



CLIMATE CHANGE IN THE UNITED STATES

Expected Environmental Impacts
and Necessary Federal Action

Molly K. Macauley and Daniel F. Morris

There is little doubt that adapting to a changing climate will be necessary in the years ahead. Climate adaptation is generally defined as the range of steps taken to respond to climatic changes such as increases in the frequency of extreme weather, longer and more severe droughts, a rising sea level, and other effects. The term

also can include additional steps to shore up resiliency against extremes, by protecting shorelines from ocean encroachment as sea level rises, for instance. Some climatic changes may be beneficial as well, such as longer growing seasons in some regions.

Many actions are likely to be taken by the private sector as businesses and consum-

Corbis



Waves explode over a seawall and into Galveston, Texas as Hurricane Ike approaches on September 12, 2008.

ers adapt naturally, perhaps without much problem. Here, insurance for floods and other disasters provides a buffer for economic losses. Actions may also be required of the government, however, including federal, regional, state, and local officials. What role exists for government has received little attention until quite recently, when the U.S. Global Change Research Program, a federal interagency effort established by the 1990 Global Change Research Act, began to include climate adaptation on its list of priorities.

Acknowledging this gap, Resources for the Future in 2008 launched its Domestic Adaptation Project. While climate impacts and adaptation in developing countries had long been recognized and under way, little attention had been accorded adaptation in the United States. This spring RFF released a summary report and findings from the project, containing over 30 specific policy

recommendations for the role of the federal government in helping the nation adapt to a changing climate.

What are the expected effects of a changing climate?

The project began with six independently authored reports summarizing the state of scientific understanding of the possible effects of a changing climate on the United States. The reports considered agriculture, coastal and marine resources, freshwater resources, infrastructure, public health, and terrestrial ecosystems. (These sectors were chosen to conform to the sectors on which the efforts of the United Nation's Intergovernmental Panel on Climate Change have long been focused.) The reports highlighted several main findings in synthesizing the scientific literature:

Agriculture

Assessments of agricultural effects vary widely, but many indicate that the U.S. food supply is under little threat from climate changes. Carbon dioxide fertilization may offset some effects of temperature and precipitation changes. Agricultural productivity in the southern part of the country is likely to decline and be more vulnerable to drought and extreme temperatures, whereas northern areas may receive increased precipitation and become more productive. Livestock production may decline overall as a result of higher summer temperatures unless livestock management practices advance to mitigate this risk.

Coastal and Marine Resources

Effects on marine and coastal systems carry a host of concerns, ranging from changes in ocean and air temperatures to acidification, increased freshwater runoff, ice loss in the Arctic, sea level rise, and changes in upwelling and ocean circulation. These



effects place stress on some marine ecosystems that already suffer from overfishing and land-based pollution. Coral reefs are of particular concern because they are already in decline. Coastal and marine effects will vary widely across the nation, however. Some communities will be more vulnerable than others and in all coastal areas, land use is a closely related concern.

Freshwater Resources

Increased variability in precipitation extremes across the United States will be an issue, including large floods and prolonged droughts. Water availability for both human uses and ecosystems will

become less predictable with a changing climate. Moreover, reduced volumes of water in rivers and lakes due to increased evaporation may have long-term hydrological consequences as well as implications for water quality. The frequency and extreme nature of future weather events could push the adaptive capacities of human and natural systems to their limits in the absence of additional action.

Infrastructure

Public infrastructure—such as transportation, energy generation and transmission, water and sewer systems, telecommunications, and coastal defense—will experience climate effects in different ways. Some infrastructure has been engineered to have built-in tolerance to extreme events, including sea level rise, water scarcity, temperature changes, and demand-induced effects such as increased electricity consumption. Public infrastructure often is long-lived with a regular maintenance schedule, which provides an opportunity to routinely improve adaptive capacity. Some costs of improvement, however, may grow too large to sustain over the long term, requiring new investment altogether.

Public Health

Climate change will not introduce new sources of morbidity and mortality in the United States, but may alter the factors that lead to them. Effects include heat stress and heat waves, exacerbation of aeroallergen distribution and allergic diseases, changes in the nature and patterns of epidemic infectious diseases, and increased ambient air pollution. The public health community differs in perspective as to what level of urgency should be used to address climate change, though most practitioners agree that primary prevention and enhanced health surveillance systems are needed.

Terrestrial Ecosystems

Plants and animals will have to adapt to weather extremes, prolonged droughts, and other effects while remaining in the same habitat or migrating outside their current geographic distribution. One of the connections between climate changes and ecosystem response is the life-cycle timing and early season growth of plants due to earlier spring-like conditions. Not only are changes in average temperature and precipitation of concern, but so too is the likelihood of more extremes, as these may be more difficult for ecosystems to accommodate. For instance, some organisms die at even slightly higher or lower sustained or variable temperatures. Similarly, disturbance events (droughts, floods, and wildfires, for example) can stress ecosystems to the point of altering their basic structure, a situation that may be more prominent under new climate regimes. As a result, native species may struggle while invasive species flour-

ish. Because natural ecosystems typically receive little active management from humans, deliberate adaptation actions may be required.

In light of these effects, what might be the roles of the federal government in response?

The RFF project identified three characteristics for a course of federal policy action:

- » improving and strengthening incentives to use resources wisely, not only now but especially as climate changes;
- » reforming existing institutions to enhance their flexibility to respond to these effects; and
- » greatly enhancing the traditional role of government in providing information—particularly about the nature, likelihood, and timing of extreme events—to enable consumers, businesses, and other decision-makers to take appropriate actions.

In brief, the RFF team found the following:



» Markets play a critical role in adaptation, but they can function efficiently only when incentives are correctly in place.

