APPENDIX B: NATIONAL ASSESSMENT OF THE POTENTIAL CONSEQUENCES OF CLIMATE VARIABILITY AND CHANGE, OVERVIEW CONCLUSIONS, 2000

In 1997 the Clinton administration asked the United States Global Change Research Program (USGCRP) to conduct a comprehensive assessment of the possible consequences of climate change and options for easing adaptation. The study and the resulting report, "The 2000 National Assessment of the Potential Consequences of Climate Variability and Change," were managed by the National Assessment Synthesis Team (NAST)—a committee of experts from government, academia, industry, and NGOs. Climate models provided a range of possible global and regional changes in temperature, precipitation, water levels, forest growth, and other sensitive areas; for example, the report assumes that the accumulation of greenhouse gases in the atmosphere would cause temperatures in the United States to rise between 5 and 9 degrees Fahrenheit (3–5 degrees Celsius) in the next 100 years.

What follows are main conclusions from the Assessment's "Foundation Report," published in 2000 and written by the NAST in cooperation with independent regional organizations. The complete reports are available online at http://www.usgcrp.gov/usgcrp/nacc/default.htm

Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change, Overview Conclusions

Large Impacts in Some Places

The impacts of climate change will be significant for Americans. The nature and intensity of impacts will depend on the loca-

tion, activity, time period, and geographic scale considered. For the nation as a whole, direct economic impacts are likely to be modest. However, the range of both beneficial and harmful impacts grows wider as the focus shifts to smaller regions, individual communities, and specific activities or resources. For example, while wheat yields are likely to increase at the national level, yields in western Kansas, a key US breadbasket region, are projected to decrease substantially under the Canadian climate model scenario. For resources and activities that are not generally assigned an economic value (such as natural ecosystems), substantial disruptions are likely.

Multiple-stresses Context

While Americans are concerned about climate change and its impacts, they do not think about these issues in isolation. Rather they consider climate change impacts in the context of many other stresses, including land-use change, consumption of resources, fire, and air and water pollution. This finding has profound implications for the design of research programs and information systems at the national, regional, and local levels. A true partnership must be forged between the natural and social sciences to more adequately conduct assessments and seek solutions that address multiple stresses.

Urban Areas

Urban areas provide a good example of the need to address climate change impacts in the context of other stresses. Although large urban areas were not formally addressed as a sector, they did emerge as an issue in most regions. This is clearly important because a large fraction of the US population lives in urban areas, and an even larger fraction will live in them in the future. The compounding influence of future rises in temperature due to global warming, along with increases in temperature due to local urban heat island effects, makes cities more vulnerable to higher temperatures than would be expected due to global warming alone. Existing stress-

es in urban areas include crime, traffic congestion, compromised air and water quality, and disruptions of personal and business life due to decaying infrastructure. Climate change is likely to amplify some of these stresses, although all the interactions are not well understood.

Impact, Adaptation, and Vulnerability

As the Assessment teams considered the negative impacts of climate change for regions, sectors, and other issues of concern, they also considered potential adaptation strategies. When considered together, negative impacts along with possible adaptations to these impacts define vulnerability. As a formula, this can be expressed as vulnerability equals negative impact minus adaptation. Thus, in cases where teams identified a negative impact of climate change, but could not identify adaptations that would reduce or neutralize the impact, vulnerability was considered to be high. A general sense emerged that American society would likely be able to adapt to most of the impacts of climate change on human systems but that the particular strategies and costs were not known.

Widespread Water Concerns

A prime example of the need for and importance of adaptive responses is in the area of water resources. Water is an issue in every region, but the nature of the vulnerabilities varies, with different nuances in each. Drought is an important concern in every region. Snowpack changes are especially important in the West, Pacific Northwest, and Alaska. Reasons for the concerns about water include increased threats to personal safety, further reduction in potable water supplies, more frequent disruptions to transportation, greater damage to infrastructure, further degradation of animal habitat, and increased competition for water currently allocated to agriculture. The table below illustrates some of the key concerns related to water in each region.

WATER ISSUES

Region	Floods	Droughts	Snowpack/Snowcover	Groundwater	Lake, River, and Reservoir Levels	Quality
Northeast	X	X	X	X		X
Southeast	X	X		X		X
Midwest	X	X	X	X	X	X
Great Plains	X	X	X	X	X	X
West	X	X	X	X	X	X
Northwest	X	X	X		X	
Alaska		X	X			
Islands	X	X		X		X

Note: This table identifies some of the key regional concerns about water. Many of these issues were raised and discussed by stakeholders during regional workshops and other Assessment meetings held between 1997 and 2000.

Health, an Area of Uncertainty

Health outcomes in response to climate change are highly uncertain. Currently available information suggests that a range of health impacts is possible. At present, much of the US population is protected against adverse health outcomes associated with weather and/or climate, although certain demographic and geographic populations are at greater risk. Adaptation, primarily through the maintenance and improvement of public health systems and their responsiveness to changing climate conditions and to identified vulnerable subpopulations should help to protect the US population from adverse health outcomes of projected climate change. The costs, benefits, and availability of resources for such adaptation need to be considered, and further research into key knowledge gaps on the relationships between climate/weather and health is needed.

