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Ecosystem Resilience to Disruptions Linked to Global Climate Change: An Adaptive Approach to Federal Land Management

Robert L. Glicksman
George Washington University Law School, rglicksman@law.gwu.edu

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* Robert W. Wagstaff Distinguished Professor of Law, University of Kansas; Member Scholar, Center for Progressive Reform. The author thanks Andrew Torrance, Margaret Giblin, and Townsend Peterson for helpful comments on earlier drafts, and Christopher Steadham, Faculty Services & Research Librarian, University of Kansas School of Law, for his valuable help in collecting many of the materials needed to write this Article. The author also thanks the Center for Progressive Reform and the University of Nebraska College of Law for co-hosting the conference at which the symposium papers in this volume were first presented. A condensed version of this Article will appear as a chapter in GLOBAL WARMING: A READER (William H. Rodgers, Jr. et al., forthcoming).

I. INTRODUCTION

The federal government has faced significant challenges in its efforts to protect from environmental harms the value of the lands and resources it owns and manages on behalf of the American people. Most of the threatened harms have resulted from activities occurring on the federal lands themselves (and either conducted or approved by federal land managers) or on state or private lands adjacent to federal holdings. Clearcutting has decimated areas of the national forests.[1] Overgrazing of the public rangelands has contributed to soil erosion and displacement of native vegetation by invasive species.[2] Mineral development has scarred landscapes and left thousands of abandoned mines on federal lands in its wake.[3] Off-road vehicle use has damaged landscapes and interfered with other forms of recreational use of the federal lands.[4]

These kinds of damage to federal lands and resources share at least two characteristics. First, they result primarily, if not entirely, from activities taking place on or near federal lands. Second, there is usually little difficulty in identifying the activities responsible for the harms or threatened harms of concern, although the government's authority to stop or limit those activities is often vigorously contested. Both characteristics make it relatively easy for the government to design strategies to reduce harm to federal lands and resources from the identified activities, assuming it has legal authority, adequate funds to exercise that authority, and the political will to act. Federal land

1. GEORGE CAMERON COGGINS ET AL., FEDERAL PUBLIC LAND AND RESOURCES LAW 691–92 (6th ed. 2007); Oliver A. Houck, *The Water, the Trees, and the Land: Three Nearly Forgotten Cases that Changed the American Landscape*, 70 TUL. L. REV. 2279, 2291–2300 (1996) (discussing W. Va. Div. of Izaak Walton League of Am. v. Butz, 522 F.2d 945 (4th Cir. 1975)).
2. Raymond B. Wrabley, Jr., *Cowboy Capitalism or Welfare Ranching? The Public Lands Grazing Policies of the Bush Administration*, 29 PUB. LAND & RESOURCES L. REV. 85, 91 (2008); *see generally* Debra L. Donahue, *The Western Range Revisited: Removing Livestock from Public Lands to Conserve Native Biodiversity*, *in* 5 LEGAL HISTORY OF NORTH AMERICA (Gordon Morris Bakken et al. eds., 1999).
3. *See* Paul Stokstad, *Structuring a Reclamation Program for Abandoned Noncoal Mines*, 25 ECOLOGY L.Q. 121, 126 (1998); 4 GEORGE CAMERON COGGINS & ROBERT L. GLICKSMAN, PUBLIC NATURAL RESOURCES LAW § 42:27 (2d ed. 2007).
4. *See* Norton v. S. Utah Wilderness Alliance, 542 U.S. 55 (2004) (litigation challenging the failure of the Bureau of Land Management to prevent impairment of wilderness study areas from off-road vehicle use); Sierra Club v. Clark, 756 F.2d 686 (9th Cir. 1985).

managers, however, now face a threat of relatively recent vintage—the threat to lands and resources posed by global climate change—which shares neither of these characteristics. Consequently, federal land management agencies face a sobering set of challenges as they seek to prevent resource impairment resulting from climate change.

The government's task in devising strategies to protect federal lands and resources from the adverse effects of climate change is likely to be more difficult than avoiding damage from activities such as clearcutting, grazing, mineral development, and off-road vehicle use. The government can restrict grazing on federal lands as a means of preventing soil erosion. It can limit the use of the most environmentally destructive timber harvesting practices or bar harvesting altogether in environmentally sensitive or vulnerable areas. It can restrict mineral exploration and development in ecologically important areas or condition the right to engage in those activities on compliance with pollution control and reclamation requirements. Climate change, however, is a global phenomenon. The location of a source that emits greenhouse gas ("GHG") emissions is irrelevant to its capacity to contribute to rising surface temperatures and the attendant consequences. GHG emissions from a Chinese coal-fired power plant will contribute to atmospheric conditions that result in early snowmelt in mountainous areas of a western U.S. national park to the same extent as a similar plant located near that park.[5]

As a result, most activities that contribute to climate change are beyond the control of the federal land management agencies (and those taking place in other countries are for the most part beyond the regulatory jurisdiction of the entire federal government). Even if the land management agencies were to completely eliminate all GHG emissions from activities on the federal lands, climate change would continue to harm those lands. It is therefore far from obvious what federal land managers can do (other than to preserve forested areas and other areas that serve effectively as carbon sinks) to protect the resources entrusted to their care from the unavoidable adverse effects of climate change. What is clear is that climate change presents daunting challenges to the federal government's ability to manage its lands and resources in ways that ensure that the priceless natural heritage that these land and resources comprise remains available in

5. This kind of impact concerns climate change on a global scale. Two additional kinds of climate change problems that may affect federal lands involve species movement and the nonlinear, cascading effects that one kind of effect linked to climate change may have (such as increased wildfires that may destroy the habitat of a species, whose disappearance may affect both its predators and its prey in that location). Townsend Peterson is responsible for differentiating these three kinds of climate change impacts for the author.

substantially unimpaired condition to both present and future generations of Americans.

One of the challenges results from the fact that the laws governing the activities of federal land management agencies, including the National Forest Service ("NFS"), the Bureau of Land Management ("BLM"), the National Park Service ("NPS"), and the Fish and Wildlife Service ("FWS"), have outlasted the scientific assumptions on which policymakers relied in enacting and implementing those laws. In particular, Congress adopted many of those laws at a time when scientists and natural resource management policymakers assumed that ecological systems tend toward a natural equilibrium.[6] Subsequently, the science of ecology experienced a "paradigm shift."[7] The discipline no longer views natural systems as being in equilibrium or moving toward it. Rather, "[t]he contemporary paradigm recognizes that ecosystems are open and not necessarily in equilibrium. It recognizes disturbances to be a natural and necessary part of ecosystems."[8] Further, it recognizes that disturbance is inevitable, and that natural resource management efforts that fail to consider the consequences of these disturbances, particularly potentially catastrophic ones, are not likely to succeed at preserving the affected resources in the long term.[9]

When this paradigm shift occurred, it should have become clear that natural resource management strategies based on the equilibrium paradigm were likely to be ill-suited to achieving their goals. Something different was needed. As one government report put it, "By transforming management and goal-setting approaches from a static, equilibrium view of the natural world to a highly dynamic, uncertain, and variable framework, major advances in managing for change can be made."[10] Under a dynamic approach, for example, resource managers would no longer be subject to the dictates of a land

6. *See* Fred P. Bosselman & A. Dan Tarlock, *The Influence of Ecological Science on American Law: An Introduction*, 69 CHI.-KENT L. REV. 847, 863–69 (1994) (discussing "equilibrium theory"). The National Forest Management Act (NFMA), 16 U.S.C. §§ 1600–1687, which governs management of the national forests, was adopted in 1976, as was the Federal Land Policy and Management Act (FLPMA), 43 U.S.C. §§ 1701–1785. Congress passed the Wilderness Act, 16 U.S.C. §§ 1131–1136, which governs management of wilderness areas across the entire spectrum of federal lands categories, in 1964.

7. Judy L. Meyer, *The Dance of Nature: New Concepts in Ecology*, 69 CHI.-KENT L. REV. 875, 877 (1994).

8. *Id*.

9. *Id*. at 878–79.

10. U.S. CLIMATE CHANGE SCIENCE PROGRAM & THE SUBCOMMITTEE ON GLOBAL CHANGE RESEARCH, PRELIMINARY REVIEW OF ADAPTATION OPTIONS FOR CLIMATE-SENSITIVE ECOSYSTEMS AND RESOURCES 9-5 (2008), *available at* http://www.climatescience.gov/Library/sap/sap4-4/final-report/sap4-4-final-report-Ch9-Synthesis.pdf [hereinafter ADAPTATION OPTIONS].

use plan set in stone upon adoption and subject to a cumbersome amendment process. Instead, they would manage by adaptation, changing management strategies on an ongoing basis in response to information on the effects of past strategies and on unexpected changes in natural systems resulting from largely unforeseen disturbances.[11]

A report issued in 2008 by the U.S. Climate Change Science Program illustrates the potential value of a dynamic approach in dealing with climate change, an environmental and natural resource management problem that is likely to dwarf any that the federal government has tackled to date. It calls on federal land managers to "reduce the risk of adverse environmental outcomes through activities that *increase the resilience* of ecological systems to climate change."[12] As the report noted, "Management of ecosystems for any objective will be made easier if the systems are resilient to change - whether it is climate change or any other disturbance."[13]

The symposium of which this Article is a part is devoted to exploration of the concept of resilience and its relevance to natural resource management law and policy. The symposium articles address resilience from a variety of perspectives, not all of which conceptualize resilience in the same way. This Article relies on the definitions of resilience provided by the Climate Change Science Program: "the ability of a system to return to its initial state and function in spite of some major perturbation,"[14] or "the amount of change or disturbance that a system can absorb *before it undergoes a fundamental shift* to a different set of processes and structures."[15]

11. There appears to be a tension between affording discretion to agencies to adapt land use management plans to changing circumstances and ensuring that agency decision-making is accountable. Thus, for example, challenges to land use plan provisions that do not bind subsequent site-specific plans are less likely to be justiciable than binding plan provisions. *Cf.* 36 C.F.R. § 219.3(b) (2008) (providing that Forests Service land and resource management plans do not create any legal rights); Norton v. S. Utah Wilderness Alliance, 542 U.S. 55, 71 (2004) (dismissing as non-justiciable a series of challenges to the Bureau of Land Management's management of off-road vehicle use on public lands, noting that "a land use plan is generally a statement of priorities; it guides and constrains actions, but does not (at least in the usual case) prescribe them"). *See generally* Alyson C. Flournoy, *Protecting a Natural Resource Legacy While Promoting Resilience: Can It Be Done?*, 87 NEB. L. REV. (2009).

12. ADAPTATION OPTIONS, *supra* note 10, at 9-16 (emphasis in original).

13. *Id*. The report provides an example: a resilient forest ecosystem would quickly re-establish plant cover after a major fire, without significant loss of soils or fertility. *Id*.

14. *Id*.

15. *Id*. (emphasis in original). *Cf*. Mona L. Hymel, *The Population Crisis: The Stork, the Plow, and the IRS*, 77 N.C. L. REV. 13, 29 n.93 (1998) ("Resilience is the capacity of an ecosystem to recover from shocks and stresses."). *See generally* C.S. HOLLING, ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (1978).

Calling on the federal land management agencies to act adaptively to increase the resilience of the lands and resources they manage as a means of minimizing the disruptive impacts of climate change, however, is potentially problematic. The laws from which these agencies derive their management authority often do not emphasize (and sometimes do not even appear to recognize the value of) resilience as a resource management or risk reduction strategy. That result is understandable in light of the prominence of the equilibrium paradigm at the time Congress enacted those laws. Indeed, it would not be surprising to find that the laws passed before the scientific paradigm shift create obstacles for agencies seeking to promote resource resilience through adaptive management. If the federal land management laws shackle the agencies in that manner, the agencies may lack the tools necessary for land and resource preservation in the face of the myriad disruptions anticipated to result from climate change.

This Article assesses the capability of the federal land management agencies under current law to deal with climate change and the threats it poses to federal lands and resources and to protect the incalculable value they contribute to society. Part II of the Article summarizes three categories of impacts climate change is having or is expected to have on federal lands and resources: physical, biological, and socio-economic. Part III expands on the scientific paradigm shift from an equilibrium to a disequilibrium model and the relevance of that shift to the importance of striving to achieve resilience as a resource management technique. It also describes the existing statutory framework under which the federal government manages its rich natural resource heritage and the extent to which that framework may authorize the land management agencies to anticipate and respond to climate change. In particular, it assesses whether the organic statutes of the land management agencies delegate to them sufficient authority to promote resilience in the natural resources they control. That discussion highlights deficiencies in the nature, scope, and implementation of existing legislation.

Part IV re-conceives the legal framework for managing the public lands. It makes ten general recommendations for changing either the statutes or the manner in which they are implemented to strengthen the capacity of the federal land management agencies to mitigate the impacts of climate change and avoid disruption or collapse of ecosystems in the face of it. The recommendations are designed to ensure that the land management agencies have ample authority to protect the resources for which they are responsible by managing them in an adaptive fashion, to promote ecosystem resilience and enhance their capacity to mitigate and adapt to climate change. Part IV also includes several examples of the kinds of protective measures that the recommendations will facilitate.

II. THE IMPACT OF CLIMATE CHANGE ON FEDERAL LANDS AND RESOURCES

Climate change is already affecting or is anticipated to affect the entire spectrum of ecosystems represented on the federal lands, including forests, fresh water and wetlands ecosystems, grass and shrublands, and coastal and marine environments. Climate change is linked to three categories of effects—physical, biological, and socio-economic—although in many instances the categories overlap and the effects in one category cause or result from effects in another.[16] This Part summarizes the principal ways in which we can expect global climate change to affect federal lands and resources.

A. Physical Effects

Anticipated changes in global weather patterns are likely to significantly alter the physical characteristics of federal lands and resources. One set of effects stems from changes in the timing, nature, and amount of precipitation and evaporation due to rising temperatures. According to the Intergovernmental Panel on Climate Change ("IPCC"), rising global temperatures are very likely to increase precipitation in high latitudes and decrease it in lower latitudes. Daily heavy rainfall events may increase, even in regions in which mean rain decreases. In the United States, annual mean precipitation is very likely to increase in the northeast but decrease in the southwest.[17] These changes will affect conditions on the federal lands, perhaps dramatically.

Rising temperatures have already caused noticeable changes in the western United States,[18] where some winter precipitation has shifted from snow to rain. During the past half century, temperature increases have produced smaller late fall and early spring snowpacks and earlier melting in the western mountains, such as the Cascades and Sierra Nevadas, often despite increases in total winter precipitation. Scientists have measured a fifteen to thirty percent reduction in

16. This tripartite characterization of the effects of global climate change is used in U.S. Gov't Accountability Office, *Climate Change: Agencies Should Develop Guidance for Addressing the Effects on Federal Land and Water Resources*, GAO-07-863 (2007), *available at* http://www.gao.gov/new.items/d07863.pdf [hereinafter GAO, *Climate Change*].

17. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS 91 (Susan Soloman et al. eds., 2007), *available at* http://www.ipcc.ch/ipccreports/ar4-wg1.htm.

18. Temperature changes are not likely to be uniform across all federal lands locations. Between 2004 and 2007, temperatures in the Colorado River Basin rose twice as fast as in the rest of the world. *See* Christa Marshall, *The Western U.S. Heats up Faster—Report*, CLIMATEWIRE, Mar. 28, 2008, *available at* http://www.eenews.net/cw/2008/03/28 (citing report by the National Oceanic and Atmospheric Administration).

April first snow water equivalent since 1950 in these areas.[19] Even under optimistic projections, snowpack will decline by thirty to seventy percent during the second half of the century in the Sierra Nevadas.[20] In addition, because snowmelt is occurring earlier, so is peak stream and river flow, causing dryer summers.[21] Studies have attributed as much as sixty percent of changes in river flows and snowpack in the western U.S. during the last fifty years to human-induced climate change.[22] Scientists predict that displacement of snow by rain and midwinter melting of snowpack caused by warmer winters in the mountainous west will increase winter flooding, which in turn will increase avalanches, soil erosion, sedimentation, and stream turbidity.[23] The flip side of the coin is that scientists predict a decrease in summer surface water flows and more extreme droughts, particularly in interior portions of the United States.[24] Groundwater levels may decline, reducing the flow of streams into which they feed.[25] Extreme weather events of all kinds are likely to increase. Scientists have confirmed what many people already perceive to be happening: the United States is experiencing one of the most intense periods of hurricane activity ever recorded.[26]

Another important phenomenon linked to climate change is glacial melting. The impact of climate change on glaciers and ice sheets is usually illustrated by the impact of rising surface air temperatures on

19. Kathleen A. Miller, *Climate Change and Water in the West: Complexities, Uncertainties, and Strategies for Adaptation*, 27 J. LAND, RESOURCES & ENVTL. L. 87, 88–89 (2007).

20. Joe Gertner, *The Future Is Drying Up*, N.Y. TIMES MAG., Oct. 21, 2007, at 68, 70. For a discussion of the effects of changing patterns of snowmelt due to climate change on hydrology in Washington, see Marketa M. Elsner et al., *Implications of 21st Century Climate Change for the Hydrology of Washington State*, *in*, WASHINGTON CLIMATE CHANGE IMPACTS ASSESSMENT (2009), *available at* http://cses.washington.edu/cig/res/ia/waccia.shtml.

21. Stephen Saunders et al., *Losing Ground: Western National Parks Endangered by Climate Disruption*, 24 GEORGE WRIGHT F. 41, 42 (2007); *see also* Miller, *supra* note 19, at 89 (stating that "seasonal peak streamflow in the snowmelt-dominated rivers of western North America was occurring 1–4 weeks earlier by 2002 than in 1948"); Frederic H. Wagner, *Global Warming Effects on Climatically-Imposed Ecological Gradients in the West*, 27 J. LAND, RESOURCES & ENVTL. L. 109, 114 (2007) (reduced spring runoff peaks in California are occurring one to three weeks earlier); Noaki Schwartz, *Climate Changes Expected to Transform California*, LAWRENCE J.-WORLD, Dec. 30, 2007, at 6A.

22. Tim P. Barnett et al., *Human-Induced Changes in the Hydrology of the Western United States*, 319 SCIENCE 1080 (2008).

23. GAO, *Climate Change*, *supra* note 16, at 21.

24. *See* Robin Kundis Craig, *Climate Change, Regulatory Fragmentation, and Water Triage*, 79 U. COLO. L. REV. 825, 880–81 (2008).

25. *Id*. at 881.

26. *U.S. Experiencing Worst Storms on Record—Analysis*, CLIMATEWIRE, Oct. 23, 2008, *available at* http://www.eenews.net/cw/2008/10/23.

the massive ice sheets in Greenland or Antarctica.[27] But the phenomenon is also occurring much closer to home. Climate change is already causing glaciers to melt in places such as Glacier National Park, where the estimated number of glaciers has fallen from 150 to twenty-six in the last century and a half. Some scientists predict that if temperatures continue to rise, all of the glaciers in the park will be gone within twenty-five to thirty years.[28] Significant glacial attrition also has occurred in North Cascades, Mount Rainier, and Yosemite National Parks and on federal lands in Alaska.[29]

Coastal areas will experience different water-related problems.[30] Rising temperatures are causing sea levels to rise, both because heated water expands and because they contribute to the melting of ice sheets in places such as Greenland and Antarctica.[31] National wildlife refuges in Maryland, Florida, Louisiana, and Channel Islands National Park off the California coast are among the areas that may be flooded.[32] Flooding may cause inundation and saltwater intrusion that destroy coastal wetlands and the freshwater ecosystems upon which freshwater aquatic species depend. If sea levels rise by two feet by the end of the twenty-first century, as the IPCC has projected, the lower Everglades in Florida will be inundated[33] and up to fifty percent of the Everglades' fresh water marsh will be transformed into a salt

27. *See, e.g.*, John Collins Rudolf, *The Warming of Greenland*, N.Y. TIMES, Jan. 16, 2007, at D1 (stating that Danish scientists have indicated that Greenland could be losing more that 80 cubic miles of ice each year, which is three times the volume of all the glaciers in the Alps); Juliet Eilperin, *Antarctic Ice Sheet Is Melting Rapidly; New Study Warns of Rising Sea Levels*, WASH. POST, Mar. 3, 2006, at A1; *cf.* Lauren Morello, *'Human Fingerprints' Evident as Arctic, Antarctic Warm*, CLIMATEWIRE, Oct. 31, 2008, *available at* http://www.earthportal.org/news/?p=1850 (describing evidence linking warming in the polar regions to human activity).

