Adapting to Climate Change: Environmental Law in a Warmer World

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Climate change presents a choice for public policy: mitigate our contribution to it or attempt to adapt to a changing world. In its most radical form, adaptation accepts as a given fundamental changes to our environment caused by a warming climate and consequently demands similarly fundamental adaptations in our ways of life. Those adaptations could entail widespread and severe environmental impacts, complementing and enhancing the primary environmental consequences of climate change.

While environmental law has, if haltingly, moderated our environmental impacts in the recent past, this Article suggests that we should not assume that its successes will be repeated in a warmer world. Climate change threatens to exacerbate some of the problems of capacity that have limited environmental law, particularly the inability to plan comprehensively to minimize environmental effects. Climate change may also undermine the public support that has been integral to the creation and sustenance of environmental law by reorienting human relationships with the natural world. The environmental changes caused by a warming climate may convert "the environment" from an endowment to be protected to a hostile and unpredictable force to be controlled and from which we demand protection.

Although pessimistic about the prospects for environmental protection in a world of unchecked climate change, the Article concludes with some optimism about our ability to avoid the worst of adaptation's consequences through a policy of climate change mitigation.

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INTRODUCTION

The public debate about climate change is shifting. For years, the disputants have disagreed mainly about (1) whether the climate is changing, and (2) assuming it is, whether or to what extent humanity bears responsibility for it. How one answers those questions has largely determined whether one supports or opposes policies to mitigate climate change, that is, to reduce atmospheric concentrations of carbon dioxide and the other greenhouse gases that cause climatic warming. Recently, however, some opponents of mitigation have staked out a new position. They argue that mitigation is far too socially costly or simply infeasible and therefore suggest that we should instead direct our limited resources to adapting to the change.[1] One journalist has summarized the climate change skeptics' position as follows:

1. *See, e.g.*, Myron Ebell, Letter to the Editor, *Build Resilience into Society to Meet Environmental Crises Rather than Devising an Energy Starvation Diet*, FIN. TIMES (Asia ed.), Sept. 28, 2005, at 14 (from the director of Global Warming and International Environmental Policy for the Competitive Enterprise Institute); Elizabeth Kolbert, *Chilling*, NEW YORKER, Mar. 20, 2006, at 67–68 (noting the correlation of support for adaptation with skepticism of climate change); Bjorn Lomborg, *Something Is Rotten in the State of Denmark*, WALL ST. J., Jan. 23, 2003, at A14; Andrew C. Revkin, *U.S. Sees Problems in Climate Change*, N.Y. TIMES, June 3, 2002, at A1; Ronald Bailey, *Adapting to Climate Change*, REASON ONLINE, Dec. 14, 2004, http://www.reason.com/rb/rb121404.shtml; Kenneth Green, *Clouds of Global-Warming Hysteria*, NAT'L REV. ONLINE, May 8, 2006, http://article.nationalreview.com/?q=MDAyN2Y4OWMzZjQ3ZjFlZDc4ZTAxMTIzZjYxNTUwN2I= . Conversely, environmentalists and other advocates for climate mitigation are reluctant to talk about adaptation "for fear

> It is a planet where global warming isn't happening or, if it is happening, isn't happening because of human beings. Or, if it is happening because of human beings, it isn't going to be a big problem. And, even if it is a big problem, we can't realistically do anything about it other than adapt.[2]

The dichotomy of mitigation and adaptation is a false one. We have passed the point of such a binary choice, if ever there were such a point. Given inertia in the climate system, even immediate and radical steps to reduce greenhouse gas emissions cannot prevent the climate from warming; they can only moderate it.[3] Some adaptation is therefore inescapable, and the real debate must be about how much we should seek to mitigate and how much we should leave to adaptation.[4]

This Article seeks to inform that debate by describing how an adaptation-preferring climate policy—one that wholly or mostly rejects mitigation—is potentially fraught with two related problems.[5] First, adaptation has its own potentially severe adverse environmental impacts that would compound the direct or primary effects of climate change and that thus comprise indirect or secondary environmental impacts of climate change. For example, climate change will reduce mountain snowpack on which western states rely to provide natural water storage. Building more dams to make up for that loss would destroy riparian and upland habitat above the dams and fundamentally alter aquatic ecosystems below them.

it would pull the focus away from fixing the problem." Bret Schulte, *Temperature Rising*, U.S. NEWS & WORLD REP., June 5, 2006, at 36–40.

2. Joel Achenbach, *The Tempest*, WASH. POST, May 28, 2006, Magazine, at W08.

3. *See* CAL. CLIMATE ACTION TEAM, CAL. ENVTL. PROT. AGENCY, CLIMATE ACTION TEAM REPORT TO GOVERNOR SCHWARZENEGGER AND THE LEGISLATURE 20 (2006) [hereinafter CCAT], *available at* http://www.climatechange.ca.gov/climate_action_team/reports/ index.html; Gerald A. Meehl et al., *How Much More Global Warming and Sea Level Rise?*, 307 SCIENCE 1769, 1769 (2005); T.M.L. Wigley, *The Climate Change Commitment*, 307 SCIENCE 1766, 1766 (2005).

4. *See* Sally Kane & Jason F. Shogren, *Linking Adaptation and Mitigation in Climate Change Policy*, 45 CLIMATIC CHANGE 75 (2000). Indeed, a host of experts have addressed adaptation apart from the political debate about climate mitigation. *See, e.g.*, CONFERENCE BOARD OF CANADA, ADAPTING TO CLIMATE CHANGE: IS CANADA READY? (2006); WILLIAM E. EASTERING III, BRIAN H. HURD & JOEL B. SMITH, PEW CENTER ON GLOBAL CLIMATE CHANGE, COPING WITH GLOBAL CLIMATE CHANGE: THE ROLE OF ADAPTATION IN THE UNITED STATES (2004), *available at* http://www.pewclimate.org/docUploads/ Adaptation%2Epdf; Robert Mendelsohn, *Efficient Adaptation to Climate Change*, 45 CLIMATIC CHANGE 583 (2000); Barry Smit et al., *An Anatomy of Adaptation to Climate Change and Variability*, 45 CLIMATIC CHANGE 223 (2000); *see also* Ted Nordhaus & Michael Shellenberger, Op-Ed., *Preparing for Nature's Attack*, N.Y. TIMES, Apr. 1, 2006, at A15 (arguing that we need to prepare for effects of climate change).

5. In fact, an "adaptation-preferring policy" is likely to be no "policy" at all, but rather a choice implicit in a refusal to mitigate climate change. The adaptation-preferring policy on which I focus in this paper is thus the extreme end of the mitigation-adaptation spectrum. The perils of such a policy discussed below are a cautionary tale for a refusal to mitigate.

Worse still, the stresses of climate change will undermine the capacity of natural systems to assimilate the environmental impacts caused by climate adaptation. Many species will alter their distributions to adapt to new climatic conditions, a process that may cause stress for the species and interfere with reproduction or survival. Anthropogenic habitat destruction or fragmentation, such as that caused when we relocate our communities away from rising tides or increasingly flooding rivers, may compound the stress on these species. An adaptation-preferring climate policy thus risks creating a perverse synergy by failing to moderate the severity of climate change and its stresses on natural systems and simultaneously requiring adaptations that produce their own severe, and in some cases synergistic, impacts on those systems.

Adaptation's effects are not foreordained, but the task of avoiding them poses the second complication of an adaptation-preferring climate policy: adaptation may undermine the effectiveness of environmental law. Though the welter of complex regulatory regimes developed over the last forty years is in many ways flawed, it nonetheless has had some notable successes in moderating our environmental impacts. We have markedly reduced air pollution in some regions; pulled a few species, such as the gray wolf and bald eagle, back from the brink of extinction; curtailed emissions of stratospheric ozone-depleting chemicals; and sharply reduced the industrial effluent discharged to our streams and rivers. Those successes might suggest that we can also apply existing regimes, or design new ones, to moderate the harm that climate adaptations might otherwise cause. This view, however, may be unduly optimistic; the prospects for effective environmental law appear to be bleaker in a warmer world. This Article suggests that climate change stands to undermine the ability of environmental law to moderate both the new impacts of adaptation and the ongoing impacts of run-of-the-mill economic activity.

Two concerns counsel this pessimism. The first is that climate change and adaptation would exacerbate some of the challenges of institutional capacity that have historically troubled environmental law. Complexity and coordination problems are likely to be even more troublesome where climate change requires large-scale and widely distributed adaptations. Experience suggests that we lack the capacity to plan for and choose among the numerous necessary adaptations in order to minimize their massively cumulative and synergistic environmental effects.[6] While we have had some success in reducing emissions of individual air or water pollutants, for example, nothing in the history of environmental law suggests that we can carry out the kind of large-scale, panoptic planning

6. *See infra* notes 114–29 and accompanying text.

needed to manage the host of impacts that would be caused by adaptation to unchecked climate change.

The second concern is less one of capacity than of will. There are reasons to think that public ardor for environmental protection might cool as the climate warms. This Article hypothesizes that in the face of environmental changes that upset settled ways of living, such as rising sea levels or more frequent and severe storm activity, attitudes toward the environment and its preservation will not remain static. The environmental changes caused by a warming climate could undermine public commitment to environmental stewardship in a variety of ways. Climate change will disrupt some human relationships with the natural environment that have been important to public support for environmental protection. Disasters exacerbated by climate change, such as hurricanes, floods, or disruption of water supplies, may transform public conceptualization of the environment from an amenity or luxury good worth protecting to a hostile force requiring control. Finally, the simple fact of an environment constantly in flux may undermine the notion of "the environment" as an entitlement that must be preserved. In this context, faced with the challenges posed by climate change, we may be unable to muster the "republican moment" that some have argued gave birth to the late twentieth-century effusion of environmental law.[7]

Most analysis of the intersection of climate change and environmental law understandably focuses on mitigation, *viz.*, how environmental law might alter the course of climate change. This Article, by contrast, imagines the converse: how unchecked climate change, in a world of adaptation rather than mitigation, might alter environmental law.[8] Part I describes a sample of potentially grave climate-induced environmental changes. It also identifies foreseeable adaptations to those changes and suggests some secondary environmental effects we might expect from those adaptations. Part II then imagines how unmitigated climate change and our adaptations to it might alter the conditions necessary for the development and sustainability of environmental law. It thus questions whether environmental law will itself adapt to ameliorate the environmental effects of climate adaptation.

7. Daniel A. Farber, *Politics and Procedure in Environmental Law*, 8 J.L. ECON. & ORG. 59, 66–67 (1992).

8. In this Article, I make the empirically safe assumption that climate change is a fact. *See, e.g.*, Naomi Oreskes, *The Scientific Consensus on Climate Change*, 306 SCIENCE 1686 (2004) (reviewing abstracts for 928 peer-reviewed articles on climate change published in scientific journals between 1993 and 2003 and finding *none* that dispute the fact of change or the anthropogenic contribution to it); *see also* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2001: THE SCIENTIFIC BASIS 730 (2001) [hereinafter IPCC I], *available at* http://www.grida.no/climate/ipcc_tar/wg1/index.htm.

This vision of climate adaptation is stark. It suggests that a choice today to reject climate change mitigation may produce a kind of path dependence, requiring massive future environmental interventions with massive new environmental harms. These harms would occur in a natural environment increasingly less able to accommodate them and in a legal environment less able to prevent them. At the least, this means that climate policy must take into account the environmental costs of adaptation, as best they can be estimated, on the assumption that they will not be avoided. The literature and public debate about climate adaptation have yet to grapple with this problem.[9] Moreover, if we value our own concern for the environment and wish that concern to continue into the future,[10] we should consider binding ourselves to the mast by adopting a mitigation-preferring policy. In doing so, we may better preserve our ability, and our commitment, to protect our environment.

Despite its dystopian vision of a future dominated by climate adaptation rather than mitigation, this Article concludes with some guarded optimism. Growing public support for mitigation and proliferating state experimentation with mitigation policies may avoid the need for the most aggressive and damaging adaptations. The longer we wait to implement those policies, however, the more adaptation we will require and the greater the environmental costs we may have to accept.

I. ADAPTATION AND ITS DISCONTENTS

The direct environmental changes caused by unabated climatic warming will put new pressure on human communities to which they will need to adapt, either proactively or reactively.[11] In turn, those adaptations will produce secondary environmental effects scarcely discussed in the climate change literature. This Part provides several likely examples of primary climate change effects, potential adaptations to those effects, and the environmental consequences of those adaptations. The examples here

9. I have found only one passing suggestion that climate policy might take into account the environmental costs of adaptation. *See* Mendelsohn, *supra* note 4, at 593 ("For example, if controlling mosquitoes [in response to a climate-induced spread of malaria] provided a health benefit but also posed an ecological cost, the government could weigh the value of this ecological cost in[] its decision making.").

10. *See* Holly Doremus, *Shaping the Future: The Dialectic of Law and Environmental Values*, 37 U.C. DAVIS L. REV. 233, 235 (2003) (published concurrently at 27 ENVIRONS 233 (2003)) (noting "the desirability of encouraging future generations to perpetuate values we currently hold").

11. *See* Mendelsohn, *supra* note 4, at 596 (describing dichotomy of "anticipatory" and "reactive" adaptation, but suggesting that most is likely to be reactive).

are merely illustrative of the kind and scale of the impacts and adaptations that unchecked climate change might entail.[12]

A. Hydrology in the Western United States

In the western United States, one of the most important expected effects of climate change is that of rising temperatures on precipitation. Changes in precipitation patterns promise a host of challenges, including problems for water supply, energy production, and flood control.[13]

In the arid West, most precipitation falls during the winter and spring. In mountainous areas, winter precipitation falls largely as snow, which builds up over the season in a snowpack. The snowpack melts throughout the spring and summer, producing runoff in creeks and rivers. As a result, runoff is lighter in winter and early spring, is heaviest in mid- to late spring, and tapers off during the summer.

Recent studies have shown that climate change is likely to significantly affect western hydrology. As temperatures increase, some winter and early spring precipitation that currently falls as snow will begin to fall increasingly as rain.[14] Moreover, precipitation that does continue to fall as snow will have a shorter life in the snowpack as the snowpack melts ever earlier.[15] Indeed, by some accounts, the snowpack may almost disappear

12. The discussion of primary climate change effects here is as current as reasonably possible. New research is revealing that even very recent projections of climate change may be overly *conservative*, however, particularly given new information about climate feedback effects—natural processes that cause warming to accelerate as it proceeds. *See, e.g.*, Margaret S. Torn & John Harte, *Missing Feedbacks, Asymmetric Uncertainties, and the Underestimation of Future Warming*, 33 GEOPHYSICAL RES. LETTERS L10703 (2006) (finding evidence of atmospheric carbon feedback effects during prior periods of climatic warming based on Antarctic ice core samples); Sergey A. Zimov et al., *Permafrost and the Global Carbon Budget*, 312 SCIENCE 1612 (2006) (finding that the volume of carbon stored in and potentially released by melting Siberian and Alaskan permafrost is much larger than previously believed).

