BEYOND ADAPTING TO CLIMATE CHANGE: EMBEDDING ADAPTATION IN RESPONSES TO MULTIPLE THREATS AND STRESSES

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Abstract

Climate change impacts are already being experienced in every region of the United States and every part of the world, most severely in Arctic regions, and adaptation is needed now. Although climate change adaptation research is still in its infancy, significant adaptation planning in U.S. has already begun in a number of localities. This paper seeks to broaden the adaptation effort by integrating it with broader frameworks of hazards research, sustainability science, and community and regional resilience. To extend the range of experience, we draw from ongoing case studies in the Southeastern U.S. and the environmental history of New Orleans to consider the multiple threats and stresses that all communities and regions experience. Embedding climate adaptation in responses to multiple threats and stresses helps us to understand climate change impacts, themselves often products of multiple stresses, to achieve community acceptance of needed adaptations as co-benefits of addressing multiple threats, and to mainstream the process of climate adaptation through the larger envelope of social relationships, communication channels, and broad based awareness of needs for risk management that accompany community resilience.

Key words: climate change adaptation, hazards, resilience, sustainability

After a long period of neglect, adaptation to climate change impacts is finally getting a burst of attention, because it can no longer be ignored (National Academies 2009; Schipper and Burton eds. 2009) In the United States, a recent synthesis study (Karl, Melillo, Peterson, 2009) found all regions at risk to impacts, although major impacts differed from region to region based on climate change exposure, climate-sensitive economic activities, and population vulnerabilities. Examples taken from the study are shown in Figure 1. As impacts emerge, affected peoples and systems must find ways to cope. We report on the adaptation planning in the U.S that has already begun. But we also seek to go beyond these efforts to consider, in contexts of hazards research, sustainability science, and community and regional resilience, the multiple threats and stresses that all communities and regions experience, including but not limited to risks from climate change.

[Insert Figure 1 here]

Adaptation to Climate Change

We begin with a brief discussion of climate change adaptation and then move on to our concept of multiple-threat adaptation. Vulnerabilities and risks associated with possible impacts of climate change can be prevented by reducing exposure to primary effects of climate change (warming, precipitation changes, extreme weather events, and/or sea-level rise), reducing sensitivity to those effects, and/or increasing the capacity to cope with

effects (Clark et al. 2000). Of course, the most important way to reduce exposure to climate change impacts is to limit climate change itself through mitigation. Using adaptations to sea-level rise as an example, exposure can also be limited by moving populations and land uses away from a vulnerable coastline, reducing sensitivity by constructing sea-walls or hardening coastal structures to flooding. Coping capacities can be increased by strengthening emergency response capabilities.

Adapting to climate variability and change has been part of human experience for many millennia; and the historical record includes many cases of successful adaptations, often through migration (e.g., McIntosh, Tainter, and McIntosh 2000). Although research on adaptation to climate change in the modern context is still in its infancy, however, a number of the basic dimensions of adaptation are generally understood (IPCC 2001and 2007). For example, adaptation can either avoid costs or accept costs (Burton 1997). It can be "autonomous" (or "spontaneous" or "voluntary," as systems react to observed changes, the prospect of changes, or market or other signals that incorporate general concerns about risks of change) or planned (encouraged or required by public policy interventions). It can be anticipatory, avoiding or moderating impacts by actions ahead of changes, or reactive, responding to impacts as they are experienced. It can be geographically widespread or localized. It can be sectorally focused, such as on agriculture or health, or cross-cutting, such as the use of insurance to share risks (e.g., Schipper and Burton 2009).

Very little research attention has been given to adaptation costs and benefits, or even to costs of failing to mitigate. One partial exception has been costs and benefits of major alternatives for adapting to coastal impacts from sea-level rise (Tol, 2002, and Tol et al. 2006); and analyses of costs of recent severe weather events, such as hurricanes and floods, are often used to illustrate potential costs if such events were to become more intense or frequent (or shifted in location) because of climate change (IPCC 2007, Chapter 7).

In its net costs and its capacities for action, however, adaptation to climate change is deeply and complexly linked with other economic and social goals. Thus in many cases, adaptation can be done now at a relatively low cost, because of considerable co-benefits related to other aspects of sustainability and resilience. In fact, most adaptation actions in the near term to reduce impacts of climate change, most of which are relatively long-term, need to be associated with other short-term benefits in order to be acceptable and sustainable. One example is a decision by the city of Boston in 1993 to raise a new waste disposal facility on an offshore island in order to protect it from sea-level rise (Moser 2009).

