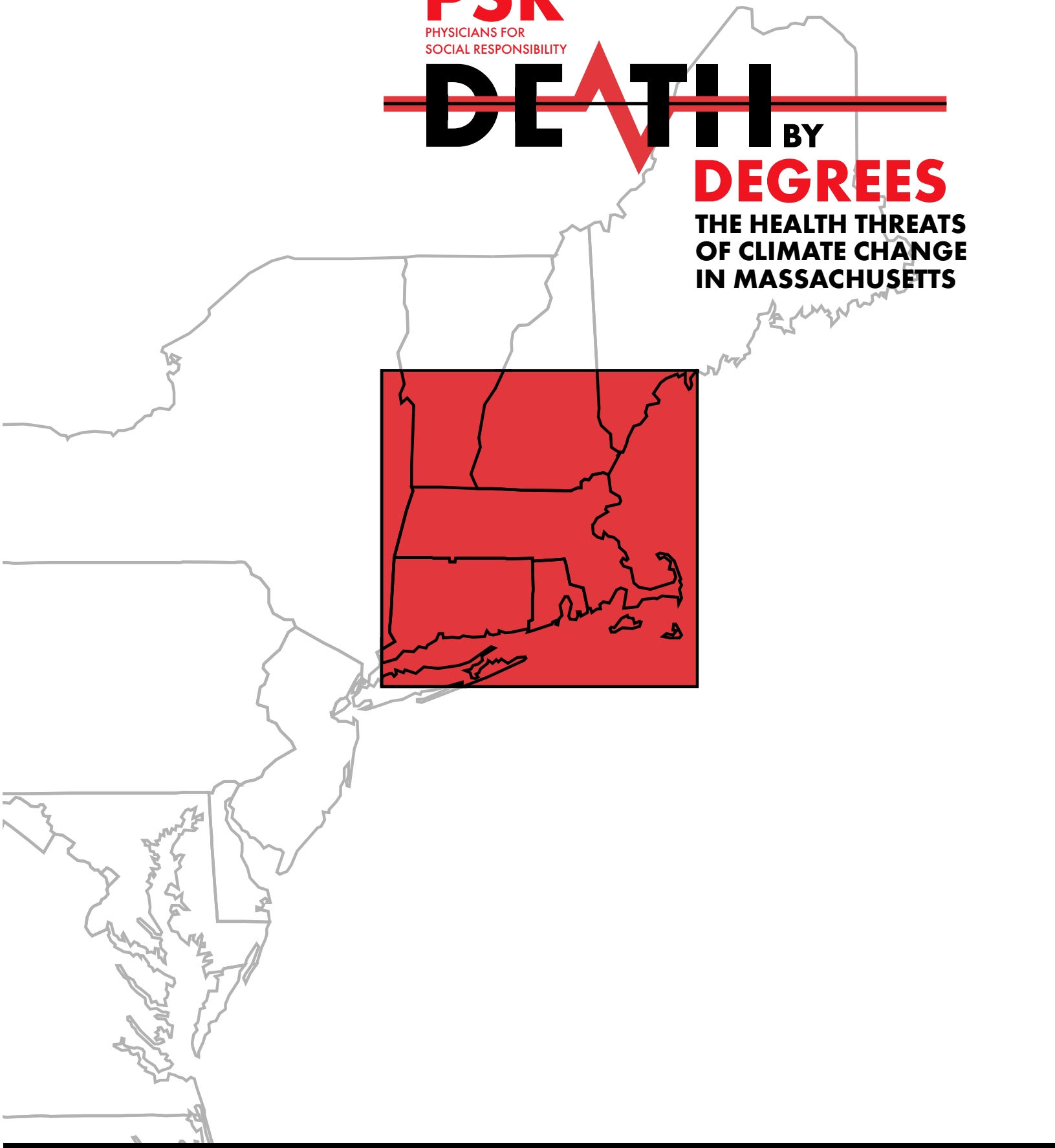
PSR
PHYSICIANS FOR SOCIAL RESPONSIBILITY

DEATH BY DEGREES

THE HEALTH THREATS OF CLIMATE CHANGE IN MASSACHUSETTS



MASSACHUSETTS REPORT

PSR
PHYSICIANS FOR
SOCIAL RESPONSIBILITY

DEATH BY DEGREES

THE HEALTH THREATS OF CLIMATE CHANGE IN MASSACHUSETTS

Physicians for Social Responsibility

Robert K. Musil, PhD, Executive Director

Sharon Newsome, Director, Environment and Health Program

Karen Hopfl-Harris, JD, Associate Director

Lara Hensley, Grassroots Organizer

Jennifer Wright, Medical Student Consultant, Tufts Medical School

PSR Death by Degrees Medical Consultant

Kent J. Bransford, MD

Massachusetts Advisory Board

Richard W. Clapp, MPH, DSc, Associate Professor, Department of Environmental Health, Boston University School of Public Health

Paul Epstein, MD, MPH, Associate Director, Center for Health and the Global Environment, Harvard Medical School

Ross Gelbspan, Author: *The Heat Is On: the climate crisis, the cover-up, the prescription*, (Perseus Books, 1998); creator of www.heatisonline.org

Kevin Griffith, MD, MPH

Ira Helfand, MD, Department of Emergency Medicine, Cooley Dickinson Hospital, Northampton, Massachusetts, Past-President of Physicians for Social Responsibility

February 2001

This report was prepared by Physicians for Social Responsibility to alert Massachusetts residents to the potential health effects of climate change and to encourage them to reverse global warming's deadly course by reducing reliance on fossil fuels.

PHYSICIANS FOR SOCIAL RESPONSIBILITY
1101 Fourteenth St., NW, Suite 700
Washington, DC 20005
tel: (202) 898-0150
fax: (202) 898-0172
website: www.psr.org

Death by Degrees

Over the last several years, we have been deluged with reports from scientists worldwide, detailing the accumulation of greenhouse gases in the atmosphere, and warning us that unless we are able to reduce our emissions of these gases, we are likely to experience major changes in the world's climate, with consequences that could prove disastrous for human beings. . . it is essential that health be at the center of the global environmental debate, and that physicians and other health professionals take the lead in educating the public and informing policy-makers about the human dimensions of global environmental change.[1]

—ERIC CHIVIAN, MD, DIRECTOR,
CENTER FOR HEALTH AND THE GLOBAL ENVIRONMENT, HARVARD MEDICAL SCHOOL

Climate fluctuations have occurred during previous centuries, but at the dawn of the 20th century a warming trend took hold that shows no signs of stopping. During the past one hundred years average global surface temperatures have increased by approximately one degree Fahrenheit. Each and every year from 1987 to 2000 has been one of the fifteen warmest years on record.[2] In 2000, scientists at the National Oceanic and Atmospheric Administration (NOAA) announced that the winter of 2000 was the warmest winter on record since the United States government began keeping weather statistics 105 years ago.[3] This is the third year in a row that record has been broken, and many other records concerning heat and temperatures continue to be topped.

Although uncertainties exist in measuring global warming, an overwhelming consensus has emerged over the last decade among scientists on several key points. First, the increase in temperature is real. Second, human activities—in particular our burning of fossil fuels—are affecting the climate system.[4] Third, warmer conditions on Earth will directly affect our lives and well-being.[5]

This report describes how the changing global climate could impact human health. Our focus is on Massachusetts, a state that may experience increased illness, mortality, more severe weather, and property damage due to changes in temperature and weather.

Executive Summary: Massachusetts—A State At Risk

In Massachusetts we can expect temperature rise and climate instability to be accompanied by more heat-related deaths, more ozone-related respiratory disease, more Lyme Disease and other insect-borne disease, more pollen allergies, and more psychological stress. Similarly, our coastal areas and wildlife will be stressed by sea level rise and habitat alterations.[6]

—DR. RICHARD CLAPP, ASSOCIATE PROFESSOR, DEPARTMENT OF ENVIRONMENTAL HEALTH, BOSTON UNIVERSITY SCHOOL OF PUBLIC HEALTH

Residents of Massachusetts are accustomed to change. They experience it every day with the region's notoriously variable weather, and they observe it over months and even decades, as shorelines shift,[7] bluffs erode, and barrier beaches and dunes migrate inland.[8] Due to the state's latitude, coastal orientation, position within the zone of westerly winds, and differences in elevation, Massachusetts is naturally prone to harsh seasonal changes.[9] But,

How Global Warming Could Threaten Health in Massachusetts

A number of health hazards may increase as a result of global warming. According to physicians who have studied global warming and its effects, the most severe health risks in Massachusetts could include the following:

- More heat-related illness and death in Massachusetts. Deaths resulting from heat distress during a typical summer could increase 50 percent, from nearly 100 heat-related deaths per summer to over 150 fatalities[10] with the predicted four to five degree rise in temperature over the next century.
- More personal injury and property damage from severe storms, lightning, flash floods, and ice storms.
- An increase in the number and severity of toxic algal blooms, or red tides, which could affect the state's multimillion dollar fishing industry and threaten the health of shellfish consumers who could contract severe illnesses, such as paralytic shellfish poisoning, from shellfish caught in affected waters.
- An increased death rate from heart failure due to temperature extremes. Massachusetts already experiences a high number of deaths due to cardiovascular diseases, with 24,736 fatalities due to heart disease and stroke in 1997 alone.[11]
- Decreased air quality in the state due to increased ozone (smog) levels, could lead to more frequent and severe cases of asthma and other respiratory diseases. Ozone-related health problems already warrant high concern in the state. In just one period, from April to October of 1997, there were 4,500 emergency room admissions and 170,000 asthma attack cases in Massachusetts related to ozone exposure.[12]
- More cases of diseases spread by ticks and mosquitoes, such as West Nile Virus and Lyme disease.
- An increase in water-borne illness caused by exposure to infectious agents like cryptosporidium and giardiasis, which could be released or become concentrated in the state's water supplies if climate change alters water levels and increases the occurrence of flooding events.
- More cases of food contaminated by E. coli, salmonellosis, Hepatitis A, listeria, shigella, cyclospora, and campylobacter could occur in association with summer heat waves. The caseload is already high, with the state reporting 1,159 cases of campylobacter[13] in 1999 and 1,212 cases of salmonellosis in 2000.[14]
- Greater risk of injury and property damage, particularly along the coastal regions of Cape Cod, Nantucket, and Martha's Vineyard due to coastal erosion associated with heightened sea levels.
- Increased allergy problems due to heightened pollen levels and air pollutants.

even tough New Englanders who have lived through many a Nor'easter may not be prepared for the changes that global warming could bring.

Over the next century, temperatures in Massachusetts could change dramatically. Based on projections made by the Intergovernmental Panel on Climate Change, by 2100, temperatures in Massachusetts could increase from four to five degrees F in all seasons. In addition, precipitation is projected to increase by 10 percent in spring and summer, by 15 percent in fall, and by 20 to 60 percent in winter.[15]

While projections look to the future, global warming appears to be influencing climate now. Heat stress days and nights have increased in Boston over the past fifty years.[16] More heat brings more cases of heat cramps, heat exhaustion, and heat stroke. In addition, heat tends to exacerbate the death rate from other medical conditions. The elderly, infirm, children, and infants will likely suffer the most.

Climate change means extremes. While global warming could cause overall temperatures to rise during the winter months, predictions also include an increase in the frequency and intensity of winter storms and weather extremes, meaning winters with more days of very low temperatures. In addition, the amount of precipitation on extreme wet or snowy days in winter is likely to increase.[17] Extreme cold also poses direct threats to human health, leading to cases of hypothermia and frostbite. Extreme weather and sudden temperature fluctuations may also affect individuals with pre-existing respiratory and heart problems, exacerbating their conditions.

Greenhouse gas concentrations increase heat and moisture in the atmosphere. Heat and water vapor create instability, leading to more frequent and possibly more severe weather activity.[18] Increased precipitation could lead to more flooding. Flooding increases the risk of water contamination, gastrointestinal illnesses, and property damage. Floods can result in cases of bacterial disease and respiratory problems as well as fungal growth in homes. Tornadoes and thunderstorms could also result. Strong winds from these events could lead to more property damage, injuries, and fatalities in the state. The forecasted atmospheric instability could lead to more thunderstorms, hailstorms, and lightning strikes.

Massachusetts' air quality could deteriorate due to climate change. Pollutants emitted from cars and the state's dirtiest power plants include carbon dioxide, which causes global warming. Other pollutants contribute to ground-level ozone. The amount of ozone in the air, the primary component of smog, commonly rises on hotter days. High ozone levels exacerbate asthma and other respiratory illnesses. In addition to asthma attacks, exposure to elevated ozone levels can cause shortness of breath, pain when breathing, lung and eye irritation, and greater susceptibility to respiratory illness, such as bronchitis and pneumonia.[19]

Water quality and availability may also be compromised as the climate changes. Reduced availability of water due to increased evaporation, reduced water reserves due to early melting of snow packs, altered seasonal cycles of runoff, and increases in river and stream flow variability may result. Lowered water levels may also necessitate the dredging of inlets, which could release toxins buried in sediment. Gastrointestinal diseases such as giardiasis and

cryptosporidosis that annually affect many Massachusetts residents could become more common.

Contaminated water could impact Massachusetts' food supply as people ingest water-borne toxic agents.[20] Further, increased temperatures can encourage the growth of food contaminants such as *E. coli*, salmonella, Hepatitis A, listeria, shigella, cyclospora, and campylobacter. These contaminants cause illnesses that already affect Massachusetts residents each year.

Global warming also may change the chemical composition of the water that fish and shellfish inhabit, causing the amount of life-sustaining oxygen in the water to decline, while dangerous pollution and salt levels increase.[21] Additionally, climate change, warmer oceans, and more extreme weather events may combine to increase the occurrence and severity of poisonous algal blooms, also known as "red tides," which threaten shellfish consumers with serious illnesses.

Climate change may increase the human health risk for vector borne disease as well. Warming and other climate changes could expand the habitat of disease-carrying insects and rodents, increasing the potential for transmission of the diseases they carry. Temperature is an important determining factor with respect to transmission of a viral agent by a vector, such as a tick or mosquito.[22] In Massachusetts, diseases spread by ticks include Lyme disease and ehrlichiosis, a disease that attacks blood cells. Mosquitoes already flourish in Massachusetts. Some carry West Nile Virus, a serious disease that has recently spread to the state. Global warming could shift northwards the region where these mosquitoes breed and over winter.

Extreme weather events can affect the populations of nuisance organisms. Drought, for example, can increase the populations of urban mosquitoes related to the spread of West Nile Virus, while rains can increase the populations of rural mosquitoes capable of carrying Eastern Equine Encephalitis. If conditions become warmer and wetter, mosquito populations could increase, thereby increasing the risk of transmission of these diseases.[23]

Sea levels are forecast to rise even more as a result of global warming. It is likely that sea level will rise along the Gulf and Atlantic coasts by 22 inches over the next century.[24] Such a rise could dramatically increase storm surges and lead to coastal erosion, particularly along Cape Cod and the islands of Nantucket and Martha's Vineyard.

Climate change could also affect Massachusetts' agriculture, reducing silage, hay, and other crops by as much as 45 percent.[25] Weather-stressed crops also can increase nitrate concentrations in plants. High concentrations can lead to respiratory and nervous system disorders in animals,[26] and possibly in humans. Plants subjected to high levels of carbon dioxide can have fewer nutrients than normal.[27] Wetter weather can increase crop pests especially fungi and nematodes, while drought can increase aphids. Freezing, thawing and refreezing may increase the vulnerability of trees to pest infestations. Pest infestations, in turn, can increase the vulnerability of forests to fires.

Finally, Massachusetts' forests could change as a result of global warming. Forests weakened by pollution and dried from warmer temperatures are at risk from fire. Fires not only damage wildlife and property, but also create serious health problems, as smoke from forest fires can increase cases of respiratory illness.

As temperatures increase, maple-dominated hardwood forests could be replaced by oak and conifer stands, species that are more tolerant of higher temperatures.[28] This change would vastly diminish the state's brilliant autumn foliage, which currently brings substantial tourist dollars into the area. As a result, jobs related to fall tourism could be lost, possibly influencing the ability of individuals dependent upon these jobs to afford health insurance. Already, state uninsured rates are of concern. Despite a recent decrease in the number of uninsured people in Massachusetts, in 1998, 10.3 percent of Massachusetts residents remained without health insurance coverage.[29]

Massachusetts needs to be deeply concerned about the potential health impacts of global warming on its population. Only precautions taken now can avert the potential health problems of the future. The following sections describe the specific health effects that are predicted to result from global warming over the next fifty to one hundred years. In some cases, there is a

The Complex Origins of Climate Change

Since the end of the last Ice Age 10,000 years ago, temperatures worldwide have risen about 9 degrees Fahrenheit, mainly due to natural changes in the geographical distribution of the sun's energy and in the amounts of dust, carbon dioxide, and other gases in the atmosphere.

In recent years, the rate of increase in temperatures has been accelerating. On any given day the average temperature is about 1 degree F higher than it was a century ago. Eight of the ten warmest years in recorded history occurred in just the last decade, with 1998 topping them all.[30]

Some greenhouse gases, such as carbon dioxide, methane, nitrous oxide, and water vapor, occur naturally, residing in the atmosphere and insulating the earth. These gases retain heat from the sun's rays and keep the earth's surface some 60 degrees F warmer than it otherwise would be.[31] However, the amount of greenhouse gases in the atmosphere has been rapidly increasing. Since the beginning of the industrial revolution, atmospheric concentrations of carbon dioxide have increased nearly thirty percent, methane concentrations have more than doubled, and nitrous oxide concentrations have risen by about fifteen percent.[32] The increases are staggering and show no signs of stopping. In 1999, for example, the United States released 13 percent more greenhouse gases than in 1990.[33] Such increases have enhanced the heat-trapping capacity of the earth's atmosphere.

Human activities are among the most important factors making Earth warmer. Fuel burned to run cars and trucks, heat homes and businesses, and power factories generates approximately 80 percent of carbon dioxide emissions in the United States.[34] Deforestation, livestock production, landfills, industrial production, and mining can also change the levels of greenhouse gases by increasing emissions or by decreasing the absorption of gases by plants.

In 1994, the United States was responsible for releasing about one-fifth of global greenhouse gas emissions into the atmosphere. If current trends continue, carbon dioxide concentrations could increase by 30 to 150 percent by the year 2100.[35] Scientists recently detected a new greenhouse gas 18,000 to 22,200 times more powerful than carbon dioxide, with an atmospheric life span of up to 3,500 years.[36] The gas trifluoromethylsulphur pentafluoride, or SF_5CF_3, has been found in the atmosphere five to twenty miles above the Earth's surface, where it contributes to global warming by absorbing heat radiating from Earth's surface. The gas is of human origin and researchers speculate that the gas is a breakdown product of high voltage equipment, but an exact source is unknown. Studies suggest that emissions began in the late 1950s and since then levels have increased from near zero to 0.12 parts per trillion in 1999. In addition, its rate of growth may be accelerating. SF_5CF_3's long lifespan means that unless its production is prevented, its levels can be expected to increase as the gas accumulates in the atmosphere. It, along with other greenhouse gases, will remain there for centuries, trapping heat and threatening human health.

high level of certainty about the predictions. In others, the evidence is less definitive. The United States has the ability to adapt to, and prepare for, these changes because of its health care infrastructure and strong economy. However, we will only ameliorate the potential health effects of climate change by decreasing greenhouse gas emissions today and investing in strategies that will help us to prepare for what is to come.

The State of the Science

Recent scientific studies suggest that global warming is underway and that temperatures are rising due to increases in greenhouse gases. Scientists studying ice cores, oceans, solar changes, volcanic activity, and temperature trends, to name a few topics, all conclude that warming is occurring and human activities are likely playing a role. Our current understanding of the potential impacts of climate change is limited by the accuracy of climate models that are still being developed and perfected. However, forecasting models are gaining credibility every day as weather patterns and other environmental occurrences confirm projected scenarios.

Further, the Intergovernmental Panel on Climate Change (IPCC), a United Nations-sponsored group of hundreds of scientists, recently distributed a report to government officials worldwide stating that human generated pollutants have "contributed substantially" to climate change. The new IPCC assessment on the science of global warming predicts that by 2100, average global surface temperatures will rise from 2.5 to 10.4 degrees F (1.4 to 5.8 degrees C). This is a significantly greater increase than the 1 to 3.5 degree C increase predicted in the second assessment report of the IPCC from 1995.[37]

In an October 2000 report in the journal *Science*, researchers from the National Climatic Data Center and the National Center for Atmospheric Research analyzed 20 global climate models, along with weather patterns documented over the past century. Scientists concluded that extreme weather will occur more frequently as climate changes, and warned that hotter days, warmer nights, heavier rain and snowfall events, and more floods are expected over the coming years, as carbon dioxide and other greenhouse gases affect the Earth's climate.[38]

In December 2000, climate analysts at the National Center for Atmospheric Research quantified the effects of El Niño events and major volcanic eruptions on average global temperatures. Volcanic emissions tend to block sunlight and El Niño episodes can raise overall temperatures, which mask temperature trends. Adjusting for these effects, scientists discovered an intense warming trend over the past century, with temperatures increasing by one quarter of a degrees Celsius per decade. Lead analyst Tom Wigley concluded that human activities are the primary cause of the warming.[39]

A July 2000 study in the journal *Science* found that human activity is the primary contributing force behind the sharp global warming of the 20th century. Using extensive climactic analysis and modeling, geologist Thomas Crowley determined that natural forces, such as solar changes and volcanic activity, could only account for 25 percent of the warming since 1900.[40] The finding suggests human activities, like burning forests and fossil fuels, could be responsible for up to 75 percent of global warming.