13. The following discussion is limited to changes in the timing and form of precipitation, as opposed to change in total volume. Projections of change in the volume of precipitation in the West are mixed. Some models project increases, while others project decreases, and precipitation may increase in some places while declining in others. *See* CCAT, *supra* note 3, at 29; MICHAEL KIPARSKY & PETER H. GLEICK, PACIFIC INSTITUTE, CLIMATE CHANGE AND CALIFORNIA WATER RESOURCES: A SURVEY AND SUMMARY OF THE LITERATURE 5–6 (2003). Yet either result could exacerbate the problems described in this section: more precipitation would aggravate flooding problems and less would aggravate water-supply problems.

14. *See* CCAT, *supra* note 3, at 28; T.P. Barnett et al., *Potential Impacts of a Warming Climate on Water Availability in Snow-dominated Regions*, 438 NATURE 303 (2005); Norman L. Miller et al., *Potential Impacts of Climate Change on California Hydrology*, 39 J. AM. WATER RESOURCES ASS'N 771, 777 (2003).

15. *See* CCAT, *supra* note 3, at 28; KIPARSKY & GLEICK, *supra* note 13, at 9; Miller et al., *supra* note 14, at 783.

from some western mountain ranges, such as California's Sierra Nevada, by century's end.[16]

The combination of earlier snowmelt and an increasing proportion of precipitation falling as rain means that runoff will increase in the winter and early spring months and decrease in the late spring and summer.[17] Streams will run dry earlier in the season as more water is released during winter and early spring. Late spring and summer runoff may be further reduced by climate-induced increases in evapotranspiration, the process by which plants take up water from the soil through their roots and release it to the atmosphere through their leaves, though the extent of potential increases remains unclear.[18] Direct evaporation from soil and water bodies, including reservoirs, also increases with temperature, further reducing the water available in warmer months.[19]

1. Water Supply

Water supply systems in the West were designed around the existing hydrologic regime. Because precipitation falls mostly during the winter and early spring, water must be stored for use throughout the rest of the year. These systems rely heavily on the snowpack to provide natural *in situ* storage of water over the winter and spring and to gradually release it over the late spring and summer.[20] Engineered reservoirs then catch and retain runoff from snowmelt, which allows water deliveries to downstream users to be further extended into the dry summer and early fall months. Reservoirs release water into rivers for diversion through a complex of canals and further reservoirs, such as the Bureau of Reclamation's massive Central Valley Project in California, for eventual delivery to end users.

It is hard to overstate the significance of climate change's implications for western water supply. More winter rain and earlier snowmelt undermines the crucial assumption that snowpack is available to augment engineered storage. As it stands, the system does not include sufficient engineered storage to compensate for the loss of the snowpack.[21] Reser-

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16. *See* CCAT, *supra* note 3, at 28 (noting projected 90 percent reduction in snowpack at high estimates of temperature increase).

17. *See* KIPARSKY & GLEICK, *supra* note 13, at 9–10; Barnett et al., *supra* note 14, at 305; Miller et al., *supra* note 14, at 783.

18. *See* KIPARSKY & GLEICK, *supra* note 13, at 9, 12–13.

19. *See id.* at 9.

20. *See* CCAT, *supra* note 3, at 28–29 ("The snowpack in the Sierra Nevada provides natural water storage equal to about half the storage capacity in California's major man-made reservoirs."); KIPARSKY & GLEICK, *supra* note 13, at 9–11.

21. *See* CCAT, *supra* note 3, at 28–29; KIPARSKY & GLEICK, *supra* note 13, at 13–14; Barnett et al., *supra* note 14, at 305.

voirs that reach capacity with winter and early spring runoff will be forced to release some of that runoff before the summer and fall months, when it is most needed. Thus, even assuming that climate change does not affect the total volume of precipitation, the change in its timing and form will mean that more water must be released to flow to the ocean. The problem is compounded by increased evaporative losses in warmer months and increases in summer and early fall water demand caused by increasing summer temperatures. In California, for example, assuming median estimates of warming, "[b]y the end of [the] century, increasing temperatures are expected to increase the crop demand for water [by] 13 percent."[22] A warmer climate would also stimulate increased urban water demand, an effect likely to be exacerbated by the significant population growth expected in the West in coming decades.[23]

What kinds of adaptations and secondary impacts might these changes encourage? To adapt to declining water storage in snowpack, we might expand engineered storage by building new dams and reservoirs or raising existing dams to increase the capacity of existing reservoirs.[24] Dams and reservoirs have a number of adverse environmental effects. They fundamentally alter upstream aquatic habitat, replacing riparian areas with flat water, and inundate and destroy terrestrial ecosystems. Dams also block fish access to former spawning grounds and may impair downstream water conditions by, for example, raising water temperatures or reducing or eliminating flow.[25]

Alternative responses are of course available, with a range of potential environmental effects. In lieu of on-stream storage in reservoirs, runoff could be released from reservoirs early in the season, but captured downstream and pumped into groundwater aquifers for later withdrawal.[26] Seawater desalination may also become economically feasible

22. CCAT, *supra* note 3, at 29.

23. *See* David S. Gutzler & Joshua S. Nims, *Interannual Variability of Water Demand and Summer Climate in Albuquerque, New Mexico*, 44 J. APPLIED METEOROLOGY 1777, 1786 (2005); *see also* Joel B. Smith et al., *Potential Consequences of Climate Variability and Change for the Western United States*, *in* CLIMATE CHANGE IMPACTS ON THE UNITED STATES: THE POTENTIAL CONSEQUENCES OF CLIMATE VARIABILITY AND CHANGE 219, 225 (Nat'l Assessment Synthesis Team ed., 2001), *available at* http://www.gcrio.org/NationalAssessment/ foundation.html (follow "West (Chapter 8): PDF" hyperlink).

24. *See, e.g.*, William E. Riebsame, *Adjusting Water Resources Management to Climate Change*, 13 CLIMATIC CHANGE 69, 91, 93 (1988) (noting that climate change may overwhelm operational adaptations in the management of water supply infrastructure and require structural adaptations); Smith et al., *supra* note 23, at 228.

25. Don C. Erman et al., *Environmental Quality and Recreation*, *in* COMPETITION FOR CALIFORNIA WATER: ALTERNATIVE RESOLUTIONS 103 (Ernest A. Engelbert & Ann Foley Scheuring eds., 1982).

26. *See generally* Herman Bouwer, *Artificial Recharge of Groundwater: Hydrogeology and Engineering*, 10 HYDROGEOLOGY J. 121, 137–38 (2002).

for high-value urban water uses.[27] These adaptations may not involve the severe ecological costs associated with the expansion of engineered on-stream storage, but they will have their own adverse effects. Large-scale aquifer recharge is energy intensive, as water must be pumped twice: into the aquifer for storage and then out again for use. Desalination also uses a great deal of energy in pumping saline water through a filter membrane at very high pressure.[28] Power generation to satisfy these energy demands could have significant pollution impacts.[29] Desalination has potential adverse effects as well in impinging and entraining aquatic species in influent water and releasing highly concentrated brine as a byproduct of treatment.[30]

Other potential adaptations include the establishment of more robust water markets to reallocate increasingly scarce water[31] and mandatory agricultural or urban water conservation or recycling. Water markets have potential distributional impacts on in-stream water uses by shifting flows among basins and water bodies without regard to ecosystem needs.[32] Water conservation and recycling appear to have the least severe environmental consequences of the available adaptations.[33] The challenge, as Part II describes, comes in seeing that such least-environmental-

27. Recent innovations in desalination technology have already caused coastal communities in California to begin to explore construction of seawater desalination plants. *See* CAL. COASTAL COMM'N, SEAWATER DESALINATION AND THE CALIFORNIA COASTAL ACT 9, 15–16 (2004), *available at* http://www.coastal.ca.gov/energy/14a-3-2004-desalination.pdf; Michael Burge, *Carlsbad OKs Desalination Plant*, SAN DIEGO UNION-TRIB., June 14, 2006, at B2. Desalination is an uncertain alternative to surface water storage, however, as some coastal communities that would have access to desalinated water are not currently served by snowmelt-fed surface water, and it may not be practicable to deliver desalinated seawater to the inland communities that are currently served by runoff. Moreover, the rising sea levels caused by climate change, *see infra* Part I.C, may threaten desalination plants that necessarily would be built in coastal areas.

28. *See* CAL. COASTAL COMM'N, *supra* note 27, at 34, 36.

29. Because I am hypothesizing a world without climate change mitigation, I assume here that expansion of renewable energy generation—a dominant climate change mitigation strategy—would not be significant. As a consequence, climate-induced increases in power generation would also have a feedback effect, further exacerbating climate change by increasing greenhouse gas emissions.

30. *See* CAL. COASTAL COMM'N, *supra* note 27, at 68–78.

31. *See, e.g.*, Smith et al., *supra* note 23, at 228.

32. *See* Kevin M. O'Brien & Robert R. Gunning, *Water Marketing in California Revisited: The Legacy of the 1987–92 Drought*, 25 PAC. L.J. 1053, 1081–83 (1994).

33. They are not necessarily environmentally costless, however. For example, although lining of irrigation ditches prevents water losses to seepage (and evaporation where ditches are replaced with pipe), the loss of seepage can eliminate ecosystems that have developed around unlined ditches in reliance on a long history of seepage. *See, e.g.*, Protect the Historic Amador Waterways v. Amador Water Agency, 11 Cal. Rptr. 3d 104, 106–07 (Ct. App. 2004) (invalidating environmental review for a canal-lining project with impacts to an ecosystem created by seepage from the unlined canal over more than 100 years).

cost alternatives can compete in the political arena with more costly alternatives.

2. Hydropower

Beyond its effects on water supply, acceleration of runoff could also disturb the western energy grid. Western states rely heavily on hydropower, particularly to meet summer energy demand.[34] Storage of water in mountain reservoirs allows a steady flow of hydropower as water is released during the spring and summer; reservoirs effectively store power by storing water. As runoff accelerates, water released during the winter and spring months to prevent dam overflows will be unavailable to generate hydropower during the critical summer months, when electricity demand peaks to run air conditioners.[35] Moreover, as summer temperatures rise with a warming climate, electricity demand would increase inversely with the decline in hydropower production.[36]

Of the potential water supply adaptations discussed previously, only construction or expansion of engineered on-stream reservoirs, with the attendant severe environmental impacts discussed previously, could avert the loss of hydropower. Beyond adding new storage capacity, another foreseeable adaptation to the loss of hydropower is expanding reliance on other energy sources, most likely coal or natural gas.[37] While hydropower generation causes impingement or entrainment of fish and changes the timing of flows in downstream rivers, fossil fuel-fired electricity generation has a broader array of impacts to ecosystems and human health. Fossil fuel combustion produces a raft of harmful air pollutants including oxides of nitrogen (NOx), sulfur dioxide, and mercury, as well as climate-forcing carbon dioxide.[38] The extraction of fossil fuels imposes enormous ecological and health costs as well.[39]

Alternatively, the energy deficit left by the loss of hydropower might be made up with nuclear power or renewable energy sources such as wind and solar or as-yet-untapped sources such as tidal power. Of course, nuclear power entails a variety of infamous environmental and health risks,

34. For example, hydropower supplies about 15 percent of California's electricity demand. CCAT, *supra* note 3, at 35.

35. *See id.* at 35.

36. *See id.* at 27.

37. *See, e.g.*, DEP'T OF ENERGY, ENERGY INFO. ADMIN., DOC. NO. DOE/EIA-0629, STATE ELECTRICITY PROFILES 2003 22 tbl.5, 176 tbl.5, 224 tbl.5 (2003) (listing the 2003 shares of total electricity production for hydropower and other sources in California, Oregon, and Washington), *available at* http://tonto.eia.doe.gov/FTPROOT/electricity/06292003.pdf.

38. *See, e.g.*, Patrick C. McGinley, *From Pick and Shovel to Mountaintop Removal: Environmental Injustice in the Appalachian Coalfields*, 34 ENVTL. L. 21 (2004) (describing the social and environmental costs of coal mining in Appalachia).

39. *Id.*

concern for which has prevented development of new nuclear generating capacity in the United States.[40] Renewable sources would avoid most of the human health and ecological impacts that nuclear and fossil fuels produce, but are not without environmental effects.[41] In any event, in a world of climate adaptation rather than mitigation, the greenhouse gas regulation and attendant price signals that could have encouraged the development of such alternatives to fossil-fueled energy sources would be absent.

3. Flood Control

By storing and gradually releasing water from precipitation, the mountain snowpack also provides flood control benefits. With unmitigated climate change, higher winter and early spring runoff would deliver more water to overtaxed reservoirs. Reservoir management involves a tradeoff between storage of runoff for use in the dry season and short-term storage of winter and early spring storm runoff to prevent downstream flooding.[42] Filling reservoirs earlier in the year to ensure water supply for the dry season renders them unable to accommodate late season storm events, but reserving capacity in the reservoir for late season storms risks leaving the reservoir below capacity heading into the dry season if late precipitation does not materialize.[43] Higher early-season runoff caused by climate change increases the risk of early-season floods, as runoff that exceeds the capacity of existing reservoirs must be released. Those releases would be augmented by increased runoff from storm events made more severe by climate change, potentially causing flooding in communities downstream.[44] In California, for instance, the low-lying Sacramento urban area in the floodplains of the American and Sacramento Rivers already faces a flood risk greater than that of recently and catastrophically flooded New Orleans,[45] and that risk will be exacerbated

40. *See* Joseph P. Tomain, *Nuclear Futures*, 15 DUKE ENVTL. L. & POL'Y F. 221, 229–32 (2005).

41. Wind power, for instance, has proved controversial because of the often-heavy toll it takes on birds. *See* Victoria Sutton & Nicole Tomich, *Harnessing Wind Is Not (by Nature) Environmentally Friendly*, 22 PACE ENVTL. L. REV. 91 (2005).

42. *See* Noah Knowles & Daniel R. Cayan, *Potential Effects of Global Warming on the Sacramento/San Joaquin Watershed and the San Francisco Estuary*, 29 GEOPHYSICAL RES. LETTERS 38, 38 (2002).

43. *See* Riebsame, *supra* note 24, at 91.

44. *See* Smith et al., *supra* note 23, at 226–27; *see also* Jinwon Kim, *A Projection of the Effects of the Climate Change Induced by Increased CO_2 on Extreme Hydrologic Events in the Western U.S.*, 68 CLIMATIC CHANGE 153, 165–66 (2005).

45. *See* Dan Walters, *As Weather Warms, Snowpack Melts—A Reminder of Perpetual Peril*, SACRAMENTO BEE, May 3, 2006, at A3.

by climate-induced changes in precipitation and runoff.[46] Some early flooding might be avoided by keeping reservoirs low to absorb early runoff, but at the cost of aggravating water supply shortfalls in the dry months.