28. GAO, *Climate Change*, *supra* note 16, at 5, 18–19.

29. Saunders et al., *supra* note 21, at 43.

30. For a description of some of the areas of the United States at risk of inundation and erosion from rising sea levels, see James G. Titus & Charlie Richman, *Maps of Lands Vulnerable to Sea Level Rise: Modeled Elevations Along the U.S. Atlantic and Gulf Coasts*, 18 CLIMATE RES. 205 (2000).

31. *See* Robert L. Glicksman, *Global Climate Change and the Risks to Coastal Areas from Hurricanes and Rising Sea Levels: The Costs of Doing Nothing*, 52 LOY. L. REV. 1127, 1135–40 (2006).

32. *See* GAO, *Climate Change*, *supra* note 16, at 21–22; Saunders et al., *supra* note 21, at 63.

33. *See* FLORIDA STATE UNIV. CTR. FOR ECON. FORECASTING & ANALYSIS, CLIMATE CHANGE IN COASTAL AREAS IN FLORIDA: SEA LEVEL RISE ESTIMATION AND ECONOMIC ANALYSIS TO YEAR 2080, 2 (Julie Harrington & Todd L. Walton, Jr. eds., 2008), *available at* http://www.cefa.fsu.edu/uploaded%20current%20projects/FSU%208%2014%202008%20final.pdf.

water system.[34] Coastal flooding and associated wetlands losses also could destroy storm buffers in low-lying areas.[35]

The problem in some federal land locations will be too little water, instead of too much. Drought is a source of stress for many native plant species found on the federal lands. Drought conditions due to reduced precipitation and rising temperatures linked to climate change are already adversely affecting resources at locations as diverse as the Cerbat Mountains of Arizona (where old growth pinyon-juniper pine trees are dying), the Colorado Plateau (where shrubs such as cliffrose are disappearing), the northern portions of Yellowstone National Park (where droughts and wetlands desiccation have contributed to severe declines in amphibian species native to the Park),[36] and the Chugach National Forest (where lake levels have declined and former ponds have been transformed into grassy basins).[37] Scientists anticipate that droughts linked to climate change are likely to cause a decline in forage quality in places like Wyoming's rangelands.[38] When wet periods occur, invasive species such as annual grasses may fill gaps in native vegetation. These invasive species may be able to survive wildfires better than native species such as saguaro cacti and Joshua trees.[39] Among the areas most at risk of losing forests are Bandelier National Monument and Mesa Verde National Park.[40] Drought conditions have the potential to transform large expanses of woodlands into shrub or grasslands. According to the Government Accountability Office, "some rare ecosystems, such as alpine

34. Cornelia Dean, *The Preservation Predicament*, N.Y. TIMES, Jan. 29, 2008.

35. ALLIANZ GROUP & WORLD WILDLIFE FUND, CLIMATE CHANGE AND INSURANCE: AN AGENDA FOR ACTION IN THE UNITED STATES 16 (2006), *available at* http://www.worldwildlife.org/climate/Publications/WWFBinaryitem4913.pdf [hereinafter, ALLIANZ GROUP]; *see also* ELIZABETH A. STANTON & FRANCK ACKERMAN, FLORIDA AND CLIMATE CHANGE: THE COSTS OF INACTION 66, 68 (2007), *available at* http://www.ase.tufts.edu/gdae/Pubs/rp/Florida_hr.pdf.

36. *See* Sarah K. McMenamin et al., *Climactic Change and Wetland Desiccation Cause Amphibian Decline in Yellowstone National Park*, 105 PROC. NAT'L ACAD. SCI. 16988 (2008).

37. *See generally* Phillip J. van Mantgem et al., *Widespread Increase of Tree Mortality Rates in the Western United States*, 323 SCIENCE 521 (2009) (detailing impact of climate change on tree mortality in western old-growth forests); William S. Eubanks, II, *The Sugar Maple and the Regional Greenhouse Gas Initiative's Potential Solution*, 17 PENN. ST. ENVTL. L. REV. 81 (2008).

38. Eryn Gable, *Researchers Examine Global Warming's Effects on Wyo. Rangelands*, LAND LETTER, Sept. 18, 2008, *available at* http://www.eenews.net/Landletter/2008/09/18/2/.

39. GAO, *Climate Change*, *supra* note 16, at 27.

40. *See* Saunders et al., *supra* note 21, at 48 ("Sudden, widespread, climate-driven loss of forests is now occurring in the American Southwest, where semiarid conditions make even the hardy trees that can survive there susceptible to drought.")

tundra, California chaparral, and blue oak woodlands in California may become extinct altogether."[41]

Many of these changes have the potential to impair water quality. Severe storms following extended dry spells may accelerate soil erosion and sedimentation in lakes, rivers, and streams. In addition, reduced flow rates will increase concentrations of pollutants already in the water. Saltwater intrusion caused by coastal flooding could impair the quality of water that is essential to the survival of aquatic species or that is used for drinking. Climate change is also predicted to increase acidification of coastal and ocean ecosystems because increases in CO_2 concentrations result in decreased concentrations of carbonate ion in seawater. Falling carbonate ion concentrations, in turn, reduce the biocalcification rate in corals and other marine organisms. The result could be compromised coral reefs and other changes in ocean chemistry in places such as the Florida Keys National Marine Sanctuary.[42]

The increasingly arid conditions that exist in areas starved of precipitation, runoff, and summer flows will increase the risk of wildfires. "Summer increase heat strongly correlates with fire increase," and larger and more frequent wildfires, and longer wildfire seasons, have occurred since the 1980s in the west and southwest.[43] Increased wildfire activity in the northern Rockies is associated with increases in summer heat and earlier spring snowmelt.[44] In addition, warmer and drier conditions are likely to facilitate the spread of insect infestations that kill trees, creating more fuel for forest fires.[45] Wildfires increase, sometimes for long periods, the amounts of sediment, debris, heavy

41. GAO, *Climate Change*, *supra* note 16, at 26.

42. *See* UNITED NATIONS ENV'T PROGRAMME, IN DEAD WATER: MERGING OF CLIMATE CHANGE WITH POLLUTION OVER-HARVEST, AND INFESTATIONS IN THE WORLD'S FISHING GROUNDS 35–37 (Christian Nelleman et al. eds., 2008); GAO, *Climate Change*, *supra* note 16, at 22.

43. ALLIANZ GROUP, *supra* note 35, at 18; *see also* Sean P. Healey et al., *The Relative Impact of Harvest and Fire upon Landscape-Level Dynamics of Older Forests: Lessons from the Northwest Forest Plan*, 11 ECOSYSTEMS 1106 (2008) (describing correlations between increase in wildfire activity in forests of the Pacific Northwest and changing climate conditions).

44. ALLIANZ GROUP, *supra* note 35, at 17–18; *see also* Miller, *supra* note 19, at 89–90 (documenting "a sudden and marked increase in wildfire activity beginning in the mid 1980s" in places that include the northern Rockies); Lauren Morello, *Warming, Management Practices Spark New Fire Concerns*, CLIMATEWIRE, Aug. 19, 2008, *available at* http://www.eenews.net/cw/2008/08/19 (decrease in spring snowpack likely to create longer and larger wildfires).

45. NAT'L WILDLIFE FED'N, INCREASED RISK OF CATASTROPHIC WILDFIRES: GLOBAL WARMING'S WAKE-UP CALL FOR THE WESTERN UNITED STATES 2 (2008). Warmer temperatures also may produce more severe thunderstorms with increased frequency of lightning. *Id.*; *see also* Douglas Fischer, *Climate Change Has Doubled Forest Mortality,* DAILY CLIMATE, Jan. 22, 2009 (discussing increases in death rates of even the most stable and resilient forests in western North America).

metals, and nutrients that enter surface water bodies, adversely affecting water quality and aquatic species. Further, watersheds damaged by fires are more susceptible to flash floods.[46] Fire also decreases the capacity of affected forests to sequester carbon, at least until new growth emerges.[47] Finally, forest fires are themselves huge generators of CO_2, so that they increase atmospheric concentrations of CO_2, and thereby contribute to conditions responsible for even further temperature rises.[48]

B. Biological Effects

The biological effects of climate change are at least as dramatic as the effects discussed in the preceding section. Climate change will alter the habitat upon which myriad plant and animal species depend.[49] Rising water levels in the Everglades have already prompted fears on the part of Florida's wildlife officials that flooding could result in significant declines in deer populations.[50] In many cases, species will have to migrate to new areas as the ecosystems that previously sustained them become unsuited to their needs.[51] Entire ecosystems

46. ALLIANZ GROUP, *supra* note 35, at 90.

47. *See* Dominique Bachelet et al., *The Importance of Climate Change for Future Wildlife Scenarios in the Western United States, in* REGIONAL IMPACTS OF CLIMATE CHANGE: FOUR CASE STUDIES IN THE UNITED STATES 22, 29 (2007), *available at* http://www.pewclimate.org/docUploads/Regional-Impacts-FullReport.pdf.

48. *See* John J. Fialka, *Are Large Forest Fires "Natural" or Huge, Man-Made Sources of Carbon Emissions?*, CLIMATEWIRE, Sept. 17, 2008, *available at* http://www.eenews.net/cw/2008/09/17. Another example of this self-perpetuating phenomenon occurs when rising surface temperatures caused by increasing GHG concentrations result in the melting of permafrost that releases methane gas, a potent GHG, into the atmosphere. *See* Gabrielle Walker, *Climate Change 2007: A World Melting from the Top Down*, 446 NATURE 718 (Apr. 12, 2007) (describing an ever-escalating positive-feedback loop). Measured on a ton-by-ton basis, the energy trapping capacity of methane gas is twenty-three times more potent than that of CO_2. AM. BAR ASS'N, SECTION OF ENV'T, ENERGY, AND RES., GLOBAL CLIMATE CHANGE AND U.S. LAW 5 (Michael B. Gerrard ed., 2007).

49. Scientists working for the International Union for the Conservation of Nature's World Conservation Congress have estimated that one quarter of all mammal species worldwide is already threatened with extinction, and that half of mammal populations are declining, as a result of activities such as overharvesting, habitat loss, and overuse of the oceans. Jan Schipper, *The Status of the World's Land and Marine Mammals: Diversity, Threat, and Knowledge*, 322 SCIENCE 225, 228–29 (Oct. 10, 2008), *available at* http://www.sciencemag.org/cgi/reprint/322/5899/225.pdf. Moose populations throughout the northwest portions of the United States have declined as the animals have been unable to adapt to warmer temperatures. *See* Daniel Cusik, *Mysterious Climate Stress Stalks North Woods Population*, CLIMATEWIRE, Dec. 15, 2008.

50. Robin Bravender, *Flooding Could Wipe Out Wildlife Populations—Officials*, GREENWIRE, Oct. 21, 2008, *available at* http://www.eenews.net/Greenwire/2008/10/21/21.

51. Some species are more adaptable than others. Bald eagles, for example, have already adjusted their feeding habits in response to climate change and the re-

themselves may migrate if the ecological conditions that characterize an ecosystem shift location to accommodate changing physical conditions. A study of 130 species of trees in North America found that by the end of the twenty-first century, a massive migration of these species northward is likely to occur. Ranges of some species could shift by 400–500 miles. Ranges could decline by up to fifty-eight percent if tree species cannot adapt to climate change by dispersing their progeny to more favorable areas (and thus survive only in areas that overlap with their current climatic range). The climate in much of the southern U.S. could be outside the known climatic tolerances for most of the 130 species studied.[52] The Audubon Society has studied the movement of birds in response to warming temperatures. It found that although many bird species have moved to cooler areas, some species are incapable of moving and may perish if climate change continues unabated. Some grassland birds, for example, have not shifted to the north despite rising temperatures in their current habitat because conversion of grasslands to intensive human uses has reduced the availability of grassland habitat in cooler locations.[53]

As much as one-third of the land area of the eleven western states could experience a change in dominant vegetation type by 2100. High elevation areas are most likely to be affected.[54] Scientists have already verified tree-line changes and shifts in alpine vegetation.[55] Trees in Mount Rainier National Park have begun encroaching on high-mountain meadows in which they never previously appeared as a result of a decline in snowfall attributable to climate change.[56] Some animals are capable of shifting along with the vegetation that sup-

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sulting physical changes in the eagles' environment. They are eating more marine birds because climate change has contributed to a decline in fish and sea otter populations that made up the traditional bald eagle diet. Robert G. Anthony et al., *Bald Eagles and Sea Otters in the Aleutian Archipelago: Indirect Effects of Trophic Cascades*, 89 ECOLOGY 2725 (2008).

52. Daniel W. McKenney et al., *Potential Impacts of Climate Change on the Distribution of North American Trees*, 57 BIOSCIENCE 939 (2007).

53. NAT'L AUDUBON SOC'Y, BIRDS AND CLIMATE CHANGE; ECOLOGICAL DISRUPTION IN MOTION 8 (Feb. 2009), *available at* http://www.audubon.org/bird/bacc/index.html.

54. According to one source, "[s]ubalpine forests could be replaced by temperate evergreen forests in North Cascades National Park; Boreal forests could be replaced by mixtures of temperate evergreen forests, shrub steppes, and savanna woodlands in Grand Teton, Rocky Mountain, and Yellowstone national parks; Shrub steppes could largely be replaced by savanna woodlands and grasslands across the many national parks of the Colorado Plateau." Saunders et al., *supra* note 21, at 50.

55. Eric Bontrager, *Experts Weigh Warming's Effect on Wildfires, Pests*, GREENWIRE, Feb. 12, 2008, *available at* http://www.eenews.net/Greenwire/2008/02/12/17.

56. Hallie Martin, *Trees Encroaching on Mount Rainier's Meadows*, CLIMATEWIRE, Oct. 2, 2008, *available at* http://www.eenews.net/cw/2008/10/02/

ports them.[57] But shifts in vegetation can be problematic for, if not fatal to, plant and animal species located at the northern and upper-elevational edges of their ranges that depend on low temperatures.[58] Rare ecosystems such as alpine tundra, California chaparral, and blue oak woodlands in California might become entirely extinct.[59]

Seasonal variations in temperature and precipitation will affect phenology, the seasonal timing of biological events such as migration, reproduction, and leaf emergence.[60] The changes could impair the viability of affected species. For example, studies have already documented the arrival of robins in Rocky Mountain National Park before the emergence of the food species they traditionally consume.[61] Similarly, due to earlier spring thaws, white-tailed ptarmigan in the Park hatch much earlier, at a time when less food is available to them, than they did in the 1970s.[62] One study analyzed the times at which plants flower, comparing data accumulated by Henry David Thoreau near Walden Pond in the 1850s with current data at the same site. The data show that plants are flowering earlier than they did in Thoreau's time and that the plants least adaptable to changes in temperature have experienced the sharpest declines.[63]

57. "The most chronicled, based on decades of observations, is the range of Edith's checkerspot butterfly (*Euphydryas editha*) from northern Baja California to southern British Columbia. Between the 1930s and 1990s, the species' distribution shifted 92 km northward and 105 meters upslope." Wagner, *supra* note 21, at 110.

58. *Id.* at 110.

59. GAO, *Climate Change*, *supra* note 16, at 26; *see also* Wagner, *supra* note 21, at 47 (finding that rising temperatures could eliminate all alpine tundra from Rocky Mountain National Park).

60. For a discussion of the extent and effects of seasonal changes linked to climate change, see generally A.R. Sine et al., *Changes in the Phase of the Annual Cycle of Surface Temperature*, 457 NATURE 435 (2000).

61. *See* Wagner, *supra* note 21, at 112. If animals increase their metabolism before plant food sources have sprouted, they could die from starvation. *See* THE WILDLIFE SOC'Y, GLOBAL CLIMATE CHANGE AND WILDLIFE IN NORTH AMERICA 7 (Krista E.M. Gallery ed., 2004), *available at* www.nwf.org/nwfwebadmin/binaryVault/Wildlife_Society_Report2.pdf (stating that if rising temperatures cause migratory birds to change location at different times, their migrations may no longer match the availability of essential food sources such as invertebrates and plant seeds); Vincent Devictor et al., *Birds Are Tracking Climate Warming, but Not Fast Enough*, 275 PROC. ROYAL SOC'Y SEC. B 2743 (2008) (discussing phenological disruptions that may occur if different species in an ecosystem track climate change at a different pace).

62. *See* Saunders et al., *supra* note 21, at 57.

63. Charles G. Willis et al., *Phylogenetic Patterns of Species Loss in Thoreau's Woods Are Driven by Climate Change*, 105 PROC. NAT'L ACAD. SCI. 44 (Oct. 2008); *see also* Cornelia Dean, *Thoreau Is Rediscovered as a Climatologist*, N.Y. TIMES, Oct. 28, 2008, at D1.

Animals that leave hibernation early could be vulnerable to predators they have not previously encountered.[64] Climate change may result in differential changes in development rates that create mismatches in timing between other predator and prey species, a phenomenon called phenological disjunction.[65] Phenological changes could disrupt the balance of entire ecosystems. Severe winter temperatures have helped to keep elk populations in Rocky Mountain National Park under control. As temperatures warm, that regulating effect may weaken, resulting in an overabundance of elk populations. Increased elk populations could adversely affect plant communities, reducing biological diversity.[66] Warming water temperatures may reduce food supplies, causing an increase in the intervals between reproduction events of aquatic species.[67] In short, "[t]here is now compelling evidence that species are already shifting their ranges in response to on-going changes in regional climates, that species are altering their phenology and that some species are facing extinction, or have become extinct."[68]

Climate change will increase damaging pest infestations, as pests move to and thrive in environments previously inhospitable to them or less frequently experience the low winter temperatures that kill them. These scourges are likely to include species such as bark beetles, grasshoppers, fungi, and diseases transmitted by bacteria, parasites, and viruses. This phenomenon is already well underway. Southern pine beetles have migrated into red spruce territory in the southeast. Spruce bark beetles have infested the Chugach National Forest, causing high mortality rates on more than 400,000 acres of spruce forests.[69] Pine beetles have damaged the Great Smoky Mountains

64. Eryn Gable, *Global Warming May Change Hibernation Patterns*, LAND LETTER, Feb. 7, 2008, *available at* http://www.eenews.net/ll/2008/02/07.

65. Humphrey Q.P. Crick, *Migratory Wildlife in a Changing Climate*, *in* UNITED NATIONS ENV'T PROGRAMME AND THE SECRETARIAT OF THE CONVENTION ON THE CONSERVATION OF MIGRATORY SPECIES OF WILD ANIMALS, MIGRATORY SPECIES AND CLIMATE CHANGE: IMPACTS OF A CHANGING ENVIRONMENT ON WILD ANIMALS 40, 41 (2006), *available at* http://www.cms.int/publications/pdf/CMS_CimateChange.pdf.