» Some federal actions are likely necessary to help communities adapt, and while most existing management and regulatory structures are not designed to address adaptation, they can achieve a great deal with some basic reforms.

» Climate change will result in extreme events that go beyond current experience and knowledge, so proper adaptation will require better data gathering and more information relayed to decisionmakers.

Incentives

As the climate shifts, prices need to be flexible enough to reflect new levels of scarcity. In some cases, the federal government may need to alter subsidies that inhibit private actors from making necessary adjustments.

In other cases, the federal government may be the one setting the price, and it will need to adjust its current practices. In still other cases, there are no existing effective pricing mechanisms and government will need to work to develop them.

Key reforms include revising the nation's approach to pricing insurance for flood protection and reducing existing subsidies of electricity, water, and agricultural commodities (including crop price supports and other distortions in trade policy). Getting incentives right provides a host of benefits that can enable government, resource managers, and consumers to respond more readily to climate change.

Institutions

Adapting to a changing climate is often thought to be local, in that most actions, such as protecting coastal shorelines or

Drought conditions take their toll on the shoreline of Lake Powell in Utah.



MORE READING ON ADAPTATION

The RFF publications listed below address the most compelling and urgent of actions that could frame U.S. climate adaptation policy. They are available at www.rff.org/adaptation.

UNDERSTANDING THE IMPACTS

Adapting to Climate Change: The Public Policy Response—Public Infrastructure,
James E. Neumann and Jason C. Price

Agriculture and the Food System: Adaptation to Climate Change, *John M. Antle*

An Adaptation Portfolio for the United States Coastal and Marine Environment, *David Kling and James N. Sanchirico*

Emerging Climate Change Impacts on Freshwater Resources: A Perspective on Transformed Watersheds, *Alan P. Covich*

Terrestrial Ecosystem Adaptation,
Steven W. Running and L. Scott Mills

Adapting to Climate Change: Public Health,
Jonathan M. Samet

REFORMING INSTITUTIONS AND MANAGING EXTREMES

Promoting Innovative Climate Adaptation through Federalism, *Winston Harrington*

Ecosystem Services and Climate Adaptation, *James W. Boyd*

Pre-Positioned Policy as Public Adaptation to Climate Change, *V. Kerry Smith*

Climate Adaptation and Watershed Trans-boundary Governance Institutions,
Marc K. Landy

Adaptations to Sustain High-Quality Freshwater Supplies in Response to Climate Change,
Alan P. Covich

Climate Adaptation Policy: The Role and Value of Information, *Molly K. Macauley*

Adapting to Extreme Events: Managing Fat Tails, *Carolyn Kousky and Roger M. Cooke*

Climate Dependencies and Risk Management: Microcorrelations and Tail Dependence,
Roger M. Cooke and Carolyn Kousky

Public Health: Adapting to Climate Change,
Jonathan M. Samet

Adaptation of Agriculture and the Food System to Climate Change: Policy Issues,
John M. Antle

Climate Adaptation and Federal Megadisaster Policy: Lessons from Katrina, *Marc K. Landy*

Adapting to Climate Change in Public Lands Management, *Joel B. Smith and William R. Travis*

Encouraging Adaptation to Climate Change: Long-Term Flood Insurance,
Howard Kunreuther and Erwann Michel-Kerjan

Adaptation to Climate Change: Revisiting Infrastructure Norms, *James E. Neumann*

Better Defined Rights and Responsibilities in the Marine Environment, *James N. Sanchirico*

A Legal Framework for Climate Adaptation Assessment, *Daniel A. Farber*

sheltering persons during hurricanes, are executed by subnational governments. Yet the federal government can take many steps to improve management efforts and expand the capacity for local governments to act, particularly by coordinating efforts across jurisdictions, and employing innovative options to improve national regulations and management systems for resources such as water and lands, as well as public goods like infrastructure and public health.

the likelihood and extent of these effects can help decisionmakers steer resources toward their most effective use. The supply of information, including that required to enable the public to anticipate extreme events, has long been a role of government. Climate scientists at present collect massive amounts of data on the ground as well as from satellites, aircraft, and ocean buoys to model and measure the physical properties of Earth's climate; evaluating these data and

Getting incentives right provides a host of benefits that can enable government, resource managers, and consumers to respond more readily to climate change.

Institutional reforms that may be needed include the establishment of ocean governance practices through planning and allocating use rights, forming state and federal institutions for transboundary governance of watersheds, and coordinating regional efforts in managing land (such as protecting wildlife corridors). The federal government can play an additional role in promoting coordination between state and local agencies in long-term planning for water scarcity (for example, by providing deep reservoir storage).

Information and Managing Extremes
As the climate baseline shifts, events that were once considered extreme and rare are expected by many scientists to be likely to occur with greater frequency and stronger intensity. If so, formerly reliable buffers against severe events like hurricanes, floods, and droughts could become less effective. Similarly, historical benchmarks would no longer provide useful guidance for at-risk communities to adjust to new climate patterns. New and better information about

enhancing them to support decisionmaking for adaptation will be critical. These observing stations can also help to provide "early warning" of possible climate tipping points or abrupt climate changes.

Adaptation policies, in some cases, may also be contentious as regions and demographic groups experience different effects. For example, extreme long-term drought in the Southwest or Southeast may lead to water-rationing that generates significant controversy. Low income communities can be vulnerable to the effects of extreme weather events yet often lack capacity to adapt. Also, sea level rise may eventually overwhelm urban areas such that people will need to relocate and infrastructure will be abandoned. Enhancing national resiliency to a changing climate, then, requires both more effective incentives, institutions, and information, and a means to balance inevitable distributional effects.