

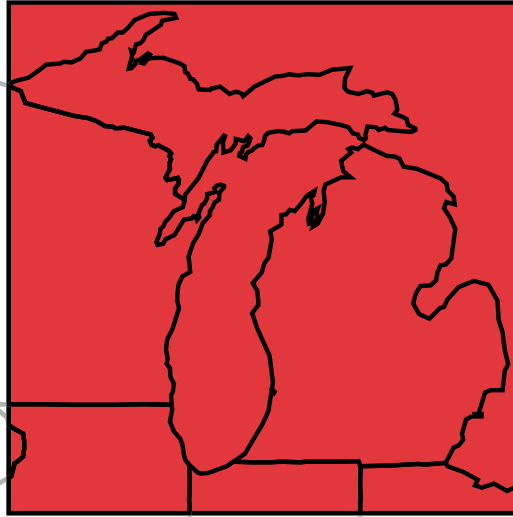
PSR

PHYSICIANS FOR
SOCIAL RESPONSIBILITY

DEATH BY

DEGREES

**THE HEALTH THREATS
OF CLIMATE CHANGE
IN MICHIGAN**



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This report was prepared by Physicians for Social Responsibility to alert Michigan 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.

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Death by Degrees

The rapid rate of warming since 1976, 0.35 degrees per decade, is consistent with the projected rate of warming based on human-induced effects. In fact, scientists now say that they cannot explain this unusual warmth without including the effects of both human-generated greenhouse gases and aerosols.

—D. JAMES BAKER, ADMINISTRATOR,
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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 1999 has been one of the fifteen warmest years on record.¹ This year 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.² This is the third year in a row that record has been broken,³ 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 Michigan, a state that may experience increased illness, mortality, and property damage due to changes in temperature and weather.

Executive Summary: Michigan—A State at Risk

Year after year, we're seeing record warmth at the global level. It's one more piece of evidence that continues to suggest we're entering an unusually warm period in the history of the planet.⁶

—JAMES A. TEERI, DIRECTOR, UNIVERSITY OF MICHIGAN BIOLOGICAL STATION

Due to its mid-latitude location, variations in elevation, and proximity to the Great Lakes, Michigan for decades was known for its cool summers and moderately cold winters.⁷ The lake waters responded slowly to temperature changes,⁸ so the harsh summer heat and bitter cold of other states often bypassed this land of Great Plains, dense forests, and heavily industrialized urban centers. Climate change, however, threatens to disrupt Michigan's natural system of checks and balances.

Over the next century, temperatures in Michigan could change dramatically. Based on projections made by the Intergovernmental Panel on Climate Change and results from the United Kingdom Hadley Centre's climate model, by 2100 temperatures in Michigan could increase by two to eight degrees F in all seasons. In addition, precipitation is projected to increase by 5 to 15 percent in winter, spring, and fall, and by around 20 percent (with a range of 10 to 40 percent) in summer.⁹

How Global Warming Could Threaten Health in Michigan

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 Michigan could include the following:

- Over the past 40 years the number of four-day heat waves in Detroit has more than doubled. This trend could continue if Michigan temperatures rise as predicted by up to 8 degrees over the next century.
- As day and nighttime temperatures rise, more cases of heat-related illness and mortality could result.
- More heavy precipitation events in winter could intensify winter storms, leading to more cases of hypothermia, frostbite and carbon monoxide poisoning.
- The number of deaths caused by diseases of the heart, already the leading cause of death in Michigan, may increase as weather conditions grow more extreme and air quality deteriorates.
- The caseload of water-borne diseases could increase as the number of flood-producing storms rise. One such disease, giardiasis already sickens over 1,000 Michigan residents annually.
- During ozone season in 1997, ozone levels sent 6,300 Michigan residents to the emergency room and caused 280,000 asthma attacks. An eight percent increase in ground-level ozone levels is predicted to accompany a 4 degree warming, sending thousands more to the hospital every year for respiratory conditions, including some of the 180,000 children in Michigan with asthma.
- Pollen levels in Michigan could double over the next fifty years if Michigan's coal-fired power plants continue to produce more and more carbon dioxide.
- Despite the predicted rise in precipitation, water levels in the Great Lakes could drop by 4-5 feet due to increased evaporation affecting drinking water supplies, fish stocks, shipping and recreation.
- More cases of diseases spread by ticks and mosquitoes, such as Lyme disease and encephalitis, could result as warmer temperatures play a role in increasing insect populations.

While projections look to the future, global warming appears to be influencing climate now. Heat stress days have increased in Detroit and hot nights have increased statewide over the past fifty years.¹⁰ 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 extremely wet or snowy days in winter is likely to increase.¹¹ Extreme cold also poses direct threats to human health leading to cases of hypothermia and frostbite. Extreme weather and sudden temperature fluctuations can 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.¹² Increased precipitation could lead to more flooding, increasing the risk of water contamination, gastrointestinal illnesses, and property damage. Changes in the atmosphere could also cause more tornadoes and thunderstorms to form, possibly accompanied by more lightning. Lightning can cause injury and death¹³. From 1980 to 1995, 1,318 deaths were attributed to lightning nationwide.¹⁴

Michigan's air quality could deteriorate as a result of climate change. The amount of ground-level ozone, the primary component of smog, commonly rises on hotter days exacerbating 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.¹⁵

Water quality and availability may also be compromised as the climate changes. Given Michigan's numerous lakes, rivers and streams, these issues warrant serious concern in the state. Among the changes that may occur as a result of global warming are 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 and variability.

Already, Lakes Superior, Michigan and Huron are at a 35-year low,¹⁶ which could impede shipping activity on the lakes and add to coastal erosion problems. Low water flows can concentrate pollutants in Michigan's waters, and necessitate the need for dredging for shipping purposes. More Human exposure to toxic substances that threaten human health such as dioxin, PCBs, pesticides, and mercury could result.¹⁷ Gastrointestinal diseases such as giardiasis and cryptosporidiosis that annually affect many Michigan residents could become more common.

Contaminated water could impact Michigan's food supply as people ingest waterborne toxic agents.¹⁸ Further, increased temperatures can encourage the growth of food contaminants, such as *E. coli*, salmonella, Hepatitis A, and campylobacter, illnesses that already affect Michigan residents each year.

Climate change may increase the human health risk from vector borne disease. Warming and other climate changes could expand the habitat of disease-carrying insects, and their ability to survive, thus increasing the potential for transmission of the vector-borne diseases. Temperature is the most important determining factor with respect to transmission of a viral agent by a vector, such as a tick or mosquito.¹⁹ In Michigan, diseases spread by ticks include Lyme disease, Rocky Mountain Spotted Fever and ehrlichiosis. Global warming could shift northwards the region where these ticks and mosquitoes breed and over winter. If conditions become warmer and wetter, mosquito populations could increase, thereby increasing the risk of transmission of encephalitis and other diseases.²⁰

Lastly, climate change could affect Michigan's agriculture, reducing corn, soybean, hay, fruit and other crops by as much as 34 percent.²¹ Weather-stressed crops also can increase nitrate concentrations in plants, which may lead to respiratory and nervous system disorders in animals,²² and possibly in humans. Some studies have shown that plants subjected to high levels of

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 a century ago. Seven of the ten warmest years in recorded history occurred in just the last decade, with 1998 topping them all.²³

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.²⁴ 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 30 percent, methane concentrations have more than doubled, and nitrous oxide concentrations have risen by about fifteen percent.²⁵ These 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.²⁶ 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.²⁷ If current trends continue, carbon dioxide concentrations could increase by 30 to 150 percent by the year 2100.²⁸ 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.²⁹ The gas trifluoromethylsulphur pentafluoride, or SF₅CF₃, 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. SF₅CF₃'s long lifespan means that unless its production is prevented, its levels can be expected to increase as it accumulates in the atmosphere. It, along with other greenhouse gases, will remain there for centuries, trapping heat and threatening human health.

carbon dioxide have fewer nutrients than normal.³⁰ Michigan's forests could also 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. For example, smoke from forest fires can increase cases of injury and respiratory illness.

Michigan needs to be deeply concerned about the potential health impacts of global warming on its population. Only precautions taken now can avert problems in the future. The following sections of this report 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 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, are all concluding that warming is occurring and human activities are 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 as well as the human ability to predict the future. However, the forecasting models are gaining credibility every day as weather patterns and other environmental occurrences confirm projected scenarios.

In January 2000, scientists at NASA's Jet Propulsion Laboratory announced that the persistence of La Niña and El Niño events might be part of a larger, long-lasting climate pattern.³¹ In addition, scientists studying the world's oceans discovered that in the past 50 years the world ocean has exhibited a net warming. The warming is likely due to both natural variability and human activities, however, researchers believe that Earth's excess heat is accumulating in the ocean.³² This study provides an answer to one criticism levied against many climate models that predict the impacts of greenhouse gases: the 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.³³

Study after study concludes that warming rates are accelerating. For example, scientists at the National Climatic Data Center (NCDC) reported in early 2000 that for sixteen consecutive months (May 1997 to September 1998) each month broke the previous monthly world average temperature record.³⁴ According to Thomas R. Karl, lead author of the NCDC paper, there is only a one-in-twenty probability that this string of record high temperatures was simply a chance event.³⁵ A recent National Academy of Sciences report

also states that there is no question that Earth's warming has accelerated during the past two decades.³⁶

Additionally, University of Michigan geologist Henry Pollack and his colleagues confirmed that temperatures accelerated upwards in the latter half of the 20th century. According to the geologist's February 2000 report published in the journal *Nature*, the determination was based upon subsurface temperature readings from 616 borehole sites from around the world. The readings covered a 500-year span and showed a rise in temperatures over the last 5 centuries. Eighty percent of the net temperature increase occurred in the nineteenth and twentieth centuries, with the twentieth century being the warmest of the past five.³⁷

Recently, 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.³⁸ Using extensive climatic 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 1900.³⁹ The finding suggests human activities, like burning forests and fossil fuels, are responsible for 75 percent of global warming.