Scientists at the Tyndall Centre for Climate Change Research at the University of Anglia in Norwich, England, analyzed climate models and weather patterns throughout the world and determined that several countries could be devastated by the effects of global warming. Countries mentioned in the November 2000 study include Saudi Arabia, Afghanistan, Iran, and Africa. A projected warming of 5 degrees C would most certainly increase drought and famine levels in these parts of the world.[41] Warming in Canada and in the Antarctic could rise even more, by 6 degrees C,[42] heightening the threat of sea level rise due to melting glaciers, which could impact residents in Massachusetts.

In January 2000, scientists at NASA's Jet Propulsion Laboratory announced that the persistence of La Niña and El Niño events—which cause abnormal sea-surface temperatures thereby affecting worldwide weather patterns—might be part of a larger, long-lasting climate pattern.[43] In addition, scientists studying the world's oceans discovered that in the past 50 years the world ocean has exhibited a net warming down to a depth of 3 kilometers. The warming is likely due to both natural variability and human activities, however, researchers believe that Earth's excess heat must primarily be accumulating in the ocean. This study provides an answer to one criticism levied against many climate models that predict the impacts of greenhouse gases: Earth's atmosphere is not warming as rapidly as predicted. The study suggests that the world's oceans, which can store and transport large amounts of heat, could be storing this missing heat, thus helping to explain the inconsistencies in past climate forecasting.[44] This stored heat may be an early indicator of the further warming of air and sea temperatures in the next ten years.[45]

Today concentrations of greenhouse gases appear higher than they have been in the past 420,000 years.[46] Even if certain individuals are able to adapt to changes caused by global warming, some populations will remain susceptible. The most vulnerable individuals include infants, children, the elderly, and the infirm.

Clearly the availability and continued development of better information on the potential impacts of climate change, and the interaction of these impacts with other important factors, is critical if society is to understand the science of climate change and to prepare for the changes global warming could bring. Natural climate variability and other factors, such as air quality, land use, population, water quality, health care infrastructure, and the economy, may also impact projections. A few scientists even argue that countervailing climatic forces, such as sulfur dioxide, actually are cooling the atmosphere. However, the majority of climate scientists agree that greenhouse gases produced by humans are changing Earth's atmosphere and that now is the time to take action on a global level.

Many Massachusetts Residents are Vulnerable to the Health Effects of Climate Change

Certain populations within the United States—the poor, the elderly, children and immunocompromised individuals—may be more vulnerable to many of the health risks that might be initially exacerbated by climate change.[47]

—REPORT OF THE HEALTH SECTOR OF THE US NATIONAL ASSESSMENT ON CLIMATE CHANGE

Many Massachusetts residents are particularly vulnerable to the potential health effects of climate change. *Infants* and *children* are at risk because their immune and other protective systems are not yet fully developed. Children less than a year old are most sensitive to heat stress because their heat regulatory systems have not fully matured.[48] In addition, a child's higher susceptibility to heat and cold is due to its body surface area being greater by percentage for its weight. A child dehydrates easier due to external heat or fever compared to an adult with the same fever or in the same external temperatures.

Individuals with existing illnesses are especially sensitive to heat stress, air pollution, and other possible effects of global warming. People with cardiovascular and respiratory illness or impairment are less able to adapt to additional physical stress caused by warmer and more humid environments. Air pollution has also been shown to have a more severe impact on persons suffering from heart and lung diseases.[49]

Higher average temperatures could elevate the number of deaths due to heart disease. Diseases of the heart are the leading cause of death in Massachusetts. In fact, the state ranks 12th in the nation for deaths resulting from cardiovascular disease.[50] Total deaths due to cardiovascular disease in Massachusetts numbered 24,736 in 1997 alone.[51] It is possible that warmer winters could reduce the number of deaths in winter months, however experts agree that the relationship between winter weather and mortality has been difficult to interpret.[52] Many Massachusetts residents also have behavioral factors that could put them at higher risk of developing diseases of the heart. For example, 57.9 percent of individuals in the state aged between 55 and 64 years old were reported as being overweight during a 1996–1997 health surveillance conducted by the Centers for Disease Control and Prevention.[53] According to the Massachusetts Department of Public Health, 20.6 percent of the state's adults smoked in 1997.[54] Of this group of smokers, nearly 30 percent were between the ages of 18 and 24.[55]

Several factors could make the state's *elderly* more susceptible to the potential health-related impacts of global climate change, particularly to heat-related illness. Elderly individuals may have less efficient heat-regulating systems. The temperature at which sweating begins is higher, affecting an elderly person's ability to adjust to warmer temperatures. In addition, the elderly may have a harder time perceiving changes in temperature, preventing them from taking appropriate measures to avoid overheating. Further affecting the elderly, pre-existing conditions, such as cardiovascular or pulmonary diseases, make a person more vulnerable to the effects of heat.

And, some commonly taken medications, such as tranquilizers and anticholinergics, increase susceptibility to heat-related illnesses.[56]

If global warming increases levels of air pollution, *poorer populations* may be hit hardest. Poverty can be an important risk factor for poor health status.[57] Rates of children hospitalized for asthma, for example, increase as family income declines.[58]

Individuals without medical insurance may also be more susceptible to the potential health effects of climate change because they do not routinely see health care providers. They may delay seeking treatment until a condition is severe or at a more advanced, less-treatable stage.[59] Cost may play a role in seeking health care, and this factor may disproportionately affect minorities in Massachusetts. For example 10.3 percent of African Americans and 15.9 percent of Hispanics reported cost as a barrier to obtaining health care in 1997 compared to 6.5 percent of whites.[60]

Global Warming at a Local Level

Although the average temperature worldwide is increasing, hence the term "global warming," the story becomes more complicated at the local level. One reason is that a warmer atmosphere holds greater amounts of water, resulting in more humidity and more intense precipitation. Another is that warmer air means changes in wind patterns. The resulting weather changes will vary from place to place. In general, we can expect more extremes—more heat waves, more storms, wetter climates in some places, drier climates in others, and even cooler temperatures in certain areas. Many scientists, therefore, prefer the term "global climate change" to "global warming." In this report, we use the two terms more or less interchangeably.

Weather Extremes May Lead to Increases in Illness and Mortality

Climate change means extremes. Climate models predict not only higher temperatures, but also more unpredictability in weather patterns and more extreme weather conditions, including extremely cold days.[61] Greenhouse gas concentrations increase heat and moisture in the atmosphere. Heat and water vapor create instability, leading to more frequent, and possibly more severe, weather activity.[62] This may mean more floods, tornadoes, ice storms, Nor'easters, heat waves, and other natural disasters. Extreme weather can cause profound human suffering and huge economic loses. In 1999, insured losses from weather-related natural catastrophes in Massachusetts totaled 85 million dollars.[63] During the 1990's, insured losses totaled nearly 1.2 billion dollars.[64]

Weather extremes and temperature fluctuations can have wide-reaching health impacts, including illness, injury, and death. They can disrupt electrical power sources, compromise access to public service broadcasts, and contaminate drinking water supplies, placing populations in jeopardy. Downed electrical power lines and leaks from natural gas or propane tanks can cause fires, electrocutions, and explosions. Intense rainstorms and floods can wash raw sewage into drinking water supplies and spread infectious diseases. Tornadoes, high winds, thunderstorms, and drought can intensify forest fires, possibly leading to injuries, fatalities, and exacerbated respiratory illness. Residents displaced from their homes by natural disasters can also experience

psychological problems, ranging from depression to post-traumatic stress disorder.[65]

Depending on their severity, extreme weather events can tax, or even cripple, emergency care programs. The consequences could prove disastrous in Massachusetts, where the number of hospital beds is only three for every 1,000 people.[66] Residences are also hit hard. A series of thunderstorms in late July 1999 caused thousands of people to lose power.[67] And, on June 2, 2000, at least 15,000 homes lost power due to damages caused by 73–112 mph winds.[68]

Direct Effects of Heat on Health

Increased mortality (particularly in the very young and elderly with pre-existing cardio-pulmonary deficit) is likely to be influenced as a result of temperature increases within the Boston Metropolitan Area. Increased hospitalizations for respiratory problems are likely sequelae of heat stress.[69]

—DAVID M. GUTE, PH.D., M.P.H., ASSOCIATE PROFESSOR OF CIVIL AND ENVIRONMENTAL ENGINEERING, TUFTS UNIVERSITY

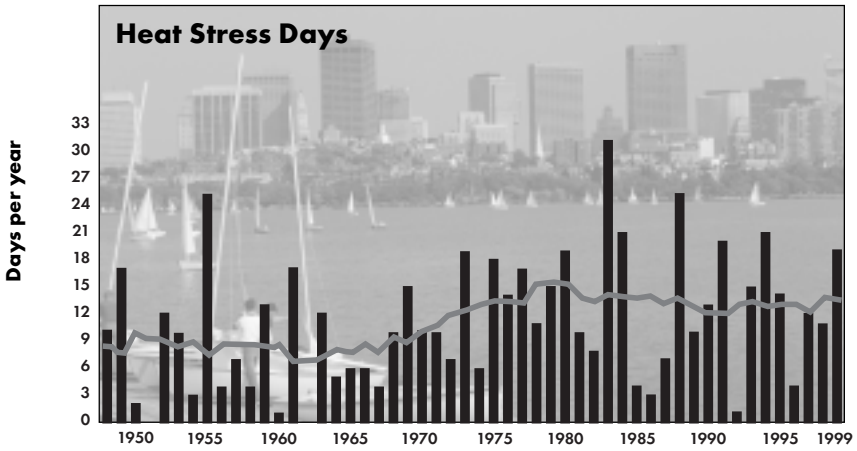
The fourteen years from 1987 to 2000 have each been among the fifteen warmest years ever recorded. Global land temperatures in 1999 made the year the second hottest year on record, beaten only by temperatures in 1998. These warming trend holds true in Massachusetts as well. Average temperatures in Amherst have increased 2 degrees F over the last century.[70] Based on projections made by the Intergovernmental Panel on Climate Change and results from the United Kingdom's Hadley Centre's climate model, a model that accounts for both greenhouse gases and aerosols, it is projected that by 2100 temperatures in Massachusetts could increase by 4 degrees F (with a range of 1–8 degrees F) in winter and spring and by about 5 degrees F (with a range of 2–10 degrees F) in summer and fall.[71] To put this into perspective, the average global temperature at the time of the last Ice Age was only nine degrees lower than temperatures are today.

A recent analysis of data from over 100 weather stations nationwide further reveals that the number of heat stress days and heat stress nights across the country has almost doubled over the past fifty years. The number of four-day heat waves almost tripled nationally.[72] In this study, heat stress days are calculated using the heat index, a combination of temperature and humidity. Heat index gives a better sense of what the human body actually feels on a warm day because humidity can make an individual uncomfortable, and it may threaten health. That is because humidity inhibits the body's natural ability to cool itself through evaporative heat loss and perspiration, resulting in discomfort and heat stress, leading, in some cases, to death.[73] The number of heat stress days and four-day heat waves in Boston has risen over the past fifty years. In the 1950s, temperatures went over the daily average heat index threshold an average of 9 days per year. However, by the 1990s, temperatures raised above the threshold an average of 15 days per year.[74]

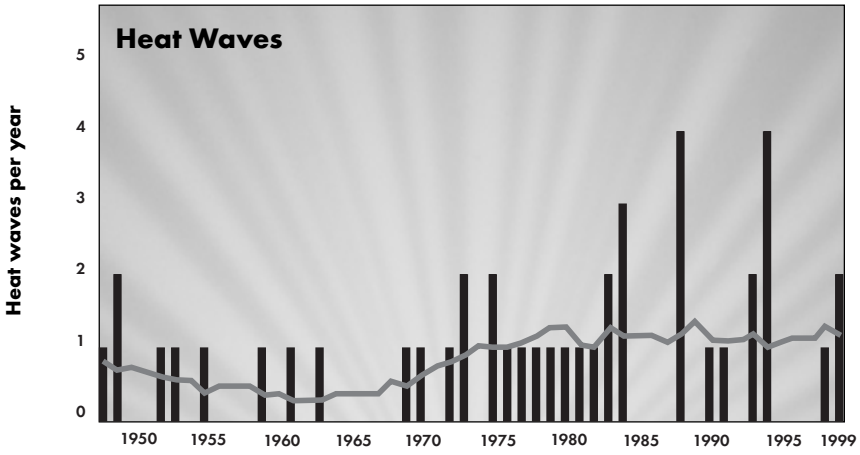
The rise in heat stress nights in Boston has increased even more drastically. In the 1950s, temperatures went over the nightly average heat index

FIGURE 1

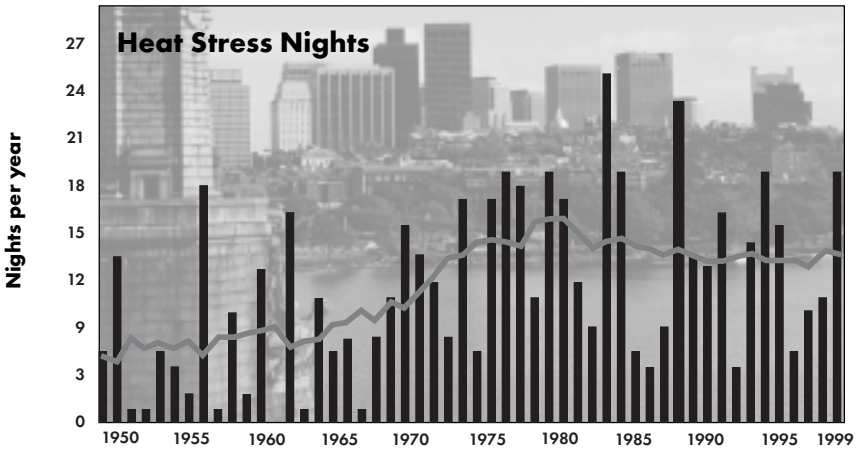
Extreme Heat in Boston, 1948–1999



Number of days with extreme temperatures per year in Boston, 1948–1999



Number of extreme heat waves per year in Boston, 1948–1999



Number of nights with extreme temperatures per year in Boston, 1948–1999

Source: Ozone Action/Physicians for Social Responsibility. 1948–1995 data from Gaffen and Ross, 1998, *Nature*, vol 396, p. 529. 1996–1999 NOAA data was analyzed by Physicians for Social Responsibility and Ozone Action.

threshold 5–6 nights per year. By the 1990s temperatures raised above the threshold an average of 12 nights per year.[75] Nighttime heat can be especially dangerous. Usually the body has a chance to cool down in the evening, but on hotter nights, relief from high daytime temperatures does not arrive. Massachusetts normally experiences over 90 degree F temperatures in the summer months. [76] If nighttime temperatures continue to rise after days of hotter temperatures, mortality could increase as well.

A 1997 study by scientists at the University of Delaware Center for Climatic Research examined mortality and weather data for a series of cities in the United States. During oppressive heat waves there was a significant increase in the number of deaths per day for the general population, with the elderly being most at risk.[77] Massachusetts could be especially susceptible to increased numbers of heat-related deaths because of its irregular, intense heat waves.[78] According to the United States Environmental Protection Agency (EPA), one study projects that by 2050 in Boston, deaths resulting from heat distress during a typical summer could increase by 50 percent, from nearly 100 heat-related deaths per summer to over 150 fatalities.[79]

Heat can directly affect health. According to the American Red Cross, heat-related disorders are caused by a reduction in, or collapse of, the body's ability to shed heat by circulatory changes and sweating. Such disorders may also develop due to a chemical (salt) imbalance caused by too much sweating.[80] Heat may lead to severe health problems, such as heat cramps, heat exhaustion, exertional heat injury, and heat stroke. In addition to heat and humidity, risk factors for these conditions include advanced age, lack of air conditioning, and use of certain medications. Vulnerable populations, including the elderly, children, infants, and the infirm, will suffer the most. Cardiovascular diseases, like coronary heart disease, also are a risk factor. Compounding the public health burden of heat waves is the fact that as excessive heat increases, so does the death rate from other medical conditions.[81]

Heat cramps are muscle spasms that primarily affect people who exert themselves through strenuous work or exercise. Mineral imbalances likely cause these cramps and salt and water replacement usually relieves them. A more severe condition is exertional heat injury that commonly occurs among runners who are not properly conditioned and hydrated. The body can reach 102 to 104 degrees, with symptoms that include goose bumps, chills, nausea, vomiting, and unsteady gait. In severe cases, people may have incoherent speech, or even lose consciousness. Muscles, kidneys, and blood cells may be damaged.

Heat exhaustion, or heat collapse, is the most common heat-related condition. It occurs when the cardiovascular system cannot keep up with heat demands. An affected person feels dizzy, weak, cold, and clammy, and has ashen skin and dilated pupils. The individual may require hospitalization.[82] At greatest risk are infants, small children, the elderly, those working or exercising outdoors, persons with impaired mobility, and individuals suffering from cardiovascular disease.[83] When moved to a cool place, victims of heat exhaustion usually recover.

Heat stroke, the most severe of these conditions, can be fatal. If body temperature reaches 106 degrees or above, damage to the kidneys, muscles,

heart, and blood cells is likely. Sweating stops altogether. Death can occur immediately, or could be delayed up to several weeks due to complications, such as renal failure.[84] On average, 400 people die each year in the United States from heat-related causes.[85] In Massachusetts, 2 fatalities occurred as a result of heat exhaustion on July 5, 1999.[86] The lowest recorded temperature on that day was 81 degrees.[87]

Health Consequences of Extreme Cold and Wet Weather

Weather related death and injuries are a part of every major storm. Intensification of the hydrologic cycle could result in more extreme and intense precipitation events. Resulting floods and ice storms could significantly stress the public health infrastructure.[88]

—NEW ENGLAND REGIONAL ASSESSMENT,
HEALTH AND CLIMATE VARIABILITY WORKSHOP

While average temperatures are expected to rise in Massachusetts in the winter, the increased frequency of weather extremes may also mean winters with more days of extremely low temperatures.[89] In addition, over the next several decades, the state could experience much heavier precipitation. Some locations in the state have already experienced a 20 percent increase in precipitation,[90] much of it falling in heavier individual events. According to the EPA, over the next century precipitation in Massachusetts could increase by 10 percent in spring and summer, by 15 percent in fall, and by 20–60 percent in winter.[91]

As overall temperatures increase, more of the Bay State's winter precipitation may fall in the form of rain, sleet, and ice, increasing the likelihood of events such as the October 1996 flood. In 1996, water backups and overflows caused major damage in several sections of Boston. Flooding overtook the Massachusetts Bay Transportation Authority rail system's Green Line subway tunnel and four of its stations, causing major damage and interrupting service for several weeks.[92] Flooding of the MBTA alone caused more than 64 million dollars worth of damage.[93]

Unexpectedly cold weather and large snowfalls can pose a variety of possible health risks, such as hypothermia, frostbite, cardiac-related deaths, pedestrian falls on icy surfaces, automobile accidents, air travel threats, and carbon monoxide poisoning.

The Perfect Storm

The Perfect Storm, chronicled in the best-selling novel of the same name by Sebastian Junger, exemplifies the kind of harrowing weather event that global warming is likely to bring in the future. In fact, unusually warm ocean water contributed to the October 1991 storm[94] that caused property damage in 7 states, including Massachusetts.[95] David Sullivan and Robert Shatford of Gloucester, along with the rest of the crew of the Andrea Gail, a swordfishing boat, perished in the storm.[96]

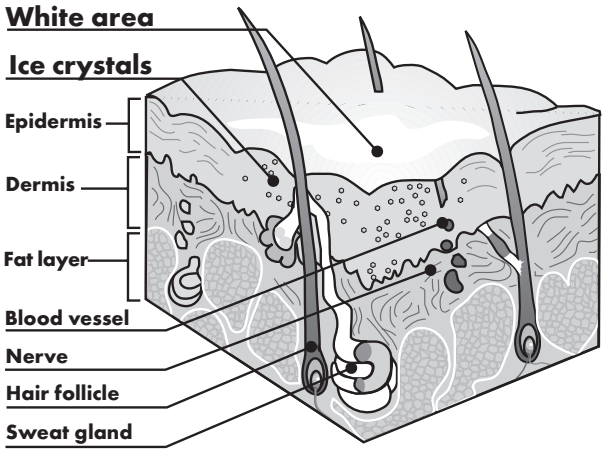
Off the coast of Massachusetts during the storm, 25-foot waves rode atop a high tide that was 4 feet above normal.[97] Winds gusted up to 78 mph in Chatham. Sea walls, boardwalks, bulkheads, and piers were destroyed. Several small boats sunk at their berths and thousands of lobster traps were reduced to splinters.[98] Many roads closed due to coastal flooding and hundreds of citizens were evacuated. In the Massachusetts cities of Marshfield, North Beach, and Brant Point over 100 homes were destroyed or severely damaged. The counties of Barnstable, Dukes, Nantucket, Essex, Plymouth, Norfolk and Suffolk all were declared federal disaster areas.[99] Damages throughout the state as a result of The Perfect Storm totaled hundreds of millions of dollars.[100]

- **Hypothermia**, an unintentional lowering of the core body temperature to or below 95 degrees F, is a deadly medical emergency.[101] Persons over 65 are most susceptible; the annual death rate from hypothermia for this age group being four times that of the general population.[102] Early signs of hypothermia often are insidious. They include shivering, numbness, fatigue, poor coordination, slurred speech, impaired mental state, blueness or puffiness of the skin, and irrationality.[103] More serious cases can result in coma, low blood pressure, and cardiac irregularities.

