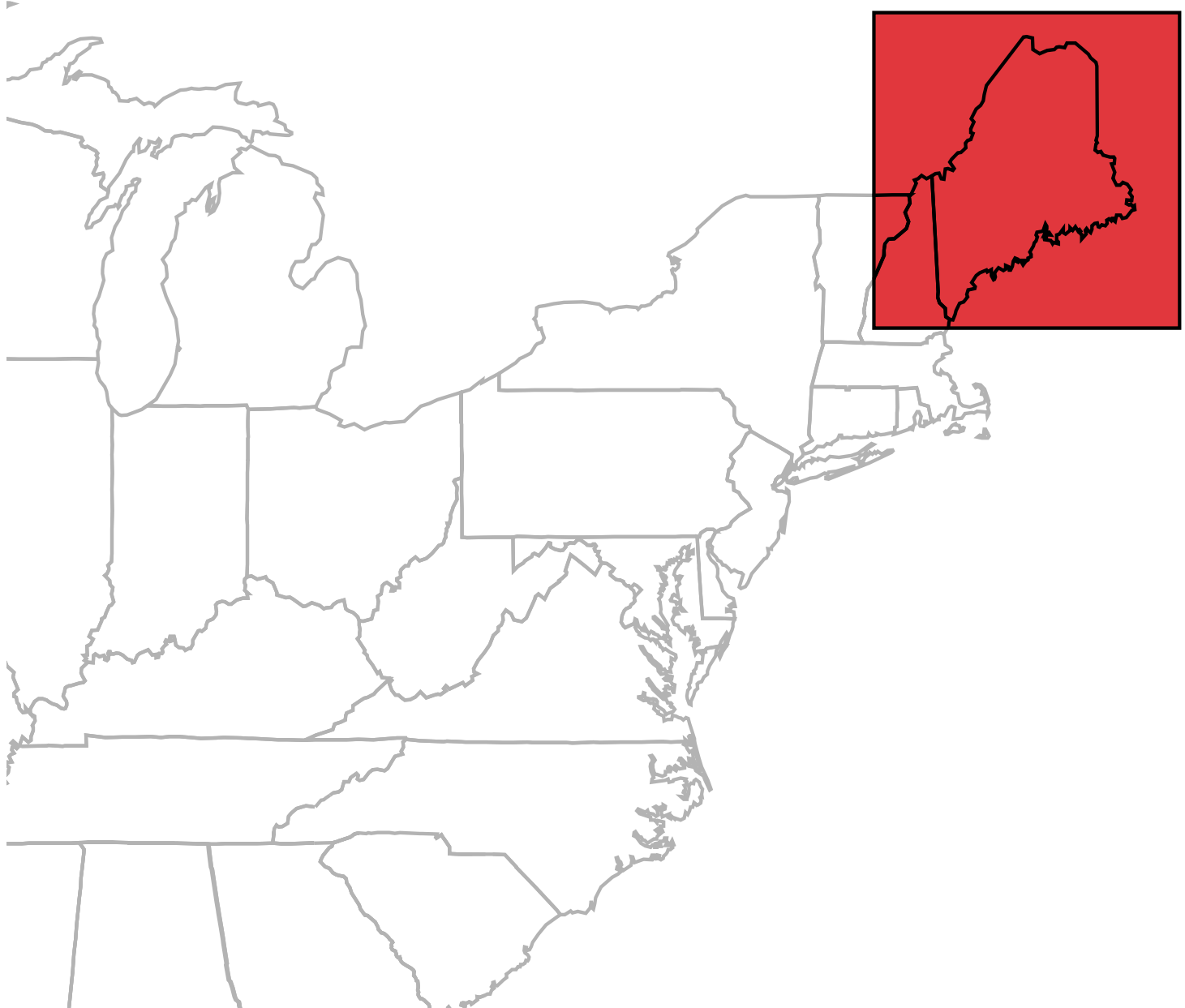


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PHYSICIANS FOR  
SOCIAL RESPONSIBILITY

# **DEATH** BY **DEGREES**

**THE EMERGING  
HEALTH CRISIS OF  
CLIMATE CHANGE  
IN MAINE**





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**February 2000**

**This report was prepared by Physicians for Social Responsibility to alert Maine residents to the damaging 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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*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,  
U.S. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

**The world is getting warmer at an unprecedented rate,** never before seen in recorded history. Climate fluctuations have occurred during previous centuries, but at the dawn of the 20<sup>th</sup> century, a warming trend took hold that shows no signs of stopping.<sup>1</sup> During the past one hundred years, average global surface temperatures have increased by approximately 1 degree Fahrenheit. Eight of the warmest ten years on record happened in the last decade.

Although uncertainties exist in measuring this complicated phenomenon, 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.<sup>2</sup> Third, warmer conditions on Earth will directly affect our lives and well-being.<sup>3</sup>

This report describes how the changing global climate will impact human health. Our focus is on Maine, a state that is likely to experience more health problems and increased mortality due to the expected changes.

### **How Global Warming Could Threaten Health in Maine**

Numerous 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 Maine could include:

- More “extreme weather events,” such as ice storms, hurricanes and flooding, leading to more drownings, electrocutions and other accidental deaths.
- More respiratory and cardiovascular disease, especially for those with asthma, due to increased air pollution.
- More waterborne disease, such as intestinal distress from drinking contaminated water or consuming toxins present in fish and shellfish.
- More outbreaks of infectious disease spread by insects.
- More deaths and injuries, such as drownings caused by storm surges, related to sea level rise and coastal erosion.
- More incidents of heat-related disease, such as heat stroke.
- More deaths and injuries due to forest fires intensified by droughts, hurricanes and other extreme weather conditions associated with global climate change.

## Maine: A State At Risk

*The world is definitely warmer than it was 150 years ago, and the warming appears to have accelerated during recent decades. Many of my students are very concerned. They are worried about how these changes could affect their lives and, in the future, the lives of their children. I think their concern is justified. It's a dangerous game we're playing now, altering natural systems.*

—DR. OLAF ELLERS, DIRECTOR OF THE COASTAL STUDIES CENTER,  
BOWDOIN COLLEGE, BRUNSWICK, MAINE

“As Maine goes, so goes the nation” was a common phrase during the 1800’s.<sup>5</sup> Then the saying referred to how the state voted two months before the rest of the country. Now it may apply to the way in which Maine reacts to the health threats posed by global climate change.

These threats include heat stroke, respiratory illness, hypothermia, cardiac arrest and carbon monoxide poisoning, all of which can be triggered by temperature extremes. Maine already experiences extreme temperatures

during the winter and summer months.<sup>6</sup> However global warming likely will lead to more such days of excessive cold and heat.

Maine residents also can expect to see a greater number of injuries and deaths resulting from surges, and other natural forces, that can develop during storms.<sup>7</sup> That is because both Nor’easters and hurricanes could become more frequent and severe. The National Weather Service says global warming impacts could result in 10 to 20 foot storm surges along Maine’s shoreline.<sup>8</sup>

Floods and droughts could occur on a more regular basis, increasing the risk of water contamination and gastrointestinal illnesses.<sup>9</sup> Water quality problems in rivers such as the Androscoggin, where pollution already poses health risks, could be exacerbated.<sup>10</sup>

Further water contamination could occur due to rising sea levels, which could bring saltwater into drinking water supplies. Increased sea level rise also could lead to more severe flooding of low-lying property, loss of coastal wetlands, erosion of beaches, and decreased longevity of low-lying roads, causeways and bridges.<sup>11</sup>

Maine can expect more severe cases of asthma and other respiratory problems associated with elevated ozone levels. At present, ozone in Maine causes breathing difficulty for 395,000 people, approximately one-third of the population.<sup>12</sup>

### The Complex Origins of Climate Change

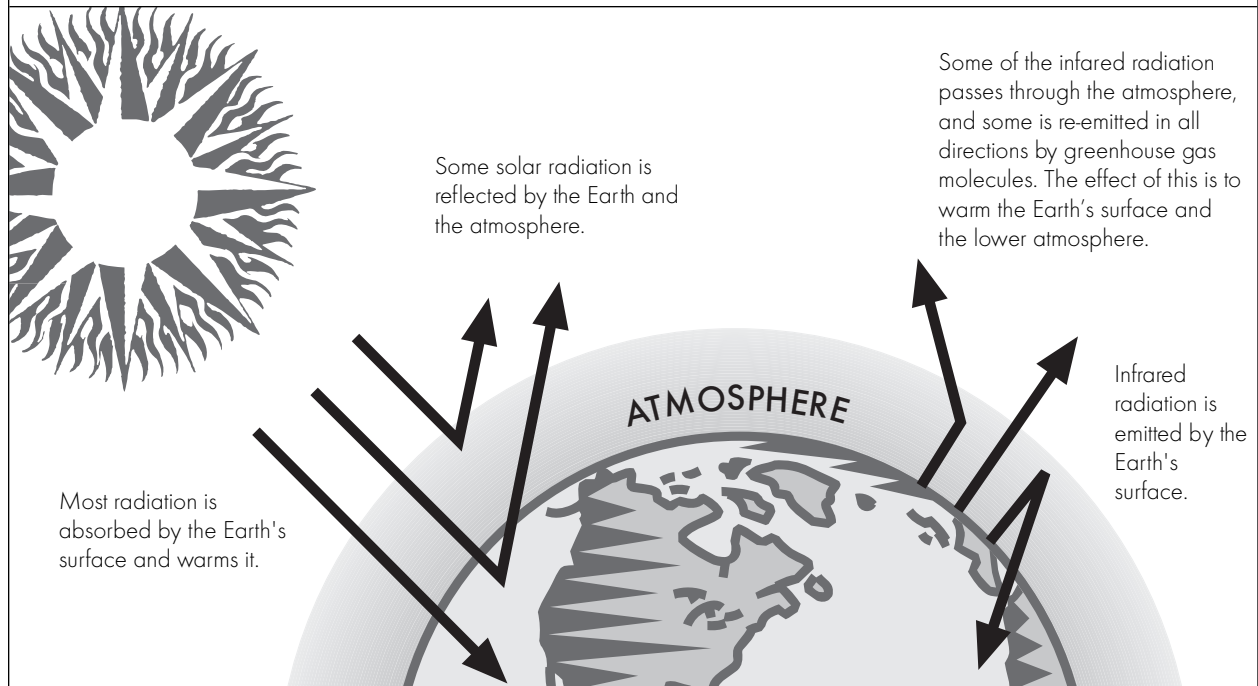
Since the end of the last Ice Age 10,000 years ago, temperatures worldwide have risen about 9 degrees Fahrenheit, mainly due to natural changes in the geographical distribution of the sun’s energy and in the amounts of dust, carbon dioxide and other gases in the atmosphere.