The greater flood risks under unmitigated climate change invite a range of adaptations. Potential engineered adaptations include construction or expansion of reservoirs to store storm runoff (discussed above), construction of new levees, or raising of existing levees. Non-engineered adaptations include redirection of new development away from floodplains and relocation of existing floodplain development. Buildings may be designed to withstand a flood, such as by raising the ground floor of the structure above the elevation of the projected flood.[47] The environmental effects of these adaptations range in severity from plainly severe (reservoir construction or relocation of entire communities away from floodplains) to likely minor (building design). Given this range of impacts, the question again is whether we will be able to make a choice that minimizes or moderates those impacts.[48]

B. Vector-borne Diseases and Pests

Climate change will also, and indeed has already begun to, modify species' distributions.[49] As the climate warms, some species adapt by shifting their range, and some become more successful in both existing and new habitats. Species that previously found certain elevations or latitudes inhospitable will be able to survive in those environments, and some species will be unable to survive in the environments to which they have previously adapted. For example, species sensitive to cold may begin to move or expand their ranges north or higher in altitude.[50] Although some species will adapt by moving, populations of other less mobile species may decline, or they may simply become extinct.[51]

46. Knowles & Cayan, *supra* note 42, at 38. Beyond the Sacramento Valley, climate change is projected to produce an increase in the incidence of severe floods throughout temperate regions. *See* P.C.D. Milly et al., *Increasing Risk of Great Floods in a Changing Climate*, 415 NATURE 514 (2002) (finding a climate-related increase in the frequency of severe floods over the twentieth century and projecting the trend to continue).

47. *See* Christopher P. Jones, *Flood Resistance of the Building Envelope*, WHOLE BUILDING DESIGN GUIDE, May 12, 2006, http://www.wbdg.org/design/env_flood.php.

48. *See infra* Part II.

49. *See* Robert L. Peters II, *The Effect of Global Climatic Change on Natural Communities*, *in* BIODIVERSITY 450, 453–57 (E.O. Wilson ed., 1988); Gian-Reto Walther et al., *Ecological Responses to Recent Climate Change*, 416 NATURE 389, 390–91 (2002).

50. *See, e.g.*, Carol Miller & Dean L. Urban, *Forest Pattern, Fire, and Climatic Change in the Sierra Nevada*, 2 ECOSYSTEMS 76, 76 (1999).

51. *See* Walther et al., *supra* note 49, at 394.

Vector-borne diseases[52] such as malaria that currently do not occur or are uncommon in the United States are expected to expand into previously inhospitable areas.[53] In some cases, the disease vector, such as the anopheles mosquito, is already present in the United States, but the parasite does not develop under current climatic conditions.[54] Increasing temperatures may expand the range of vectors and allow parasites to thrive in new locations.[55]

Greater use of pesticides to control vectors is a foreseeable response to rising risks of vector-borne disease.[56] The recent discovery of West Nile virus in the United States has prompted aerial spraying of pesticides targeting its mosquito vector.[57] As vector-borne disease raises the stakes of mosquito control, moreover, we may look to stronger pesticides to reduce risk. For instance, although DDT was largely banned in the United States in 1972,[58] it is still produced for use in some tropical countries to control mosquitoes that carry malaria.[59] Indeed, in 2006, the World Health Organization reversed its policy against the use of DDT and is promoting indoor spraying of DDT to fight malaria.[60] It is not difficult to imagine scenarios in a warmer world in which DDT is reintroduced in the United States to control mosquitoes carrying newly prevalent tropical diseases. Expanding pesticide use to combat vector-borne diseases would have environmental effects of varying severity, dependent on the pesticides used. For example, prior to being banned in the United States, DDT was

52. Vector-borne diseases are infectious diseases transmitted by an animal vector such as a mosquito or a tick.

53. *See, e.g.*, Andrew K. Githeko et al., *Climate Change and Vector-Borne Diseases: A Regional Analysis*, 78 BULL. WORLD HEALTH ORG. 1136, 1141–42 (2000); P. Martens et al., *Climate Change and Future Populations at Risk of Malaria*, 9 GLOBAL ENVTL. CHANGE S89, S96–99 & fig.4 (1999). *But cf.* David J. Rogers & Sarah E. Randolph, *The Global Spread of Malaria in a Future, Warmer World*, 289 SCIENCE 1763 (2000) (suggesting a more limited future spread of malaria in North America).

54. Martens et al., *supra* note 53, at 99.

55. *Id.*

56. *See, e.g.*, Mendelsohn, *supra* note 4, at 584 tbl.1.

57. *See, e.g.*, Edie Lau & Chris Bowman, *W. Nile Spray Study Prompts Praise, Caution*, SACRAMENTO BEE, Feb. 22, 2006, at B1 (describing one study of pesticide spraying in Sacramento).

58. *See* David L. Mulliken et al., *DDT: A Persistent Lifesaver*, 19 NAT. RESOURCES & ENV'T 3, 4–6 (2005).

59. *See* C.F. Curtis & J.D. Lines, *Should DDT Be Banned by International Treaty?*, 16 PARASITOLOGY TODAY 119, 119–20 (2000).

60. *See* Celia W. Dugger, *W.H.O. Supports Wider Use of DDT to Combat Malaria*, N.Y. TIMES, Sept. 16, 2006, at A7; *see also* Tina Rosenberg, *What the World Needs Now Is DDT*, N.Y. TIMES, Apr. 11, 2004, Magazine, at 38 (arguing that DDT can be used safely to eliminate malarial mosquitoes); Mulliken et al., *supra* note 58, at 3.

shown to contribute significantly to the decline of a variety of bird species by thinning and weakening their egg shells.[61]

Under climate change, agricultural and silvicultural pests, diseases, and weeds are likely to expand their ranges and become more successful.[62] For instance, studies suggest that a warming climate has already played a role in the expansion of pests and diseases into northern forests from which they were previously excluded by cold temperatures.[63] Like the expansion of vector-borne diseases, new agricultural and silvicultural pest outbreaks are likely to encourage greater use of pesticides. Increased incidence of silvicultural pests and diseases might also encourage more aggressive timber harvesting;[64] proponents of two recent legislative initiatives, the so-called "Timber Salvage Rider"[65] and the Healthy Forests Restoration Act of 2003,[66] used pest and disease outbreaks to justify facilitating timber harvesting on federal lands.[67]

C. Rising Sea Level

A warming climate also means a global increase in sea levels. Over the past century, sea levels have risen approximately ten to twenty centimeters as global average temperature has increased.[68] Estimates of the

61. *See* Ian Newton, *Pollutants and Pesticides*, *in* CONSERVATION SCIENCE AND ACTION 66, 69–74 (William J. Sutherland ed., 1998). This effect was the basis of the book that, some suggest, launched the environmental movement, Rachel Carson's *Silent Spring*. *See* RACHEL CARSON, SILENT SPRING (1962).

62. *See* CCAT, *supra* note 3, at 30 ("Growth rates of weeds, insect pests, and pathogens are also likely to increase with elevated temperatures, and their ranges may expand."); *id.* at 34 ("Historically, pests and disease have caused significant damage to California forests. The changing climate may exacerbate these effects by expanding the range and frequency of pest outbreaks."); Miller & Urban, *supra* note 50, at 85.

63. *See* Alex Woods et al., *Is an Unprecedented* Dothistroma *Needle Blight Epidemic Related to Climate Change?*, 55 BIOSCIENCE 761 (2005); *see also* R.A. Fleming & W.J.A. Volney, *Effects of Climate Change on Insect Defoliator Population Processes in Canada's Boreal Forest: Some Plausible Scenarios*, 82 WATER, AIR & SOIL POLLUTION 445 (1995).

64. *See* Mendelsohn, *supra* note 4, at 584 tbl.1, 596.

65. Act of July 22, 1995, Pub. L. No. 104-19, §§ 2001–2002, 109 Stat. 194, 240–47 (1995) (codified as amended at 16 U.S.C. § 1611 (2006)).

66. Healthy Forests Restoration Act of 2003, Pub. L. No. 108-148, 117 Stat. 1887 (2003) (codified as amended at 16 U.S.C. §§ 6501–6591 (2006)).

67. *See* Richard J. Lazarus, *Congressional Descent: The Demise of Deliberative Democracy in Environmental Law*, 94 GEO. L.J. 619, 643 (2006) (noting that for the Salvage Rider, "the nominal, stated purpose was the prevention of fire and insect infestation"); Reda M. Dennis-Parks, Comment, *Healthy Forests Restoration Act—Will It Really Protect Homes and Communities?*, 31 ECOLOGY L.Q. 639, 645 (2004) ("The second purpose of [the Healthy Forests Act] is the promotion of other efforts to safeguard communities and watersheds, and to address threats to forest health, specifically wildfire and insect infestation.").

68. IPCC I, *supra* note 8, at 663; *see also* Meehl et al., *supra* note 3, at 1769–70 (noting observed increase of fifteen to twenty centimeters).

magnitude of future sea level rise have varied considerably.[69] Even higher estimates of sea level rise typically assumed little contribution from the large masses of terrestrial ice (mainly in Greenland and Antarctica) in the form of calving glaciers and disintegrating ice shelves. Terrestrial ice was expected to remain largely in equilibrium due to increased precipitation caused by climatic warming.[70] Recent evidence, however, has called that assumption into question,[71] with important ramifications for sea levels: the Greenland and Antarctic ice sheets together are estimated to hold enough water to raise sea levels by approximately seventy meters.[72] Although such a radical increase would accompany only the most massive warming over a very long time horizon, the recent evidence showing that the ice sheets are losing mass faster than expected suggests that sea levels may rise more significantly and more quickly than previous models predicted.[73]

Sea level increases at the high end of the estimated ranges would have serious consequences for coastal areas in the United States. Very low-lying areas, some of which include portions of dense urban areas, may be subject to inundation, whether periodic—caused by a combination of sea level rise and storm surge—or permanent.[74] In some areas, particularly those with very high-value real estate, adaptive responses might include the construction of sea walls and levees to keep out the rising water,[75] with attendant construction impacts to riparian and aquatic areas. In others, however, developed coastal land will have to be ceded to the rising tide, and dislocated residents will be forced to relocate, necessitating further land development in inland areas to accommodate the

69. *See* CCAT, *supra* note 3, at 32 (four to thirty-three inches by 2100); IPCC I, *supra* note 8, at 642 (0.09 m to 0.88 m by 2100); Richard B. Alley et al., *Ice-Sheet and Sea-Level Changes*, 310 SCIENCE 456, 456 (2005) (0.5 m ± 0.4 m by 2100); Meehl et al., *supra* note 3, at 1770 (0.13 to 0.30 m by 2100, based solely on thermal expansion).

70. Indeed, evidence shows that ice formation and release were in balance in the late twentieth century, while the climate was warming. *See* Richard A. Kerr, *A Worrying Trend of Less Ice, Higher Seas*, 311 SCIENCE 1698, 1699 (2006).

71. *See* Alley et al., *supra* note 69, at 456; Julian A. Dowdeswell, *The Greenland Ice Sheet and Global Sea-Level Rise*, 311 SCIENCE 963, 963 (2006) (noting a recently observed increase in the speed of Greenland's glaciers releasing ice into the ocean); Kerr, *supra* note 70, at 1699 (suggesting that Antarctic snowfall is not replenishing the continent's mass of ice and snow sufficiently to offset the accelerating loss of ice to the ocean from glaciers).

72. Alley et al., *supra* note 69, at 456.

73. *See* Dowdeswell, *supra* note 71, at 963; Jonathan T. Overpeck et al., *Paleoclimatic Evidence for Future Ice-Sheet Instability and Rapid Sea-Level Rise*, 311 SCIENCE 1747, 1750 (2006).

74. *See* John E. Hay & Nobuo Mimura, *Sea-Level Rise: Implications for Water Resources Management*, 10 MITIGATION & ADAPTATION STRATEGIES FOR GLOBAL CLIMATE CHANGE 717, 720–21 (2005).

75. *See* Mark Meo, *Sea Level Rise and Policy Change: Land Use Management in the Sacramento-San Joaquin and Mississippi River Deltas*, 19 POL'Y STUD. J. 83, 83 (1991).

coastal refugees.[76] That development might occur in already-developed urban areas through infill and densification, or it might occur, as it largely does now in many parts of the country,[77] in undeveloped areas along the borders of suburban and exurban communities. Development in these areas is likely to cause habitat loss and fragmentation, loss of agricultural land, and the impacts of connecting new remote communities to existing urban centers.

Further, rising sea levels threaten coastal estuaries such as Chesapeake Bay, the Mississippi Delta, and the San Francisco Bay Delta. In California, rising sea levels will cause saltwater to intrude further upstream into the San Francisco Bay Delta. One commentator "estimates that a 1 meter rise in sea level could easily inundate the entire Delta and triple the areal extent of the San Francisco Bay."[78] The Delta ecosystem is already under severe pressure from California's water supply infrastructure, which uses it as a conduit for delivery of freshwater to agricultural users in the San Joaquin Valley and eventually to urban users in Southern California. The freshwater diversions change salinity levels and the pattern of flows through the Delta contributing to the decline of some species.[79] Rising sea levels will further increase the salinity of Delta waters.[80] Furthermore, rising sea levels would threaten the water supply system itself and thus require adaptations on a grand scale. If saltwater were to intrude far enough into the Delta, it would reach the pumps and headgates of the massive canals that divert freshwater south, rendering the canals useless.[81]

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76. *See id.* Meo cites 1980s estimates of costs associated with *in situ* mitigation in the range of $50 to $100 billion, based on estimates of sea level rise in the range of 0.5 to 1.5 meters. *Id.* at 84. Estimates based on the more severe sea level increases now believed to be possible would presumably be much higher. In either event, the high cost of *in situ* adaptation suggests the likelihood of inland migration.

77. *See* Robert H. Freilich, *Smart Growth In Western Metro Areas*, 43 NAT. RESOURCES J. 687, 687 (2003).

78. Meo, *supra* note 75, at 85 (citing PHILIP WILLIAMS & ASSOCS., THE IMPACTS OF CLIMATE CHANGE ON THE SALINITY OF THE SAN FRANCISCO BAY (1988)).

79. *See* State Water Res. Control Bd. Cases, 39 Cal. Rptr. 3d 189, 206 (Ct. App. 2006); Mike Taugher, *Delta's Health in Rapid Decline*, SAN JOSE MERCURY NEWS, Jan. 5, 2006, at A1.

80. Changing precipitation conditions in the headwaters of the rivers that feed the Delta due to climate change may also independently exacerbate salinity conditions in the Delta. *See* Knowles & Cayan, *supra* note 42, at 38.