FIGURE 2
Effects of Frostbite

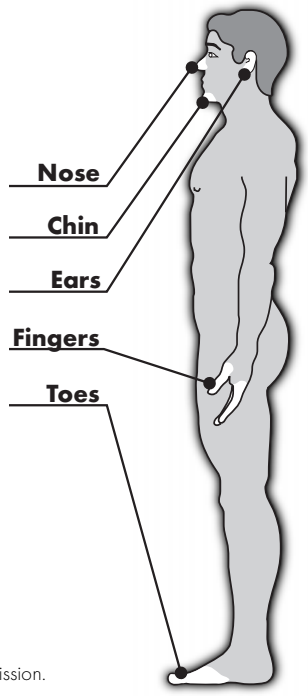
Global climate change could bring colder temperatures and winter storms to Massachusetts. One resulting threat to health is frostbite.

Frostbite occurs when the skin is exposed to temperatures below 23 degrees Fahrenheit. Extremely tiny ice crystals, floating in the body fluid under the skin, become larger until they damage cells. Skin first turns whitish, then becomes numb. A black tinge indicates the area has been damaged permanently.



Body parts most vulnerable

When the body becomes super-cooled or exposed to the cold elements of winter, it instinctively draws its blood supplies inward toward vital organs–leaving body parts on the fringes to suffer the effects of cold, wind and wetness, and without adequate blood to provide warmth.



Who's most at risk for frostbite?

➤ Seniors, especially those with poor circulation.

➤ Homeless, because of constant exposure to cold air, freezing conditions and dampness.

➤ People with diabetes. A common complication of diabetes is neuropathy, or loss of nerve sensation in the feet because of nerve damage.

➤ Children, whose bodies may not retain heat as efficiently as adults and who may not notice the symptoms of frostbite if they're actively involved in playing or fun outdoor activities.

- **Frostbite** occurs when the skin is exposed to temperatures below 23 degrees F. Such extreme cold increases the size of ice crystals under the skin.[104] These crystals can cause damage at varying levels of severity: 1. frostnip, where skin turns white and may be slightly numb, 2. superficial frostbite, involving the skin and tissue, and, 3. deep frostbite, involving skin, tissue and bone.[105] At the final level, affected areas may have to be amputated.

- **Congestive heart failure** is the most frequent reason for hospitalization among older adults.[106] During cold weather cardiovascular systems must work harder in order to keep the body at the correct temperature, thereby putting people with heart problems at risk.[107] The predicted increase in the number and severity of storms could lead to more deaths due to heart failure and other forms of cardiovascular disease. Already Massachusetts has a high death rate for diseases of the heart and stroke, with 21,326 deaths due to heart disease and 3,410 deaths due to stroke in 1997 alone.[108]

  In a 1999 study published in the *American Journal of Epidemiology*, researchers looked at deaths from heart attacks, strokes, and respiratory diseases in the month of January over a six-year period. Researches determined that total mortality increased on days of extreme climatic conditions, defined as days with temperatures below 19.4 degrees F and snowfall greater than 1.18 inches.

  This combination of snow and cold as compared to milder weather conditions caused death rates from heart attacks to triple among men 35–49 years old and rise for men over 50. Death rates for women over 65 also increased.[109] One reason is that prolonged exposure to cold makes the blood more likely to clot, as breathing cold air constricts small blood vessels that carry blood away from the heart. [110]

  The biggest hazard, according to researchers, is probably snow shoveling. Studies have shown that snow shoveling is a demanding aerobic activity that can endanger people with cardiac risk factors, and may contribute to cardiovascular events reported after heavy snowfalls.[111] The energy needed and risks associated with snow shoveling are not surprising when one considers that the average shovel full of dry snow weighs on average about eight pounds, taking into account the weight of the shovel.[112]

- **Pedestrian falls on icy surfaces** are another winter health risk that could increase with more extreme weather events due to climate change. Falls already are a serious public health problem among older adults, with one out of three people 65 years and older injured or killed in the United States each year.[113] Slippery and uneven surfaces, which often occur as a result of winter storms, are a primary risk factor for falls.[114] Even moderate injuries sustained in a fall may increase the risk of premature death.[115] These are costly injuries as well. In 1994, the total direct cost of all fall injuries nationwide for people aged 65 years or over was 20.2 billion dollars.[116]

- **Automobile accidents**, where poor driving conditions due to weather are a contributing factor, also could increase with the forecasted rise in extreme weather events. On March 12, 1998, a snowstorm dropped visibility close to zero on Interstate 495 in Boxborough. The poor driving conditions

resulted in a deadly pile-up of 30 to 35 vehicles that killed a 45 year-old man and a 3-month-old infant.[117]

- **Air travel threats and cancellations due to weather** may also rise due to climate change. A heavy snowstorm forced the cancellation of half of the scheduled 700 flights from Logan International Airport in Boston on February 25, 1999.[118] The airport that day reported 6.5 inches of snow.[119] In the future, heavier snowfalls, flooding and sea level rise may necessitate relocation of Logan's runways and the construction of new dikes and seawalls.[120] A severe increase in storm activity could require the relocation of the entire facility,[121] which is located on land fill in Boston Harbor at an elevation of only 17 feet above sea level.

- **Carbon monoxide poisoning** poses yet another winter health risk in Massachusetts.[122] Carbon monoxide is the leading cause of non-intentional poisoning deaths in the United States.[123] Each year, according to the U.S. Consumer Product Safety Commission, approximately 5,000 people are treated in hospital emergency rooms for carbon monoxide poisoning, and nearly 300 fatalities are reported.[124] These figures are actually believed to be quite low, as many people who get ill mistake carbon monoxide poisoning for the flu and therefore never get treated.[125]

  Carbon monoxide is an odorless, colorless, and tasteless gas produced from incomplete combustion of fuels containing carbon, such as kerosene, natural gas, liquid petroleum, gas, and wood.[126] Carbon monoxide can attach itself to hemoglobin, impairing the oxygen-carrying capacity of the blood and starving a body's tissues and organs of oxygen.[127]

Gas And Oil Problems Heat Up

We're potentially looking at a major crisis here. The amount of oil we have available in New England is frighteningly low and the price of that oil is frighteningly high. There's an emergency right at our doorstep and we've got to do something.[128]

–SENATOR CHRISTOPHER DODD (D-CT)

Winter weather extremes associated with climate change create a dangerous cycle for heating oil use. Burning fossil fuels, such as oil, adds to the pollutants that likely drive global warming. During periods of extreme cold weather, individuals burn more oil to keep warm, which increases the risk for even more severe winter weather in the future.

Demand already is high for heating oil in Massachusetts. Heating-oil consumption in the Northeast accounts for 63 percent of the U.S. total. When oil supplies plummeted in January 2000, prices rose 78 cents, to $1.96 per gallon.[129] Natural gas users will suffer from increased prices as well. An average home heating bill in the winter of 2000–2001 is predicted to cost $834 for consumers who use natural gas. This figure is up 62 percent from 1999.[130] Heating oil users will pay even more, with winter costs projected at $1,044.[131]

The greatest economic, environmental, and human health costs in the long run result from our inefficient use of fossil fuels. Tight supplies of fossil fuels only add to the problem. Until reliance upon fossil fuels is reduced, the vicious cycle likely will go on, leading to more extreme winter weather conditions that may result in the use of even more heating oil and natural gas. Immediate strategies for reducing our reliance on fossil fuels include a transition to more sustainable, renewable energy source, and improved efficiency of power plants as well as appliances and cars.

Carbon monoxide poisonings can occur during blizzards when people sit in idling automobiles with exhaust pipes blocked by snow.[132] Poisonings also occur during power outages when people are more likely to use unvented residential appliances such as stoves and heaters.[133] Kerosene and propane-fueled space heaters, gas-fueled log sets, and cooking devices used improperly for heating can expose people to potentially hazardous levels of carbon monoxide, as well as other toxic gases.[134]

Injuries Related to Freezing Rain and Hail

Dangerous freezing rain and hailstorm events may occur more frequently and with heightened severity because of greater instability in the atmosphere due to climate change. Freezing rain is precipitation that falls onto a surface, such as trees, cars and roads, forming a coating of ice. Even small accumulations of ice due to freezing rain can cause significant hazards.[135] On January 18, 1999, freezing rain caused severe icing of roadways, especially in the valleys of Franklin, Hampshire, and Hampden Counties.[136] Many towns on that day reported a state of emergency as a result of the freezing rain.[137]

Hail develops when strong rising currents of air carry water to a height where freezing may occur.[138] Ice particles grow in size, until they become too heavy to be supported by the updraft and fall to the ground in the form of hail.[139] Hailstones often fall at speeds exceeding one hundred miles per hour [140] and can cause injury and property damage. On July 6, 1999, baseball-sized hail fell in Brockton and throughout Norfolk and Plymouth Counties.[141] The force was great enough to damage many cars.[142] Later that same month, on July 24, a hailstorm centered in Boston's North and South Shore communities downed trees and power lines. As a result, thousands of people lost power across the Bay State.[143]

Deaths and Injuries Due To Snow Storms

Climate change may also lead to more frequent and intense snowstorms during the winter months. Extreme snowfall events already have increased in the Boston area over the past 50 years,[144] impacting human health in the state. For example, on February 25, 1999, exposure to snow and cold from a severe snowstorm was a contributing factor in the death of a 9 year-old boy in Norton in Bristol County. The storm also caused over 16,000 homes to lose power.[145]

Snow squalls, or sudden, violent bursts of wind followed by snow, can be equally damaging. A snow squall on November 30, 1999, occurred during the morning rush hour. Dozens of accidents occurred, ranging from single-car crashes to six-vehicle pileups. The area at Interstate 495 and Route 24 near Bridgewater and Taunton had to be closed due to the high number of accidents that occurred during the snow squall.[146]

Risks Posed By Thunderstorms, Tornadoes and Strong Winds

Climate change will be manifested in a catalogue of disasters such as storms, droughts and flooding unparalleled in modern times.[147]

—INTERNATIONAL FEDERATION OF RED CROSS AND RED CRESCENT SOCIETIES

Atmospheric instability could increase the likelihood of more severe and more frequent wind and thunderstorms. More tornadoes may develop and touch down in Massachusetts as the climate changes. Tornadoes, which already are a cause for concern in the state, often lead to injuries and property damage. On May 29, 1995, a tornado tore a path from Prospect Lake in North Egremont to Morley Hill in Sandisfield.[148] Three people in a car died when their automobile was lifted several hundred feet into the air before falling on a wooded hillside.[149] The National Weather Service classified the storm as "devastating." At least 24 people were injured, mostly due to flying glass. Several homes were either destroyed or damaged, including a nursing home that lost its roof.[150]

Even without forming a tornado, high winds can be deadly. In May 1998, a windstorm in Northern Worcester County resulted in the deaths of two Winchendon men. Both were traveling in a car on Route 202 when winds estimated at 60 to 70 mph toppled a tree that crushed them.[151] On July 6, 1999, a similar accident, caused by a wind-blown tree branch, led to the death of a man traveling in Hampshire County.[152]

When high winds combine with cold temperatures, a dangerous wind chill can develop.[153] According to the National Weather Service, wind chill is based on the rate of heat loss from exposed skin caused by the combined effects of wind and cold. As the wind increases, heat is carried away from the body at an accelerated rate, driving down body temperature.[154]

Lightning, which often occurs during turbulent thunderstorms, also can have deadly consequences. A person struck by lightning can experience unconsciousness, cerebral bleeding, brain damage, and severe burns. The force of a strike can prevent breathing.[155] This is not surprising when one considers that a single bolt of lightning could power a 100-watt light bulb for more than three months.[156] Many victims of lightning are caught outside and cannot reach proper shelter. On June 27, 2000, lightning struck and killed a 15 year-old boy in Westford who was doing yard work.[157] Three other 8 year-old children were injured during the same storm.[158] A lightning storm on July 23, 1998, led to 11 injuries.[159] One of the victims was a 7 year-old Stow boy who was inside his house next to a dehumidifier.[160]

Health Threats From Floods

There is a general consensus that global climate change will significantly alter precipitation patterns. Extreme events may occur more frequently and with greater intensity, causing an impact on the Metro Boston Area. . . If drainage and flood management infrastructure is rendered insufficient, flooding can put life and property at risk, as well as causing significant damage to other dimensions of Boston's infrastructure, such as transportation, energy distribution and wastewater treatment.[161]

—PAUL KIRSHEN AND PABLO SUAREZ, TUFTS UNIVERSITY

Flooding occurs in Massachusetts virtually every year; the location and severity vary according to ground conditions and weather. Given the forecasted rise in precipitation throughout the state by 2100 and the expectation of heavier precipitation events, more floods could be on the way. The situation is made worse as the amount of pavement and other impervious surfaces grows in and around floodplain areas.

Floods cause an average of 146 deaths per year nationwide, most of which are due to drownings associated with motor vehicle accidents in flash flood conditions.[162] Floods also often cause costly property damage. Flooding on June 13, 1998, resulted in 13 million dollars worth of damage.[163] President Bill Clinton declared Essex, Middlesex, Norfolk, Suffolk, and Bristol Counties federal disaster areas.[164] Numerous streams and rivers overflowed their banks during the storm, which produced 6–12 inches of rainfall in many locations. Cars stalled in waist-deep muddy water on flooded roads and highways. About 12,000 homes lost power.[165]

Flash floods pose further risks in Massachusetts. Flash floods occur within a few minutes or hours of heavy rains, a dam or levee failure, or a sudden release of water held by an ice jam. Their power is tremendous. Flash floods can roll boulders, tear out trees, destroy buildings and bridges, and carve out new channels. Because these events happen so suddenly, and with little warning, most flood deaths are due to flash floods.[166]

Many people underestimate the dangers of flash floods. Actually, water weighs 62.4 pounds per cubic foot. Just an extra foot or two of water can prove to be deadly. Two feet of water is enough to overtake most automobiles. Many flash floods occur at night, increasing their danger and making it extremely difficult to plan an appropriate course of action. [167] A flash flood in Massachusetts was strong enough to submerge Morrissey Boulevard and Quincy Shore Drive during a September 1999 rainfall centered in Boston. There were numerous reports of flooding in Middlesex County, affecting homes in the cities of Newton, Natick and Framingham. Sections of Route 9 in Framingham were covered with several feet of water.[168]

If floodwaters are contaminated with bacteria and parasites, cases of intestinal illness and infectious disease can result. Intestinal illnesses occur with symptoms of nausea, vomiting, diarrhea, and fever. Diarrhea usually lasts only a few days, but for individuals with

Besides closing roads and causing property damage, floodwaters can carry bacteria and parasites causing illness and infectious disease.

suppressed immune systems, depending on the organism, this condition can persist and even be fatal.

Floodwaters can also contain human and animal fecal material causing water-borne infectious disease outbreaks. Sources include overflowing sewage systems and flooded croplands. When pastures and crop fields are flooded, the state's farming communities, in particular, may face health risks from water-borne disease and increased exposure to pesticides in runoff. Although skin contact with floodwater rarely poses a serious health risk, there is a threat of disease from eating or drinking anything contaminated with floodwater.

Diseases and conditions such as tetanus, head lice, scabies, tularemia, and leptospirosis also can occur after a flood.[169]

- **Leptospirosis** is caused by a rodent-borne bacteria and has various manifestations. Symptoms include sudden onset of fever, headache, chills, severe muscle aches, watery eyes, rash, anemia, jaundice, mental confusion, and depression.[170] Symptoms usually appear within ten days. The disease is treated with antibiotics.
- **Tularemia**, or rabbit fever, is a bacterial disease caused by the bite of ticks, mosquitoes, or deer flies, contact with the blood or tissue of an infected animal, or by drinking contaminated water. Floods increase the likelihood of contracting the disease by contaminating water supplies, creating environments in which vectors proliferate, and drowning animals. Symptoms of tularemia may include slow-growing ulcers, usually on the hands, and swollen lymph nodes. If the bacteria are inhaled, a pneumonia-like illness can follow. If ingested, the bacteria can cause sore throat, abdominal pain, diarrhea, and vomiting. Symptoms can emerge two to ten days after exposure and are typically treated with streptomycin or other antibiotics.[171] In 1999, two cases of tularemia were reported in Massachusetts.[172]

Air Pollution and Respiratory and Cardiovascular Disease May Increase

Precipitation and temperature are important parameters when considering connections between air pollution and human health. Air masses, homogenous sources of air that move along particular tracks, can kill people. Ground level ozone and pollen alerts will increase if heat and pollution, working in concert, are combined with climate anomalies…New England states have characteristically irregular intense heat days. The elderly and urban poor within New England are at the highest risk from air pollution and heat stress due to a lack of air conditioning, pre-existing conditions, and a tendency to live within poorly ventilated brick structures. Synoptic climatologists have identified several characteristic air masses that are associated with increases in death rates.[173]

—NEW ENGLAND REGIONAL ASSESSMENT,
HEALTH AND CLIMATE VARIABILITY WORKSHOP

Some air pollutants are affected by heat, such as ozone and volatile organic compounds (VOCs). As temperatures rise due to climate change, these

Air Conditioning and the Filthy Five: Massachusetts' Most Polluting Power Plants

Together "the filthy five" emit 48 percent of the sulfur dioxide emissions in the state and 99 percent of the sulfur dioxide emissions from power plants in Massachusetts. On average they each emit more than one thousand times as much sulfur dioxide per MW (megawatt) as new power plants in Massachusetts. Sulfur dioxide contributes to acid rain, which in turn causes acidification of lakes and streams and contributes to damage of trees at high elevations. . .[174]

–BARBARA BERNEY,
ENVIRONMENTAL LEAGUE OF MASSACHUSETTS

Although residents of warmer states seem to acclimate to hot temperatures, one of the sad lessons of the heat waves of the 1990's is that people who are unaccustomed to hot weather and who do not have air conditioning suffer the most. In the deadly 1995 Chicago heat wave that killed over 600 people, the highest casualties were among elderly residents with no air conditioning. Unlike previous heat waves, overnight temperatures did not drop sufficiently to provide much needed relief. Minimum nighttime temperatures increased abruptly in the 1970's and are on the rise, thus the cooling effect of night air is no longer available during heat waves.[175]

Those who can afford air conditioning are likely to use it more as the weather gets warmer. Demand for air conditioning throughout New England and the Northeast already was at record levels in the exceptional heat during the summer of 1999.[176] The increased energy used to provide air conditioning can result in more greenhouse gas emissions in the atmosphere that cause global warming, as well as increased emissions of other air pollutants from power plants like the Filthy Five.

The Filthy Five actually refers to the five corporations that own six of Massachusetts' most polluting power plants. The filthies are the Brayton Point generating station in Somerset and the Salem Harbor plant, both owned by Pacific Gas and Electric Corporation of San Francisco;[177] 50-year old Mystic Station in Charlestown, owned by Sithe Energy; Montaup Station in Somerset, owned by NRG Energy Incorporated; the Mount Tom plant in Holyoke, owned by Northeast Utilities; and Canal Electric in Sandwich, owned by The Southern Corporation.[178]

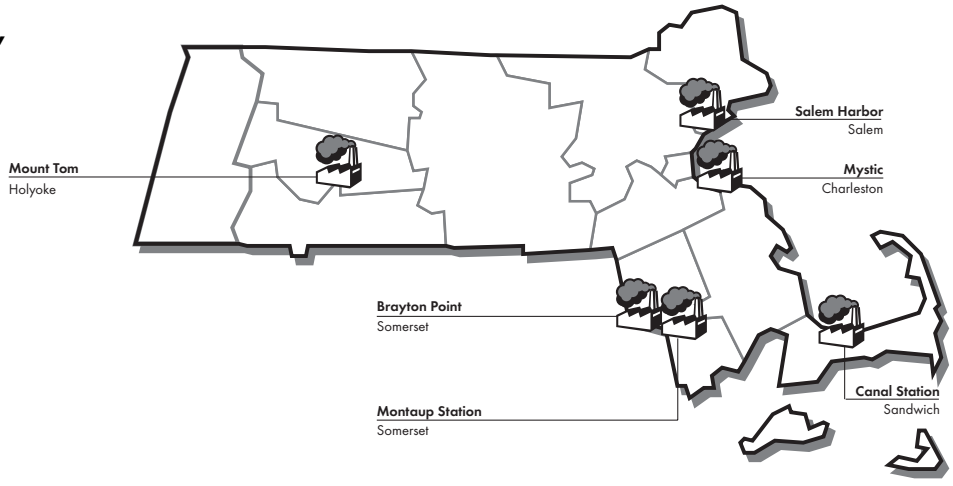
The utility industry claims that there are no significant local health threats associated with the Filthy Five.[179] A recent study prepared by the Harvard School of Public Health directly refutes these claims. According to the May 2000 report entitled *Estimated Public Health Impacts of Criteria Pollutant Air Emissions from the Salem Harbor and Brayton Point Power Plants*, these two plants alone can be linked to more than 43,000 asthma attacks and nearly 300,000 incidents of upper respiratory symptoms per year in the areas surrounding the plants.[180] At greatest risk are people living close to the plants, but twenty percent of the total health impact affects eight percent of the population that lives within thirty miles of the facilities.[181]

The Harvard researchers also analyzed the potential health benefits that would occur if current emission levels at the Salem and Brayton plants were lowered to standards required of new power plants per the 1977 Clean Air Act. The researchers estimated that 124 premature deaths would be averted

continued on page 24

FIGURE 3
"The Filthy Five" Power Plants in Massachusetts

The filthy five are the five corporations that own six of Massachusetts' most polluting power plants.



