingram, *supra* note 389, at 283.

399 Karkkainen IV, *supra* note 397, at 970 ("The attempt to execute an accurate and comprehensive one time, synoptic, prospective assessment of environmental impacts and the full range of possible solutions turns out to be an extremely time and resource intensive exercise that produces a massive, highly uncertain, tardy, and often, when all is said and done, not terribly informative document.").

400 *See id.* at 907, 926, 970 (asserting that the assessments are "tardy").

401 *See id.* at 927 ("NEPA does not generally require 'post project assessment,' that is, ongoing monitoring . . . .").

402 However, DOI and USFS have considered incorporating adaptive management into rules implementing NEPA. *See supra* note 225 and accompanying text.

403 *See* Karkkainen IV, *supra* note 397, at 928 (noting a lack of monitoring data is one critical reason that it was impossible to determine the accuracy of predicted impacts).

404 *See id*. at 908 ("[I]n the absence of follow-up monitoring we have no assurance that the mitigation measures . . . will turn out to be as effective as anticipated.").

405 *See* Farber, *supra* note 398, at 10609 ("NEPA provides few learning mechanisms").

406 *See* Karkkainen IV, *supra* note 397, at 946–48 (pointing out that although EPA, the Center for Environmental Quality, and even the Office of the Federal Register do, in a limited sense, compile some data produced under NEPA, many NEPA analyses are not subject to reporting or easily accessible).

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require federal agencies to conduct adaptive management of NEPA decisions, including: (1) regular monitoring of agency actions that require NEPA clearance; (2) systematic assessment of adopted management strategies comparing any mitigation measures against their initial projected effects; and (3) periodic adjustment of such strategies and measures over time. To cultivate intergovernmental information sharing, Congress would also have to establish a national clearinghouse of NEPA information akin to that proposed in Part V.A.[407]

However, because NEPA only contemplates information gathering and assessment in the context of declared agency actions, amending NEPA alone may not sufficiently cover important contexts in which adaptive governance and information sharing may be useful and necessary. NEPA only applies when federal action is proposed.[408] Yet because the initial question in adaptation planning is not how a particular human action will affect the environment, but rather how to minimize the effects of climate change most effectively, proactive adaptation to climate change may necessitate analyses in contexts in which federal action has not been proposed.[409]

As such, Congress should also establish an adaptive governance framework as part of organic adaptation planning legislation. Such a statute could take many forms, but, in addition to establishing the comprehensive information repository detailed in Part V.A, *supra*, it should include four elemental features. First, such legislation should require and fund robust agency monitoring of existing natural systems. Through such observation, agencies can better understand the systems they regulate and better tailor management strategies to be more effective at achieving program goals.

Second, it should require the creation, monitoring, and periodic adjustment of adaptation plans by federal and state[410] natural resource agencies. Congress

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[407] *Cf.* DiMento & Ingram, *supra* note 389, at 300–02 (recommending establishing joint federal-state repositories for environmental information generated under NEPA).

[408] Kleppe v. Sierra Club, 427 U.S. 390, 399 (1976). *See also* Farber, *supra* note 389, at 10608.

[409] *See* Farber, *supra* note 398, at 10607 ("Adaptation planning . . . flip[s] current practices in environmental law around: instead of asking how human activities impact the environment, we instead begin by asking how environmental change will impact humans.").

[410] Congress could require adaptation planning by state resource agencies that receive federal funding for conservation activities on nonfederal lands. *See, e.g.*, American Clean Energy and Security Act of 2009, *supra* note 285, at § 479(a)–(b) (proposing a requirement that states seeking adaptation funding assistance adopt natural resource adaptation plans). *See also* PETERS, *supra* note 355, at 22 (discussing the State Wildlife Grants program, the North American Wetlands Conservation Act, the Farm Bill conservation programs, and the Cooperative Endangered Species Fund).

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should oblige such plans to include (1) information about the projected effects of climate change on natural systems, (2) how the agency's statutorily-mandated goals are implicated (if at all) by such potential effects, and (3) adaptation strategy alternatives to address such effects in furtherance of the agency's goals. Congress should also require agencies to monitor, assess, and adjust such plans periodically and to make such information publicly accessible. As opposed to previous adaptive management experiments such as the Glen Canyon AMP, agencies must be given not only the permission to monitor and assess performance with such goals, but also the *responsibility* to do so.[411] Such a directive would provide an explicit incentive for agencies to learn, advance governmental accountability, and reduce uncertainty, thus helping private and public actors respond more effectively to the effects of changing climate.

Third, such agencies must be charged with engaging in adaptive governance: periodically monitoring, assessing, and adapting not only their adopted adaptation plans, but also their resource programs in furtherance of congressional goals for that program. For this to occur, regulatory programs like the Glen Canyon AMP must identify priorities and goals, requiring legislative direction regarding the difficult tradeoffs between competing resource values. The agency must also create measurable performance thresholds for evaluating management decisions, resource managers, and the regulatory program itself. Cultivating this adaptive governance will improve the accountability and legitimacy of agency decision making by providing metrics to the agencies, Congress, and stakeholders for evaluating agency strategies and the agencies themselves. In the context of climate change, adaptive governance also provides a way to reduce and manage the substantial uncertainties that arise in trying to adapt both natural and regulatory systems to incomparable change. Agency personnel will have the obligation to generate, and the opportunity to access, up-to-date information about not only the projected local effects of climate change, but also how successful existing strategies have been in responding to other stressors.