81. Worse still, the poor structural condition of the levees used to exclude the Delta's waters from farmland and residential areas on islands that are below water level exacerbates the risk to California's water supplies. *See* Meo, *supra* note 75, at 85. The projected widespread failure of those levees in a strong earthquake would cause Delta water to fill the basin-like centers of the islands and draw saltwater further upstream into the Delta and toward the pumps. *See* Betsy Mason, *Quake Could Devastate Levees*, CONTRA COSTA TIMES, Apr. 20, 2006, at A1; *cf.* CAL. DEP'T OF WATER RESOURCES, FLOOD WARNINGS: RESPONDING TO CALIFORNIA'S FLOOD CRISIS 7 (2005) (describing cessation of pumping after levee failure to avoid saltwater

To adapt to rising sea levels in the San Francisco Bay Delta and prevent saltwater from reaching the canals, freshwater might need to be diverted further upstream by building a "peripheral canal" that would bypass the Delta entirely.[82] The canal would have adverse environmental effects in the construction of massive canals and diversion structures, such as habitat loss and fragmentation.[83] Whether it would help or harm the Delta ecosystem as a whole, however, is subject to debate. Some have argued that it would damage the ecosystem by preventing freshwater from reaching the Delta and thus encouraging further saltwater intrusion from the Bay.[84] By contrast, others note that the canal would eliminate the massive pumping of water from the southern Delta thought to harm Delta species.[85]

Finally, rising sea levels will also cause or increase saltwater intrusion into coastal aquifers presently used for drinking water or irrigation.[86] The loss of water supply in turn would require development of new water supplies or further abandonment of coastal areas and concomitant inland development. As previously discussed, water supply adaptations in coastal areas such as desalination and groundwater recharge have high energy demands, and inland development often occurs on undeveloped open space and destroys or fragments habitat.

D. Increasing Storm Intensity

Widespread speculation about the possible role of climate change followed closely in the wake of Hurricanes Katrina and Rita in 2005. Although it is impossible to link any individual storm to climate change, atmospheric scientists have predicted a general increase in tropical storm intensity linked to climate change–induced warming of tropical waters.[87]

contamination of the water supply), *available at* http://www.publicaffairs.water.ca.gov/ newsreleases/2005/01-10-05flood_warnings.pdf.

82. *See* Meo, *supra* note 75, at 86, 90; Dan Walters, *Auburn Dam, Peripheral Canal Back on the Table for Discussion*, SACRAMENTO BEE, Sept. 18, 2006, at A3. A peripheral canal was first approved in the 1960s, but was subsequently defeated in a referendum by California voters in 1982. *See* Meo, *supra* note 75, at 86.

83. *See* Timothy Pfaff, *California's Peripheral Canal*, 24 ENV'T 25, 30 (1982).

84. *See id.* at 30–31.

85. *See* Michael Gardner, *Prospect of Canal to Region is Revived*, SAN DIEGO UNION-TRIB., Apr. 24, 2006, at A1.

86. *See* Meo, *supra* note 75, at 84.

87. *See* James B. Elsner, *Evidence in Support of the Climate Change: Atlantic Hurricane Hypothesis*, 33 GEOPHYSICAL RES. LETTERS L16705 (2006); C.D. Hoyos et al., *Deconvolution of the Factors Contributing to the Increase in Global Hurricane Intensity*, 312 SCIENCE 94, 94 (2006); Thomas R. Knutson & Robert E. Tuleya, *Impact of CO_2-Induced Warming on Simulated Hurricane Intensity and Precipitation: Sensitivity to the Choice of Climate Model and Convective Parameterization*, 17 J. CLIMATE 3477 (2004); Michael E. Mann & Kerry A. Emanuel, *Atlantic Hurricane Trends Linked to Climate Change*, 87 EOS 233 (2006); Kevin E. Trenberth &

Consistent with that prediction, the 2005 hurricane season set a flurry of new records: fifteen hurricanes (previous record was twelve), twenty-eight named storms (previous record was twenty-one), four Category Five hurricanes (previous record was two), four major hurricanes touching down in the United States (previous record was three), and five storm names "retired" in a single season due to their extensive damage and loss of life.[88]

As Katrina and Rita powerfully demonstrated, severe storms damage the natural and human environment in coastal areas with high winds and storm surges. An increase in storm intensity caused by climate change can be expected to increase that damage by producing large storms more frequently. Worse still, sea level rise caused by climate change would exacerbate the risks of increased storm severity. Rising sea levels increase the relative height, and thus damage, of storm surges.[89] Moreover, although coastal wetlands can moderate the damage inflicted by storm surges and floodwaters by absorbing rising water and dissipating the surge's destructive energy,[90] because of their low elevation and proximity to the existing shoreline, they will be some of the first sites submerged by rising seas.[91]

The risk of storms intensified by climate change would require aggressive adaptation in hurricane-affected regions, as the scale of the ongoing reconstruction on the Gulf Coast suggests. Foreseeable adaptations include construction or expansion of levees and storm surge barriers, coastal armoring,[92] and mass relocation of settlements inland away from

Dennis J. Shea, *Atlantic Hurricanes and Natural Variability in 2005*, 33 GEOPHYSICAL RES. LETTERS L12704 (2006).

88. *See* Jyotika I. Virmani & Robert H. Weisberg, *The 2005 Hurricane Season: An Echo of the Past or a Harbinger of the Future?*, 33 GEOPHYSICAL RES. LETTERS L5707 (2006); Tom Skilling, *Record Five Retirees from a Memorable 2005 Hurricane Season*, CHI. TRIB., Apr. 17, 2006, Metro, at 6; *NOAA Reviews Record-Setting 2005 Atlantic Hurricane Season: Active Hurricane Era Likely to Continue*, NOAA NEWS ONLINE, Nov. 29, 2005, http://www.noaanews.noaa.gov/stories2005/s2540.htm (updated Apr. 13, 2006).

89. *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2001: IMPACTS, ADAPTATION AND VULNERABILITY 365 (2001) [hereinafter IPCC II], *available at* http://www.grida.no/climate/ipcc_tar/wg2/index.htm; Hay & Mimura, *supra* note 74, at 720–22; Meo, *supra* note 75, at 84.

90. *See* James Salzman, *A Field of Green? The Past and Future of Ecosystem Services*, 21 J. LAND USE & ENVTL. L. 133, 135 (2006). Indeed, some have concluded that the progressive loss of Louisiana's coastal wetlands over the last century was responsible for some of the devastation wrought by Hurricanes Katrina and Rita. *See id.*

91. *See* Hay & Mimura, *supra* note 74, at 722–23; Meo, *supra* note 75, at 84.

92. Coastal armoring is the fortification of coastal areas to reduce erosion and protect coastal developments. *See* MARINE SANCTUARIES DIV., NAT'L OCEANIC & ATMOSPHERIC ADMIN., DOC. NO. MSD-0503, THE IMPACTS OF COASTAL PROTECTION STRUCTURES IN CALIFORNIA'S MONTEREY BAY NATIONAL MARINE SANCTUARY (2005), *available at* http://www.sanctuaries.noaa.gov/special/con_coast/stamski.pdf.

areas affected by storm surges.[93] As a dramatic example, some have proposed physically relocating the mouth of the Mississippi River to reduce potential impacts to New Orleans.[94] Structural adaptations cause construction impacts, such as destruction of riparian areas, and alter the hydrology of the affected water body.[95] As noted above, mass inland migration converts undeveloped inland open space areas for new development with attendant natural resource and habitat impacts.

E. Synergistic Effects

Though the secondary adaptation impacts discussed above range in their severity, some are certainly daunting. Yet adaptation's impacts may be more severe than at first appears due to the compounding influence of the primary environmental effects of a warming climate. As illustrated above, climate change stresses natural systems, for example, in forcing species to adapt to new habitats and new conditions. Broadly speaking, natural systems are less resilient when under stress.[96] These climate stresses "will exacerbate [anthropogenic] environmental problems"; the "intensification of certain existing pollution problems is an important indirect consequence of a warmer climate."[97] Coral reefs, for example, are already experiencing the primary effects of climate change,[98] but "[t]he greatest impact of climate change will be a synergistic enhancement of direct anthropogenic stresses (excessive sediment and pollution from the land; over-fishing, especially via destructive methods; mining of coral rock and sand; and engineering modifications), which currently cause most damage to coral reefs."[99]

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93. *See* Robert S. Boyd, *Visions Adapt to Hot Future*, TIMES UNION (Albany), Oct. 1, 2006, at A1.

94. *See id.*

95. For example, coastal armoring of one stretch of shoreline can accelerate neighboring beach erosion by preventing replenishment with eroded material from the armored area and can fragment beaches and eliminate lateral access. *See* MARINE SANCTUARIES DIV., *supra* note 92, at 9–10.

96. *See generally* David J. Rapport & Walter G. Whitford, *How Ecosystems Respond to Stress*, 49 BIOSCIENCE 193 (1999).

97. Michael Oppenheimer, *Climate Change and Environmental Pollution: Physical and Biological Interactions*, 15 CLIMATIC CHANGE 255, 255 (1989).

98. *See* John P. McWilliams et al., *Accelerating Impacts of Temperature-Induced Coral Bleaching in the Caribbean*, 86 ECOLOGY 2055 (2005).

99. Clive R. Wilkinson, *Global Change and Coral Reefs: Impacts on Reefs, Economies and Human Cultures*, 2 GLOBAL CHANGE BIOLOGY 547, 547 (1996). On other synergistic interactions of anthropogenic impacts and climate stresses, see William F. Laurance & G. Bruce Williamson, *Positive Feedbacks Among Forest Fragmentation, Drought, and Climate Change in the Amazon*, 15 CONSERVATION BIOLOGY 1529 (2001), and Marianne V. Moore et al., *Potential Effects of Climate Change on Freshwater Ecosystems of the New England/Mid-Atlantic Region*, 11 HYDROLOGICAL PROCESSES 925, 935–42 (1997) (noting five possible "interactive effects of

Like other anthropogenic environmental impacts, the impacts of adaptation discussed above will create perverse synergies with primary climate effects. For example, "if new pest outbreaks [caused by climate change] are countered with increased pesticide use, non-target species might have to endure both climate- and contaminant-linked stressors."[100] The research on climate synergies indicates that natural systems would be less able to accommodate the new, potentially severe impacts of adaptation than they would in a world without climate stress.

To be sure, climate change is unlikely to stress systems uniformly. In some areas, for example, climate change might reduce stresses attributable to cold weather.[101] A warmer world will undoubtedly be more hospitable to some species (such as the pests and diseases discussed above), or simply cause species to expand or shift their ranges without causing significant harm. The stress referred to here, however, is not that caused by warmer conditions, but rather the stress of the change itself, the stress caused by relatively rapid changes in systems that have adapted during a long period of relative climate stability. The stress of change is likely to exacerbate at least some of the adverse effects of adaptation.

* * *

A variety of adaptations may be available to respond to each primary effect of unchecked climate change, involving a range of environmental consequences from the minor to the exceptionally severe. Depending on our choice of adaptations, the cumulative impact of those adaptations could be devastating, particularly given the likely synergistic combination of primary and secondary effects. We might moderate that impact, however, if we could effectively identify and implement those adaptations with the mildest environmental effects.

II. INSTITUTIONAL RESPONSES TO ADAPTATION

Perhaps we can use existing or new environmental law tools to moderate or prevent the effects of climate adaptation, just as we have moderated and prevented, to some degree, other environmental impacts over the past forty or so years. For instance, we might mandate adaptations

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climate and direct human effects," including an increase in bioaccumulation of pollutants associated with warming temperatures).

100. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE AND BIODIVERSITY 42 (2002) [hereinafter IPCC, BIODIVERSITY], *available at* http://www.ipcc.ch/pub/tpbiodiv.pdf; *see also* IPCC II, *supra* note 89, at 273.

101. *See, e.g.*, W.J.M. Martens, *Climate Change, Thermal Stress and Mortality Changes*, 46 SOC. SCI. & MED. 331 (1998) (projecting a net decrease in human mortality in twenty cities worldwide based on reduced winter mortality, exclusive of potential short-duration, extreme weather events).

that promise the least severe effects, or require that adaptations' effects be moderated or offset by mitigation measures.

Reasonable people can debate how successful environmental law has been to date in mitigating impacts. Yet there are reasons to be skeptical that even our successes thus far could be repeated in the warmer world left by an adaptation-preferring climate policy. The history of environmental law may prove to be less a model for responding to the effects of climate adaptation than a cautionary tale.

A. Capacity to Respond

Environmental law, as it stands or as it might be foreseeably reconfigured, may lack the capacity to respond to the threats posed by adaptation to climate change. In the best of circumstances, the subject matter of environmental law and the structure of American government create well-known challenges for effective regulation, and climate change is likely to exacerbate those challenges.

The enormous complexity of both environmental problems and their solutions has been perhaps the perennial challenge for environmental law.[102] That complexity has several facets. First, natural systems, from ecosystems to the human body, are enormously complex and our understanding of them—the baseline against which the severity of our environmental effects is to be judged—is partial at best.[103] Second, complexity obscures the true effects of human activities. Although some activities have straightforward consequences, such as the replacement of habitat with homes and roads, many also have less obvious effects distant from their causes in space and time, or effects that are the cumulative result of causes that are multifarious and individually insignificant or obscurely synergistic.[104] Third, the diversity of human activities with environmental consequences greatly complicates the design of legal institutions. The choice of policy responses adds another level of complexity by requiring predictions of the varying responses of diverse regulated parties and how those responses will alter the environmental effects of those parties' activities. Those policy choices also may have unforeseen environmental repercussions of their own, either directly[105] or by affecting the behavior of unregulated third parties.[106]

102. *See* RICHARD J. LAZARUS, THE MAKING OF ENVIRONMENTAL LAW 16 (2004) ("For those who study, teach, or practice environmental law, its complexity is virtually a mantra.").

103. *See id.* at 17–21.

104. *See* Bradley C. Karkkainen, *Information as Environmental Regulation: TRI and Performance Benchmarking, Precursor to a New Paradigm?*, 89 GEO. LJ. 257, 334 (2001).

105. The fuel oxygenate methyl tertiary-butyl ether (MTBE) is the now-classic example. Added to gasoline to reduce emissions of combustion byproducts in compliance with the 1990

Compounding challenges of complexity are the crisscrossing fractures of the American political system, which hinder comprehensive solutions to complex environmental problems.[107] The lawmaking process is structurally fragmented and creates countervailing centers of power that inhibit coordination and rational problem solving.[108] Interest group pressure can distort the legislation that does result.[109] Environmental law and its implementation are also fractured along several additional axes. The law is compartmentalized into isolated regulatory programs based on individual media, resources, or categories of pollutants, such as water pollution, endangered species, and hazardous waste, and that division is further reflected in the distribution of implementation responsibilities to multiple agencies and distinct offices within agencies. These divisions are, to say the least, in tension with the integrated nature of environmental problems.[110] Water is regulated wholly separately from air despite their obvious physical connections—for example, the single largest source of mercury pollution in water is air emissions from coal-fired power plants.[111] The same medium may be regulated differently by adjacent states though they share common natural systems, such as a watershed. And land use patterns, which have a host of environmental consequences, are dictated by a patchwork of local jurisdictions despite their common membership in seamless ecological and human communities. Federalism also complicates vertical coordination in implementation, as states are responsible for most of the implementation of federal environmental pol-

Clean Air Act Amendments, it was later found to cause widespread groundwater contamination. *See* Thomas O. McGarity, *MTBE: A Precautionary Tale*, 28 HARV. ENVTL. L. REV. 281 (2004).