Source: MASSPIRG

Power Plants *continued from page 24*

per year, along with 34,000 fewer asthma attacks, and 230,000 fewer incidents of upper respiratory problems.[182] Further, environmentalists say the effect of pollution reductions at the six plants would be the equivalent of taking 750,000 cars off the road.[183] Clearly Massachusetts has much to gain if The Filthy Five clean up their act.

Old power plants are able to emit more pollution than more modern and efficient plants due to legal loopholes in the Clean Air Act (CAA). The CAA, as amended in 1977 and 1990, exempts older coal-burning power plants from stricter new source standards; this allows them to emit from four to ten times the amount of pollution emitted by new plants.[184] The CAA also allows all power plants, regardless of age, to emit unlimited amounts of carbon dioxide.[185] Following this unfortunate trend, the Bay State's plants are some of the worst polluters in the nation—especially the Filthy Five.

Pollutants emitted by these plants far exceed modern standards. For example, the Salem Harbor plant released 33,232 tons of sulfur dioxide into the state's air in 1997. That is 445 percent more than modern standards. Sulfur dioxide is a source of fine particulate matter—soot—that can cause premature death. That same year, Salem Harbor emitted 6,818 tons of nitrogen oxide, an amount 123 percent above modern standards. Nitrogen oxide helps to create smog. Incredibly, the Mount Tom plant emits even more of these two harmful pollutants, with 8,568 tons of sulfur dioxide and 2,264 tons of nitrogen oxide having been released in 1997.[186]

Mercury is a harmful pollutant released in very high levels by The Filthy Five. The Brayton plant alone emits an average of 603–744 pounds of airborne mercury each year.[187] Once in the environment, much mercury is converted by bacteria into an even more toxic substance, methyl mercury. Fish ingest methyl mercury as they feed. They also absorb it from water as it passes over their gills. The substance is stored in fish flesh. Trimming or cooking cannot remove it. Nearly all fish contain methyl mercury, with large fish and sport fish having the greatest concentrations.[188]

Methyl mercury is rapidly absorbed from the gastrointestinal tract and readily enters the adult, child, and fetal brain.[189] A report known as the Jacobsons' Michigan Maternal Cohort study looked at 242 mother-infant pairs.[190] Each of the mothers had consumed contaminated fish before and during their pregnancies. The study determined that infants of these mothers had reduced gestational age, decreased birth weight, and decreased head circumference. The report's authors examined the children again when they were 11 years old. At that age, the children had lower than normal IQs, poor reading comprehension skills, reduced memory span, and attention deficits.[191]

pollutants will likely increase and air quality will worsen, especially in urban areas. Both ozone and VOCs have adverse health impacts. Climate change could also affect pollen levels that exacerbate allergies. Given Massachusetts' current problems with air pollution, the possible effects of global warming on the state's air warrant high concern.

Smog

Ground-level ozone is the major component of what we commonly call smog, the most pervasive outdoor air pollutant in the United States. Smog is at its worst on hot, sunny days, which are likely to become more numerous with global warming. Ozone is a toxic and irritating gas that, even in small amounts, can affect lungs and health. Ozone, or smog, is formed when nitrogen oxides and VOCs, emitted from motor vehicles, power plants, refineries, factories, and other combustion and industrial sources, are heated by sunlight.[192]

A 4-degree warming in Massachusetts is projected to increase concentrations of ground-level ozone by 4 percent.[193] Already ground-level

ozone concentrations in the state have exceeded national standards during periods throughout the past several years.[194] In 1997, for example, all of Massachusetts was classified as a "serious" nonattainment area for ozone.[195] In March 2000, Springfield in western Massachusetts was declared a nonattainment area.[196] Without taking into account the effects of climate change on ozone, the state currently experiences serious threats to air quality and health due to ozone.

In 1999, statewide there were 85 violations of the proposed EPA eight-hour standard for ozone.[197] This means that the state's air quality had ozone levels exceeding 85 parts per billion (ppb) on those occasions.[198] During this same year, Massachusetts violated the less strict current ozone standard of 125 ppb five times.[199] Massachusetts' air pollution not only affects air in the Bay State, but also travels northward where it contributes to poor air quality in Maine's coastal communities.[200]

Exposure to elevated ozone levels can cause severe coughing, shortness of breath, pain when breathing, lung and eye irritation, and greater susceptibility to respiratory illness such as bronchitis and pneumonia.[201] Numerous studies have shown that higher ozone levels cause more asthma attacks, increase the need for medication and medical treatment, and result in more hospital admissions and visits to emergency rooms.[202]

Even moderately exercising healthy adults can experience a 15 to 20 percent or greater reduction in lung function from exposure to low levels of ozone over several hours.[203] And, some healthy people simply are more sensitive to ozone than others, experiencing more health effects from ozone exposure than the average person.[204] In just one period, from April to October of 1997, there were 4,500 emergency room hospital admissions and 170,000 asthma attack cases in Massachusetts related to ozone exposure.[205]

A Harvard Medical School study has found a link between air pollution and heart problems.[206] An individual's heart rate varies somewhat throughout the day, depending on the person's physical activities and emotions. The heart of a healthy person is generally able to respond quickly to activity changes, such as going from a state of rest to exercising. On days with high ozone levels, the heart function of test subjects showed lower heart rate variability, an indicator that has been associated with heart problems and death.[207] Everyday air pollution may therefore impair the heart's ability to change the speed at which it beats, which could lead to cardiovascular problems and heart-related deaths.[208]

The relation between ozone and asthma episodes is of special concern. Asthma is reaching epidemic proportions in the United States, affecting fifteen million people, including five million children. A leading cause of absences from school, asthma can reduce lung capacity and, if left untreated, can be fatal.[209] Asthma accounts for one in six pediatric emergency room visits in the U.S. In 1997, 117 adults and children in Massachusetts died from asthma.[210] The overall death rate from asthma in the United States is up 66 percent over the last decade, and 117 percent in the in the last two decades.[211]

Children have smaller airways than adults and breathe more rapidly, making them more vulnerable to asthma. When a person suffers repeated asthma attacks, lung pathways become so narrow that simple breathing is as

difficult as "sucking a thick milk shake through a straw."[212] The prevalence of asthma in children under age eighteen rose 72 percent from 1982 to 1994 in the United States, while the death rate from asthma for children nineteen years and younger in the United States increased by 78 percent from 1980 to 1993.[213]

Asthma not only affects human health, but also the Massachusetts economy. Statewide, charges for preventable hospitalizations of uninsured children with asthma added up to $789,920 in 1995.[214] Nationawide, a total of 1.9 billion dollars per year is spent directly to treat both insured and uninsured children with asthma.[215] Total health care costs in the U.S. for asthma amount to 7.5 billion dollars annually.[216]

Physicians do not fully understand what causes asthma, but warmer weather likely will make it worse. One study found that warmer average temperatures are associated with increased asthma prevalence, possibly because higher temperatures are associated with higher levels of allergen exposure.[217]

Volatile Organic Compounds (VOCs)

Another set of air pollutants consists of VOCs, which are generated by power plants and municipal waste combustors, as well as motor vehicles, solvent use, and the chemical and food industries. VOCs include a variety of hazardous air toxins, including benzene, butanes, and toluene. VOCs in the atmosphere have two major health impacts: they are precursors to the photochemical production of ozone, and some VOCs are directly toxic. These hazardous air pollutants are associated with cancer as well as adverse neurological, reproductive, and developmental effects.[218] Following heart disease, cancer is the leading cause of death in Massachusetts. In 1996, 13,920 individuals in the state died from cancer.[219] Higher temperatures cause VOCs to evaporate and disperse more rapidly into the atmosphere causing ozone formation and health problems near and far from the pollutant's source.[220]

Pollen

As the thermometer starts rising on warm days, pollen counts may rise as well. A recent report from the U.S. Department of Agriculture studied the amount of ragweed pollen in the air. The results indicate that higher carbon dioxide levels may have doubled the amount of pollen that ragweed produces, mostly over the past four or five decades. Another doubling could occur by the end of this century.

Studies of pollen counts on ragweed grown in indoor chambers resulted in alarming findings. At carbon dioxide levels of 280 parts per million (ppm), the amount that was in the air in 1990, pollen production was approximately 5.5 grams per plant. In today's atmosphere consisting of 370 ppm of carbon dioxide, pollen reached 10 grams per plant. At carbon dioxide levels of 660 ppm, the amount models project to exist in the next 50 years, pollen production could hit 20 grams per plant. Findings also showed that high carbon dioxide levels might produce ragweed pollen earlier in the year.

Car Trouble: The Gasoline-Greenhouse Gas Connection

Driving a private car is one of the most polluting activities a typical citizen does each day.[221] Statistics in Massachusetts are daunting. Out of the 200 million vehicles in the United States in 1996, 4,793,000 vehicles were registered in Massachusetts. That same year, the total number of miles driven in the state was 47.5 billion, up 3 percent from the total miles driven in 1993. Drivers in the state consumed 2.85 billion gallons of motor fuel. These statistics mean that on each day of 1996, Massachusetts drivers traveled 130 million miles in their cars, and each vehicle consumed 595 gallons of gasoline.[222]

Up to 33 percent of pollutants that cause global warming come from transportation, primarily personal automobiles.[223] This is largely due to the imperfect combustion process involved in running all gasoline-powered cars.[224]

When gasoline is combined with air in a typical engine combustion system, unburned hydrocarbons, oxides of nitrogen, carbon monoxide, and carbon dioxide are released into the atmosphere. They escape by three principle methods: evaporation of fuel in the engine, even when the car is not running; refueling losses; and exhaust emissions.[225] The released pollutants can lead to serious public health problems.

Hydrocarbons react in the presence of nitrogen oxides and sunlight to form ground-level ozone, or smog.[226] Ozone can damage lung tissue, aggravate respiratory disease, and make people more susceptible to respiratory infections. Otherwise healthy individuals can suffer from choking, coughing, and stinging eyes associated with smog.[227]

Nitrogen oxides, like hydrocarbons, are precursors of smog. They also contribute to the formation of acid rain, which can contaminate drinking water, damage vegetation, hurt aquatic life, and erode buildings and other structures.[228]

Carbon monoxide enters the bloodstream through the lungs and forms a compound that inhibits the blood's capacity to carry oxygen to organs and tissues.[229] Infants, the elderly, and individuals with respiratory and heart diseases are particularly sensitive to the effects of carbon monoxide. But even a healthy person can experience impaired exercise capacity and problems with visual perception, manual dexterity, learning functions, and ability to perform complex tasks after breathing this dangerous pollutant.[230]

Carbon dioxide is a greenhouse gas that traps Earth's heat and contributes to global warming.[231]

Gasoline is not the only transportation fuel associated with dangerous pollutants. A study published in the July issue of the American Journal of Respiratory and Critical Care Medicine found that diesel fuels cause respiratory inflammation.[232] The inflammation, in turn, has been linked to asthma.[233]

Although automobile manufacturers have introduced cars with improved emission control systems, car emission levels remain exceptionally high, even with the introduction of lower volatility gasoline.[234] There are a few main reasons why.

First, the number of cars on the road, and the miles they travel, has doubled nationwide since 1970.[235] This is partly due to population growth. Making matters worse are older, dirtier cars and the incredibly popular new sport utility vehicles (SUVs), which are the source of the majority of vehicle-related air pollution in the nation.[236] SUVs are legally treated as trucks when it comes to the minimum miles per gallon standard a vehicle is required to achieve. Thus, these vehicles get much lower miles to the gallon than cars and produce more carbon dioxide and other hazardous air pollutants. A December 2000 study by the Environmental Protection Agency found that if today's fleet of cars had the same average weight and performance as in 1981—meaning minus light trucks such as SUVs—with today's technologies, gasoline use each year could be reduced nationally by 10 billion gallons.[237] In fact, the average number of miles per gallon for all 2000 model year passenger vehicles is at a 20-year low due to the fact that light trucks, which get approximately 8 miles per gallon less than standard cars, now make up virtually half of all automobile sales nationally.[238]

Until steps are taken to solve Massachusetts', and the nation's, collective car troubles, pollutants emitted by automobiles likely will continue to threaten human health and heighten environmental, health, and economic problems associated with global climate change.

Although less ragweed grows in cities, exposure to air pollutants such as ground-level ozone can make people more sensitive to ragweed pollen.[239] Earlier springs and warmer winters could also impact pollen counts.

During May of 1999, Chelmsford experienced over 4,000 grains per cubic meter of tree pollen.[240] That same month, Chelmsford experienced over 40,000 spores per cubic meter of mold.[241] Scientists believe that rising temperatures will create favorable conditions for an even wider variety of pollen-producing plants, leading to an increase in levels of airborne pollen and spores that aggravate respiratory disease, asthma, and allergic disorders.[242]

Upper and lower respiratory allergies are also influenced by humidity and floods. The EPA notes that a two degree F warming and wetter conditions could increase respiratory allergies.[243] Thus, residents of Massachusetts who suffer from allergies could experience more attacks during more months of the year as the climate changes.

Climate Change Conditions that Foster the Spread of Disease

A Plague of Ticks and Mosquitoes

Because of the heating of the atmosphere, disease-bearing insects are breeding faster and living longer at higher altitudes and latitudes. Witness the rapid increases in malaria, yellow fever, hantavirus, and Lyme disease in the northern latitudes. Most remarkably, there is no debate over climate change in any country except the United States.[244]

—ROSS GELBSPAN, CLIMATE AUTHOR

In the warmer and wetter days to come, insects and rodents— referred to as vectors—could multiply in number, increasing the human health risks for the diseases they spread. In terms of vector-borne disease, meaning diseases carried by a host, such as a mosquito or tick, the rate of insect biting and the rate of maturation for the disease-carrying microorganisms are temperature-dependant. Both rates can increase with warmer weather.[245] In fact, field and laboratory studies have shown that temperature is a limiting factor with respect to transmission of a viral agent by a vector.[246] A changed climate could allow vectors and the diseases they carry to spread to, and survive in, new territories. Therefore, in the future, residents of Massachusetts could suffer from diseases only previously seen in other parts of the country.

Diseases Transmitted By Mosquitoes

True to the models, malaria is reappearing north and south of the tropics. The U.S. has long been home to Anopheles mosquitoes, and malaria circulated here decades ago. By the 1980's mosquito-control programs and other public health measures had restricted the disorder to California. Since 1990, however, when the hottest decade on record began, outbreaks of locally transmitted malaria have occurred during hot spells in Texas, Florida, Georgia, Michigan, New Jersey and New York, as well as Toronto.[247]

—DR. PAUL EPSTEIN, ASSOCIATE DIRECTOR, CENTER FOR HEALTH AND THE GLOBAL ENVIRONMENT AT THE HARVARD MEDICAL SCHOOL

West Nile Virus, Eastern Equine Encephalitis, malaria, and dengue are mosquito-borne diseases that pose current or potential health threats in Massachusetts.

West Nile Virus is a serious disease. Mild West Nile Virus infections cause fever, headache, and body aches, often coinciding with a skin rash and swollen lymph glands. Severe infections can lead to neck stiffness, stupor, disorientation, coma, tremors, convulsions, and paralysis.[248] In the worst cases, victims suffer from inflammation of the brain or inflammation of both the lining of the brain and the spinal cord.[249] About 3–15 percent of infected individuals who develop these symptoms die from the disease.[250] The disease is spread to humans by the bite of an infected mosquito. Mosquitoes become infected after biting a bird that is carrying the virus. Persons older than 50 years of age have a higher risk of serious illness if bitten by an infected mosquito.[251] There is no known cure for the disease, but doctors can treat the underlying symptoms.[252] Victims who survive may never fully recover.[253]

West Nile Virus was first discovered in Uganda in 1937. While it later was diagnosed among individuals in the Middle East, Asia and Europe, the disease did not spread to the United States until 1999.[254] Although West Nile Virus has only threatened parts of this country for a short time, the disease already has claimed the lives of at least 8 individuals and sickened at least 78 others,[255] many of whom were left with some form of chronic disability.[256] The virus quickly spread to New York, New Jersey, Maryland and the District of Columbia. In October 2000, a bird carrying the disease was found in North Carolina. Health officials forecast that the disease will spread to even more states in the future.[257]

On July 26, 2000, the Massachusetts Department of Public Health announced that West Nile Virus had been confirmed in Massachusetts.[258] At the time, the disease was identified in only one bird, a dead crow found in Boston.[259] By October 28, 2000, 392 infected birds had been identified.[260] Mosquitoes and a horse in the state also showed signs of the virus.[261] So far, there have been no confirmed reports of humans becoming infected with the disease in Massachusetts, but several cases of individuals with West Nile Virus-like symptoms have been investigated.[262] On November 1, 2000, researchers presenting at the American Society of Tropical Medicine and Hygiene announced that common house sparrows may be a potential reservoir for the disease. When these birds are bitten by an infected mosquito, the infection lasts for up to 5 days in their bodies, a lengthy time when compared with other avian species.[263] As the virus continues to spread throughout insect, bird, and animal communities, West Nile Virus becomes a greater threat to human populations.

Many scientists believe that climate change may be contributing to the emergence of West Nile Virus in the United States, and that it may be fueling the virus' spread. An August 2000 article in *Scientific American* by Dr. Paul Epstein of Harvard Medical School theorized that the mild winter and spring and summer drought of 1998–1999 contributed to the amplification of West Nile Virus among urban mosquitoes and birds, while the means of entry into the US remains unknown. Drought during the spring and summer months can increase mosquito breeding in organically-rich city storm drains and catch basins, and may have reduced the mosquitoes' natural predators, such as frogs and darning needles.[264] The drought also reduced water sources, which could

The Problem with Pesticides

We obviously need to deal with the spread of this virus, but in doing so we don't want to create a whole new public health problem by exposing residents to these pesticides.[266]

–MATT WILSON, TOXICS ACTION CENTER, COMMENTING ABOUT THE USE OF PESTICIDES IN MASSACHUSETTS TO STOP THE SPREAD OF WEST NILE VIRUS

Shortly after the West Nile Virus was detected in birds and mosquitoes in the Boston area, the city began an intensive pesticide-spraying program to control mosquito populations. During August and September of 2000, areas in and around Jamaica Plain, The Fenway, Allston, West Roxbury, Mission Hill, Brighton, Roslindale, and Hyde Park[267] were sprayed with Resmethrin, a synthetic pesticide.[268]

Although Resmethrin is probably less harmful to humans than other insecticide products that the city could have used, such as malathion, it is important to remember that all pesticides are inherently toxic and, as such, are not risk-free to humans.[269] Resmethrin contains two active chemicals—resmethrin, a synthetic pesticide, and piperonyl butoxide, which prevents insects from detoxifying resmethrin in their bodies[270]—along with a petroleum distillate. Both resmethrin and piperonyl butoxide may impact human health.

Exposure to high levels of resmethrin could affect the nervous system, causing incoordination, tremors, tingling, or skin numbness. Short-term exposure to high levels of resmethrin may cause irritation of the eye, skin, nose, throat or lung.[271] There also is evidence that chemicals like resmethrin can harm the thyroid.[272]

Both resmethrin and piperonyl butoxide have been shown to affect pregnancies among laboratory animals.[273] Further studies of piperonyl butoxide reveal that it can cause liver tumors in rats and mice.[274] Piperonyl butoxide has been classified by the Environmental Protection Agency as a possible human carcinogen.[275] Use of Resmethrin could harm ecosystems, as it is highly toxic to bees and fish.[276]

Now that West Nile Virus has been documented in Massachusetts, it is probable that cities such as Boston will continue spraying programs to keep the virus in check, programs that may themselves have adverse impacts on human health and the environment.