Further, another *Nature* study examined Antarctic ice cores and found that atmospheric temperatures historically correlate with atmospheric concentrations of the greenhouse gases carbon dioxide and methane.⁴⁰ Unfortunately, today concentrations of greenhouse gases appear higher than they have been in the past 450,000 years.⁴¹ 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, can also impact climate change 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 Michigan 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.⁴²

—REPORT OF THE HEALTH SECTOR OF THE U.S. NATIONAL ASSESSMENT

Many Michigan residents are particularly vulnerable to the potential health effects of climate change. In addition, certain factors that can put people at risk of different diseases, which are exacerbated by climate change, are already a problem in Michigan. For example, the number of overweight Michigan adults has increased steadily from 23.5 percent of the population in 1988 to 34.5 percent in 1997.⁴³ Twenty-six percent of Michigan adults smoke. These statistics rank Michigan as fourth and tenth, respectively, among the states for prevalence of these conditions among adults in a state.⁴⁴

Smoking and obesity are risk factors for diseases of the heart, the leading cause of death in Michigan. In 1998 heart diseases accounted for 27,851 deaths in the state: a rate of 283.7 per 100,000 individuals.⁴⁵ The national average is 268 deaths per 100,000 individuals. Higher average temperatures caused by climate change could further elevate the number of deaths due to heart disease. Warmer winters may also reduce the number of deaths in winter months, however experts agree that the relationship between winter weather and mortality has been difficult to interpret.⁴⁶ In addition, many Michigan residents have behavioral factors that would put them at higher risk of developing these diseases

Individuals with existing illnesses are also especially sensitive to heat stress, air pollution, and other possible effects of global warming. Like people with cardiovascular disease, those with respiratory illness or impairment are less able to adapt to additional physical stress caused by warmer and more humid environments. Air pollution, which can increase on hotter days, has also been shown to have a more severe impact on persons suffering from heart and lung diseases.⁴⁷

Men tend to be more susceptible to heat illness because they perspire more than women and therefore become more quickly dehydrated.⁴⁸ In addition, certain age groups are more vulnerable to hotter temperatures. Children are at risk of heat-related illness because their immune and other protective systems are not yet fully developed.⁴⁹ Children less than a year old are most sensitive to heat stress because their heat regulatory systems have not fully matured.⁵⁰ 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.

In addition, several factors could make Michigan's elderly more susceptible to the potential health-related impacts of global climate change. Elderly individuals may have less efficient heat-regulating systems. The temperature at which sweating begins is higher, affecting their 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 prevent overheating. 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.⁵¹

Poverty can also be an important risk factor for poor health status.⁵² Rates of children hospitalized for asthma, for example, increase as family income declines.⁵³ If global warming increases levels of air pollution, poorer populations may be hit hardest.

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. An uninsured person may delay seeking treatment until a condition is severe or at a more advanced, less treatable stage.⁵⁴ Cost can also play a role in seeking health care, and this factor may disproportionately affect minorities. For example 10.9 percent of African Americans in Michigan and 22.7 percent of Hispanics reported cost as a barrier to obtaining health care in 1997 compared to 7.6 percent of whites.⁵⁵

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 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.

Lastly, Native Americans in Michigan, including the Chippewa, Potawatomi, Odawa, Ottawa, Ojibwe and other tribes, may experience additional stresses, due to their dependence on natural resources, such as waterfowl, wild rice, and fish from the Great Lakes region,⁵⁶ which could all diminish or become tainted with contaminants due to changes in water levels. Already, many tribal regions have experienced a disproportionate share of environmental, socio-cultural, and economic impacts from pollution released from Michigan industries.⁵⁷

Weather Extremes May Lead to Increases in Illness and Mortality

Climate change can mean a gradual temperature change over a period of time. However, it can also mean extremes. Climate models predict not only higher temperatures, but also more unpredictability in weather patterns and more extreme weather conditions, including extremely cold days.⁵⁸ 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.⁵⁹ This may mean more floods, tornadoes, heat waves, and other natural disasters. Extreme weather can cause profound human suffering and huge economic losses. In 1999, insured losses from weather-related natural catastrophes in Michigan totaled \$375 million.⁶⁰ During the 1990s, insured losses totaled just shy of \$1 billion.⁶¹

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.⁶²

Depending on their severity, extreme weather events can tax, or even cripple, emergency care programs. The consequences could prove disastrous in Michigan, where the ratio of hospital beds is 3 per every 1,000 residents.⁶³ The loss of power that often occurs during storms may result in an inability to run oxygen machines and other necessary medical equipment, especially if back-up systems also fail, thereby endangering the health of many Michigan residents. In May 2000, 170,000 residents of Detroit were without power for at least two days,⁶⁴ putting those with emphysema and asthma at risk of depleting their at-home supply of ventilator oxygen.⁶⁵

Direct Effects of Heat on Health

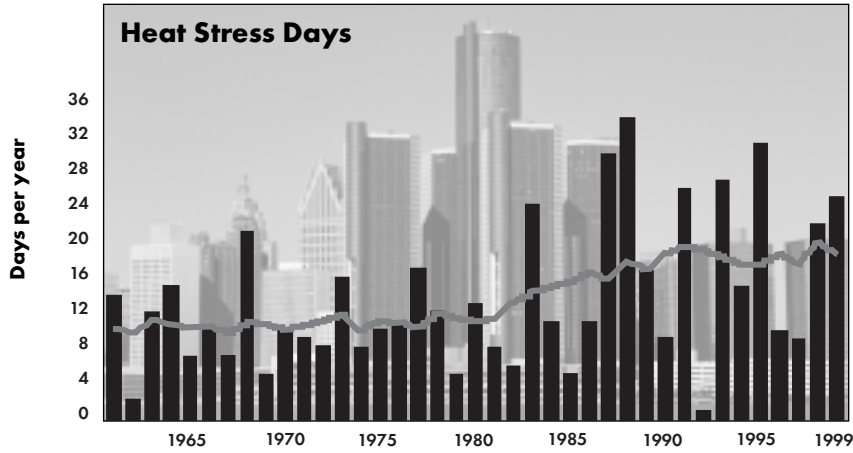
*Hot weather is an important determinant of human mortality. In the United States, a major heat wave can cause literally thousands of excess deaths in a given summer.*⁶⁶

—DR. EDWIN M. KILBOURNE, NEW YORK MEDICAL COLLEGE

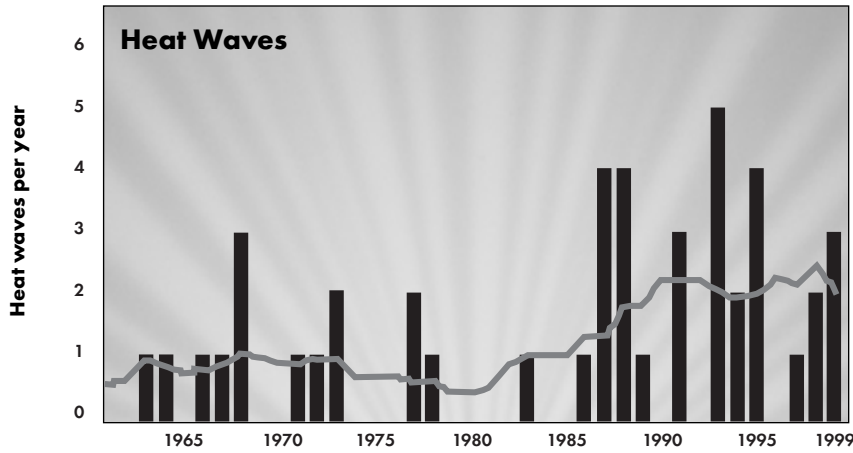
The thirteen years from 1987 to 1999 are each among the fifteen warmest years on record. Global land temperatures in 1999 made the year the second hottest year recorded, beaten only by temperatures in 1998. The warming trend holds true in Michigan as well. Average temperatures in Ann Arbor have increased 1 degree F over the last century.⁶⁷ Based on projections made by the Intergovernmental Panel on Climate Change and results from the United Kingdom Hadley Centre's climate model, a model that accounts for both greenhouse gases and aerosols, it is projected that by 2100 temperatures in Michigan could increase by 4 degrees F (with a range of 2 to 8 degrees F).⁶⁸ 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 have almost doubled over the past fifty years. The number of four-day heat waves almost tripled nationally.⁶⁹ In this study heat stress days were calculated using the heat index, a combination of temperature plus humidity.⁷⁰ Heat index gives a better sense of what the human body actually feels on a warm day. Humidity adds to an individual's discomfort and inhibits the body's natural ability to cool itself through evaporative heat loss and perspiration, resulting in heat stress and other heat-related illness.⁷¹ The number of heat stressed days and four-day heat waves in Detroit has risen dramatically. In the

