

# **Climate Change and the Public's Health: The Coming Crisis for the U.S. Gulf Coast**

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## **Abstract**

This paper reviews the scientific consensus as to how climate change will affect human health on a global scale and describes the limited, emerging research findings concerning climate change health impacts along the U.S. Gulf Coast. Through myriad pathways, climate change is likely to make the Gulf Coast less hospitable and more dangerous for Americans, and may prompt substantial migration from and into the region. The paper also summarizes the primary prescriptions and adaptations found in the public health literature for meeting climate change's threats to human health, along with several recent findings that America's state and local public health agencies recognize the approaching problems but lack the resources to make climate change preparedness, education, needs assessment or adaptation high priorities. It also should be noted that several factors besides climate change are converging to exacerbate the fragility of this region, including coastal erosion and subsidence and the ongoing threat of energy infrastructure failure (such as the Deepwater Horizon oil spill catastrophe). This paper provides a comprehensive survey of current U.S. federal government activities—as yet uncoordinated and inadequately funded—to elucidate the public health implications of climate change and to help all levels of government create the tools and institutional structures necessary to adapt to the coming crisis. Finally, it considers pending legislation and executive branch actions to jump start public health adaptation to climate change.

# 1. Introduction

There is a growing literature regarding the health and public health consequences of climate change, a crisis considered by some leading experts to be “the biggest global health threat of the 21<sup>st</sup> century” (Costello, 2009). Published articles and reviews point to greater morbidity and mortality from direct exposure to more frequent and more severe storms, heat waves and floods (CCSP, 2008B; Costello, 2009; IPCC, 2007; Levi & Vinter, 2009; Luber, 2009). They also predict increased risk from vector, rodent and water-borne infectious agents, ozone, particulates, aeroallergens, ultraviolet radiation, toxic plants and seafood, and surface contaminants. Furthermore, concerns have been raised about deteriorating water supply and quality and diminishing agricultural productivity, factors which may combine to increase malnutrition and susceptibility to illness and disease. Climate change-induced or exacerbated disruptions of local ecosystems, infrastructure and economies likewise will increase joblessness, poverty, undernourishment and vulnerability to diseases.

Finally, this literature emphasizes that climate change will cause widespread migration away from areas that can no longer provide sufficient food, water and shelter for the current human populations (Brown, 2008). In the most extreme cases, rising seas will claim some current human settlements, including some that would be viable but for their elevation.

A large body of research focuses on particular manifestations of climate change along the Gulf Coast and other parts of the Caribbean basin (e.g., sea level rise, coastal erosion, saltwater intrusion, extreme heat events and these items in various combinations).<sup>i</sup> To date, however, no single study or group of studies has focused primarily on the impacts of climate change on the health of the residents of the U.S. Gulf Coast, whether from direct exposure, out-migration or in-migration. No scholar has yet linked the variegated physical manifestations of climate change with an intimate knowledge of regional conditions, to generate health scenarios for the states, counties, parishes, and municipalities in this part of the country. This paper will help explain why this deficiency exists.

In addition to naming the generic categories of potential health impacts that scientists expect to observe on a global scale, the literature on the health impacts of climate change has several other broad, recurring themes. First, climate change already is occurring. Chameides writes that “because of the inertia of the climate system, the climate changes of the next 20 to 30 years are already in the ‘pipeline’” (Chameides, 2009), or as climate scientists would say, “committed” (IPCC, 2007A; UCAR, 2005). However, such locked in changes do not, in and of themselves, condemn Americans to suffer negative health impacts on a vast scale. Recent reports from United States Global Change Research Program (USGCRP)<sup>ii</sup> emphasize that “whether or not increased health risks due to climate change are realized will depend largely on societal responses and underlying vulnerability” (GCRP, 2009, p. 89).

Second, the development of the tools needed to cope effectively with climate change—regional and local scale climate models, research on the impacts of climate change on local and regional ecosystems, research on the effectiveness of specific adaptations, comprehensive surveillance of risk factors, early warning systems and incentives or regulations to induce people to change their lifestyle (CCSP, 2008B)—has not kept pace with advances in climate science itself. The scientific community has a better understanding of how and why the global climate is changing, than of how changes will play out in any particular location or how to prepare in advance for whatever changes may arise locally. According to Eric J. Barron, director of the National Center for Atmospheric Research:

“The research strategies and investments needed to define impacts and vulnerabilities and to enable wise decisions are not in place...Currently, 40 years of intensive climate model development is being coupled to what amounts to a cottage industry of impact sciences. The result is that our understanding of how ecosystems, water, human health, agriculture, and energy will respond to climate change advances only slowly” (Barron, 2009, p. 643).

Even with a much more robust and well-funded research program than exists today, uncertainty about the impacts of climate change on human society, in general, and on human health, in particular is likely to increase (California Natural Resources Agency, 2009; Costello, 2009, p. 27). In other words, adaptation science, policy and practice will be playing catch up with climate change indefinitely. Consequently, there is still fairly limited ability to predict the specific climate-change related health issues that may develop along the Gulf coast, and limited awareness and understanding of how communities on the Gulf Coast can adapt to climate change so as to minimize negative health consequences.

At the same time, the prospect of developing the necessary tools, dedicated funding sources, institutional arrangements and changes in governance appears daunting. In a 2009 report entitled Managing the Health Effects of Climate Change, the Lancet argued that “management of the health effects of climate change will require inputs from all sectors of government and civil society, collaboration between many academic disciplines, and new ways of international cooperation that have hitherto eluded us” (Costello, 2009, p. 1693). Although there have been some recent positive signs, the American political system, as is the case for the health and public health systems, has not yet embraced climate change adaptation with anywhere near the requisite urgency.

Third, little work has been done to date which attempts to analyze or integrate the range of threats facing the coast-line of the Gulf states, where complex hazards include not merely climate change, but also severe erosion, subsidence and—given the immense amount of energy production infrastructure—the ever-present potential for large-scale industrial accidents. Populations in the region which are already vulnerable because of economic or other disparities will face extraordinary risk to health and well-being as the consequences of complex threats conspire to create new levels of concern for political and public health leaders. Finally, echoing an observation from the disaster research

literature, the world's poor and powerless are likely to suffer not just disproportionately from climate change, but fatally.