Since many scientists, including Paul Epstein at Harvard University,[277] believe climate change may be fueling the emergence and spread of disease, pesticides are only treating the symptom, and not the cause of the overall problem. And, spraying is only one method of curbing proliferation of the disease. For example, regular spring cleaning of urban drains and catch basins could decrease the breeding sites for the mosquitos involved. Periods of drought are particularly hazardous as they dry up the water in drains and concentrate organically rich material in mosquito breeding sites. Cleaning out drains may also make bacteria used as larvaecides more effective, decreasing the use of chemicals now used for larvaecidal activities. All this could decrease the potential for widespread use of pesticides.

have caused birds to congregate near dwindling watering holes frequented by mosquitoes.[278] The mixture of hot weather, which speeds viral maturation of the West Nile Virus, and the likelihood of blood exchange between birds and mosquitoes may have set the stage for West Nile's current threat to human health in northeastern and southern states.[278]

Eastern Equine Encephalitis (EEE) is another deadly disease that is spread by mosquitoes in the state. Since 1955, 190 individuals in the Northeast have become infected with EEE.[279] Mosquitoes contract the EEE virus from infected birds, and then pass it on to humans when feeding on their blood. Sixty percent of all human cases result in death, and the disease is nearly 100 percent fatal in horses. In humans, a severe headache may be the only warning sign of the disease, which attacks the central nervous system. The disease may also result in sudden fever, weakness, and irritability. Within a day, and sometimes within hours, the victim can become disoriented and

comatose. A human vaccine is being developed, but so far there is no available protection for the disease.[280]

Malaria generally is associated with the tropics, but every year residents of Massachusetts contract malaria abroad and bring the disease back home. In 1999, reported cases totaled 22.[281] That figure rose to 27 in 2000.[282]

Anopheline mosquitoes that can transmit the disease are already found in Massachusetts. Temperature, precipitation, and extreme weather events can have an effect on the viability and geographical distribution of these mosquitoes. Many scientists estimate that an increase in average global temperatures of several degrees by the year 2100 could increase the capacity of mosquitoes to transmit the disease 100-fold in temperate countries.[283] Although excellent disease surveillance programs and health care infrastructure make a malaria epidemic in the United States unlikely, as the climate warms and becomes more humid, locally transmitted malaria could appear in Massachusetts.

Dengue fever is considered an exotic disease. However, health officials now consider the disease to be established in southern Texas.[284] Like malaria, subjects may also bring dengue fever back home after traveling. Between 100 and 200 cases of dengue are introduced into the U.S. by travelers each year.[285] The EPA warns that climate change may increase the potential for dengue-spreading mosquitoes in the state itself, by shifting the regions where the mosquitoes breed and over winter.[286] Already, insects that have the potential to carry dengue fever have spread as far north as Chicago.[287] Referred to as "breakbone fever," dengue causes symptoms that include muscle pain, fever, headache, chills, nausea, and skin eruptions.

Tick-Borne Disease In Massachusetts

Lyme disease, Rocky Mountain Spotted fever, and ehrlichiosis are diseases spread by ticks in Massachusetts.

Lyme disease is endemic to several regions of the United States and accounts for more than 95 percent of all reported cases of vector-borne illness in the country.[288] The number of cases reported annually in the United States has increased about 25-fold since national surveillance began in 1982.[289] From 1993 to 1997, 12,500 cases were reported annually,[290] a figure that has likely gone up during the past few years.

Lyme disease is the most commonly reported vector-borne disease in Massachusetts, accounting for more than 93 percent of all reported vector-borne cases in the state.[291] In 1999, 781 cases were reported in the state. In 2000, there were 1,098 reported cases[292] The disease is especially prevalent amongst residents of Barnstable, Dukes, Middlesex, and Nantucket counties[293]

All but three Massachusetts counties have an annul incidence rate at or well above the national mean rate of 5.5 cases per 100,000 population.[294]

Most cases are reported during the summer months when ticks thrive, but a warming trend could increase Massachusetts' tick population even more, while warmer winters permit people to enter tick-infested habitats earlier in the season, thereby increasing the risk of transmission of the disease.[295] A recent Swedish study found that a combination of mild winters (fewer days

with minimum temperatures below -7°C) and extended spring and autumn seasons (more days with minimum temperatures from 5 to 8°C) was related to increased tick density.[296]

If left untreated, Lyme disease causes chronic conditions such as arthritis, neurological symptoms, and cardiac problems. Early symptoms include a rash or ring lesion at the site of the tick bite, fatigue, headache, neck pain, stiffness in muscles and joints, fever, and swollen glands. The rash may not develop for more than a month, if it does at all. Chronic disease symptoms may develop weeks, months, or even years after being bitten.[297] Although a new vaccine for Lyme disease is available in certain states, health experts warn that it does not offer complete protection from the disease.[298]

Rocky Mountain Spotted Fever (RMSF) is a disease appearing in late spring and summer, but global warming could broaden the lifespan and range of the tick that carries the disease, allowing RMSF to pose a health threat during even more months out of the year. RMSF is caused by rickettsia that can be transmitted to humans by the bite of the American dog tick. The tick often is found in areas with tall grass and weeds, such as uncultivated fields and meadows. They cling to grass at the edges of paths or animal trails, waiting to latch onto an animal or human.

Rocky Mountain Spotted Fever can be fatal. Symptoms include sudden fever, headache, and muscle pain, usually followed by a rash that first appears on the arms and legs, before spreading to the trunk, palms, and soles of feet. During the early stages of the disease, it may be confused with other illnesses, including meningitis.[299]

Ehrlichiosis is a relatively new disease caused by a bacteria carried by the Lone Star tick. The first ever case was diagnosed in 1986 when a man from Michigan was exposed to ticks in Arkansas. Since then cases have been recorded from the southeastern United States to the Great Lakes. In 1999, six cases of the disease were reported in Massachusetts.[300] Symptoms of Ehrlichiosis appear 7–21 days after infection and include sudden fever, headache, and muscle pain. Ehrlichiosis can be fatal if left untreated. If the diagnosis is made early, tetracycline antibiotics are administered.[301] At most risk for severe infection are people taking immunosuppressant drugs, individuals with chronic illness, and the elderly.[302]

Diseases Transmitted By Rodents

In recent years, sporadic cases of rodent-borne disease have been reported in the northeast.[303] Of these illnesses, Hantavirus Pulmonary Syndrome poses the greatest threat to Massachusetts residents. Although the state has yet to confirm a case of this disease, several suspected occurrences of the illness have been investigated over the years.[304]

Many scientists attribute the emergence of the disease to changes in the climate. A 1999 study by a team of southwest medical experts linked the disease outbreak in the Southwestern United States to the extreme weather and temperature events of the early 1990's.[305] Hantavirus Pulmonary Syndrome emerged after a period of heavy precipitation, followed by drought.[306] Since climate change is predicted to bring more extreme weather conditions to Massachusetts, Hantavirus Pulmonary Syndrome may emerge in

the state, as it already has in New York, Washington, Colorado, New Mexico, Arizona, California, Idaho, Iowa and Montana.[307]

Hantavirus Pulmonary Syndrome is spread by Peromyscus maniculatus, a common deer mouse native to most of the United States, including Massachusetts.[308] The early symptoms resemble conditions associated with the flu: fever, muscle aches, chills, headache, nausea, vomiting, diarrhea, abdominal pain, and cough.[309] Symptoms develop within one to six weeks after rodent exposure.[310] After several days, initial respiratory problems worsen rapidly.[311] A victim's lungs may fill with fluid,[312] and the victim may die of respiratory failure.[313] There is no known cure.[314]

Climate Change Impacts On Water and Food

Water quality, and wastewater collection and treatment are important components of urban infrastructure. Climate change has several potential implications for these infrastructure elements. If sea level rises, there is the possibility of saltwater intrusion into coastal aquifers, freshwater and estuarine marshes, ponds, and similar water bodies, thereby reducing their water quality…If severe storm events become more frequent, more effects could occur. Increased runoff contamination from non-point sources, more frequent bypassing of sewage at treatment plants, and increased usage of combined sewer overflows will all reduce water quality of both surface and groundwaters.[315]

—WAYNE CHUYDYK AND CHARLES WILSON, TUFTS UNIVERSITY

Global warming is predicted to impact sea level rise and food and water quality in Massachusetts.

Sea Level Rise

Sea level along much of the United States coastline has been rising at a rate equal to 10–12 inches per century.[316] Most of the rise has occurred as warmer temperatures cause the ocean to expand. Melting glaciers and Antarctic ice shelves also contribute to the rise. In 1996, a Rhode Island-sized ice shelf broke off, melted, and turned into seawater.[317] Global warming is predicted to increase the rate of sea level rise due to further expansion of the sea's surface layer and glacial melting.[318] It is likely that sea level will rise along the Gulf and Atlantic coasts by 22 inches over the next century.[319]

Sea level rise can result in flooding of low-lying property, loss of coastal wetlands, erosion of beaches, saltwater contamination of drinking water, and decreased longevity of low-lying roads, causeways and bridges. It also increases the vulnerability of coastal areas to storms and associated flooding.[320] Each of these possibilities brings with it a number of health risks, including gastrointestinal distress from drinking contaminated water, car accidents due to damaged roadways, drownings associated with storm surges, and psychological distress from loss of income and property.

Each year, an average of 65 acres of upland is submerged by a combination of rising seas and subsiding land. Most of this loss is occurring along the

south-facing coast between Rhode Island and the outer shore of Cape Cod, including the islands of Nantucket and Martha's Vineyard.[321] This data does not include coastal land that has been lost because of erosion attributed to storm waves or wetland erosion.[322] The financial loss due to further such erosion would be tremendous. According to one estimate, a relative sea level rise of 1.57 feet would submerge 10,000 acres of land valued at roughly $1 million dollars per acre.[323]

Climate Change And Water Supplies

Research shows that climate change will have major effects on precipitation, stream flows, storm surges, runoff, water temperatures, and evaporation, thereby affecting Massachusetts' water supply. Both the quantity

Coastal Erosion on Cape Cod and the Islands Region

If relative sea level continues to rise and if global warming leads to increased severity of weather patterns and storms, coastal residents of Cape Cod can anticipate more rapid erosion of coastal bluffs and shorelines, including locations where homes presently stand.[323]

–WOODS HOLE OCEANOGRAPHIC INSTITUTION REPORT ON CAPE COD COASTAL EROSION

Coastal erosion is a natural process, resulting from the dymanic interface between land and sea. Climate change is forecast to dramatically speed up this process, however, through increasing sea levels and heightened storm activity. The resulting erosion is likely to have a devastating impact on Massachusetts' coastal regions, particularly along Cape Cod and the islands of Nantucket and Martha's Vineyard. Already, there are signs that global warming is affecting these areas.

The Great Storm of 1978 completely demolished a large parking lot along the eastern shore of Cape Cod. More recently, private homes in Chatham have fallen into the ocean as a result of coastal erosion.[324] In 1996, the historic Nauset Lighthouse in Eastham, Cape Cod, was less than 25 feet away from the edge of a sixty-foot high eroding cliff and in extreme danger of falling over.[325] The lighthouse had to be moved to a new location 300 feet west of its original one.[326]

Perhaps an even more dramatic example is Truro, Massachusetts, a Cape Cod town that is literally being eroded away.[327] For many years, the area between the Pamet River and Beach Point averaged less than one half of a foot of erosion per year, or less than 50 feet per century.[328] However, recent studies show that Truro bluffs may be eroding at a rate of 10–15 feet over a two to seven year period.[329] This is likely due to periods of extreme weather activity and sea level changes. Since global warming may affect these forces, coastal erosion at Truro may worsen in the future.

The northern part of Cape Cod became the center of attention in the summer of 1992, when Hurricane Bob struck the area. Truro and surrounding areas were severely damaged. Provincetown has only one access road, Route 6, which was washed out for a distance of 250 feet, virtually preventing any of Provincetown's 10,000 residents from entering or leaving the area.[330] The ocean then began to erode away the narrow spit of the cape, almost turning Provincetown into an island.[331]

Future damage may not only directly threaten residents of Cape Cod, Martha's Vineyard, and Nantucket who live near coastal areas, but also it could undermine the economy of these regions. As it stands, the areas have limited local economies, due to isolation and transportation limitations. This is particularly true of the islands.[332] The region's economic vitality, which relies heavily upon tourism, is seasonal and subject to weather patterns.[333] The erosion, extreme weather events, and property damage that climate change is likely to bring could disrupt the financial growth of these areas and threaten the jobs of locals who work at hotels, in retail, or in any other positions related to tourism.

and quality of available water could be at risk. Increasing saltwater intrusion from rising sea levels, for example, may impact rivers, aquifers,[334] and wells.

There remains considerable uncertainty as to specifically how regional precipitation and waterways could be affected by global climate change. Certain facts, however, are clear. Low stream flows cause substances in water to concentrate, leading to more polluted waters. On the other end of the spectrum, excess water runoff can bring more pesticides, along with agricultural and human wastes, into the water supply.

Extreme weather events that cause flooding or disruptions in water supplies may have an impact on the spread of gastrointestinal diseases. Water-borne disease outbreaks in New York State in 1998 and in Walkerton, Canada in 2000 following heavy rains that flushed farm wastes into clean water supplies demonstrate that such diseases are related to extreme weather events. Two of the greatest threats are from giardia and cryptosporidium.

- **Giardiasis** is an illness caused by a one-celled microscopic parasite that lives in the intestines of people and animals. It survives well in water. During the past 15 years, Giardia lamblia has become recognized as one of the most common causes of water-borne human disease in the United States.[336] In 1999 there were 864 cases of giardiasis in Massachusetts,[337] but the true number of cases in the state was probably several times higher. Diarrhea, abdominal cramps and nausea are the most common symptoms of giardiasis.

- **Cryptosporidiosis:** Another major threat to the United States water supply is from an organism called Cryptosporidium, which is small, difficult to filter, resistant to chlorine and ubiquitous in many animals.[338] Symptoms of the illness include diarrhea, stomach cramps, upset stomach, or slight fever. Cryptosporidiosis can be serious, long lasting, and sometimes fatal for people with AIDS, and others with weakened immune systems.[339] In 1999, there were almost 3,500 cases of cryptosporidiosis in the United States. There were 71 reported cases of the illness in Massachusetts in 1999, while 2000 had 30 reported cases.[340]

Warmer Weather Could Increase Food Contamination

Warmer, moister weather encourages the spread of diseases caused by food contaminated with toxic *E. coli*, salmonella, Hepatitis A,[341] listeria, shigella, cyclospora, and campylobacter. People ingest these microbiologic agents by drinking contaminated water, eating seafood from contaminated waters, or by eating fresh produce irrigated or processed with contaminated water.[342] Higher ambient temperatures foster the growth of the pathogens that cause these illnesses.[343] Heavy rainfall and runoff can wash the contaminants into public water supplies thereby helping to spread the disease.[344]

Escherichia coli (0157:87) is a bacterium that can cause bloody diarrhea. In the worst cases, infection may result in kidney failure, particularly in young or elderly victims whose blood cells may be destroyed by the illness.[345] About two to seven percent of all infections lead to this complication. Massachusetts reported 188 cases of E. coli in 1999 and 168 cases in 2000.[346]

Salmonellosis is caused by the salmonella bacteria. There were 1,208 cases of salmonellosis reported in Massachusetts in 1999, and 1,212 cases in 2000.[347] Most infected persons develop diarrhea, fever, and abdominal cramps 12 to 72 hours after infection.[348] Hospitalization is required in some cases. In the most severe cases, the salmonella infection may spread from the intestines to the blood stream, and then to other body sites. At this point, the illness can cause death unless the person is treated promptly with antibiotics. The elderly, infants, and those with impaired immune systems are more vulnerable.[349] A small number of victims can develop Rieter's syndrome, which can lead to chronic arthritis that can last from months to years.[350]

Hepatitis A is a liver disease with symptoms that include jaundice, fatigue, abdominal pain, loss of appetite, intermittent nausea, and diarrhea. Hepatitis A usually is transmitted through fecal-oral routes of exposure from food and water-borne sources. 142 cases were reported in Massachusetts in 1999[351] and 123 were reported in 2000.[352] Warmer temperatures and extreme weather events could bring these numbers up even higher in the months and years to come.

Listeriosis, a serious infection caused by eating food contaminated with the bacterium Listeria monocytogenes, has recently been recognized as an important public health problem in the United States.[353] The illness can cause fever, muscle aches, nausea, and diarrhea. If infection spreads to the nervous system, symptoms such as headache, stiff neck, confusion, loss of balance or convulsions can occur. Infected pregnant women may experience only a mild case, but the illness could lead to premature delivery, infection of the newborn, or even stillbirth.[354] In 1999, there were 38 cases of listeriosis reported in Massachusetts.[355]

Shigella is the name of one of the bacteria that causes shigellosis, or dysentery of the bowel. Severe cases can lead to dehydration that can be life threatening for young, old, or immunocompromised individuals. In rare cases, the disease may spread to other parts of the body and the victim could experience seizures.[356] 748 cases were reported in 1999, and 273 cases were documented in 2000.[357]

Cyclospora is a parasitic infection that may cause weight loss, bloating, cramps, nausea, vomiting, lethargy, sore muscles, fever, loss of appetite, and diarrhea. For most people, the diarrhea will last for a few days, but some people can be sick with the illness for several weeks.[358] In 1999, seven cases were reported in Massachusetts.[359]

Campylobacter is yet another bacterial disease that could increase in Massachusetts due to predicted warmer temperatures that may foster its growth, and runoff following heavy rains, as water usually becomes contaminated with campylobacter bacteria when sewage enters the drinking water supply.[360] This disease may cause diarrhea, abdominal pain, fever, vomiting, and nausea.[361] Since climate change leads to land subsidence that in turn can result in broken sewer systems, there may be an increased risk for developing this disease in the near future. In 1999, there were 1,159 cases of campylobacter in Massachusetts.[362]

Massachusetts Fisheries

One lobsterman talked of going out to his traps in Salem Sound one day and finding all dead lobsters—and his friends did the same that day—they attribute it to a toxic slug of chlorine-the lobsters never came back. Some of the lobstermen—these strong, tough guys—nearly broke down as they talked of their livelihood, of their friends out of work, of their families, of their children who would probably never follow the generations of family tradition as fisherman and lobstermen.[363]

—POLLY BRADLEY, CHAIR, BOARD OF DIRECTORS,
SAFER WATERS IN MASSACHUSETTS

Massachusetts' fisheries are among the most valuable in the United States. In New England, they are the most valuable, topping even Maine's catches.[364] Massachusetts' world famous lobsters make up most of the value of the total catch. Lobsters support the biggest single fishing industry in the Northeast. In 1996 alone, lobsters accounted for 25 percent of all Northeast fishing revenue and were valued at 242 million dollars, supporting 50,000 jobs.[365]

According to the EPA, global warming could have many devastating impacts on lobsters, fish, and other aquatic species. Some bodies of water may become too warm for the fish and shellfish that inhabit those areas.[366] This already appears to be happening in New England. For example, there is evidence that shrimp populations are on the decline, possibly due to temperature changes.[367] Global warming also may change the chemical composition of the water that fish and shellfish inhabit, causing the amount of life-sustaining oxygen in the water to diminish, while dangerous pollution and salt levels increase.[368] Just last year, these conditions led to the deaths of worms, sea urchins, crabs, sponges, and sea cucumbers off the coast of Maine.[369]

Such effects impact human health in two ways: they can hurt the fishing industry, causing economic and psychological stress; and they may lead to deadly diseases caused by consumption of contaminated fish and shellfish.

Red Tides and Seafood Poisonings

Certain seafood-related health problems arise when poisonous algae, known as dinoflagellates, bloom along New England shores in the spring or fall. Global warming is predicted to increase the occurrence and severity of such blooms. The harmful algae often stain water red—hence the expression "red tides." In 1999 red tides resulted in precautionary closures for shell fishing in New England.[370]

Nationally, such harmful algal blooms (HABs) are on the rise and appear to be expanding throughout the United States.[371] Before 1972, there were only isolated HAB outbreaks around New England.[372] Since that time, HAB events have occurred along the entire New England coastline. Red tides, and other HABs, impact human health when individuals consume shellfish that feed in the infected waters. Raw or cooked shellfish then pass the toxins to humans, causing shellfish poisoning. Described below are the principle types of seafood/shellfish poisoning that occur in the Northeast.

- **Paralytic Shellfish Poisoning (PSP):** PSP is the most common type of HAB in Massachusetts and New England. It is extremely serious, as symptoms appear rapidly and severely. Symptoms include tingling, numbness, burning, drowsiness, fever, rash, and staggering. Respiratory arrest occurs within 24 hours of consuming toxic shellfish in the most severe cases. There is no known antidote.[373] In June 1990, six fishermen working off of the Nantucket coast contracted PSP and were admitted to a local hospital emergency room. They had cooked infected shellfish, which diminished the effects of the disease, but two of the men, including one who had recovered from loss of consciousness, required hospitalization for 2–3 days.[374]
- **Amnesic Shellfish Poisoning (ASP):** ASP can be life threatening. It may become evident up to 24 hours after an individual consumes toxic shellfish. Symptoms include nausea, vomiting, abdominal cramps, and diarrhea. In severe cases, neurological symptoms also appear, such as dizziness, headache, seizures, disorientation, short-term memory loss, respiratory difficulty, and coma. In 1987, four victims died after consuming toxic mussels from Prince Edward Island, Canada.[375]
- **Diarrhetic Shellfish Poisoning (DSP):** DSP produces gastrointestinal symptoms, usually beginning from 30 minutes to a few hours after consumption of toxic shellfish. The disease can cause diarrhea, nausea, vomiting, abdominal cramps, and chills.[376]
- **Neurotoxic Shellfish Poisoning (NSP):** This condition can cause many of the same conditions described above, as well as respiratory problems, such as asthma-like episodes.

The Precautionary Principle

Legislators and environmentalists often refer to a legal term called "the precautionary principle" when dealing with global warming issues. The term's definition states, "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context, the proponent of an activity, rather than the public, should bear the burden of proof."[377]

This principle comes down to common sense. In practice it is nothing new. An early example of the precautionary principle in action happened in 1854. During that year, London had a cholera epidemic. A doctor by the name of John Snow mapped the locations of local cholera deaths and discovered that most of them occurred within 250 yards of a public water pump. Suspecting that the water pump was the source of the contagion, Dr. Snow had the handle removed, making the pump inoperable and ending the plague. This was years before the biological cause of cholera was known.[378]

The precautionary principle has four main components. First, communities have a duty and a right to take anticipatory action to prevent harm. Second, the burden of proof of the harmlessness of a new technology, process, activity, or chemical is the responsibility of the proponents, not the public. Third, communities have an obligation to discuss and to explore a full range of alternatives to the hazards posed. Lastly, decisions must be open, informed, and democratic.