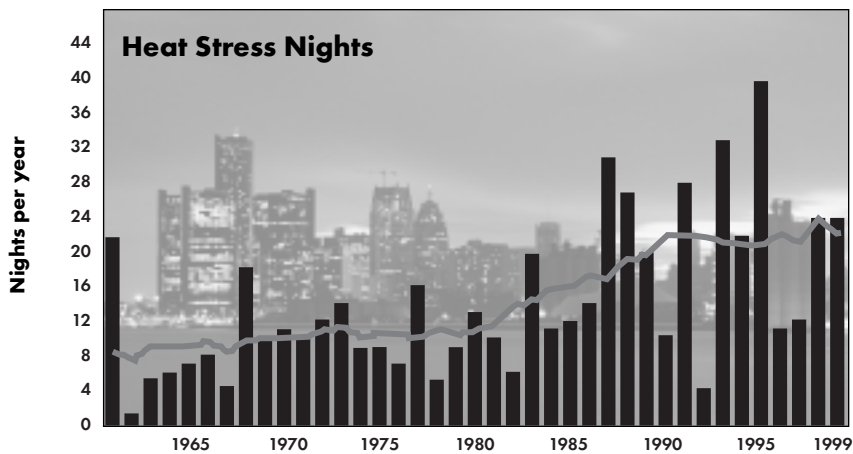
FIGURE 1
Extreme Heat in Detroit, 1961-1999



Number of days with extreme temperatures per year in Detroit, 1961 - 1999



Number of extreme heat waves per year in Detroit, 1961 - 1999



Number of nights with extreme temperatures per year in Detroit, 1961 - 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.

1960s, temperatures went over the daily average heat index threshold in 10 days per year, however, by the 1990s temperatures raised above the threshold an average of 22 days per year.⁷²

Michigan normally experiences over 90 degree F temperatures in the summer months, and these temperatures combined with higher nighttime temperatures could increase mortality.⁷³ It is the rise in heat-stressed nights throughout Michigan that is most evident. While daytime temperatures have risen more slowly and erratically in the rest of the state, in Detroit, Grand Rapids, Flint, Muskegon, and Sault Ste. Marie, the number of hot nights has been on the rise. Nighttime heat can be especially dangerous. Usually the body has a chance to cool down in the evening, but on hot nights relief from high daytime temperatures is lacking.

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, including Detroit. During oppressive heat wave events there was a significant increase in the number of deaths per day for the general population, with the elderly being most at risk. Detroit had ten deaths per day during extreme heat wave events.⁷⁴ Scientists went on to project future heat-related mortality under different climate scenarios. Assuming full acclimatization of a population over time, estimated excess mortality for an average summer season rose from the current mortality level of 110 by 50 to 118 percent by 2020 and by 130 to 145 percent by 2050.

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.⁷⁵ 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.⁷⁶

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.⁷⁷ At greatest risk are infants, small children, the elderly, those working or exercising outdoors, persons with impaired mobility, and individuals suffering

from cardiovascular disease.⁷⁸ On June 7, 1999 a heat wave contributed to the heat exhaustion of two children, who had to be taken to Pontiac hospital in Oakland for treatment.⁷⁹ 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.⁸⁰ On average, 400 people die each year in the United States from heat-related causes.⁸¹ In Michigan, at least 52 individuals experienced heat-related illness on Independence Day in 1999.⁸² Triple digit temperatures led to numerous cases of heat stroke, heat exhaustion, dehydration, and severe sunburn.⁸³ Later that same week, Oakwood Hospital, Henry Ford Hospital, and the Detroit Medical Center all reported patients who were being treated for conditions related to heat including a 24-year-old man who suffered seizures as a result of the hot weather.⁸⁴

Health Consequences of Extreme Cold and Wet Weather

No single weather event is directly attributable to a warming climate, of course, but global warming means increased weather catastrophes. The increasing frequency of freakish storms is becoming apparent to the public.⁸⁵

—MICHAEL NOBLE, MINNESOTANS FOR AN ENERGY EFFICIENT ECONOMY

While average temperatures are expected to rise in Michigan in the winter, the increased frequency of weather extremes may also mean winters with more days of extremely low temperatures.⁸⁶ 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, much of it falling in more heavy precipitation events.⁸⁷ According to the Environmental Protection Agency (EPA), over the next century precipitation in Michigan could increase by 5 to 15 percent in winter, spring and fall, and by 20 percent (with a range of 10 to 40 percent) in summer.⁸⁸

As overall temperatures increase, more of Michigan's winter precipitation may fall in the form of rain, sleet, and ice, increasing the likelihood of events such as the crippling winter storms of 1999. On just one day, January 4, 1999, a massive snowstorm contributed to 29 injuries and 3 fatalities.⁸⁹ A man froze to death while walking home early in the morning in Pontiac; an elderly woman died in a driveway later that same morning; and, a young man was found frozen to death in West Bloomfield.⁹⁰

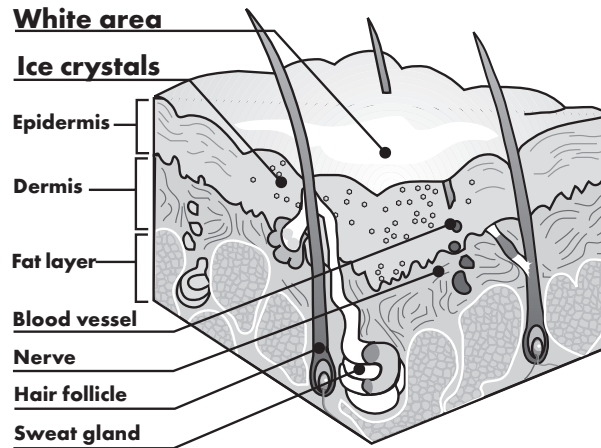
Unexpectedly cold weather and large snowfalls can pose a variety of possible health risks, such as hypothermia, frostbite, cardiac-related deaths, and carbon monoxide poisoning.

- **Hypothermia**, an unintentional lowering of the core body temperature to, or below, 95 degrees F, is a deadly medical emergency.⁹¹ From 1979 to 1995, Michigan experienced a 0.3 per 100,000 death rate from hypothermia, with the elderly being most at risk.⁹² Early signs of hypothermia often are insidious. They include shivering, numbness, fatigue, poor coordination,

FIGURE 2
Effects of Frostbite

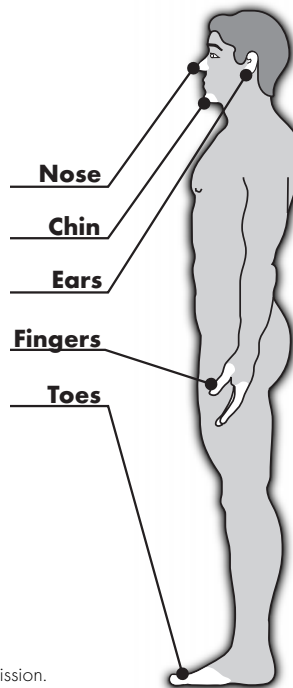
Global climate change could bring colder temperatures and winter storms to Michigan. One resulting threat to health is frostbite.

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.

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slurred speech, impaired mental state, blueness or puffiness of the skin, and irrationality.⁹³ More serious cases can result in coma, low blood pressure, and cardiac irregularities.

- **Frostbite** occurs when the skin is exposed to temperatures below 23 degrees F.⁹⁴ Such extreme cold increases the size of ice crystals under the skin.⁹⁵ 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.⁹⁶ At the final level, affected areas may have to be amputated.

- **Congestive heart failure** is the most frequent reason for hospitalization among older adults.⁹⁷ 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.⁹⁸ 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 Michigan has a high death rate for diseases of the heart and stroke, with 33,611 deaths attributed to these causes in 1998 alone.⁹⁹

In a study published in the American Journal of Epidemiology in 1999 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.¹⁰⁰ 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.¹⁰¹

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.¹⁰² 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.¹⁰³

- **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.¹⁰⁴ Slippery and uneven surfaces, which often occur as a result of winter storms, are a primary risk factor for falls.¹⁰⁵ Even moderate injuries sustained in a fall may increase the risk of premature death.¹⁰⁶ 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.¹⁰⁷
- **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 January 12, 1999 a snowfall reached historic proportions in the state and crippled many roads.¹⁰⁸ Compounding the problem was a sustained cold spell during the first half of January that prevented any of the snow from melting.¹⁰⁹
- **Carbon monoxide poisoning** poses yet another winter health risk in Michigan. Carbon monoxide is the leading cause of non-intentional

poisoning deaths in the United States.¹¹⁰ 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.¹¹¹ 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.¹¹² From 1987 to 1989, 103 deaths were related to unintentional carbon monoxide poisoning in Michigan.¹¹³

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.¹¹⁴ 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.¹¹⁵

Carbon monoxide poisonings can occur during blizzards when people sit in idling automobiles with exhaust pipes blocked by snow.¹¹⁶ Poisonings also occur during power outages when people are more likely to use unvented residential appliances such as stoves and heaters.¹¹⁷ 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.¹¹⁸