66. Guiming Wang et al., *Impacts of Climate Changes on Elk Population Dynamics in Rocky Mountain National Park, Colorado, U.S.A.*, 54 CLIMATIC CHANGE 205 (2002).

67. Crick, *supra* note 65, at 41; *see also* THE WILDLIFE SOC'Y, *supra* note 61, at 7 (discussing the possibility that warmer temperatures will cause reductions in the size of amphibians, leading to reduced mating success, or will change sex ratios in some reptile species).

68. Wilfried Thuiller et al., *Predicting Global Change Impacts on Plant Species' Distributions: Future Challenges*, 9 PERSP. PLANT ECOLOGY, EVOLUTION AND SYSTEMATICS 137, 138 (2008) (citations omitted).

69. GAO, *Climate Change*, *supra* note 16, at 23–24; *see also* Jim Robbins, *Bark Beetles Kill Millions of Trees in West*, N.Y. TIMES, Nov. 18, 2008 at D3 (linking mountain beetle infestations to rising temperatures).

National Park and the Colorado forests, where warmer winters and drought conditions have facilitated the spread of the infestation.[70] Higher water temperatures may increase toxic algal blooms in both freshwater and ocean ecosystems. They will also facilitate the proliferation of pathogens, a phenomenon that has already occurred in the Yukon River as it flows through the Yukon Delta National Wildlife Refuge.[71] Increased microbial activity attributable to warmer water could adversely affect fish and other aquatic life.[72]

Climate change is already responsible for the spread of invasive species in many federal land areas. Invasive species are those that are not native to a particular ecosystem and whose introduction disrupts the invaded ecosystem and species that depend on it. Invasive species tend to be particularly adaptable, allowing them to accommodate to changed conditions more successfully than native species. Once they enter a new area, they can displace native species either by competing for food and shelter or exposing native species to parasites or diseases for which they have built up no defenses.[73] According to one estimate, invasive plants cause an estimated $20 billion each year in economic damage in the United States, and they already infest at least 2.6 million acres of the national parks. The culprits include Russian olive trees that destroy plant and animal habitat in national parks in New Mexico and Arizona; tamarisks that deplete water in national parks on the Colorado Plateau; weeds that take over stream corridors and degrade salmon spawning habitat in the northwestern national parks; and exotic grasses that threaten native cacti in desert national parks.[74] Invasive grasses on public lands in the Mojave Desert have helped transform some desert communities into annual grasslands. Warming temperatures in the Great Lakes have allowed nonnative zebra mussels to displace native species and rising water

70. Gable, *supra* note 64.

71. GAO, *supra* note 16, at 25–26.

72. *Id.*

73. *See, e.g.*, Selene Baez & Scott L. Collins, *Shrub Invasion Decreases Diversity and Alters Community Stability in Northern Chihuahuan Desert Plant Communities*, 3 PLoS One 1 (2008) (documenting biodiversity declines in grasslands following shrub invasion induced by global warming). Some research supports the conclusion that invasive species may be capable of enhancing biodiversity under certain conditions. *See* Dov F. Sax & Steven D. Gaines, *Species Invasions and Extinction: The Future of Native Biodiversity on Islands*, 105 Proc. Nat'l Acad. of Sci. 11490 (2008) (analyzing impact of introduction of invasive species in New Zealand).

74. Saunders et al., *supra* note 21, at 52. Weeds that proliferate as atmospheric CO_2 concentrations increase may be useful as biofuels that reduce fossil fuel use. *See* Tom Christopher, *Can Weeds Help Solve the Climate Crisis?*, N.Y. Times Mag., June 29, 2008, at 42.

temperatures in the Chesapeake Bay may create conditions conducive to the spread of oyster predators.[75]

The array of physical and biological effects summarized here does not exhaust the list of potential adverse consequences of climate change. Hotter air, for example, may facilitate the formation of tropospheric ozone pollution, which may impair tree and other plant growth as well as contribute to respiratory problems for people and other animals.[76] In addition, the various stresses resulting from climate change may have synergistic effects. Forests damaged by fires spurred by droughts and hot weather, for example, may be more susceptible to pest infestations than would healthy forests.

The upshot of these changes is likely to be the extinction of some species that now inhabit the federal lands, with a resulting reduction in biodiversity. Among the species at greatest immediate risk are Joshua trees in Joshua Tree National Park, white-tailed ptarmigans in Rocky Mountain National Park, mountain yellow-legged frogs in the Sierra Nevadas, desert bighorn sheep across their entire range, and pikas in the lower elevations of their range.[77] One study projected that the extinction rate of immobile butterfly species may be as high as thirty-seven percent by 2050.[78] The consequences of the resulting loss of biodiversity are impossible to predict.[79]

C. Socio-Economic Effects

Significant adverse social and economic effects will accompany the physical and biological impacts of climate change discussed above. According to the U.S. Environmental Protection Agency ("EPA"), fishing opportunities may shrink significantly, especially at the southern boundaries of the habitat of cool and cold water species. The agency has raised the possibility that cold water fish habitats could be lost entirely in certain states in the northeast and midwest.[80] The decline

75. GAO, *Climate Change*, *supra* note 16, at 6, 26.

76. *See* ROBERT L. GLICKSMAN ET AL., ENVIRONMENTAL PROTECTION: LAW AND POLICY 392 (5th ed. 2007).

77. Saunders et al., *supra* note 21, at 48, 53, 56; GAO, *Climate Change*, *supra* note 16, at 27; Schwartz, *supra* note 21.

78. Wagner, *supra* note 21, at 113.

79. On the other hand, climate change may create new opportunities for organisms (such as tropical fish or coral reef organisms) that once occupied portions of the United States when temperatures there were warmer, but that no longer do. In the short term, these species may be regarded as invasive, but in the longer term they may be regarded as cyclical natives. I owe this insight to Andrew Torrance.

80. U.S. ENVTL. PROT. AGENCY, CLIMATE CHANGE AND COLD WATER FISH: IS TROUT FISHING AN ENDANGERED SPORT?, EPA-236-F-99-002 (May 1999), *available at* http://yosemite.epa.gov/oar/GlobalWarming.nsf/UniqueKeyLookup/SHSU5BNNWD/$File/ccandcoldwaterfish.pdf.

in fish species ill adapted to warm water conditions[81] may affect not only recreational opportunities, but the economic vitality and lifestyle of communities dependent on the fishing industry, such as communities in Alaska that depend on subsistence fishing.[82] Climate change has the capacity to cause hardships to other segments of the economy. Ranchers, for example, could experience reduced incomes as drought conditions and shifting vegetation patterns make it harder to sustain range populations at their previous size.[83] Destruction of forests by fire, pest infestation, or species migration may adversely affect the timber and tourism industries.[84]

Industries that depend on recreational use of the federal lands, such as tourism, may be hard hit by the consequences of climate change. The federal lands may become less attractive places to spend leisure time as the decline of fish, waterfowl, and other species makes fishing and hunting more difficult to enjoy.[85] Prominent attractions may lose some of their allure; prolonged droughts may result in less frequent eruptions of Old Faithful at Yellowstone National Park, for example.[86] The seasons for winter sports such as skiing may shrink as temperatures rise and snowpacks decline.[87] Loss of beaches due to coastal flooding will eliminate additional recreational opportunities. Hiking and camping on the federal lands may become less popular as temperatures (particularly in the southwest) rise and bugs and other pests proliferate.

Climate change will almost certainly increase the operating costs of the federal land management agencies as climate-related events such as wildfires, severe storms, and flooding require resource rehabilitation. In some instances, the seasons for recreational use may expand as spring comes earlier and fall ends later. As a result, repair

81. Warmer water temperatures may make fish species such as salmon vulnerable to bacteria that could not survive in colder waters. *See* Patrick Reis, *Climate Change Could Be Disaster for Alaskan Stocks*, GREENWIRE, June 16, 2008, *available at* http://www.eenews.net/Greenwire/2008/06/16/19/.

82. GAO, *Climate Change*, *supra* note 16, at 33.

83. *Id.* at 34.

84. *Cf.* Hallie Martin, *Beetle Infestation Threatens New England Trees*, GREENWIRE, Oct. 23, 2008, *available at* http://www.eenews.net/Greenwire/2008/10/23/25 (describing threats to the timber, tourism, and maple syrup industries in New England posed by an infestation of Asian Longhorned beetles, though the infestation appears to have resulted from the arrival of beetles in a shipping crate from China, rather than from climate change).

85. *See* GAO, *Climate Change*, *supra* note 16, at 30.

86. Shaul Hurwitz et al., *Climate-Induced Variations of Geyser Periodicity in Yellowstone National Park, USA*, 36 GEOLOGICAL SOC'Y OF AM. 451 (2008).

87. *See* Saunders et al., *supra* note 21, at 68–69 (discussing decline of opportunities for snow-dependent recreation in national parks in Colorado and Wyoming). For discussion of the laws governing the issuance of special use permits for skiing in the national forests, see generally 3 COGGINS & GLICKSMAN, *supra* note 3, at §§ 31:31–31:35.

and maintenance costs in the national parks, forests, and other federal lands will need to increase to meet the demands imposed by heavier use. Storms and fires linked to climate change have already impaired the infrastructure at places such as Chugach National Forest and Glacier National Park.[88] Increased firefighting costs have already forced the Forest Service to close recreation areas. Further increases could require the agency to cut other expenditures to provide additional resources to fight fires, even though some of the eliminated projects have the potential to reduce the risk of fire.[89]

The impact of climate change on water quantity and quality will have significant economic effects.[90] Greater variability in runoff on the federal lands will reduce the reliability of storage of water used for drinking and other domestic and commercial uses both on and off the federal lands.[91] One study has predicted that Lake Mead, which is fed by the Colorado River and provides water to cities like Phoenix and Las Vegas, has a fifty percent chance of becoming unusable by 2021 under even moderate climate scenarios due to reduced snowpacks and runoff.[92] The problem is widespread. The GAO reported in 2003 that state water managers in thirty-six states anticipated water shortages in the next ten years. Assuming drought conditions, the number rose to forty-six.[93]

III. SCIENTIFIC MODELS, ORGANIC STATUTES, AND CLIMATE CHANGE

The preceding Part described some of the changes that the federal lands may experience as a result of climate change. This Part as-

88. Heavier use also may generate more crime, more interactions between people and bears, and more frequent need for rescue operations. All of these will increase operating costs. *See* GAO, *Climate Change*, *supra* note 16, at 31–32. Some of these increased costs could be offset if the federal lands experience declines in winter use. *Id.*

89. *See* Noelle Straub, *Firefighting Costs Devastating Other Programs*, E&ENEWS PM, Aug. 20, 2008 (citing as examples road and trail maintenance, wilderness management, and community forestry activities).

90. For a description of the effects of climate change on water resources in the United States, see generally Katherine Jacobs et al., *Potential Consequences of Climate Variability and Change for the Water Resources of the United States*, *in* CLIMATE CHANGE IMPACTS ON THE UNITED STATES: THE POTENTIAL CONSEQUENCES OF CLIMATE VARIABILITY AND CHANGE 428 (Nat'l Assessment Synthesis Team 2001), *available at* http://www.usgcrp.gov/usgcrp/Library/nationalassessment/foundation.htm.

91. *See* G. Tracy Mehan, III, *Energy, Climate Change, and Sustainable Water Management*, 38 ENV'T REP. (BNA) 2637, 2641 (2007).

92. Felicity Barringer, *Lake Mead Could Be Within a Few Years of Going Dry, Study Finds*, N.Y. TIMES, Feb. 13, 2008, at A14.

93. U.S. Gen. Accountability Office, *Freshwater Supply: States' Views of How Federal Agencies Could Help Them Meet Challenges of Expected Shortages*, GAO-03-514 (July 2003).

sesses whether the laws that govern the management of these lands are likely to provide resource managers with the authority they need to anticipate and respond to climate change-related impacts that threaten the value of federal lands and resources. Some of the federal land laws delegate broad discretion to land management agencies such as the NFS and the BLM. That discretion allows the land management agencies to manage the lands and resources they control with an eye toward fostering resilient ecosystems. This Part argues, however, that, at least in some respects, Congress's reliance in enacting the federal land laws on scientific understandings that scientists have since abandoned creates a fundamental problem for agency efforts to protect federal lands and resources from the adverse effects of climate change. Moreover, even when the statutes themselves are sufficiently flexible to allow management for biodiversity protection and resilience, agency decisionmakers for the most part have not yet appreciated the importance of preparing for climate change. Part IV suggests ways to realign the federal land laws so that they better conform to current scientific models of the ways in which ecosystems respond to disruptions.

A. Scientific Paradigm Shifts and Ecosystem Resilience

Science plays an integral role in the development of environmental and natural resource management policy, although the relationship between science and environmental law is often "uneasy."[94] At the inception of modern environmental law in the late 1960s, the prevailing conception of the manner in which nature worked was that it produced a "relatively stable dynamic equilibrium."[95] According to Professors Bosselman and Tarlock, the book most responsible for triggering the environmental movement in the United States, Rachel Carson's *Silent Spring*,[96] reflected the view that human activities (such as the use of pesticides) were disturbing the "balance of nature."[97] Environmental policymakers at the time found the equilibrium theory attractive, accepting uncritically the notion, expressed in the works of Eugene Odum and others, that "[h]omeostasis at the organism level is

94. A. Dan Tarlock, *Who Owns Science?*, 10 PENN ST. ENVTL. L. REV. 135, 135–36 (2002); *see also* Osa Armi, *Controlling Environmental Policy: The Limits of Public Law in Germany and the United States, by Susan Rose-Ackerman*, 23 ECOLOGY L.Q. 137, 139 (1997) (book review) (describing Rose-Ackerman's view that "science, economics, and politics are inextricably intertwined in the area of environmental regulation").

95. Bosselman & Tarlock, *supra* note 6, at 864 (quoting Arthur G. Tansley, *The Use and Abuse of Vegetational Concepts and Terms*, 16 ECOLOGY 284 (1935)); *see also* ROBERT H. MACARTHUR & EDWARD O. WILSON, THE THEORY OF ISLAND BIOGEOGRAPHY (1967).

96. RACHEL CARSON, SILENT SPRING (1962).

97. Bosselman & Tarlock, *supra* note 6, at 864–65.

a well known concept of physiology. . . . We find that equilibrium between organisms and environment may also be maintained by factors which resist change in the system as a whole."[98] The concept of ecosystem stability thus

> provided a theoretical basis for the environmental laws of the 1970s. The protection of longstanding ecosystems from the deleterious effects of human interference nurtured preservation as an affirmative governmental goal. The Wilderness Act, for example, sought to preserve designated lands from the harms of "occup[ation] and modif[ication]" by mankind through "the preservation of their wilderness character." Similarly, the Endangered Species Act sought to "conserve" species from being lost; the Wild and Scenic Rivers Act protected and preserved rivers in their "free-flowing condition;" and the National Environmental Policy Act encouraged "harmony between man and his environment." Just as ecology focused on the adverse consequences of human activity, environmental law focused on preserving and protecting the underlying equilibrium of nature from human disturbance in order to prevent ecological transformation.[99]

Professors Bosselman and Tarlock, however, have described Odum's theory of ecosystem equilibrium as "one of the last gasps of 19th century deterministic science."[100] Other scientific disciplines had already shifted from deterministic to probabilistic theories, and even ecologists working at the time of the birth of environmental law reported research results that did not conform to the equilibrium theory. Soon, "[c]racks in Odum's steady-state theories began to appear."[101] By then, however, Congress had already erected the fundamental building blocks of environmental law in the United States, so that the law was built upon a homeostasis paradigm at the very time that ecologists began to contest its accuracy.[102]

98. *Id.* at 866 (quoting EUGENE P. ODUM IN COLLABORATION WITH HOWARD T. ODUM, FUNDAMENTALS OF ECOLOGY 25 (2d ed. 1959)).

99. Julie Thrower, Comment, *Adaptive Management and NEPA: How a Nonequilibrium View of Ecosystems Mandates Flexible Regulation*, 33 ECOLOGY L.Q. 871, 875 (2006). Dan Tarlock has identified the non-degradation provisions of the Clean Air and Water Acts and the provisions of the Clean Water Act that protect wetlands against development as examples of pollution control provisions that are rooted in the equilibrium paradigm. A. Dan Tarlock, *Slouching Toward Eden: The Eco-Pragmatic Challenges of Ecosystem Revival*, 87 MINN. L. REV. 1173, 1183 (2003); *see also* Lakshman D. Guruswamy, *Sustainable Agriculture: Do GMOs Imperil Biosafety?*, 9 IND. J. GLOBAL LEGAL STUD. 461, 465 (2002) (listing the ESA, the Wilderness Act, the non-degradation provisions of the Clean Air and Water Acts, and the wetlands protection provisions of the latter as statutes that are based on the equilibrium paradigm premise "that nature is best protected when it is left untouched"); Lakshman D. Guruswamy, *Integration and Biocomplexity*, 27 ECOLOGY L.Q. 1191, 1194 (2001) (same).

100. Bosselman & Tarlock, *supra* note 6, at 867.

101. *Id.* at 868.

102. *Id.* at 868–69.

Since then, "the equilibrium paradigm has undergone a Kuhnian revolution."[103] It has ultimately been replaced as the basic ecological model by "a dynamic view of communities and ecosystems as constantly evolving, disorderly mosaics in creative disequilibrium."[104] Daniel Botkin, for example, has posited that, "we understand, in spite of our wishes, that nature moves and changes and involves risks and uncertainties and that our judgments of our own actions must be made against this moving image."[105] Eugene Odum himself published a list in 1992 of twenty "great ideas" for ecology; the first such idea was that "an ecosystem is a thermodynamically open, far from equilibrium system."[106] Further, the non-equilibrium paradigm now forms the basis of conservation biology, a discipline that seeks to manage nature by mimicking natural systems.[107] Conservation biology, according to one proponent, is a "mission oriented" discipline that rests on the fundamental premise that "biodiversity is good and ought to be preserved."[108]

The problem is that the ecologists' switch from a "balance of nature" to a disequilibrium paradigm "potentially undermine[s] much of the resources management . . . strategies of classic environmental law based on the theory that it is enough to isolate ecosystems of human contamination."[109] As Professor Robert Keiter has pointed out, the legal system governing public lands and resources tends not to prioritize biological considerations over other concerns, at least until the

103. *Id.* at 869; *see also* Reed F. Noss, *Some Principles of Conservation Biology, as They Apply to Environmental Law*, 69 CHI.-KENT L. REV. 893, 893 (1994) ("Among the new paradigm in ecology, none is more revolutionary than the idea that nature is not delicately balanced in equilibrium, but rather is dynamic, often unpredictable, and perhaps even chaotic.").

104. Bradley C. Karkkainen, *Biodiversity and Land*, 83 CORNELL L. REV. 1, 11 n.39 (1997). Professor Karkkainen notes that the rise of the disequilibrium model resulted from a "sea-change in thinking among ecologists and conservation biologists[, who] rejected the 'balance of nature' paradigm." *Id.*; *see also* Thrower, *supra* note 99, at 876–77 ("Recognition of the constantly changing nature of ecosystems destroyed the notion of a fixed natural baseline that could be relied on to define the 'undisturbed' ecosystem—the desirable condition to achieve.").

105. DANIEL B. BOTKIN, DISCORDANT HARMONIES: A NEW ECOLOGY FOR THE TWENTY-FIRST CENTURY 190 (1990), *quoted in* GLICKSMAN ET AL., *supra* note 76, at 22.

