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DEATH BY
DEGREES
**The Health Threats
of Climate Change
in Florida**

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This report was prepared by Physicians for Social Responsibility to alert Florida 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

Climate change and human disease are intricately related. It is a phenomenon we will see more of as we continue to experience global warming.

—JOHN TAYLOR, PH.D., UNIVERSITY OF CALIFORNIA AT
BERKELEY COLLEGE OF NATURAL RESOURCES (1).

Climate fluctuations have occurred during previous centuries, but at the dawn of the 20th century a warming trend took hold that now shows no signs of stopping. During the past 100 years, average global surface temperatures have increased by approximately 1°F (2). In Florida, the average temperature during the period from 1966 to 1995 was 2°F higher than it was from 1892 to 1921 (3). The last 13 years, from 1987 to 2000, are among the 15 warmest years on record (4). 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 (5).

Although uncertainties exist in measuring global warming, an overwhelming consensus among scientists has emerged during the last decade on several key points:

- The increase in temperature is real.
- Human activities—in particular our burning of fossil fuels—are affecting the climate system (6).
- Warmer conditions on Earth will directly affect our lives, health, and well-being (7).

This report describes how the changing global climate could affect human health. Our focus is on Florida, a state that many consider to be at unusually high risk for increased illness, injury, and mortality due to changes in temperature and weather.

Executive Summary: Florida—A State At Risk

Climate change occurs on a global scale, so most international documents focus on regions throughout the world that are projected to experience the greatest effects, such as the Pacific Islands, Bangladesh, Venice, and Japan. Along with these high-impact areas, climatologists almost always mention Florida. Virtually every natural feature that makes Florida desirable, including its 8,000 miles of coastline, abundant sunshine, and low-lying beach areas, also makes the state vulnerable to the effects of climate change.

Florida's natural environment is changing: Florida's coastal forests are gradually dying out due to flooding from encroaching seas (8), and once-vibrant coral reefs are becoming bleached and lifeless skeletons (9). Some of these changes are directly a result of climate change. Some are related to changes in land use, pollution, or some combination of all of these forces. Florida's natural environment and variety of ecosystems, when healthy, can provide many useful benefits to help keep the human populations in Florida

How Global Warming Could Threaten Health in Florida

According to physicians who have studied global warming and its effects, the most severe health risks in Florida could include the following:

Decreased air quality, causing more frequent and severe attacks of asthma and worsening of other respiratory and cardiac problems, could result from:

- Increased ozone (smog) levels.
- Greater emissions of carbon dioxide, nitrogen oxide, sulfur dioxide, particulate matter, and other toxic pollutants.
- Increased pollen levels.
- Smoke from forest fires sparked by drought.
- Dust blown from African deserts.

Heat-related illness:

- Number of heat-related deaths could increase significantly.
- Senior citizens, the very young, and the poor are at greatest risk of death from heat stress.

Increased accidents and injuries could result from:

- An increase in extreme weather events.
- A projected increase in sea level of 18 to 20 inches by 2100 would bring worsening storm surges, flooding, and coastal erosion.

Infectious Diseases:

- Water used for drinking, recreation, and shellfish harvesting can become contaminated by animal and human wastes. This is more apt to occur after heavy rainfall and can lead to bacterial, parasitic, and viral infections.
- Food-borne disease risks from *Cyclospora* associated with fruits and vegetables and *Vibrio vulnificus* infections associated with shellfish increase with warmer temperatures.
- Increased episodes of harmful algal blooms that can cause diseases such as ciguatera poisoning and neurotoxic shellfish poisoning in humans.
- Increased risk of mosquito-carried diseases.

Food and Water Supply:

- Potentially decreased yields of citrus, corn, sugarcane, and potatoes.
- Warmer temperatures leading to enhanced evaporation combined with changes in precipitation could require more crop irrigation further jeopardizing water resources.
- An increase in extreme weather events could lead to more flooding or droughts further compromising water supply and quality.

healthy. Florida's greatest challenges may be on the horizon, though, given the further changes that global warming could bring.

According to the U.S. Environmental Protection Agency (EPA), average temperatures in Florida could increase by 3° to 4°F during the next century (3). Based on information from new studies, the IPCC (Intergovernment Panel on Climate Change) revised its previous temperature projections upward and now anticipates average global temperatures to increase by 2.5° to 10.4°F by 2100 (2). Temperatures over landmasses likely will be even higher (2). Local temperature projections for Florida have not been revised yet, but it is reasonable to expect a further increase.

The distribution of precipitation also is projected to change. During the next century, increases of rainfall in some areas of Central Florida and the Panhandle, and decreases in the Keys and portions of South and Central Florida may lead to more frequent droughts in some areas and more frequent floods in others (3). Both droughts and floods can cause significant negative health effects from increases in insect-borne and water-borne diseases and compromised food and water supply and quality. Severe flooding also can cause direct injuries and accidents (2).

While projections look to the future, global warming appears to be influencing climate now. Numbers of very hot days and nights have already increased throughout the state during the past 50 years (10). More heat brings more cases of heat cramps, heat exhaustion, and heat stroke. In addition, heat can cause death and tends to exacerbate the death rate from other medical conditions. The elderly, chronically ill, and the poor will likely suffer the most (11). Florida has the largest proportion of senior citizens of any state. In 2000, more than 2.85 million people older than 65 were living in Florida—about one-fifth of the population. By 2025, that number is expected to increase to 5.45 million and make up more than one-fourth of the population of the state (12).

Through complex interactions, increases in global temperature will result in changes in the global climate, with increased climate variability becoming more likely (13). There is some evidence to suggest that there will be small increases in the frequency of Atlantic hurricanes and considerable evidence to suggest that there will be more heavy precipitation events, with some local variability (13). More frequent storms with heavy rainfall could have significant negative effects on the health of Florida's residents from injuries and flooding-related water contamination.

Climate change also is expected to affect people's exposure to, and to some extent the actual amounts of, air pollutants. As climate change affects local and regional weather, air pollutants may be concentrated in a particular area or be blown away from an area. Actual amounts of air pollutants such as sulfur oxides, nitrogen oxides, volatile organic compounds, and particulate matter are expected to rise with increased fossil-fuel energy consumption needed to power air conditioners as people try to adapt to warmer temperatures. More growth and development leading to increased burning of fossil fuels to power vehicles, industry, businesses, and homes also will lead to increased amounts of pollutants in the air. Higher temperatures cause more volatile organic compounds to escape into the air when people fuel and run their vehicles. With warmer temperatures and sunlight, ground-level ozone,

which is the major component of smog, is formed from nitrogen oxides and volatile organic compounds (14). Ozone is known to make chronic respiratory diseases like asthma and chronic obstructive pulmonary disease much worse. Even healthy Florida residents who breathe ground-level ozone, or smog, can experience coughing, lung and eye irritation, shortness of breath, and problems with short-term lung function (14).