Injuries Related to Hail

Dangerous hailstorms may occur more frequently and with heightened severity because of greater instability in the atmosphere due to climate change. Hail develops when strong rising currents of air carry water to a height where freezing may occur.¹¹⁹ 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.¹²⁰ Hailstones often fall at speeds exceeding one hundred miles per hour¹²¹ and can injure or kill humans, plants, and animals. For example, on July 24, 1999 golfball-sized hail was reported in Kawkawlin, Bay City, Zilwaukee and Southfield.¹²² The unexpected hailstorm injured exposed mariners, causing individuals to suffer from welts and bruises.¹²³ The hailstorm also capsized a dozen boats and demasted two sailboats.¹²⁴

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.*¹²⁵

—INTERNATIONAL FEDERATION OF RED CROSS AND RED CRESCENT SOCIETIES

Atmospheric instability could increase the likelihood of more severe and more frequent wind and thunderstorms. Tornadoes, which are already a cause for concern in the state, often lead to injuries and property damage. In July 1999, a strong tornado tore a path of destruction from Lewiston to the county line of Barton City, completely destroying a church, fire department, and post office, as well as 10 homes and 4 businesses. Forty-nine other homes and

businesses were damaged and 2 injuries were reported.¹²⁶ In October 1998, a tornado in Big Rapids injured 12 people at Ferris State University.¹²⁷

High winds can also be dangerous. In May 1998, a windstorm in Grand Haven caused one fatality.¹²⁸ Later that year, winds in September centered near Gaylord injured at least 15 people.¹²⁹ Extensive property damage occurred at the Norandex Building Supply Company and forced the walls of a large cinder block warehouse to collapse. The building's metal roof and steel trusses were torn off and debris from the building blew onto Gaylord High School, forcing it to close for three days after the storm.¹³⁰

When high winds occur at the same time as cold temperatures, a dangerous wind chill can develop. 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.¹³¹

Lastly, lightning, which often occurs during turbulent thunderstorms, can have deadly consequences. A person struck by lightning can experience unconsciousness, cerebral bleeding, brain damage, severe burns, and a loss of the ability to breathe. It can also stop a victim's ability to breathe.¹³² 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.¹³³ From 1980 to 1995, 1,318 deaths were attributed to lightning nationwide.¹³⁴ Many victims are caught outside and cannot reach proper shelter.

Health Threats From Floods

*We were flabbergasted, to be honest with you. Our best information is that global warming is having an impact on rainfall now.*¹³⁵

—THOMAS R. KARL, NATIONAL CLIMATIC DATA CENTER, ON FINDING CLEAR EVIDENCE THAT EXTREME RAINFALL EVENTS HAVE INCREASED IN RECENT DECADES IN THE UNITED STATES

With its many streams, lakes, and rivers, Michigan is constantly under the threat of flood-producing storms. Flooding occurs in Michigan virtually every year; the location and severity varying according to ground and run-off conditions and weather. Even if lake levels drop due to increased evaporation, high precipitation events and earlier concentrated runoff could cause flooding. 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.¹³⁶ Floods also often cause costly property damage. On February 17, 1998, flooding in Macomb, Monroe, Oakland, and St. Clair resulted in \$1.1 million worth of damage.¹³⁷ High waters and pounding surf destroyed docks and flooded roads. A state of emergency was declared for much of Wayne County. Many homes and businesses suffered extensive damage.¹³⁸ Floods can also cause psychological stress ranging from depression to post-traumatic stress disorder, as residents suffer economic losses and are displaced from their homes.¹³⁹

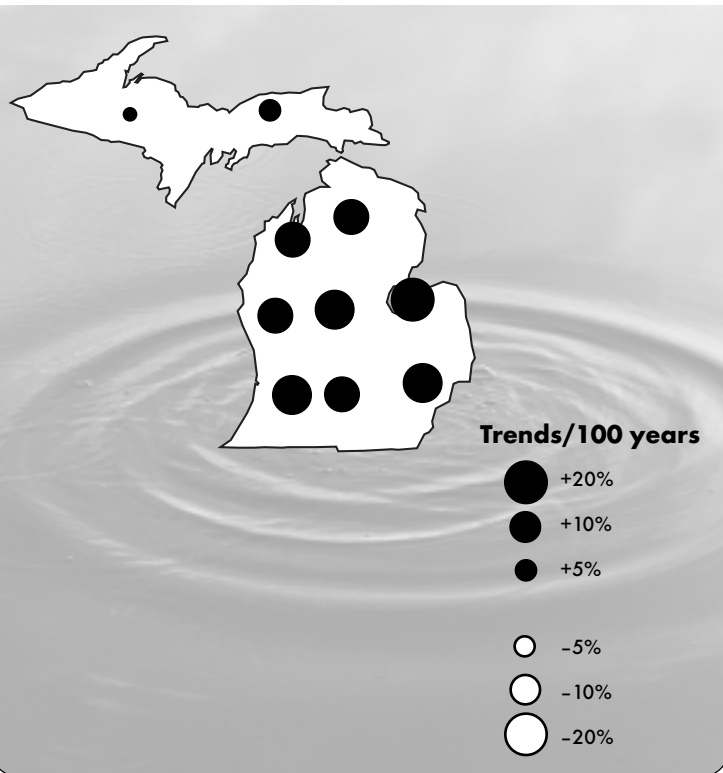
If floodwaters are contaminated with bacteria and parasites, cases of intestinal illness and infectious disease can result. Intestinal illnesses occur with symptoms of nausea, vomiting, diarrhea, and fever. Diarrhea usually lasts only a few days, but for individuals with suppressed immune systems, depending on the organism, this condition can persist and even be fatal. Two of the more common illnesses carried in waters include giardiasis and cryptosporidiosis.

- **Giardiasis** is an illness caused by a one-celled microscopic parasite that lives in the intestines of people and animals and survives well in water. During the past fifteen years, *Giardia lamblia* has become recognized as one of the most common causes of water-borne human disease in the United States.¹⁴⁰ In 1998, 1,172 cases of giardiasis were reported in Michigan. 1999's caseload was also high, with 1,166 individuals contracting the illness.¹⁴¹ If the number of cases that go untreated or unreported is taken into account, the true caseload is probably several times higher.

- **Cryptosporidium** poses another major threat to the water supply. It is an organism that is small, difficult to filter, resistant to chlorine, and ubiquitous in many animals.¹⁴² Symptoms of the illness include diarrhea, stomach cramps, upset stomach, and slight fever. Cryptosporidiosis can be serious, long lasting, and sometimes fatal for people with weakened immune systems.¹⁴³ In Michigan there were 49 and 39 reported cases of cryptosporidiosis in 1999 and 1998, respectively.¹⁴⁴ The potential for a much greater caseload exists, however, as evidenced by a 1993 cryptosporidiosis outbreak in nearby Milwaukee, Wisconsin. Lake Michigan, the source of Milwaukee's water, is treated by filtration and disinfection. However, due to a period of heavy rainfall and runoff the treatment plant was ineffective, resulting in an increase in the turbidity of the treated water. Increased turbidity can be, and was in this case, an indicator of higher levels of *Cryptosporidium*. Over 400,000 people were affected by cryptosporidiosis after the runoff, more than 4,000 were hospitalized and between 50 and 100 deaths were attributed to the disease.¹⁴⁵

FIGURE 3
Michigan Precipitation on the Rise

This figure shows precipitation trends in Michigan from 1900 to 1996.
Source: U.S. Environmental Protection Agency.



Floodwaters can also contain human and animal fecal material causing water-borne infectious disease outbreaks. Sources include overflowing sewage systems, extreme stormwater run-off, and flooded croplands. Sewers and flood control drainage systems are often interconnected in the state, which further heightens the risk for water contamination. For example, Clinton Township, Fraser and Center Line officials have admitted to dumping thousands of gallons of untreated water into waterways during heavy rains.¹⁴⁶ Michigan's farming communities, in particular, may face health risks when pastures and crop fields are flooded not only from water-borne disease, but also from 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.¹⁴⁷ While the caseload is not high, all of these communicable diseases have been reported in the state during the past three years.¹⁴⁸ *Leptospirosis* is a group of bacterial diseases with various manifestations. Symptoms include sudden onset of fever, headache, chills, severe muscle aches, watery eyes, rash, anemia, jaundice, mental confusion, and depression.¹⁴⁹ 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.¹⁵⁰

Flash floods pose another set of health risks in Michigan and many people underestimate their danger. Water weighs 62.4 pounds per cubic foot and just an extra foot or two of water can prove to be deadly: two feet of water is enough to overtake most automobiles. 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



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

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. In addition, many flash floods occur at night, increasing their danger and making it extremely difficult to plan an appropriate course of action.¹⁵¹ A flash flood in Michigan that led to six feet of water on the ground was strong enough to float cars during a July 1998 rainfall centered in Wayne County.¹⁵² Roads, airlines, and business had to shut down until the next morning, when waters finally receded.¹⁵³

Car Trouble: The Gasoline-Greenhouse Gas Connection

Up to 33 percent of pollutants that cause global warming come from transportation, primarily personal automobiles.¹⁵⁴ This is largely due to the imperfect combustion process involved in running all gasoline-powered cars.¹⁵⁵ Even the finest of Michigan's fuel-burning automobiles emits dangerous pollutants.