106. Bosselman & Tarlock, *supra* note 6, at 870 (quoting Eugene P. Odum, *Great Ideas in Ecology for the 1990s*, 42 BIOSCIENCE 542 (1992)).

107. *Id*. at 870–71; *see also* Noss, *supra* note 103, at 906 (stating that "[h]uman disturbances that mimic or simulate natural disturbances are less likely to threaten species than are disturbances radically different from the natural regime").

108. Noss, *supra* note 103, at 895, 898–907. Noss identifies, as one of the ecosystem management principles stemming from conservation biology, the premise that "[m]aintaining viable ecosystems is usually more efficient, economical, and effective than a species-by-species approach." *Id*. at 904 (italics omitted).

109. Bosselman & Tarlock, *supra* note 6, at 869; *see also* Noss, *supra* note 103, at 893 (arguing that "classical preservationist approaches to conservation, to the extent that they attempt to hold nature static, do not reflect realities of nature").

point at which a species faces the threat of extinction.[110] Particularly in the context of the multiple use land systems, protection of fish and wildlife is not given any special place of pride among all of the competing permissible uses.[111] Even the Endangered Species Act ("ESA"), which was long considered an absolute mechanism for species protection[112] (albeit for the most part not until the species had been laid upon its deathbed), turns out, the Supreme Court now tells us (thirty-five years on), to be not so absolute after all, and must bow to other statutes that impose nondiscretionary duties on federal agencies.[113]

The resulting mismatch between science and law may have important implications.[114] It may affect, for example, how the legal system allocates the burden of proof. The National Environmental Policy Act ("NEPA"),[115] adopted in 1970 before the revolution took root, essentially allocates the burden of proving that a proposed agency action is environmentally destructive to project opponents. Projects such as dams, highways, and timber sales are presumed to be benign unless an environmental impact statement demonstrates to the contrary.[116] Even then, NEPA is entirely procedural, so that agencies are free (at least so far as NEPA is concerned) to proceed with even environmentally disastrous proposals.[117] The science of conservation biology points in the opposite direction:

> The philosophy underlying conservation biology and other applied sciences is one of prudence: in the face of uncertainty, applied scientists have an ethical obligation to risk erring on the side of preservation. Thus, anyone attempting

110. Robert B. Keiter, *Conservation Biology and the Law: Assessing the Challenges Ahead*, 69 CHI.-KENT L. REV. 911, 913 (1994); *see also* 16 U.S.C. § 1532(6) (2006) (defining endangered species as "any species which is in danger of extinction throughout all or a significant portion of its range").

111. Keiter, *supra* note 110, at 913.

112. *See, e.g.*, Tenn. Valley Auth. v. Hill, 437 U.S. 153, 173, 184, 194 (1978) (stating that the provision prohibiting federal agencies from engaging in actions that are likely to jeopardize listed species, 16 U.S.C. § 1536(a)(2) (2006), "admits of no exception," that Congress's plain intent was "to halt and reverse the trend toward species extinction, whatever the cost," and that the statute makes it "abundantly clear that the balance has been struck in favor of affording endangered species the highest of priorities").

113. *See* Nat'l Ass'n of Home Builders v. Defenders of Wildlife, 127 S. Ct. 2518 (2007) (holding that EPA did not have to comply with the ESA's no jeopardy provision in deciding whether to delegate permitting authority under the Clean Water Act for point source discharges to a state).

114. *Cf.* Lee P. Breckenridge, *Can Fish Own Water?: Envisioning Nonhuman Property in Ecosystems*, 20 J. LAND USE & ENVTL. L. 293, 302 (2005) (asserting that "[t]he growing scientific understandings of complex dynamics of resilience and adaptation in ecosystems have led to disconcerting questions about the adequacy of human institutions").

115. 42 U.S.C. §§ 4321–4370f (2000).

116. *See* Noss, *supra* note 103, at 896.

117. *See* Winter v. Natural Res. Def. Council, 129 S. Ct. 365, 376 (2008); Strycker's Bay Neighborhood Council v. Karlen, 444 U.S. 223 (1980).

> to modify a natural environment and put biodiversity at risk is guilty until proven innocent. This shift in burden of proof is consistent with the precautionary principle, which is gaining increased support in many professions.[118]

In addition, NEPA is a bad fit with the nonequilibrium paradigm because "the EIS process calls for a front-end analysis outlining with relative precision the environmental impact of a proposed project, and requiring certainty in the estimation of how that impact could be mitigated or avoided through alternatives."[119] The nonequilibrium paradigm's recognition of the unpredictability of scientific outcomes and of the need for iterative, flexible resource management may pose problems for agencies seeking to explain and craft alternatives for dealing with uncertain climate change scenarios.

The mismatch between the scientific underpinnings of much of the current federal land and resource laws and the realities "on the ground" is also relevant to the ability of those laws to provide resilience to the resources those laws are designed to manage. According to a 2008 report by the U.S. Climate Change Science Program, one of the two general concepts that best frames the goal of managing for resilience is the biodiversity concept.[120] The idea is that policymakers should strive "to ensure that ecosystems have all the components they need in order to recover from disturbances."[121] That idea is rooted in the belief that diversity at various levels (such as functional groups, species, and genetic populations) is critical for resilience. The upshot is "that it is both practical and sensible as a precautionary act to protect biodiversity as a means of promoting resilience."[122] To the extent that the current federal natural resource management laws fail to protect biodiversity, they are likely to fall short of what is needed to provide the resilience needed to withstand the disturbances linked to climate change. The next section surveys those laws, as they are both written and implemented, with an eye toward assessing their capacity to meet that end.

B. Current Statutory Authority to Address Climate Change

The federal land management agencies tend to have broad discretion to manage the lands and resources within their jurisdiction, although some are subject to more significant constraints than others. The organic statutes of the agencies vest them with sufficient authority to begin addressing climate change in some ways. Other, cross-

118. Noss, *supra* note 103, at 897.
119. Thrower, *supra* note 99, at 883.
120. The other concept is "structural concern," which stresses the importance of supporting species that provide the structural foundation of an ecosystem, such as corals or trees. ADAPTATION OPTIONS, *supra* note 10, at 9–17.
121. *Id*.
122. *Id*. at 9–18.

cutting statutes applicable to all federal agencies—including NEPA, the ESA, and the federal pollution control laws—may require that they do so. Nevertheless, the land management agencies have responded slowly to the challenges of climate change for various reasons, including statutory constraints (some of which appear to derive from the scientific mismatch described above),[123] inadequate information and resources, poor planning, leadership deficiencies, and lack of political will.

1. The Organic Acts

The organic acts that supply most of the authority for the National Park Service ("NPS"), the National Forest Service ("NFS"), the Bureau of Land Management ("BLM"), and the Fish and Wildlife Service ("FWS") provide a foundation that enables those agencies to take steps to both mitigate the extent of climate change and adapt to its effects. The NPS, for example, is responsible for conserving the scenery, natural and historic objects, and wildlife found in the national parks and monuments in a manner that "leave[s] them unimpaired for the enjoyment of future generations."[124] That mandate requires that the agency manage for the future as well as the present, and that it take actions to ensure the long-term integrity of the natural resources it controls. It clearly authorizes the NPS to select management actions responsive to the threats posed by climate change.

Congress has directed the NFS to rely on multiple use, sustained yield management principles in managing the national forests.[125] The multiple use mandate requires "periodic adjustments in use to conform to changing needs and conditions," authorizes the agency to use some land for "less than all of the resources," and requires management that does not impair the productivity of the land.[126] These provisions empower the NFS to change its management approach in response to climate-related environmental changes and to limit or prohibit certain uses if their authorization in the face of climate change threatens permanent resource impairment. The sustained yield directive requires maintenance of the output of various renewable resources without impairment of land productivity.[127] The NFS therefore may take steps, such as increasing preservation efforts and restricting extractive or high-intensity recreational use, if necessary to prevent impairment of resources adversely affected by climate change.

123. *See supra* Part III.A.
124. 16 U.S.C. § 1 (2006).
125. *Id*. §§ 529, 1601(d) (2006).
126. *Id.* § 531(a).
127. *Id*. § 531(b).

The National Forest Management Act ("NFMA") requires that the NFS manage the national forests in accordance with land use plans, which are designed to protect forest resources (including watershed, wildlife, and fish) and provide for biodiversity of plant and animal communities.[128] Land use plans also must restrict timber harvests where necessary to prevent irreversible damage to soil, slope, or watershed conditions or where harvesting is likely to adversely affect water conditions or fish habitat.[129] These provisions have obvious potential as means to abate activities that exacerbate the adverse effects of climate change on the national forests. If fires or flooding linked to climate change were to create a risk of soil erosion in a national forest, for example, the NFS would have the authority to halt timber harvesting or grazing that might exacerbate that risk.

The Federal Land Policy and Management Act ("FLPMA") subjects the BLM to a multiple use, sustained yield management mandate similar to the one that governs the NFS,[130] although it may impose even fewer constraints on the agency's management discretion than the NFMA and other multiple use laws do. Various FLPMA provisions seem well-suited to accommodating climate change. These include the mandate to manage the public lands under the BLM's control to protect scientific, scenic, ecological, environmental, "air and atmospheric," and water resource values and to provide food and habitat for fish and wildlife.[131] Although the FLPMA planning provisions tend to be vaguer than the analogous NFMA provisions, they still allow the BLM to anticipate and respond to climate change. BLM land use plans, for example, must "give priority to the designation and protection of areas of critical environmental concern."[132] Those are areas where special management attention is required "to protect and prevent irreparable damage to . . . fish and wildlife resources or other natural systems and processes."[133] Those provisions may be useful in protecting portions of the BLM lands that are richer in biological diversity than most.

The FWS is responsible for administering the national wildlife refuges "for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats . . . for the benefit of present and future generations of Americans."[134]

128. *Id*. § 1604(g)(3), (i) (2006); *see generally* Robert L. Glicksman, *Bridging Data Gaps through Modeling and Evaluation of Surrogates: Use of the Best Available Science to Protect Biological Diversity Under the National Forest Management Act*, 83 IND. L.J. 465 (2008).
129. 16 U.S.C. § 1604(g)(3)(E).
130. 43 U.S.C. § 1712(c)(1) (2000).
131. *Id*. § 1701(a)(8).
132. *Id*. § 1712(c)(3).
133. *Id*. § 1702(a).
134. 16 U.S.C. § 668dd(a)(2).

The agency must ensure the "biological integrity, diversity, and environmental health" of the refuge system and "assist in the maintenance of adequate water quantity and water quality to fulfill the mission of the System and the purposes of each refuge."[135] The organic statute governing administration of the refuge system requires that the FWS afford priority consideration to compatible wildlife-dependent recreational uses in refuge planning and management.[136] A "compatible use" is one that, in the FWS's judgment, "will not materially interfere with or detract from the fulfillment of the mission of the System or the purposes of the refuge."[137] These provisions authorize the FWS to control uses, including recreational uses, that threaten wildlife species or the ecosystems upon which they depend that have been or may be disrupted by climate change. The authorization to restore refuge resources is particularly significant.

2. Cross-Cutting Statutes

In addition to the organic statutes that supply the lion's share of the statutory authority of the federal land management agencies, several cross-cutting statutes supplement the authority of these agencies to take steps to address climate change, in both procedural and substantive fashion. NEPA requires all federal agencies to prepare environmental impact statements when they propose major federal actions that have the potential to significantly affect the quality of the human environment.[138] The courts have begun to demand that agencies factor climate change considerations into their environmental impact evaluations under NEPA.[139] NEPA, however, only requires consideration and disclosure of potential climate change considerations. It may encourage and facilitate agency planning for projects that may affect or be affected by climate change, but it has no substantive clout.

The ESA includes both substantive and procedural mandates. Section 7 requires that federal agencies insure that their actions (including approval of private projects) are not likely to jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of the critical habitat of those species.[140] In fulfilling that mandate, the action agency must consult with either the FWS or the National Oceanic and Atmospheric Association ("NOAA") Fisheries, depending on the species involved. In ap-

135. *Id.* § 668dd(a)(4)(B), (F).
136. *Id.* § 668dd(a)(4)(C).
137. *Id.* § 668ee(1).
138. 42 U.S.C. § 4332(2)(C).
139. *See, e.g.*, Ctr. for Biological Diversity v. Nat'l Highway Traffic Safety Admin., 538 F.3d 1172 (9th Cir. 2008).
140. 16 U.S.C. § 1536(a)(2) (2006).

propriate cases, the FWS or NOAA Fisheries must prepare a biological opinion that determines, based on the best scientific and commercial data available, whether an agency proposal would contravene section 7 and, if so, recommend reasonable and prudent alternatives to avoid jeopardy or critical habitat destruction. These provisions have the potential to act as powerful constraints on the ability of the land management agencies to proceed with projects that might adversely affect listed species at risk due to climate change. The battle over whether to list the polar bear is illustrative.[141] Politicians in Alaska fought the proposed listing, fearing that it would restrict the federal government's ability to issue oil and gas leases in polar bear habitat.[142] In addition, section 9 of the ESA prohibits the taking of listed species, which includes habitat modification.[143] As with NEPA, climate change considerations have begun to emerge in ESA cases. In one case, a court found a biological opinion prepared by the FWS to be unlawful because it failed to acknowledge and analyze record low levels of the listed species at issue, as revealed by available studies, and neglected to consider the impact of climate change on the species and its habitat.[144]

The role of the ESA in constraining agency actions linked to climate change is currently unclear. A month before the Bush Administration left office, the FWS and the NOAA Fisheries officially declared that "section 7(a)(2) is not an appropriate or effective mechanism to assess individual Federal actions as they relate to global issues such as global climate change and warming. We do not believe that Congress designed or intended the ESA to be utilized as a tool to regulate the global process, nor is it appropriate to hold an agency responsible for global processes."[145] The two agencies revised the regulations governing ESA consultation procedures by adding an exemption from those procedures that was designed to significantly narrow if not eliminate the obligations of federal agencies to consider the effects of their

141. Endangered and Threatened Wildlife and Plants; Special Rule for the Polar Bear; Interim Final Rule, 73 Fed. Reg. 28,306 (May 15, 2008) (to be codified at 50 C.F.R. pt. 17) (describing decision to list the polar bear as a threatened species and the consequences of that decision).

142. *See, e.g.*, Dan Joling, *State Will Sue Over Polar Bear Listing, Palin Says*, ANCHORAGE DAILY NEWS, May 22, 2008, *available at* http://www.adn.com/polar bears/story/413710.html (describing Alaska Governor's vow to sue the Interior Department to invalidate the listing in order to protect the state's oil and gas industry).

143. 16 U.S.C. § 1538(a)(1)(B); Babbitt v. Sweet Home Chapter of Cmtys. for a Great Or., 515 U.S. 687 (1995).

144. Natural Res. Def. Council v. Kempthorne, 506 F. Supp. 2d 322, 367–70 (E.D. Cal. 2007).

145. Interagency Cooperation Under the Endangered Species Act, 73 Fed. Reg. 76,272, 76,283 (Dec. 16, 2008).

actions on climate change.[146] It is not clear whether the Obama Administration will repudiate that approach, but it has already been judicially challenged in court. One indication that the Obama Administration will repudiate the Bush approach occurred within a month after the new president took office. The FWS agreed, in settling a lawsuit with the Center for Biological Diversity, to reconsider a petition to list the American pika, whose ability to live in its high elevation habitats is being threatened by climate change.[147]

The federal pollution control laws, which apply to all the land management agencies, may restrict their ability to pursue projects that risk exacerbating the adverse effects of climate change. The Clean Air Act ("CAA") requires the agencies to protect the lands and resources under their charge against the adverse effects of air pollution. The extent to which the agencies' obligation to protect air quality-related values and visibility extends to pollutants, such as CO_2 and other greenhouse gases ("GHGs"), for which EPA has not adopted national ambient air quality standards, is not yet clear.[148] The Clean Water Act ("CWA") requires all federal agencies engaged in activities resulting in the discharge or runoff of pollutants to comply with the Act's provisions to the same extent as private parties.[149] If flooding or erosion generated by climate change impairs the quality of streams or rivers that run through the national forests or BLM public lands, the CWA and state water quality standards adopted under it may prohibit authorization of road building, timber harvesting, and other activities that may exacerbate runoff.[150]

146. The regulations provide that agencies need not consult on an action when its direct and indirect effects are not anticipated to result in species take and those effects "are manifested through global processes," provided, among other things, the effects cannot be reliably predicted at the scale of a listed species' current range, or the effects would result "in extremely small, insignificant impact on a listed species or critical habitat." *Id*. at 76,287 (to be codified at 50 C.F.R. § 402.03(b)).

147. *See* Patrick Reis, *Feds to Weigh New ESA Listing on Climate Change Grounds*, E&ENEWS, Feb. 12, 2009. In early 2009, Congress authorized the Secretary of the Interior to, within a specified sixty-day period, withdraw or reissue the Bush Administration's 2008 revisions to its regulations governing consultations under § 7(a)(2) of the ESA. Pub. L. No. 111-8, § 429(a)(1), 123 Stat. 524, 749 (2009).

148. 42 U.S.C. §§ 7475(d), 7491–7492 (200). The Supreme Court has held, however, that CO_2 qualifies as a pollutant under the CAA. Massachusetts v. EPA, 127 S. Ct. 1438 (2007).

149. 33 U.S.C. § 1323(a) (2000).

150. *See, e.g.*, Nw. Indian Cemetery Protective Ass'n v. Peterson, 795 F.2d 688 (9th Cir. 1986), *rev'd on other grounds sub nom.* Lyng v. Nw. Indian Cemetery Protective Ass'n, 485 U.S. 439 (1988).

C. Climate Change Challenges to Federal Lands Under Existing Law

The statutes that govern the activities of the federal land management agencies seem to authorize those agencies to pursue a wide range of actions that might help avoid ruinous climate change, mitigate its adverse effects, or restrict activities that might exacerbate those effects. The agencies' organic statutes, however, are known for the breadth of the discretion they afford the agencies.[151] As a result, there are likely to be many situations in which those statutes allow the agencies to pursue various measures but do not compel them to do anything. That discretion can be problematic because to date addressing climate change has not been a priority for any of the land management agencies. According to the GAO, the agencies tend to focus on "near-term activities they are required to take," at the expense of long-term problems such as climate change. The agencies have tended to use historical data to react to changes that have already occurred rather than anticipate potential future change.[152] That strategy is woefully inadequate to address the anticipated impacts of climate change on federal lands and resources.

Some organic acts appear to require agencies to anticipate the manner in which their activities may affect the impact of climate change on the resources they control and to take appropriate steps to address the adverse effects. Even then, the agencies sometimes ignore that mandate or give it short shrift. The NFS, for example, has come close to gutting the provision of the NFMA that requires it to provide for and preserve biodiversity.[153] Yet, conservation biologists contend that the protection of biodiversity is precisely what is most needed to maximize the resilience of the ecosystems present on federal lands.[154] Whether the NFS's misapplication of the biodiversity provision is the result of policymakers who fail to appreciate the significance of biodiversity under the disequilibrium paradigm or of those who value

151. *See, e.g.*, Perkins v. Bergland, 608 F.2d 803, 806 (9th Cir. 1979) (describing the Multiple-Use, Sustained-Yield Act as a statute that "breathe[s] discretion at every pore").