The precautionary principle is no different than practicing preventive medicine. Most of us go to the doctor when we feel that we may be at risk for a certain ailment. In other words, we take action to prevent something bad from happening to us. Global warming requires that same sense of precaution and a willingness to take action.

How Global Warming Could Change Massachusetts' Forests and Agriculture

The White Mountains region is at risk of disruptive changes as a result of global warming. These include the long-standing traditions of timber management, maple-syrup gathering, and fishing, as well as the more modern economies of skiing, foliage viewing, and other tourism and outdoor recreation activities. The economic importance of the White Mountains relies in large part on the persistence of historical climate patterns, which are poised to change substantially over the next century unless action is taken to slow global warming now.[379]

—DR. JANINE BLOOMFIELD, ENVIRONMENTAL DEFENSE FUND

How Climate Change Could Impact Agriculture

Agriculture is important to the state's economy and averages 500 million dollars in annual revenues.[380] Three-fourths of this amount comes from crop yields.[381] The major crops in the state are silage, hay and potatoes.[382] Since farming is influenced by climate conditions and water availability, global warming could greatly impact Massachusetts' agriculture. If the climate warms according to certain model projections, crop yields could fall by 45 percent.[383] Plants that do survive may change biochemically as a result of warmer temperatures. Such changes could impact human and animal health.

Nitrate poisoning is one such risk. Weather stresses, such as hot, dry conditions, can cause inefficient fertilizer uptake by certain crops, such as corn. This, in turn, causes nitrate to accumulate in the plants. Nitrate concentrations above 1,000 parts per million can pose health problems.[384] In livestock acute nitrate poisoning may result in breathing difficulty, blue mucous membranes, a rapid weak pulse, dark brown blood, weakness, muscle tremor, or sudden death. Longer exposures may result in miscarriages and retarded growth.[385]

Plants subjected to heightened levels of carbon dioxide, a greenhouse gas associated with global warming, also showed surprising impacts. James Teeri, Director of the University of Michigan Biological Station, found that plants grown in high concentrations of carbon dioxide grew to large sizes, displaying a form of gigantism. Despite the apparent vigorous growth, they had fewer nutrients than normal.[386] Insects who fed during the experiments had to consume 40 percent more of the plants, using up much of their metabolic energy in doing so. This slowed the growth of their bodies and curtailed normal development. Considering that carbon dioxide levels are projected to double from today's already high levels in 50 to 60 years,[387] the findings merit high concern.

Projected Impact On Forests

Global warming could significantly change Massachusetts' forests by influencing biological diversity and forest growth.[388] Changes in precipitation, higher temperatures, and extreme weather events could wreak havoc on Massachusetts' 3,225,000 acres of timber stands, which cover 64 percent of

the state.[389] Specifically, droughts—like the long 1998–1999 drought across Western Massachusetts[390]—dry out forests, paving the way for forest fires.

Forest fires pose numerous public concerns. For example, they can have a devastating effect on timber production and wildlife, and can destroy homes and other high-value property. Wildfires can kill young trees that represent the timber of tomorrow.[391] From a health standpoint, fires may cause injuries and fatalities to firefighters and nearby residents. Smoke, which can cover a wide area, may increase respiratory illness, such as asthma and chronic obstructive pulmonary disease, particularly for people with pre-existing respiratory conditions.[392] Nationwide, between 1990 and 1998, 133 individuals died while involved in wild land fire activities.[393]

An economic impact could also be felt if, as projected by the EPA, Massachusetts' maple-dominated hardwood forests give way to forests dominated by species more tolerant of higher temperatures, such as oaks and conifers.[394] Sugar maples, in particular, bring fall tourists to the state, because their leaves seasonally change color. As a result, jobs related to fall tourism could be lost, possibly influencing the ability of individuals in these jobs to afford health insurance. Already, state uninsured rates are of concern. Despite a recent decrease in the number of uninsured people in Massachusetts, in 1998, 10.3 percent of Massachusetts residents remained without health insurance coverage.[395]

What You Can Do

Unless we take action now to curb global warming, people in New England and all over the world could face serious consequences. The good news is that we can curb global warming and help the economy if we become more energy efficient, develop cleaner technologies, and stop giving our tax dollars to the coal and oil industries.[396]

—HENRY KENDALL, NOBEL LAUREATE AND CHAIRMAN OF THE UNION OF CONCERNED SCIENTISTS

This paper has reviewed in depth the threats to human health that could result due to climate change. The United States has a greater ability to adapt to, and prepare for, these changes than other countries due to our health care infrastructure and strong economy. However the potential health effects of climate change are real and demand attention. Increased levels of heat, extreme weather events, vector-borne and water-borne diseases, and air and water pollution will affect all Americans, however, the poor, elderly, young, and immunocompromised will be the hardest hit. We have the power to ameliorate the impacts of climate change by decreasing greenhouse gas emissions and investing in strategies that will help us to prepare for what is to come. But we must act now.

Can residents of Massachusetts do anything to reverse global warming before it creates a perpetual state of emergency? Yes, they can. The number one priority is to lower the use of fossil fuels. Opportunities for doing so are everywhere. As an added benefit, the energy conservation techniques recommended here to combat global warming are very similar to those desperately needed to cut air pollution. In addition, they can increase our standard of living while reducing economic costs. Our quality of life in the future depends upon the actions we take today.

Communities and individuals can do a lot in Massachusetts, starting now, to combat global warming and decrease the consumption of fossil fuels.

1 Get your own house in order. Use energy-efficient light bulbs. Install a solar thermal system to help provide your hot water (carbon dioxide reduction: 720 pounds per year). Recycle all of your home's waste newsprint, cardboard, glass and metal (carbon dioxide reduction: 2,480 pounds per year). Lower your thermostat in winter and raise it in summer, thereby reducing the demand for electricity and the burning of fossil fuels. When purchasing a home or remodeling, request efficient insulation, and energy efficient appliances, refrigerators, and water heaters. The Commonwealth of Massachusetts offers a number of tax credits and incentives for individuals and businesses that use renewable energy resources. For further information, contact the Department of Revenue at 617-727-4545 or the Division of Energy Resources at 617-727-4732.

2 Carpool more and drive less. Leave your car at home for one or two days a week and you will save tons of carbon dioxide emissions. Nationally, cars contribute about 30 percent of greenhouse gases in the air. Massachusetts is a part of this growing problem. Population growth could

lead to even more motor vehicles and longer commutes. Do your part, by carpooling and using public transportation whenever possible.

3 If you are buying a new car, go for a more energy-efficient one. Cars and light trucks are responsible for as much as 45 percent of the ozone causing compounds that can cause respiratory problems.[397] This percentage figure is actually on the rise, due to increased use of light trucks and sport utility vehicles. Encourage automakers to develop and sell cars, trucks, and sport utility vehicles (SUVs) with better mileage and higher fuel efficiency, or CAFE, standards. At a web site launched by the EPA and the U.S. Department of Energy (http://www.fueleconomy.gov), you can do a side-by-side comparison and select the most energy-efficient vehicle that meets your needs.

4 Keep your car's tires properly inflated at all times. According to the Department of Energy, Americans could save 100,000 barrels of oil, or 4 million gallons of gasoline, a day by properly inflating their tires.[398] If your car's tires are under-inflated by just 4 pounds, it could cost up to a half-mile per gallon of gasoline.[399]

5 Demand that electric utilities use low-carbon technologies and renewable energy. Massachusetts has dirty power plants, like the Filthy Five, that need to clean up their act. Support efforts that require all power plants to meet federal air pollution standards.

6 Urge businesses to become energy-efficient. U.S. businesses spend about $100 billion on energy each year to operate commercial and industrial buildings. By using energy efficient products and procedures, organizations could reduce their energy use by 35 percent, or $35 billion nationally. There are now numerous programs in place to help businesses change their energy usage and save money at the same time. Put your favorite businesses in touch with EPA's Energy Star Buildings program (1-888-STAR-YES, http://www.epa.gov/greenlights), and Climate Wise program (1-800-459-WISE, http://www.epa.gov/climatewise).

7 Support efforts to separate sewer and flood water lines in the state. As it stands, many water systems in Massachusetts are vulnerable to contamination from pollutants and pathogens in untreated sewer water during flood events. Urge officials to continue to update sewer and flood water lines, as they have in constructing the new Deer Island sewage treatment facility, to avoid such problems in the future.

8 Encourage your town to join the International Council for Local Environmental Initiatives (www.ICLEI.org), an organization that is helping cities to develop inventories of greenhouse gas emissions, set reduction targets, and devise and implement action plans. So far Boston, Brookline, Cambridge, Lynn, Medford, Newton, and Springfield have joined.

9 Support political leaders who have taken a stand in favor of ratifying the Kyoto Protocol to the Framework Convention on Climate Change. An international strategy for curbing global warming and cutting greenhouse gas emissions is essential. Also, tell your members of Congress that you are not afraid of higher fuel efficiency, or CAFE, standards—for cars, SUVs and light trucks—and they should not be either!

10 Work with local groups and chapters of national organizations to promote awareness of global warming and related issues in Massachusetts. These include: the Massachusetts chapters of Physicians for Social Responsibility, PSR/Central Massachusetts (508-366-7687), PSR/Greater Boston (617-497-7440), PSR/Pioneer Valley (413-253-2300), Massachusetts Climate Action Network (781-643-5911 or 617-492-6614), Northeast Sustainable Energy Association (413-774-6051), American Lung Association of Massachusetts, ALA/Middleboro (508-947-7204), ALA/Greater Norfolk County (508-668-6729), ALA/Middlesex County (781-272-2866), ALA/Western Massachusetts (413-737-3506), American Heart Association Massachusetts, AHA/Framingham (508-620-1700 or 1-800-662-1701), AHA/South Yarmouth (508-760-6818), AHA/West Springfield (413-827-0400), Massachusetts Energy Consumers Alliance (617-524-3950), Solar Boston (617-524-3950), Earthwatch Institute (800-776-0188), Environmental League of Massachusetts (617-742-2553), Sierra Club Massachusetts Chapter (617-423-5775).

Where Physicians for Social Responsibility Stands

Physicians for Social Responsibility (PSR), the active conscience of American medicine, uses its members' expertise and professional leadership, influence within the medical and other communities, and strong links to policy makers, to address this century's greatest threats to human welfare and survival.

While we recognize that uncertainties exist in the measurement of global warming—just as all scientific measurement is uncertain—we are moved to action for several compelling reasons. First, the overwhelming consensus among scientists is that the Earth's temperature is increasing and weather patterns are changing in ways potentially harmful to human health. This fact is overlooked in statements funded by the energy industry that attempt to minimize the severity of global warming. Second, just like businesses, governments, and responsible individuals, PSR feels the need to act decisively in the face of uncertainty to protect those whose welfare has been entrusted to us.

We cannot say exactly when to expect a noticeable increase in floods, or in deaths from asthma among people living in smog-congested cities. No one can. But as Surgeon General Luther Terry stated in his 1962 report on motor vehicles and air pollution, the need for further research should not stop us from taking "all practicable steps to minimize" the hazard. We are certain that fossil fuels play a role in global warming, one step that we can control. For the sake of our own well-being, and that of future generations, we need to act now.

PSR is working to create a world free of global environmental pollution, nuclear weapons, and gun violence. PSR is an organization in official relations with the World Health Organization. In 1985, PSR shared the Nobel Peace Prize with the International Physicians for the Prevention of Nuclear War.

NOTES:

1. Chivian E, Educating The Medical And Public Health Communities About The Threat Of Climate Change And Human Health, September 11, 1995. http://www.greenpeace.org/~climate/impacts/chivian.
2. National Oceanic and Atmospheric Administration (NOAA), Climate of 1999—Annual Review. http://www.ncdc.noaa.gov/ol/climate/research/1999/ann/ann99.html; NOAA, 2000 In Review, December 18, 2000. http://www.noaanews.noaa.gov/stories/s547.htm.
3. Associated Press, NOAA: Winter Warmest on Record, March 13, 2000.
4. Intergovernmental Panel on Climate Change (IPCC), *The Regional Impacts of Climate Change: An Assessment of Vulnerability*, 8.4.6. (1998). http://www.epa.gov/globalwarming/reports/pubs/ipcc/chp8/america15.html.
5. IPCC, *Climate Change 1995, Second Assessment Report, Working Group I Summary for Policy Makers* (1996).
6. Personal communication with Richard Clapp, Associate Professor, Department of Environmental Health, Boston University School of Public Health, October 23, 2000.
7. United States Environmental Protection Agency (EPA), Stormy Forecast for New England?, November 18, 1997. http://www.epa.gov/oppeoee1/globalwarming/greenhouse/greenhouse1/stormy.html.
8. Woods Hole Oceanographic Institution, Cape Cod Coastal Erosion: A Case Study, April 1998. http://www.whoi.edu/seagrant/education/focalpoints/erosion.html.
9. Keim B, New England Regional Assessment, Current Climate of the New England Region, June 1999.
10. EPA, Climate Change and Massachusetts, September 1997.
11. American Heart Association, New England Affiliate, Statistics-Massachusetts Heart and Stroke Facts. http://www.americanheart.org/newengland/massstats.html
12. Clean Air Task Force, Adverse Health Effects Associated With Ozone In The Eastern United States, October 1999.
13. Massachusetts Department of Public Health State Laboratory Institute, 1999 Statistics (compiled upon request), October 18, 2000.
14. Centers for Disease Control and Prevention (CDC), Notifiable Diseases/Deaths in Selected Cities Weekly Information, *MMWR*, 49(51):1159–1166 (Jan 5, 2001).
15. EPA, Climate Change and Massachusetts.
16. Physicians for Social Responsibility (PSR) and Ozone Action, Heat Waves And Hot Nights, Heat Stress Days: Number of extreme days per year in Boston, MA, from 1950–1999. http://www.ozone.org/heatstress/14739.html; PSR and Ozone Action, Heat Waves And Hot Nights, Heat Stress Nights: Number of extreme nights per year in Boston, MA, from 1948-1999. http://www.ozone.org/heatstress/14739.html.
17. EPA, Climate Change and Massachusetts.
18. Longstreth J, Public Health Consequences of Global Climate Change in the United States—Some Regions May Suffer Disproportionately, *Environ Health Persp*, 107(Supp 1):169-179 (Feb 1999).
19. EPA, Health and environmental effects of ground-level ozone-Fact Sheet, July 17, 1997. htpp://ttnwww.rtpnc.epa.gov/naaqsfin/o3health.htm; Dickey JH, *No room to breathe*. http://www.psrus.org/breathe.htm.
20. Patz J, et al, The Potential Health Impacts of Climate Variability and Change for the United States: Executive Summary of the Report of the Health Sector of the U.S. National Assessment, Workshop Summary, *Environ Health Persp*, 108(4):367–376 (Apr 2000). http://ehis.niehs.nih.gov/topic/global/patz-full.html.
21. EPA, Global Warming Impacts—Fisheries. http://ww.epa.gov/globalwarming/impacts/fisheries/index.html.
22. World Health Organization (WHO), *Climate Change and Human Health*, eds. AJ McMichael, A Haines, R Slooff, and S Kovats (Geneva: WHO, 1996).
23. EPA, Climate Change and Massachusetts.
24. EPA, Climate Change and Massachusetts.
25. EPA, Climate Change and Massachusetts.
26. Ohio Department of Agriculture, ODA Offers Free Aflatoxin Testing On Drought-Stressed Corn, September 16 1999.
27. Personal communication with James Teeri, Director of the University of Michigan Biological Station, July 2000.
28. EPA, Climate Change and Massachusetts.
29. U.S. Census Bureau, Health Insurance Coverage: 1998—State Uninsured Rates. http://www.census.gov/hhes/hlthins/hlthin98/3yr98.html.
30. NOAA, Climate of 1999—Annual Review. http://www.ncdc.noaa.gov/ol/climate/research/1999/ann/ann99.html; NOAA, 2000 In Review, December 18, 2000. http://www.noaanews.noaa.gov/stories/s547.htm.
31. EPA, Global Warming Site: Climate; EPA, Global Warming Site: Atmospheric Change—Past, http://www.epa.gov/globalwarming/climate/atmospheric/past.html.
32. EPA, Global Warming Site: Climate.
33. Hebert HJ, Kyoto Pact In Peril, White House Says, AP, November 11, 2000.

34. EPA, Global Warming Site: National Emissions—Recent Trends, http://www.epa.gov/globalwarming/emissions/national/trends.html.

35. EPA, Global Warming Site: Climate.

36. Sturges W, et al, A Potent Greenhouse Gas Identified in the Atmosphere: SF5CF3, Science, 289:611—613, July 28, 2000.

37. IPCC, IPCC WGI Third Assessment Report, Summary for Policy Makers, Shanghai Draft 21-01-2001 20:00; AP, Humans to Blame For Global Warming, October 26, 2000.

38. National Center for Atmospheric Research, Press release, Extreme Weather on the Rise as Climate Changes, October 7,2000; Easterling DR, et al, Climate Extremes: Observations, Modeling, and Impacts, *Science*, 289:2068-2074, September 22, 2000.

39. National Center for Atmospheric Research, Press release, Global Warming Greater Minus El Niños, Volcanoes, December 13, 2000. http://www.newswise.com/articles/2000/12/CLIMATE.CAR.html.

40. Crowley T, Causes of Climate Change Over the Past 1000 Years, *Science*, Vol 289, July 14, 2000.

41. Bowles C, New Scientist Press Release: The Poor Get Hotter, November 8, 2000.

42. Bowles.

43. Jet Propulsion Laboratory, Media Relations Office, La Niña's persistence may be part of larger climate pattern, January 19, 2000.

44. Levitus S, et al, Warming of the World Ocean, *Science*, 287:2225–9, March 24, 2000.

45. Hebert J, Oceans getting warmer, AP, March 27, 2000.

46. Petit JR, et al, Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica, *Nature*, 399:429–435, June 3, 1999.

47. Patz J, et al, The Potential Health Impacts of Climate Variability and Change for the United States.

48. Longstreth J, Public Health Consequences of Global Climate Change in the United States—Some Regions May Suffer Disproportionately, *Environ Health Persp*, 107(Supp 1):169–179 (Feb 1999).

49. Longstreth.

50. American Heart Association, New England Affiliate, Statistics-Massachusetts Heart and Stroke Facts, accessed October 10, 2000. http://www.americanheart.org/newengland/massstats.html.

51. American Heart Association, Statistics-Massachusetts Heart and Stroke Facts.

52. Patz.

53. CDC, Surveillance for Five Health Risks Among Older Adults—United States, 1993–1997, *MMWR*, 48(SS08):89–130 (Dec 17, 1999). http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/ss4808a5.htm.

54. MA Department of Public Health Chronic Disease Surveillance Program, Health Risks & Preventative Behavior Among Massachusetts Adults, 1997, June 1999.

55. MA Department of Public Health Chronic Disease Surveillance Program, Health Risks & Preventative Behavior Among Massachusetts Adults, 1997, June 1999.

56. WHO, *Climate Change and Human Health*; Kilbourne EM, Illness due to thermal extremes, *Public Health and Preventive Medicine*, 13th ed., eds. JM Last and RB Wallace (Norwalk, CT: Appleton Lange, 1992) 491–501; National Institute on Aging (NIA), Hyperthermia: A hot weather hazard for older people. http://www.nih.gov/nia/health/agepages/hyperthe.htm.

57. National Center for Health Statistics, *Health, United States, 1998, with Socioeconomic Status and Health Chartbook*, Hyattsville, MD, 1998, 84–7.

58. National Center for Health Statistics, *Health, United States, 1998, with Socioeconomic Status and Health Chartbook* at 83.

59. Longstreth.

60. CDC, State-Specific Prevalence of Selected Health Behaviors, by Race and Ethnicity-Behavioral Risk Factor Surveillance System,1997, *MMWR*, 49(SS02):1–60, March 24, 2000.

61. IPCC, *The Regional Impacts of Climate Change.*

62. Longstreth.

63. U.S. Public Interest Research Group Education Fund (USPIRG), Storm Warning: Global Warming And The Rising Costs Of Extreme Weather, April 6, 2000.

64. USPIRG, Storm Warning: Global Warming And The Rising Costs of Extreme Weather.

65. Gerrity ET & Flynn BW, Mental Health Consequences of Disasters, in *The Public Health Consequences of Disasters* (Noji E, ed), 101–21 (New York: Oxford University Press, 1997).

66. U.S. Department of Health and Human Services (HHS), CDC, Health, United States, 1998 With Socioeconomic Status and Health Chartbook. DHHS Publication number (PHS) 98-1232.