When gasoline is combined with air in a typical engine combustion system, unburned hydrocarbons, nitrogen oxides, carbon monoxide, and carbon dioxide are released into the atmosphere.¹⁵⁶ They escape by 3 principle methods: evaporation of the fuel itself in the engine, even when the car is not running; refueling losses; and exhaust emissions.¹⁵⁷ The released pollutants lead to serious public health problems.

Hydrocarbons react in the presence of nitrogen oxides and sunlight to form ground-level ozone, or smog.¹⁵⁸ **Ozone** can damage lung tissue, aggravate respiratory disease, and make people more susceptible to respiratory infections. Otherwise healthy individuals can suffer from the choking, coughing, and stinging eyes associated with smog.¹⁵⁹

Nitrogen oxides, like hydrocarbons, help to form 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.¹⁶⁰

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.¹⁶¹ 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.¹⁶²

Carbon dioxide is a greenhouse gas that traps Earth's heat and contributes to global warming.¹⁶³

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.¹⁶⁴ The inflammation, in turn, has been linked to asthma.¹⁶⁵

Although automobile manufacturers, such as Michigan's big three—Ford, Daimler/Chrysler and General Motors—have introduced cars with improved emission control systems, car emission levels remain exceptionally high, even with the introduction of lower volatility gasoline.¹⁶⁶ There are a few main reasons why.

The first is that the number of cars on the road and the miles they travel has doubled nationwide since 1970.¹⁶⁷ 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.¹⁶⁸ SUVs are legally treated as trucks when it comes to minimum miles per gallon the vehicle is required to get. Thus, these vehicles get much lower miles to the gallon than cars and produce more carbon dioxide and other hazardous air pollutants.

Driving a private car is one of the most polluting activities a typical citizen does each day.¹⁶⁹ Until drastic steps are taken to solve Michigan's, 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. Every person can do their part in minimizing the amount of carbon dioxide and other pollutants from cars by carpooling or taking public transportation, minimizing the distance traveled between home and work, and buying the most fuel-efficient vehicle possible.

Air Pollution and Respiratory and Cardiovascular Disease May Increase

Possible increases in the duration of heat/cold waves may result in higher levels of air pollutants (e.g., ozone, particulate matter) particularly if air stagnation episodes occur with these weather conditions. Increased energy production during these extended heat/cold waves could also contribute to elevated levels of air pollutants. Increased air pollutant concentrations could lead to increased morbidity and mortality.¹⁷⁰

—HUMAN HEALTH SECTOR REPORT FOR CLIMATE CHANGE
IN THE GREAT LAKES REGION

Some air pollutants are affected by heat, such as ozone and volatile organic compounds (VOCs). When these pollutants increase, air quality decreases, especially in urban areas. Both ozone and VOCs have adverse health impacts. Climate change could also affect pollen levels that exacerbate allergies. 100,000 tons of carbon monoxide and between 325,000 and 406,000 tons of nitrogen dioxide are released into the Michigan environment each year,¹⁷¹ as well as lead and sulfur dioxide, each causing its own health problems.¹⁷² Given Michigan's 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.¹⁷³

A 4-degree warming in the Midwest is projected to increase concentrations of ground-level ozone by as much as 8 percent.¹⁷⁴ Areas not meeting national health standards, such as Muskegon, could almost triple their amounts of ozone.¹⁷⁵

In 1999, there were 228 violations of the proposed EPA eight-hour standard for ozone statewide.¹⁷⁶ This means that the state's air quality had ozone levels exceeding 85 parts per billion (ppb) on those occasions.¹⁷⁷ During this same year, Michigan air violated the less strict current ozone standard of 125 ppb sixteen times.¹⁷⁸ This pollution not only affects air in Michigan, but also travels eastward to New York, Connecticut, Massachusetts, and Pennsylvania where it contributes to the poor air quality in those states.¹⁷⁹ In response, the EPA in December 1999, found that Michigan pollution was contributing to bad air in other states and issued a mandate to Michigan and 11 other states requiring 392 of their polluting facilities to reduce nitrogen oxide emissions, a precursor to ozone, by 510,000 tons a year by May 2003.¹⁸⁰

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.¹⁸¹ 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.¹⁸²

Even moderately exercising healthy adults can experience a 15 to an over 20 percent reduction in lung function from exposure to low levels of ozone over several hours.¹⁸³ And, some healthy people simply are more sensitive to ozone than others, experiencing more health effects from ozone exposure than the average person.¹⁸⁴ In just one period, from April to October of 1997, there were 6,300 emergency room hospital admissions and 280,000 asthma attack cases in Michigan related to ozone exposure.¹⁸⁵

A recent Harvard Medical School study has found a link between air pollution and heart problems.¹⁸⁶ 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.¹⁸⁷ 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.¹⁸⁸

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 nationwide. A leading cause of absences from school, asthma can reduce lung capacity and, if left untreated, can be fatal.¹⁸⁹ Asthma accounts for one in six pediatric emergency room visits in the U.S. In 1997, 170 adults and children in Michigan died from asthma.¹⁹⁰ 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."¹⁹¹ 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 1993.¹⁹²

Statewide, there were 35,697 children under 15 years of age discharged from Michigan hospitals with the principle diagnosis of asthma from the five-year period between 1989 and 1993.²⁰⁹ This frightening statistic means that 34 out of every 10,000 children suffered from asthma

Startling Statistics About Asthma¹⁹³

- Asthma is the #1 chronic disease of childhood, both nationally and in Michigan.
- 180,000 children in Michigan have asthma.
- The incidence of asthma is soaring. Up to 80 percent of kids in certain areas of Michigan suffered from the condition over the last 15 years.
- Nearly 1/2 of Michigan's asthma deaths in the last decade were recorded in Detroit.
- Asthma's overall death rate in the United States is up 66 percent in the last decade, and 117 percent in the in the last two decades.
- Nationally, \$1.9 billion per year is spent directly to treat children with asthma. Total health care costs for asthma amount to \$7.5 billion annually.

Coal's Toll on Health and the Environment

When you rush your asthmatic child to an emergency room some smoggy day this summer, be sure to think of Consumer's Energy and Detroit Edison. In the new electric utility deregulation legislation just passed, these companies lobbied long and hard—and successfully—to avoid requirements to add modern pollution control equipment that would have cut down the asthma-linked air pollutants from their dirty old coal-burning plants.¹⁹⁴

—LANA POLLACK, MICHIGAN STATE SENATOR 1983–1993,
AND CURRENT PRESIDENT AND DIRECTOR,
MICHIGAN ENVIRONMENTAL COUNCIL

Despite technological advances in developing newer, cleaner power plants, Michigan still heavily relies upon coal-fired plants. At least sixty percent of Michigan's power comes from old, coal-fired plants.¹⁹⁵ In addition to generating power, these plants produce copious amounts of air pollution.¹⁹⁶

Power plants that either use coal exclusively, or combine it with oil and gas, are scattered throughout the state. These include the Dan E. Karn, J.C. Weadock, Harbor Beach, St. Clair, Marysville, Belle River, Trenton Channel, Wyandotte, River Rouge, Conners Creek, J.R. Whiting, Monroe, Eckert Station, Endicott, Erickson, J.B. Sims, James De Young, J.H. Campbell, B.C. Cobb, Presque Isle, and Shiras plants.¹⁹⁷ One of the greatest power producers is the Monroe plant, which regularly generates over 2,000 megawatts of power.¹⁹⁸ Unfortunately there is a price for its energy, as all four of its boilers use coal with oil as a fuel.¹⁹⁹

Coal-fired power plants, such as those in Michigan, account for more than 60 percent of the nation's sulfur dioxide and 23 percent of its nitrogen oxide emissions.²⁰⁰ These pollutants contribute to acid rain and smog.²⁰¹ Coal plants also produce more than 32 percent of toxic mercury pollution.²⁰² Further, plants nationwide emit more than 31 percent of the United State's carbon dioxide.²⁰³

Like old cars, 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 old coal-burning power plants from new source



standards, allowing them to emit between 4 to 10 times more pollution than new plants.²⁰⁴ The CAA also allows all power plants, regardless of age, to emit unlimited amounts of carbon dioxide and mercury.²⁰⁵ Michigan's plants are some of the worst polluters in the nation. Power plants in just fifteen states, including Michigan, account for 75 percent of the global warming emissions from increased electricity generation at coal-fired facilities.²⁰⁶ In-state carbon dioxide emissions increased by an incredible 10,271,792 tons from 1992 to 1998.²⁰⁷

For now, Monroe and other coal-fired plants are able to get away with it, thanks to the CAA loophole and lobbyists representing the coal power industry. Until the public demands that these plants clean up their act, Michigan's coal-fired power plants will continue to release precursors to asthma inducing smog, toxic emissions of mercury, acid rain-forming oxides, and carbon dioxide emissions that cause global warming.²⁰⁸

during that period. The rate for children under 5 was approximately 3 times that for children aged 5 to 14.²¹⁰ Boys and African American children had particularly high rates, with boys developing asthma 1.7 times more than girls, and African American children developing asthma at a rate three times higher than non-African American children.²¹¹

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.²¹²

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. 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.²¹³ 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.²¹⁴ Cancer is the second leading cause of death in Michigan, just under heart disease. In 1998, 19,442 individuals in the state died from cancer.²¹⁵

Pollen

As the thermometer starts rising on warm days, pollen counts may rise as well. A new study from the U.S. Department of Agriculture studied the amount of ragweed pollen in the air. Their 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 hit 20 grams per plant. Findings also showed that high carbon dioxide levels might produce ragweed pollen earlier in the year. Although less ragweed grows in cities, exposure to air pollutants such as ground-level ozone can make people more sensitive to ragweed pollen.²¹⁶

During May of 1999, Michigan experienced over 3,000 grains per cubic meter of pollen,²¹⁷ several times higher than the daily average for the state. 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.²¹⁸

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.²¹⁹ Thus, Michigan residents who suffer from allergies could experience more attacks during more months of the year as the climate changes.