But adaptations also have physical, economic, or institutional limits. Physical limits to adaptation are identified by constraints such as the maximum height of levees and sea walls, the drawdown and rates of application of irrigation water, and the sizing and replacement of culvert capacity. Before their physical limits are reached, the costs of adaptations may exceed both customary usage and even future estimates of potential

losses avoided. Institutional practice, determined by ignorance, uncertainty, custom, law, regulation, or competing agendas further constrain adaptations. For example, coastal regions face uncertain increases in hurricane intensity and sea level rise, while regulations are based on storm surges to 100 year flood plains, and losses are government subsidized for flood but not for wind or erosion damage.

Case Studies of Climate Change Adaptation in the United States

Examples of planned adaptations to climate change are still rare in the United States, aside from Alaska, because most climate change impacts lie in the future, shrouded in uncertainties. But the risks are serious enough that a number of states and localities have begun to take adaptation planning seriously (Moser 2009).

In most cases, planning for impacts of climate change at a regional or local level in the United States can be traced to the first U.S. National Assessment of Potential Consequences of Climate Variability and Change (NACC 2001), which included attention to possible regional impacts, with one of the regions a metropolitan area (New York City). Since then, a family of 21 summaries of climate change science, termed Synthesis and Assessment Products was commissioned by the U.S. Climate Change Science Program (CCSP) between 2005 and 2008 on the regional and more local implications of climate change (http://www.climatescience.gov), with 7 of the 21 specifically concerned with climate change impacts and adaptations (the reports numbered 4.1 through 4.7).

At a state scale, Alaska is a focus of action, not just planning, because climate change impacts are already proving to be significant (e.g., Sakakibara 2008). It has established an Alaska Climate Change Sub-Cabinet to prepare and implement an Alaska Climate Change Strategy (http://www.climatechange.alaska.gov/aag/aag.htm) and is seeking to implement plans to protect six native communities requiring immediate relocation (IAW, 2009). Seven other states (California, Maryland, Oregon, Florida, Washington, Massachusetts, and New Hampshire) have begun climate change adaptation planning in parallel with discussions of mitigation issues (Pew Center 2008; Moser 2009). California has used climate change as a catalyst for addressing enormous environmental and economic challenges in the Sacramento-San Joaquin Delta, facing heavy water demands for agricultural and urban development in southern California (Feldman et al. 2008). And Florida is considering adaptation challenges presented by prospects of intensified coastal storms combined with sea-level rise in a state where coastal amenities are keys to continued economic and social development.

Local adaptation planning has emerged as a focus more recently. Since 2006, New York City has organized an ambitious effort to prepare a climate change adaptation plan within the context of a broader sustainability and growth management initiative, PlaNYC. A community-wide Climate Change Adaptation Task Force was formed, provided with climate change projections, and asked to identify "acceptable levels of risk" and to determine how to develop flexible adaptation pathways that would facilitate strategies to keep risks within those levels (NYPCC 2009). This adaptation planning effort was

intended to contribute to the integration of PlaNYC's three challenge areas: growth, infrastructure, and environment (http://www.nyc.gov/html/planyc2030/html/plan/plan.shtml), not separate from those goals.

But the effort is not limited to large cities alone. A collaboration between Seattle/King County, WA, with Local Governments for Sustainability (ICLEI) produced both an adaptation plan and a handbook to assist other cities and communities with adaptation planning (Snover et al. 2007). This handbook provided a tutorial for the ICLEI's new Climate Resilient Communities Program. The first of five pilot efforts to be completed is Keene, New Hampshire, a city of 23,000. Keene created a Committee comprised of the senior city leadership as a focus for broad-based community participation. As the Keene committee identified climate change vulnerabilities, with support from ICLEI and help from New England RISA, they grappled with difficulties in developing actions to address those vulnerabilities, They found it difficult to separating climate-related actions from more general sustainability and green economy issues and have included all three in their adaptation plan, identifying a number of targeted actions. Since completion of the plan in 2007, some of the targeted actions have already been implemented and many more are to be "mainstreamed" by inclusion as part of a Community Master Plan to be completed in 2010 (Kates, Robert W. 2009, personal communication with ICLEI and Keene officials).