This paper reviews the scientific consensus as to how climate change will affect human health on a global scale and describes the limited, emerging research findings concerning climate change health impacts along the U.S. Gulf Coast. It next discusses the primary prescriptions found in the public health literature for meeting climate change's threats to human health and summarizes the results of several recent studies that have highlighted a lack of preparedness within America's state and local public health agencies. Finally, this paper surveys U.S. federal government activities to elucidate the public health implications of climate change and to help all levels of government create the tools and institutional structures necessary to adapt to this oncoming environmental catastrophe.

## 2. How Climate Change May Adversely Affect Human Health

### 2.1 Global Health Impacts

The main physical manifestations of climate change are increasing atmospheric concentrations of carbon dioxide and other greenhouse gases; rising surface temperatures on both land and water; sea level rise; changes in atmospheric and oceanic energy circulation patterns such as the El Nino Southern Oscillation and the Atlantic Thermohaline Circulation (NOAA, 2010; Rahmstorf, 2006); increased climate variability; and increased frequency, intensity and severity of storms and floods, heat waves and droughts (Costello, 2009, pp. 1698-1700). IPCC's Fourth Assessment Report contains a foundational chapter on the human health impacts of such changes (IPCC, 2007, pp. 391-431). It associates the following health trends with climate change and assigns a confidence level to each statement (TABLE 1).

**TABLE 1. IPCC Health Trends with Confidence Ratings**

<b>Very High</b>	In some places the geographical range of malaria will contract, elsewhere the geographical range will expand and the transmission season may be changed.
<b>High</b>	An increase in malnutrition and consequent disorders, including those relating to child growth and development
	An increase in the number of people suffering from death, disease and injury from heat waves, floods, storms, fires and droughts
	Continued changes in the range of some infectious disease vectors
	A decline in deaths from cold, and other minor health benefits
	An increase in cardio-respiratory morbidity and mortality associated with ground-level ozone
<b>Medium<sup>iii</sup></b>	An increase in the burden of diarrheal diseases
<b>Low</b>	An increase in the number of people at risk of Dengue

**Source:(IPCC, 2007)**

“High confidence” means the authors believed there was “about an 8 out of 10 chance” the assertion was correct, very high “at least 9 out of 10” (IPCC, 2007, p. 4). USGCRP’s most recent summary of health impacts (GCRP, 2009, pp. 89-98) is generally consistent with IPCC’s Medium to Very High confidence list, but also emphasizes increases in allergies and mental health problems.

Other potential health impacts that the IPCC was unable to rate using its confidence level guidelines include increased:

- Mental health problems arising from more frequent and severe extreme events;
- Exposure to other infectious diseases;
- Direct exposure to lead, volatile organic compounds, and other chemical contaminants and toxic materials due to extreme flooding events;
- Failure of sanitary systems;
- UVR-related illnesses including melanomas, cataracts and sunburn;
- Incidence of pneumonia, chronic obstructive pulmonary disease and asthma due to exposure to ozone and particulates;

Adverse health effects also are likely to result from:

- Changes in the seasonality of allergies due to changes in pollen seasons;
- Decreased food production due to saltwater intrusion, drought, flood destruction of crops, change in crop pests and diseases, severe event disruption of food supply chains; and
- Changes in ecosystems, agriculture, livelihoods and infrastructure (IPCC, 2007, pp. 393-405).

Some of the health impacts envisioned in these studies are intuitive. Without adaptations such as more rational land use patterns, better evacuation plans and more effective hazard and warning communications, more severe hurricanes will lead to more floods, injuries and drowning. Likewise, without more air conditioning, public cooling stations, early warning systems, or other adaptations such as the neighborhood-based response plan that Philadelphia instituted fifteen years ago (GCRP, 2009, p. 91), longer heat waves at higher summer temperatures may produce mortality on the scale of a 1995 heat wave in Chicago that caused nearly 500 deaths (Klinenberg, 2002; Naughton, et al., 2002, p. 221) and a 2006 California heat wave that may have killed up to 450 people (Ostro, Roth, Green, & Basu, 2009, p. 614).

But there are complex pathways from climate change to health impacts that are not as obvious. A USGCRP study estimated that over the next 50-100 years, a sea-level rise of 4 feet<sup>iv</sup> could permanently inundate 2400 miles (27%) of the major roads between Mobile and the Houston/Galveston area--including roads that currently are designated as major evacuation routes--and 246 miles of freight rail lines (GCRP, 2009, pp. 62-63; Savonis, et al., 2008). Coupled with hurricanes that would drop more rainfall and generate stronger winds and higher storm surges, such a rise in sea level also would reduce life expectancy

and dramatically increase maintenance and repair expenditures for roads, rail lines, pipelines, bridges, airports and other transportation and communications systems on which the Gulf Coast economy depends (GCRP, 2009, p. 68). The impacts of individual floods and storms on illness, injury and death will be all too apparent. The less obvious long-term effects could include the exodus of a tax base, the physical deterioration and under-maintenance of drinking water, sanitation systems and power supplies and the constriction of both public and private health services. The remaining population could be far more vulnerable and exposed than today's coastal population.

Climate change-induced migration also may adversely affect human health in numerous ways. Besides creating the potential for violent conflicts over land, food and water, migration may increase crowding and unhealthy conditions at the destination locales, and overwhelm the existing public health infrastructure. Migration that results in the spread of densely developed cities is likely to increase the prevalence of the "urban heat island effect," in which the built up portions of an urban area can be significantly warmer than their surroundings (EPA, 2010). The International Organization for Migration (IOM) anticipates that depopulation of compromised areas will result in "hollowed economies," as individuals and families with the least capital, education and skills will be the last ones able to move away (Brown, 2008, p. 33), and could accelerate the "brain drain" that is already a huge problem for many developing countries (Brown, 2008, p. 33). These dynamics could leave behind increasingly impoverished communities that are incapable of providing for their basic nutritional, water and health needs.