152. GAO, *Climate Change*, *supra* note 16, at 7–8.

153. 16 U.S.C. § 1604(g)(3)(B) (2006). For analysis of the history of the NFS's interpretation of the diversity provision, see generally Glicksman, *supra* note 128. The Forest Service's weakening of the diversity protection provision is particularly troublesome in light of the 9th Circuit's decision to overrule a series of cases in which it had taken seriously its duty to take a hard look at what the agency had done in implementing the provision. Lands Council v. McNair, 537 F.3d 981, 990–1000 (9th Cir. 2008). In certain contexts, the diversity requirement, at least as the courts have interpreted it, has the potential to allow the Forest Service to manage the national forests in ways that would undermine the ecological resilience of natural systems in the forest. *See* notes 270–75 and accompanying text.

154. *See supra* notes 108, 120–21 and accompanying text.

mineral development more than ecosystem preservation is not entirely clear.

In rare instances, existing statutes specifically require the agencies to address climate change. The NFMA, as amended in 1990, requires the NFS to include in the long-range planning program it is periodically required to transmit to the President recommendations that "account for the effects of global climate change on forest and rangeland conditions, including potential effects on the geographic ranges of species, and on forest and rangeland products."[155] The planning program is supposed to guide the formulation of land and resource management plans for individual forest units, which then constrain decisions on site-specific initiatives such as timber sales.[156] Yet, few of those plans even mention climate change, no less make it a priority concern.[157] Similarly, the Secretary of the Interior issued an order in 2001 that requires agencies within the Department to "consider and analyze potential climate change impacts" in long-range planning, setting research priorities, and making major decisions concerning resource use.[158] The order refers specifically to planning and management activities associated with energy resource and mineral development and water projects and resources.[159] Yet, more than six years after its issuance, Department headquarters had yet to provide guidance to resource managers about how to implement the order. NPS, BLM, and FWS officials all confirmed this lack of direction and stressed the importance of getting it.[160]

Some of the cross-cutting statutes constrain agency management discretion more significantly than the organic acts do. The "no jeopardy" and taking provisions of the ESA provide perhaps the best examples. But the ESA has long been criticized as a statute whose scope is too narrow in that it focuses on protecting particular species against identifiable, direct threats, instead of protecting biodiversity more generally.[161] On occasion, the FWS and the NOAA Fisheries have

155. 16 U.S.C. § 1602(5)(F) (2006).

156. *Id.* § 1604(i) (requiring that permits, contracts, and other instruments for the use and occupancy of the national forests be consistent with land management plans).

157. *See, e.g.*, GAO, *Climate Change*, *supra* note 16, at 7–8 (finding that NFS officials at the Chugach National Forest have not placed a priority on planning for climate change because it was not listed as a priority threat by the NFS Chief and, astonishingly, is not considered to be a strategic issue by the agency).

158. Secretary of the Interior Order No. 3226, Evaluating Climate Change Impacts in Management Planning, § 3 (Jan. 19, 2001).

159. *Id.*

160. GAO, *Climate Change*, *supra* note 16, at 8–9.

161. *See, e.g.*, Holly Doremus, Comment, *Patching the Ark: Improving Legal Protection of Biological Diversity*, 18 ECOLOGY L.Q. 265 (1991); J.B. Ruhl, *Ecosystem Management, the ESA, and the Seven Degrees of Relevance*, 14 NAT. RESOURCES & ENV'T 156, 159 (2000). In this sense, the ESA reflects the equilibrium paradigm

purported to incorporate into their ESA consultation documents analytical techniques such as adaptive management which, as described below, have the potential to enhance the land management agencies' ability to protect against the adverse effects of climate change. Even then, the courts have chastised them for doing so in ways that excuse the agencies' failure to act in the face of uncertainty about future conditions rather than facilitate their ability to provide protective responses to changing conditions.[162] Thus, the ESA's approach is not fully consistent with the focus of conservation biologists on protecting biodiversity, and the FWS and NOAA Fisheries apparently have not taken to heart the discipline's insistence that policymakers act in precautionary fashion. Moreover, as indicated above, the FWS and the NOAA Fisheries have concluded, at least for now, that the application of the ESA to activities that might affect climate change is limited.[163] If the decisions of such environmental policymakers continue to put biodiversity at risk, federal lands ecosystems are not likely to be sufficiently resilient to withstand the system shocks associated with climate change.

The absence of legal guidance on the role of climate change in planning and project-level decisionmaking has been exacerbated by the dearth of scientific information needed to make informed decisions on how best to ameliorate the potential adverse impacts of climate change. The land management agencies often lack adequate baseline data such as resource inventories that would enable them to determine whether the conditions of plant and animal species found on federal lands are within the range of normal variability or have already

by seeking to prevent disruption of ecosystem equilibria by activities that pose threats to species that are a part of and relate to that state of equilibrium in predictable ways. *See* Orly Lobel, *The Renew Deal: The Fall of Regulation and the Rise of Governance in Contemporary Legal Thought*, 89 MINN. L. REV. 342, 427 (2004); *see also* Jim Chen, *Webs of Life: Biodiversity Conservation as a Species of Information Policy*, 89 IOWA L. REV. 495, 545 (2004) ("The strict separation of nature from human culture—an attitude that underlies both federal wilderness policy and the Endangered Species Act—assumes the validity of an equilibrium model under which biological diversity unequivocally enhances ecological stability."); *id*. at 549 (arguing that the law has not yet abandoned core natural resource management statutes such as NEPA or the ESA, even though they rely on "increasingly obsolete foundations" based on the equilibrium paradigm). *But cf*. Oliver Houck, *Why Do We Protect Endangered Species, and What Does that Say About Whether Restrictions on Private Property to Protect Them Constitute "Takings?",* 80 IOWA L. REV. 297, 301 (1995) (describing the ESA as "very much a surrogate law for ecosystems").

162. *See, e.g.*, Natural Res. Def. Council v. Kempthorne, 506 F. Supp. 2d 322 (E.D. Cal. 2007) (describing matrix incorporated in FWS biological opinion as nothing more than an organizational flow chart that prescribed meetings if certain criteria were exceeded, but that failed to define any quantified mitigation goals or specify any time for implementation of mitigation measures).

163. *See supra* notes 145-147 and accompanying text.

begun to experience climate-related changes. The agencies often lack computer modeling programs capable of providing input needed to make site-specific decisions on activities potentially relevant to climate change.[164]

This brief discussion hardly exhausts the obstacles that current laws and practices pose to the ability of the federal land management agencies to deal effectively with climate change. Another is the fragmentation of responsibility for resource protection among multiple agencies. Two of the fundamental precepts of the new paradigm associated with conservation biology teach that (1) ecosystem boundaries should be determined by reference to ecology, not politics; and (2) ecosystem management requires cooperation among agencies and landowners whose activities affect the resources within those ecosystems.[165] These precepts seem completely at odds with the manner in which federal law allocates the authority to manage federal lands and resources.

What makes the splintering of authority problematic is the likelihood that the scope of specific problems will outstrip the authority of any single agency to respond to them effectively. Agency jurisdictional boundaries and the ecological parameters of climate change impacts often do not correspond. Similarly, activities that take place outside the borders of federal lands may exacerbate resource problems linked to climate change, thereby limiting an agency's ability to provide a sufficient response. Savings clauses which preserve state authority to manage resources such as water and wildlife also limit the extent to which the federal land management agencies can implement holistic strategies for preserving resources found on the federal lands in the face of climate change and the risks with which it is associated.[166]

IV. ACCOMMODATING CLIMATE CHANGE THROUGH RESILIENCE

It is perhaps unfair to place undue blame for the failure of the existing federal land management and cross-cutting statutes to specifically require agencies to address climate change, or even to prescribe decisionmaking techniques for land and resource management that are up to the task of dealing with the phenomenon of climate change. The statutes by and large were adopted before climate change became

164. GAO, *Climate Change*, *supra* note 16, at 9.

165. *See* Noss, *supra* note 103, at 905, 907. One court held that the NFMA does not require the NFS to apply principles of conservation biology in implementing the provision, 16 U.S.C. § 1604(g)(3)(B) (2006), that requires the agency to protect the diversity of plant and animal communities. Sierra Club v. Marita, 46 F.3d 606 (7th Cir. 1995).

166. *See* ADAPTATION OPTIONS, *supra* note 10, at 6–32.

a prominent concern. Further, the magnitude and complexity of the issues raised by climate change far exceed any resource management issue experienced by either Congress or the land management agencies. Similar excuses are not available to land managers who have buried their heads in the ground or failed to take advantage of the discretion they do enjoy to craft strong programs for anticipating climate change, enhancing the resilience of the resources they manage, and laying the groundwork for dealing with the potential for climate change which puts valuable federal lands and resources at risk.

This Part makes ten recommendations for better equipping the federal land management agencies to manage their resources in ways that minimize the adverse effects of global climate change. The recommendations are relevant to both mitigation of, and adaptation to, climate change. Some of them require statutory amendments, while others can be implemented under existing law. After listing the recommendations and briefly describing the purpose of each, the Article provides specific examples of the opportunities available to the agencies under a reconceived statutory and regulatory regime to manage federal lands and resources to emphasize biodiversity protection as a means of enhancing the resilience of federal lands systems in the face of the threats posed by climate change.

A. Recommendations for Resource Management in the Face of Climate Change

The changes recommended here encompass changes to the enabling legislation of the federal land management agencies, the manner in which the agencies prepare for and make decisions that implement that legislation, and some of the cross-cutting (or overlay) statutes that both govern all of the land management agencies and determine the degree to which their decisions are subject to accountability checks such as judicial review. One commenter on a draft of this Article at the meeting at which the symposium papers were first presented described the net impact of these recommendations as fostering an "institutional resilience" that would facilitate the ability of the land management agencies to set the stage for the physical and biological resilience that will be needed to protect the integrity of federal lands and resources in the face of climate change.

1. The federal land management agencies need to *adapt their planning processes* (with legislative directives, if necessary) to afford priority to climate change issues and to emphasize the long-term consequences of climate change. As Congress recognized when it adopted FLPMA, "the national interest will be best realized if the public lands and their resources are periodically and systematically inventoried and their present and future use is projected through a land use planning process coordinated with other Federal and State planning ef-

forts."[167] Similarly, Congress directed the NFS under the NFMA to "use a systematic interdisciplinary approach [to planning] to achieve integrated consideration of physical, biological, economic, and other sciences."[168] The organic statute for the National Wildlife Refuges requires the FWS to prepare conservation plans for all units within the System[169] to help achieve the agency's statutory mission of conserving wildlife and its habitat for the benefit of present and future generations.[170] Even the NPS, whose narrowly defined mission makes planning somewhat less vital to the implementation of its mission than is true of the other land management agencies, is required by its organic act to develop general management plans for each unit of the National Park System.[171]

The existence of statutorily-imposed planning requirements, however, assures neither intelligent nor effective land and resource management. As the U.S. Climate Change Science Program's 2008 report recognizes, the usefulness of management plans may be limited by factors that include a failure to adequately address evolving issues, a failure to identify actions worthy of priority attention, reliance on outdated management goals, and the use of a planning horizon that is too short.[172] Some of these flaws have hampered the efforts of the federal land management agencies to prepare for climate change. Climate change represents the greatest and most sustained challenge that has ever faced federal land managers. Yet, climate change considerations are apparently not addressed at all, and certainly not in any depth, in many current planning efforts. In interviews with the GAO, planners from the NPS, NFS, and FWS confessed to confusion about the nature of their agencies' mandates to deal with climate change and to uncertainty about how to build climate change considerations into the planning and management process.[173] As one observer put it, land use plans are "an accountability tool . . . . What is not in a plan tends to be considered unimportant."[174]

The U.S. Climate Change Science Program's conclusions are consistent with the GAO's findings. Its 2008 report found that some management systems have failed to recognize climate change as a "significant problem or stressor" and that, more generally, agency policies and plans are not flexible enough to deal effectively with uncer-

167. 43 U.S.C. § 1701(a)(2) (2000).
168. 16 U.S.C. § 1604(b) (2006).
169. *Id.* § 668dd(e).
170. *Id*. § 668dd(a)(2). The FWS's refuge planning policy is summarized in 2 COGGINS & GLICKSMAN, *supra* note 3, at § 16:16.
171. 16 U.S.C. § 1a-7 (2006).
172. ADAPTATION OPTIONS, *supra* note 10, at 9-28.
173. *See* GAO, *Climate Change*, *supra* note 16, at 36–39.
174. David Welch, *What Should Protected Area Managers Do in the Face of Climate Change?*, 22 GEORGE WRIGHT F. 75, 86 (2005).

tainty and change.[175] The report singles out effective management of shifts in species distributions and prevention of possible species extirpations as the likely consequences of these policy and planning failures.[176] These failures represent the antithesis of planning to enhance resilience.

To overcome these problems, it is essential that top agency officials make climate change a priority in the planning process and clearly convey that message throughout their organizations. The Climate Change Science Program's 2008 report recommends the use of flexible and long-term planning horizons, an emphasis that runs counter to the proclivity of decisionmakers to focus on immediate crises and short-term objectives. In addition, planners should seek out opportunities to coordinate with those planning for nearby but separate management units, whether those are within the same or different federal lands systems.[177] According to the report, "[m]anagement plans that are allowed to incorporate climate change adaptation strategies but that have not yet done so provide a blank canvas of opportunity."[178]

2. The land management agencies, in the planning process as well as in other contexts, must *rely heavily* on the management technique known as *adaptive management*.[179] The Interior Department's most recent NEPA regulations define adaptive management as "a system of management practices based on clearly identified outcomes and monitoring to determine whether management actions are meeting desired outcomes; and, if not, facilitating management changes that will best ensure that outcomes are met or re-evaluated. Adaptive management recognizes that knowledge about natural resource systems is sometimes uncertain."[180] Biologists have distinguished among different types of adaptive management. The one endorsed here is active adaptive management, which involves "learning about environmental impacts by creating specific scientific experiments designed to test hypotheses."[181]

175. ADAPTATION OPTIONS, *supra* note 10, at 9-28.
176. *Id.*
177. *Id.* at 9-29.
178. *Id.* at 9-30.
179. On adaptive management, see generally J.B. Ruhl, *Regulation by Adaptive Management— Is It Possible?*, 7 MINN. J. L. SCI. & TECH. 21 (2005); Bradley C. Karkkainen, *Toward a Smarter NEPA: Monitoring and Managing Environmental Performance*, 102 COLUM. L. REV. 903 (2002).
180. Implementation of the National Environmental Policy Act (NEPA) of 1969, 43 C.F.R. § 46.30 (2008); *cf. In re* Operation of the Mo. River Sys. Litig., 363 F. Supp. 2d 1145, 1163 (D. Minn. 2004), *aff'd in part, vacated in part*, 421 F.3d 618 (8th Cir. 2005) ("Adaptive management is an approach to natural resources management, in which policy choices are made incrementally."). On the role of adaptive management in NEPA compliance, see DANIEL R. MANDELKER, NEPA LAW AND LITIGATION § 7:13.1 (2d ed. 2008).
181. Thrower, *supra* note 99, at 885. Thrower adds,

Adaptive management is a planning and management device tailor-made for dealing with uncertainty.[182] The vast majority of scientists no longer disagree that climate change has begun or that human activities that generate GHG emissions are largely responsible for causing it. Yet major uncertainties remain over the timing, extent, and distribution of climate change and its associated impacts. The planning process must provide resource managers with sufficient flexibility to deal with unanticipated effects of climate change. Adaptive management can provide that flexibility.

According to some observers, some federal land management systems have long relied on static policies that fail to reflect the "dynamic management actions," such as adaptive management, needed to tackle climate change.[183] But all of the federal land management agencies already appear to rely on adaptive management to some extent. As indicated above,[184] the Interior Department's NEPA regulations incorporate adaptive management into the NEPA evaluation process.[185] In addition, the FWS has listed "providing a basis for adaptive management by monitoring progress, evaluating plan implementation, and updating refuge plans accordingly" as one of the eight goals of planning for the National Wildlife Refuge System.[186] The agency has

> Information gathered from these experiments is used to confirm predictions or detect unpredicted impacts early enough to prevent irreversible damage. . . . [A]ctive adaptive management recognizes the uncertainty in scientific understanding of environmental impacts, but offers a reasonable method for action in the absence of complete information. In order to determine how to proceed in the face of such uncertainty, active adaptive managers evaluate the consequences of each decision and make necessary changes, depending on the observations, to improve the environmental outcome of the specific action.

Id. For a discussion of two other types of adaptive management, evolutionary and passive, see *id*. at 884–85.

182. "Adaptive management is a methodology in which one can proceed with only limited or uncertain knowledge. It is an approach whereby an intervention is conducted as if it were a scientific experiment, with measurable, time-bound targets set in advance (policy = hypotheses), careful measurement of results as things happen (intervention = experiment), and approaches adjusted as new information becomes available (reporting, analysis, re-setting hypotheses)." Welch, *supra* note 174, at 87 (citations omitted).

183. ADAPTATION OPTIONS, *supra* note 10, at 9-28.

184. *See supra* note 180 and accompanying text.

185. Some courts have approved the use of adaptive management as a means of complying with the obligation to prepare a supplemental EIS under NEPA. *See, e.g.*, Or. Natural Res. Council Action v. U. S. Forest Serv., 59 F. Supp. 2d 1085, 1096 (W.D. Wash. 1999); *see also In re* Operation of the Mo. River Sys. Litig., 363 F. Supp. 2d 1145, 1163–64 (D. Minn. 2004), *aff'd in part, vacated in part*, 421 F.3d 618 (8th Cir. 2005) (concluding that Corps of Engineers' adoption of adaptive management process for river management did not violate NEPA).

186. Refuge Planning Policy Pursuant to the National Wildlife Refuge System Administration Act as Amended by the National Wildlife Refuge System Improvement Act of 1997, 65 Fed. Reg. 33,892, 33,906 (May 25, 2000). The FWS defines adap-

recognized, however, that it needs to provide additional guidance dealing with the principles of adaptive management and monitoring.[187] Similarly, the Forest Service has characterized land management planning as "an adaptive management process that includes social, economic, and ecological evaluation; plan development, plan amendment, and plan revision; and monitoring."[188] To carry out that process, the agency in the latest iteration of its planning regulations has included a prohibition on the implementation of a project or activity (such as a timber sale) approved under a plan until the responsible official either establishes an environmental management system for the Forest System unit concerned or conforms the project or activity to a multi-unit, regional, or national level system.[189]

According to the U.S. Climate Change Science Program, "[c]limate change creates new situations of added complexity for which an adaptive management approach may be the only way to take management action today while allowing for increased understanding and refinement tomorrow."[190] Yet, the land management agencies must be careful how they implement an adaptive management approach. The courts are not always impressed with the process and may regard it as a mechanism for achieving an end-run around statutory planning requirements. In one case, for example, the Ninth Circuit held that the BLM violated the requirement that management decisions conform to preexisting plans[191] by changing resource management plan provisions without a formal amendment.[192] The court rejected the agency's claim that its actions constituted mere efforts to "maintain" the plan, and that formal amendment was therefore unnecessary under BLM regulations.[193] The court refused to allow the BLM to conduct timber sales in a manner inconsistent with the plan by characterizing the ac-

tive management as "[t]he rigorous application of management, research, and monitoring to gain information and experience necessary to assess and modify management activities. A process that uses feedback from refuge research and monitoring and evaluation of management actions to support or modify objectives and strategies at all planning levels." *Id.*

187. *Id.* According to the agency, "[t]he refuge planning policy only touches on the need for adaptive management and monitoring to assure that we are meeting refuge purposes, goals, and objectives and that management strategies are appropriate. We will develop additional Service policy and guidance on both the adaptive management process and monitoring." *Id*. at 33,900. The FWS estimated that it might take years to assess the planning process and the resulting products in a manner sufficient to identify measures and standards for adaptive management. *Id.*

188. 36 C.F.R. § 219.3(a) (2008).