67. NCDC, Climate Data Events, Hail, July 24, 1999.

68. NCDC, Climate Data Events, Tornado, June 2, 2000.

69. Gute D, CLIMB Human Health Effects Issue Paper, March 13, 2000. http://www.tufts.edu/tie/climb/healtheffects.html.

70. EPA, Climate Change and Massachusetts.

71. EPA, Climate Change and Massachusetts.

72. In this study, a national temperature threshold was calculated. When the heat index crosses this threshold, heat related mortality begins to increase. High heat stress days and nights are defined as those exceeding the 85th percentile threshold for the historic climate of each location (1961–1990) for summer months (July and August) at each weather station. Heat stress nights are defined as those exceeding the 85th percentile for daily minimum (night) heat index. PSR and Ozone Action, Heat Waves And Hot Nights, July 26, 2000. http://www.psr.org/heatsheet.html.

73. PSR and Ozone Action, Heat Waves and Hot Nights, July 26, 2000.

74. PSR and Ozone Action, Heat Waves and Hot Nights, Heat Stress Days: Number of extreme days per year in Boston, MA, 1950–1999. http://www.ozone.org/heatstress/14739.html.

75. PSR and Ozone Action, Heat Waves and Hot Nights, Heat Stress Nights: Number of extreme nights per year in Boston, MA, from 1948–1999.

76. NCDC, Mean Number of Days with Maximum Temperature 90 Degrees F or Higher, data through 1998. http://www.ncdc.noaa.gov/ol/climate/online/ccd/max90temp.html.

77. Kalkstein LS & Greene JS, An Evaluation of Climate/Mortality Relationships in Large U.S. Cities and the Possible Impacts of a climate change, *Environ Health Persp*, 105(1):84–93 (1997).

78. EPA, Climate Change and Massachusetts.

79. EPA, Climate Change and Massachusetts.

80. American Red Cross, Heat Wave: A Summer Killer, fact sheet distributed by the National Weather Service. Accessed April 2000. http://www.nws.noaa.gov/om/nwspub.htm.

81. CDC, Heat related deaths-United States, 1993, *MMWR*, 42(28):558-560 (July 23, 1993).

82. CDC, Heat related deaths—United States, 1993.

83. WHO, *Climate Change and Human Health*.

84. CDC, Heat related deaths—United States, 1993.

85. Heart Information Network, Watch Out For the Heat. http://www.heartinfo.com/news97/heat62797.htm.

86. NCDC Climate Data Events, Record Heat, July 5, 1999.

87. NCDC Climate Data Events, Record Heat, July 5, 1999.

88. New England Regional Assessment, Health and Climate Variability Workshop, Weather-Climate and Extremes, March 31, 1999. http://www.necci.sr.unh.edu/Report-html/NERA-Health-Weather-brief.html.

89. WHO, Potential health effects of climate change (1990). http://www.ciesin.org/docs/001-007/001-007.html.

90. EPA, Climate Change and Massachusetts.

91. EPA, Climate Change and Massachusetts.

92. ICLEI, Cities At Risk: Assessing the Vulnerability of United States Cities to Climate Change, Boston Case Study. http://www.iclei.org/co2/car-textonly.htm.

93. NCDC, Climate Data Events, Flood, June 13, 1998.

94. NCDC, Unnamed Hurricane 1991, November 6, 1997. http://www.ncdc.noaa.gov.

95. NCDC, "Perfect Storm" Damage Summary October 1991, November 6, 1997. http://www.ncdc.noaa.gov.

96. Ufish, The Andrea Gail Perfect Storm page. http://www.ufish.com/Andrea_Gail/AndreaGail.htm.

97. NCDC, "Perfect Storm" Damage Summary October 1991, November 6, 1997.

98. NCDC, The Perfect Storm, October 1991, updated June 30, 2000. http://www.ncdc.noaa.gov.

99. NCDC, "Perfect Storm" Damage Summary October 1991.

100. NCDC, "Perfect Storm" Damage Summary October 1991.

101. CDC, Hypothermia-Related Deaths—Georgia, January 1996–December 1997, and United States, 1979–1995, *MMWR*, 47(48):1037–1040 (Dec 11, 1998). http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/00055930.htm.

102. CDC, *MMWR*, Hypothermia-Related Deaths.

103. CDC, *MMWR*, Hypothermia-Related Deaths.

104. *The Cincinnati Enquirer*, Effects of Frostbite, updated Feb 28, 1998. http://enquirer.com/editions/1999/01/08/frostbitegraphic.html.

105. Ohio Department of Health (ODH), Tips To Help Make Winter Safer, Jan 3, 2000. http://www.odh.state.oh.us/public/news61.htm.

106. CDC, Changes in Mortality from Heart Failure-United States, 1980–1995, *MMWR*, 47(30):633-7 (Aug 7, 1998). http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/00054249.htm.

107. EPA, Global Warming Impacts—Health. http://www.epa.gov/globalwarming/impacts/health/index.html.

108. American Heart Association New England Affiliate, Statistics Massachusetts Heart and Stroke Facts. http://www.americanheart.org/newengland/massstats.html.

109. Gorjanc ML, et al, Effects of temperature and snowfall mortality in Pennsylvania, *Am J Epidemiol*, 149(12):1152–60, June 15, 1999.

110. Free Press News Services, Snow, cold create deadly combination, *Detroit Free Press*, February 15, 2000.

111. Smolander J, et al, Energy expenditure and clearing snow: a comparison of shovel and snow pusher, *Ergonomics*, 38(4):749–53, April 1995; Franklin BA, et al, Cardiac demands of heavy snow shoveling, *JAMA*, 273(11):880–2, March 15, 1995.

112. Ohio Department of Health (ODH), Tips To Help Make Winter Safer, Jan 3, 2000.

113. CDC, The Costs of Fall Injuries Among Older Adults. http://www.cdc.gov/ncipc/factsheets/fallcost.htm.

114. Larson-Bright M, New Mexico Department of Health, Improving Our Health Odds-Falls and Fractures: A Risk For Older Persons!

115. CDC, National Center for Injury Prevention and Control, The Costs of Fall Injuries Among Older Adults, January 27, 2000. http://www.cdc.gov/ncipc/factsheets/fallcost.htm.

116. CDC, The Costs of Fall Injuries Among Older Adults.

117. NCDC, Climate Data Events, Snow Squall, March 12, 1998.

118. NCDC, Climate Data Events, Heavy Snow, February 25, 1999.

119. NCDC, Climate Data Events, Heavy Snow, February 25, 1999.

120. ICLEI, Cities At Risk: Assessing the Vulnerability of United States Cities to Climate Change, Boston Case Study. http://www.iclei.org/co2/car-textonly.htm

121. ICLEI, Cities At Risk.

122. Methuen Fire Department, Carbon Monoxide Detectors. http://www.mdc.net/~captdb/meth13.html.

123. ODH, The Inside Story: What is Indoor Air Pollution?, *Prevention Monthly*, vol 21(5), May 1998. http://www.odh.state.oh.us/public/publications/webpm2/iaq.htm.

124. William Beaumont Hospitals in Michigan, Health Body and Mind: Prevent carbon monoxide poisoning. http://www.beaumont.edu/bodymind/safety_carbon.html.

125. William Beaumont Hospitals in Michigan, Health Body and Mind.

126. ODH, The Inside Story: What is Indoor Air Pollution?

127. Mayo Clinic, Carbon monoxide: How to protect your family. http://www.mayohealth.org/mayo/9812/htm/co.htm.

128. Gorlick A, Lawmakers seek heating oil relief, September 21, 2000. http://www.centralmaine.com/news/stories/000921heatingo.shtml.

129. Business Week Report, Heating-Oil Rescue Plan—Or Just a Drop in the Bucket?, July 12, 2000. http://www.businessweek.com/bwdaily/dnflash/july2000/nf00712e.htm.

130. Connole P, Natural Gas Prices Soar, May Get Worse, December 6, 2000.

131. Connole.

132. CDC, Carbon monoxide poisonings associated with snow-obstructed vehicle exhaust systems- Philadelphia and New York City, January 1996, *MMWR*, 45(01):1–3 (Jan 12, 1996).

133. CDC, Community needs assessment and morbidity surveillance following an ice storm-Maine, January 1998, *MMWR*, 47(17):351–354 (May 8, 1998).

134. CDC, Use of unvented residential heating appliances—United States, 1988–1994, *MMWR*, 46(51):1221–1224 (Dec 26, 1997).

135. NOAA, Winter Storms- The Deceptive Killers A Guide To Survival, November 1991. http://www.nws.noaa.gov/om/wntrstm.htm.

136. NCDC, Climate Data Events, Freezing Rain, January 18, 1999.

137. NCDC, Climate Data Events, Freezing Rain, January 18, 1999.

138. NWS, Thunderstorms and Lightning: The Underrated Killers A Preparedness Guide, January 1994.

139. NWS, Thunderstorms and Lightning.

140. NWS, Thunderstorms and Lightning.

141. NCDC, Climate Data Events, Hail, July 6, 1999.

142. NCDC, Climate Data Events, Hail, July 6, 1999.

143. NCDC, Climate Data Events, Hail, July 24, 1999.

144. EPA Office of Policy, Planning and Evaluation, Office of Economy and Environment, Global Warming: What Does It Mean for New England? A report on the June 26, 1997 EPA Regional Conference.

145. NCDC, Climate Data Events, Heavy Snow, February 25, 1999.

146. NCDC, Climate Data Events, Snow Squalls, November 30, 1999.

147. USPIRG, *Flirting With Disaster: Global Warming and the Rising Costs of Extreme Weather*, October 27, 1999, quoting The International Federation of Red Cross and Red Crescent Societies, Red Cross World Disasters Report.

148. NCDC, Climate Data Events, Tornado, May 29, 1995.

149. NCDC, Climate Data Events, Tornado, May 29, 1995.

150. NCDC, Climate Data Events, Tornado, May 29, 1995.

151. NCDC, Climate Data Events, Thunderstorm Wind, May 31, 1998.

152. NCDC, Climate Data Events, Thunderstorm Wind, July 6, 1999.

153. NOAA, What type of winter weather can I expect in New Mexico? http://www.srh.noaa.gov/abq/preparedness/wwxaware-1.htm.

154. NWS, Winter Storms: the Deceptive Killers, November 1991. http://www.nws.noaa.gov/om/wntrstm.htm.

155. NWS, New Mexico Flash Flood and Lightning Awareness Week, June 14–18, 1999. factsheet; CDC, Lightning-Associated Deaths—United States, 1980–1995.

156. NWS, Thunderstorms and Lightning The Underrated Killers A Preparedness Guide, January 1994.

157. NCDC, Climate Data Events, Lightning, June 27, 2000.

158. NCDC, Climate Data Events, Lightning, June 27, 2000.

159. NCDC, Climate Data Events, Lightning, July 23, 1998.

160. NCDC, Climate Data Events, Lightning, July 23, 1998.

161. Kirshen P & Suarez P, CLIMB Background Paper, Possible Impacts of Climate Change on Drainage, River Flood Management Systems, and Coastal Flooding in Boston Metro Area, March 6, 2000. http://www.tufts.edu/tie/climb/drain.html.

162. CDC, Flood-related mortality–Georgia, July 4–14, 1994, *MMWR*, 43(29):526–30 (July 29, 1994).

163. NCDC, Climate Data Events, Flood, June 13, 1998.

164. NCDC, Climate Data Events, Flood, June 13, 1998.

165. NCDC, Climate Data Events, Flood, June 13, 1998.

166. NWS, Flash Floods and Floods. . . the Awesome Power! A Preparedness Guide, July 1992. http://www.nws.noaa.gov/om/ffbro.htm.

167. NWS, Flash Floods and Floods…the Awesome Power!

168. NCDC, Climate Data Event Details, Flash Flood, September 10, 1999.

169. ODH, Precautions Against Disease and Injury in Flood Areas.

170. ODH, Precautions Against Disease and Injury in Flood Areas.

171. ODH, Precautions Against Disease and Injury in Flood Areas.

172. Massachusetts Department of Public Health State Laboratory Institute, 1999 Statistics (compiled upon request), October 18, 2000.

173. New England Regional Assessment, Health and Climate Variability Workshop, Weather-Climate and Extremes, March 31, 1999. http://www.necci.sr.unh.edu/Report-html/NERA-Health-Weather-brief.html.

174. Berney B, Testimony on Proposed Amendments to 310 CMR 7.00 et. Seq: 310 CMR 7.29 Emissions Standards for Power Plants, accessed October 19, 2000.

175. Epstein PR, The impact of climate change on human health, in *New England Regional Climate Change Impacts Workshop: Workshop Summary Report*, Sept. 3, 1997.

176. As the heat goes on, so do power switches; CMP sets a record for power use amid the hot weather's assault, *Portland Press Herald*, July 23, 1998, p. 1A.

177. News Brief, Governor Cracks Down on Dirty Power Plants, May 10, 2000. http://www.energyonline.com/Restructuring/news_reports/news/0510ma.html.

178. News Brief, Governor Cracks Down on Dirty Power Plants, May 10, 2000.

179. MA Clean Water Action Clean Water Fund, We'd Rather Be Breathing: Clean Up the Filthy Five Hearing Kit.

180. Harvard School of Public Health, HSPH Report Quantifies Health Impact of Air Pollution From Two Massachusetts Power Plants, May 4, 2000.

181. Harvard School of Public Health.

182. Harvard School of Public Health.

183. News Brief, Governor Cracks Down on Dirty Power Plants, May 10, 2000. http://www.energyonline.com/Restructuring/news_reports/news/0510ma.html.

184. USPIRG, Lethal Legacy: The Dirty Truth About The Nation's Most Polluting Power Plants, April 2000.

185. USPIRG, Up In Smoke: Congress' failure to control emissions from coal power plants, 1999.

186. MASSPIRG, Facts on the Filthy 5, June 25, 1998. http://www.pirg.org/masspirg/enviro/cleanair/plants.htm.

187. MASSPIRG, Facts on the Filthy 5, June 25, 1998.

188. MDMH, Charts of Specific Advisories, accessed August 2000. http://www.mdmh.state.mi.us/pha/fish/charts.htm.

189. Commission on Life Sciences, the Toxicological Effects of Methylmercury (2000), National Academy Press. http://books.nap.edu/books/0309071402/htm/10.html.

190. DeRosa C, Persistent Toxic Substances and Health Effects in the Great Lakes Basin, State Of The Great Lakes 1999 Annual Report, Office of the Great Lakes.

191. DeRosa C, Persistent Toxic Substances and Health Effects in the Great Lakes Basin, State Of The Great Lakes 1999 Annual Report, Office of the Great Lakes.

192. Spellman FR & Whiting NE, Environmental Science and Technology, 185 (Governments Institute 1999).

193. EPA, Climate Change and Massachusetts.

194. EPA, Climate Change and Massachusetts.

195. EPA, Climate Change and Massachusetts.

196. EPA, USA Air Quality Nonattainment Areas, March 27, 2000. http://www.epa.gov/airs/nonattn.html.

197. USPIRG, Danger in the Air: Unhealthy Smog Days In 1999.

198. USPIRG, Danger in the Air.

199. USPIRG, Danger in the Air.

200. MA Department of Environmental Protection, Ozone Season '99—A Recap, accessed October 2000. http://www.state.ma.us/dep/bwp/ozone/dailyoz.htm.

201. EPA, Health and environmental effects of ground-level ozone-Fact Sheet, July 17, 1997. htpp://ttnwww.rtpnc.epa.gov/naaqsfin/o3health.htm; Dickey JH, No room to breathe. http://www.psrus.org/breathe.htm.

202. Weisel CP, et al, Relationship between summertime ambient ozone levels and emergency department visits for asthma in central New Jersey, Environ Health Persp 103(Supp 2):97–102 (1995).

203. EPA, Health and environmental effects of ground-level ozone-Fact Sheet, July 17, 1997.

204. EPA, Office of Air Quality Planning and Standards, Smog—Who Does It Hurt? What You Need To Know About Ozone and Your Health.

205. Clean Air Task Force, Adverse Health Effects Associated With Ozone In The Eastern United States, October 1999.

206. Gold DR, et al, Ambient pollution and heart rate variability, Circulation 2000; 101(11):1267–73; Zablocki E, Air pollution linked to health problems, deaths, WebMD Medical News, Mar 20, 2000, http://webmd.lycos.com/content/article/1728.55867.

207. Zablocki.

208. Zablocki.

209. CDC, Asthma—a speaker's kit for public health professionals. http://www.cdc.gov/nceh/programs/asthma/speakit/cover.htm.

210. CDC, 1997 State-Specific Mortality Data, Table 2: Lung Disease: Number of Deaths. In all races. By ICD code. 1997.

211. American Lung Association of Michigan, Programs of the American Lung Association Will Help Your Asthmatic Children, 1999. http://www.lungusa.org/michigan/asthma.html.

212. EPA, Office of Air Quality Planning and Standards, Smog—Who Does It Hurt?

213. CDC, Facts about asthma, Aug 8, 1997. http://www.cdc.gov/od/oc/media/fact/asthma.htm.

214. MA Citizens for Children, Massachusetts Kids Count Data Report: Health Care for All Our Children: We Can Make It Happen1997. http://www.masskids.org/kidscount/kd_rep_1997healthcare.html.

215. American Lung Association of Michigan, Programs of the American Lung Association Will Help Your Asthmatic Children.

216. American Lung Association of Michigan, Programs of the American Lung Association Will Help Your Asthmatic Children.

217. Hales S, et al, Prevalence of adult asthma symptoms in relation to climate in New Zealand, in *Environ Health Persp* 106:607–10 (1998).

218. Rushton L & Cameron K, Selected Organic Chemicals, in *Air Pollution and Health* (Holgate ST, et al eds) 813–838 (Academic Press, 1999).

219. MA Department of Public Health, Heart Disease and Cancer. http://www.state.ma.us/dph/stats/dth96/dtdb9e1.htm.

220. New Hampshire Department of Environmental Services, Reducing toxic air pollutants in New Hampshire. http://www.des.state.nh.us/ard/toxpage.htm.

221. EPA, Automobile Emissions: An Overview, August 1994. Fact Sheet Number 400-92-007. http://www.epa.gov/otaq/05-autos.htm.

222. Leiner, Craig & Regan, Terry (prepared), *Massachusetts Transportation Facts*, Executive Office of Transportation and Construction, September 1998.

223. Konrad R, Environmental lobby stops in Detroit, which won't see accompanying ad campaign, *Detroit Free Press*, October 13, 1999. http://www.freep.com/business/qnet13.htm.

224. EPA, Automobile Emissions: An Overview, August 1994. Fact Sheet Number 400-92-007. http://www.epa.gov/otaq/05-autos.htm.

225. EPA, Automobile Emissions.

226. EPA, Automobile Emissions.

227. EPA, Automobiles and Ozone, January 1993. Fact Sheet OMS-4. http://www.epa.gov/otaq/04-ozone.htm.

228. The Columbia Encyclopedia, Sixth Edition 2000, acid rain.

229. EPA, Automobiles and Carbon Monoxide, OMS Fact Sheet #3, January 1993. http://www.epa.gov/otaq/03-co.htm.

230. EPA, Automobiles and Carbon Monoxide.

231. EPA, Automobile Emissions.

232. American Thoracic Society, American Thoracic Society: News Tips for July 2000. http://www.newswise.com/articles/2000/7/07TIPS.ATS.html.

233. Layton L, Drive Against Diesel Buses Armed With Asthma Data; D.C. Wants Metro to Test Natural Gas Models, The Washington Post, July 6, 2000.

234. EPA, Automobiles and Ozone, January 1993. Fact Sheet OMS-4. http://www.epa.gov/otaq/04-ozone.htm.

235. EPA, Automobiles and Ozone.

236. Ohio EPA, Health Effects From Automobile Emissions. http://www.epa.state.oh.us/dapc/mobile/healthef.html.

237. Pickler N, AP, Thirsty SUVs, trucks drain U.S. miles per gallon to 20-year low, San Francisco Chronicle, December 20, 2000.

238. Pickler.

239. United States Department of Agriculture, Global Warming's High Carbon Dioxide Levels may Exacerbate Ragweed Alergies, Release No. 0278.00, Aug 15, 2000; Manning A, Ragweed warms to Climate Change, Increasing CO2 has doubled pollen, misery, *USA Today*, 8D, August 15, 2000.

240. National Allergy Bureau, Tree Pollen Chart Readings For Chelmsford, MA, January 29 1999–September 10,1999 http://www.aaai.org/scripts/nab/pChart.asp?city=Chelmsford&state=MA.

241. National Allergy Bureau, Mold Spore Chart Readings For Chelmsford, MA, January 29 1999–October 12,1999.

242. Executive Office of the President, Office of Science and Technology Policy, Climate Change: State of Knowledge, Oct 1997, at 12.

243. EPA, Climate Change and Ohio; EPA, Climate Change and New Mexico.

244. Gelbspan R, Chilling evidence of climactic meltdown, Boston Globe, Jan 21, 1999.

245. Epstein PR, Climate ecology and human health, *Consequences*, 3(2):1997.

246. WHO, *Climate Change and Human Health* at 91.

247. Epstein P, Is Global Warming Harmful to Health?, *Scientific American*, August 2000. http://www.sciam.com/2000/0800issue/0800epstein.html.

248. MA Department of Public Health, Bureau of Communicable Disease Control, West Nile Virus Encephalitis Fact Sheet, July 2000. http://www.state.ma.us/dph/cdc/wnvfax.htm.

249. City of Boston Public Health, General Information on West Nile Virus. http://www.ci.boston.ma.us/publichealth/westnile.