Carbon monoxide, sulfur oxides, and nitrogen oxides all have negative health effects, including toxicity, lung irritation, reduced lung function, and aggravation of existing cardiovascular diseases. In addition, sulfur oxides and

Ominous Signs of Climate Change In And Around Florida's Waters

There has been unprecedented bleaching of hard and soft corals throughout the coral reefs of the world from mid-1997 to late-1998.

—CLIVE WILKINSON, AUSTRALIAN INSTITUTE OF MARINE SCIENCE (85)

Climatologists often speak of what may happen as a result of global warming in the future. However, many predicted changes forecast during the past several years already appear to have come true, and evidence continues to mount that climate change is real and is leading to environmental, economic, and human health impacts. Perhaps nowhere is this more evident than in Florida, where trees are dying in areas affected by sea level rise, coral reefs are dying at unprecedented rates, and even the state's lighthouses are close to slipping into the ocean due to coastal erosion.

In the 1990s, researchers from the University of Florida began a seven-year study of forested areas in the islands of Waccasassa Bay State Preserve, south of Cedar Key, Florida. They monitored the health, reproductivity, and growth of the trees and how increasing groundwater salinity and tidal flooding affected them (8). By the end of the research project, many of the trees had died due to frequent flooding in the region. Older trees and palms that did manage to survive often failed to produce new seedlings (8), meaning that the once dense forests of islands dotting Florida's coast are effectively dying out. The researchers blame sea level rise accelerated by humans (8).

The state's once vibrant coastal reefs south of the Florida Keys also are dying. Coral reefs, which consist of thousands of microscopic plants called zooanthellae, cover more than 6,500 square miles of ocean bottom in Florida, the Caribbean, and the

Pacific. In recent years, over 10% have been severely damaged or destroyed (9). A 1999 study revealed that when the reefs are stressed, such as from rising ocean temperatures, they expel the symbiotic zooanthellae and turn white or bleach (9), a condition that can seriously damage or kill entire reefs. In addition to global warming, over-fishing and direct damage from water pollution are affecting Florida's coral reefs (9).

Lighthouses, which in past years withstood nature's force with ocean gales and pounding waves, appear to be little match for the effects of climate change. Accelerated sea level rise is increasing the rate of coastal erosion, undermining the iron foundations of lighthouses. Once symbols of security, safety, and industry, many lighthouses in Florida have already been destroyed or are severely damaged. Several this century have already been damaged beyond repair by hurricanes (86). Due to coastal erosion, the 72-foot tower at Cape St. George near Apalachicola is on the verge of falling into the Gulf of Mexico (86).

Eroded lighthouses, dying trees, and reefs are ominous warnings of what climate change can do. In terms of direct human impacts, South Florida is projected to be among the areas hardest hit by climate change, with much of its low-lying lands predicted to be underwater in the next 100 years. In that same period of time, South Florida's heat index, which indicates human comfort level, could be at least 8-15 °F higher (31), which likely will increase rates of heat-related illness, such as heat stroke. Hurricane damage in the region could increase by 5-10%, due to greater storm surges resulting from conditions presented by rising seas (31). Efforts to curtail global warming, therefore, are an investment not only in Florida's coastal forests and coral reefs, but they also are an investment in human health and safety.

nitrogen oxides can combine with other pollutants in the air to form particulate matter (14). People who are exposed to particulate matter can experience exacerbation of chronic respiratory or cardiovascular diseases, damage to lung tissue, and changes in the body's ability to fight off diseases that can lead to premature death and possibly contribute to cancer (14). The elderly, children, and anyone with underlying heart or lung disease is especially vulnerable (14).

Water quality and availability also may be compromised as the climate changes. We may see reduced availability of water due to increased evaporation, altered seasonal cycles of runoff, variable river and stream flow, greater salinity in the coastal zones due to encroaching sea waters, and higher consumption. Droughts and enhanced soil evaporation from higher temperatures may require more water to be used for crop irrigation. If more of Florida's precipitation comes in the form of heavy rainfall events, there will be an increase in runoff and a decrease in groundwater recharge rates.

Both floods and droughts can result in water contaminated with germs causing water-borne diseases. If contaminated water is used to irrigate or process crops, the food supply also could become contaminated (15). *Cyclospora* and *Vibrio vulnificus* are two germs that are apt to be more of a problem with warmer temperatures. *Cyclospora* causes infection associated with fresh produce, and *Vibrio vulnificus* causes infection when infected shellfish are eaten. Increased temperatures cause increases in growth of the organisms (15).

Warmer air temperatures lead to warmer water temperatures that may change the chemical composition of the water that fish and shellfish inhabit, causing the amount of life-sustaining oxygen in the water to decline while dangerous pollution and salt levels increase (16). Warmer water temperatures may also affect the occurrence and severity of *Pfiesteria* and other harmful algal blooms, known as "red tides," which put fishermen and fish consumers at risk from illness (17).

Climate change, moreover, could increase the risk of insect or vector-borne diseases that occur in the state. Warmer temperatures can make it easier for an insect to transmit a disease to humans (18). Fortunately, other factors such as higher living standards, window and door screens, and a vigilant public-health infrastructure should keep these diseases from becoming an unmanageable problem in Florida (19). However, if disease surveillance systems are not strengthened and maintained, new vector-borne diseases such as West Nile Virus could become a problem.

By 2100, nearly 772 square miles of dry land are expected to be lost in the state (7) due to encroaching seas and erosion. The Florida Everglades may be submerged under water and destroyed by sea level rise (20). One of every four homes built within 500 feet of shoreline could be flooded and destroyed (21). Virtually Florida's entire coastline, consisting of over 8,000 miles including island shores, bays, and lagoons (22), is at risk from sea-level-rise impacts.

Climate change could further affect the production of Florida's primary crops, such as citrus, corn, potatoes, and hay. Citrus and corn yields could decrease as a result of climate change (3). Sorghum, cotton, and other crops

could produce plants with fewer or smaller seeds and fruit (3). If summer temperatures rise significantly, livestock also may be adversely affected.

Finally, Florida's forests could change as a result of global warming. The mixed conifer and hardwood forests of Florida's northern and panhandle sections are likely to retreat northward (3). Forests weakened by pollution and dried from warmer temperatures may be at greater risk from fire. During just one short period, June–July of 1998, a total of 2,277 fires had burned through 499,477 acres in Florida (23). Fires and smoke not only damage wildlife and property but also increase cases of respiratory illness (23).

Given all of these potentially harmful effects of climate change in Florida, people in the farming, fishing, and tourism industries could face far-reaching socioeconomic impacts. One problem may be their ability to afford health insurance. Already, state uninsured rates are of concern. In 1999, 19% of Florida residents were without health insurance coverage (24). The additional economic burden on existing coverage, especially Medicare and Medicaid, could be substantial. Lack of health insurance and loss of income could significantly reduce access to health care.