## **2.2 Climate Change's Impact on Health along the U.S. Gulf Coast**

Table 2 summarizes USGCRP's discussion of climate change's major impacts on the "Southeast" region (which includes Arkansas, Tennessee, Kentucky, Virginia, Georgia and the Carolinas as well as the Gulf Coast) for the remainder of the 21<sup>st</sup> century.

The physical impacts of climate change in Louisiana are expected to be especially severe. It is widely recognized that portions of the Gulf Coast—particularly coastal Louisiana and South Florida—are extremely exposed to sea level rise due to their low elevation and that the entire coastal region is vulnerable to more intense hurricane winds, rainfall and storm surges. Additional factors make coastal Louisiana triply vulnerable to these climate change impacts. The first is subsidence. Due to "massive oil and gas extraction, the continental shelf is collapsing like a deflating balloon," at a rate of up to 10 millimeters per year (Lemonick, 2010). As the sea is rising along the Gulf Coast, the land also is falling.

Second, long-term land use patterns coupled with powerful hurricanes have substantially eroded barrier islands and wetlands that are coastal communities' first line of defense against winds, waves and storm surge. "Since the 1930s, over 2,400 square miles of wetlands in coastal Louisiana have been lost," at a rate of 15 to 40 square miles each year (LCPRA, 2010, p. 2), with virtually the entire Louisiana shoreline (more than 95%) "suffering some form or level of erosion" (USACE, 2009, p. 17). In a Congressionally-mandated study to address hurricane protection and coastal restoration in Louisiana and

**TABLE 2: CLIMATE CHANGES AND THEIR IMPACTS ON THE SOUTHEAST DURING THE 21<sup>ST</sup> CENTURY**

Average temperatures will rise 4.5 – 9 degrees F, depending upon the greenhouse gas (GHG) emissions scenario. Summer temperatures will rise as much as 10.5 F.
Spring and summer rainfall in Florida will decline; in the other Gulf states, there will be less rainfall in winter and spring
Generally, less water will be available. The frequency, duration and intensity of droughts will continue to increase
Average sea level will rise up to 2 feet <sup>v</sup>
Atlantic hurricanes will have higher peak winds, rainfall intensity, storm surge height and strength
More frequent and intense wildfires
Significant deterioration and disruption of ecosystems
Increased salinity of estuaries, coastal wetlands and tidal rivers, and potentially abrupt saltwater intrusion into coastal forests and freshwater aquifers
Intense outbreaks of insects that had not previously been pests

**Source:(GCRP, 2009, pp. 111-116)**

Mississippi following Hurricanes Katrina and Rita, the U.S. Army Corps of Engineers concluded that "continuing erosion of coastal wetlands reduces the natural buffer separating coastal communities from the Gulf of Mexico. As coastal wetlands disappear, these communities will face a choice of building higher and stronger structural defenses; relocating to areas with lower risks; or continuing to live in areas under ever-increasing risk"(USACE, 2009, p. 242).

Finally, over a century of navigation, flood control, hydropower and water storage projects on the Mississippi and its tributaries has captured much of the river's annual sediment load behind dams, cut the amount that reaches the river's delta by half (Blum & Roberts, 2009, p. 488) and thereby contributed to the conversion of wetlands into open water. Scientists at Louisiana State University recently estimated that without efforts to divert significant amounts of river sediment back towards the delta, approximately 3,800 to 5,200 square miles of the delta will be lost during this century, and that "significant drowning is inevitable, even if sediment loads are restored, because sea level is now rising at least three times faster than during delta-plain construction" (Blum & Roberts, 2009, p. 488). Looking at this issue a decade ago, Burkett et al warned that these factors "portend serious losses of life and property in the New Orleans MSA unless flood-control levees and drainage systems are upgraded" (Burkett, Zilkowski, & Hart, 2003, p. 70).

One has to search a diverse research literature simply to find suggestions of how these regional climate changes may manifest themselves in adverse regional public health trends. The state health department websites generally do not discuss these issues in any depth, and it appears that even for scientists who can anticipate the physical



consequences of storms, droughts, sea level rise and changes in ecosystems, making the leap to the associated health consequences is anything but straightforward.

The previously-cited USGCRP analysis of Gulf Coast transportation infrastructure does not attempt to link the inundation of transportation resources and regional health (Savonis, et al., 2008). A 2001 EPA scoping exercise concluded that salt water contamination of surface drinking water sources along the Gulf Coast (due to sea level rise) was a minor concern, yet it did not explore the potential health implications of the four water systems—serving in aggregate over 90,000 people—that it found to be “at high risk of salt water intrusion” (Furlow, Scheraga, Freed, & Rock, 2002, p. 4; Scheraga, 2007, p. 13). As another example, a March 2010 international conference on sea level rise in the Gulf of Mexico included thirty presentations (Harte, 2010), but only two described a specific pathway by which sea level rise could impair health (Dokken, 2010; Maslin, 2010). Lastly, a new report by organizations representing drinking water, wastewater and sanitary systems (AMWA, 2010; NACWA, 2010) estimates that USGCRP’s Southeast region will need to spend \$21-\$47 billion over the next 40 years to adapt its wastewater systems to climate change, and \$78-\$149<sup>vi</sup> billion for its drinking water systems (NACWA, 2009, pp. 3.7-3.10). The authors unquestionably understand that failure to make these immense investments could have extraordinary impacts on health, yet did not attempt to identify or quantify them.

Among the specialists in emerging infectious diseases who have highlighted climate change’s potential to change the geographic range of known vectors (Gage, Burkot, Eisen, & Hayes, 2008; Greer, Ng, & Fisman, 2008), several recently have highlighted the reappearance in the United States—particularly in the southeast—of Dengue fever, a painful viral disease (Barclay, 2008; Hayden, 2009; Knowlton, 2010; Morens & Fauci, 2008, p. 215). Morens and Fauci called Dengue “one of the world’s most aggressive reemerging infections” and asserted that “widespread appearance of Dengue in the continental United States is a real possibility” (Morens & Fauci, 2008, p. 214). During a Congressional briefing last fall, Mary Hayden of the National Center for Atmospheric Research documented the explosion of WHO-reported cases of Dengue throughout South America, Central America and Mexico since the late 1970s and noted that in the 2005 Dengue outbreak on the South Texas border, 38% of the residents of Brownsville and 77% of the residents of Matamoros, Mexico were exposed to the virus (Hayden, 2009). Florida health officials have confirmed more than twenty cases of locally contracted Dengue in the summer and fall of 2009, “the first locally-transmitted infections in Florida in more than 40 years” (Knowlton, 2010). CDC and University of Florida entomologists have documented the spread of one of the two Dengue-carrying mosquito vectors throughout the Southeast and most of southeast Texas by 2001 (Benedict, Levine, Hawley, & Lounibos, 2007, p. 11).