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. Eight of the ten warmest years in recorded history occurred in just the last decade, with 1998 topping them all.

Human activities are among the most important factors making Earth warmer. When motor vehicles burn gasoline and electric utilities burn coal, they release carbon dioxide and other gases into the atmosphere that trap warm air near Earth’s surface, in much the same way as glass panels trap warm air inside a greenhouse—hence the term, “greenhouse effect.” Over the past 200 years, the concentration of greenhouse gas in the atmosphere has increased by 30 percent. The gas will remain there for centuries, trapping heat and putting human health at risk.<sup>4</sup>

FIGURE 1

### The Greenhouse Effect



Energy from the sun drives Earth's weather and climate, as shown in this illustration. Water vapor, carbon dioxide and other atmospheric greenhouse gases trap some of the sun's energy, creating a natural "greenhouse effect." However, problems arise when the greenhouse effect is enhanced by human-generated emissions of greenhouse gases, such as through the burning of fossil fuels.

Economically, Maine also has much at stake, as many residents make a living from natural resource industries, such as lumber, tourism, agriculture, and fishing.<sup>13</sup> Each of these industries could be adversely impacted by global climate change, leading to possible job losses. Without sufficient income, some residents may be unable to afford health insurance.

Making matters worse, numerous Maine citizens already are vulnerable to the effects of climate change. These include the young, the infirm, and the elderly. Young individuals are at risk because their immune system, and other protective systems, have not yet fully developed.<sup>14</sup> In the case of heat stress, for example, sensitivity to heat is greatest in children less than a year old whose heat regulatory systems have not yet developed to adult potential.<sup>15</sup> The infirm are at risk because they are sensitive to heat stress, air pollution, and other possible effects of global warming. Certain medications, such as those taken for treatment of AIDS or kidney transplants, also increase sensitivity.<sup>16</sup> The elderly are at risk due to a host of factors, including a possible drop in the efficiency of their heat-regulating systems, an increase in the temperature at which sweating begins, a decrease in the ability to perceive changes in temperature, and pre-existing conditions, such as cardiovascular or pulmonary diseases.<sup>17</sup> Given that the percentage of individuals 65 years old

and over in the state now exceeds the national average,<sup>18</sup> many Maine residents could be hit hard by the effects of global warming.

Maine, like the rest of the country, needs to be deeply concerned about the impact of climate change on the health of its population.

### *Are we already experiencing the effects of global warming?*

No one knows better than Maine residents that there has always been the occasional hot summer, or the unusually bad storm. Such events do not necessarily indicate a long-term pattern. But trends in recent years correspond closely to computer predictions of climate change, and may well be warning signs. These include:

- *More prevalent extreme weather conditions, exemplified by this year's winter.* Until January 2000, much of the state experienced over 300 days without snow, record high temperatures, and 2 1/2 inches below normal rainfall this winter.<sup>19</sup> In less than a week this dramatically changed, as a deep freeze settled over New England, plummeting the wind-chill by as much as 100 degrees.<sup>20</sup>
- *A spate of heat waves.* Nationwide, the number of heat-stressed days has approximately doubled during the past 50 years. New England is no exception. Last spring, the driest April on record unfolded into one of the worst droughts in history. It killed more than 270 people in the Northeast.<sup>21</sup>
- *Rising sea levels along Maine's coast.* For the last 2,000-3,000 years, sea levels rose about .8mm (.0026 feet) per year. Now that rate has doubled in most areas, and even tripled around cities such as Eastport.<sup>22</sup> This has led to growing concern among Maine's coastal communities about property damage, coastal erosion, and drinking water contamination.<sup>23</sup>

Such trends are further brought to light in countless scientific reports. Of note most recently, the National Academy of Sciences presented a 71-page document that states there is no question Earth's warming has accelerated during the past two decades.<sup>24</sup> On January 19, 2000, NASA's Jet Propulsion Laboratory issued a release stating that the persistence of La Niña and El Niño events, which cause warmer and cooler than normal sea-surface temperatures, may be part of a larger, long-lasting climate pattern.<sup>25</sup>

The following sections describe the specific health effects that are predicted to result from global warming over the next 50 or 100 years, together with supporting evidence. In some cases, there is a high level of certainty about the predictions. In others, the evidence is less definitive. For all cases, there is reason for concern.

## **More Extreme Weather Events Leading to More Heat-Related Illness, Drownings, Electrocutions, and Other Accidental Deaths**

Global warming means not only warmer temperatures, but also more unpredictability in weather patterns and more extreme weather conditions.<sup>26</sup> The concentration of greenhouse gases that cause global warming increases heat and moisture in the atmosphere. Heat and water vapor create instability, leading to more frequent, and possibly more severe, weather activity.<sup>27</sup> In addition, the effects of changing weather patterns associated with melting polar ice are expected to be felt more strongly in northern areas, such as Maine.<sup>28</sup>

All of this could mean more ice storms, floods, hurricanes, Nor'easters, droughts, heat waves and other natural disasters. Although Maine is accustomed to rapid and extreme swings in weather conditions,<sup>29</sup> the events forecasted to occur with global climate change may be surprising and severe. Already Maine sustains incredible damage from natural disasters. In 1998, for example, Maine was the eighth highest-ranked state in the country for receiving federal disaster funds.<sup>30</sup> Insurance losses and federal disaster aid allocated to Maine that year totaled \$144,048,658.<sup>31</sup>

Extreme weather conditions can have wide-reaching health impacts. They can cause accidents, illnesses, injuries, and deaths. They can disrupt electrical power supplies, compromise access to public service broadcasts, and contaminate drinking water supplies, thereby placing populations in jeopardy. Downed electrical power lines and leaks from natural gas, or propane, tanks can cause fires, electrocutions, or explosions. Intense rainstorms can cause floods that wash raw sewage into drinking water supplies and spread infectious diseases such as salmonella, cryptosporidiosis, and giardiasis. Ice storms, hurricanes, and droughts can intensify forest fires, possibly leading to injuries, fatalities, and respiratory illnesses. Residents displaced from their homes by floods and hurricanes also may experience psychological problems, ranging from depression to post-traumatic stress syndrome.<sup>32</sup>

Depending on their severity, extreme weather events can tax, or even cripple, emergency care systems. A survey of hospital emergency departments in Maine found a 47 percent increase in the number of patients treated during the ice storm of 1998.<sup>33</sup> The loss of power that often occurs during such storms can result in an inability to run oxygen machines and other necessary medical equipment. This may endanger the health of many citizens, particularly those at most risk.<sup>34</sup>

### ***Direct Effects Of Heat On Health***

While average global temperatures have increased by 1 degree Fahrenheit, temperatures in Maine appear to be rising at a much higher rate. For example, over the last century, the average temperature in Lewiston has increased 3.4 degrees Fahrenheit.<sup>35</sup> Already, there are 11 more frost-free days in New England than there were two decades ago.<sup>36</sup> This upward trend is predicted to escalate. By 2100, average temperatures could increase by a full

8 degrees F.<sup>37</sup> To put this into perspective, for hundreds of millions of years, average temperatures across the globe have varied by no more than five to seven degrees. The average global temperature at the time of the last ice age was only nine degrees lower than temperatures are today.

Heat waves also have been on the rise in New England for the last 20 years. In Portland, Maine the number of 3-day heat waves went from 4 in 1956–1965 to 21 in 1986–1995.<sup>38</sup> In addition, the northeastern United States is seeing a rise in maximum daytime temperatures, along with higher nighttime minimum temperatures.<sup>39</sup>

Heat can directly affect health, as explained below. Often heat leads to high humidity, which can interfere with the body's ability to cool itself through perspiration. In Boston, the nearest city in New England for which heat wave projections have been made, one study predicts that a warming of

### **Air Conditioning: The Vicious Cycle**

Although residents of warmer states seem to acclimate to hot temperatures, one of the sad lessons of the heat waves of the 1990's is that people who are unused to hot weather and who do not have air conditioning suffer the most. In the deadly 1995 Chicago heat wave that killed over 600 people, the highest casualties were among elderly residents with no air conditioning. Unlike previous heat waves, overnight temperatures did not drop sufficiently to provide much needed relief. Minimum nighttime temperatures increased abruptly in the 1970's and are on the rise, thus the cooling effect of night air is no longer available during heat waves.<sup>40</sup>

About one-third of households in the Northeast do not have any form of air conditioning.<sup>41</sup> Maine, with its occasional heat waves, could also therefore be susceptible to increases in heat-related deaths.<sup>42</sup> Considering that temperatures across many parts of Maine, such as Lewiston, have already increased over 3 degrees this century,<sup>43</sup> the potential for disaster is certainly present. Already, nearby New Hampshire has had to receive federal emergency funds, for 1999's summer heat wave, to assist its residents who are most vulnerable to extreme climate changes.

Those who can afford air conditioning are likely to use it more as the weather gets warmer. Demand for air conditioning throughout New England and the Northeast already was at record levels in the exceptional heat during the summer of 1999.<sup>44</sup> This certainly was true as well for Maine, as evidenced by the increased energy output during this time by the Wyman Station power plant on Cousins Island near Yarmouth.