Florida needs to be deeply concerned about the potential health effects of global warming on its population. Precautions taken now can help to lessen or avert potential health problems in the future. The following sections describe the specific health effects that could result from global warming during the next 50 to 100 years. In some cases, there is a high level of certainty about the projections. In others, the evidence is less definitive. The United States has some ability to adapt to, and prepare for, these changes because of its health care infrastructure and strong economy. However, only by taking action now to decrease greenhouse gas emissions can we hope to stabilize the climate before damage to the planet is beyond repair.

The Complex Origins of Climate Change

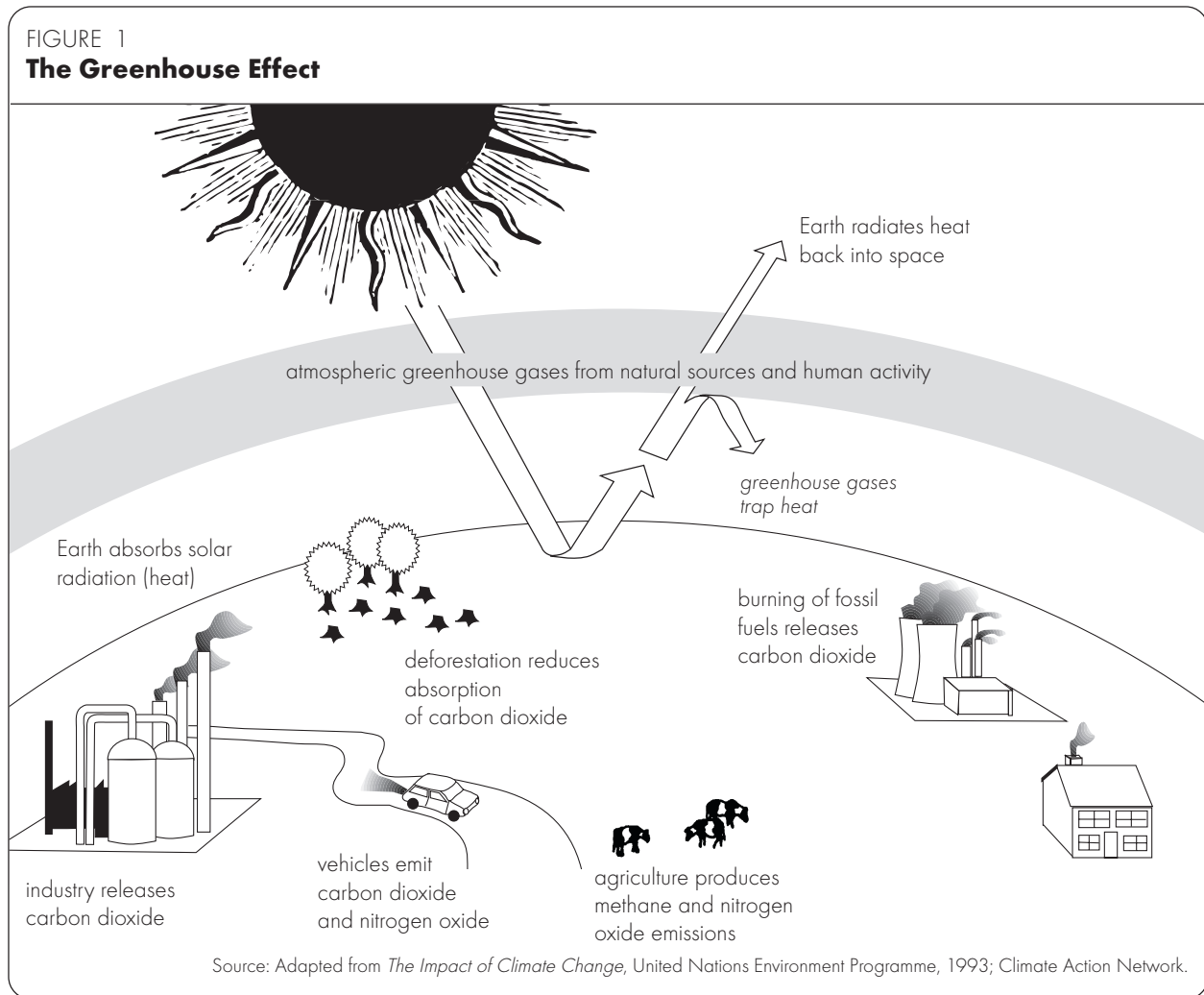
Since the end of the last Ice Age 10,000 years ago, average temperatures worldwide have risen only 9°F, mainly due to natural changes in the geographical distribution of the sun's energy and in the amounts of dust, carbon dioxide, and other gases in the atmosphere. In recent years, the rate of increase in temperatures has been accelerating. Some greenhouse gases, such as carbon dioxide, methane, nitrous oxide, and water vapor occur naturally, residing in the atmosphere and insulating Earth. These gases retain heat from the sun's rays and keep Earth's surface about 60°F warmer than it otherwise would be (25).

However, since the beginning of the industrial revolution, atmospheric concentrations of these greenhouse gases have greatly increased. Carbon dioxide concentrations have increased by 31% and are responsible for more than 60% of the "enhanced" greenhouse effect. Methane is released from garbage dumps, farm animals, coal mining, and natural gas producers and contributes up to 20% of the climate change impacts caused by greenhouse gases. Methane concentrations have more than doubled. Nitrogen oxides result from burning fossil fuels and have a lifespan of about 150 years, meaning that fuels burned now will remain in the atmosphere and

potentially contribute to climate change until the year 2150. Nitrogen oxide concentrations have risen by about 15% (25). These increases have caused Earth to heat up.

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% of carbon dioxide emissions in the United States (26). Deforestation, livestock production, landfills, industrial production, and mining also can change the levels of greenhouse gases by increasing emissions or by decreasing the absorption of gases by plants.

In 1996, the United States was responsible for releasing about 24% of global energy-related carbon emissions into the atmosphere. In 1999, the United States released 13% more greenhouse gases than in 1990 (27). If current trends continue, carbon dioxide concentrations could increase by 30% to 150% by the year 2100 (25). One certain way to reduce carbon dioxide emissions and slow the climate change trend is to drastically reduce the amount of fossil fuels burned in the U.S.



The State of the Science

There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.

—INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, 2001 (2)

The Intergovernmental Panel on Climate Change, a United Nations-sponsored group of more than 2,500 experts from all aspects of the field of climate change, recently distributed a report to government officials worldwide stating that by 2100 average global surface temperatures will increase 2.5° to 10.4°F (1.4° to 5.8°C). This is a significantly greater increase than the 1° to 3.5°C increase predicted previously (2). New studies and better methods for analyzing the data have “led to a better understanding of climate change” (2).