250. City of Boston Public Health, General Information on West Nile Virus; MA Department of Public Health, Bureau of Communicable Disease Control, West Nile Virus Encephalitis Fact Sheet, July 2000. http://www.state.ma.us/dph/cdc/wnvfax.htm

251. City of Boston Public Health, General Information on West Nile Virus.

252. City of Boston Public Health, General Information on West Nile Virus.

253. Lives That Have Been Changed Forever From the Aftereffects of a Mosquito Bite, New York Times, August 19, 2000.

254. Spraying for West Nile virus begins, Boston Globe, July 28, 2000.

255. New York State Department of Health, Fact Sheet- Information Related to Insecticide Use For Preventing the Spread of West Nile Virus, July 2000. http://www.health.state.ny.us/nysdoh/pest/hlthwnv.htm; West Nile Virus Spreads Father South, Reuters, October 23, 2000. http://dailynews.yahoo.com/h/nm/20001023/hl/westnile_1.html.

256. Proceeding from *Challenges of Emerging Illness in Urban Environment*, The New York Academy of Medicine, Dec 11–12, 2000; Chen DW, Lives That Have Been Changed Forever From the Aftereffects of a Mosquito Bite, NYT, Aug 19, 2000.

257. West Nile Virus Spreads Father South, Reuters, October 23, 2000.

258. The Commonwealth of Massachusetts Executive Office of Health and Human Services Department of Public Health, West Nile Virus Detected In Massachusetts, July 26, 2000. http://www.magnet.state.ma.us/dph/media/pr0726.htm.

259. West Nile Virus Detected In Massachusetts.

260. Personal communication with Franka DesVignes, Epidemiologist, MA Department of Public Health, October 2000.

261. Personal communication with Franka DesVignes.

262. West Nile Virus Confirmed In Boston, Boston Globe July 27, 2000.

263. American Society for Microbiology, Sparrows Potential Reservoir for West Nile Virus, November 1, 2000.

264. Epstein P, Is Global Warming Harmful to Health?, *Scientific American*, August 2000.

265. Epstein P, Is Global Warming Harmful to Health?

266. Spraying for West Nile Virus Begins, Boston Globe, July 28, 2000.

267. City of Boston, Mosquito Spraying Schedule. http://www.ci.boston.ma.us/publichealth/westnile/virus4.asp.

268. City of Boston, Pesticide Information. http://www.ci.boston.ma.us/publichealth/virus2.asp.

269. City of Boston, Pesticide Information.

270. Safe2Use, Resmethrin Fact Sheet. http://www.safe2use.com/poisons-pesticides/pesticides/pyrethroids/resmethrin.htm.

271. City of Boston, Pesticide Information.

272. Safe2Use, Resmethrin Fact Sheet.

273. City of Boston, Pesticide Information.

274. City of Boston, Pesticide Information.

275. Safe2Use, Resmethrin Fact Sheet.

276. Safe2Use, Resmethrin Fact Sheet.

277. Epstein P, Is Global Warming Harmful to Health?

278. Epstein P, Is Global Warming Harmful to Health?

279. New England Regional Assessment, Health and Climate Variability Workshop, Arboviruses-Eastern Equine Encephalitis. http://www.necci.sr.unh.edu/Report-html/NERA-Health-Enceph-brief.html.

280. Heinlein G, State fears encephalitis outbreak: Disease carried by mosquitoes is fatal to humans, horses, The Detroit News, August 2, 1999.

281. CDC, Notifiable Diseases/Deaths in Selected Cities Weekly Information, *MMWR*, 48(51):1183–1190 (Jan 7, 1999).

282. CDC, Notifiable Diseases/Deaths in Selected Cities Weekly Information, *MMWR*, 49(51):1159–1166 (Jan 5, 2001).

283. WHO, *Climate Change and Human Health*.

284. Texas Department of Health, The Latest Buzz on Mosquito-borne Disease in Texas, *Disease Prevention News*, 60(10).

285. CDC, Fact Sheet: Dengue/Dengue Hemorrhagic Fever, June 1997. http://www.cdc.gov/ncidod/dvbid/dhfacts.htm.

286. EPA, Climate Change and Massachusetts.

287. EPA, Climate Change and Michigan, September 1997.

288. CDC, Recommendations for the use of Lyme disease vaccine recommendations of the Advisory Committee on Immunization Practices (ACIP), *MMWR*, 48(RR07):1–17 June 4,1999).

289. CDC, Division of Vector-Borne Infectious Diseases, Lyme Disease: Introduction, June 1, 1999. http://www.cdc.gov/ncidod/dvbid/lymeinfo.htm.

290. CDC, Division of Vector-Borne Infectious Diseases, Lyme Disease.

291. MA Department of Public Health Bureau of Communicable Disease, Newsletter—Communicable Disease Update, Vol. 8, No. 2, Spring 2000.

292. CDC, Notifiable Diseases/Deaths in Selected Cities Weekly Information, *MMWR*, 49(51):1159–1166 (Jan 5, 2001).

293. MA Department of Public Health Bureau of Communicable Disease, Newsletter—Communicable Disease Update.

294. MA Department of Public Health Bureau of Communicable Disease, Newsletter—Communicable Disease Update.

295. WHO, *Climate Change and Human Health*.

296. Lindgren E., Tälleklint L., & Polfeld T, 2000: Impact of Climatic Change on the Northern Latitude Limit and Population Density of the Disease-Transmitting European Tick Ixodes Ricans, *Environ Health Persp* 108:119–123.

297. ODH, Lyme Disease. http://www.odh.state.oh.us/public/public-f.htm.

298. Campbell M, Vaccine can't guarantee protection from Lyme, *The Detroit News*, July 28, 1999.

299. ODH, Rocky Mountain Spotted Fever. http://www.odh.state.oh.us/public/public-f.htm

300. MA Department of Public Health State Laboratory Institute, 1999 Statistics (compiled upon request), October 18, 2000.

301. MI Dept. of Community Health, Disease Control, Cases of Selected Communicable Diseases By Year Michigan 1998, 1999, 2000 to date, July 19, 2000.

302. Schubert C, Cases of tick-borne HE disease must be reported to state, Milwaukee Journal Sentinel, July 10, 2000.

303. New York State Department of Health, Communicable Disease Fact Sheet—Hantavirus Infections, February 1999. http://www.health.state.ny.us/nysdoh/consumer/hanta.htm.

304. MA Department of Public Health, Bureau of Communicable Disease Control, Hantavirus fact sheet, March 1994. http://state.ma.us/dph/cdc/hantav.htm.

305. Engelthaler D, et al, Climatic and Environmental Patterns Associated with Hantavirus Pulmonary Syndrome, Four Corners Region, United States, *Emerging Infectious Diseases*, 5(1), January–March 1999. http://www.cdc.gov/ncidod/_vti_bin/shtml.dll/eid/vol5no1/engelthaler.htm/map1.

306. Engelthaler.

307. CDC, Update: Hantavirus Pulmonary Syndrom—United States, 1999, *MMWR*, 48(24);521–525 (June 25, 1999). http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/mm4824a4.htm.

308. MA Department of Public Health, Bureau of Communicable Disease Control, Hantavirus fact sheet, March 1994. http://state.ma.us/dph/cdc/hantav.htm.

309. Ettestad P, First Hantavirus Case in 2000 in New Mexico Confirmed in San Juan County Woman, April 11, 2000. http://www.health.state.nm.us.

310. Ettestad.

311. New York State Department of Health, Communicable Disease Fact Sheet: Hantavirus Infections, February 1999.

312. New York State Department of Health.

313. New York State Department of Health.

314. New York State Department of Health.

315. Chudyk W & Wilson C, CLIMB Background Paper, Possible Impacts of Climate Change on Water Quality and Wastewater Collection & Treatment in the Boston Metropolitan Area, March 6, 2000. http://www.tufts.edu/tie/climb/WQ_Issue.html.

316. EPA Global warming site-tends: sea level. Available at: http://www.epa.gov/globalwarming/climate/trends/sealevel.html.

317. Maine Department of Environmental Protection, Global Climate Change ("Global Warming"). http://janus.state.me.us/dep/air/global.htm.

318. Titus JG, Greenhouse effect, sea-level rise and barrier islands, *Coastal Management,* 18 (20), 1990.

319. EPA, Climate Change and Massachusetts.

320. Maine Department of Environmental Protection, Global Climate Change.

321. EPA, Climate Change and Massachusetts.

322. EPA, Climate Change and Massachusetts.

323. Ozone Action, Global Warming and Sea Level Rise. http://www.ozone.org/sealevel.html.

324. Frederick KD, et al, Water and global climate change (Pew Center 1999).

325. WHOI, Cape Cod Coastal Erosion: A Case Study, April 1998. http://www.whoi.edu/seagrant/education/focalpoints/erosion.html.

326. Nauset Light, Coastal Erosion Along Outer Cape Cod, MA. http://www.nausetlight.org/Nlerode.htm.

327. Klink T, Coastal Erosion Along The Outer Shore of Cape Cod: Cape Cod Massachusetts, April 23, 1999. http://www.geo.wvu.edu/~wilson/Geol'/termr/capecod.htm.

328. Klink T, Coastal Erosion Along the Outer Shore of Cape Cod: Cape Cod, Massachusetts.

329. Klink.

330. WHOI, Cape Cod Coastal Erosion: A Case Study.

331. WHOI, Cape Cod Coastal Erosion: A Case Study.

332. Klink.

333. Klink.

334. MA Economic Affairs report, Choosing to Compete, Chapter Fifteen: Cape and Islands Regional Profile, Characteristics of the Region. http://www.magnet.state.ma.us/econ/ch15.htm.

335. MA Economic Affairs report, Choosing to Compete.

336. CDC, Giardiasis Fact Sheet. http://www.cdc.gov/ncidod/dpd/giardias.htm.

337. MA Department of Public Health State Laboratory Institute, 1999 Statistics (compiled upon request), October 18, 2000.

338. Guerrant RL, Cryptosporidiosis: an emerging, highly infectious threat, CDC Synopses. http://www.cdc.gov/ncidod/EID/vol3no1/guerrant.htm.

339. CDC, Cryptosporidiosis Fact Sheet. http://www.cdc.gov/ncidod/dpd/crypto.htm.

340. CDC, Notifiable Diseases/Deaths in Selected Cities Weekly Information, *MMWR,* 49(51):1159–1166 (Jan 5, 2001).

341. Epstein PR, The impact of climate change on human health, in *New England Regional Climate Change Impacts Workshop: Workshop Summary Report,* Sep 3, 1997.

342. Patz.

343. National Institute of Environmental Health and Sciences, Climate-controlled disease?, *Environ Health Persp*, 107(5), May 1999. http://ehpnet1.niehs.hih.gov/docs/1999/107-5/forum.html#climate.

344. Patz; NIEHS, Climate-controlled disease?

345. CDC, Escherichia coli O157:H7 fact sheet, April 4, 2000. http://www.cdc.gov/ncidod/dbmd/diseaseinfo/escherichiacoli_g.htm.

346. CDC, Notifiable Diseases/Deaths in Selected Cities Weekly Information, *MMWR,* 49(51):1159–1166 (Jan 5, 2001).

347. CDC, Notifiable Diseases/Deaths in Selected Cities Weekly Information, *MMWR,* 49(51):1159–1166 (Jan 5, 2001).

348. CDC, Salmonellosis fact sheet, March 30, 2000. http://www.cdc.gov/ncidod/dbmd/diseaseinfo/salmonellosis_g.htm.

349. CDC, Salmonellosis fact sheet, March 30, 2000.

350. CDC, Salmonellosis fact sheet, March 30, 2000.

351. CDC, Notifiable Diseases/Deaths in Selected Cities Weekly Information, *MMWR,* 49(51):1159–1166 (Jan 5, 2001).

352. CDC, Notifiable Diseases/Deaths in Selected Cities Weekly Information, *MMWR,* 49(51):1159–1166 (Jan 5, 2001).

353. MA Department of Public Health Bureau of Communicable Disease Control, Listeria fact sheet, January 22, 1999. http://www.state.ma.us/dph/cdc/listeria.htm.

354. MA Department of Public Health Bureau of Communicable Disease Control, Listeria fact sheet, January 22, 1999.

355. MA Department of Public Health State Laboratory Institute, 1999 Statistics (compiled upon request), October 18, 2000.

356. MA Department of Public Health, Shigella fact sheet, October 1996.

357. CDC, Notifiable Diseases/Deaths in Selected Cities Weekly Information, *MMWR*, 49(51):1159–1166 (Jan 5, 2001).

358. MA Department of Public Heath, Cyclospora fact sheet, August 1997.

359. MA Department of Public Health State Laboratory Institute, 1999 Statistics (compiled upon request), October 18, 2000.

360. NM Dept. of Health, Campylobacter fact sheet.

361. NM Dept. of Health, Campylobacter fact sheet.

362. MA Department of Public Health State Laboratory Institute, 1999 Statistics (compiled upon request), October 18, 2000.

363. Bradley P, Crash in Lobsters Near Sewage Outfalls, March 20, 1998. http://www.nahant.org/larvallobsters.html.

364. Johnson, J., *Maine*, Compton's Encyclopedia Online v3.0.

365. Massachusetts Lobstermen Association, How Healthy Is the Lobster Resource? http://www.lobstermen.com/facts.htm.

366. EPA, Global Warming Impacts- Fisheries. http://ww.epa.gov/globalwarming/impacts/fisheries/index.html.

367. Richardson J, The wait's almost over for Maine shrimp, Business News, January 17, 2000. http://www.mainebusiness.com/news/biz/biz0117a.shtml.

368. EPA, Global Warming Impacts—Fisheries.

369. Personal communication with Dr. Olaf Ellers, January 2000.

370. Personal communication with John Hurst, Director of Biotoxin Monitoring, Maine Department of Marine Resources, February 2000.

371. Woods Hole Oceanographic Institution, Harmful Algal Blooms in your region. http://www.redtide.whoi.edu/hab/HABdistribution/habexpand.html.

372. Justice G, Shellfishing bans lifting as season of red tide ebbs, *The Boston Globe*, July 9, 1993, p. 76; Morris J, Midnight poachers ignoring red tide; officials fear market consequences, *The Union Leader*, June 13, 1993, p. A1.

373. Natural Office for Marine Biotoxins and Harmful Algal Blooms, The Harmful Algae Page: Human Illnesses Associated with Harmful Algae. http://www.redtide.whoi.edu/hab/illness/illness.html.

374. CDC, Epidemiologic Notes and Reports Paralytic Shellfish Poisoning—Massachusetts and Alaska, 1990, *MMWR*, 40(10):157–161 (March 15, 1991). http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/00001927.htm.

375. Natural Office for Marine Biotoxins and Harmful Algal Blooms, The Harmful Algae Page.

376. Natural Office for Marine Biotoxins and Harmful Algal Blooms, The Harmful Algae Page.

377. Tickner J, Precautionary Principle, The Networker, The Newsletter of the Science and Environmental Health Net, Vol. 2, 34, May 1997.

378. Tickner J, Precautionary Principle.

379. Environmental Defense Fund, Study Shows Potential Impacts of Global Warming on White Mountains, September 2, 1997. http://www.edf.org/pubs/NewsReleases/1997/Sep/a_whtmtns.html.

380. EPA, Climate Change and Massachusetts.

381. EPA, Climate Change and Massachusetts.

382. EPA, Climate Change and Massachusetts.

383. EPA, Climate Change and Massachusetts.

384. Ohio Department of Agriculture, ODA Offers Free Aflatoxin Testing On Drought-Stressed Corn, Sep 16 1999.

385. Ohio Department of Agriculture, ODA Offers Free Aflatoxin Testing On Drought-Stressed Corn.

386. Personal communication with James Teeri, Director of the University of Michigan Biological Station, July 2000.

387. Personal communication with James Teeri, Director of the University of Michigan Biological Station, July 2000.

388. EPA, Climate Change and Massachusetts.

389. MA Division of Forest and Parks Bureau of Forestry, 1999 Forest Health Highlights Massachusetts, February 2000. http://willow.ncfes.umn.edu/fhh/fhh-99/ma/ma_99.htm.

390. NCDC, Climate Data Events, Drought, August 1, 1999.

391. Maine Forest Service, Forest Fires Control Division Report. http://www.state.me.us/doc/mfs/ffchome.htm.

392. Duclos P, et al, The 1987 forest fire disaster in California: Assessment of emergency room visits, *Arch Environ Health* 45:53–8 (1990).

393. Department of Agriculture Forest Service, Wildland Fire Fatalities—Part One, accessed October 19, 2000. http://www.fs.fed.us/fire/safety/fatalities/part1.shtml.

394. EPA, Climate Change and Massachusetts.

395. U.S. Census Bureau, Health Insurance Coverage: 1998—State Uninsured Rates. http://www.census.gov/hhes/hlthins/hlthin98/3yr98.html.

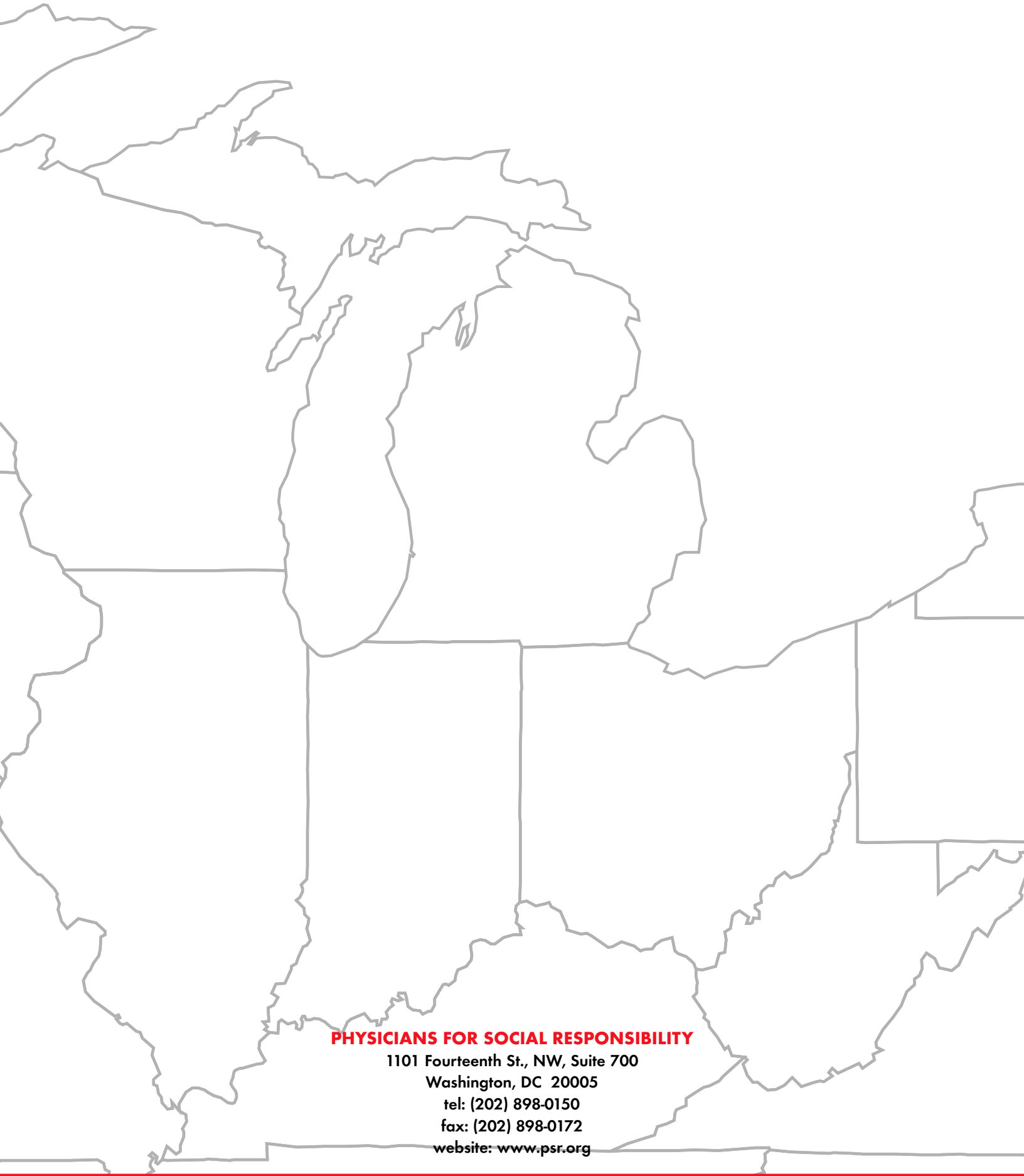
396. Union of Concerned Scientists, New England Reckons with Global Warming Consequences and Solutions, April 7, 1997. http://www.ucsusa.org/releases/4-7-97.html.

397. Ohio EPA, Division of Air Pollution Control, Ohio E-Check Facts. http://www.epa.state.oh.us/dapc/mobile/echeckfc.html.

398. EPA, Your Car (or Truck) and the Environment, Turn Air Into Oil. http://www.pueblo.gsa.gov/cic_text/cars/cartruck/cartruck.txt.

399. EPA, Your Car (or Truck) and the Environment.

Printed on recycled paper.



PHYSICIANS FOR SOCIAL RESPONSIBILITY
1101 Fourteenth St., NW, Suite 700
Washington, DC 20005
tel: (202) 898-0150
fax: (202) 898-0172
website: www.psr.org