Global Warming's Impact on Michigan's Water Supply and the State of The Great Lakes

*The seasonal rising and falling of Great Lakes water levels has changed considerably over the past 140 years. It is likely that climate change has contributed significantly to these changes.*²²⁰

—JOHN D. LENTERS, RESEARCH ASSOCIATE,
INSTITUTE FOR ENVIRONMENTAL STUDIES, UNIVERSITY OF WISCONSIN

Climate scenarios suggest that climate change will affect precipitation, stream flows, runoff, water temperatures, and evaporation rates, thereby impacting Michigan's waters. The state's water supply draws primarily from two sources. Seventy-five percent comes from surface waters, such as those found in the Great Lakes or in the state's many rivers. The remaining twenty-five percent comes from groundwater, used mostly in rural areas for agricultural purposes.²²¹ Both the quantity and quality of water available from each of these sources could be at risk from climate change.

Pollutants collect in water. In addition, changes in climate may lead to weather extremes and periods of heavier than normal precipitation. This could increase the potential for flooding and exposure to waters contaminated with disease-causing parasites, such as giardiasis and cryptosporidiosis.

Despite the predicted increase in precipitation, rivers and lakes may experience a drop in water levels due to increased evaporation resulting from overall warmer temperatures and a decrease in soil moisture. Lower water levels could concentrate some pollutants. Warm spring seasons may also be a cause of depleted groundwater supplies. A reduction in the amount of water available for personal, agricultural, and industrial use could result. In addition, low lake water levels could require dredging to insure passage for ships. Dredging releases pollutants such as PCBs and dioxin that have settled in lake sediment and are harmful to human health.

Michigan's years of heavy industry have historically had a devastating impact on the state's waters. For example, the Detroit River has been named one of the dirtiest waterways in the entire nation by the Environmental Protection Agency.²²² Pollution in Lake St. Clair is also high. Clinton River in Pontiac, which feeds into Lake St. Clair, had 200,000 gallons of raw sewage dumped into it in early June 2000.²²³ Several Macomb communities at the time even admitted that they had illegally pumped untreated wastewater into area rivers and streams.²²⁴ Further, a report on Michigan Public Water System

Violations reveals that during 1998 there were 478 water violations in the state.²²⁵ Many of the pollutants in Michigan's waters, such as dioxin, PCBs, dibenzofurans, PAHs, pesticides and organic forms of mercury and lead, are known as persistent toxic substances that could endanger the health of humans and wildlife.²²⁶ If climate change causes the depletion of water sources in the state, some concentration of pollutants and bacteria could result.

The State of The Lakes

*The issues of invasive species, the air deposition of persistent toxic substances, biodiversity decline and climate change, some of the basin's most serious environmental threats, all have significant global dimensions. Not only must we take actions within the basin to address these issues, but also we must be more engaged internationally to influence worldwide action.*²²⁷

—GARY GULEZIAN, GREAT LAKES NATIONAL PROGRAM OFFICE, U.S. EPA

An emerging problem in the state concerns the lowered water levels of The Great Lakes. In particular, Lakes Superior, Michigan, and Huron are at a 35-year low.²²⁸ Additionally, a recent University of Wisconsin study found that Lakes Erie and Ontario are actually rising and falling roughly one month earlier in the year than they did 139 years ago. Maximum lake levels for Lake Superior also occur earlier in the year.²²⁹ These changes suggest that global warming is affecting entire seasons, rather than just having an impact on individual periods of weather, which could disrupt ecosystems in and around the lakes. Most of these changes are consistent with predicted impacts of global warming on spring snowmelts and runoff in the Great Lakes region.²³⁰ Increased water evaporation and higher air temperatures over the past three years likely further affected lake levels.²³¹

Lakes Michigan, Huron, Erie, and St. Clair all require melting snow to replenish their water supplies.²³² Snow levels have been minimal in the Lake Superior basin for the past two years, which has contributed to the lowering of the lakes.²³³ For example, the normal seasonal water rise for the Great Lakes and Lake St. Clair is approximately 11 inches. As of spring 2000, there was no seasonal rise.²³⁴ The future looks grim as well. Many climate change models predict a drop in lake water levels, up to 4 or 5 feet, due to excessive evaporation and reduced snow packs.²³⁵

Low lake levels could create a vicious cycle of problems, beginning with threats to commercial and recreational boating on the lakes. The state's 970,879 registered boat owners may have to drag their boats into the lake or even use smaller boats due to the lack of water.²³⁶ Shipping to and from Michigan ports could also be impaired due to diminished water levels in the shipping channels connecting the lower Great Lakes, however shorter ice cover seasons could increase the amount of time boats are able to navigate certain water bodies.²³⁷ Injuries to riders of personal watercraft and water-skiers could occur more frequently, due to exposed topographical highs and rocks.²³⁸

Changing water levels may also affect homeowners who live around and near the lakes. There is great concern that altered lake levels will increase

current rates of erosion and lead to waterfront property damage. Erosion can occur with both increased and decreased water levels, the two extremes that climate change is likely to bring. While low water levels may decrease the amount of erosion caused by waves, similar water levels could expose shorelines to more wind damage, while floodwaters could cause mudslides that erode portions of the coastline. At Sheldon Dunes in Ottawa County, for example, a revetment project projected to cost hundreds of thousands of dollars and destroy 900 feet of beach has been proposed to keep homes from sliding into Lake Michigan.²³⁹ A huge slide already damaged a stream at Antrim County's Cedar River in September of 1998, dumping 55 tons of mud into the once-clear trout stream.²⁴⁰

The Great Lakes collectively form one of the largest bodies of fresh water in the world and have a tremendous impact on ecosystems in the region. Alterations to these systems can impact human health. Like Michigan's other water sources, pollution from industrial sources, individual polluters, and increased outdoor recreational activity already have reduced water quality.²⁵⁴

Michigan's Mercury-Poisoned Waters

*Larger and older fish tend to collect more contaminants. Fish that eat other fish, such as muskie, northern pike, walleye and bass, tend to collect chemicals such as mercury. Fatty fish, such as carp, catfish, lake trout and large salmon, tend to collect PCBs and similar chemicals.*²⁴¹

—MICHIGAN DEPARTMENT OF COMMUNITY HEALTH

Those who have gone fishing in Michigan's waters are probably familiar with the warning listed above. The state issues such warnings for good reason. The Great Lakes Basin is vulnerable to the accumulation of pollutants released as byproducts of commerce and industry.²⁴² *Dioxin, PCBs, and other known toxic pollutants are in almost every Michigan body of water. Perhaps the most prevalent, and dangerous, pollutant is mercury.*

Coal-burning power plants and other industries release mercury, which is then converted by bacteria into an even more toxic substance, methyl mercury.²⁴³ Fish ingest methyl mercury as they feed. They also absorb it from water as it passes over their gills.²⁴⁴ The substance is stored in fish flesh. Trimming or cooking cannot remove it.²⁴⁵ Nearly all fish contain methyl mercury, with large fish and sport fish, such as those caught from Michigan's lakes, having the greatest concentrations.²⁴⁶

Methyl mercury is rapidly absorbed from the gastrointestinal tract and readily enters the adult and fetal brain.²⁴⁷ A report known as the Jacobsons'

Michigan Maternal Cohort study looked at 242 mother-infant pairs.²⁴⁸ 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.²⁴⁹ 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.²⁵⁰

Michigan State University researcher Dr. Jane Courval conducted another study. She analyzed the effects of mercury on 625 couples of reproductive age. Her findings suggest that the health of fathers is also impacted by methyl mercury. Couples participating in the analysis had experienced problems with conception, and study controls pointed to male difficulties²⁵¹ caused by mercury ingestion. A University of Wisconsin study additionally found that individuals who ate fish from Michigan's waters had increased incidence of joint pain, liver disease, diabetes, and memory loss.²⁵²

Research committees have called for further studies on methyl mercury's impact on the prevalence of hypertension and cardiovascular disease in the United States, as well as cancer, immunity deficiencies, and neurological effects.²⁵³ For now, the extremely harmful substance continues to accumulate in Michigan's fish, threatening the health of humans and animals that consume them.