106. When production of ozone-depleting chlorofluorocarbons (CFCs) was restricted by the Montreal Protocol and the Clean Air Act, for example, some CFC users switched to hydrofluorocarbons which do not deplete stratospheric ozone, but are greenhouse gases far more potent than carbon dioxide. *See* U.S. ENVTL. PROT. AGENCY, DOC. NO. EPA 430-R-06-002, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2004, at 12, 14–15 (2006), *available at* http://epa.gov/climatechange/emissions/usinventoryreport.html.

107. *See* LAZARUS, *supra* note 102, at 32–38; Jody Freeman & Daniel A. Farber, *Modular Environmental Regulation*, 54 DUKE L.J. 795, 809–10 (2005).

108. *See* MICHAEL T. HAYES, INCREMENTALISM AND PUBLIC POLICY (1992); *see also* LAZARUS, *supra* note 102, at 32–35. To make matters worse, changes in the legislative process since 1990 have made prohibitively difficult the kind of comprehensive environmental regulatory regimes developed in the 1970s and 1980s and instead encouraged poorly vetted piecemeal changes through the appropriations process. Lazarus, *supra* note 67, at 662–64.

109. *See, e.g.*, BRUCE A. ACKERMAN & WILLIAM T. HASSLER, CLEAN COAL/DIRTY AIR (1981) (describing the influence of the eastern coal lobby in the 1977 Clean Air Act Amendments).

110. *See* Freeman & Farber, *supra* note 107, at 809–10 (describing fragmentation of environmental regulatory agencies).

111. *See* K.R. Rolfhus & W.F. Fitzgerald, *Linkages Between Atmospheric Mercury Deposition and the Methylmercury Content of Marine Fish*, 80 WATER, SOIL & AIR POLLUTION 291, 291 (1995); *see also* Freeman & Farber, *supra* note 107, at 810 (noting the problem of cross-media spillovers).

icy.[112] Finally, implementation, like legislation, can suffer from the distorting effects of disproportionate participation by powerful interests.[113]

These challenges are hardly new, but they will likely continue to hamstring environmental law and hinder attempts to respond to adaptation's impacts. In fact, these challenges are likely to be more acute in the context of adaptation. Unchecked climate change would create widespread and systemic primary effects, but the selection of adaptations would remain ad hoc and fragmented. Even taken individually, the environmental effects of adaptation present thorny coordination problems. We lack a mechanism for the concerted planning necessary to make intelligent choices from among competing adaptations with different environmental consequences. Existing impediments to environmental planning are likely to be exacerbated by the breadth and scale of adaptation and its effects.

1. Comparative Analysis of Adaptation Alternatives

No mechanism exists to make coordinated and expert judgments about which adaptations are environmentally superior, assuming such judgments are possible. One of the perennial divisions in the administration of natural resources law is the separation of "project" or "action" agencies such as the Bureau of Reclamation or the U.S. Army Corps of Engineers from "resource" agencies such as the U.S. Fish and Wildlife Service (USFWS). Action agencies are not well positioned to estimate and compare the environmental effects of contending adaptation alternatives, such as options for addressing a shrinking water supply. Rather, resource agencies have primary responsibility for protecting the species and habitats that could be significantly affected by projects, such as dam construction or changes in the operation of water distribution infrastructure. Neither do the resource agencies' missions allow for comprehensive environmental planning, however. For example, while USFWS and state resource agencies would be concerned with the wildlife and habitat impacts of dam construction or other infrastructure development, a further set of agencies, including the federal Environmental Protection Agency (EPA) and state and local air quality management agencies, are responsible for assessing and minimizing the air impacts that would be produced by power plants providing power to desalination plants or aquifer recharge operations. Neither group of agencies is empowered to weigh the environmental tradeoffs between these competing adaptations.

112. *See* DENISE SCHEBERLE, FEDERALISM AND ENVIRONMENTAL POLICY (2d ed. 2004).

113. *See, e.g.*, Joel A. Mintz, *Has Industry Captured the EPA?: Appraising Marver Bernstein's Captive Agency Theory After Fifty Years*, 17 FORDHAM ENVTL. L. REV. 1 (2005).

Environmental impact assessment regimes such as the National Environmental Policy Act (NEPA)[114] imperfectly fill the role of minimizing the impacts of competing plans. The impact assessment process typically focuses slavishly on individual projects and thus shortchanges evaluation of cumulative impacts.[115] It also suffers from the problem of fragmented jurisdiction, as agencies focus solely on their own projects and programs.[116] In any event, the track record of environmental assessment is less than reassuring, even absent the complications posed by climate adaptation.[117] In sum, adaptation's environmental effects are unlikely to get the comprehensive evaluation necessary to ensure that they are minimized.

Yet even if a cadre of "ecological mandarins"[118] could be assembled to comprehensively assess and compare the impacts of competing adaptations in developing a coordinated adaptation plan, how would they balance the diverse impacts of competing adaptations? The trade-offs involved in deciding among alternative water supply options, for instance, involve competing values that are at least plausibly incommensurable.[119] That decision might require a choice between, on the one hand, habitat and species losses from dam construction, and on the other, increased air pollution and aquatic impacts caused by groundwater recharge and desalination. As many commentators have lamented, environmental law has been mostly unable to make comparative choices far narrower than this, such as comparing human health risks from different sources.[120] The difficulty of comparing the various carcinogenicity risks of different potentially regulated substances pales before the comparison of impacts to di-

114. 42 U.S.C. §§ 4321–4370f (2006).

115. *See* C.K. Contant & L.L. Wiggins, *Toward Defining and Assessing Cumulative Impacts: Practical and Theoretical Considerations*, *in* ENVIRONMENTAL ANALYSIS: THE NEPA EXPERIENCE 336, 337 (Stephen G. Hildebrand & Johnnie B. Cannon eds., 1993); COUNCIL ON ENVTL. QUALITY, EXECUTIVE OFFICE OF THE PRESIDENT, CONSIDERING CUMULATIVE EFFECTS UNDER THE NATIONAL ENVIRONMENTAL POLICY ACT 4 (1997); Bradley C. Karkkainen, *Toward a Smarter NEPA: Monitoring and Managing Government's Environmental Performance*, 102 COLUM. L. REV. 903, 923 & n.87 (2002).

116. Under one of NEPA's progeny, the California Environmental Quality Act, CAL. PUB. RES. CODE §§ 21000–21177 (2005), for example, an agency need not mitigate an impact if the only feasible mitigation is within the jurisdiction of a different agency. CAL. CODE REGS. tit. 14, § 15091(a)(2) (2006).

117. *See* Karkkainen, *supra* note 115, at 928–29 (describing high rates of predictive error found by longitudinal studies of environmental assessment).

118. WILLIAM OPHULS & A. STEPHEN BOYAN, ECOLOGY AND THE POLITICS OF SCARCITY REVISITED 214–15 (1992).

119. *See* Cass R. Sunstein, *Endogenous Preferences, Environmental Law*, 22 J. LEGAL STUD. 217, 248–49 (1993). On the problems of making trade-offs among diverse environmental values, see James Salzman & J.B. Ruhl, *Currencies and Commodification of Environmental Law*, 53 STAN. L. REV. 607 (2000).

120. *See, e.g.*, STEPHEN G. BREYER, BREAKING THE VICIOUS CIRCLE: TOWARD EFFECTIVE RISK REGULATION (1993).

verse environmental systems and resources. We simply lack a ready common currency for comparisons of species loss and air pollution.[121] Assuming these values are not truly incommensurable, an exceptionally sophisticated cost-benefit analysis might attempt to reconcile the competing environmental costs, but existing environmental law provides no precedent for success in such ambitious analysis.[122]

2. Planning for the Implementation of Adaptation

Even if we could comprehensively identify environmentally preferable adaptations, we lack mechanisms that would allow us to coordinate implementation of those adaptations. Approval and implementation of adaptations are likely to continue to be distributed and ad hoc. Take the example of water supply in California. Like most if not all states, California has no coordinated approval process to select and implement a comprehensive water supply strategy for the state. While the state Department of Water Resources (DWR), State Water Resources Control Board (SWRCB), and federal Bureau of Reclamation play important roles in approving major surface water projects such as dam construction, they would play a lesser role, if any, in approving development of alternative water sources, such as groundwater recharge and desalination, and less role still in adaptations that do not involve new supply, such as mandatory conservation or water recycling.[123] Moreover, in California, no agency regulates withdrawals from groundwater, though groundwater injection (which would be required for aquifer storage) is regulated by the Department of Toxic Substances Control, an agency with no water supply planning authority or expertise. Likewise, local governments and the California Coastal Commission make siting decisions for desalination

121. *See* Salzman & Ruhl, *supra* note 119, at 634 ("Many environmental trades, particularly those involving habitat management, are not amenable to measures of risk. As one moves from regulation of pollutants to habitat, the risk paradigm becomes awkward because the loss of habitat may have little bearing on human health.").

122. We do attempt to monetize natural resource damages in environmental litigation and enforcement. *See, e.g.*, 43 C.F.R. § 11.10–.93 (2006) (Department of Interior guidelines for preparation of natural resource damage assessments under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Clean Water Act). Nevertheless, such analysis is limited to the ex post setting of litigation or administrative enforcement actions, where the damage has already been done, and we thus face a choice between attempting to monetize the damage or simply ignoring it. By contrast, I can think of no examples in an ex ante setting in which costs for impacts to radically different environmental resources or health effects are estimated to compare the impacts of competing prospective decisions. Indeed, no agency has the comprehensive jurisdiction and expertise necessary to make such cross-media, cross-resource cost comparisons.

123. Development approvals would likely come from local governments and the California Coastal Commission. Mandatory conservation or recycling would require local or state legislative action.

plants,[124] though neither has much interest in or authority to do comprehensive water supply planning.[125] Accordingly, even if a comprehensive evaluation of the impacts of competing adaptations led to a conclusion that an array of alternative adaptations was preferable to dam construction, no agency exists to compel implementation of such alternatives. Moreover, there is reason to question whether such a hypothetical coordinating agency could make intelligent adaptation decisions.[126]

In other words, California has no single mechanism or coordinated mechanisms to make a comprehensive choice between dam building and alternative adaptations with fewer environmental impacts. Worse still, the absence of mechanisms for planning adaptations may affirmatively encourage adoption of the most destructive adaptations. The inability to coordinate and evaluate the effectiveness of widely distributed smaller-scale water projects such as groundwater recharge, mandatory conservation, and desalination may encourage large, centralized solutions such as reservoir construction.

Managing adaptation's environmental effects will likely be so difficult in part because those effects will be massively cumulative. Climate change will have pervasive effects that will demand equally pervasive adaptations. Though the activities will be isolated, many of their impacts will not, at least from an ecological perspective. Individual adaptation impacts may in some cases appear insignificant, but they will contribute to cumulatively significant impacts—a death by a thousand cuts. One category of climate-induced cumulative impacts is habitat loss caused by the relocation of coastal or floodplain residential development and construction of new water management, flood control, and tide control infrastructure. The loss to development of, say, a single small wetland might not have great significance, but pervasive loss of wetlands across a watershed, region, or state would have serious ramifications for wetland-dependent species, flood control, and water quality. Given the lack of coordinating institutions, those adaptations will be subject to diffuse and piecemeal regulation by local jurisdictions. Similarly, the pervasive effects of climate change will cause widespread changes in individuals' daily behavior, such as greater use of air conditioners to combat increasingly op-

124. *See* CAL. COASTAL COMM'N, *supra* note 27, at 22–23.

125. Both agencies lack incentives to plan for statewide water supply needs. The Coastal Commission focuses narrowly on the strip of land and resources along the coast, and its mandate involves little consideration of the needs of inland residents. Local governments also can be expected to be reluctant to site major new desalination facilities for the good of water users outside their jurisdictions.

126. *See* Riebsame, *supra* note 24, at 69 ("Recent studies of how social institutions respond to climate fluctuations suggest a tendency for conservative or muddled decision-making, and inappropriate policies, that lead to substantial climate-induced losses.").

pressive summer heat.[127] Such widely distributed, but cumulatively destructive, behavior has thus far proved resistant to regulation.[128]

In sum, by causing simultaneous effects widely diffused across jurisdictions, climate change portends uncontrolled or poorly controlled cumulative effects on a new scale. Environmental law so far has failed to effectively address cumulative impacts, in large measure because of the coordination problems discussed here.[129] We have little reason to expect that poor performance to improve when we are confronted with new cumulative impacts on an even larger scale.

Finally, as noted above in Part I.E, some primary climate effects and secondary adaptation effects would be synergistic: the impacts' total effect would be greater than the sum of their parts. Those synergies create at least two new challenges for environmental law.

First, climate change will magnify some anthropogenic harms and require more aggressive measures to maintain even existing levels of environmental quality. Climate change will exacerbate pollution risks, effectively moving the goal posts back for regulators.[130] For instance, increases in the number of warm, sunny days would cause more frequent and severe ground-level ozone events by facilitating the photochemical reactions of ozone precursors, oxides of nitrogen (NOx) and volatile organic compounds.[131] To make matters worse, a warming climate will increase summer ozone precursor emissions from electricity generating plants and motor vehicles to power air conditioning—a perverse synergy of primary and secondary climate effects.[132] Climate change thus would necessitate more stringent regulation of existing emissions of ozone precursors just to maintain smog at current levels. In some regions, of course, regulators already struggle to meet ambient air quality standards. The health costs of a given level of ozone pollution would also increase in a warmer climate.

127. *See* CCAT, *supra* note 3, at 27 ("On peak demand summer days in 2100, California would need at least ten percent more electricity, compared to total generation capacity today, for air conditioning alone.").

128. *See generally* Symposium, *The Next Environmental Frontier: Individual and Household Environmental Behavior*, 35 Envtl. L. Rep. (Envtl. Law Inst.) 10,721 (Nov. 2005).

129. *See* Karkkainen, *supra* note 104, at 334 ("As elsewhere in environmental regulation, no consideration is given [under the Toxics Release Inventory] to the problem of co-causation—the synergistic, interactive, or cumulative effects of multiple toxic pollutants, each of which may escape reporting if it falls below reporting thresholds."); Lance N. McCold & James W. Saulsbury, *Including Past and Present Impacts in Cumulative Impact Assessments*, 20 ENVTL. MGMT. 767, 768, 776 (1996).

130. *See* Oppenheimer, *supra* note 97.

131. *See, e.g.*, CCAT, *supra* note 3, at 25–26 ("Results from statistical analyses indicate that the number of days meteorologically conducive to pollution formation may rise by 75 to 85 percent in the high ozone areas of Los Angeles (Riverside) and the San Joaquin Valley (Visalia) by the end of the century if temperatures rise to the higher projected warming range . . . .").

132. *See id.* at 25.