The hotter it gets, the more the demand for air conditioning increases. The increased energy used to

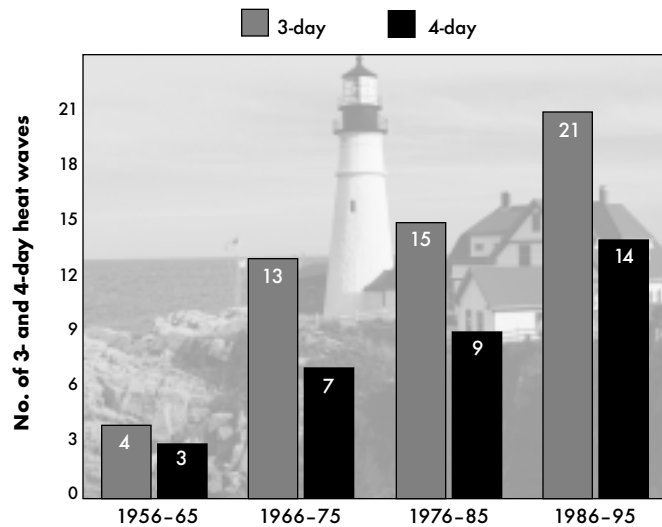
provide air conditioning can result in more greenhouse gas emissions in the atmosphere that may cause global warming, as well as increased emissions of other air pollutants from power plants. Taxed power plants powering air conditioners emit fine particulate matter (PM)<sup>45</sup> and are believed to be the biggest (per measurable point) source of air pollution concentrations along the East Coast.<sup>46</sup> In 1998, the Wyman Station plant ran about twice as much as normal in July to meet a high demand for power in New England. PM from the plant was said to be heavy enough to coat cars, homes, boats, and lawn furniture with thick layers of soot.<sup>47</sup>

PM is possibly the greatest consistent threat to respiratory health. Health effects of inhaling PM include premature death, increased hospital admissions and emergency room visits, increased respiratory symptoms and disease, decreased lung function, alterations in lung tissue and structure, and changes to respiratory tract defense mechanisms. Sensitive groups that appear to be at greater risk from such effects include the elderly, individuals with respiratory disease, such as asthma, and children.

As weather heats up, people with respiratory illnesses who do not have air conditioning are more likely to keep their windows open to allow for air circulation. Unfortunately, it is during the summer months that air pollutant levels are at their highest, thus increasing the chances of exposure to PM and ozone, another air pollutant that increases as temperatures rise and can exacerbate asthma and other respiratory conditions. To make matters worse, a disproportionate number of asthma sufferers are poor, and therefore are less likely to be able to afford adequate air conditioning.<sup>48</sup>

FIGURE 2

**Occurrence of deadly heat waves on the rise in Maine**



Along with the increase in average global surface temperatures during the past several decades, there has been a dramatic increase in the occurrence of deadly heat waves. This graph shows the rise in number of 3 and 4 day heat waves in Portland, Maine over 10 year periods from 1956-1995.<sup>49</sup>

Source: National Oceanic and Atmospheric Administration.

3 degrees Fahrenheit could increase heat-related deaths during a typical summer by 50–100 percent.<sup>50</sup>

Heat can 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, such as coronary heart disease, also are a risk factor.<sup>51</sup> Maine currently has the highest death rate from heart disease in New England.<sup>52</sup>

**Heat cramps** are muscle spasms that primarily affect people who exert themselves through strenuous work or exercise. These cramps are believed to be caused by mineral imbalances. Salt and water replacement usually relieves them. A more severe condition is exertional heat injury, which commonly occurs among runners who are not properly conditioned and hydrated. The body can reach 102 to 104 degrees, with symptoms that include goosebumps, 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.<sup>53</sup> At greatest risk are infants, small children, the elderly, those working or exercising outdoors, persons with impaired mobility, and individuals suffering from cardiovascular disease.<sup>54</sup> When moved to a cool place, a victim of heat exhaustion usually recovers.

**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 may come immediately, or could be delayed until several weeks later.<sup>55</sup> The public health burden of heat waves is compounded, as excessive heat increases the death rate for other medical conditions.<sup>56</sup>

### ***Hypothermia, Carbon Monoxide Poisoning, and Other Health Problems Associated with Ice Storms***

*The ice storm of 1998 was one of the worst events I've ever lived through. I think a lot of Maine residents would agree with me on that. Many of the health effects were unexpected, such as people falling off of roofs or succumbing to carbon monoxide poisoning. I hope that we never experience anything like this again. But the potential is there, given current global warming patterns.*

—ELIZABETH DESOMBRE, PROFESSOR OF ENVIRONMENTAL STUDIES & GOVERNMENT,  
COLBY COLLEGE, WATERVILLE, MAINE

While average temperatures are expected to rise in Maine in the winter, the increased variability of the climate may also mean winters with more days of extremely low temperatures.<sup>57</sup> Over the next several decades, the state can expect much heavier precipitation in the winter. Some estimates for New England forecast precipitation increases on the order of 25 to 50 percent.<sup>58</sup> And certain models predict precipitation changes for Maine that include little change in spring, an increase by 10 percent in summer and fall (with a range of 5–15 percent), and an increase of up to 30 percent in winter (with a range of 10–50 percent).<sup>59</sup>

As average temperatures increase, more of Maine's winter precipitation may fall in the form of rain, sleet and ice, increasing the likelihood of events such as the ice storm of 1998, which caused an estimated \$320 million in direct costs for Maine, plus \$300 million for repair of long-term forest damage.<sup>60</sup> Although the conditions necessary for the formation of ice storms are hard to predict, some scientists expect that warmer winter temperatures will lead to more ice storms in the future.<sup>61</sup>

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

- *Hypothermia*, an unintentional lowering of the core body temperature to less than or equal to 95 degrees Fahrenheit, is a deadly medical emergency.<sup>62</sup> From 1979 to 1995, 1 out of approximately every 333,000 people in Maine died from a hypothermia-related illness.<sup>63</sup> Already, 1 individual in Maine has died from hypothermia during the winter of 2000.<sup>64</sup> Early signs of hypothermia often are insidious. They include shivering, numbness, fatigue, poor coordination, slurred speech, impaired mental state, blueness or puffiness of the skin, and irrationality.<sup>65</sup> Other clinical problems may include blood, respiratory, renal and glandular abnormalities. Coma, low blood pressure and cardiac irregularities characterize severe hypothermia.

- *Heart failure* is a disabling chronic disease that is the leading principal diagnosis for hospitalization among older adults.<sup>66</sup> People with heart problems are vulnerable to temperature extremes because their cardiovascular systems must work harder to keep their bodies regulated.<sup>67</sup> The predicted increase in the number and severity of ice storms could, therefore, lead to more deaths due to cardiovascular disease. Already Maine has a high death rate for this condition, with 276 individuals dying of heart failure in 1995 alone.<sup>68</sup>

## The Ice Storm of 1998

The extreme weather events projected to occur as a result of global climate change may be exemplified by the severe ice storm that hit Maine, as well as much of the northeastern United States and southeastern Canada, from January 5 through January 9, 1998. No one who lived in Maine at that time could forget this storm, even long-time residents who have seen their fair share of inclement weather.

The storm began innocently enough on a Monday morning with freezing drizzle. As the day progressed, the drizzle turned to freezing rain—a rain that did not let up until late Friday.<sup>69</sup> By Saturday morning, January 10, much of the state was dangerously encased in 1 to 9 inches of ice.<sup>70</sup> The town of Gray declared a state of emergency, and residents were asked to stay indoors due to the risk of falling ice and other hazards. In parts of northern Maine, more than two feet of snow fell during the week and 6 to 10 inches of sleet were reported in parts of north central Maine.<sup>71</sup>

Statewide, the storm knocked out power to about 365,000 customers, affecting 840,000 people, or about 70 percent of the state's population of 1.2 million. About one third of those that lost power were without electricity for more than a week. For some, the electricity was off for up to 3 weeks. During this time, residents and those involved with the restoration efforts had to contend with snow, additional freezing rain, rain, slippery roads, falling ice and other debris, sub-zero temperatures, strong winds, and dangerous wind chills. For many homes, the lack of electrical power also meant no heat, no running water, and no means for cooking food.

Damage to property and public lands was extensive, and still persists to this day. By late April 1999, the storm had damaged an estimated \$300 million worth of timber and most of the maple trees used for syrup were hurt severely, affecting the economic well-being of many residents.<sup>72</sup> Numerous

trees turned into “widow makers,” whose dangling, heavy limbs could fall and crush anyone who works, walks or drives through wooded areas. At least 4 communication towers fell during the storm. In the Bar Harbor area, a 1/2-inch guy wire was reported to be encased in ice 9-inches in diameter.<sup>73</sup> At least 5 deaths were attributed to the storm. Two men died in separate incidents from carbon monoxide poisoning from inadequately ventilated generators. Carbon monoxide poisoning actually reached epidemic proportions in Maine at this time, with over 400 people treated at local hospitals. One man died when a tree fell on him as he was cleaning up debris. Tragically, an elderly man died of hypothermia after he fell down a flight of stairs in his dark, unheated home. Yet another man was crushed by the roof over a gas station island which was weighed down with ice and snow from the storm.<sup>74</sup>

The ice storm led to further accidents, as well as illnesses. A survey of three hospitals after the storm showed a marked rise in bone fractures, neck injuries, eye injuries, non-fracture muscle and bone injuries, cases of cold exposure, burns, lower respiratory tract illness, cardiac disease, acute gastrointestinal distress and even increases in alcohol, substance abuse and mental health problems.<sup>75</sup> A survey among residents further revealed incidents of vomiting, cough with fever and severe headaches with dizziness. The direct cause of these conditions was not specified. Many of these people dangerously were left without power or telephone service for almost the entire month.<sup>76</sup>

The storm left a heavy price tag in its wake, not only in terms of the damage to human health and property, but also economically. Numerous disaster shelters were set up throughout affected areas. President Clinton declared a federal disaster and more than \$13.7 million was provided in federal assistance to Maine.<sup>77</sup> Overall, the storm cost the United States \$1.4 billion and \$3 billion in Canada.<sup>78</sup>

Most of us are aware of the risks posed by heart failure and hypothermia, but the ice storm of 1998 showed that a number of less familiar problems result from such weather events. After the '98 storm, both the Maine Bureau of Health and the Centers for Disease Control and Prevention developed a community needs survey to assess the potential health hazards to residents of the state who remained without power.<sup>79</sup> The assessment revealed that individuals experienced a variety of health problems following the storm, including vomiting, diarrhea, cough with fever, severe headaches with dizziness, burns, lower respiratory tract disease and severe cuts.<sup>80</sup> Other than the ice storm itself, the report does not list the specific causes of these conditions.