Adaptation In A Broader Context Of Sustainability And Resilience

These early experiments in planning for adaptation to impacts of climate change have approached climate change adaptation not as a narrow infrastructure/emergency preparedness assignment of traditional disaster planning but as an opportunity for broad-based participation by a wide range of stakeholders. Either as an initial objective or as an outcome of the participative process, they have framed adaptation as an element of community or regional resilience and sustainability, related to current development stresses as well as longer-term projections of climate change. In many cases, in fact, climate change has become the catalyst for more integrated attention to sustainability issues beyond climate change alone (Wilbanks 2003).

States, cities, and towns recognize that climate change is only one of many driving forces for global change that shape the sustainability of localities, regions, and nations. Its importance is wrapped up in how it interacts with other driving forces such as demographic change, global economic change, technological change, and institutional change (IPCC 2007, Chapter 7). For example, climate change can mean exposure to more severe weather events, increased water scarcity, or sea-level rise; but these effects interact with changing population sizes and distributions, global and regional economies, public policies, and issues associated with resource consumption and waste disposal. Thus climate change prevention and adaptation is important as a dimension of sustainability, not as an issue in itself.

They also recognize that most climate change impacts themselves are products of multiple stresses. For example, the coastal region from Mobile, AL to Galveston, TX is now experiencing coastal retreat from the combined effects of increased hurricane intensity, subsidence, sea level rise, wetlands destruction, and human settlement (Savonis, Burkett, and Potter 2008). And the increased wildfire experience in the mountain west is a combined product of previous fire management, drought, storm intensity, and human settlement. Thus resilience to multiple threats and stresses may be an effective way to incorporate climate change adaptation in to a wider effort for community and regional resilience.

The most common meaning of resilience is drawn from the engineering sciences, as the capacity to absorb disturbances and to return to a prior (relatively stable) state. An alternative meaning is drawn from the ecological sciences, where resilience is both the capacity to absorb disturbance and to reorganize into a system that still retains its previous functions (Gunderson 2008). Some interdisciplinary scientists use the term resilience to describe specific responses (adjustments, adaptations, coping actions, or adaptive capacity) used to reduce vulnerability to climate impacts. Sustainability scientists tend to use all of three of these concepts, including the capacity to absorb perturbations and return to previous states, but beyond these the capacity to reorganize in order to move toward a state better than the previous state.

A current research project (the Community and Regional Resilience Institute) has defined community resilience as *a community or region's capability to anticipate, prepare for,*

respond to, and recover from significant multi-hazard threats with minimum damage to public safety and health, the economy, and national security (Kates and Wilbanks 2009). As a concept for discussion and a goal to be sought, community resilience is real but it is not simple. Through the choice of a community or region, resilience is place-based, rooted in linked social, economic, and environmental systems that are always in some ways unique to a particular place. By addressing multi-hazard threats, including the geophysical, biological, and social, resilience means the capacity to address these often in combination, as well as surprises or threats that were not and could not have been anticipated. By espousing minimal damage as a criterion for success, the community commits itself to reduce the vulnerability of all parts of the community. By addressing concerns from local safety and health to national security, community resilience recognizes that no community is a self-sufficient island, but is linked with other communities, its region, the nation, and indeed the world. Finally, as a measure of a community's capability, community resilience is a continuing process that adapts to changes in circumstances and learns from its (and others') experience as threats, vulnerabilities, and resources for response and recovery change through time.

Case Studies of Climate Change Adaptation in a Broader Context of Community Resilience

The Community and Regional Research Institute (CARRI) is an ongoing study involving the cities of Charleston, SC, Memphis, TN, and Gulfport, MS. These case studies in the southeastern US are intended to improve our understanding of how to enhance community resilience for the future. Threats being considered include natural and other

disasters that may be associated with climate change, as well as earthquakes, economic changes, and exposures to health risks.

Charleston, SC

Charleston, SC, understands the idea of multiple threats to a community's well-being. Besides being threatened by hurricanes and other severe coastal storms, with associated flooding, wind damage, and other impacts, e.g., from Hurricane Hugo in 1989, and by earthquakes along its inland margins, its greatest threat in recent memory was the economic impact of the closure of the Charleston Naval Base and Shipyard in 1974. The economy of the city of Charleston itself is vulnerable because it is rather narrowly focused on tourism in contrast to its neighboring city of North Charleston, which is a regional commercial hub.

Climate change adaptation in Charleston would be expected to emphasize the possibility of increased risks of disruptive coastal storms, coupled with sea-level rise. Other climate-related vulnerabilities could include changes in exposures to health risks as pandemics arise and disease vectors shift location with climate change and changes in urban comparative advantage in such sectors as tourism as competitors, markets, and sources of inputs in other areas are affected by climate change.