While acknowledging that global warming may have contributed to the expansion of a Dengue vector along the Texas border, USGCRP was cautious about describing Dengue as a public health concern because “most people [in the United States] are protected living indoors due to quality housing”<sup>vii</sup> (CCSP, 2008, p. 44). Nonetheless, this statement

indicates the risk to Gulf residents who may be unaware of Dengue's presence or—like the citizens of Matamoros—unable to afford housing that will protect them.<sup>viii</sup>

## 2.3 Migration

The impacts of climate change-induced migration away from, or to the Gulf Coast have not received systematic attention, either. In spite of certain dire prognoses for continued loss of land and habitat, few studies describe scenarios involving the loss of current Gulf Coast communities, economic dislocations, deterioration of water resources or other factors that might induce out-migration. Nor have there been significant published reports that project where an exodus from the Gulf Coast would go in the near and long term, suggest which receiving communities might bear that burden or consider the long-term psychological impacts on the affected populations. As climate change has the potential to destroy or dramatically alter communities, it is important to consider how a “loss of place” may impact community resilience as time goes on.

As noted by Stedman (Stedman, 2002, p. 561), place attachment is a bond between people and their natural environment, based on cognition and affect. The subsequent loss of this bond can have a negative impact on mental health. This feeling of anguish is particularly acute among children, who most associate a loss of place with feelings of instability. Research has shown that people understand geographic places not simply as physical settings, but as the totality of the human activities and human social and psychological processes rooted in the setting. These findings led Ryden to assert that “the place has become a shaping partner in our lives, we partially define ourselves in its terms, and it carries the emotional charge of a family member or any other influential human agent” (Ryden, 1993, p. 66). In this regard, the issues surrounding Hurricane Katrina offer a prominent warning of what the future may hold. With up to 35,000 children still seeking treatment for mental health issues associated with the storm two years later (Dewan, 2007), it is necessary to consider how new climate change oriented problems will exacerbate psychological needs.

Additionally, few studies address the possibility that the Gulf Coast might receive new inhabitants from other impacted nations in the Caribbean Basin. Perhaps this shouldn't be surprising given IPCC's position that migration is an extremely complex phenomenon and that “estimates of the number of people who may become environmental migrants are, at best, guesswork”(IPCC, 2007, p. 365). That being said, the low elevation and vulnerability to tropical storms of most of the Caribbean basin is a prima facie basis for paying close attention to this issue.

The degree to which humans may be able to prevent the inundation of coastal transportation infrastructure, deterioration of drinking water and sanitary facilities, and ecosystem changes that permit the spread of infectious disease vectors through reduction in GHG emissions, engineering solutions or changes in land use patterns is subject to debate and beyond the scope of this paper. To the extent such impacts of climate change materialize, they would make the Gulf Coast a harsher, less hospitable and more dangerous natural environment for humans than it is today.

## 3. What is Needed?

### 3.1 The mainstream consensus

Several leading experts have expressed a high degree of confidence that the basic tenets and tools of the public health discipline are up to the challenges of climate change (Ebi, Kovats, & Menne, 2006; Ebi & Semenza, 2008; Frumkin, Hess, Luber, Malilay, & McGeehin, 2008; Luber, 2009). They view climate change adaptation as analogous to public health preparedness, i.e., “actions taken in advance of climate change impacts or reactions in response to perceived or real health risks” (Ebi & Semenza, 2008, p. 501), in either case to reduce the health burden of climate changes that society no longer can prevent from occurring. These observers also are comfortable that the public health profession’s “Ten Essential Services” is a sufficient analytical and ethical platform on which to mount a compelling response (Frumkin, et al., 2008, pp. 438-442; Keim, 2008). In their view, the profession mainly needs more and better resources devoted to these essential functions, particularly in relation to surveillance, monitoring, communications and localized climate change models.

But they also espouse substantially more interaction and coordination with other disciplines. Frumkin, for example, writes that “new collaborations must be developed...with architects and city planners (whose design work can reduce energy demand and limit vulnerability to heat, flooding, and other risks) [and] transportation planners (who can design transportation systems that reduce greenhouse gas emissions and promote safe, healthy travel)” (Frumkin, et al., 2008, p. 440). Ebi et al recapitulate a USGCRP recommendation (CCSP, 2008) for “enhance[d] collaboration across the multiple agencies and organizations with responsibility and research related to climate change-related health impacts, such as weather forecasting, air and water quality regulations, vector control programs, and disaster preparedness and response” (Ebi, et al., 2009, p. 858). The need for state public health collaboration and interagency relationships is prominent in the California Climate Adaptation Strategy (California Natural Resources Agency, 2009). By and large, however, the calls for more collaboration, interagency cooperation and interdisciplinary approaches have not delineated how such partnerships might function—and be funded—and what the roles of public health professionals should be.

There is also substantial overlap among the recommendations of the IPCC, the USGCRP and the Lancet report entitled Managing the Health Effects of Climate Change. In USGCRP’s Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems, a summary table (CCSP, 2008, pp. 69-71) outlining “community, state and national agency roles and responsibilities for adaptation to climate change health risks” has five recurring themes across multiple categories of health threats:

- providing scientific and technical guidance;
- implementing and enhancing early warning and alert systems;
- improving surveillance and monitoring;
- conducting research;

- increasing and improving education, outreach, dissemination of information and risk communications.

All the major reports emphasize the importance of increasing nations' and communities' "adaptive capacity," defined as "the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (CCSP, 2008, p. 177; IPCC, 2007, p. 869).