The devastating '98 storm further showed the health risk posed by carbon monoxide, as carbon monoxide poisonings reached epidemic proportions statewide. Between 300 and 400 people were treated at area hospitals, possibly the largest outbreak of carbon monoxide poisoning ever in the nation.<sup>81</sup>

Carbon monoxide poisonings can occur during blizzards when people sit in idling automobiles with exhaust pipes blocked by snow.<sup>82</sup> Poisonings may also occur during power outages, when people often use unvented residential appliances such as stoves and heaters.<sup>83</sup> Inadequately ventilated generators pose another risk, and led to the deaths of two Maine men in 1998. 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.<sup>84</sup>

Carbon monoxide is an odorless, colorless gas that can attach itself to hemoglobin, impairing the oxygen-carrying capacity of the blood and starving a body's tissues and organs of oxygen.<sup>85</sup> The poor and the elderly especially are vulnerable to carbon monoxide poisoning. As of 1996, 11.2 percent of Maine's population lived below the poverty level,<sup>86</sup> many of whom were youths under the age of 18.<sup>87</sup> The poor are less able to afford proper heating systems, and often live in crowded housing with inadequate ventilation,<sup>88</sup> factors that heighten the risk for carbon monoxide poisoning. The elderly are vulnerable due to decreased lung capacity,<sup>89</sup> pre-existing health conditions, and other factors. 13.9 percent of Maine's population is 65 years old and over,<sup>90</sup> a figure that increases every year.

### ***Health Threats From Snowfall Extremes: The Winter of 1999–2000***

Carbon monoxide poisoning, hypothermia, heart failure and weather-related accidents also may occur as a result of extreme snowfall. Climate change models predict more variability in snowfall conditions, which can lead to such extremes. These conditions are evidenced by the winter of 1999–2000. Already, this year's winter promises to break many records. For example, only trace amounts of snow fell in the city of Portland during December, 1999. Normal snowfall for that time of year is 17 inches.<sup>91</sup> This is the smallest quantity of snow in 119 years of December snowfall records.<sup>92</sup>

Snow finally came on January 16, 2000, but, at 8 inches, was heavy, and accompanied by bitter cold and strong winds. Temperatures in the single digits and wind gusts of 30 to 50 miles per hour made the temperature feel as cold as 50 degrees F below zero.<sup>93</sup> 3,500 Maine residents lost power in the cities of Belgrade, Mount Vernon, Manchester, Oakland and Rome. Another 500

customers lost power in Denmark and Sebago.<sup>94</sup> Hazardous road conditions affected drivers. At least one death was attributed to the harsh snowfall and storm.<sup>95</sup> Snow and ice conditions increased the number of distress calls for inadequate heat.<sup>96</sup>

### ***More Illnesses, Injuries And Fatalities Related to Precipitation, Floods, Thunderstorms and Hurricanes***

Over the next several decades, precipitation in Maine is projected to show little change in spring, increase by 5–15 percent in summer and fall, and increase by 10 to up to 50 percent in winter.<sup>97</sup> The amount of rain on extremely wet days also is predicted to increase. Such heavy rainfalls can cause flooding, especially when combined with sea level rise, which is already a problem throughout much of Maine.

Floods cause an average of 146 deaths per year nationwide, most of which are due to drownings associated with motor vehicles in flash flood conditions.<sup>98</sup> Monetary damages associated with floods usually are steep. Just one flash flood in 1997 at North Monmouth caused \$250,000 damage to roads and \$100,000 damage to homes.<sup>99</sup> Floods also may result in cases of infectious disease, through contamination of drinking water supplies by bacteria and parasites. The most common of these illnesses, diarrhea, usually lasts only a few days. For individuals with weakened immune systems, however, this condition can be long-lasting and even fatal.

Floodwaters can contain fecal material from industrial and agricultural byproducts, and overflowing sewage systems. Maine's farming communities, in particular, face risks when pastures and crop fields are flooded. Although skin contact with floodwater does not, by itself, pose a serious health risk, there is a threat of disease from eating or drinking anything contaminated with floodwater. Floods may cause not only physical, but also mental, illnesses. Residents displaced from their homes may experience psychological problems, ranging from depression to post-traumatic stress syndrome.<sup>100</sup> These problems could hit hard in Maine, since numerous residents, especially the elderly, have lived in the same region and home for much of their lives.

In addition to an increased risk for floods, climate change may also heighten chances for more turbulent thunderstorms, due to predicted increases in atmospheric instability. As it stands, severe thunderstorms already are cause for concern in Maine. For example, a thunderstorm in the town of Westbrook during August, 1998, created extensive damage.<sup>101</sup> Many homes and vehicles were struck by falling trees. Wind gusts of up to 70 miles per hour left more than 30,000 homes without electricity. The cost for repairs totaled well over 2 million dollars.



Lightning from such events causes deaths and injuries in Maine each year. On just one day—February 22, 1997—a lightning storm sent nearly a dozen people to hospitals in the towns of Oxford and Greenville.<sup>102</sup> Even more injuries and fatalities due to lightning are expected to occur as a result of global warming.

### ***More Droughts Predicted***

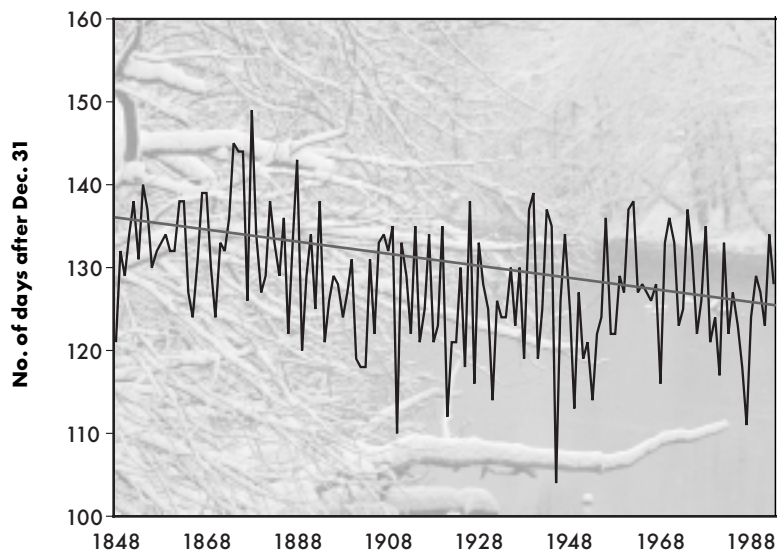
*We have begun to experience drought conditions in the summer, which not only affect our ability to grow crops, but also potentially impact our access to clean drinking water from our wells. With drought, sometimes water in the wells gets so low that “septic tank water” or saltwater—if the homes are on the coast—can intrude.*

—PAM PERSON, PROGRAM DIRECTOR, COALITION FOR SENSIBLE ENERGY,  
AND CO-CHAIR, MAINE GLOBAL CLIMATE CHANGE INC.

It may seem odd to think about droughts alongside floods and increased rainfall, but a variable and unstable climate that can shift from one extreme to another is precisely what global warming is likely to bring. The climate shifts predicted by some global climate change models may increase the frequency and severity of New England droughts.<sup>104</sup>

On average, New England experiences moderate drought conditions about once every ten years.<sup>105</sup> The worst episode this century was in the mid-1960’s. More recently, a prolonged drought occurred in the summer of 1997. In

FIGURE 3  
**Ice Out on Moosehead Lake, Greenville, Maine**



The date of “ice out” (the date at which ice melts) on Moosehead Lake has been reported since 1848. The data shown assigns a numbered day of the year to each reported date, based upon the number of days after December 31st. For example, January 1 = 1 and February 1 = 32. The trend line indicates a tendency to earlier dates, suggesting less severe winters and earlier spring conditions, both of which are predicted to occur as a result of global warming.<sup>103</sup>

Source: Publius Research

addition to economic losses, drought can result in water shortages, which can impair local sewer systems or force individuals to curtail their use of water for hygiene, washing food, and managing crops. Most of Maine experienced a severe drought in the summer of 1999, accompanied by reports of wells running dry and water shortages. More than 60 percent of Maine households draw their drinking water from groundwater supplied from private or public wells or springs.<sup>106</sup> These individuals may be particularly vulnerable to the effects of drought.

Droughts also concentrate microorganisms in water supplies and encourage pests such as aphids, locusts and whiteflies that can damage crops.<sup>107</sup> A pattern of drought interrupted by sudden rains can lead to large increases in rodent populations that can carry diseases such as hantavirus.<sup>108</sup> Lastly, drought conditions can dry out forests, increasing the risk for forest fires.

## Climate Change, Water Quality and Disease

Research shows that climate change will have major effects on precipitation, stream flows, storm surges, runoff, water temperatures, and evaporation, thereby affecting Maine's water supply. Both the quantity and quality of available water could be at risk. Increasing saltwater intrusion from rising sea levels, for example, may impact rivers and aquifers.<sup>109</sup>

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

### Threats to Groundwater

Groundwater, or water that is located beneath the surface of the ground in fractures in bedrock and between grains of sand and gravel deposits, is a valuable resource in Maine. Over sixty percent of all households in the state get their drinking water from these underground sources, primarily through wells. Agriculture relies upon groundwater for crop irrigation and livestock watering. Industries use groundwater in food processing, mining, metal finishing and other processes. Individuals and municipalities use groundwater for drinking water and waste disposal, garden and lawn watering and watering of golf courses.<sup>110</sup>

Given its importance in Maine, there is particular concern about what effect global warming will have on the quality and quantity of this water. Changing climate is expected to increase evaporation and precipitation.<sup>111</sup> Both of these conditions could damage Maine's groundwater. The first could dry up wells, a serious problem in a state that is predicted to experience longer and hotter summers accompanied by drought. The second could cause flooding, which perhaps is even more dangerous.