As ozone pollution becomes more severe due to warmer summer weather, those warmer temperatures will also have direct stress effects on public health, particularly for sensitive populations such as the elderly and especially in urban areas where pollution concentrations and temperatures are highest.[133] These simultaneous heat and pollution stresses may interact synergistically.[134]

The synergistic combination of primary climate effects and the impacts of adaptation also puts new pressure on already taxed natural resources managers. Even under current climatic conditions, for instance, a welter of federal, state, and local agencies have had great difficulty in effectively managing the San Francisco Bay Delta to protect aquatic species.[135] As a rising sea level pushes saltwater farther into the Delta, climate stress on the Delta ecosystem would compound existing managerial challenges.[136] To combat increasing salinity in the Delta, water managers may need to allow more of the scarce freshwater demanded by consumptive water users to flow through the Delta to the sea. In short, a warmer climate will exacerbate the conflict between water users and the Delta's aquatic ecosystem, a conflict that has thus far proved beyond our managerial capacity.[137]

Climate-related synergies also present complexity problems. In some settings, the interaction between multiple synergistic causes is likely to be complex or simply obscure, and thus the synergy may go unrecognized. Because the multiple causes of synergistic effects are often inscrutable, adaptation may have effects that we cannot foresee. Where the true significance of the synergy's component impacts is obscure, regulators and resource managers will underestimate the true environmental cost of the activity that contributes to the synergy.

As climate change proceeds, moreover, the true severity of adaptation's effects, synergistic or otherwise, may become increasingly difficult to discern. In many or most cases, we have only limited knowledge of baseline environmental conditions and the ecological significance of anthropogenic changes to that baseline.[138] Climate change threatens to exacerbate that problem by creating a constantly moving baseline; the influence of climate change may undermine our understanding of the real significance of anthropogenic environmental impacts, including but not

133. *See* IPCC II, *supra* note 89, at 43, 397. Urban areas often experience higher temperatures than nearby rural areas—a "heat island" effect. *See* U.S. EPA, Heat Island Effect, Basic Information, http://www.epa.gov/heatisland/about/index.html (last visited Dec. 25, 2006).

134. *See* IPCC II, *supra* note 89, at 457–58, 461–62.

135. *See* Meo, *supra* note 75, at 90–91; Taugher, *supra* note 79.

136. *See supra* Part I.C.

137. *See* sources cited *supra* note 79.

138. *See supra* note 103 and accompanying text.

limited to the effects of climate adaptations.[139] For example, evaluation of an adaptation's effects on a species will be based on existing studies of that species' habitat and behavior. The influence of a changing climate on the species may moot that data by shifting the species' range or otherwise altering its behavior.[140] At the least, effective environmental impact assessment in a warmer world will require frequent reevaluation of existing research to track the moving baseline.

Having evaluated the existing environmental problems facing the San Francisco Bay and Mississippi River Deltas and the complications added by climate change, Mark Meo contends that

> [i]n view of the multiple impacts associated with climate change, both [delta] cases demonstrate clearly the limited ability of each state and the federal government to respond effectively to ill-defined, cumulative, or synergistic effects. As complex social and natural systems, coastal regions and fragile systems, such as river deltas, will necessitate better integration of potential climate change effects with an assessment of remedial or protective actions.[141]

As Meo suggests, and this Article corroborates, that integration would be difficult, at least given our experience with environmental law to date. Existing institutions appear inadequate to respond to the qualitatively and quantitatively new challenges posed by climate change. Adaptation would call for the creation of new and unprecedented institutions that succeed precisely where thus far we have not: panoptic environmental planning.

B. Willingness to Respond

Even under the best of circumstances, the challenges of climate adaptation for the institutions of environmental law appear difficult to surmount. Yet unchecked climate change could also undermine the political will to create the new institutions needed in a warmer climate. Strong public support for environmental protection historically has been crucial to the formation and endurance of environmental law, but for several reasons that may not be immediately obvious, a warming climate and its dislocations could press that support thin. The environmental movement has been fairly successful in mobilizing and leveraging popular desire to protect the environmental status quo, but how might dramatic changes to that status quo affect public demand for environmental protection? This

139. Indeed, resource managers may be slow to recognize even the direct effects of climate change. *See* Riebsame, *supra* note 24, at 74.

140. *See* sources cited *supra* note 49.

141. Meo, *supra* note 75, at 90–91. More worrying, Meo's less-than-sanguine view was based on the less severe predictions of climate change prevailing in 1991.

section suggests that we may lose some of our appetite for environmental regulation, and more specifically for control of adaptation's environmental impacts, while the Earth we have previously tried to protect shifts beneath our feet.

The story of the development and durability of environmental law is one of the successful mobilization of a broad-based public constituency for environmental protection. Many commentators have argued that the genesis of the major federal environmental statutes is striking for the minor role played by interest-group politics. The birth of environmental law is said to have been a "republican moment" characterized by an efflorescence of other-regarding public deliberation and participation in politics, reflected in the widespread public participation in the first Earth Day in 1970.[142] To be sure, others have taken issue with this account.[143] Even assuming that environmental interest groups played an important role in the formation of early federal environmental statutes, that role depended on an undercurrent of strong public support for environmental protection.[144]

The now-entrenched environmental lobby remains heavily dependent for its success on continuing public demand for environmental protection.[145] During the 1980s, the environmental movement still lacked the fi-

142. *See* LAZARUS, *supra* note 102, at 43–44; Farber, *supra* note 7, at 65–67; *see also* E. Donald Elliott et al., *Toward a Theory of Statutory Evolution: The Federalization of Environmental Law*, 1 J.L. ECON. & ORG. 313, 319–21 (1985) (contending that environmental groups were largely absent from the formation of the early federal environmental statutes); Sunstein, *supra* note 119, at 243–45.

143. *See* Christopher H. Schroeder, *Rational Choice Versus Republican Moment—Explanations for Environmental Laws, 1969–73*, 9 DUKE ENVTL. L. & POL'Y F. 29 (1998) (arguing that public choice theory can explain the formation of both environmental interest groups and environmental law). There are certainly examples of interest groups shaping the early regulatory programs, such as the automobile industry's success in obtaining federal regulation that largely preempted state automobile standards in 1967, *see* Elliott et al., *supra* note 142, at 331, or the eastern coal industry's successful manipulation of the legislative history of the 1977 Clean Air Act Amendments to encourage EPA to adopt technology specification standards that would discourage fuel-switching to low-sulfur western coal, *see* ACKERMAN & HASSLER, *supra* note 109.

144. For example, in a classic story of the birth of environmental law, Ralph Nader manipulated a political contest between Richard Nixon and Edmund Muskie, both of whom sought to woo the environmental vote, by policing the politicians' credit-claiming in the development of the 1970 Clean Air Act Amendments. *See* JAMES E. KRIER & EDMUND URSIN, POLLUTION AND POLICY 203 (1977); Elliott et al., *supra* note 142, at 335–37. Nader threatened at one point that Muskie stood to lose his title of "Mr. Pollution Control" based on his failure to outdo Nixon's legislative proposal. *See* Elliott et al., *supra*, at 336; *see also* KRIER & URSIN, *supra*, at 180 (noting Nader's similar steps in the run-up to the Motor Vehicle Pollution Control Act of 1967). Lacking the pecuniary political resources available to industry, Nader wielded influence with a different political currency: the broad-based and growing public support for environmental protection. *See* Elliott et al., *supra*, at 335–37.

145. SAMUEL P. HAYS, A HISTORY OF ENVIRONMENTAL POLITICS SINCE 1945 196 (2000) ("The broad support for environmental objectives within the general public meant that, for the

nancial wherewithal of anti-regulatory interests, but its base of public support for environmental protection expanded in reaction to the Reagan administration's efforts to roll back environmental and natural resource protections.[146] Congress responded to this support by aggressively scrutinizing the Reagan administration's implementation of environmental and public lands law and by adopting new legislation that sharply limited administrative discretion, such as the Hazardous and Solid Waste Amendments (HSWA) of 1984.[147] Though Congress has since undergone a political realignment, critics of environmental law still find it difficult to make major inroads into the regimes built in the 1970s. Nearly all legislation that touches those regimes is strategically couched in terms of improving environmental quality.[148]

Whether because it is supported by a broad and diffuse public constituency or by interest groups that derive their power from such a constituency, public support for environmental protection is critical for the continued vitality of environmental law.[149] If that support wanes as the climate warms, adaptation will produce new and more severe environmental impacts just as the mechanisms needed to reduce those impacts become less available. Similarly, where we face a choice between competing adaptations with differing environmental consequences—assuming we have a real capacity to make those choices—declining public concern

environmental community, the main political support on which they could rely was the general public and the voters."); LAZARUS, *supra* note 102, at 247.

146. For example, membership in the Sierra Club expanded from 181,000 in 1980 to 630,000 in 1990. Christopher J. Bosso, *Seizing Back the Day: The Challenge to Environmental Activism in the 1990s*, *in* ENVIRONMENTAL POLICY IN THE 1990S 53, 62 tbl.3-1 (Norman J. Vig & Michael E. Kraft eds., 3d ed. 1997).

147. Hazardous and Solid Waste Amendments of 1984, Pub. L. No. 98-616, 98 Stat. 3221 (1984) (codified in scattered sections of 42 U.S.C.); *see also* LAZARUS, *supra* note 102, at 247. The so-called "land ban" enacted as part of HSWA prohibited all land disposal of hazardous waste unless EPA adopted disposal regulations by a specific date. *See* 42 U.S.C. § 6924(d), (e) (2006).

148. *See, e.g.*, Threatened and Endangered Species Recovery Act of 2005, H.R. 3824, 109th Cong. (as passed by House, Sept. 29, 2005) (amending the Endangered Species Act to, inter alia, eliminate critical habitat designations, narrow interagency consultation, and provide presidential waivers of the act for natural disasters); *see also* LAZARUS, *supra* note 102, at 248 (noting a Republican polling firm's advice that legislators should describe policy proposals in pro-environmental terms). Recent congressional efforts to roll back or carve exceptions from environmental statutes have also relied heavily on appropriations riders rather than amendments in stand-alone authorization legislation, in part because the former stand a better chance of flying beneath the public radar. *See* Lazarus, *supra* note 67, at 663–64.

149. I do not mean to propose a blandly mechanistic model of policy formation in which policy makers are robotic maximizers of political support who lack any independent ideological or philosophical commitments that might favor environmental protection. Nevertheless, I think it safe to assume that a widespread decline in public support for environmental protection would be reflected in a similar shift in the personal attitudes of many policy makers.

for environmental values would encourage selection of the least expensive (excluding environmental costs), but more destructive, adaptations.

Although little research has addressed the potential attitudinal and psychological effects of climate change, and none has considered its effects on policy-relevant attitudes, we should not expect public attitudes toward environmental protection to remain static in the face of potentially dramatic exogenous environmental change. As Paul Stern notes in the only available work on the "psychological dimensions" of climate change, "Global changes that result in environmental catastrophes (more frequent floods, droughts, or storms, for example) will create stress on individuals and communities."[150] Such catastrophes are only one aspect of the likely attitudinal changes effected by climate change and its primary environmental consequences.

These changes have public policy ramifications. There is little reason to believe that environmental law's "republican moments" are a ratchet that can only produce improvements in or maintenance of environmental quality. The kind of civic engagement that has supported new and sustained environmental initiatives might as easily support the large-scale, environmentally destructive public endeavors that adaptation might produce. For example, in a warmer republican moment, a civic-minded public might agree to absorb the costs, fiscal and environmental, of massive new infrastructure projects to compensate for climate-induced threats to western water supply or to protect the Gulf Coast from hurricanes intensified by climate change. The public-spiritedness thought to motivate support for environmental law may, in a different setting, produce quite different results.

Imagining public attitudes toward environmental protection decades hence, and in the unfamiliar world of a warmer climate, is inherently speculative, but several factors suggest that public support for environmental law could recede. First, to the extent that some environmental attitudes are based on personal relationships with the natural world,[151] climate change would alter those attitudes by changing the underlying relationships. That may include altering existing attitudes of those who experience change over their lifetimes, but perhaps more importantly,

150. Paul C. Stern, *Psychological Dimensions of Global Environmental Change*, 43 ANN. REV. PSYCHOL. 269, 295 (1992). Stern devotes only a single paragraph to "individual response to environmental stressors" in the context of climate change and even then does not address the potential ramifications for policy-relevant attitudes. *Id.* Lacking a literature directly on point, the discussion that follows extrapolates from broader theories about public environmental concern.

151. *See* SAMUEL P. HAYS, *Three Decades of Environmental Politics: The Historical Context*, *in* EXPLORATIONS IN ENVIRONMENTAL HISTORY: ESSAYS BY SAMUEL P. HAYS 334, 344 (1998); LAZARUS, *supra* note 102, at 223; Doremus, *supra* note 10, at 244–49.

preventing the formation of such attitudes in future generations born in a warmer world.

One such relationship likely to be affected is winter outdoor recreation. According to a ski industry association, in the 2004–2005 season, ski resorts nationwide received an estimated fifty-seven million visits from skiers and snowboarders.[152] Recall that temperature increases are expected to substantially reduce snowpack in the western states: in the Sierra Nevada, for example, temperature increases at the high end of the projected range are likely to reduce the snowpack by up to 90 percent by the end of the century.[153] Such reductions would nearly eliminate popular winter activities, and even "in lower temperature scenarios the ski season could shorten by as much as a month."[154] A ski resort is hardly a pristine ecosystem, but the visitation statistic shows that outdoor winter recreation gives millions of people an opportunity to interact with the natural environment, an opportunity that would be severely degraded under an adaptation-preferring climate regime. One can imagine a variety of other examples of changing conditions in a warming environment, such as the loss of beaches to rising seas or the extinction of or severe changes in the distribution of "charismatic megafauna," that threaten our established personal relationships with the natural world.[155]

Second, public support for environmental protection might decline insofar as the public comes to view the environment as hostile or dangerous.[156] Several of the primary climate effects described above in Part I could produce such a perception: increasing ferocity of storms, more flooding from winter runoff, new pest infestations, new prevalence of dangerous diseases, and rising tides inundating coastal communities. In describing the psychological effects of environmental disasters, Michael

152. *See* Nat'l Ski Areas Ass'n, Estimated U.S. Ski Industry Skier Visits by Region, http://www.nsaa.org/nsaa/press/historical-visits.pdf (last visited Dec. 25, 2006).

153. *See supra* note 16 and accompanying text. The ski industry unsurprisingly has been an early advocate for a mitigation-preferring climate policy. *See, e.g.*, Brief of Aspen Ski Corp. as Amicus Curiae in Support of Petitioners, Massachusetts v. EPA, No. 05-1120 (S. Ct. Aug. 31, 2006), 2006 WL 2563381; Nat'l Ski Areas Ass'n, Climate Change, http://www.nsaa.org/nsaa/environment/climate_change/ (last visited Dec. 25, 2006) (noting that the industry association supports "[a]dvocat[ing] the national reduction of GHG emissions through legislative, regulatory or voluntary measures").