In regard to the issue of adaptive capacity, it is worth noting that USGCRP states that "the most important adaptation to ameliorate health effects from climate change is to support and maintain the United States' public health infrastructure" (CCSP, 2008B, p. 8). Maintaining a system that already exists and that has evolved largely independent of concerns about climate change is a peculiar use of the term adaptation, but it usefully highlights the difficulties that some within the public health profession are having in imagining societal responses to climate change that are different in kind rather than simply different in scale from the current system. Various articles describe as "adaptations to climate change health impacts" activities that public health professionals in other contexts would simply consider business as usual: a community workshop, public-private partnerships, planning and needs assessments, and preparedness (Ebi, et al., 2006; Ebi & Semenza, 2008; Keim, 2008). Furthermore, the list of "adjustments" for individuals, families and communities on the CDC Climate Change Program website<sup>ix</sup> is quite generic, and amounts essentially to eating better, exercising more, reducing one's carbon footprint and utilizing the resources available at Ready.gov (CDC, 2009).

Other oft-repeated prescriptions include capacity building; improving primary health care systems; creating tools to model climate changes and predict health impacts at all levels of spatial aggregation; obtaining massive and low carbon increases in food production and improvements in water management; reducing—not just limiting the spread of—urban heat islands; improving the coordination and accountability of global governance; and identifying and promoting "co-benefits" (Costello, 2009, pp. 1694-1696).

### **3.2 Co-Benefits**

"Co-benefits" refers to improvements in public health that should result from policies and activities designed to reduce GHG emissions. The improvements would appear as reductions in the social burdens of heart disease, obesity, mental health problems and other conditions about which Americans (and other wealthy country citizens) are deeply concerned, regardless of what they believe or dispute about climate change. The rallying cry for co-benefits is simple: "Overall, what is good for tackling climate change is good for health" (Gill & Stott, 2009, p. 1953). Health professionals have an obligation to communicate all scientifically supportable co-benefits to a wide public audience and ensure that such benefits are counted when policy-makers debate the costs of climate change mitigation efforts (Roberts, 2009, p. 213).

A recent six-article series in *The Lancet* and an unrelated survey of mental health literature (Gill & Stott, 2009; Haines, Wilkinson, Tonne, & Roberts, 2009; Horton, 2009; Nilsson, Beaglehole, & Sauerborn, 2009; Nurse, Basher, Bone, & Bird, 2010; Smith, et al., 2009; Watts, 2009) present evidence that even in a rich countries, varied measures to reduce GHG emissions could generate significant reductions in certain health burdens (TABLE 3):

**TABLE 3: HEALTH CO-BENEFITS OF GHG MITIGATION MEASURES IN DEVELOPED COUNTRIES**

<b>Mitigation (GHG Emission Reduction) Measure</b>	<b>Types of Health Benefits Expected</b>
More house insulation; better ventilation and heat recovery; switch to electric heat; lower thermostat by 1°C*	Reduced exposure to fine particulates, radon and CO2 poisoning.
Less car use accompanied by “safe urban environments for more active travel” i.e., walking and bicycling*	Reduced heart disease, stroke, breast cancer, dementia and depression
Low carbon electricity generation such as wind, tide, solar*	Reduced cardiopulmonary and respiratory disease & lung cancer
Reduced livestock production and meat and dairy consumption*	Reduction in heart disease, obesity and diet-related cancers
“Increases in green spaces and natural environments”†	Enhanced cognition and emotional development in children; reduced stress and anger, crime and violence; better work performance and concentration; faster recovery from medical procedures.

**Sources:** \* (Chan, 2009; Gill & Stott, 2009; Horton, 2009; Nilsson, et al., 2009; Smith, et al., 2009; Watts, 2009); †(Nurse, et al., 2010)

### 3.3 Costs

How much would an adequate program of climate change adaptation cost just in the United States? To the authors’ knowledge, nobody has attempted such an analysis. Presumably, the previously discussed gaps in understanding of how climate change will manifest itself and affect health at local and regional levels, and the limited understanding of what adaptations may be effective, are huge obstacle to any kind of informed estimate of adaptation costs. But at least one group of analysts has put a price on an adequate research program to begin to fill those gaps. Ebi et al estimated that the U.S. federal government would need to spend at least \$250 million per year to fund an adequate research program on the health impacts of climate change, as outlined in TABLE 4.

**TABLE 4: A PROPOSED RESEARCH BUDGET FOR CLIMATE CHANGE-RELATED HEALTH IMPACTS AND ADAPTATION**

Research Category	Annual cost (\$millions)
“A comprehensive surveillance and monitoring system to address the health risks of climate change that included indicators for climate, atmospheric, and ecosystem conditions as well as the health of domestic animals, wild animals, and humans...”	>\$100 million
Supplemental “field, laboratory and epidemiology research programs” above and beyond existing research in climate sensitive health problems like ozone, particulates and asthma.  For at least 10 regional centers of excellence at \$5 million/center  For investigator-initiated intramural and extramural research	\$50 million  \$100 million
Software and models to simulate and predict public health impacts of climate change at national, state and local scales.	At least \$2 million

**Source: (Ebi, et al., 2009, p. 861)**

It is important to emphasize that this is the recommended budget for data collection, surveillance, monitoring, analysis, research and evaluation only. It doesn't even scratch the surface of the investments that will be required to implement adaptations that are based upon sound scientific evidence. The cost of defending vulnerable coastlines through engineering solutions or, alternatively, relocating vulnerable communities further inland, will entail costs many orders of magnitude greater. One can say the same with regard to retrofitting residential and commercial buildings to dissipate heat, increasing urban vegetation to increase shade, building infrastructure to accommodate bicycle commuting, creating new vaccines and medical treatments to deal with emerging infectious diseases, providing health services to arriving environmental refugees and providing climate change adaptation assistance to poorer nations.