Flooding can contaminate groundwater with illness-causing bacteria and parasites. Fecal material from overflowing sewage systems, industrial and agricultural byproducts and saltwater also can contaminate groundwater. Pollutants may come from landfills, road salt storage, animal wastes, septic systems, underground petroleum storage tanks and the misuse and disposal of chemicals.<sup>112</sup> Even without floods and other events predicted to occur more often as a result of global climate change, these pollutants are causing problems for Maine's groundwater. A survey of wells by the Department of Environmental Protection in Maine revealed that 270 of the state's wells are contaminated and 342 are threatened with the risk of contamination.<sup>113</sup>

Contaminated groundwater can have serious health and economic impacts on individuals and municipalities. Drinking contaminated groundwater may cause significant health problems, including nervous system disorders, kidney and liver disorders and cancer.<sup>114</sup> The costs of cleaning contaminated groundwater can be staggering. In many cases, the water will not be usable again as a drinking water supply. In addition, property values in the affected areas may fall sharply.<sup>115</sup> At present, such problems are under control in Maine. But if climate change projections hold true, tragic consequences are in store for residents who rely upon groundwater.

Extreme weather events that cause flooding or disruptions in water supplies may bring on gastrointestinal disease. Two of the greatest threats are from giardia and cryptosporidium.

- *Giardiasis*: Giardiasis is an illness caused by an one-celled microscopic parasite that lives in the intestines of people and animals. It survives well in water. During the past 15 years, *Giardia lamblia* has become recognized as one of the most common causes of waterborne human disease in the United States.<sup>116</sup> In 1994 there were 335 cases of giardiasis in Maine,<sup>117</sup> but the true number of cases in the state was probably several times higher. In 1999, 240 cases were reported.<sup>118</sup> Diarrhea, abdominal cramps and nausea are the most common symptoms of giardiasis.
- *Cryptosporidiosis*: Another major threat to the United States water supply is from an organism called *Cryptosporidium*, which is small, difficult to filter, resistant to chlorine and ubiquitous in many animals.<sup>119</sup> Symptoms of the illness include diarrhea, stomach cramps, upset stomach, or slight fever. Cryptosporidiosis can be serious, long lasting and sometimes fatal for people with AIDS, and others whose immune systems are weakened.<sup>120</sup> In 1999, there were almost 3,500 cases of cryptosporidiosis in the United States. Incidents of the disease have been rising in Maine. In 1994 there were 22 reported cases, while 1999 had 30.<sup>121</sup>

## Food Contamination

Warmer, moister weather encourages the spread of diseases caused by food contaminated with toxic E. coli, salmonella, cyclospora and hepatitis-A.<sup>122</sup>

**Hepatitis A** is a liver disease with symptoms that include jaundice, fatigue, abdominal pain, loss of appetite, intermittent nausea, and diarrhea. An estimated 125,000–200,000 total infections of Hepatitis-A occur each year in the United States, of which about two-thirds can cause clinical disease and approximately 100 are fatal.<sup>123</sup> Hepatitis-A usually is transmitted by fecal-oral routes of exposure from food and waterborne sources. An outbreak of this disease occurred in Maine in 1997, and sent 66 people to local hospitals.<sup>124</sup>

**E. coli and salmonella** also have jeopardized health in Maine. In 1998, for example, 37 cases of E. coli were reported in the state.<sup>125</sup> 1995 saw 66 cases of E. coli. Salmonella has been an even greater problem in the state. In 1998 there were 165 reported salmonella cases. Maine had 192 cases in 1994.<sup>126</sup> The predicted warmer, moister weather could bring these numbers up even higher in the coming years.

## Red Tides And Seafood Poisonings

Certain seafood-related health problems arise when poisonous algae, known as dinoflagellates, bloom along New England shores in the spring or fall. Global warming is predicted to increase the occurrence and severity of such blooms. The harmful algae often stain water red—hence the expression “red tides.” In 1999 red tides resulted in two precautionary closures for shellfishing. The first was for mussels in the southern part of the state.

The second occurred in northern Maine, near Canada, and applied to soft shell clams.<sup>127</sup>

Nationally, such harmful algal blooms (HAB's) appear to be on the rise and seem to be expanding throughout the United States.<sup>128</sup> Before 1972, there were only isolated HAB outbreaks around the southern coast of Maine.<sup>129</sup> Since that time, HAB events have occurred along the entire New England coastline. Red tides, and other HAB's, impact human health when individuals consume shellfish that previously fed in infected waters. Raw or cooked shellfish can then pass the toxins to humans, causing shellfish poisoning. During the 1980's, Maine had over 8,000 reported cases of shellfish poisonings.<sup>130</sup> Luckily, none proved to be fatal. The number of cases has dramatically reduced since that time, due to effective monitoring and public education. The threat of illness, however, remains. As described below, there are five principle types of seafood/shellfish poisoning.

- *Amnesic Shellfish Poisoning (ASP)*: ASP can be life threatening. It may become evident up to 24 hours after an individual consumes toxic shellfish. Symptoms include nausea, vomiting, abdominal cramps and diarrhea. In severe cases, neurological symptoms also appear, such as dizziness, headache, seizures, disorientation, short-term memory loss, respiratory difficulty and coma.<sup>131</sup> In 1987, four victims died after consuming toxic mussels from Prince Edward Island, Canada.<sup>132</sup> Fish and crab also may cause ASP. From 1985 to 1995, 6 to 10 ASP events occurred along the coast of Maine,<sup>133</sup> causing shellfishing closures.<sup>134</sup>
- *Ciguatera Fish Poisoning (CFP)*: CFP produces all of the above symptoms, as well as reversal of temperature sensation, muscular aches, anxiety, sweating, and a

## Endangered Salmon

Maine's fisheries are among the most valuable in the United States. In New England they are second only to those of Massachusetts. Lobsters, ocean perch, pollack, cod, clams and shrimp are among the catch. Salmon used to make up a big portion of this catch, but no more. On November 18, 1999, the federal government proposed an endangered species listing for Atlantic salmon in Maine.<sup>135</sup>

What happened to the salmon? While factors such as dams and over-fishing can reduce fish populations, a report issued by the Maine Atlantic Salmon Commission suggests that one of the principle reasons for the salmon's decline is sea surface temperature changes. Atlantic salmon thrive in 4 to 10 degree Celsius waters, but beyond this range, their survival rate appears to be compromised.<sup>136</sup> Right now, small numbers of adult salmon are returning to Maine to spawn, and young smolts in Gulf of Maine rivers are surviving at a lower rate than expected.<sup>137</sup>

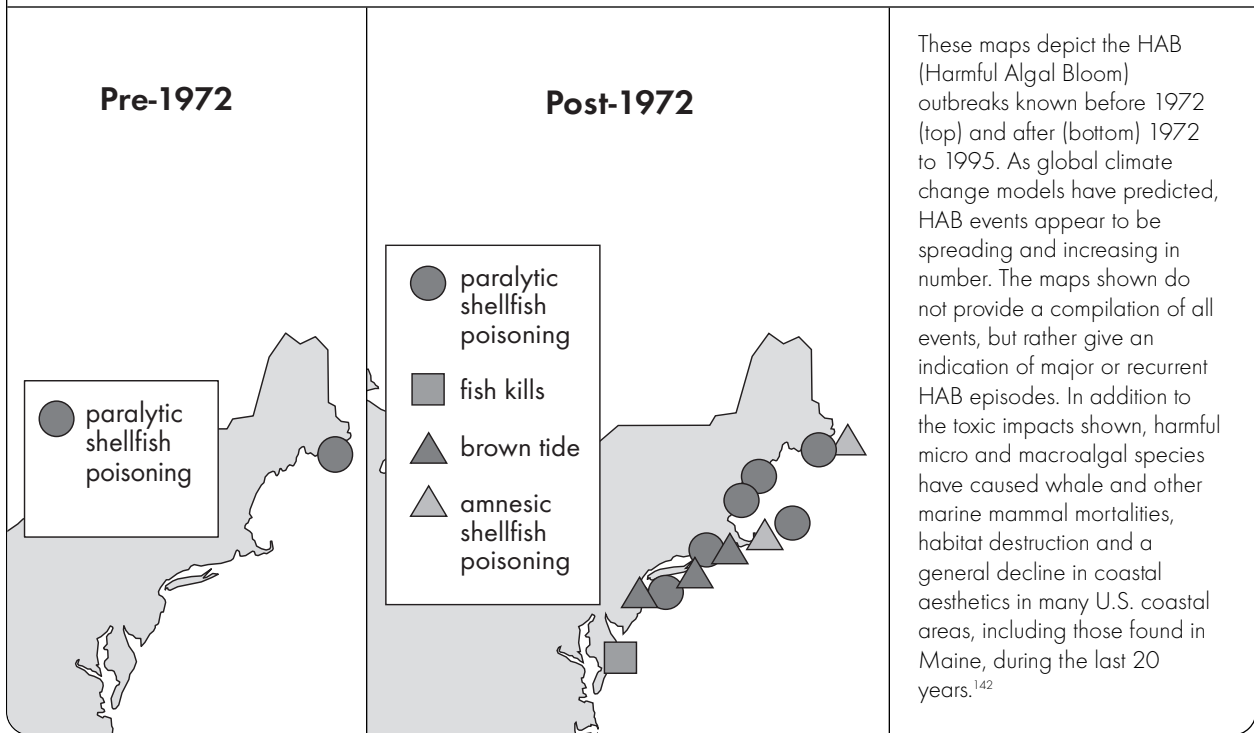
Global warming likely is the culprit. The EPA projects that global warming may change, and perhaps already has, the temperature and chemical composition of the waters that fish inhabit.<sup>138</sup> The amount of oxygen in the water may decline, while pollution and salinity levels increase<sup>139</sup> and can literally poison the fish to death.