154. CCAT, *supra* note 3, at 29.

155. *See* HAYS, *supra* note 151, at 344 ("Especially significant in extending an interest in natural environments was the growing appreciative interest in wildlife"). In some circumstances, of course, shifting species populations may allow people to develop new relationships with wildlife. Nevertheless, the reduction in biodiversity likely to accompany climate change suggests that on the whole the result is likely to be negative. *See* IPCC, BIODIVERSITY, *supra* note 100, at 1–2; Jay R. Malcolm et al., *Global Warming and Extinctions of Endemic Species from Biodiversity Hotspots*, 20 CONSERVATION BIOLOGY 538 (2006).

156. *See* Doremus, *supra* note 10, at 246 & n.42 (suggesting that experience of the natural world as threatening may hamper development of environmental concern).

Edelstein identifies an "inversion of the environment," in which "the former assumption of a benign backdrop to human activity is reversed" and through which affected individuals develop "a distrust or general suspicion of the environment as harboring danger."[157]

Just as anthropogenic environmental disasters traditionally have catalyzed public support of environmental protection,[158] disasters caused by climate change might precipitate a view of the natural world as hostile and thereby prompt public demands for control of the environment through aggressive climate adaptation. Indeed, environmental protection has often been quickly shunted aside in a disaster's wake. Environmental law incorporates many exemptions for disaster response and other emergencies, which recently have been applied to bypass environmental regulation in the response to the 9/11 and Hurricane Katrina disasters.[159] Beyond application of de jure exemptions, these disasters also produced de facto exemptions, as disaster response and recovery efforts simply ignored environmental restrictions.[160] Such disasters are also cited to justify further de jure exemptions: a flurry of federal legislation was introduced after Hurricane Katrina that would carve new exemptions from federal environmental statutes.[161] A string of Katrinas linked to climate change might easily result in broad support for limiting environmental law mandates in the name of rebuilding and adaptation.

The notion of the natural world as hostile is inconsistent with several of the attitudes that undergird support for environmental protection, including views of the environment as an amenity or as important for public health.[162] The perception of a hostile environment may undercut anthropocentric justifications for environmental protection, *viz.*, justifications

157. *See* Michael R. Edelstein, *Contamination: The Invisible Built Environment*, *in* HANDBOOK OF ENVIRONMENTAL PSYCHOLOGY 559, 574 (Robert B. Bechtel & Arza Churchman eds., 2002); *see also supra* note 150 and accompanying text.

158. The examples are infamous and numerous, including Love Canal, the Cuyahoga River fire, the Santa Barbara oil spill, Bhopal, and the Exxon Valdez spill. *See, e.g.*, ANDREW SZASZ, ECOPOPULISM 51–56, 64–65 (1994) (describing the Love Canal hazardous waste debacle in the late 1970s as motivating the enactment of CERCLA in 1980); Jonathan H. Adler, *Fables of the Cuyahoga: Reconstructing a History of Environmental Protection*, 14 FORDHAM ENVTL. L.J. 89 (2002) (describing the 1969 Cuyahoga River fire and subsequent support for the Clean Water Act).

159. *See* Michael Davis et al., *Environmental Protection After a Disaster: A Right or a Privilege?*, 20 NAT. RESOURCES & ENV'T 15, 15 (2006); Michael B. Gerrard, *Emergency Exemptions from Environmental Laws After Disasters*, 20 NAT. RESOURCES & ENV'T 10, 10–11, 14 (2006).

160. *See* Gerrard, *supra* note 159, at 10–11.

161. *Id.* at 14.

162. *See* SAMUEL P. HAYS, BEAUTY, HEALTH, AND PERMANENCE: ENVIRONMENTAL POLITICS IN THE UNITED STATES, 1955–1985, at 22–26 (1987).

based on protecting oneself or other humans.[163] A view of nature as hostile and requiring control rather than protection would not be new, of course; it was a widespread attitude toward uncultivated nature prior to the advent of the conservation and environmental movements.[164] If a changing climate could reinvigorate that view, the public might be less likely to demand restrictions on adaptation in the name of protecting a hostile environment.

Third, the bare fact of environmental change—that our environmental baseline will continuously shift as the climate warms—may itself undermine support for environmental law. Research in cognitive psychology and behavioral economics suggests public support for environmental protection is based in part on an endowment effect that presumes a static status quo from which we are reluctant to depart.[165] Significant climate-induced shifts in the environmental status quo might undermine the public's sense of the environment *qua* endowment, as one might well have difficulty developing a firm sense of entitlement to a constantly shifting state of affairs. Experimental research has confirmed that the magnitude of an endowment effect in an object is correlated with the duration of ownership.[166] We might extrapolate from that result to hypothesize that the magnitude of an endowment effect in the existing environment varies with the duration of that environmental state.[167]

Furthermore, to the extent the public views a changing environment as a threat to the status quo, unrestrained climate adaptation might in fact *benefit* from an endowment effect. That is, the public may come to view the cultural and economic status quo as a more important "endowment" and therefore value aggressive adaptation over protection of the environment from adaptation's effects. Opponents of environmental regulation of adaptive measures could be expected to exploit the threat of cli-

163. Environmental psychologists have identified a tripartite typology of motivations for individuals' support for environmental protection comprised of "egoistic," "altruistic," and "biospheric" motivations. *See* P. Wesley Schultz, *Empathizing with Nature: The Effects of Perspective Taking on Concern for Environmental Issues*, 56 J. SOC. ISSUES 391, 393 (2000) (citing Paul C. Stern & Thomas Dietz, *The Value Basis of Environmental Concern*, 50 J. SOC. ISSUES 65 (1994)).

164. *See, e.g.*, RODERICK NASH, WILDERNESS AND THE AMERICAN MIND 23–43 (3d ed. 1982).

165. *See* Farber, *supra* note 7, at 74; Sunstein, *supra* note 119, at 224, 231. "Endowment effect," "status quo bias," and "loss aversion" are all used more or less synonymously to refer to the phenomenon of weighting losses more heavily than foregone gains. *See generally* Daniel Kahneman et al., *Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias*, 5 J. ECON. PERSP. 193 (1991).

166. *See* Michal A. Strahilevitz & George Loewenstein, *The Effect of Ownership History on the Valuation of Objects*, 25 J. CONSUMER RES. 276, 276, 285 (1998).

167. *Cf. id.* at 286 (suggesting that their study's findings about endowment effects in ownership of objects may "also apply to nonobject endowments, such as romantic attachments and academic success").

mate-induced dislocations in deeply rooted economic and cultural activities to mobilize support for unconstrained adaptation.[168] In that event, public demand for protection of environmental values from adaptation's impacts would decline, and the public might be mobilized to support unconstrained, aggressive adaptation.

To make matters worse, severe environmental changes caused by climate change may produce feedback effects that reinforce declining public support for environmental protection. Cass Sunstein has hypothesized that public preferences for environmental protection are adaptive to existing environmental conditions, a variant of the endowment effect.[169] He suggests that residents of degraded environments may undervalue environmental quality, because, among other reasons, they adapt their preferences to the degraded baseline condition.[170] He also suggests that such adaptive preferences for environmental quality may produce an increase in support for environmental protection over time as environmental conditions improve.[171] If he is correct about adaptive preferences, then *reductions* in environmental quality over time may also reinforce declining support for environmental protection. Primary climate-induced impairment of environmental quality, such as the increased severity and frequency of smog caused by rising temperatures or the loss of charismatic species, thus may itself reduce demand for environmental protection.

Studies in environmental psychology suggest an additional feedback effect. They have found that both acute and chronic exposure to uncontrollable environmental stress can induce a "learned helplessness" or apathetic pessimism that causes the affected individuals to underestimate prospects for improvement.[172] If learned helplessness manifests in political attitudes and behaviors, climate-induced environmental stress might prevent mobilization of affected individuals to support environmental protection. Although the studies apparently have not specifically evalu-

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168. *See* Sunstein, *supra* note 119, at 231 (noting that political actors attempt to exploit endowment effects by opportunistically characterizing the status quo).

169. *Id.* at 236–37.

170. *Id.* at 236. There is some reason for skepticism about this argument, however. Support for environmental protection is typically strongest among urban residents living in degraded environmental conditions. *See, e.g.*, HAYS, *supra* note 162, at 71. Moreover, the environmental justice movement, which has emerged most forcefully since Sunstein's article, shows that residents of low-income and marginalized communities, often in the most degraded of urban environments, can be very much concerned about environmental quality. *See* Evan J. Ringquist, *Environmental Justice: Normative Concerns and Empirical Evidence*, *in* ENVIRONMENTAL POLICY IN THE 1990S, *supra* note 146, at 231.

171. Sunstein, *supra* note 119, at 237.

172. *See* Gary W. Evans & Rachel Stecker, *Motivational Consequences of Environmental Stress*, 24 J. ENVTL. PSYCHOL. 143 (2004) (literature review of studies involving environmental stressors including noise, crowding, and pollution); *see also* Edelstein, *supra* note 157, at 569–70 (describing "loss of control" as a psychological response to environmental disasters).

ated the motivational effects of environmental stressors on political attitudes and behavior, they do suggest that a wide range of behaviors are affected, including behaviors not directly related to the stressor.[173]

The psychological phenomena of adaptive preferences and learned helplessness suggest that declining public concern for environmental protection might be subject to feedback effects that could cause public support to plummet. The more altered conditions become, the less the public will care to protect the environment (adaptive preferences) and the less they will believe that anything can be done to stem the loss (learned helplessness). Add to this the vulnerability of public opinion to "cascades," in which a change has rapid ripple effects throughout the population,[174] and declining public concern might become a runaway train. At some point, the public might perceive environmental conditions to be so altered or degraded that protection is deemed a lost cause. At that point, public support for maintenance or improvement of environmental quality would evaporate and with it the prospect for sustained or strengthened environmental law to mitigate the impacts of adaptation.

Finally, the primary environmental effects of climate change may undermine the "republican moments" important for environmental policy formation by undermining confidence in the public institutions responsible for environmental protection. As Michael Edelstein describes, people affected by environmental disasters can lose trust in government based on frustrated expectations that government will bear responsibility for preventing or ameliorating those disasters.[175] Particularly to the extent that the public perceives severe climate-induced effects, such as strong storms and floods, to be anthropogenic and thus amenable to prevention by appropriate government action,[176] affected individuals may lose trust in government institutions and withhold their participation in or support for the development of public mechanisms to moderate adaptation's effects.

To be sure, support for environmental law rooted in narrowly anthropocentric concerns might well survive unchecked climatic warming. To the extent the public views components of environmental law as protecting human health, it might continue to support at least those components. Yet the frequently obscure causal connections between environ-

173. *See* Evans & Stecker, *supra* note 172, at 160–63.

174. *See* Sunstein, *supra* note 119, at 240–41 (noting that "mass behavior is . . . fragile in the sense that small shocks can frequently lead to large shifts in behavior" (internal quotation marks omitted)).

175. *See* Edelstein, *supra* note 157, at 576–77; *see also* Davis et al., *supra* note 159, at 15 ("In the wake of disasters, both natural and otherwise, those affected look to their government for assistance and support.").

176. *See* Edelstein, *supra* note 157, at 576.

mental harm and human health will have difficulty competing with the immediate and tangible consequences of environmental disasters that unchecked climate change could cause.[177] And health concerns will not justify the protection of natural resources and systems, such as species habitat, which have only the most inscrutable or remote connections to public health.

In addition to its direct effects on adoption, maintenance, and implementation of environmental law, declining public support for environmental protection could undermine environmental law indirectly by reducing voluntary regulatory compliance, or over-compliance, and increasing the burden on enforcement. Legal rules and their attendant threat of legal sanctions for noncompliance are not the only factors motivating regulated entities to reduce their impact on the environment. Studies of regulated firms' environmental practices reveal that informal social norms can prevent firms from shirking compliance with formal legal rules and inspire actions that go "beyond compliance."[178] These norms comprise a "social license" that supplements a firm's formal regulatory permits and mobilizes informal community monitoring of compliance. The root of the social license is the firm's need to accommodate community concerns about its treatment of the environment, preserve its reputation with consumers, and streamline its relationships with government regulators.[179] To the extent that firms feel a need to comply with the social license, declining public concern about environmental harm would result in less compliance and beyond-compliance behavior and thus reduced protection from both existing environmental threats and the new impacts of climate adaptation.[180]

Moreover, unabated climate change would undercut the social license's beneficial effect of reducing the cost of enforcing environmental

177. *See supra* notes 159–61 and accompanying text (describing avoidance of environmental regulation in the wake of 9/11 and Hurricane Katrina).

178. *See, e.g.*, NEIL GUNNINGHAM ET AL., SHADES OF GREEN: BUSINESS, REGULATION, AND ENVIRONMENT (2003); Neil Gunningham et al., *Social License and Environmental Protection: Why Businesses Go Beyond Compliance*, 29 L. & SOC. INQUIRY 307 (2004).

179. *See* Gunningham et al., *Social License*, *supra* note 178, at 319–20. The power of the social license should not be overstated. Neil Gunningham, Robert Kagan, and Dorothy Thornton describe limits on the social license imposed by the "economic license," which include the marketplace constraints of preserving profitability, attracting capital, etc. *See* GUNNINGHAM ET AL., SHADES OF GREEN, *supra* note 178, at 60–61. They point out disjunctions between the social license and formal regulatory licenses, as affected communities may prioritize perceptible harms, such as odors and visible pollutants, over invisible but possibly more severe harms. *See id.* at 56–58.

180. Declining support for environmental protection among the general public would presumably be accompanied by a similar erosion of firm managers' internalized environmental norms, which some argue are an important motivating factor for firms' voluntary compliance with environmental law. *See* GUNNINGHAM ET AL., SHADES OF GREEN, *supra* note 178, at 28 (describing literature on the influence of managerial attitudes).

law. Because firms find constraint in informal community norms, they comply voluntarily with the overlapping dictates of formal environmental law.[181] Communities may also adopt a more formal role in enforcement by monitoring and reporting firms' behavior or bringing citizen enforcement actions. Administrative enforcement is costly, and thus regulators may take advantage of the space created for them by the social license to reduce the frequency and stringency of resource-intensive compliance monitoring and enforcement actions. Without the assistance of the social license and informal community enforcement, regulators would be forced to either accept an increase in noncompliance or augment compliance monitoring and take more formal and aggressive actions against violating firms.[182] The necessary expansion of formal enforcement would greatly increase the expense of implementing environmental law by increasing the regulatory agency's procedural obligations to the violating firm and giving the firm both the opportunity and incentive to challenge the penalty in litigation.[183] It is likely, then, that the loss of the social license would cause greater noncompliance.

Diminished public support for environmental protection and the resulting diminution in the power of the social license would also narrow the range of tools available to regulators. Information-based regulation, for example, would lose most of its force once environmental protection has lost its salience. The theory behind programs such as the Toxics Release Inventory[184] or California's Proposition 65,[185] which require dissemination of information about firms' environmental risks, is that firms concerned about their public reputations will reduce their responsibility for environmental risks when they become public. Some commentators see such tools as the "next generation" of environmental policy,[186] but they cannot function effectively unless consumers are troubled enough by the

181. *See* GUNNINGHAM ET AL., SHADES OF GREEN, *supra* note 178, at 56; Gunningham et al., *Social License*, *supra* note 178, at 319–24.