The United States' drinking water and wastewater facilities are a critical category of infrastructure—although hardly the only one—that will require massive capital investment to adapt to climate change. A preliminary estimate of the national adaptation costs for that sector alone is \$448-\$944 billion over the next 40 years (NACWA, 2009, pp. ES-8). These and other adaptations will entail significant expenditures at all levels of government. Adaptation will have to compete for funding with other urgent social priorities and with economic growth, and will have to be more or less consistent with Americans' distaste for governmental restrictions on their freedom of action.

### 3.4 Local and State Preparedness

The scope and costs of a full-throated public health response to climate change are particularly important at the state and local level, where financial resources and staffing limitations are the most pronounced. For example, during the winter of 2008, the Environmental Defense Fund, George Mason University and the National Association of County and City Health Officials (NACCHO) conducted a structured phone survey of 133 local public health agency directors (Balbus, Ebi, & Finzer, 2008, pp. 7-8). One year later, the Association of State and Territorial Health Officials (ASTHO) conducted a

**TABLE 5: NACCHO AND ASTHO SURVEY KEY RESULTS**

	<b>Percent Respondents</b>
<b>NACCHO: Local Public Health Directors Perceptions</b>	
<b>Source: (Balbus, et al., 2008, pp. iv-v)</b>	
My jurisdiction has experienced/ <b>will experience</b> climate change in the past/ <b>next</b> 20 years	70/78
One or more serious public health problems will occur in my jurisdiction in the next two decades as a result of climate change	60
Preventing or preparing for climate change is an important/ <b>TOP 10</b> priority for my department	51/19
My department has ample expertise to assess local health impacts of climate change/ <b>craft adaptation plans</b>	23/17
My state health department/CDC has the needed expertise to develop adaptation plans	26/34
<b>ASTHO: State and Territorial Chief Health Officers Perceptions</b>	
<b>Sources: (ASTHO, 2009, 2009A)</b>	
My state/territory will experience one or more serious climate-change related public health problems in the next 20 years	73
Climate Change is one of my agency's Top 10/ <b>TOP 5</b> Priorities	23/19
My agency has sufficient expertise to educate the public on climate change	67
My agency has sufficient expertise to conduct climate change needs assessments/ <b>undertake response activities</b>	42/26
My agency has adequate surveillance capacity to address health impacts of ozone and particulates/ <b>mental health issues</b>	26/26
My agency currently uses long-range weather/climate information to inform programmatic activity	37
The respondent is involved in multi-agency initiatives to address climate change, in her/his state or territory	33

similar survey of the chief health officers of 43 state and territorial health agencies (ASTHO, 2009A, p. 19). The key findings of these surveys are shown in TABLE 5. The local health department executives exhibited widespread recognition of and concern about climate change's health implications at the local level, coupled with a pervasive belief that neither local departments, state health departments nor the CDC were yet up to the challenge of facing those implications. The state-level officials exhibited a somewhat higher level of confidence than their local counterparts, yet their responses suggest that state public health departments have inadequate surveillance capabilities, are not widely involved in interagency climate-change initiatives and lack the staff and tools to engage in climate change needs assessments and response activities.

A 2009 analysis by Trust for America's Health utilized some simple indicators to conduct a preliminary review of states' readiness to address climate change health impacts. The indicators included the creation of a state climate change plan or strategy that "included a detailed vision of the role public health would play in preventing and preparing for climate change;" creation of a state climate change commission or advisory panel reporting to the governor or legislature, including a representative from state or local public health departments; receipt in fiscal year 2009 of a CDC Environmental Public Health Tracking Program<sup>x</sup> or National Asthma Control Program grant;<sup>xi</sup> and receipt in fiscal year 2008 of CDC funding to participate in the "ArboNet"<sup>xii</sup> vector-borne disease surveillance system (Levi & Vinter, 2009, pp. 35-39). While acknowledging that this set of indicators was not conclusive, the study authors believed that it did "help identify gaps in current climate change preparedness and response" (Levi & Vinter, 2009, p. 33).

The five Gulf Coast states all participated in ArboNet, but only two had received asthma grants (Mississippi and Texas) or Environmental Public Health Tracking grants (Florida and Louisiana). None of the five had a plan or an advisory body that completely matched the above criteria. Although Florida had created both a plan and an advisory board, the study found them lacking the requisite public health component and participation. The other four states had not created any climate change plan or advisory body (Levi & Vinter, 2009, p. 34).

We applied a simplistic test to determine if state health departments are educating their citizens about the health dimensions of climate change. In March 2010 we searched the websites of the five Gulf state health departments<sup>xiii</sup> for "hits" on the terms "climate change" and "global warming," for links to the CDC Climate Change program website and links to the major climate change research programs (USGCRP and IPCC). Except for Florida, we came up almost empty-handed (TABLE 6). Today, a resident of Alabama, Louisiana, Mississippi or Texas could be excused for concluding that her state health department is not particularly concerned about climate change. Regardless of what those state governments are actually doing, their health departments' portals don't communicate that there is a profound link between climate change and human health.



**TABLE 6: SEARCH RESULTS FOR GULF STATES DEPARTMENTS OF HEALTH WEBSITES MARCH 26, 2010**

<b>Climate Change Related Subject</b>	<b>AL</b>	<b>FL</b>	<b>LA</b>	<b>MS</b>	<b>TX</b>
Number of hits for “climate change”/ “ <b>global warming</b> ”	0/0	8/1	0/0	0/0	8*/2
Number of hits for “sea level rise”	0	1	0	0	0
Number Hits For Dengue	0	1	0	0	0
Links to <a href="http://www.cdc.gov/climatechange">www.cdc.gov/climatechange</a>	0	1	0	0	0
Links to Global Change Research Program, Climate Change Science Program or IPCC (full name or acronym)	0	0	0	0	0
*Only 2 links directed the viewer to information about climate change and health					

None of these findings should be surprising, given the lack of federal resources to help state and local governments staff up for climate change, a competing decade-long federal emphasis on pandemic and all-hazards public health preparedness, some governors’ overt hostility to the concept of climate change and the absence of a cohesive federal policy, approach or strategy for addressing the health implications of climate change.