Viewing these sorts of vulnerabilities, along with others, through a resilience lens rather than a climate change lens, the Charleston tri-county metropolitan area (Berkeley,

Charleston, and Dorchester) has concluded that its long-term well-being depends fundamentally on being ready for any of a wide variety of possible disasters (or combinations of them), adopting the CARRI philosophy that community resilience involves communication and cooperation across all parts of the community: not only government agencies but also business and industry, non-governmental organizations and volunteer groups, neighborhoods, the media, and other components of a system of vulnerabilities and responses.

This effort is being coordinated by the Tri-County Council of Governments (COG), focused initially on a set of resilience challenges that were identified through a series of community-wide focus group discussions (CARRI Charleston 2009) Addressing these would contribute directly to climate change adaptation, such as transportation and mobility vulnerabilities and region-wide communication and information challenges.

One particular emphasis has been on improving the resilience of a large scattering of economically disadvantaged and rather isolated small municipalities east of the Cooper River, relying substantially on a network of faith-based organizations to be prepared to provide communications coordination and the distribution of goods and services in an emergency. This network not only offers resilience to possible disasters in the future, it pays benefits every month in coordinating dental, medical, educational, and training services that address chronic aspects of poverty in the area.

Clearly, these activities incorporate adaptation to possible climate change impacts, without any significant needs for a community climate change adaptation plan or external funding of adaptation actions. Maybe most important, they are perceived locally as providing benefits in current community operations, not just in the uncertain future event of a climate change related disaster.

Memphis, TN

The Memphis, TN, area is a major focus of transportation systems of crucial national importance, from natural gas pipelines to Federal Express, and it is seriously threatened by earthquake hazards in the New Madrid zone along the course of the Mississippi River. Of more immediate concern to the community is an annual risk of severe tornadoes in the region, which in 2003 caused severe damage, along with its experience that in times of coastal hurricane exposures, the Memphis area becomes a destination for evacuees.

Climate change adaptation in the Memphis area would tend to focus on possible heat index increases associated with average warming, possible health effects, and effects associated with changes in the intensity or tracks of severe weather events, especially tornadoes. It would not include attention to such risks as earthquakes, and it would be weakened by the fact that existing climate models do not project tornado behavior.

The Memphis area has emphasized unprecedented networking among groups not previously in contact with each other, working toward a communication process that

bridges diversity, layer after layer, evolving as leaders change and people move. The Memphis resilience enhancement effort is coordinated by the Shelby County Joint Economic and Community Development Board (JECDB). It also guided in its initial priorities, like Charleston, by the results of a series of community-wide discussion that identified focus areas including the following – again directly relevant to climate change adaptation (CARRI MUA 2009), such as identifying vulnerable residents, small business continuity and disaster recovery, and volunteer coordination

A particular concern is with identifying and being prepared to address special needs, not only among the area's own population but also among evacuees that can arrive on very short notice in numbers that require creating an instant evacuee city. In addition, Shelby County has supported an innovative information and education program to increase community awareness of risks and vulnerabilities, using the theme: "I'm ready!"

As in the Charleston case, the Memphis urban area experience with community resilience enhancement seems very likely to make this area more adaptable to climate change impacts through local initiative, with near-term benefits that include improving relationships and communication structures across diverse groups within the community.

Gulfport, MS

Gulfport, MS, shares aspects of both the New Orleans case (below) and the two other CARRI cases, because its perspectives on community resilience are dominated by its

experience with Hurricane Katrina in late August 2005 and the months and years that followed. Responding to risks of similar events in the future is one of its challenges, seriously exacerbated by projections of land subsidence over the next half-century in the Gulf Coast region, associated with a projection that "apparent sea-level rise" is likely to be 2 to 4 feet by 2050 (Savonis, Burkett, and Potter 2008), along with the likelihood that coastal storms will become more intense with climate change. In addition, the area faces possible vulnerabilities to both international trade impacts and pandemics because of its proximity to and trade linkages with the Caribbean and Latin America.

Memories of the pain of Katrina for residents of the Gulfport area are still so vivid that thinking beyond that one kind of vulnerability has been difficult; but at the same time the community feels a strong need to get beyond such a close identification with hurricane risks that its prospects for tourism and other kinds of economic development are undermined. The main themes of multi-threat resilience discussions in Gulfport have been the need to know the community and the need to come up with innovative solutions to problems that emerge in disaster conditions that were not anticipated. A community is not resilient because it has a plan; it needs to be prepared to listen, observe, adapt, address problems, and welcome unconventional partners in the emergency response.