189. National Forest System Land Management Planning; Final rule and record of decision, 73 Fed. Reg. 21,468, 21,475 (Apr. 21, 2008); 36 C.F.R. § 219.5(d).

190. ADAPTATION OPTIONS, *supra* note 10, at 9-25.

191. 43 U.S.C. § 1732(a) (2006).

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

193. 43 C.F.R. § 1610.5-4 (2007).

tions it took as adaptive management modifications that were contemplated by the plan and made necessary by newly available information.[194] In another case, a federal district court found that the Forest Service violated the NFMA, and a land and resource management plan adopted under it that required monitoring of the effects of grazing on forest resources, when it stated in an environmental impact statement that it would develop and implement a monitoring plan through an "iterative process" that was part of an adaptive management strategy.[195] The court found that these references provided an inadequate explanation of how the agency would comply with the plan's requirements.[196]

The courts have reached similar results in cases in which the Fish and Wildlife Service relied on its commitment to engage in adaptive management to justify its failure to discuss mitigation measures in a biological opinion issued under the ESA.[197] Although the court acknowledged that adaptive management can be beneficial and that flexibility is an essential incident of adaptive management, it concluded that the agency failed to strike an appropriate balance between the dual needs of flexibility and certainty in that it did not provide reasonable assurance that the admitted adverse effects of the project would actually be mitigated.[198] These cases caution that the land management agencies should not use reliance on adaptive management as an excuse for deferring real planning in favor of a "don't-worry-about-it-now-because-we'll-figure-out-what-we-need-to-do-when-it-happens" approach.

3. Planning and project level decisions are only as good as the information on which they are based.[199] Resource managers have stressed the need for *better information*, both about baseline resource conditions on the federal lands and about the potential effects of climate change on particular ecosystems or federal land units.[200] Agency officials have bemoaned the paucity of computational models

194. *Boody*, 468 F.3d at 559–60.

195. W. Watersheds Project v. U. S. Forest Serv., 62 Env't Rep. Cas. (BNA) 1142, 2006 WL 292010, at *10 (D. Idaho Feb. 7, 2006).

196. *Id.*

197. Natural Res. Def. Council, Inc. v. Kempthorne, 506 F. Supp. 2d 322, 351 (E.D. Cal. 2007).

198. *Id.* at 357.

199. Holly Doremus has noted that "[i]ncorporating accurate scientific information into environmental-policy decisions is therefore essential to ensuring that those decisions move society toward its chosen goals, and even to identifying goals that accurately reflect societal preferences." Holly Doremus, *Scientific and Political Integrity in Environmental Policy*, 86 TEX. L. REV. 1601, 1601 (2008).

200. *See, e.g.*, Noss, *supra* note 103, at 907 (listing as one of the basic principles of conservation biology the idea that ecosystem management requires cooperation among agencies and landowners and coordination of inventory, research, monitoring, and management activities).

capable of projecting small-scale climate-related changes.[201] Absent that information, it is difficult to anticipate problems or plan for their resolution. In addition, if agencies employ adaptive management techniques, they will need the resources to monitor conditions on an ongoing basis to allow them to adjust management approaches in light of prior successes or failures.

As the U.S. Climate Change Science Program has recognized, "[a]daptation is predicated upon research and scientific information."[202] Gaps in scientific information due to budgetary restrictions that limit the degree to which agencies can implement adequate monitoring programs, coupled with the scientific uncertainties surrounding the effects of climate change on particular ecosystems, are likely to hamstring efforts to address climate change in a fashion that protects federal lands and resources.[203] To make matters worse, the agencies may lack personnel with adequate training, expertise, or experience to interpret the data and put it to good use even if it exists.[204] Particularly at a time when economic difficulties make expansions of agency budgets unlikely, these constraints are potentially significant ones.

The Climate Change Science Program suggests collaboration and information-sharing among agencies as one palliative. It also recommends the adoption of uniform training, information-gathering, and assessment techniques to facilitate information-sharing among the agencies.[205] In addition, Professor Wendy Wagner has provided an important set of recommendations for supplying missing information about the health and environmental effects of industrial and developmental activity. These reforms may be useful in reducing data gaps that plague effective planning and action to combat the effects of climate change. She suggests, for example, the creation of incentives to produce missing information by basing regulatory standards on worst-case predictions. The severity of regulation could then be reduced if regulated entities produce credible information that risks or harms have been exaggerated.[206] This approach need not be confined to federal land users. If it were applied to large producers of GHGs, such as auto manufacturers, industrial companies would have incentives to plug the data gaps with information that might be useful to federal

201. GAO, *Climate Change*, *supra* note 16, at 41–42; *see also* ADAPTATION OPTIONS, *supra* note 10, at 9-32.

202. ADAPTATION OPTIONS, *supra* note 10, at 9-31.

203. *Id*. at 9-32.

204. *Id.* at 9-30.

205. *Id.*

206. Wendy E. Wagner, *Commons Ignorance: The Failure of Environmental Law to Produce Needed Information on Health and the Environment*, 53 DUKE L.J. 1619 (2004).

land managers.[207] One problem is that many of those responsible for the products or activities that generate the most GHGs, like the auto companies and the operators of coal-fired power plants, are typically not federal land users subject to management by the federal land management agencies. This method of reducing data gaps concerning climate change would therefore likely require changes in laws beyond those that govern federal land management.

Another way to provide new resources to federal land managers, in a time of shrinking resources, would be to sell instead of give away emissions allowances under any cap-and-trade scheme that Congress includes in climate change legislation. The government may then allocate part of the revenues it accumulates to efforts by federal land managers to prepare for and react to climate change. The indelible images of Hurricane Katrina in 2005 graphically illustrate the dangers of shoddy preparation.

4. The effects of climate change are not bounded by human jurisdictional designations. If climate change exacerbates wildfire risks in a national park, it will also do so for adjacent National Forest System lands.[208] The U.S. Climate Change Program's 2008 report on *Adaptation Options* finds that experience gained from natural resource management programs teaches us "that it may be necessary to define the management scale beyond the boundaries of a single habitat type, conservation area, or political or administrative unit to encompass an entire ecosystem or region."[209] It adds, "Although a single national park or national forest may have limited capacity for adaptation, the entire system of parks and forests and refuges in a region may have the capacity for adaptation."[210] Ultimately, "[t]he scale of the challenge posed by climate disruption and the uncertainty surrounding future changes demand coordinated, collaborative responses that go far beyond traditional 'agency-by-agency' responses to stressors or threats."[211]

207. Information on the likely rise in sea levels caused by climate change, for example, might help the NPS plan for the risk that the Everglades will be flooded as a result of the glacial melting caused by climate change. *See supra* notes 33–34 and accompanying text.

208. *See, e.g.*, Thrower, *supra* note 99, at 877:

> Although the outmoded equilibrium theory itself did not incorporate human boundaries in its definition of an ecosystem, the regulatory structure adopted during that period managed land based on artificial boundaries rather than on the ecosystem of which the land was a part. Examples of this focus on artificial boundaries include differing legal treatment for private versus public land, and for national parks versus national forests. In contrast, the nonequilibrium paradigm recognizes that activities outside of a legal boundary could affect an ecosystem inside the designated line.

209. ADAPTATION OPTIONS, *supra* note 19 at 9-35.

210. *Id.*

211. *Id.* at 9-36.

Accordingly, land managers must *make greater efforts to coordinate management* of the nation's public lands and resources, both among themselves and with state and local resource managers.[212] Greater information sharing among the land management agencies would represent one step toward this goal. Coordinated planning is another. The land management agencies typically plan for the management and use of discrete units, making it difficult "to fully consider the matrix in which [these units] are embedded and the extent to which those attributes may vary over time in response to drivers external to the management system. Climate change adaptation opportunities may be missed if land and water resources are thought of as distinct, static, or out of context of a regional and even continental area."[213]

Inter-agency cooperation to plan for an entire ecosystem is not unprecedented. In response to the controversy created by the application of NEPA and the ESA to logging and related activities within the habitat of the northern spotted owl, President Clinton in 1993 created an inter-agency, interdisciplinary team called the Forest Ecosystem Management Assessment Team. The Team recommended that the NFS and the BLM manage the lands in question by using an ecosystem management approach. In response, the two agencies in 1994 adopted the Northwest Forest Plan.[214] The Plan covered 24.5 million acres of land managed by the NFS and the BLM in Washington, Oregon, and northern California that is within the range of the northern spotted owl.[215] When the validity of the Plan was challenged, the courts upheld it.[216] The Plan had two principal goals: protection of the long-term health of the forest ecosystem, and provision of a sustainable supply of timber and other forest products.[217] One analyst deemed the Plan "a grand experiment in ecosystem planning . . . [that]

212. Periodically, legislators propose moving the Forest Service into the Interior Department to enhance the government's ability to manage its lands in coordinated fashion. Increasing firefighting costs have spurred recent proposals to that effect. Eric Bontrager, *GAO to Study Combining Agency with Interior,* GREENWIRE, Mar. 21, 2008, *available at* http://www.eenews.net/Greenwire/2008/03/21/13/; *see also* Healey et al., *supra* note 43 (finding increased wildfire activity in the western United States to be correlated to climate change, and recommending coordinated management to protect forests).

213. ADAPTATION OPTIONS, *supra* note 10, at 9-35.

214. Nw. Ecosystem Alliance v. Rey, 380 F. Supp. 2d 1175, 1181–82 (W.D. Wash. 2005).

215. *Id*. at 1182 n.2; *see also* Or. Natural Res. Council Fund v. Brong, 493 F.3d 1120, 1126 (9th Cir. 2007).

216. Seattle Audubon Soc'y v. Lyons, 871 F. Supp. 1291 (W.D. Wash. 1994), *aff'd sub nom*. Seattle Audubon Soc'y v. Moseley, 80 F.3d 1401 (9th Cir.1996).

217. *Nw. Ecosystem Alliance*, 380 F. Supp. 2d at 1182.

could determine the fate of hundreds of species."[218] The point is not that the Northwest Forest Plan was a complete success.[219] Rather, the point is that there may be more flexibility to arrange inter-agency planning efforts than is normally assumed.

There are limits to that flexibility, however. Only Congress, for example, has the authority to create or change the boundaries of wilderness areas.[220] As a result, if the land management agencies themselves are not capable of planning beyond the confines of the individual units they manage, either because the existing organic statutes prevent them from doing so or because of the fear of ceding jurisdiction and power to others, Congress should require that they do so and establish appropriate processes.[221]

5. As indicated above, one of the most significant effects of climate change will be species migrations. As a result, what is desert today may be grassland tomorrow, and what is tundra this year may be temperate forests the next. Joshua Tree National Park may soon be devoid of Joshua trees.[222] These kinds of shifts in the nature of the resources found in particular federal land units may require dramatic changes in the management directives that govern these units. To address these kinds of ecosystem disruptions, the President, the land management agencies, and Congress should use available authority to *change the status of particular land units*, *alter the mix of permissible uses*, and *alter the boundaries of adjacent units* (e.g., a national wildlife refuge next to a national forest) to accommodate species migrations and other climate-related changes in the condition and location of resources such as wildlife.[223]

218. Brent Foster, *The Failure of Watershed Analysis Under the Northwest Forest Plan: A Case Study of the Gifford Pinchot National Forest*, 5 HASTINGS W.-NW. J. ENVTL. L. & POL'Y 337, 337 (1999).

219. For commentary on the Plan, see Michael C. Soules, *An Analysis of Northwest Forest Plan Land Use Allocations*, 42 NAT. RESOURCES J. 353 (2002).

220. Wilderness Soc'y v. Norton, 434 F.3d 584, 592 (D.C. Cir. 2006) (stating that "it is clear from 16 U.S.C. § 1132(c) that only Congress can designate lands as wilderness"); Reeves v. United States, 54 Fed. Cl. 652, 668 (2002) (finding that FLPMA "provides that only Congress may actually designate land for wilderness preservation"); *see also* 3 COGGINS & GLICKSMAN, *supra* note 3, at § 25:1.

221. *See also* Noss, *supra* note 103, at 905 (listing as one of the basic principles of conservation biology the tenet that ecosystem boundaries should be determined by reference to ecology, not politics).

222. *See* Schwartz, *supra* note 21.

223. Species, like humans, may be able to acclimate to the changes that accompany climate change by adapting to changing physical conditions. If they are unable to do so, the remaining options may be to track current conditions as they move (presumably to cooler climates) or perish. For discussion of species migration in response to climate change, see *Biodiversity*, *in* CLIMATE CHANGE AND BIODIVERSITY (Thomas E. Lovejoy & Lee Hannah eds., 2005). Lovejoy and Hannah state that "In many instances, species will no longer be able to adjust their ranges to

To a certain extent, the land management agencies have authority to shift the nature of permissible uses within the lands they manage. For example, within limits, the Secretary of the Interior has the authority under FLPMA to make, modify, or revoke withdrawals.[224] FLPMA also delegates to the Secretary the power to modify or terminate classifications as part of the land use planning process.[225] The Forest Service and the BLM also have broad discretion under their organic acts to determine the extent to which each of the multiple uses authorized on their lands should be permitted.[226] In addition, the President has the power to reserve lands for particular uses and to exclude others. The Antiquities Act, for example, allows the President to reserve as national monuments federal lands of historic or scientific interest.[227] The agencies and the President should use these powers when appropriate to enhance the capacity of federal lands and resources to adjust to the ecosystem disturbances resulting from climate change. If a major restructuring of the federal land system map becomes necessary, however, Congress will need to take the lead in altering that map to enhance the resilience of federal lands and resources in the face of climate change.

6. Given the potential for climate change to cause resource devastation on a magnitude rarely seen to date, it may make sense to *change the balance of uses permitted* in the various federal land systems. If flooding, fire, or droughts linked to climate change result in soil erosion that significantly impairs water quality in streams or rivers, it may be appropriate to curtail uses that might exacerbate the risks of further erosion, such as grazing or off-road vehicle use.

The statutes that provide management authority to the dominant use[228] agencies (the NPS and the FWS, in its administration of the National Wildlife Refuge System) by definition preclude or

track changing climatic conditions. Implications of this reduced response may include genetic impoverishment or extinction." *Id*. at 325–26.

224. 43 U.S.C. § 1714(a) (2006); *see* 2 COGGINS & GLICKSMAN, *supra* note 3, at §§ 14:13 to 14:18.

225. 43 U.S.C. § 1712(d) (2006).

226. *See, e.g.*, Perkins v. Bergland, 608 F.2d 803, 806 (9th Cir. 1979) (characterizing the Multiple-Use, Sustained-Yield Act of 1960 as a statute that "breathe[s] discretion at every pore").

227. 16 U.S.C. § 431 (2006). *See generally* THE ANTIQUITIES ACT: A CENTURY OF AMERICAN ARCHAEOLOGY, HISTORIC PRESERVATION, AND NATURE CONSERVATION (David Harmon et al. eds., 2006); Christine A. Klein, *Preserving Monumental Landscapes Under the Antiquities Act*, 87 CORNELL L. REV. 1333 (2002); Mark Squillace, *The Monumental Legacy of the Antiquities Act of 1906*, 37 GA. L. REV. 473 (2003).

228. For discussion of the meaning of the concept of "dominant use" in the context of federal land management, see Jan G. Laitos, *The Multiple to Dominant Use Paradigm Shift in Natural Resources Management*, 24 J. LAND RESOURCES & ENVTL. L. 221 (2004).

subordinate some uses to the preservation goals they seek to promote.[229] Even the multiple use lands managed by the NFS and the BLM may be limited to less than all of the uses covered by the two agencies' organic statutes.[230] Agency discretion is probably broad enough under most of the organic acts to allow land managers to restrict or eliminate particular uses that are otherwise appropriate, at least in specific areas and until the threats have been reduced. The courts have tended to defer to efforts by the agencies to eliminate uses on the ground that pose threats to the accomplishment of statutory missions or to the resources the agencies are charged with managing.[231] But Congress should consider amending the statutes, particularly the multiple use, sustained yield statutes, to provide explicit authorization.

7. Activities that threaten to create damaging synergies with adverse conditions resulting from climate change are not confined to the federal lands. Development outside a federal land unit, for example, may prevent wildlife or plant species whose natural habitat has migrated from relocating to areas suited to their needs. The Property Clause of the Constitution[232] vests in the federal government the authority to regulate conduct on nonfederal land that threatens to harm federal parcels.

For more than a century, the courts have interpreted that power expansively.[233] In *Camfield v. United States*,[234] the U.S. Supreme Court endorsed the federal government's authority to order the abate-

229. *See* 16 U.S.C. § 1 (2006) (declaring that the purpose of the national parks is "to conserve the scenery and the national and historic objects and the wild life therein and to provide for the enjoyment of the same [so as to] leave them unimpaired for the enjoyment of future generations"); *id*. § 668dd (declaring the mission of the National Wildlife Refuge System to be "to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats . . . for the benefit of present and future generations of Americans").

230. *See* Wind River Multiple-Use Advocates v. Espy, 835 F. Supp. 1362, 1372 (D. Wyo. 1993), *aff'd*, 85 F.3d 641 (Table), 1996 WL 223925 (10th Cir. May 3, 1996) (recognizing that "some land will be used for less than all of the resources").

231. *See, e.g.*, Chistianson v. Hauptmann, 991 F.2d 59 (2d Cir. 1993) (upholding NPS's exclusion of seaplanes from Fire Island); S. Utah Wilderness Alliance v. Nat'l Park Serv., 387 F. Supp. 2d 1178 (D. Utah 2005) (upholding NPS regulation barring motorized access to certain portions of Canyonlands National Park); Niobrara River Ranch, L.L.C. v. Huber, 277 F. Supp. 2d 1020 (D. Neb. 2003) (upholding FWS moratorium on issuance of licenses for commercial recreation outfitters in response to evidence of potential harm to nesting birds), *aff'd*, 373 F.3d 881 (8th Cir. 2004).

232. U.S. CONST. art. IV, § 3, cl. 2 (vesting in Congress the "Power to dispose of and make all needful Rules and Regulations respecting the Territory or other Property belonging to the United States").

233. Peter Appel, *The Power of Congress "Without Limitation:" The Property Clause and Federal Regulation of Private Property*, 86 MINN. L. REV. 1, 94–96 (2001) (arguing that federal regulatory power over external activities posing threats to

ment of fences that interfered with access to public lands. *United States v. Alford*[235] upheld the authority of the federal government to prohibit leaving fires burning near national forests. According to Justice Holmes, "Congress may prohibit the doing of acts upon privately owned lands that imperil the publicly owned forests.[236] The lower courts have since recognized the federal government's constitutional authority to regulate the use of snowmobiles and motorboats on state and private inholdings within a federal wilderness area[237] and upheld the NFS's prohibition on the use of sailboats and houseboats by private owners possessing littoral rights in a lake within a federal wilderness area.[238]

The degree to which agencies are statutorily authorized to address external threats, or have an obligation to do so, is less clear, at least in certain instances. According to one source, "Congress seldom exercises [its power to control external threats], the land agencies seldom claim it, and the Department of Justice seldom asserts it in federal land litigation."[239] Agencies such as the NPS have succeeded in addressing some outside activities, such as spraying pesticides[240] and forcing reductions in air pollution that would have affected the Grand Canyon,[241] that created threats to federal lands and resources. Other, similar efforts have failed, however.[242] Indeed, the once-leading case recognizing a trust duty on the part of the NPS to protect park resources from external threats (in that case, logging practices on land adjacent to Redwoods National Park that were responsible for aesthetic and ecological damage within the park) has been "somewhat discredited."[243]

As a result, the scope of the authority of the land management agencies under existing law to control external threats is unclear and

federal lands or resources exists as long as the aggregated effects of the extraterritorial activities are "substantially related" to federal property).