Evidence that human activities have changed the climate system has been collected from scientists studying satellite data, sea surface temperatures, coral reefs, tropical glaciers, and changes in the polar regions. Recently, two new studies lend additional strength to the evidence. An April 6, 2001, report in the journal *Science* presented data showing a progressive warming of tropical oceans since at least 1950. The authors, from the National Center for Atmospheric Research and NOAA, say this supports other evidence for human-induced climate change (28). The researchers also found a correlation between the warming oceans and climate changes in Northern Hemisphere winters during the 50-year study period (28). The warm waters appear to heat the tropical atmosphere, which influences atmospheric pressure patterns and winds over the North Atlantic and North Pacific, shifting storm paths to the North (28). Yet another study, published the following week in *Science* by researchers from the Scripps Institute of Oceanography, found evidence for a “human-produced warming in the upper 3,000 meters of the world’s oceans” (29). The National Academy of Science, in a special study recently commissioned by President Bush, examined all the existing data available on

climate change and concluded, “Greenhouse gases are accumulating in Earth’s atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise” (33).

No longer are there questions about whether Earth is warming. That evidence is now indisputable. The questions now are how much will Earth warm, how will it affect people, and what can be done to slow the process. The ensuing section will describe potential health effects of global warming on people.

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 term “global climate change” or just “climate change” most frequently but still occasionally use “global warming” some of the time.

How Could Climate Change Affect the Health of Florida Residents?

Climate change is likely to have wide-ranging and mostly adverse impacts on human health.

—INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, 2001 (6)

Direct Effects of Heat On Health

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 (11). Heat may lead to severe health problems, such as heat cramps, exertional heat injury, heat exhaustion, and heat stroke, all of which could increase in Florida as climate change causes more extreme heat days.

Heat cramps are muscle spasms that primarily affect people who exert themselves through strenuous work or exercise in a warm environment. Workers on farms, in construction and fishing, as well as tourists, may experience heat cramps as a first sign of heat stress. 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°F, with symptoms that include goose bumps, chills, nausea, vomiting, and unsteady gait (11).

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, clammy, and has ashen skin and dilated pupils. The individual may require hospitalization (11). When moved to a cool place, victims of heat exhaustion usually recover.

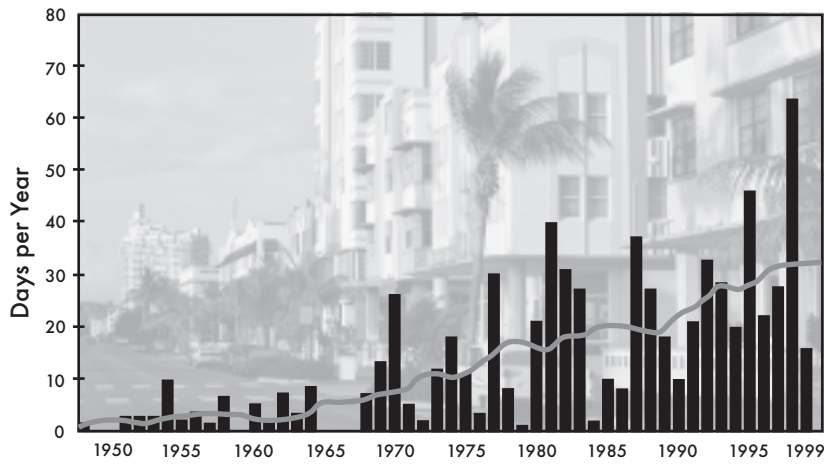
Heatstroke, the most severe of these conditions, can be fatal. If body temperature reaches 105°F or above, damage to the kidneys, muscles, heart, and blood cells is likely. Sweating stops altogether. Death can occur immediately or could be delayed up to several weeks due to complications, such as kidney failure (11).

Heat Stress, Heart Attacks, and Stroke

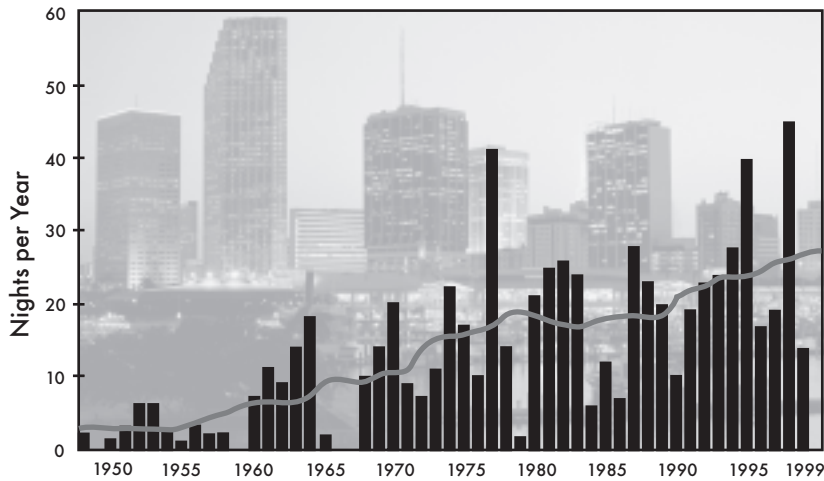
A 1997 study by scientists at the University of Delaware Center for Climatic Research examined mortality and weather data for a series of cities in the United States. During oppressive heat wave events there was a significant increase in the number of deaths per day for the general population, with the elderly being most at risk (30). Some of the deaths are from heatstroke, but many of the deaths are thought to be from heart attacks and stroke. When a person overheats, the heart tries to pump harder and faster to try to dissipate the heat. Heat stress may also cause the blood to form clots more easily (11). In general, hospital admissions and emergency room visits from all causes increase during hotter weather (11).

Despite Florida's usual high summer temperatures, residents could still be susceptible to heat waves and increased temperatures. The "heat index" is one

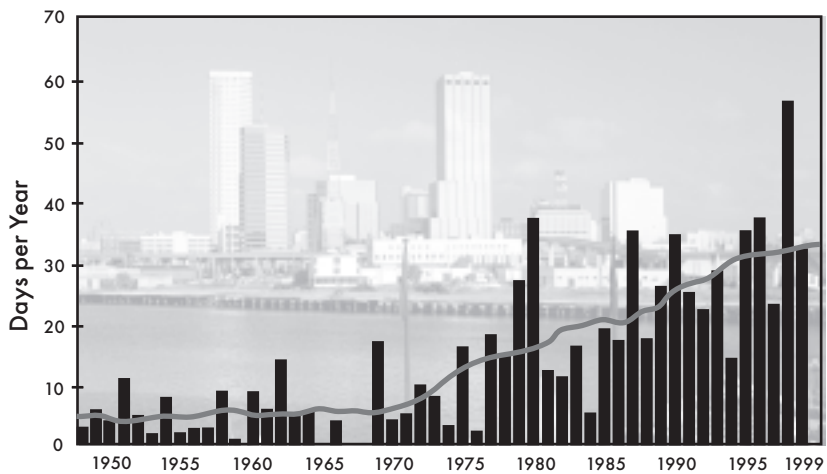
FIGURE 2
Heat Stress Days and Nights in Florida



Number of heat stress days per year in Miami, FL from 1948 - 1999



Number of heat stress nights per year in Miami, FL from 1948 - 1999



Number of heat stress nights per year in Tampa, FL from 1948 - 1999

Source:
 Ozone Action/Physicians for Social Responsibility. 1948 - 1995 data from Gaffen and Ross, 1998, *Nature*, Vol. 396, p.529. 1996-99 NOAA data was analyzed by Ozone Action

common way to compare environmental conditions that could lead to heat stress. The heat index combines the effects of temperature and humidity to better describe what the human body feels. Projected changes in the heat index for Florida are the most dramatic in the nation. The most conservative estimates project an increase of 8° to 15°F during the next century. Another commonly used model projects the heat index will increase by more than 20°F (31). For example, one study projected the average annual number of people dying from heat stress in Tampa to more than double from 28 to 68 by the year 2020 (30).