Particular emphases in Gulfport include tracing out interdependencies among community functions and facilities, improving communication structures across the community in order to keep messages accurate and consistent, getting schools and businesses back in operation as quickly as possible (e.g., reopening local businesses to sell emergency

materials and commodities, keeping the sales taxes within the community), and institutionalizing a local source of expertise regarding resilience knowledge (the University of Southern Mississippi has established a Center for Policy and Resilience in the area to serve as a local/regional focus).

The case of Gulfport is different from the other two CARRI partner cities because it starts with a focus on a particular climate-related disaster and then broadens to begin considering other threats as well, rather than beginning with a comprehensive frame and considering climate change impacts within that frame. If the projection of an apparent sea-level rise of 2 to 4 feet in 40 years or less turns out to be accurate, then this community is vulnerable to effects of intense coastal storms that could threaten its viability in the latter half of the 21st century. In this case, considering a combination of climate change and other environmental changes could push the limits of potentials for adaptation in situ, raising questions about contingency planning for the gradual relocation of some coastal land uses.

Gulfport, in fact, might be an exception to the more general CARRI observation that multi-threat resilience should be the starting point, not climate change adaptation. Here, more attention to climate change risks and vulnerabilities might encourage the community to consider needs to adapt to longer-term risks and vulnerabilities not limited to coastal hurricanes alone – and it is related to a potential for climate change-related risks to be a game-changer for the community in coming decades, in which case climate

change adaptation could mean a need to consider such structural changes as a relocation of population and socioeconomic activities.

General Lessons From The CARRI Experience

Lessons from these three community resilience enhancement cases include the following:

(1) Community resilience means all-hazards planning – and also links with other community issues, such as poverty or economic growth. In order to sustain itself, resilience has to show that coordination offers benefits in daily operations, not just in the event of an emergency.

(2) Resilience means that, in a community, people who need to respond together in an emergency know each other ahead of time. From Mayor Wharton of Shelby County, TN: "A community that prepares together is going to stay together when something happens." (CARRI Charleston Forum 2009) In fact, the benefits from broader acquaintanceships in a community extend well beyond the immediate purpose of preparedness.

(3) Timely communication structures that bridge community diversity are critical: especially non-traditional structures as normal structures fail to operate during an emergency. NGOs and faith-based organizations are often adaptable gap-fillers if they are included in the resilient community network ahead of time.

The Case of New Orleans

New Orleans has an extraordinary history of multihazard threats, experience, and resilience. Located on the on the subsiding delta of the lower Mississippi River, much of the city is below sea level. It has experienced 27 major floods over the past 290 years (Kates et al. 2006), as well as nineteenth-century invasions, yellow fever epidemics, twentieth-century drinking water pollution, and a declining population and economy. (Colten 2005). The decline in population and economy was accelerated by Hurricane Katrina. Today, flooding remains the most pressing concern with future vulnerability increased by climate change increases in hurricane intensity, continued subsidence, loss of protective wetlands, and inadequate protection.

To deal with flooding, local and national institutions have combined to erect an extensive flood protection system, to create river flood and hurricane forecasting, and develop evacuation plans. Exposure to flooding was relatively small in the most vulnerable locations until hurricane Betsy in 1965. Following that storm, new levees and improved internal drainage encouraged new development in low-lying areas, increasing the most exposed population by 170,000 households across the metropolitan area.

When Hurricane Katrina arrived in August 2005, the storm overwhelmed the levee system and flooded 80 percent of the city, caused about 1300 deaths, forced a long evacuation that led to the relocation (perhaps permanently) of 100,000 residents,

damaged 70% of the city's residences, and caused an estimated monetary loss of $40-50 billion. Almost four years after Katrina, a population the equivalent of 70% of the pre-storm population has returned, building permits for more than a third of residences have been issued, and the hospitality economy has been restored. But large areas of the city are still empty tracts, leading economic sectors in medicine and education have not recovered, organized reconstruction is just beginning, and some neighborhoods may have been lost forever.