234. 167 U.S. 518 (1897).

235. 274 U.S. 264 (1927).

236. *Id.* at 267; *see also* McKelvey v. United States, 260 U.S. 353 (1922).

237. Minnesota v. Block, 660 F.2d 1240 (8th Cir. 1977); *see also* Izaak Walton League of Am., Inc. v. Kimbell, 516 F. Supp. 2d 982, 997 (D. Minn. 2007).

238. Stupak-Thrall v. United States, 70 F.3d 881 (6th Cir. 1995), *aff'd by an equally divided court*, 89 F.3d 1269 (8th Cir. 1996).

239. 1 COGGINS & GLICKSMAN, *supra* note 3, at § 3:14; *see also Stupak-Thrall*, 70 F.3d 881 (asserting that "federal agencies have been extremely loathe to assert extraterritorial jurisdiction," despite the growing need to address the spillover effects of activities on adjacent lands).

240. United States v. S. Fla. Water Mgmt. Dist., 922 F.2d 704 (11th Cir. 1991); *see also* United States v. Moore, 640 F. Supp. 2d 164 (S.D. W. Va. 1986).

241. Central Ariz. Water Conservation Dist. v. EPA, 990 F.2d 1531 (9th Cir. 1993).

242. *E.g.*, United States v. City & County of Denver, 656 P.2d 1 (Colo. 1982) (unsuccessful effort to protect minimum stream flows within Dinosaur National Monument).

243. 1 COGGINS & GLICKSMAN, *supra* note 3, at § 3:14.

efforts to exercise it, when they have occurred, have achieved "mixed success."[244] According to Professors Sax and Keiter, existing law is particularly inadequate in vesting in the land management agencies the authority to cooperate with each other in addressing external threats.[245] This gap in statutory authority is particularly problematic if the issue is whether the land management agencies have the authority to cooperate in addressing threats to federal lands and resources that are linked to (or are likely to exacerbate the adverse effects caused by) climate change. As indicated above,[246] the problems posed by climate change will not respect the political boundaries separating federal from state or private land, or the divisions of federal jurisdiction among the land management agencies. Cooperation is essential to maximize the effectiveness of the federal government's efforts to protect its domain from the impacts of climate change and to take steps to increase the resilience of federally owned resources to climate change impacts that cannot be avoided. Although individual legislators from time to time have introduced bills that would expand agency authority to control activities posing external threats, either across the board or in particular circumstances, Congress has yet to enact any of them.[247] The land management agencies must have *enhanced authority to manage external threats* to the resources under their control. Commentators have characterized federal interagency efforts in particular to abate external threats as inadequate.[248] Congress should reinforce and expand that authority.

8. In certain instances, regulation of external threats will be politically impossible or legally difficult because of the effects it would have on the property rights of neighboring landowners. The federal land management agencies have no inherent authority to exercise the power of eminent domain.[249] They have some condemnation authority, however, either through specific statutory authorization or under

244. 3 COGGINS & GLICKSMAN, *supra* note 3, at § 23:5.

245. *See* Joseph L. Sax & Robert B. Keiter, *The Realities of Regional Resource Management: Glacier National Park and Its Neighbors Revisited*, 33 ECOLOGY L.Q. 233 (2006); Joseph L. Sax & Robert B. Keiter, *Glacier National Park and Its Neighbors: A Study of Federal Interagency Relations*, 14 ECOLOGY L.Q. 207 (1987) [hereinafter Sax & Keiter, *Glacier I*].

246. *See supra* notes 209–21 and accompanying text.

247. Some of this proposed legislation is discussed in Robert Keiter, *On Protecting the National Parks from the External Threats Dilemma*, 20 LAND & WATER L. REV. 355, 357 (1984); *see also* Harry R. Bader, *Not So Helpless: Application of the U.S. Constitution Property Clause to Protect Federal Parklands from External Threats*, 39 NAT. RESOURCES J. 193 (1999); William J. Lockhart, *External Threats to Our National Parks: An Argument for Substantive Protection*, 16 STAN. ENVTL. L.J. 3 (1997) (addressing the National Park Service's legal authority to deal with threats arising outside park boundries).

248. *See, e.g.*, Sax & Keiter, *Glacier I*, *supra* note 245.

249. 1 COGGINS & GLICKSMAN, *supra* note 3, at § 12:4.

the General Condemnation Act ("GCA").[250] Indeed, courts on occasion have interpreted statutes lacking an explicit delegation of condemnation authority to vest that power in federal agencies if it is necessary to achieve statutory purposes.[251] Congress also has authorized the land management agencies to engage in land exchanges.[252]

But existing authority to condemn and acquire by exchange is limited. Under the GCA, for example, an agency's authority to condemn is only as broad as its authority under other laws to acquire lands through voluntary transactions.[253] Laws authorizing condemnation often restrict the purposes for which it is appropriate. The BLM, for example, may condemn land only to provide access to federal lands and then only in the amount necessary for reasonable access.[254] In addition, President George W. Bush signed an executive order purporting to restrict federal condemnation authority.[255] Congress should *expand the power of the land management agencies to acquire or exchange land* as a means of abating the adverse consequences of climate change.[256] This expanded power should include allowing the land management agencies to exchange land among themselves if doing so would be consistent with the purposes of the land management systems involved and would promote the resilience of affected ecosystems to disturbances linked to climate change (such as by preserving corridors for wildlife migration likely to result from climate change).

Past partnerships between the government and non-governmental organizations demonstrate the potential utility of land acquisitions and exchanges to mitigate the adverse consequences of climate change. Private groups such as the Nature Conservancy and the Trust for Public Land have purchased undeveloped lands that provide wildlife habitat and arranged for their reconveyance to the federal

250. 40 U.S.C. § 257 (2000). The General Condemnation Act itself provides no acquisition authority. If that authority is supplied by another statute, however, the Act vests in the government broad discretion to select the tracts for condemnation. *See* United States v. Carmack, 329 U.S. 230, 254 n.5 (1946) (finding support in the legislative history for the conclusion that "Congress intended to give its agents . . . the fullest possible authority of Congress in selecting cities and sites").

251. *See, e.g.*, United States v. 1.33 Acres, 9 F.3d 70 (9th Cir. 1993).

252. *E.g.*, 16 U.S.C. § 668dd(b)(3) (2006) (FWS); 43 U.S.C. § 1716 (2000) (BLM).

253. United States v. Kennedy, 278 F.2d 121, 122 (9th Cir. 1960).

254. 43 U.S.C. § 1715(a) (2000).

255. Exec. Order No. 13,406, 71 Fed. Reg. 36,973 (June 23, 2006). The Order does not, however, restrict preexisting authority to condemn private property "to prevent or mitigate a harmful use of land that constitutes a threat to the public health, safety, or the environment." *Id*. § 3.

256. *But cf*. William H. Rodgers, Jr., *Adaptation of Environmental Law to the Ecologists' Discovery of Disequilibria*, 69 CHI.-KENT L. REV. 887, 889 (1994) (questioning whether condemnation of a fee simple in parklands and exclusion of inholders is always necessary to achieve protection of parks and wildlife).

government.[257] Congress has facilitated such transactions by providing tax credits for the participants. In some instances, the lands acquired were inholdings within the National Forest System. Consolidation of previously scattered government holdings can make it easier for the Forest Service to fight fires because it eliminates access issues.[258] Future transactions of this kind can result in safe harbors for species vulnerable to climate change or provide corridors of federal land that afford access for those species to areas suited to their needs.

9. The land management agencies must place *greater emphasis on protecting the integrity of entire ecosystems and protecting biodiversity* instead of focusing on the status of individual species deemed to be at risk due to climate change. As conservation biologists recognize, biodiversity strengthens the resilience of an ecosystem, and therefore its capacity to withstand stresses, including those caused by climate change.[259] It is impossible to predict the precise impacts of climate change. The elimination or addition of one species can trigger a cascade of changes in the ecosystem that supports it.[260] As Professor Mary Jane Angelo has noted, "[s]ome conservation biologists believe that the extinction of a keystone species could result in a domino effect whereby numerous species go extinct and the entire ecosystem is drastically altered."[261]

257. Kirk Johnson, *Deal Is Struck in Montana to Preserve Forest Areas*, N.Y. TIMES, July 1, 2008, at A14. Partnerships with private land trusts and conservation groups may alleviate some of the government's financial burden. *See, e.g.*, Colleen Luccioli, *Purchase of Claims Protects Idaho Wilderness Area from Potential of Renewed Mining*, LAND LETTER, Oct. 30, 2008, *available at* http://www.eenews.net/Landletter/2008/10/30/8/ (describing private-federal partnership to purchase about 6,000 acres of mining claims in an Idaho wilderness area).

258. Johnson, *supra* note 257, at A14.

259. *See supra* notes 108, 121–22 and accompanying text.

260. *See, e.g.*, William J. Ripple & Robert L. Beschta, *Trophic Cascades Involving Cougar, Mule Deer, and Black Oaks in Yosemite National Park*, 141 BIOLOGICAL CONSERVATION 1249 (2008) (discussing "trophic cascade" of widespread changes in an ecosystem that follows removal of a top predator).

261. Mary Jane Angelo, *Embracing Uncertainty, Complexity, and Change: An Eco-Pragmatic Reinvention of a First-Generation Environmental Law*, 33 ECOLOGY L.Q. 105, 135 (2006) (citing MALCOLM L. HUNTER, JR., FUNDAMENTALS OF CONSERVATION BIOLOGY 74 (1996)); *see also* Bo Ebenman et al., *Community Viability Analysis: The Response of Ecological Communities to Species Loss*, 85 ECOLOGY 2591, 2591 (2004) (describing how "[t]he loss of a species from an ecological community can set up a cascade of secondary extinctions that in the worst case could lead to the collapse of the community"); Roger Fleming & Dr. John D. Crawford, *Habitat Protection Under the Magnuson-Stevens Act: Can It Really Contribute to Ecosystem Health in the Northwest Atlantic?*, 12 OCEAN & COASTAL L.J. 43, 60 (2006) (summarizing scientists' claim that "the decimation of the cod and other large groundfish species has led to 'cascade effects': declines in top-predator abundance which in turn allow populations that would otherwise serve as prey

Recent changes observed in Yellowstone National Park are illustrative. Canada thistle is a plant that originated in the Mediterranean but that appeared in Yellowstone more than a century ago. The plant was kept in check by temperatures higher than those in which it thrives. As temperatures have warmed in Yellowstone, the thistle has flourished. The thistle has doubled its range along the Lamar River valley just since 1989, as drought conditions have allowed it to invade drier ground. The spread of Canadian thistle has benefitted the Park's pocket gophers, who feed on its starchy roots. As the gophers tunnel underneath the tubers, they churn up the surface soil, facilitating the growth of even more thistle. In addition, grizzly bear populations appear to have grown because the bears feed on pocket gophers.[262]

Congress has recognized the importance of protecting ecosystems. The enabling act for the FWS's administration of the National Wildlife Refuge System, for example, directs the agency, in administering the System, to "plan and direct the continued growth of the System in a manner that is best designed to accomplish the mission of the System, to contribute to the conservation of ecosystems of the United States."[263] The stated function of the ESA is "to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved."[264] But the agencies responsible for managing federal lands and resources too often lose sight of the forest for the trees. Critics have charged, for example, that the ESA's substantive provisions tend to be focused on preservation of individual species, instead of species habitat.[265] According to Holly Doremus, "[t]he species-by-species focus of the ESA precludes effective protection of biological diversity, which should properly be the focus of pro-

for groundfish, such as herring, shrimp, crab, and lobster, to grow rapidly and dominate the food web").

262. Jim Robbins, *In a Warmer Yellowstone, a Shifting Environmental Balance*, N.Y. TIMES, Mar. 18, 2008, at F3. A non-climate change-related example makes the same point. The reintroduction by the NPS of wolves into Yellowstone National Park and its environs (where the wolves had once existed naturally but no longer did) has had significant, and perhaps unanticipated effects. The reintroduced wolves have killed half of the coyotes in the area. In the absence of coyotes, the prey of those animals, including rodents, have thrived. In turn, other rodent predators, such as hawks and eagles, benefited. Further, the reintroduction of wolves affected aspen trees because of their impact on the ability of elks and moose to feed on those trees. DALE D. GOBLE & ERIC T. FREYFOGLE, WILDLIFE LAW: CASES AND MATERIALS 1287 (2002).

263. 16 U.S.C. § 668dd(a)(4)(C) (2006); *cf. id.* § 668dd(a)(2) (describing the mission of the System to be the administration of "a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States").

264. 16 U.S.C. § 1531(b) (2006).

265. *See, e.g.*, JOHN COPELAND NAGLE & J.B. RUHL, THE LAW OF BIODIVERSITY AND ECOSYSTEM MANAGEMENT 190 (2d ed. 2006).

tective policy."[266] Other scholars have suggested strategies for shifting the focus of the ESA to protection of biodiversity and ecosystem integrity.[267]

The federal land management agencies should prioritize biodiversity protection rather than disable statutory and regulatory provisions designed to accomplish that, as the NFS has done in its shifting interpretations of the NFMA's biodiversity provisions.[268] The organic statutes of those agencies provide them with some authority to do so.[269] If statutes such as the ESA focus too narrowly on preservation of individual species in isolation, Congress should amend them to require the administering agencies to broaden their focus.

Congress also should consider amending the NFMA's diversity requirement to reduce the potential for the NFS's implementation of it to undermine rather than promote protection of the resilience of natural systems in responding to human and natural disturbances. The statute requires the NFS to build mechanisms into its land and resource management plans that "provide for diversity of plant and animal communities."[270] The NFS regulations in effect before 2000 required that management prescriptions "preserve and enhance the diversity of plant and animal communities . . . so that it is at least as great as that which would be expected in a natural forest and the diversity of tree species similar to that existing in the planning area."[271] The Sierra Club challenged the NFS's failure to manage the Chequamegon and Nicolet National Forests in a manner consistent with principles of conservation biology, alleging a violation of the statutory requirement.[272] In particular, the Sierra Club claimed that the diversity provision required the NFS to set aside large, unfragmented habi-

266. Doremus, *supra* note 161, at 265. Professor Doremus argues that "[b]roadening the focus of federal policy beyond individual species would result in more efficient and more effective protection of the full range of biological resources in this country." *Id*. at 268.

267. *See, e.g.*, William Snape III et al., *Protecting Ecosystems Under the Endangered Species Act: The Sonoran Desert Example*, 41 WASHBURN L.J. 14 (2001); Federico Cheever, *The Road to Recovery: A New Way of Thinking About the Endangered Species Act*, 23 ECOLOGY L.Q. 1 (1996) (urging greater reliance on the provisions relating to species recovery).

268. *See* Glicksman, *supra* note 128.

269. *E.g.*, 16 U.S.C. § 1604(g)(3)(B) (2006) (directing the NFS to issue regulations for developing land management plans that "provide for diversity of plant and animal communities"); 43 U.S.C. § 1701(a)(8) (2000) (establishing a policy of managing the BLM public lands "in a manner that will protect the quality of . . . ecological . . . values"); *id*. § 1702(c) (defining "multiple use" to include "coordinated management of the various resources without permanent impairment of the productivity of the land and the quality of the environment").

270. 16 U.S.C. § 1604(g)(3)(B).

271. 36 C.F.R. § 219.26 (2000).

272. Sierra Club v. Marita, 46 F.3d 606 (7th Cir. 1995).

tats to protect at least some old-growth forest communities.[273] The court rejected the challenge, pointing out that the planning regulations "do not actually require the promotion of 'natural forest' diversity but rather the promotion of diversity at least as great as that found in *a* natural forest."[274] That interpretation leaves open the possibility that the NFS can comply with the diversity that would be characteristic of a different natural forest ecosystem than the ecosystem being managed. Even if the forest that the NFS chooses as its management model were to contain a greater number of species than the forest in question would support in its natural state, the model forest might not be capable of providing the same degree of ecological resilience to disturbances that the natural forest in question could have provided.[275] The NFMA should require management that protects the kind of diversity that contributes to ecosystem resilience, not management that seeks to mimic the array of diversity found in *any* natural forest, regardless of the value of the diversity at issue in contributing to resilient ecosystems.

10. Statutory and regulatory directives to plan for climate change, rely on adaptive management, regulate external threats, or protect biodiversity are meaningless if the land management agencies fail to abide by them. It is critical that the agencies be accountable. Judicial review is perhaps the most important avenue to ensure it. Individual statutes, such as the ESA[276] and the Administrative Procedure Act,[277] authorize judicial review of both agency actions and failures to act. But judicial decisions have narrowed opportunities for judicial review, making it more difficult to hold the land management agencies accountable for failing to abide by their statutory responsibilities.[278]

Congress should *restore the ability of adversely affected or otherwise interested members of the public to seek judicial review of land management agency decisions*, to the extent that Article III of the Constitution permits. To accomplish that end, it should consider waiving the statutory limitations, such as the zone of interest test,[279] for liti-

273. *Id*. at 620.
274. *Id*. at 621 (emphasis added).
275. *Cf.* CHRISTINE KLEIN ET AL., NATURAL RESOURCES LAW: A PLACE-BASED BOOK OF PROBLEMS AND CASES 347 (2005) (comparing the usefulness of preserving a suburban backyard containing a large array of plant and animal species with the usefulness of preserving an undisturbed forest, with a closed canopy of ancient trees, that contains relatively few species).
276. 16 U.S.C. § 1540(g) (2006).
277. 5 U.S.C. §§ 702, 704, 706 (2006).
278. *See, e.g.*, Norton v. S. Utah Wilderness Alliance, 542 U.S. 55 (2004) (restricting judicial review of agency inaction); Ohio Forestry Ass'n v. Sierra Club, 523 U.S. 726 (1998) (restricting judicial review of land use plans).
279. Statutory limitations on standing are derived from provisions such as the APA's requirement that litigants demonstrate that they have "suffer[ed] legal wrong because of agency action, or [been] adversely affected or aggrieved by agency ac-

gants challenging decisions by the land management agencies on the ground that those decisions fail to protect biodiversity on federal lands. In addition, Congress should consider waiving the prudential limitations on standing,[280] such as the prohibition on relying on the rights of third parties or on bringing suits to redress generalized grievances, that would otherwise permit Congress and the courts to restrict opportunities for those same litigants to sue in federal court to a narrower range of circumstances than the Constitution allows.

B. Specific Examples of Desirable Mitigation and Adaptation Measures

What kinds of initiatives to manage federal lands to promote resilience and mitigate and adapt to climate change might these ten general recommendations enable the land management agencies to pursue? The stewardship framework sketched out above would facilitate efforts to use the federal lands to minimize both the extent to which human activities contribute to climate change and the degree to which the climate change that cannot be prevented wreaks havoc on the nation's human and natural resources.