### **3.5 Another perspective**

Finally, the discussion within the public health profession over climate change includes a persistent voice which suggests that the dedication of more resources to the “Ten Essential Services of Public Health,” even if coupled with more coordination and collaboration, may be an inadequate societal response. This position argues that “a new advocacy and public health movement is needed urgently to bring together governments, international agencies, non-governmental organizations (NGOs), communities and academics from all disciplines to adapt to the effects of climate change on health” (Costello, 2009, p. 1693). Just below the surface lurks the belief that only a radical redistribution of wealth towards the worlds’ poorest, coupled with commensurate curtailment of carbon-intensive consumption by the “developed” world, can avert widespread misery from climate change’s predictable global health impacts (McMichael & Kovats, 2000, p. 57).

This argument has an implied warning that by themselves, more of the public health tools and techniques that have served the developed world so well will not inoculate the richer nations against unwelcome, involuntary changes in their lifestyle and limitations on their freedom of choice. For instance, Smith writes that “the rich will find their world to be more expensive, inconvenient, uncomfortable, disrupted, and colorless—in general, more unpleasant and unpredictable, perhaps greatly so” (Smith, 2008, p. 1). Capon et al imply that attaining a “healthy way of life” in the face of climate change may necessitate a narrower spectrum of urban settlements in which, regardless of preferences, everyone must walk, bike or ride the bus everywhere and

seek cultural enrichment in a more limited geographic space (Capon, Synnott, & Holliday, 2009, p. 25).

The Lancet report entitled “Managing the Health Effects of Climate Change” makes this point directly: “the biggest sociopolitical challenge affecting the success of climate change mitigation is the lifestyle of those living in rich nations and a small minority living in poor nations, which is neither sustainable nor equitable” (Costello, 2009, p. 1696). Although this statement refers to reduction of greenhouse gas emissions rather than climate change adaptation, its message is unambiguous. Health impacts unavoidably will compound and worsen unless the richer nations learn to live with less.

## **4. U.S. Federal Government Preparedness for Climate Change Health Impacts**

### **4.1 Where we are today**

Several experts have observed that current federal research efforts on climate change and human health are unfocused and inadequate, and have called for a major overhaul in funding and priorities. For instance, at a January 2009 Institute of Medicine workshop on a research agenda for climate change and human health, John Balbus characterized the current state of affairs as “wheels spinning, no movement” (Balbus, 2009, p. 29). Around the same time, Ebi and her colleagues concluded that research funding for climate change health impacts across the entire federal government was just a small fraction of their previously-noted recommendation of at least \$250 million per year (Ebi, et al., 2009, p. 861). It also is clear that the elaborate institutional mechanisms created over the last decade in the National Infrastructure Protection Plan (NIPP) to address the “all hazards” vulnerability of health and public health, transportation, agricultural, water system and sanitary system infrastructure scarcely recognize climate change as a threat (DHS, 2009). The same is true of the Department of Health and Human Service’s recent “National Health Security Strategy” (DHHS, 2009). Agencies like CDC and NIH are funding very limited amounts of research and capacity building in state and local governments (CDC, 2010A; GAO, 2009A, p. 49; NIH, 2010A).<sup>xiv</sup> Unfortunately, however, the Government Accountability Office recently concluded that “the federal government’s emerging adaptation activities are carried out in an ad hoc manner and are not well coordinated across federal agencies, let alone state and local governments” (GAO, 2009B, p. 58).

### **4.2 Where we may be heading**

In the summer of 2009, the House of Representatives passed an energy and climate bill known as Waxman-Markey (Clerk of the House, 2009),<sup>xv</sup> and several months later, a Senate Committee reported a similar bill (known as Kerry-Boxer)<sup>xvi</sup> to the full chamber (Boxer, 2009). These bills would have allocated approximately \$1 billion over ten years to fund new climate change-related public health adaptation, research and capacity-

building initiatives in the Department of Health and Human Services (**CBO, 2009, 2009A**). It should be noted that the new contemplated HHS funding—about \$100 million per year—is barely 40% of the previously-noted recommendation for research, surveillance and monitoring alone (Ebi, et al., 2009). The bills also would have provided complementary funding for a new National Climate Service, a revamped and expanded Global Change Research Program, a program of grants to states to build climate change resilience and programs focused on adapting to climate change impacts on water supplies and natural resources (Pew Center, 2009). The additional funding would have come from government revenues under a “cap-and-trade” program. Last October, numerous scientific, environmental and health organizations strongly endorsed the public health provisions of these bills (ASPH, 2009).<sup>xvii</sup>

There is great uncertainty about what will happen on the legislative front in the second half of 2010. According to a multi-year opinion study by Yale and George Mason Universities, “the American people are becoming less—not more—convinced that climate change is real and serious” (Maibach, 2010, p. 16). There also has been a substantial increase in the percentage of Americans who “view global warming as a more distant threat—primarily to other people—that won’t manifest for another decade or two” (Leiserowitz & Maibach, 2008; Leiserowitz, Maibach, & Roser-Renouf, 2010, p. 2). The American Power Act, the new energy and climate act that Senators Kerry and Lieberman introduced in early May (U.S. Senate, 2010), did not include the funding and programs for climate change-related health research and adaptation contained in the 2009 bills.

While Congress has hesitated on energy and climate legislation, other units of the federal government have been trying to advance a climate change research and adaptation agenda in various ways. An “Interagency Working Group on Climate Change and Health” released a report entitled “A Human Health Perspective on Climate Change” on Earth Day 2010 (NIH, 2010C). This report is notable for presenting climate change health research on which IPCC, USGCRP and others previously have reported, in terms of cancer, cardiovascular disease, stroke, allergies, asthma, COPD, mental health and stress, nutrition, human development, neurological disorders, infectious diseases and other ailments. In so doing, it implicitly has aligned climate change health impacts with political actors—various NIH institutes and centers, members of Congress and advocacy groups interested in particular diseases and health risks. This report also cautions that substantial research is still needed on the potential negative health consequences of widely-heralded GHG mitigation approaches (such as biofuels, electric cars, hydrogen fuel cells and solar electric power) and potential adaptations such as increased wastewater recycling, genetic modification of crops and greater use of air conditioners.