Changes in lake levels could concentrate some pollutants and infectious agents, like cryptosporidium, putting at risk a large segment of the state's population, especially those who rely on the Great Lakes for recreation.²⁵⁵ A report issued by the Office of the Great Lakes found that children, the elderly, and pregnant women in the region might be at high risk for health problems associated with environmental contaminants.²⁵⁶ Possible increases in atmospheric pressure in the basin may also aggravate certain maladies, such as migraines and arthritis.²⁵⁷ Increased cloud cover due to lake evaporation and precipitation changes, especially over western areas of the state, could increase the incidence of Seasonal Affective Disorder.²⁵⁸ This condition, which results from fewer hours of observed sunlight, can cause depression, fatigue, and anxiety.²⁵⁹

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.²⁶⁰

—ROSS GELBSPAN, CLIMATE AUTHOR

In the warmer and wetter days to come, insects and rodents—referred to as vectors—could multiply in number, increasing human health risks from the diseases they carry. Higher temperatures could also affect the breeding season of the vectors and their ability to survive over winter, as well as increase human exposure to the insects by increasing the periods of the year during which people tend to spend time outside. Many diseases are carried by mosquitoes and ticks. 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.²⁶¹ In fact, field and laboratory studies have shown that temperature is the most important determining factor with respect to transmission of a viral agent by a vector.²⁶² A changed climate could allow vectors and the diseases they carry to spread to, and survive in, new territories. In the future, therefore, Michigan residents could suffer from more cases of diseases already in Michigan as well as from diseases only previously seen in other parts of the country.

Tick Borne Disease in Michigan

Lyme disease, Rocky Mountain Spotted fever, and ehrlichiosis are diseases already carried by ticks in Michigan.

Lyme disease concerns many Michigan residents. In just one month in 1999 the Michigan Lyme Disease Association heard from 405 callers who thought they either had Lyme disease or were concerned that they could get

it.²⁶³ 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.²⁶⁴ From 1998 to 1999, 18 cases of Lyme disease were reported in Michigan.²⁶⁵ The number of cases, however, was likely under-reported since the Centers for Disease Control and Prevention stated that the 128,327 reported cases since 1982 may represent only one-third of the actual U.S. count.²⁶⁶ Further, Most of the cases are reported during summer months when ticks thrive, but a warming trend could increase Michigan's tick population, while warmer winters will permit people to enter tick-infested habitats earlier in the season, thereby increasing the risk for transmission of the disease.²⁶⁷ In addition if Michigan's deer population expands, more ticks will find a host and possibly come into contact with humans.

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, and chronic disease symptoms may develop weeks, months, or even years after being bitten.²⁶⁸ Although a new vaccine for Lyme disease is available in Michigan, health experts warn that it does not offer complete protection from the disease.²⁶⁹

Rocky Mountain Spotted Fever (RMSF). Each year a handful of Michigan residents contract RMSF.²⁷⁰ It is caused by bacteria that are transmitted to humans when bitten by 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. The disease can be fatal. In early June 2000, a 3 year-old died in Cassopolis from the disease.²⁷¹ Symptoms can 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. Unfortunately, during the early stages of the disease, it may be confused with other illnesses, including meningitis, making treatment more difficult.²⁷²

Ehrlichiosis is a relatively new disease caused by a bacteria carried by the Lone Star tick. In 1986, the disease was first classified in a Michigan who contracted it from a tick out-of-state. Since then cases have been recorded from the southeastern United States to the Great Lakes. Nine cases of the disease were reported in northeastern Michigan from 1990 through 1995.²⁷³ Since a reported case in the state in 1998,²⁷⁴ health officials have been watching for the potential spread of this disease. Symptoms of Ehrlichiosis appear 7 to 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.²⁷⁵ At most risk for severe infection are people taking immunosuppressant drugs, individuals with chronic illness, and the elderly.²⁷⁶

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.²⁷⁷

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

Virtually every habitat out there that has mosquitoes in it has been flooded.²⁷⁸

—NED WALKER, ASSOCIATE PROFESSOR OF ENTOMOLOGY, MICHIGAN STATE UNIVERSITY, COMMENTING ON THE RECORD NUMBERS OF MOSQUITOES THE STATE HAS HAD IN 2000, DUE TO WARM, WET CONDITIONS

Climate change is forecasted to bring with it more periods of extreme weather. Such extremes can affect mosquito populations. For example, during the early part of 2000, conditions in Michigan were relatively dry, but May brought abrupt changes, as heavy rains drenched most of the state.²⁷⁹ Due to these weather patterns, Michigan experienced two mosquito hatch periods during early spring, instead of the usual one. This was especially evident in Western Wayne County, where mosquitoes tend to proliferate.²⁸⁰ The record numbers of mosquitoes in 2000 have laid eggs that will not hatch until 2001, thus the cycle of more mosquitoes in the state likely will continue for some time to come. Mosquitos carry diseases such as different forms of encephalitis, malaria and dengue fever.

Eastern Equine Encephalitis (EEE) is spread by mosquitoes in the state. From the beginning of 1980 to July 31, 1999, 8 people became infected with EEE in Michigan and 4 died.²⁸¹ Mosquitoes get the virus from infected birds, and pass it on to humans. The disease attacks the nervous system and sixty percent of all human cases result in death. A severe headache may be the only warning sign, but other symptoms include sudden fever, weakness, irritability, disorientation and coma.²⁸² According to Dr. Mary Grace Stobierski, a Michigan Department of Community Health specialist who tracks the disease, the treatment involves high-level intensive care to maintain breathing and body functions in victims.²⁸³ A human vaccine is in development, but so far there is no available protection for EEE.²⁸⁴

Animals also suffer from EEE. The disease is nearly 100 percent fatal in horses and from 1990 to the summer of 1999, EEE claimed the lives of 84 Michigan horses.²⁸⁵

Malaria in Michigan? It sounds unlikely, but consider this: every year Michigan residents contract malaria abroad and bring the disease back to Michigan with them. In 1998, there were 50 reported cases of malaria in the state. In 1999, reported cases totaled 42.²⁸⁶ Temperature, precipitation, and extreme weather events can have an effect on the viability and geographical distribution of the Anopheline mosquitoes that transmit the disease. These mosquitoes are already found in Michigan any 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.²⁸⁷ 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 more malaria could appear in the United States.

Dengue, is generally thought of as a tropical disease, however Michigan residents who travel can contract the disease and bring it home with them. For example, in 1998 and 1999, 4 cases of dengue were reported in Michigan.²⁸⁸ 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.²⁸⁹ Already, insects infected with dengue and yellow fever have spread as far north as Chicago.²⁹⁰ Referred to as “breakbone fever,” dengue causes symptoms that include muscle pain, fever, headache, chills, nausea and skin eruptions.

Warmer Weather Could Increase Food Contamination

Warmer, moister weather encourages the spread of diseases caused by food contaminated with toxic *E. coli*, salmonella and hepatitis A.²⁹¹ 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.²⁹² Higher ambient temperatures foster the growth of the pathogens that cause these illnesses.²⁹³ Heavy rainfall and runoff can wash the contaminants into public water supplies thereby helping to spread the disease.²⁹⁴

Escherichia coli 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.²⁹⁵ About two to seven percent of all infections lead to this complication. There were 117 cases of *E. coli* reported in Michigan 1998 and 118 cases in 1999.²⁹⁶

Salmonellosis is caused by the salmonella bacteria. There were 940 cases of salmonellosis reported in Michigan in 1999, and 1,169 cases in 1998.²⁹⁷ Most infected persons develop diarrhea, fever, and abdominal cramps twelve to 72 hours after infection.²⁹⁸ Many people recover, but in some cases, hospitalization is required. In these severe cases, the salmonella infection may spread from the intestines to the blood stream, and then to other body sites. At that 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 likely to have a severe case.²⁹⁹ A small number of victims can develop Rieter’s syndrome, which can lead to chronic arthritis that can last from months to years.³⁰⁰

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 waterborne sources. 1,254 cases were reported in Michigan in 1999³⁰¹ and 2,135 were reported in 1998.³⁰² Warmer temperatures and extreme weather events could bring these numbers up even higher in the months and years to come.

Campylobacter is yet another bacterial disease that could increase in Michigan due to predicted warmer temperatures that may foster its growth and due to runoff following heavy rains, as water usually becomes contaminated with campylobacter bacteria when sewage enters the drinking water supply.³⁰³ This disease can cause diarrhea, abdominal pain, fever, vomiting, and nausea.³⁰⁴ 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. The disease is not reportable, but it may threaten the health of Michigan residents.

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.”³⁰⁵

This theory 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. Miracle of miracles, the plague ended. This was years before the biological cause of cholera was known.³⁰⁶

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 Michigan’s Forests and Agriculture

Agriculture

Agriculture is important to the state’s economy and averages \$3 billion in annual revenues.³⁰⁷ Fifty percent of this amount comes from livestock and most of the rest is due to corn, soybean, hay, and other crop yields.³⁰⁸ Since both livestock production and farming are influenced by climate conditions and water availability, global warming could greatly impact Michigan agriculture. If the climate warms according to certain model projections, corn yields could fall by 34 percent, hay yields could decrease by 17 percent, and yields from soybean crops could decrease.³⁰⁹ However, other models show little change in crop production and some predict an increase in growing season

length. Fruit production, especially in areas near Lake Michigan, could also be affected.³¹⁰

Plants that do survive may change biochemically as a result of warmer temperatures, potentially harming human and animal health. Nitrate poisoning is one such threat. Weather stresses, like 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.³¹¹ In livestock, for example, 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.³¹²

Plants subjected to heightened levels of carbon dioxide 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.³¹³ 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.³¹⁴ While further studies are planned, Teeri believes that humans could exhibit a similar response.³¹⁵ Considering that carbon dioxide levels are projected to double from today's already high levels in 50 to 60 years,³¹⁶ the findings merit high concern.