However, it is important to note that requiring states to adopt adaptation plans may include, but certainly does not necessitate, substantive review by federal authorities to ensure these state plans conform to federal adaptation efforts. Indeed, such centralized review of state efforts may be antithetical to the promotion of regulatory experimentation and innovation in adaptation activities.

411 The DOI has acknowledged that successful implementation of adaptive management requires a mandate for its use and a long-term "institutional capacity and commitment" to implement it. WILLIAMS ET AL., *supra* note 223, at 9.

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Finally, Congress must provide sufficient resources and other incentives to give agencies the motivation to participate and engage in adaptive management and regulatory adaptation. Of course, resources are always vital to the success of any regulatory program, and others have called for high and sustained levels of funding for adaptation activities.[412] Yet, an adaptive process particularly calls attention to the need for sustained resources for monitoring, implementation, and enforcement. Sustained funding is one of the most important incentives legislators can provide for encouraging agency learning.[413] Unfortunately, however, stable and sufficient support from Congress for such functions is rare.[414] Because of the longer horizon for action on climate change adaptation and a growing recognition of the limitations of existing natural resource management, legislatures may be more receptive to funding adaptive governance long-term, such as through the establishment of a trust dedicated to adaptive management and governance.[415]

Because adaptive governance would subject managers and regulators to performance evaluation many may resist it.[416] Yet it is worth noting that a key benefit of creating a publicly accessible information clearinghouse is the potential to provide incentives for managers to adjust their decisions over time. For example, providing affected stakeholders and other agencies access to

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412 *See, e.g.*, PETERS, *supra* note 355, at 16 ("Lack of funding for efforts to meet the immense threat to wildlife and ecosystems is the single greatest obstacle for natural resource agencies."); CAL. DEP'T OF WATER RES., MANAGING AN UNCERTAIN FUTURE: CLIMATE CHANGE ADAPTATION STRATEGIES FOR CALIFORNIA'S WATER 10 (2008) (stating more stable sources of funding are needed to enable sufficient climate change adaptation in California).

413 Doremus, *supra* note 16, at 572 ("By far the most important contribution legislatures can make to learning while doing, however, is to support it through stable and sufficient funding sources.").

414 *See* Camacho I, *supra* note 14, at 347–48 (describing the funding obstacles these functions face); Doremus, *supra* note 16, at 572–73 (explaining that legislatures, "made up of political actors with short time horizons," have typically focused on action and "immediate results" rather than learning through research and monitoring).

415 *See, e.g.*, COMM. ON FLOOD CONTROL ALTERNATIVES IN THE AM. RIVER BASIN, NAT'L RESEARCH COUNCIL, FLOOD RISK MANAGEMENT AND THE AMERICAN RIVER BASIN: AN EVALUATION 197 (1995) (proposing the creation and funding of an adaptive management trust fund for the American River Canyon); STEPHEN TYLER, ET AL., ADAPTIVE MANAGEMENT FRAMEWORK FOR THE CENTRAL AND NORTH COAST OF BRITISH COLUMBIA: OVERVIEW 10 (Jan. 29, 2009), *available at* http://www.ilmb.gov.bc.ca/slrp/lrmp/nanaimo/cencoast/ebmwg_docs/AMF_overview_v4_20090129.pdf (proposing a "Coast Adaptive Management Trust" for British Columbia for "impartially and transparently identifying adaptive management investment priorities; funding high priority adaptive management projects (studies and learning activities) that cannot be funded by other sources; and . . . communicating new management knowledge").

416 *Cf.* Doremus, *supra* note 16, at 571 ("[A]gencies typically enjoy enough discretion to allow them to perpetuate ignorance. Unless learning is systematically rewarded by the legislature or the highest levels of the executive branch—which is rare—there is little external incentive for agency leaders to buck tradition. Internal incentives are likely to run the other way.").

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information on the performance of an EPA strategy not only allows such parties to learn about the effectiveness of that strategy; it also gives them an increased capacity to pressure EPA to comply with adaptive management requirements and to modify the strategy when performance assessments suggest it has not been entirely effective.[417]

To further promote adaptive management and foster agency accountability, Congress should provide incentives to stakeholders—consistent with their stake and abilities—to contribute to information generation and assist actively in the governance process. Such incentives could include loans, grants, or tax credits to private parties who engage in adaptive management or other activities that provide valuable information for future adaptation activities.[418] It could also include regulatory credit programs that reduce regulatory requirements or streamline permit review processes for permit holders who generate reliable, valuable data on the efficacy of particular conservation efforts.[419] Legislators could even enlist stakeholders to buttress monitoring or evaluation of agency or third-party compliance with program goals. In short, stakeholders can and should be incentivized to participate in and help evaluate adopted strategies and agency performance.