Residents of urban areas are at greater risk of heatstroke and other heat-related causes of mortality because buildings and roads absorb heat during the day and release the heat during the night, keeping nighttime temperatures high so bodies don't get a chance to cool off and recuperate before the next day's high temperatures (11).

The elderly, who make up about one-fifth of the population of Florida, are particularly vulnerable to severe heat-related illnesses and death for the following reasons:

- Impaired ability to disperse heat through the body's physiological mechanisms.
- Greater risk of having underlying diseases.
- Greater risk of taking medications that may contribute to heatstroke.
- More problems with mobility.
- Difficulty with temperature perception.

These factors all combine to put Florida's 2.8 million senior citizens at greater risk of suffering a heat-related illness or death (11). Other groups particularly vulnerable to heat stress include babies and young children, socially isolated persons, anyone with serious cardiac or respiratory problems, anyone with mobility or other conditions limiting their ability to care for themselves and regulate their fluid intake, and the poor (11). In the year 2000, almost 369,000 individuals older than 60 in Florida reported having a mobility or self-care limitation (32) These individuals likely will be among those most vulnerable to the effects of climate change.

Health Effects from Extreme Weather Events

Temperature is a major determinant of weather and climate, so global warming will have profound effects on the global climate. The Intergovernmental Panel on Climate Change has determined that extreme weather events likely will become more common during the 21st century. For Florida, extreme weather events will be primarily heavy rainfall events (2). Some areas of Florida, however, may experience more droughts (3). There is some evidence that there also may be a slight increase in the frequency and/or intensity of Atlantic hurricanes (13), but it's more certain that the hurricanes will bring greater precipitation than has been common during past hurricanes (34).

With Florida's extensive coastline and many low-lying areas, more extreme weather events could have serious effects on health. The projected 18 to 20 inches of sea level rise during the next century make direct health effects such as traumatic deaths and injuries likely. The "sunbelt" has experienced more than 30% population growth between 1970 and 1990, most of which has been in coastal counties. In the next 25 years, the population of these coastal counties,

which is particularly vulnerable to sea level changes and extreme weather, is expected to grow another 40% (31). That means even more people will be at risk from accident and injury associated with hurricanes and storm surges.

Florida's experiences with hurricanes Floyd and Irene are good examples of some of the direct and indirect health effects that can result from hurricanes, especially when two hurricanes occur back-to-back. In September of 1999, Hurricane Floyd prompted the largest peacetime evacuation in U.S. history. Floyd, a Category 4 hurricane in the Bahamas, appeared to be heading straight toward Florida as it approached landfall in the U.S. More than 2.6 million people left their homes in advance of the hurricane (40), causing

Andrew's Aftermath

Hurricane Andrew, Florida's worst storm in 60 years (35), made landfall on the morning of August 25, 1992, killing 61 people and destroying or damaging 125,000 homes (34). Hardest hit was the city of Homestead, which experienced 200 mph winds and storm surges up to 12 feet (35). This farming and retirement-based community of 32,000 was devastated. In Broward County, 250,000 were left homeless (35).

Almost 10 years later, Andrew's impact is still being felt throughout the state. Before the hurricane, Floridians had become relatively complacent about severe storms. Coastal populations jumped from just under 7.7 million in 1980 to over 10.5 million by the early 90s making more Floridians at risk for severe damage from hurricanes than in any other state (36).

Increased population density, increased dependence on technology and specialization, and lack of preparedness all contributed to greater risk of injuries and mortality from Andrew (37). According to a 1990 study conducted by the Speaker's Task Force on Emergency Preparedness in Florida, the state then had insufficient shelter space for potential storm evacuees; large numbers of individuals with special needs, such as elderly and infirm patients in hospitals and nursing facilities; and potential shelters, schools, and churches that were not properly equipped to act as emergency shelters (36). State agencies and local governments were found lacking in coordinated disaster response communication and planning, and many counties had not established or maintained emergency management agencies (36). Further, state funding for emergency management was deemed inadequate, and the public was found to be ill-informed about how to prepare, respond to, and mitigate disasters (36). It is no wonder then that

Hurricane Andrew devastated much of Florida, particularly the southeastern corner.

Insurance companies also had become complacent. Without a major hurricane for 20 years, they courted the state's new residents, particularly in South Florida. Insured commercial property increased from \$155 billion in 1980 to \$453 billion by the early 1990s, a rise of 192% (36). Hurricane Andrew caused more than \$25 billion in damage, making it the costliest natural disaster in U.S. history (38). The situation resulted in financial disaster: After Andrew, eleven of Florida's insurance companies became insolvent. Major carriers, such as State Farm Fire and Casualty Co. and Prudential Property and Casualty Co., had to be rescued from bankruptcy by their parent companies (39). During the 1990s, insured losses totaled nearly \$22.5 billion. In 1999 alone, insured losses from weather-related natural catastrophes in Florida totaled \$222 million. Among all states, Florida ranked first for suffering the most damage for the decade (40).

Following Andrew, many insurance companies left the state, while those remaining significantly raised their rates, which makes it difficult now for many homeowners to get coverage (39). Those that can afford insurance have had to devote a larger portion of their income to coverage, a legacy from Hurricane Andrew that lingers today. Given the state's population growth in areas at high risk for storm damage, problems with Florida's disaster response plans, and heightened risk for hurricanes due to global warming, the stage is set for considerable hurricane damage to our health and property. Good disaster plans can help to reduce the number of accidents and injuries from hurricanes and other extreme weather events.

overloads to the state's transportation system (41). While Floyd's strength diminished when it made landfall in Florida, it still caused widespread power outages, water damage, coastal erosion, and property damage in excess of \$61 million (42).

Before the state could fully recover from Floyd, Hurricane Irene moved through the Florida Keys and across South Florida in October of 1999. Winds gusting 70 mph over coastal locations from Fort Pierce to Daytona Beach fueled the destructive power of intense rainfalls and resulted in eight deaths (42). Of those who died, downed power lines electrocuted five and three drowned in vehicle-related accidents (42). Hundreds of homes were flooded or damaged and 700,000 customers lost electricity. Hardest hit were beach communities, where up to 10 feet of beachfront was lost due to

Mobile Homes And Recreational Vehicles Vulnerable To Extreme Weather

We all acknowledge here today that what it took just seconds to destroy will take weeks and months and, in some cases, years to rebuild.