182. As it stands, most enforcement of environmental law is highly informal and stops far short of monetary penalties. *See* Matthew D. Zinn, *Policing Environmental Regulatory Enforcement: Cooperation, Capture, and Citizen Suits*, 21 STAN. ENVTL. L.J. 81, 90–95 (2002). Stronger sanctions for noncompliance, such as imposing or increasing monetary penalties, may offset somewhat the reduction in the informal enforcement attributable to the social license without a substantial increase in formal compliance monitoring. Putting aside the social license, for a rational profit-maximizing firm, an increase in the penalty for noncompliance can theoretically offset a decrease in the likelihood of enforcement by raising the expected enforcement cost of noncompliance. *See id.* at 96–97 & n.50. There are limits to environmental enforcers' ability to ratchet up the stringency of penalties, however. *See id.* at 97 n.50.

183. *See id.* at 99.

184. 42 U.S.C. § 11023 (2006).

185. CAL. HEALTH & SAFETY CODE § 25249.5–.13 (2006).

186. *See, e.g.*, Daniel J. Fiorino, *Rethinking Environmental Regulation: Perspectives on Law and Governance*, 23 HARV. ENVTL. L. REV. 441, 467 (1999).

resulting information to take responsive action, such as purchasing a competing brand with fewer environmental costs.

If positive environmental law cannot ameliorate the impacts of adaptation to a warmer world, might the common law step into the breach? Some have called for increased reliance on common law judicial "regulation" to supplement or supplant positive environmental law.[187] As it turns out, state and private actors have begun to look back to tort law to compensate for federal inaction on climate change mitigation,[188] relying on the twentieth-century cases brought under the federal common law of interstate nuisance,[189] such as *Missouri v. Illinois*[190] and *Georgia v. Tennessee Copper Co.*[191]

Yet a move to common law "regulation" is unlikely to gain traction where public support for environmental protection has broadly abated. Although the common law of tort and property and cognate fields such as the public trust doctrine have shown historical malleability, those institutions have evolved over time to *reflect* evolving cultural norms.[192] Undoubtedly the conservatism of common law decision making means that any ecological concerns currently built into those doctrines, such as the public trust, would persist for some time. Nevertheless, one can hardly expect the common law, over the long term, to buck the cultural trend and *expand* its solicitude for protection of environmental values in the face of declining public concern.

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In sum, even assuming we could choose intelligently among adaptations based on their environmental costs or take steps to moderate those costs, there are several reasons to think that environmental law would not keep pace with unchecked climate change. Decisions about the balance of

187. *See, e.g.*, Jonathan H. Adler, *Free & Green: A New Approach to Environmental Protection*, 24 HARV. J.L. & PUB. POL'Y 653 (2001).

188. A coalition of states, land trusts, and environmental groups have sued the top ten emitters of carbon dioxide in the United States (all electrical power plants) on the theory that their emissions, and derivatively their contributions to climate change, constitute an interstate public nuisance. *See* Connecticut v. Am. Elec. Power Co., 406 F. Supp. 2d 265 (S.D.N.Y. 2005). The district court dismissed the suit on the theory that it presented a nonjusticiable political question, *id.* at 271–74, and the case is presently on appeal to the Second Circuit. More recently, California sued automakers alleging that their products' greenhouse gas emissions constituted a nuisance. *See* Complaint for Damages and Declaratory Judgment, California *ex rel.* Lockyer v. Gen. Motors Corp., No. C06-05755 (N.D. Cal. Sept. 20, 2006).

189. *See Am. Elec. Power*, 406 F. Supp. 2d at 268, 272 n.9.

190. 200 U.S. 496 (1906).

191. 206 U.S. 230 (1907).

192. *See, e.g.*, Joseph L. Sax, *Property Rights and the Economy of Nature: Understanding* Lucas v. South Carolina Coastal Council, 45 STAN. L. REV. 1433, 1446–49 (1993).

mitigation and adaptation that we should strike must take into account the potential environmental costs of adaptation and consciously acknowledge the risk that those costs will not be avoided. We cannot uncritically assume that past successes with environmental law, such as they are, would be repeated in a warmer climate.

CONCLUSION

This Article has presented a dystopian view of the prospects for environmental protection in the warmer world created by a strongly adaptation-preferring climate policy, that is, by a refusal to mitigate climate change. As adaptation makes robust environmental law more necessary, it also makes it less likely. This vicious circle raises the stakes for the debate about the balance of mitigation and adaptation by adding to the debit side of the adaptation ledger its potentially severe, and likely unabated, environmental costs.

Happily, this vision may not be realized, as a groundswell of support for climate change mitigation appears to be rising. In fact, the threat of climate change has the potential to create just the kind of new "republican moment" in support of a mitigation-preferring policy that is unlikely to develop under an adaptation regime. Public concern about climate change is growing rapidly, as new information shows the effects of climate change occurring sooner and more severely.[193]

This increasing public concern accompanies a proliferation of state, and even local, experiments with public policies to reduce greenhouse gas emissions.[194] To name only a few, these initiatives include the following: a comprehensive greenhouse gas emission cap in California,[195] a cap-and-trade program for major utilities' emissions of carbon dioxide in nine Northeast and Mid-Atlantic states,[196] emissions standards for automobile

193. *See Seeing the Problem, Not the Solution*, TIME, Apr. 3, 2006, at 41 (reporting results of a *Time*/ABC News/Stanford University poll); OPINION RESEARCH CORP., GLOBAL WARMING & ALTERNATIVE ENERGY: A LEADERSHIP SURVEY (Mar. 15, 2006), *available at* http://www.resultsforamerica.org/calendar/files/R%20CSI%20Global%20Warming%20Leadership%20Survey%20final.pdf.

194. *See, e.g.*, BARRY G. RABE, STATEHOUSE AND GREENHOUSE: THE EMERGING POLITICS OF AMERICAN CLIMATE CHANGE POLICY (2004); Kirsten H. Engel, *Mitigating Global Climate Change in the United States: A Regional Approach*, 14 N.Y.U. ENVTL. L.J. 54 (2005); Robert B. McKinstry, Jr., *Laboratories for Local Solutions for Global Problems: State, Local and Private Leadership in Developing Strategies to Mitigate the Causes and Effects of Climate Change*, 12 PENN. ST. ENVTL. L. REV. 15 (2004).

195. *See* California Global Warming Solutions Act of 2006, CAL. HEALTH & SAFETY CODE §§ 38500–38599 (2006).

196. *See* Regional Greenhouse Gas Initiative, About RGGI, http://www.rggi.org/about.htm (last visited Dec. 25, 2006).

emissions of greenhouse gases in California and ten follow-on states,[197] state executive orders setting aggressive targets for greenhouse gas reductions,[198] and renewable energy portfolio standards for regulated utilities in a host of states.[199] Several states have also adopted a litigation strategy including lawsuits against large greenhouse gas emitters and the federal EPA, which has refused to regulate greenhouse gas emissions.[200] Although the leaders in these efforts are mainly the same states that took a leadership role in an earlier era of environmental law, the initiatives are to some extent spreading across the political map.[201]

Moreover, as state efforts proliferate and diversify into a "patchwork" of varying regulatory requirements, pressure builds on state-regulated and potentially regulated firms to support preemptive federal regulation to impose uniformity and level the national playing field.[202] Indeed, the state regulatory landscape is beginning to look very much like that of the 1960s and 1970s, when a diversity of state programs precipi-

197. *See* CAL. HEALTH & SAFETY CODE § 43018.5 (2006). "Connecticut, New Jersey, New York, Maine, Massachusetts, Vermont, Rhode Island, Washington, Oregon, and Pennsylvania have adopted or are considering adoption of California's vehicle emissions standards." *States Taking Action on Climate*, ENVIRONMENTAL DEFENSE, Sept. 12, 2006, http://www.environmentaldefense.org/article.cfm?contentid=4889.

198. *See, e.g.*, Cal. Exec. Order No. S-3-05 (June 1, 2005); N.M. Exec. Order No. 05-033 (June 9, 2005).

199. *See* RABE, *supra* note 194, at 52–53. Renewable portfolio standards require that regulated utilities derive a specified share of their electricity from renewable sources.

200. *See* Massachusetts v. EPA, --- S.Ct. ----, 2007 WL 957332 (Apr. 2, 2007) (upholding a challenge to EPA's denial of a petition requesting that EPA regulate mobile source emissions of greenhouse gases under the Clean Air Act); Petition for Review, New York v. EPA, No. 06-1148 (D.C. Cir. Apr. 26, 2006) (challenging EPA's refusal to establish a limit for carbon dioxide emissions as part of the new source performance standard for power plants under the Clean Air Act), *available at* http://www.oag.state.ny.us/press/2006/apr/ Petition_for_Review.pdf. On the suits against greenhouse gas emitters, see *supra* note 188.

201. For example, Texas, a state not typically associated with leadership in environmental policy, has adopted a renewable portfolio standard, requiring 3 percent of electricity used by regulated utilities to come from renewable sources by 2009. *See* RABE, *supra* note 194, at 53.

202. *See, e.g.*, *Advanced Technology Needed Faster to Reduce Greenhouse Gases: Execs*, PLATT'S COAL OUTLOOK, June 13, 2005, at 12 ("Executives also noted that stumbling blocks to GHG reduction in the United States included the patchwork of different rules developing among the states because the federal government hasn't developed clear rules."); Miguel Bustillo, *A Shift to Green*, L.A. TIMES, June 12, 2005, at C1 ("In addition, some companies fear that in the absence of federal action, many cities and states, which already are proposing their own regulations, will create a hodgepodge of compliance standards across the country."); John Carey & Sarah R. Shapiro, *Global Warming*, BUS. WK., Aug. 16, 2004, at 60 ("[A]s states jump in with their own patchwork of rules, execs are beginning to say that it may be time to push for uniform national limits."); Paul Nowell, *Duke Energy CEO Proposes Carbon Tax*, SFGATE.COM, Apr. 7, 2005, http://sfgate.com/cgi-bin/article.cgi?f=/n/a/2005/04/07/financial/f081527D92.DTL (quoting Duke Energy CEO as saying "The worst scenario would be if all 50 states took separate actions and we have to comply with 50 different laws.").

tated the federalization of air and water quality regulation.[203] And Congress has begun to investigate and deliberate about the risks of climate change and potential mitigation,[204] and policy entrepreneurs with an eye on nationwide office have taken up climate change as an issue ripe for credit claiming and begun to offer competing proposals.[205]In fact, as this Article goes to press, the Supreme Court has just held upheld a challenge by several states and environmental groups to EPA's decision to refuse to regulate greenhouse gases under the mobile source provisions of the Clean Air Act.[206] Although the Court's decision does not guarantee that EPA will decide to regulate automobile emissions of greenhouse gases on remand, it certainly adds to the pressure on the agency to do so. That in turn puts pressure on the automobile industry to support comprehensive legislation to regulate greenhouse gas emissions to spread the regulatory burden to other carbon-intensive sectors of the economy.[207]

If realized, a mitigation-preferring climate policy is likely to replace the vicious circle of adaptation with a virtuous circle. Steps taken to moderate the severity of climate change not only reduce the need for adaptation and its environmental costs, but also produce side benefits in the form of improved environmental quality. Many climate change mitigation

203. *See* Elliott et al., *supra* note 142, at 331 (describing automobile industry pressure for preemptive federal regulation to avoid a patchwork of state regulations); *id.* at 327–28, 335–37 (describing competition between President Nixon and Sen. Muskie, competitors for the White House in 1968 and 1972, to claim credit for environmental legislation).

204. A notable example is the white paper and subsequent conference, produced by Senators Pete Domenici (R-NM) and Jeff Bingaman (D-NM) under the auspices of the Senate Committee on Energy and Natural Resources, about the optimal design of a cap-and-trade program for greenhouse gases. *See* SEN. PETE V. DOMENICI & SEN. JEFF BINGAMAN, DESIGN ELEMENTS OF A MANDATORY MARKET-BASED GREENHOUSE GAS REGULATORY SYSTEM (2006), *available at* http://energy.senate.gov/public/_files/ClimateChangeWhitePaper.doc; *see also*, *e.g.*, *Climate Change and Marine and Terrestrial Systems: Hearing Before the Subcomm. on Global Climate Change and Its Impacts of the S. Comm. on Commerce, Science and Transportation*, 109th Cong. (2006), 2006 WL 1111572; *Efforts to Reduce Greenhouse Gases: Hearing Before the S. Comm. on Environment and Public Works*, 109th Cong. (2005), 2005 WL 2462217. Since the November 2006 election, congressional interest in climate change mitigation has increased exponentially. *See* Felicity Barringer & Andrew C. Revkin, *Measures on Global Warming Move to Spotlight in the New Congress*, N.Y. TIMES, Jan. 18, 2007.

205. *See* Janet Hook & Richard Simon, *Climate Is Changing, Politically*, L.A. TIMES, Jan. 31, 2007 (noting that several candidates for the presidency in 2008 have sponsored or vocally supported federal climate legislation). Unlike in the natal period of environmental law, however, the current incumbent president is unable to run again and thus unsurprisingly has not joined the competition. *Cf.* sources cited *supra* note 203.

206. Massachusetts v. EPA, --- S.Ct. ----, 2007 WL 957332 (Apr. 2, 2007).

207. Indeed, in a statement following the Court's decision, Congressman John Dingell of Michigan, a staunch supporter of his state's flagship industry, stated that "[t]oday's ruling provides another compelling reason why Congress must enact, and the president must sign, comprehensive climate change legislation." Felicity Barringer, *Ruling Undermines Lawsuits Opposing Emissions Controls*, N.Y. TIMES, Apr. 3, 2007. Rep. Dingell was not previously a strong supporter of climate change mitigation. *See* Barringer & Revkin, *supra* note 204.

policies are environmental "no regrets" policies, such as those that reduce conventional pollutant emissions that accompany carbon dioxide emissions or protect natural carbon sinks through conservation of forest landscapes, afforestation, or reforestation.[208] Few mitigation policies are likely to have adverse environmental side effects.[209]

Opposition to a mitigation-preferring policy remains strong, of course.[210] Moreover, the mitigation-versus-adaptation framing of the climate debate is still too novel to project a winner. Its outcome might be very different from a debate framed by questions about whether climate change is real and whether it is anthropogenic. Nevertheless, the prospects for climate mitigation, and thus avoiding some of the worst consequences of climate change and adaptation, look promising.

Unfortunately, we have already come too far to cleanly dodge the blow of climate change. Some adaptation is inevitable—the question is how much. That choice should be informed by an accurate accounting of the full costs of adaptation.

208. *See* CCAT, *supra* note 3, at 48–50.

209. Exceptions exist, however. A switch to nuclear power, which does not produce greenhouse gases, would entail a variety of environmental costs.

210. *See Mandatory* CO_2 *Cuts Remain Uphill Fight Despite Supporters' Progress*, 17 Clean Air Rep. 4 (Inside Wash. Publishers) (June 1, 2006).