Consumers of contaminated salmon and seafood face health risks. High water pollution and toxic algal blooms heightened by global climate change increase the possibility for developing ciguatera, a frightening illness that may cause paralysis and even death. In addition to the number of direct physical problems caused by global warming's effect on seafood, there is great stress on Maine's fisherman, who rely upon good catches to make a living. And it is not just the fishermen themselves. There are countless others who work in processing plants throughout the state.

A drop in the number of salmon, shrimp and other catches can lead to a drop in the income of these individuals, many of whom are already living from paycheck to paycheck. Lack of income further leads to an increased risk of health problems, not only because of increased mental stress, but also because people are not able to afford health insurance. As it stands, 12.7 percent of Maine's population is without health coverage.<sup>140</sup> Many of these individuals are children<sup>141</sup> and the elderly, people who are vulnerable to health problems associated with climate change.

FIGURE 4

**Expansion of HAB (Harmful Algal Blooms) in the Northeastern US**



numbness and tingling of the mouth and digits. Paralysis and death have been documented.<sup>143</sup> There is no antidote, but survivors have recovered after taking the drug manitol and undergoing supportive therapy.<sup>144</sup>

- *Diarrhetic Shellfish Poisoning (DSP)*: DSP produces gastrointestinal symptoms, usually beginning within 30 minutes to a few hours after consumption of toxic shellfish.<sup>145</sup> Although the illness is not fatal, it can lead to incapacitating diarrhea, nausea, vomiting, abdominal cramps and chills.
- *Neurotoxic Shellfish Poisoning (NSP)*: This condition is nearly identical to ciguatera, but also causes respiratory problems, such as asthma-like episodes. It is less severe than ciguatera, and no deaths have yet been reported.<sup>146</sup> It is, however, a debilitating and frightening illness.
- *Paralytic Shellfish Poisoning (PSP)*: PSP is extremely deadly, as symptoms appear rapidly and severely. They include tingling, numbness, burning, drowsiness, fever, rash and staggering. Respiratory arrest occurs within 24 hours of consuming toxic shellfish in the most severe cases. There is no known antidote.<sup>147</sup> 6–10 PSP events occurred along Maine’s coast from 1985–1995.<sup>148</sup> Shellfishing closures and public education efforts prevented any serious outbreaks of PSP poisonings.<sup>149</sup>

## Air Pollution, Respiratory and Cardiovascular Disease

*Projected climate changes could lead to exacerbation of respiratory disorders associated with reduced air quality in urban and rural areas and effects on the seasonality of certain allergic respiratory disorders.*

—INTERNATIONAL PANEL ON CLIMATE CHANGE,  
REGIONAL IMPACTS: NORTH AMERICA, 1998.

Two air pollutants are affected by heat: ozone and volatile organic compounds (VOC's). Each has adverse health impacts. In addition, climate changes can affect pollen levels, which exacerbate allergies.

### **Smog**

Ground-level ozone is the major component in 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 likely will become more numerous with global warming.

Ozone, or smog, is a toxic and irritating gas that, even in small amounts, can affect lungs and health. It is formed when nitrogen oxides and volatile organic compounds (VOCs), emitted from motor vehicles, power plants, refineries, factories, and other combustion and industrial sources, are heated by sunlight.<sup>150</sup> Given that cars are a source of VOCs and that the number of vehicle miles traveled in Maine continues to rise above the national average,<sup>151</sup> high ozone days, and the health problems they create, are also likely to increase. Warmer temperatures increase the concentration of these pollutants in the atmosphere.<sup>152</sup>

Exposure to elevated ozone can cause serious coughing, shortness of breath, pain when breathing, lung and eye irritation, and greater susceptibility to respiratory infections such as bronchitis and pneumonia.<sup>153</sup> 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.<sup>154</sup> Even moderately exercising healthy adults can experience a 15 to 20 percent—or higher—reduction in lung function from exposure to low levels of ozone over several hours.<sup>155</sup> In addition to the effects on those suffering from respiratory illnesses, some healthy people simply are more sensitive to ozone than others, and experience more health effects from ozone exposure than the average person.<sup>156</sup>

Maine violated the proposed EPA eight-hour standard for ozone 29 times during 1999.<sup>157</sup> This means that the state's air quality had ozone levels exceeding 85 parts per billion (ppb) on those occasions.<sup>158</sup> During this same year, Maine had three 1-hour exceedances, where ozone levels were higher than 125 ppb.<sup>159</sup>

Ozone causes breathing difficulty for 395,000 people in Maine—approximately one third of the state's entire population.<sup>160</sup> These individuals are most commonly the elderly, children, and those who have respiratory ailments.<sup>161</sup> From April to October of 1997, ozone-related illnesses, such as

respiratory and cardiovascular problems, sent thousands of people to hospitals in Maine.<sup>162</sup> Since 1980, yearly state ozone health warning level exceedance days, for 8 hour violations above 85 ppb, always numbered at least 20, and were usually way above that figure.

Numerous studies link ozone with aggravation of asthma, impaired immune function, greater susceptibility to respiratory infections (such as bronchitis and pneumonia) and lung tissue damage. The symptoms include coughing, shortness of breath, and eye and throat irritation.<sup>163</sup> Of these conditions, asthma is a special concern.

Asthma is reaching epidemic proportions in the United States, particularly among children. A leading cause of absences from school, asthma can reduce lung capacity and, if left untreated, can be fatal.<sup>164</sup> Children's airways are smaller than those of adults, which makes them more vulnerable to asthma. Adding to their vulnerability is the fact that children breathe more rapidly than adults. When someone suffers repeated asthma attacks, the pathways of the lungs become so narrow that simple breathing is as difficult as "sucking a thick milk shake through a straw."<sup>165</sup> The prevalence of asthma in children under age 18 rose 72 percent in the 12 years from 1982 to 1994, while the death rate from asthma for children 19 years and younger in the United States increased by 78 percent from 1980 to 1993.<sup>166</sup> Asthma accounts for one in six pediatric emergency room visits in the U.S. One out of every twelve children in Maine has asthma.<sup>167</sup> Children are not the only members of the population who are vulnerable to asthma. 40,000 Maine adults have asthma.<sup>168</sup> In addition, adults who smoke increase their risk for developing respiratory disorders, such as asthma.<sup>169</sup> 21.9 percent of people over the age of 55 in Maine smoke.<sup>170</sup>

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.<sup>171</sup> More generally, however, asthma is associated with air pollutants such as ozone and particulate matter.

### ***Volatile Organic Compounds (VOC's)***

Another set of air pollutants consists of VOC's that are emitted by large power plants and municipal waste combustors, as well as by small sources, such as dry cleaners, printers, cars and trucks. VOC's include a variety of hazardous air toxins, including benzene, toluene, xylenes and heavy metals such as cadmium, mercury, chromium and lead. These hazardous air pollutants are associated with cancer as well as adverse neurological, reproductive, and developmental effects. Higher temperatures cause VOC's to evaporate and disperse more rapidly into the atmosphere.<sup>172</sup>

### ***Pollen***

When the thermometer starts rising on warm days, pollen counts tend to rise as well. In 1999, Maine had 16 severe pollen count days, and numerous

other days with high pollen and mold spore counts.<sup>173</sup> Many 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.<sup>174</sup> Hay fever sufferers in Maine are likely to experience more attacks, during more months of the year.

## Sea Level Rise and Related Health Risks

*The warming is moving down the Antarctic Peninsula and is probably responsible for some of these ice shelves on both sides of the Peninsula breaking up in recent years . . . And if we already see the effects of warming on the Peninsula of the West Antarctic Ice Sheet with the breaking up of these ice shelves, then those ice shelves at the northern margins of the East Antarctic Ice Sheet, extending for 8,000 km over an enormous front, are a much greater concern.*<sup>175</sup>

—TERENCE J. HUGHES,  
INSTITUTE FOR QUATERNARY STUDIES,  
UNIVERSITY OF MAINE

The sea level along much of the United States coastline has been rising at a rate equal to 10–12 inches per century.<sup>176</sup> Most of the rise has occurred as warmer temperatures cause the ocean to expand. Melting glaciers and Antarctic ice shelves also contribute to the rise. In 1996, a Rhode Island-sized ice shelf broke off, melted and turned to sea water.<sup>177</sup> Global warming could increase the rate of sea level rise due to further expansion of the sea's surface layer and glacial melting.<sup>178</sup> The Environmental Protection Agency (EPA) and other organizations expect the sea level along

## The State of the Science

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 the 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.

Our current understanding of the potential impacts of climate change is limited by a number of factors. Climate models that project climatic changes and their impacts are still being developed and perfected. Natural climate variability and other factors such as air quality, land use, population, water quality, health care infrastructure and the economy can also impact projections. A few scientists even argue that countervailing climatic forces, such as sulfur dioxide, actually are cooling the atmosphere. However, the majority of climate scientists agree that greenhouse gases produced by humans are changing Earth's atmosphere and that now is the time to take action on a global level.

Forecasting models are gaining credibility every day as weather and other environmental occurrences confirm projected scenarios. In addition, scientists continue to uncover data that supports the occurrence of climate change. For example, a study published in the summer of 1999 in the scientific journal *Nature* examined the Antarctic ice cores. Scientists found that atmospheric temperatures historically correlate with atmospheric concentrations of the greenhouse gases carbon dioxide and methane. Today, concentrations of these gases appear higher than they have been in the past 450,000 years.<sup>179</sup>

Even if certain individuals are able to adapt to changes caused by global warming, some populations will remain susceptible. These individuals include infants, children, the elderly and the infirm. Maine's elderly population continues to grow in numbers higher than the national average,<sup>180</sup> so the state will be among those most vulnerable to climate change.