A National Academies Project called “America’s Climate Choices” released its initial reports in late May 2010 (National Research Council, 2010A, 2010B). These reports propose a set of broad and generic recommendations—including the development of a national climate change adaptation strategy—for how government and civil society in the United States should organize a national adaptation effort (National Research Council, 2010A, pp. 191-203). Unfortunately, neither the new National Academies reports nor the interagency report offers any analysis or estimate of the federal funding that would be

necessary to pursue an adequate research program, or prioritizes a diverse array of recommended research projects.

A final major initiative is the Interagency Climate Change Adaptation Task Force that President Obama created last year (White House, 2009). There is little public information about this Task Force beyond its stated mission to form recommendations towards a national adaptation strategy, to integrate climate change resilience and adaptive capacity into federal government operations and to promote adaptation at the local level (White House, 2010A).

## 5. Conclusion

There is a strong consensus within the scientific community that climate change will profoundly (and mostly negatively) affect human health for generations to come. Some direct and indirect paths between climate change and poorer health already are well-established and well-documented, while many other paths are strongly suspected and supported by theory and preliminary evidence. Scientists expect climate change to exacerbate virtually all the categories of illness which cause the majority of morbidity and mortality in the United States. Each year, the public sector spends billions of dollars to prevent and treat these illnesses through research and public health programs--a significant burden on federal, state and local budgets. The illnesses themselves take a huge toll on the U.S. economy and on household savings and wealth. On the other hand, there is a strong and compelling scientific consensus that America could protect itself from many of the worst anticipated health impacts of climate change by putting in place a robust program of adaptation policies and programs. Although the cost of such adaptations would likely be immense, the cost of a comprehensive research program to maximize the efficiency (and minimize the cost) of climate change adaptations would be small compared to the \$32 billion that the Department of Health and Human Services (largely NIH) spends on research each year.

Even so, in the United States climate change and its potential impacts on health do not command nearly the attention, interest or media coverage as the economic crisis, the Deepwater Horizon Gulf oil spill crisis or America's ongoing wars. There is hardly a groundswell of popular support or advocacy for governmental leadership to address this slowly unfolding and insidious catastrophe. Government reports, such as the recent volumes from NIH and the National Research Council, convey the magnitude of the problem but scrupulously avoid alarmist terminology and prescriptions for large scale governmental intervention. Upon the occurrence of a series of catastrophic weather events that caused untold human suffering, Americans might rally to the cause if they strongly associated those events with climate change. Absent such events, it will be an immense challenge for concerned leaders to muster a political coalition sufficient to join the battle.

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The only relatively recent study to present a comprehensive survey of climate change's myriad physical effects just in the five states that border the Gulf of Mexico was a 2001 report by the Union of Concerned Scientists and the Ecological Society of America (Twilley, Barron, Gholz, & Harwell, 2001). The United States Global Change Research Program's (USGCRP) 2009 report entitled Global Climate Change Impacts in the U.S. includes a chapter on the generic types of climate changes that can be expected in a twelve-state area referred to as "the Southeast" (GCRP, 2009, pp. 111-116). This chapter, however, does not restrict its focus to coastal states, nor does it discuss the human health impacts of climate change in the Southeast region.

<sup>ii</sup> USGCRP "was known as the U.S. Climate Change Science Program from 2002 through 2008." See (GCRP, 2010) In this report, USGCRP is used in discussing reports published under both names, although the citations will include the title in effect at time of publication.

<sup>iii</sup> Medium confidence signifies "about 5 out of 10;" and low "about 2 out of 10" (IPCC, 2007, p. 4)

<sup>iv</sup> The authors of this study provide a detailed technical analysis of their sea level rise assumption. They note that "the projected rate of relative sea level rise for the region is consistent with historical trends, other published region-specific analyses, and the IPCC 4th Assessment Report findings, which assumes no major changes in ice sheet dynamics." (Savonis, Burkett, & Potter, 2008, pp. ES-4)

<sup>v</sup> For a discussion of the uncertainties in estimating sea level rise and the expected variability of sea level rise even in a limited region such as the Gulf Coast, see (Lemonick, 2010)

<sup>vi</sup> Both amounts expressed in present value terms.

<sup>vii</sup> As noted in TABLE 1, the IPCC also assigned a relatively low level of concern to Dengue.

<sup>viii</sup> Early in 2010 CDC added Dengue to the list of nationally notifiable infectious diseases (CDC, 2010).

<sup>ix</sup> <http://www.cdc.gov/climatechange/prevention.htm>

<sup>x</sup> The CDC website provides the following: "EPHT is the ongoing collection, integration, analysis, interpretation, and dissemination of data on environmental hazards, exposures to those hazards, and health effects that may be related to the exposures. The goal of tracking is to provide information that can be used to plan, apply, and evaluate actions to prevent and control environmentally related diseases." Retrieved June 14, 2010 from <http://www.cdc.gov/nceh/tracking/pib.htm>.

<sup>xi</sup> A description of this grant program is available at <http://www.cdc.gov/asthma/nacp.htm>.

<sup>xii</sup> Described in the TFAH report as "an internet-based national arboviral surveillance system developed by state health departments and CDC in 2000 to provide public health officials and health care providers with information about disease activity in their states."

<sup>xiii</sup> Using each site's internal search engine.

<sup>xiv</sup> As of April 8, 2010, NIH had awarded four grants totaling \$1,336,369 during the initial fiscal year.

<sup>xv</sup> The House vote on Waxman-Markey was extremely close—219 to 212--(Clerk of the House, 2009) and of the 75 Members representing the five Gulf Coast states, only 19 (one fourth) voted in favor (APHA, 2010).

<sup>xvi</sup> The formal names and numbers of the House and Senate bills, respectively, are American Clean Energy and Security Act (HR 2454) and the Clean Energy Jobs and American Power Act (S 1733).

<sup>xvii</sup> Signatories included the American Public Health Association, the National Association of County and City Health Officials, the Association of State and Territorial Health Officials, American College of

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Preventive Medicine, the American Academy of Pediatrics, the Association of State and Territorial Directors of Nursing, Council of State and Territorial Epidemiologists and Association of Schools of Public Health.