—PRESIDENT CLINTON, SPEAKING TO
KISSIMMEE TORNADO SURVIVORS,
FEBRUARY 1998 (43)

Based upon mortality rates from the 1998 tornadoes and other extreme weather events, Florida's trailer parks appear to be particularly vulnerable to damage. Mobile homes in the parks provide relatively inexpensive housing for many Florida residents, including seniors and retirees. Florida also has more people living in recreational vehicles than most other states, especially during the winter months (43). Examples of some recent extreme weather events that have particularly damaged mobile homes and recreational vehicles include:

- February 1998—A tornado first hit south of Intercession City then moved on to Kissimmee and Orange County killing eight people in recreational vehicles, 15 people in mobile homes and one in an automobile. The tornado also left 150 people injured and more than 1,000 homes and business damaged or destroyed (42).
- March 1998—A tornado destroyed 13 mobile homes and recreational vehicles and damaged about 100 more in Okeechobee, causing at least 10 injuries (42).
- November 1998—A multivortex tornado touched down west of U.S. 1, damaging mobile home parks and 10 housing subdivisions as it moved northeast at 30 mph (42). Casualties included two drowning deaths and 65 injuries (42).
- April 2000—Thunderstorm winds overturned a mobile home injuring three children and one adult (42).
Climate change may increase the frequency of extreme weather events putting people who live in mobile homes and recreational vehicles at even greater risk.



erosion (42). Flooding in some regions also lasted for well over a week after the storm, displacing hundreds of people and isolating thousands more (42).

During extreme weather events, Florida's emergency management systems may be overburdened. If transportation routes are affected by the storms, evacuation and rescue efforts can be severely hampered. Extreme weather events can be terribly frightening, leaving deep psychological scars and social effects.

Health Effects of Sea Level Rise

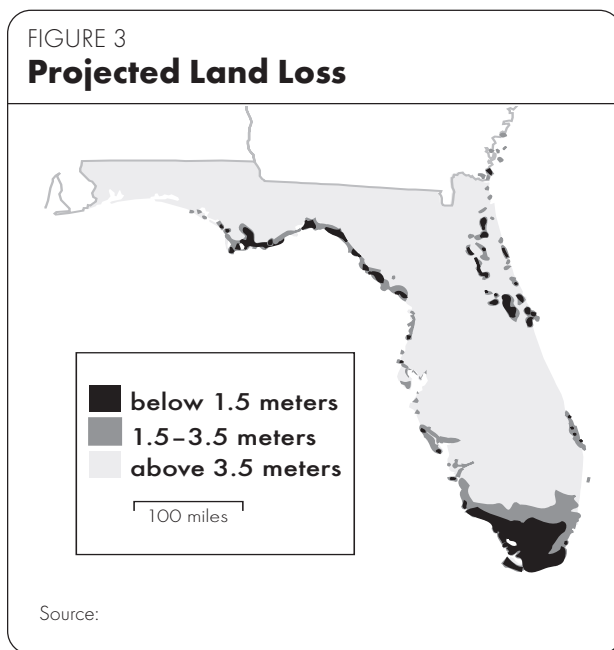
Sea level has been rising along the west Florida coast and is projected to rise at an accelerated rate because of global warming.

—ERNEST D. ESTEVEZ, PH.D., SENIOR SCIENTIST AND COASTAL RESOURCES PROGRAMS MANAGER, MOTE MARINE LABORATORY, SARASOTA, FLORIDA (44)

The Intergovernmental Panel on Climate Change, Environmental Defense, the International Institute for Sustainable Development, and other major international organizations addressing climate change all conclude that one of the worst regions to be affected by sea level rise in the world, not just nationally, will be Florida. The projections are grim. With a projected rise in sea level of 18 to 20 inches, much of the Florida Everglades, which average an elevation of 12 inches above current sea level, will almost certainly be inundated. Other important wetland ecosystems along the Gulf and Atlantic coasts also may be lost. Historically, these wetland coastal ecosystems were able to keep up with sea level rise by gradually moving inland. The projected rise in sea level during the next 100 years, though, is happening too rapidly for that to occur. In addition, development in South Florida has taken over so much coastal and near-coastal land that the Everglades, for example, can no longer migrate inland (20).

During the next century, nearly 772 square miles of dry land, mostly located in the southern tip of the state, but also lowland areas on both the Gulf Coast and the Atlantic Coast, is expected to be lost due to encroaching seas and erosion (7). Erosion rates vary greatly from one location to another. Some of the highest erosion rates in the nation are on the Gulf Coast. One of every four homes built within 500 feet of shoreline, not including major metropolitan centers like Miami, could be swallowed and destroyed (45). Virtually Florida's entire coastline, more than 8,000 miles including island shores, bays and lagoons (22), is at risk for sea level rise impacts.

Sea levels will rise as a result of melting glaciers and massive ice sheets at the poles as



well as expansion of the seawater itself as it warms (7). Waters along Florida's coast are projected to rise by 18–20 inches by the year 2100 (3). Additional studies by the EPA and others have estimated that along the Atlantic coast a 1-foot (30 cm) rise in sea level is likely by 2050 and could occur as soon as 2025. In the next century, a 2-foot rise is most likely, but a 4-foot rise is possible; and sea level will probably continue to rise for several centuries, even if global temperatures were to stop increasing in a few decades (46).

Sea level rise can accelerate coastal erosion, and erosion occurs at an even faster rate during and after extreme weather events due to storm surges. The cost of replacing or repairing lost buildings likely will be enormous. For example, the value of insured coastal property exposed to the damages inflicted by Hurricane Andrew totaled \$418 billion (36).

Sea level rise also may lead to flooding and increased water salinity in rivers, bays, and aquifers, which could wreak havoc on wildlife that depend on these water sources. Additionally, the increased salinity could reduce fresh water supplies to Florida's residents (3).

The economic well-being of individuals who live near coastal areas could also be threatened as coastal erosion undermines the economies of these regions. Erosion, extreme weather events, and property damage that climate change is likely to bring could disrupt the financial growth of these areas and threaten the jobs of locals who work in all industries.

The portion of the state's economy resulting from tourism could greatly suffer since much of this tourism relies on Florida's agreeable climate, beautiful beaches and resorts, fisheries, and wildlife, which could all be jeopardized by climate change. In 1996 alone, tourists in Florida spent more than \$48 billion (47). From the Everglades National Park to Sanibel Island, many of Florida's tourist spots are linked to natural land features and many could experience negative impacts resulting from climate change.