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 will bring.

## Maine's Battered Southern Coast

For hundreds of years, Maine's 3,500 mile coast has drawn explorers, settlers and visitors to the state. Few can resist the coast's rugged, natural beauty, which perhaps explains the number of homes located in towns and cities along the shoreline, not to mention the prevalence of hotels and recreation centers that cater to tourists who bring valuable income to the state. The Atlantic Ocean continuously beats against the coast, but the rocky shoreline appears strong and invincible, ready to withstand any torment.

Unfortunately, even Maine's coast is little match for the sea level rise and coastal erosion predicted to occur as a result of global climate change. Increased precipitation and melting glaciers and ice shelves already appear to be causing the Atlantic to swallow up portions of the coast. Nearby Massachusetts loses 65.4 acres per year of its shoreline due to coastal erosion, and Maine's rate of loss could be just as great.<sup>181</sup> At Rockland, for example, sea level already is rising 3.9 inches per century, and is likely to rise another 14 inches by 2100.<sup>182</sup> Steps can be taken to reduce damages, but these are often expensive and ineffective. The estimated cost for such measures is between \$200 to 900 million.<sup>183</sup>

The risks associated with these measures are evidenced by what happened in Maine on October 10, 1998. That day, heavy rain accompanied by strong winds spread over the southern part of the state. By afternoon, rivers, streams and low areas began to flood. Large and powerful waves caused astronomically high tides that eroded sections of the coast. The Kennebunk sea wall, erected to protect residents from such events, proved to be of little help and, in fact, became a hazard itself. 230 feet of the concrete and steel wall collapsed, causing it to slide forward and drop onto the beach.<sup>184</sup> Storm surges increased the risk for drownings and other related injuries, but miraculously, residents escaped harm. The President declared both Cumberland and York Counties federal disaster areas.

The effects of sea level rise and coastal erosion are not always so dramatic. Often they occur at a relatively slow pace, gradually eating away sections of Maine's treasured coast and, in the process, causing stress and concern for residents. This is evident in areas such as Camp Ellis in Saco, where a committee has formed to address the ever-increasing problems.<sup>185</sup> The town manager of Wells, situated along Maine's southern "Gold Coast," has issued a statement voicing concerns about problems affecting the town due to climate change and sea level rise. The situation is so bad along the coast that people are allowed to build homes there only if they take out "rolling easements," in which prospective homeowners are given permission to build, but on the condition that they will remove the structure if and when it is threatened by an advancing shoreline.<sup>186</sup>

the Gulf and Atlantic coasts to rise an additional foot by 2050, possibly as early as 2025. It is likely that sea level actually will rise by two to four feet over the next century.<sup>187</sup>

Until recently, sea level in Maine rose about .0026 feet per year. This rate lasted for thousands of years, but has begun to dramatically change in the last several decades. Now, that rate has almost tripled, according to measurements taken in Portland and Eastport,<sup>188</sup> and is even higher in areas such as Rockland.<sup>189</sup> Sea level rise can result in flooding of low-lying property, loss of coastal wetlands, erosion of beaches, saltwater contamination of drinking water, and decreased longevity of low-lying roads, causeways and bridges. It also increases the vulnerability of coastal areas to storms and associated flooding.<sup>190</sup> Each of these possibilities brings with it a number of health risks, including gastrointestinal distress from drinking contaminated water, car accidents due to damaged roadways, drownings associated with storm surges and psychological distress from loss of income and property.

Possible responses to sea level rise include allowing the sea to advance and adapting to it, and raising the land (e.g., by replenishing beach sand, elevating houses and infrastructure). Both of these responses will be costly, either in out of pocket costs or in lost land and structures.<sup>191</sup> For example, the EPA reports that the cumulative cost of sand replenishment to protect Maine's coastline from sea level rise by 2100 is estimated at \$200–\$900 million.<sup>192</sup> Hard barriers also are fallible, as evidenced by the destruction of a 230 foot sea wall in a storm at Kennebunk on October 10, 1998.<sup>193</sup>

## 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.*<sup>194</sup>

—ROSS GELBSPAN, JOURNALIST, IN AN ARTICLE FOR *THE BOSTON GLOBE*

In the warmer and wetter days to come, insects and rodents likely will multiply in number, increasing the human health risks for diseases they can spread. In terms of vector-borne illness—meaning diseases carried by a host, such as a mosquito or tick—the rate of insect biting and the rate of maturation for the disease-carrying microorganisms depend on temperature. Both rates will increase with warmer weather.<sup>195</sup> 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.<sup>196</sup> Within a certain range, warmer temperatures also enable such disease vectors to spread to higher elevations and more temperate latitudes.

Lyme disease, carried by ticks, 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.<sup>197</sup> Lyme disease is dramatically on the rise in Maine. In 1994, lyme disease cases totaled 33. In 1998 this figure more than doubled to 76 cases.<sup>198</sup> A warming trend could increase Maine's tick populations, while warmer winters will permit people to enter tick-infested habitats earlier in the season, thereby increasing the risk for transmission of the disease.<sup>199</sup> Ticks in New England also carry babesiosis (animal malaria), ehrlichiosis (a treatable bacterial disease), and a virus that can cause encephalitis.<sup>200</sup>

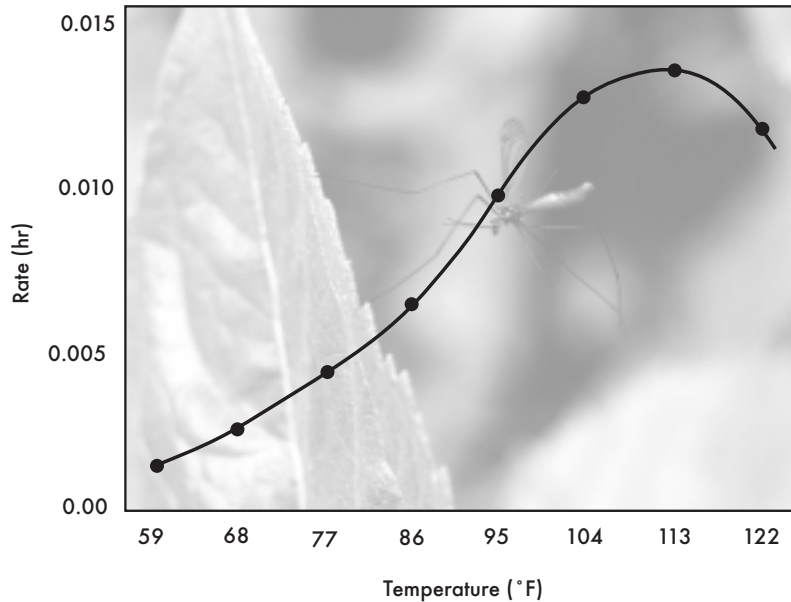
Other more exotic and frightening diseases also could become more prevalent as the weather gets hotter and wetter. Many of the organisms and processes linked to the spread of infectious diseases are especially influenced by climate variations such as temperature, precipitation, and humidity. Therefore, climate change can be expected to cause shifts in the patterns of infectious diseases and where they are seen worldwide.<sup>201</sup> For example, public health officials throughout the world are seeing an alarming resurgence of parasitic diseases, such as malaria, and arboviruses (viruses borne by arthropods), such as dengue fever.

Disease outbreaks are occurring more frequently in the United States due to factors such as increased immigration and travel abroad by Americans who bring diseases home. Once a parasite that causes a disease is brought into a state by travelers, a warmer climate fosters faster growth of the parasite, as well as the host organism, thus increasing the risk of local transmission. Some diseases that may pose new threats in Maine are West Nile virus, hantavirus, and malaria.

One of the most recent and disturbing new disease outbreaks was the West Nile virus in the New York City area in 1999. Until the summer of 1999, the virus had never been reported in the Western Hemisphere.<sup>202</sup> Fifty-six cases were identified as of October 19, 1999, resulting in seven deaths, and the

FIGURE 5

**Warmer weather promotes breeding by disease-carrying mosquitoes**



This graph shows the correlation between temperature and the rate at which mosquito larvae mature.<sup>203</sup>

Source: Focks et al 1993.

Centers for Disease Control feared the virus could travel beyond New York to other states.<sup>204</sup> The virus is carried mainly by mosquitoes, but also by ticks, and is passed along to birds and humans.

Malaria in Maine? It sounds unlikely, but consider this: Maine had 3 cases of malaria in 1999 and 5 cases in 1998, from residents who had contracted the illness while traveling.<sup>205</sup> A relationship has been observed between some exceptionally hot and humid weather and isolated spreading of malaria.<sup>206</sup> And, some scientists estimate that an increase in average global temperatures of several degrees by the year 2100 will increase the capacity of mosquitoes to transmit the disease 100-fold in temperate countries.<sup>207</sup>

Even hantavirus, a deadly disease carried by deer mice, is not inconceivable in Maine. Nearly half of all hantavirus cases result in death. The geographical range of the deer mouse extends into New England and currently, cases have been reported as far north as Rhode Island.<sup>208</sup>

## **Economic and Physical Stresses Could Result from Impacts on Forestry, Agriculture, and the Syrup Industry**

Maine's nickname, The Pine Tree State, reveals just how important stands of timber are to residents. Forests, valuable both for ecological and economic reasons, cover nearly 89 percent of the state. White pine hardwood, spruce fir and northern hardwood types dominate, and are the basis of two major industries: paper and allied products and lumber and wood products.<sup>209</sup> In fact, forestry is tied to the three most valuable industries in the state: paper and allied products, tourism, and lumber and wood products. Climate change is predicted to affect the range of forested land and the type of trees able to grow, thereby putting all of these industries at risk. Because of this potential impact to Maine's major industries, a large portion of Maine's population could be subjected to economic and psychological stress.