By paying attention to regulatory design and regulator incentives, Congress can help develop the infrastructure agencies need to learn, promote government accountability, reduce uncertainty, and thus help private and public actors respond more effectively to the effects of changing climate. Of course, Congress will have the opportunity to adjust incentives over time to more effectively promote agency learning. It is crucial that Congress persists in placing adaptive pressure on agencies to push them to manage uncertainty while managing the natural resources under their jurisdiction. Because such an adaptive governance framework would also increase the transparency of agency activities, it would promote agency accountability and serve as a no-regrets adaptation strategy.

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[417] Senior agency officials could in turn foster learning through rewards for agency divisions that institute learning procedures. Some have suggested that agencies provide training or develop performance evaluations and compensation practices that promote responsible experimentation and scrupulous assessment rather than discourage it. *See* Baron et al., *supra* note 96, at 4; Kareiva et al., *supra* note 111, at 30.

[418] Camacho I, *supra* note 14, at 356.

[419] *See id.* ("Congress could develop a credit program that allows permittees to reduce their costs for mitigation in exchange for generating and disseminating reliable data . . . ." (footnote omitted)). Negative incentives could include penalties levied on private permit holders for non-compliance with monitoring programs. *Id.*

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Undoubtedly, the start-up costs of creating an adaptive governance infrastructure will not be trivial, and many questions remain unanswered regarding the development of effective and adaptive governance. How much should Congress spend on monitoring and adjusting regulatory processes? What are the optimal monitoring and adaptation protocols? Should these vary by regulatory program or even by management strategy?

However, a fundamental advantage of the adaptive governance framework is that, over time, it can help provide key information toward addressing these questions. Through systematic monitoring and assessment of the implementation process, agencies and Congress will be able to assess the benefits of different types of monitoring and assessment approaches to determine the circumstances under which they are most appropriate. Accordingly, establishing a framework for monitoring, assessing, and adjusting agency actions and an infrastructure for gathering and disseminating such information, will enhance the capacity of regulators and managers—and more fundamentally, legislatures and the public—to improve the effectiveness of not only resource management, but also agency learning procedure. Moreover, it would increase our collective capacity to respond effectively to the multitude of new questions and environmental stressors wrought by climate change.

CONCLUSION

Regrettably, the effects of climate change are already evident and likely to worsen. Yet the type and extent of localized effects on ecosystems, and the efficacy of potential adaptation strategies, are very unclear. These unprecedented uncertainties have impeded meaningful adaptation efforts. Natural resource managers and policymakers not only lack information about future effects and the value of management strategies in particular contexts, they also lack the adaptive infrastructure to gain such information.

The limitations of existing natural resource governance may be difficult to overcome, but the potential for fundamental changes in the human and natural environment due to climate change necessitates a revisiting of entrenched models of resource management. What is needed is a natural resource governance system that manages uncertainty by allowing agencies to learn and change over time and respond to ecosystem changes and new information about the efficacy of particular management strategies and management processes. In short, natural resource regulators and managers must engage in controlled experimentation in regulatory design, and Congress must provide

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the infrastructure to facilitate this. Given the state of natural resource governance, such a system would likely qualify as a "no-regrets" adaptation that yields dividends in the performance and accountability of government regulators, regardless of the extent of the impacts of climate change.

The experience in natural resource management with adaptive and collaborative experiments may also provide valuable insight on how government officials can and must manage uncertainty that has implications for other regulatory problems. Certainly, agencies are delegated responsibility to manage many social threats under conditions of uncertainty, including other environmental risks,[420] financial market failure,[421] and terrorism.[422] Though further analysis is undoubtedly essential, the lessons of natural resource governance may prove valuable in these areas as well. In the end, the comprehensive change in governance advocated here should help minimize the mistakes that inevitably come with facing uncertain problems like climate change with tools that are, at least initially, rather imprecise.

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[420] *Cf.* Ruhl & Salzman, *supra* note 136, at 7 (discussing other "massive" environmental problems such as water hypoxia and urban sprawl).

[421] *Cf.* Steven L. Schwarcz, *Regulating Complexity in Financial Markets*, 87 WASH. U. L.R. (forthcoming 2009–2010) (discussing complexity in financial markets); Steven L. Schwarcz, *Systemic Risk*, 97 GEO. L.J. 193 (2008) (discussing systemic risk in financial markets); Ethiopis Tafara, Office of Int'l Affairs, U.S. Sec. & Exch. Comm'n, Speech by SEC Staff: Annual Conference on Capital Management of the Risk Management Association and Professional Risk Managers' International Association (Nov. 9, 2004), http://www.sec.gov/news/speech/spch110904et.htm ("Securities regulators function in . . . a world of finite information and finite resources. Making the best use of the information and resources we have in the face of uncertainty is our ongoing task.").

[422] *Cf.* David Brooks, Op-Ed, *The Uncertainty Factor*, N.Y. TIMES, Apr. 13, 2004, at A25 (discussing the U.S. government's limited competence in coping with uncertainty in terrorism prevention).

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