Health Threats from Floods and Storm Surges

More intense rainfall events accompanying global warming would be expected to increase the occurrence of floods, and warmer sea-surface temperatures could strengthen tropical cyclones

—INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, 1998. (6)

Florida has experienced remarkable growth and development in the past decade and population is expected to increase dramatically in the coming years. Florida also has experienced tremendous urbanization, leading to more people living in higher-risk areas such as coasts and floodplains. Urbanization also creates more impermeable surfaces that do not absorb water (34). Thus groundwater sources are not replenished and more of the rainfall becomes runoff creating problems with flooding and contamination. Urbanization also can lead to environmentally destructive land-use practices outside of the urbanized area by promoting deforestation and livestock overgrazing to support urban residents. In turn, that degrades the land and can lead to increased runoff volumes downstream (34).

Many communities, moreover, use combined sewage and storm water



drainage systems, meaning that both storm water and raw sewage are carried through the same pipe to a sewage treatment plant. During periods of heavy rainfall, the volume of water can overwhelm the treatment plant's capacity, and the overflow is discharged—untreated—directly into surface water bodies (17). Contaminated floodwaters can cause diarrhea from a variety of bacteria (e.g. *Salmonella* and *Shigella*), viruses (e.g. rotavirus), and protozoa (e.g. *Giardia lamblia*, amoebas, *Cryptosporidium*) (18). More about water-borne diseases is included in the section on Water Quality.

Floods also may create areas of standing water and other ideal conditions for breeding mosquitoes. Climate-related natural disasters like floods also can increase the potential exposure to mosquitoes since

residents and recovery workers may spend more time outside removing debris, rebuilding structures, and living in storm-damaged housing. One study found that one of the mosquitoes that carries St. Louis encephalitis virus was more abundant and had increased blood-feeding behavior during periods of heavy rainfall in Indian River County (48). In the continental United States, natural disasters have not yet been associated with epidemics of mosquito-carried diseases, although the potential does exist for increased risk of these diseases. Disaster response plans, especially for floods, should include heightened surveillance for mosquito-carried diseases (49).

Nationwide, floods are the leading cause of death from natural disasters and account for 40% of all injuries resulting from natural disasters (34). Drownings are the most common cause of death during a flood and, ironically, human-made structures to control floodwaters are responsible for many of these deaths. Levees, embankments, retention walls, and drainage channels all can be used effectively to control floodwaters, but when they fail they can result in injuries and deaths (34). The use of these structures may become more common in Florida as greater amounts of floodwaters and coastal storm surges need to be contained.

Finally, several studies have documented long-term psychological and physical effects in flood victims. Both children and adults have been found to suffer severe emotional impairment after their experiences during and after floods (50). Other studies have found that years after the flood occurred, victims still report more perceived health problems and more hypertension, respiratory, gastrointestinal, and cardiovascular-related health problems (50). Thus, floods pose serious threats to public health from accidental injury and

death during the disaster, from compromised sanitation and increased risk of infectious disease immediately after the disaster, and from chronic psychological and medical problems for extended periods after the disaster (50).

Health Effects from Worsening Air Quality

We're likely to see an upsurge of respiratory diseases, and worsened asthma episodes.

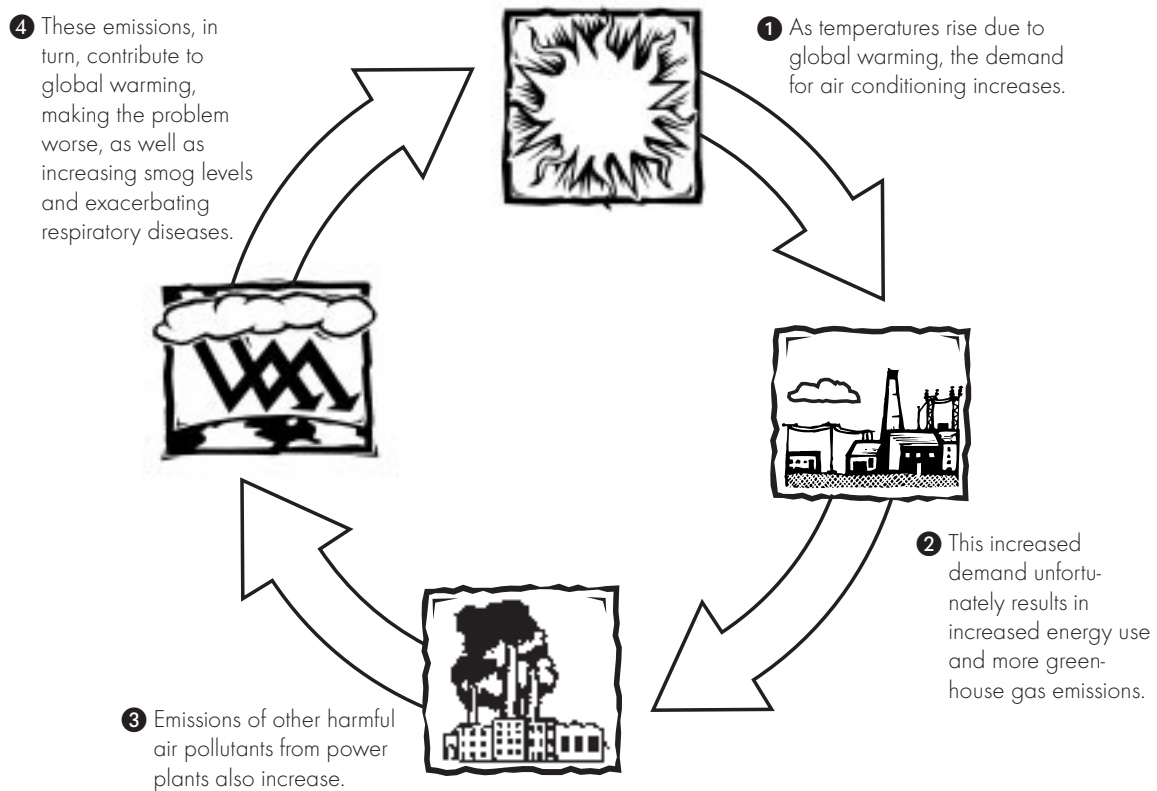
—JONATHAN SAMET, PULMONOLOGIST,
JOHNS HOPKINS SCHOOL OF PUBLIC HEALTH (51)

The Climate Change/Air Quality Link

The link between air quality and climate change is complex. Some of the greenhouse gases that contribute to climate change are air pollutants with known negative health effects; others, like carbon dioxide, are not especially associated with negative health effects but are major contributors to global climate change. Climate change is expected to affect air quality in at least five different ways.

First, pollutant concentrations in the air of a specific location may be

FIGURE 4
Air Conditioning: The Vicious Cycle



affected by local and regional weather conditions. Still air could allow pollutants to accumulate; wind could blow pollutants to other areas. Climate change could have significant effects on local weather conditions, which then have significant effects on local air quality.