Economics ties the health of the forests to human health, given the rising costs of health insurance and medical care. And impacts on the economy could increase Maine's already high percentage of citizens without health insurance coverage. Therefore, those employed in these industries could be hit hard.

The same economic and physical stresses could affect Maine citizens engaged in the maple syrup industry, particularly those residing in the White Mountains. Climate change could threaten the now-thriving industry by raising overall temperatures and increasing night warming. If this forecast holds true, the flow of sap in the White Mountains could severely drop, forcing numerous maple syrup producers out of business.<sup>210</sup>

The population of Maine that fills over 60,000 full and part-time jobs in the agriculture and agrifood industry<sup>211</sup> could also suffer. Climate change is the primary determinant of agricultural productivity.<sup>212</sup> Thus, the variable weather conditions predicted to occur due to global warming could have a significant impact on Maine farmers and the state's economy. Maine's two major crops, potatoes and hay, are especially vulnerable.<sup>213</sup> Growers of such crops could be forced to alter their farming practices, or face economic losses. Like those involved in forestry or the syrup industry, these individuals could suffer economic and psychological stress that could compromise their ability to afford proper housing, food and medical coverage for themselves and their families.

### ***More Injuries and Fatalities Predicted to Occur Because of Forest Fires***

Temperature increases and related weather extremes predicted to occur as a result of global warming, such as drought, could wreak havoc on Maine's timber stands. Droughts dry forests, paving the way for forest fires, that, at present, already are a big problem in the state. In 1999 during just one week in April—which is a relatively low fire season month—over 85 wildfires were reported in Maine.<sup>214</sup>



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.<sup>215</sup> From a health standpoint, they may cause injury and fatalities to firefighters and nearby residents. Smoke, which can cover a wide area, may increase respiratory illness, such as asthma and chronic obstructive pulmonary disease, for many people, particularly those with pre-existing respiratory conditions.<sup>216</sup>

### **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 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 International Physicians for the Prevention of Nuclear War.

# What You Can Do

*As a person becoming ill develops a fever as a sign, this planet has begun to show signs of illness, and human illness or death is certain to follow. History is full of overflowing with examples. The best action that can be taken to avoid tragedy, whether managing the illness of one or many, the earth or humanity, is early intervention.*

—LANI GRAHAM, MD, MPH; FORMER DIRECTOR, MAINE BUREAU OF HEALTH

*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,  
U.S. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Can residents of Maine do anything to reverse the trends before global warming 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.

To be sure, questions remain about the exact causes of global warming and how seriously it threatens human health, but enough is known about global warming to require action now. Its potential to cause harm is indicated by the insurance industry's decision to create a \$200 billion reserve to pay for damages expected to be caused by the increase in hurricanes and other extreme weather events.<sup>217</sup> Moreover, the energy conservation techniques recommended here to protect against global warming are basically the same as those desperately needed to cut air pollution. The quality of our children's lives will depend upon the actions we take today.

There is a lot you can do, starting now, to bring down consumption of fossil fuels.

**1** Demand that electric utilities use low-carbon technologies and renewable energy. Maine still has some 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 lbs./yr.). Leave your car at home for one or two days a week and you will save tons of carbon dioxide emissions. Lower your thermostat in winter and raise

it in summer, thereby reducing the demand for electricity and the burning of fossil fuels.

**3** If you are buying a new car, go for a more energy-efficient one. Encourage auto makers to develop and sell cars, trucks and sport utility vehicles (SUV's) with better mileage and higher fuel efficiency (CAFE) standards. At a web site newly launched by the EPA and the U.S. Department of Energy (<http://www.fueleconomy.gov>), you can do a side-by-side comparison and select the most energy-efficient vehicle that meets your needs.

**4** 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>).

**5** Carpool, and drive less. Nationally, cars contribute 30 percent of greenhouse gases in the air. In Maine, emissions from cars contributed a hefty 47 percent in 1990, a figure that is actually on the rise, due to increased use in light trucks and sport utility vehicles. Do your part, by carpooling and using public transportation whenever possible.

**6** 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 the members of Congress that we are not afraid of higher fuel efficiency (CAFE) standards—for cars, SUV's and light trucks—and they should not be either!

**7** Work with local groups and chapters of national organizations to promote awareness of global warming and related issues in Maine. These include: the Maine Chapter of Physicians for Social Responsibility (207-772-0680), Maine Global Climate Change, Inc. (207-469-6770), American Lung Association of Maine (800-499-5864), American Heart Association (800-242-8721), Independent Energy Producers of Maine (207-626-0730), Coalition for Sensible Energy (207-469-6770), Sierra Club Foundation, Maine Chapter (207-761-5616), National Resources Council of Maine (207-622-3101), Friends of Casco Bay (207-799-8574), Maine Audubon Society (207-781-2330), Maine Cardiovascular Health Council (207-622-7566), Maine Organic Farmers and Gardeners Association (207-568-3141), Consumers for Affordable Health Care Foundation (207-622-7083), Maine Peace Fund (207-772-0680), Bicycle Coalition of Maine (207-288-3028), Conservation Law Foundation, Inc. (207-594-8107),

China Region Lakes Alliance (207-445-5021), A.E. Howell Wildlife Conservation Center (207-532-6880), Forest Society of Maine (207-945-9200), Friends of Acadia (207-288-3340), The Island Institute (207-594-9209), Maine Coast Heritage Trust (207-729-7366), Natural Resources Council of Maine (207-622-3101), The Nature Conservancy, Maine Chapter (207-729-5181) and many others.

**8** Encourage local, state and national decision makers and politicians to support the Earth Day Clean Energy Agenda. On April 22, 2000, the thirtieth annual Earth Day will be celebrated all around the country. This year the Earth Day message includes the Clean Energy Agenda that calls for clean power, clean air, clean cars and clean investments. A transition to energy efficiency and renewable energy will go a long way in combating global warming. Physicians for Social Responsibility is a member of the Earth Day Network (EDN), a global alliance of environmental organizations working together to battle climate change. Our Death by Degrees report can be used as a tool to educate everyone about the potential health effects of global warming as part of a message for the need for cleaner energy. Contact the Earth Day Network (206-264-0144) or see the web site (<http://www.earthday.net>) for more information about Earth Day 2000 and to find out what events are planned in your area.

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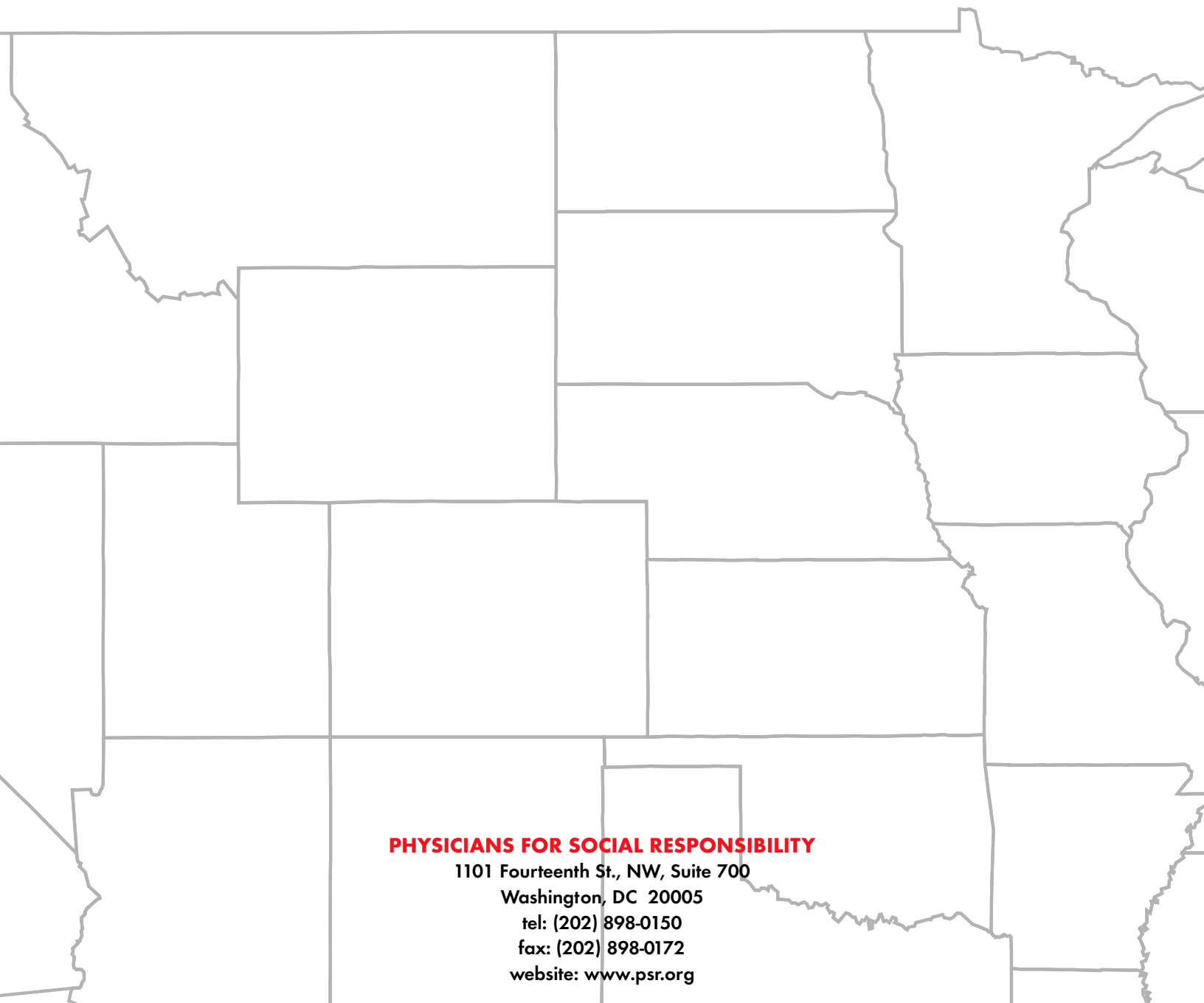
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