Lessons learned from the New Orleans's experience of the four key elements of resilience—anticipation, response, recovery, and reduced vulnerability—are detailed in a CARRI report (Colten, Kates, and Laska 2008). Six of these are especially relevant to climate change and multi-hazard adaptation:

(1) Vulnerability grows from multiple causes, not just from climate. In New Orleans, geophysical vulnerability is characterized by its below-sea level, bowl-shaped location, its accelerating subsidence, rising sea level, storm surges, and possible increased frequency of larger hurricanes from climate change. These are only partly natural phenomena and they have been made worse by settlement decisions, canal development, loss of barrier wetlands, extraction of oil and natural gas, and the design, construction, and failure of protective structures and rainfall storage. Social vulnerability grew as well as new development in low-lying areas placed an additional 170,000 households at risk. Subsequent loss of population within the city (white flight) increased social vulnerability, followed by the Katrina failure to respond to the distinctive needs of the elderly, the poor,

and households without autos.

(2) Successful short-term adaptation may lead to larger long-term vulnerability. The 40-year period between Hurricane Betsy and Katrina produced new and improved levees, drainage pumps, and canals—successfully protecting New Orleans against three hurricanes in 1985, 1997, and 1998. But these same works permitted the massive development of previously unprotected areas and, when the works themselves failed, became the major cause of the Katrina catastrophe.

(3) Adaptation is a long-term process. In New Orleans, it took 40 years to create an effective tracking and warning system and 37 years to inform the community about the catastrophic threat. It also took 40 years to reduce vulnerability with levees and drainage by a system that was only partly completed before Katrina and that subsequently failed. It will take at least 6 years to rebuild a reliable levee system to protect against a modest 100-year storm. The emergency response period following Katrina was the longest of any similar disaster in U.S. history (6 weeks). To develop a community-acceptable reconstruction plan took 21 months and to reconstruct the city after Katrina will take at least a decade more.

(4) The best available scientific and technological knowledge does not necessarily get used or widely disseminated. An extraordinary investment has been made in climate change research producing a growing body of scientific and technological knowledge. But the New Orleans experience does not auger well for its utilization. The engineering

designs for the new and improved protective works after Hurricane Betsy in 1965 took into account the effects of hurricane recurrence, storm surge, land subsidence, and rising sea level as measured at that time. But these estimates were still being used 19 years later, when sea level had risen by 7 inches, storm waves and surges by similar amounts, subsidence had lowered the land surface by 10 feet (USGS 2004), and hurricane intensity increased from climate change. Moreover, the widely used risk assessments – in the form of FEMA maps of the 100-year floodplain – have never included sea-level rise or land subsidence effects.

(5) Despite frequent references to partnerships, major response capacities and resources may be invisible to, refused by, or poorly used by the official emergency response structure. In every disaster there are unanticipated or unaddressed needs and "shadow responders" often emerge from households, friends and family, neighborhoods, non-governmental and voluntary organizations, businesses, and industry. In responding to Katrina, these emergent capabilities were sometimes refused or poorly used by government officials, even though they provided most of the initial evacuation capacity, sheltering, feeding, health care, and rebuilding, and much of the search and rescue, cleanup, and post-Katrina funding.

(6) Surprises should be expected. Every hazard event, climatic or otherwise, brings surprises and every disaster even more. Unanticipated events during Katrina included the massive breaches that flooded 80 percent of the city with upwards of 20 feet of water. In turn, these unanticipated events led to major failures in emergency response for events

that had been anticipated. Thus surprises come from unanticipated events, correctly anticipated events but failed responses, or wrongly anticipated events.

Climate Change Adaptation in a Broader Context

In summary, climate change impacts are real, and adaptation will be an unavoidable part of the response. But climate change adaptation is deeply and complexly linked with economic and social development paths and stresses. The experience to date in the growing efforts at adaptation planning finds states, cities, and towns moving beyond adaptations to climate change, seeking to be resilient to multiple threats and stresses and to achieve sustainability. It so doing, there are at least three main benefits: helping to understand climate change vulnerabilities as the products of multiple threats and stresses, achieving community acceptance of needed adaptations as co-benefits of addressing multiple threats, and mainstreaming the process of climate adaptation in the larger envelope of social relationships, communication channels, and broad based awareness of needs for risk management that accompany true community resilience.

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Figure 1. Climate change related impacts (many have multiple causes) are already being experienced in every region of the United States as documented in a recent U.S. State of Knowledge Report (Karl, Melillo, Peterson, 2009). These generalized examples were selected to illustrate that while all regions are at risk to impacts, major impacts differ from region to region based on climate change exposure, climate-sensitive economic activities , and population vulnerabilities. Text box lists major observed climate changes in the U.S. (Map developed and drawn by Michael Craghan).

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