Projected Impact on Forests

Global warming could significantly change Michigan's forests by influencing biological diversity and forest growth.³¹⁷ Changes in precipitation, higher temperatures, and extreme weather events could wreak havoc on Michigan's timber stands and affect the germination ability of seeds. If less water is available for uptake by Michigan's forests, trees could dry out, paving the way for forest fires.

Forest fires pose numerous public concerns. They can have a devastating effect on timber production and wildlife. They may destroy homes and other high value property. Wildfires can kill young trees that represent the timber for tomorrow.³¹⁸ From a health standpoint, fires may cause injuries and fatalities to firefighters and nearby residents. Smoke, which can cover a wide area, increases respiratory illness, such as asthma and chronic obstructive pulmonary disease, particularly for people with pre-existing respiratory conditions.³¹⁹ In 1999, wildfires burned 8,225 acres in the state.³²⁰ On May 2, 1999, a forest fire in Marquette County was fueled by hot, dry, and windy weather. The fire injured 4 firefighters and left 15 structures either damaged or destroyed.³²¹ 450 people in the area were evacuated from their homes for over 4 days. Costs for fighting the blaze exceeded \$1 million.³²²

An economic impact will also be felt if, as some models predict, Michigan's mixed aspen, birch, beech, sugar maple, and pine forests die out in the northern part of the state and are replaced over time by a combination of grasslands, savannah, and hardwood forests of oak, elm, and ash.³²³ Sugar



Changes in precipitation, higher temperatures, and extreme weather events could lead to more forest fires in Michigan.

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 increasing. In 1996, 8.9 percent of Michigan residents were without health coverage. In 1998, this figure jumped to 13.2 percent.³²⁴

What You Can Do

Our new data and understanding now point to the critical situation we face: To slow future change, we must start taking action soon.

—D. JAMES BAKER, ADMINISTRATOR,
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

*Never doubt that a small group of concerned citizens can change the world. Indeed, it is the only thing that ever has.*³²⁵

—MARGARET MEAD

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, air and water pollution can affect all Americans. 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 Michigan 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.

There is a lot you can do in Michigan, starting now, to combat global warming and bring down consumption of fossil fuels.

1 Demand that electric utilities use low-carbon technologies and renewable energy. Michigan has dirty power plants that need to clean up their act. Support efforts that require all power plants to meet federal air pollution standards.

2 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.

3 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. Michigan is a big part of this growing problem. The state has the ninth highest annual emissions of carbon dioxide in the United States, and emits more than all but 12 countries in the world.³²⁶ The United States' transportation system contributes about one-third of national carbon dioxide emissions.³²⁷ Population growth could lead to even more motor vehicles and longer commutes. Do your part, by carpooling and using public transportation whenever possible.

4 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.³²⁸ This percentage figure is actually on the rise, due to increased use of light trucks and sport utility vehicles. Since transportation emissions are on the rise both nationally and in the state, Michigan's auto manufacturers could play a pivotal role in reducing the risk of climate change.³²⁹ Encourage automakers to develop and sell cars, trucks, and sport utility vehicles (SUVs) with better mileage and higher fuel efficiency, or CAFE, standards. EPA provides a website, <http://www.fueleconomy.gov>, where you can do a side-by-side comparison and select the most energy-efficient vehicle that meets your needs.



More energy-efficient cars would go a long way in cutting carbon dioxide emissions.

5 Urge the businesses you patronize 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>).

6 Support efforts to separate sewer and flood water lines in the state. As it stands, many water systems in Michigan are vulnerable to contamination from pollutants and pathogens in untreated sewer water during flood events. In June of 2000, for example, 200,000 gallons of raw sewage were released into the Clinton River in Pontiac due, in part, to equipment failure.³³⁰ Urge officials to update sewer and flood water lines, to avoid such problems in the future.

7 In this election year, work for candidates who are serious about reducing emissions of carbon dioxide and other greenhouse gases. Support senators who have taken a stand in favor of ratifying the Kyoto Protocol to the Framework Convention on Climate Change. Tell your members of Congress that we are not afraid of higher fuel efficiency, or CAFE, standards—for cars, SUV's and light trucks—and they should not be either!

8 Work with local groups and chapters of national organizations to promote awareness of global warming and related issues in Michigan. These include: the Michigan chapter of Physicians for Social Responsibility (313-577-1450), American Lung Association of Michigan (248-359-5864 or 1-800-543-LUNG), American Heart Association Michigan Affiliate (in Saginaw 517-792-6400 or 1-800-968-2422, in East Lansing 517-322-0385 or 1-800-968-2425, in Grand Rapids 616-285-1888 or 1-800-968-1040, in Lathrup Village 248-557-9500 or 1-800-968-1793), Michigan Audubon Society (517-886-9144), Michigan Environmental Council (517-487-9539), Michigan Forests Association (734-913-9167), Michigan Land Use Institute (616-882-4723), Michigan Natural Areas Council (313-461-9390), Michigan Nature Association (313-324-2626), Michigan United Conservation Clubs Inc. (517-371-1041), Michigan Wildlife Habitat Foundation (517-882-3110) and the Lake Erie Clean-Up Committee Inc. (313-379-3891 or 313-242-0909).

Where Physicians for Social Responsibility (PSR) 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 nuclear weapons, global environmental pollution, and gun violence. In 1985, PSR shared the Nobel Peace Prize with the International Physicians for the Prevention of Nuclear War.

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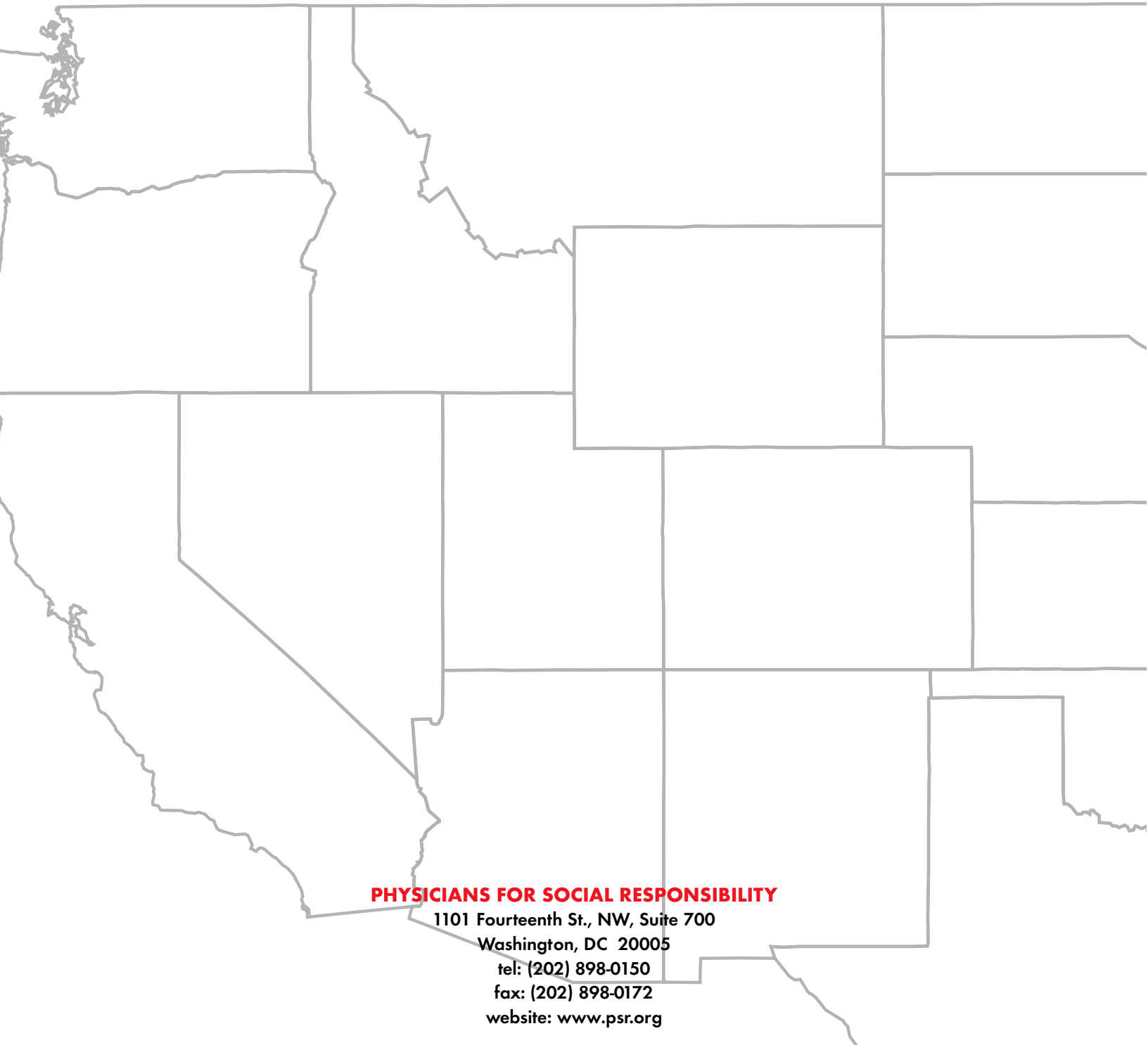
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