Vulnerable Ecosystems

Many US ecosystems, including wetlands, forests, grasslands, rivers, and lakes, face possibly disruptive climate changes. Of everything examined in this Assessment, ecosystems appear to be the most vulnerable to the projected rate and magnitude of climate change, in part because the available adaptation options are very limited. This is important because, in addition to their inherent value, they also supply Americans with vital goods and services,

including food, wood, air and water purification, and protection of coastal lands. Ecosystems around the nation are likely to be affected, from the forests of the Northeast to the coral reefs of the islands in the Caribbean and the Pacific.

ECOSYSTEM GOODS & SERVICES

Ecosystem	Goods	Services
Forests	Timber, fuelwood, food such as honey, mushrooms, and fruits	Purify air and water, generate soil, absorb carbon, moderate weather extremes and impacts, and provide wildlife habitat and recreation
Freshwater Systems	Drinking and irrigation water, fish, hydroelectricity	Control water flow, dilute and carry away wastes, and provide wildlife habitat, transportation corridors, and recreation
Grasslands	Livestock (food, game, hides, fiber), water, genetic resources	Purify air and water, maintain biodiversity, and provide wildlife habitat, employment, aesthetic beauty, and recreation
Coastal Systems	Fish, shellfish, salt, seaweeds, genetic resources	Buffer coastlines from storm impacts, maintain biodiversity, dilute and treat wastes, and provide harbors and transportation routes, wildlife habitat, employment, beauty, and recreation
Agro-ecosystems	Food, fiber, crop genetic resources	Build soil organic matter, absorb carbon, provide employment, and provide habitat for birds, pollinators, and soil organisms

ECOSYSTEM VULNERABILITY

Ecosystem Type	Impacts	NE	SE	NW	GP	WE	PNW	AK	IS
Forests	Changes in tree species composition and alteration of animal habitat	X	X	X		X	X	X	X
	Displacement of forests by open woodlands and grasslands under a warmer climate in which soils are drier		X						
Grasslands	Displacement of grasslands by open woodlands and forests under a wetter climate					X			
	Increase in success of non-native invasive plant species				X	X	X		X
Tundra	Loss of alpine meadows as their species are displaced by lower-elevation species	X				X	X	X	
	Loss of northern tundra as trees migrate poleward							X	
	Changes in plant community composition and alteration of animal habitat							X	
Semi-arid and Arid	Increase in woody species and loss of desert species under wetter climate					X			
Freshwater	Loss of prairie potholes with more frequent drought conditions				X				
	Habitat changes in rivers and lakes as amount and timing of runoff changes and water temperatures rise	X	X	X	X	X	X		
Coastal and Marine	Loss of coastal wetlands as sea level rises and coastal development prevents landward migration	X	X			X	X		X
	Loss of barrier islands as sea-level rise prevents landward migration	X	X						
	Changes in quantity and quality of freshwater delivery to estuaries and bays alter plant and animal habitat	X	X			X	X	X	X
	Loss of coral reefs as water temperature increases		X						X
	Changes in ice location and duration alter marine mammal habitat							X	

Note: The table above gives a partial list of potential impacts for major ecosystem types in various regions of the U.S. While the impacts are often stated in terms of what is likely to happen to plant communities, it is important to recognize that plant-community changes will also affect animal habitat.

Agriculture and Forestry Likely to Benefit in the Near Term

In agriculture and forestry, there are likely to be benefits due to climate change and rising CO_2 levels at the national scale and in the short term under the scenarios analyzed here. At the regional scale and in the longer term, there is much more uncertainty. It must be emphasized that the projected increases in agricultural and forest productivity depend on the particular climate scenarios and assumed CO_2 fertilization effects analyzed in this Assessment. If, for example, climate change resulted in hotter and drier conditions than projected by these scenarios, both agricultural and forest productivity could possibly decline.

Potential for Surprises

Some of the greatest concerns emerge not from the most likely future outcomes but rather from possible "surprises." Due to the complexity of Earth systems, it is possible that climate change will evolve quite differently from what we expect. Abrupt or unexpected changes pose great challenges to our ability to adapt and can thus increase our vulnerability to significant impacts.

A Vision for the Future

Much more information is needed about all of these issues in order to determine appropriate national and local response strategies. The regional and national discussion on climate change that provided a foundation for this first Assessment should continue and be enhanced. This national discourse involved thousands of Americans: farmers, ranchers, engineers, scientists, business people, local government officials, and a wide variety of others. This unique level of stakeholder involvement has been essential to this process, and will be a vital aspect of its continuation. The value of such involvement includes helping scientists understand what information stakeholders want and need. In addition, the problem-solving abilities of stakeholders have been key to identifying potential adaptation strategies and will be important to analyzing such strategies in future phases of the assessment.

The next phase of the assessment should begin immediately and include additional issues of regional and national importance including urban areas, transportation, and energy. The process should be supported through a public-private partnership. Scenarios that explicitly include an international context should guide future assessments. An integrated approach that assesses climate impacts in the context of other stresses is also important. Finally, the next assessment should undertake a more complete analysis of adaptation. In the current Assessment, the adaptation analysis was done in a very preliminary way, and it did not consider feasibility, effectiveness, costs, and side effects. Future assessments should provide ongoing insights and information that can be of direct use to the American public in preparing for and adapting to climate change.