1. Mitigation Measures

The federal lands have the potential to mitigate climate change through carbon sequestration. Congress has already taken preliminary steps in that direction. The Energy Independence and Security Act of 2007 requires the Secretary of Interior to spearhead preparation of a multi-agency report to Congress on a framework for managing geological carbon sequestration activities on public lands.[281] The report must include criteria for identifying candidate geological sequestration sites in operating and depleted oil and gas fields, unmine-

tion *within the meaning of a relevant statute*." 5 U.S.C. § 702 (2006) (emphasis added); *see* Nat'l Credit Union Admin. v. First Nat'l Bank & Trust Co., 522 U.S. 479, 489 (1998) (explaining derivation of the zone of interest test from § 702 of the APA). The Supreme Court has recognized Congress's authority to eliminate the zone of interest requirement by vesting the power to sue in "any person." *See* Bennett v. Spear, 520 U.S. 154, 164 (1997) (addressing whether the ESA's citizen-suit provision, 16 U.S.C. § 1540(g), "negates the zone-of-interests test" and concluding that it does).

280. *See* Elk Grove Unified Sch. Dist. v. Newdow, 542 U.S. 1, 12 (2004) (stating that although the Supreme Court has "not exhaustively defined the prudential dimensions of the standing doctrine, we have explained that prudential standing encompasses 'the general prohibition on a litigant's raising another person's legal rights [and] the rule barring adjudication of generalized grievances more appropriately addressed in the representative branches'").

281. Pub. L. No. 110-140, § 1714(b)(1), 121 Stat. 1492, 1715 (2007); *see generally* Karl Schulz, *Evaluating the Energy Independence and Security Act of 2007: Inclusions, Exclusions, and Problems with Implementation*, 38 ENVTL. L. REP. 10763 (Nov. 2008).

able coal seams, deep saline formations and systems used to extract heat from geothermal resources, and coalbeds used for methane recovery. The report also must include a proposed regulatory framework for the leasing of federal lands or interests for long-term CO_2 sequestration, and recommend additional legislation that may be required to ensure that public land management and leasing laws are adequate to accommodate long-term carbon sequestration.[282]

Agencies other than the federal land management agencies have begun work on assessing the practicability of carbon sequestration and promoting the development of the necessary technologies. The Department of Energy has initiated a carbon sequestration program whose goal is to develop by 2012, at research and development scale, fossil fuel conversion systems capable of capturing ninety percent of CO_2 emissions with ninety-nine percent storage permanence at less than a ten percent increase in the cost of energy services from new plants.[283] The EPA has proposed regulations under the Safe Drinking Water Act[284] for underground injection of CO_2 for the purpose of geologic sequestration as a means of mitigating climate change.[285] The feasibility and effectiveness of large-scale sequestration of this sort is far from proven, however.[286] Further, the risk of long-term leakage of buried CO_2 raises questions about the willingness of insurance companies to cover these activities.[287]

282. Pub. L. No. 110-140, § 1714(b)(1), 121 Stat. 1492, 1715.

283. Regulating Greenhouse Gas Emissions Under the Clean Air Act; Advanced Notice of Proposed Rulemaking, 73 Fed. Reg. 44,354, 44,370 (proposed July 30, 2008).

284. 42 U.S.C. §§ 300f to 300j-26 (2000 & Supp. 2005).

285. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,492 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

286. *See, e.g.*, Ann E. Carlson, *Implementing Greenhouse Gas Emission Caps: A Case Study of the Los Angeles Department of Water and Power*, 55 UCLA L. REV. 1479, 1502 (2008) (describing report concluding that "technical limitations pertaining to large-scale sequestration appear to be manageable, and that sequestration may be safe, feasible, and competitively priced if carbon emissions are regulated," but that "to move toward large-scale carbon sequestration in the near future requires . . . a significantly ramped-up government-driven effort to fund necessary research and development"). Credit Suisse Group estimated in late 2008 that carbon sequestration probably would not be ready for commercial use for ten more years. *Carbon Capture and Storage Needs $15B Investment - Analysts*, GREENWIRE, Oct. 31, 2008, *available at* http://www.eenews.net/Greenwire/2008/10/31/13/. Carbon sequestration is already mandatory in parts of Europe. Leslie R. Dubois, Comment, *Curiosity and Carbon: Examining the Future of Carbon Sequestration and Accompanying Jurisdictional Issues As Outlined in the Indian Energy Title of the 2005 Energy Policy Act*, 27 ENERGY L.J. 603, 613 (2006).

287. *See* Evan Lehmann, *The Risks of Carbon Capture Are Small But Troubling*, CLIMATEWIRE, Oct. 29, 2008 (discussing report issued by the World Resources Institute).

Congress and the land management agencies can provide additional opportunities for carbon sequestration through restrictions on timber harvesting. As the Pew Center on Global Climate Change has concluded, "[c]limate change is the major global environmental challenge of our time and in order to deal with it in the most cost-effective way, we need to consider the full range of solutions—and that includes carbon storage and forests."[288] "According to EPA estimates, growing a Douglass fir forest for a century is twenty-five to fifty percent more efficient at reducing CO_2 buildup than using an equivalent amount of land to grow biofuels."[289] Moreover, recent scientific research debunks the conventional wisdom that old-growth forests cease to accumulate carbon and are carbon neutral. One study concluded that "[o]ld-growth forests accumulate carbon for centuries and contain large quantities of it."[290] When these forests are logged, much of the carbon is released, as is additional carbon in the soil.[291]

The effectiveness and efficiency of sequestering carbon through the retention and growth of forest resources should induce federal land managers to place a priority on preserving these carbon sinks through techniques such as declaring old-growth forests off-limits to timber harvesting, imposing limitations on road construction in forested areas, and reducing the susceptibility of forests to destruction by fire or pest infestation. Reforestation of denuded areas should also be pursued.[292] Similarly, grasslands provide sinks for both carbon and methane. Restrictions on grazing capable of facilitating desertification can enhance the sequestration potential of these areas.[293]

Congress and the federal land management agencies can mitigate climate change by helping wean America from its dependence on fossil fuels. Restrictions on leasing of federal lands for the extraction of fossil fuels are one way to contribute to that effort. Use of the federal lands to produce biofuels (such as through the conversion of dead trees

288. Peter L. Gray & Geraldine E. Edens, *Carbon Accounting: A Practical Guide for Lawyers*, 22 NAT. RESOURCES & ENV'T 41, 44 (Winter 2008) (quoting from Pew Center report).

289. *Id*.

290. Sebastiaan Luyssaert et al., *Old-Growth Forests as Global Carbon Sinks*, 455 NATURE 213 (Sept. 11, 2008).

291. *Id*.

292. *See* Manuel Guariguata, *Interlinkages Between Biodiversity and Climate Change*, *in* UNITED NATIONS ENV'T PROGRAMME AND SECRETARIAT OF THE CONVENTION OF MIGRATORY SPECIES OF WILD ANIMALS, MIGRATORY SPECIES AND CLIMATE CHANGE: IMPACTS OF A CHANGING ENVIRONMENT ON WILD ANIMALS 10 (2006) (urging planting a variety of native tree species instead of a monoculture to reduce the probability of pest incidence, restore key watershed functions, and promote ecological connectivity between forest fragments).

293. *See* Yamond P. Motha & Wolfgang Baier, *Impacts of Present and Future Climate Change and Climate Variability on Agriculture in the Temperate Regions: North America*, 70 CLIMATIC CHANGE 137, 160 (2005).

into cellulosic ethanol) is another.[294] Finally, reducing the allowable degree of motorized recreation on federal lands can help reduce GHG emissions.

2. Adaptation Measures

Adaptation involves adjustments in management techniques in response to climate change and its effects. The function of adaptation is to reduce the risk that climate change will result in adverse changes to federal lands and resources by increasing the resilience of natural systems to withstand stresses caused by climate change.[295] According to a recent government study of the impact of climate change on sensitive ecosystems and resources in the United States, managers should strive to avoid changes that an ecological system is incapable of absorbing without undergoing a fundamental shift in processes or structures.[296]

Adaptation can be either anticipatory (or preventive) or reactive. *Anticipatory measures* to increase natural system resilience and integrity might include measures to protect natural systems that remain intact and relatively undisturbed.[297] Thinning of forests, prescribed burning, and the creation of fuel breaks can all contribute to minimizing the risk of damage from wildfires, insects, and air pollution. Prohibiting road construction and restricting developments such as ski area facilities can help prevent habitat fragmentation. Planting resistant species in multiple locations may reduce the risk that the species will be eliminated from a particular area. Similarly, efforts to preserve a diverse gene pool will tend to enhance protection of biodiversity.[298] The creation of habitat corridors for species threatened by species migration and the other adverse effects of climate change can remove impediments to species movement by creating connectivity between the species' old habitat and areas better suited to their needs in light of the physical changes resulting from climate

294. *See* Eryn Gable, *Can Dead Wood Fuel the Future?*, LAND LETTER, Feb. 28, 2008, *available at* http://www.eenews.net/Landletter/2008/02/28/1/.

295. *See* Joint Science Academies' Statement: Climate Change Adaptation and the Transition to a Low Carbon Society (June 2008), *available at* http://royalsociety.org/downloaddoc.asp?id=5450 (recommending that, "[a]s an immediate first step, governments can take measures to improve resilience to existing environmental stresses"); *see also* ADAPTATION OPTIONS, *supra* note 10, at 9-16 (describing the goal of adaptation as "reduc[ing] the risk of adverse environmental outcomes through activities that *increase the resilience* of ecological systems to climate change").

296. ADAPTATION OPTIONS, *supra* note 10, at 9-16.

297. *See, e.g.*, Dean, *supra* note 34 (explaining that "environmentally intact salmon streams will undoubtedly be useful if new species move into them" and that "even if much of the Everglades is lost to a rise in sea level, preserving the rest will be crucial for maintaining fresh water supplies in South Florida").

298. *See* Welch, *supra* note 174, at 82.

change.[299] So can installation of fish passages. Agencies can protect ecologically critical coastal areas by elevating land surfaces, modifying drainage systems, stabilizing dunes, and building dikes.[300]

Proactive adaptive measures also might include restoring natural systems that have degraded for reasons unrelated to climate change to a healthier state so that they become more resistant to climate change. Agencies can buttress natural capacity to withstand climate change stresses by restoring flood plains and riparian buffers and augmenting low flows in rivers and streams that provide habitat for susceptible aquatic species. Agencies can reduce water withdrawals from rivers experiencing low flows that increase sediment and pollutant concentrations or otherwise threaten aquatic life. Finally, land managers should restrict activities occurring on federal lands or external activities over which they have jurisdiction that are likely to combine with climate-related stresses to produce unwanted synergies. These might include restricting fishing in overexploited areas or limiting air pollution that might weaken plant life and make it more susceptible to climate-related threats. To accomplish the latter, the agencies might restrict automobile off-road vehicle use on significant portions of the lands they supervise in order to cut emissions of ozone precursors. Federal land managers should use their CAA authority to block the permitting of stationary sources that would emit pollutants that can contribute to acid rain that damages trees and acidifies surface waters.[301]

Adaptation also may take the form of *reacting to problems as they develop*. Land managers, for example, can facilitate migration to more suitable areas of species whose traditional habitat is no longer capable of sustaining them.[302] Until recently, the risks of such assisted migration (or assisted colonization) efforts seemed to outweigh the benefits. Human-assisted migration of plant or animal species to areas in which the transplanted species are not native creates some of the same risks that the unintentionally assisted movement of invasive species does, including the spread of parasites and the alteration of

299. The Western Governors' Association has agreed to identify and protect wildlife migration corridors. WESTERN GOVERNORS' ASS'N, WILDLIFE CORRIDORS INITIATIVE (June 2008).

300. *See* John C. Field et al., *Potential Consequences of Climate Variability and Change on Coastal and Marine Resources*, *in* CLIMATE CHANGE IMPACTS ON THE UNITED STATES: THE POTENTIAL CONSEQUENCES OF CLIMATE VARIABILITY AND CHANGE 461, 481 (2001), *available at* http://www.usgcrp.gov/usgcrp/Library/nationalassessment/foundation.htm.

301. *See* Linda Joyce et al., *Potential Consequences of Climate Variability and Change for the Forests of the United States*, *in* CLIMATE CHANGE IMPACTS ON THE UNITED STATES: THE POTENTIAL CONSEQUENCES OF CLIMATE VARIABILITY AND CHANGE 489, 495 (2001), *available at* http://www.usgcrp.gov/usgcrp/Library/nationalassessment/foundation.htm.

302. *See, e.g.*, Dean, *supra* note 34 (describing assisted migration).

local genetic populations.[303] But assisted migration is attracting attention now as a potential strategy in certain low-risk situations (involving populations from areas in which they are seriously threatened by climate change to other parts of the same biogeographic region) in which more traditional conservation practices are not enough to avoid species losses linked to climate change.[304] In particular, assisted migration may provide the best option for saving a species that is threatened by climate change and whose movement to more suitable habitat is blocked by human development.[305] Acquisition of fee interests or conservation easements might aid in assisted migration efforts. Other nations have already proposed or created wildlife "highways" to assist the movement of animals seeking to escape conditions in which their viability is now threatened as a result of climate change.[306]

Agencies can introduce species to areas they previously inhabited but no longer do as a result of human activities, provided the reintroduction sites are better capable of supporting the transplanted species than their current habitat is. The NPS's successful gray wolf reintroduction project in the Yellowstone National Park area during the 1990s might provide a model, despite controversy and uncertainty over the legality of various aspects of the effort under the ESA.[307] By 2007, the northern Rocky Mountain wolf population had achieved the FWS's numerical recovery goal of 30 breeding pairs and 300 wolves for eight consecutive years, although it had not achieved genetic exchange among the three subpopulations.[308] Indeed, the effort was so successful that the FWS sought to reduce protections for the wolf under the ESA by delegating management responsibility for the wolf's fate to the states and delisting at least some of the animals.[309] A federal district

303. *See* O. Hoegh-Guldberg et al., *Assisted Colonization and Rapid Climate Change*, 321 SCIENCE 345 (July 18, 2008).

304. *Id*. (urging resource managers to "contemplate moving species to sites where they do not currently occur or have not been known to occur in recent history," even though that strategy "flies in the face of conventional conservation approaches").

305. *Id*. (citing the endangered Quino checkerspot butterfly as an example).

306. *See, e.g.*, *"Highway" to Allow Species to Escape from Warming*, CLIMATEWIRE, Apr. 24, 2008 (discussing thirty-mile long road in Gloucestershire, England).

307. *See* Wyo. Farm Bureau Fed'n v. Babbitt, 199 F.3d 1224 (10th Cir. 2000) (holding that the wolf reintroduction effort did not violate the provisions of the ESA governing experimental populations, 16 U.S.C. § 1539(j)); United States v. McKittrick, 142 F.3d 1170 (9th Cir. 1998) (same).

308. Defenders of Wildlife v. Hall, 565 F. Supp. 2d 1160, 1165 (D. Mont. 2008).

309. *See, e.g.*, Endangered and Threatened Wildlife and Plants; Final Rule Designating the Northern Rocky Mountain Population of Gray Wolf as a Distinct Population Segment and Removing This Distinct Population Segment From the Federal List of Endangered and Threatened Wildlife, 73 Fed. Reg. 10,514 (Feb. 27, 2008) (to be codified at 50 C.F.R. pt. 17); Endangered and Threatened Wildlife and Plants; Revision of Special Regulation for the Central Idaho and Yellowstone Area Nonessential Experimental Populations of Gray Wolves in the Northern Rocky Mountains, 73 Fed. Reg. 4720 (Jan. 28, 2008) (to be codified at 50 C.F.R.

court later preliminarily enjoined those agency actions, concluding that they likely violated the ESA.[310]

Land managers might be able to provide food sources for species experiencing phenological disruptions until they are capable of migrating. Where feasible, they should control nonnative species that are able to invade formerly inhospitable terrain due to climate change and that threaten to crowd out native species. They should try to restore habitat degraded by fire, flooding, or drought to which climate change contributed. They should restrict or ban fishing and hunting of species that appear to be at risk, even if they are not listed under the ESA.

Anticipatory adaptive measures are generally preferable to reactive ones. The former are likely to be both more efficient and effective, just as preventing pollution tends to cost less and protect resource value better than after-the-fact remediation. Anticipation is particularly important when the consequences of acting too late may be irreversible, such as species extinctions. The precautionary approach to environmental protection has long been the hallmark of federal pollution control statutes such as the CAA. Congress should endorse its application in the natural resource management context more clearly than it has done and require federal land managers to use the expanded information at their disposal and the revised planning processes described above to minimize the vulnerability of federal lands and resources to climate change.

V. CONCLUSION

Climate change presents a challenge to federal land managers that is unlike anything they have addressed before. First, the variety and magnitude of the impacts that climate change may have on federal lands and resources are likely to far exceed those resulting from any single phenomenon or activity in the past. Climate change is capable of changing meadows to forests, grasslands to deserts, and wetlands to lands completely submerged by rising sea levels. Each of these changes is likely to trigger a cascade of impacts on plants, wildlife, and other components of the affected ecosystems. Second, despite the

pt. 17). Park Service biologists predicted, however, that the Yellowstone wolf population would decrease significantly in the winter of 2008–09 as a result of disease to which wolf pups are vulnerable and attacks by wolves on each other. Compression of the wolf's habitat has been linked to infighting among wolves. *See Disease, Infighting Decreasing Yellowstone's Wolf Population*, GREENWIRE, Oct. 29, 2008. This prediction highlights the need for a precautionary approach to management of wildlife species and other resources on federal lands, and cautions against declaring victory and moving on too soon.

310. *Hall*, 565 F. Supp. 2d 1160 (preliminary injunction reinstating Rocky Mountain gray wolf after designation of distinct population segment and delisting).

development of more sophisticated climate models, the location, timing, and magnitude of these effects is highly uncertain, in part because the level of future GHG emissions is unknown.

Congress drafted most of the federal land management statutes well before the threats posed by climate change were widely acknowledged or understood. In addition, as section III.A above illustrates, the scientific foundations of managing natural systems have shifted since the adoption of these laws. The organic statutes of the land management agencies tend to delegate to them broad discretion to govern the use of federal lands and resources, and the courts often defer to the exercise of that discretion. The existing statutory framework provides the agencies with the authority to take some steps to protect federal lands and resources from the threats posed by climate change. The agencies, however, have apparently been slow to respond to those threats,[311] and the courts have in several instances reversed their decisions for failure to consider climate change impacts as required by NEPA and the ESA.

This Article argues that the decisions of the land management agencies to date have not taken adequate account of climate change and that, in important respects, the existing statutory framework provides them with insufficient authority to do so. In order to protect federal lands and resources from the potential ravages of climate change, the agencies must reduce the degree to which federal land use generates GHG emissions that contribute to climate change, take advantage of available opportunities to use federal lands as carbon sinks that help to reduce atmospheric concentrations of the GHGs that contribute to climate change, and prepare for the consequences of any climate change that cannot be avoided by protecting biodiversity on all federal land systems in an effort to make those systems more resilient and therefore more likely to withstand the disturbances resulting from climate change without ecosystem collapse. The discussion above provides some initial suggestions for how the agencies may accomplish those goals. It also provides recommendations for amending the public land laws to enhance their authority to do so and to require that they prepare for, rather than ignore, the threats posed by climate change.

311. David Adelman and Kirsten Engel have pointed out, for example, that "[i]t took decades for foresters to appreciate the important role that fire plays in maintaining the biological diversity and resilience of forest ecosystems and for them to alter their policies" and that in this and other situations involving threats to biodiversity "the phenomena are complex, the data are scarce, and understanding is thin." David E. Adelman and Kirsten H. Engel, *Adaptive Federalism: The Case Against Reallocating Environmental Regulatory Authority*, 92 MINN. L. REV. 1796, 1815 (2008). As indicated above, climate change is likely to increase the risk of wildfires on federal lands. *See supra* notes 43–48 and accompanying text.