Second, concentrations of human-made pollutants could increase as a result of increased fossil-fuel use. As temperatures get warmer, air conditioners, for example, will be used more. More energy will be needed to power the air conditioners, and the production of energy from fossil fuels will release more greenhouse gases into the air contributing to further climate change and warmer temperatures (See *Air Conditioning: The Vicious Cycle* 19). Air pollutants such as ground-level ozone, carbon monoxide, particulate matter, nitrogen oxides, and sulfur dioxides all have negative health effects. Climate change can increase concentrations of these pollutants as well as compound effects of these pollutants. Growth and development will require greater amounts of energy. If that energy comes from fossil fuels, emissions of pollutants will continue to increase.

Third, natural (nonhuman-made) sources of air pollutants also could increase. For example, higher temperatures cause forests and other sources of natural volatile organic compounds to emit greater amounts.

Fourth, ground-level ozone is formed from nitrogen oxides and volatile organic compounds (both natural and human-made) in the presence of sunlight and heat. As temperatures increase, ground-level ozone formation increases. While ozone in the upper atmosphere, called stratospheric ozone, helps to protect us from the harmful effects of the sun's ultraviolet rays, ground-level ozone, called tropospheric ozone, is very harmful to breathe.

Lastly, airborne allergens, such as pollens, could change in concentration and distribution. Each of these pollutants is discussed in greater detail in the following section.

Health Effects of Air Pollutants

Ozone

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 health. Ozone, or smog, is formed when nitrogen oxides and volatile organic compounds emitted from motor vehicles, power plants, refineries, factories, and even some natural sources like plants are heated by sunlight (52).

The health of Florida's residents is threatened by smog, as evidenced by state air quality indexes. During 1998, Daytona, Bradenton, Ft. Lauderdale, Ft. Myers, Jacksonville, Kissimmee, Lakeland, Melbourne, Miami, Ocala, Orlando, Pensacola, St. Petersburg, Sanford, Sarasota, Tampa, and West Palm Beach experienced a combined total of 120 unhealthy air days, which are defined as days when active children and adults, as well as people with respiratory problems, should avoid prolonged outdoor exertion, and everyone else should

limit prolonged outdoor exertion (53). Exposure to elevated ozone levels can cause severe coughing, shortness of breath, pain when breathing, lung and eye irritation, and greater susceptibility to respiratory illnesses such as bronchitis and pneumonia (54). Even moderately exercising healthy adults can experience from 15% to more than 20% reduction in lung function from exposure to low levels of ozone over several hours.⁵⁴ For the half million adults and quarter million children who have asthma and live in Florida, ozone is of special concern. 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 for people with asthma (55).

Volatile Organic Compounds (VOCs)

Another group of air pollutants consists of VOCs, which are generated by power plants, municipal waste combustors, motor vehicles, solvent use, and the chemical and food industries. VOCs include a variety of hazardous air toxins, including benzene, butanes, and toluene. VOCs in the atmosphere have two major health impacts: They are directly toxic and can combine with nitrogen oxides to form ozone. These hazardous air pollutants are associated with cancer as well as adverse neurological, reproductive, and developmental effects (56). As temperatures increase, more VOCs are emitted when people fuel and operate motor vehicles (14). Some VOCs are emitted from natural sources like forests. Warmer temperatures lead to increased natural emissions as well. For example, natural emissions increase two-fold with an increase of 10°C temperature (57). Thus, climate change is expected to increase levels of both human-made and natural sources of VOCs, increasing ozone levels.

Nitrogen Oxides

Like VOCs, nitrogen oxides have multiple roles in adversely affecting health: nitrogen dioxide can be directly toxic in the lungs and it also combines with VOCs to form ozone. In the lungs, nitrogen dioxide combines with water to form acids that damage the lung tissue (58). Nitrogen oxides also oxidize in the atmosphere to become nitric acid, a major component of acid rain (14). Higher temperatures accelerate this process, increasing the potential for acid rain with climate change (14). Nitrogen oxides also combine with sulfur dioxide to form particulates, discussed in more detail in the next section.

Sulfur Dioxide and Particulate Matter

Sulfur dioxides, like nitrogen oxides, are oxidized in the atmosphere to become acid rain and can combine with nitrogen oxides to form fine particles, called particulate matter (14). Particulate matter can be emitted directly from the combustion of fossil fuels, industrial processes, and transportation; created by the combination of gases such as nitrogen oxides and sulfur dioxides (14); formed from dust and smoke from wildfires; and transported to Florida in clouds of desert dust from Africa (59). Several studies have documented that both the elderly and children had an increase in hospital admissions for respiratory and cardiac causes when concentrations of particulate matter increased (60) (61–65). One study conducted by a well-known group of

researchers from Harvard discovered that long-term exposure to air pollution significantly increased the risk of death (60). Another group of Boston researchers discovered that particulate matter can trigger a heart attack in people who are obese, inactive, or have a history of heart problems. The risk for heart attack peaked two hours and again 24 hours after exposure to increased levels of fine particles, even though the levels were never above federal air quality standards (66).

Fine particles are especially dangerous for babies and young children. Children breathe 50% more air per pound of body weight than adults, thus taking in more pollutants. One study found that infants living in cities with high levels of fine particles have a 26% increased risk for sudden infant death syndrome, and infants living in high pollution areas were 40% more likely to die of respiratory causes (67).

Pollen and Natural Allergens

Natural allergens such as pollens and fungal spores also contribute to air pollution and may increase with climate change. An increase in temperature and precipitation could lead to increased fungal growth, which could

The Precautionary Principle

Legislators, physicians, ethicists, and environmentalists often refer to a term called “the precautionary principle” when dealing with climate change 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”.⁶⁴

The precautionary principle has four main components.

- 1) Communities have a duty and a right to take anticipatory action to prevent harm.
- 2) The burden of proof of the harmlessness of a new technology, process, activity, or chemical is the responsibility of the proponents, not the public.
- 3) Communities have an obligation to discuss and to explore a full range of alternatives to the hazards posed.
- 4) Decisions must be open, informed, and democratic.

The precautionary principle is already used in some areas regarding health. Immunizations are

given to protect someone against the relatively slim chance of developing a disease. The individual receiving the immunization does not know for certain that they would have contracted the disease if the immunization had not been given, but the possible risk of disease was significant enough to warrant taking the precautionary step of obtaining the immunization.

Global warming requires that same sense of precaution and a willingness to take action. We have strong evidence that global warming is occurring and is largely the result of burning fossil fuels and other human activities. We don’t know *exactly* how much or how soon temperatures will rise; we don’t know *exactly* what all the consequences will be; we don’t know *exactly* how much and in what ways any individual will be affected. We do know, however, that there is significant risk of multiple, severely negative consequences of doing nothing and allowing the climate change situation to get worse. Therefore, applying the precautionary principle to the issue of climate change dictates that we take steps to slow global warming and climate change by greatly reducing our consumption of fossil fuels.

The Problem With Pesticides

To control insect numbers in Florida, state health officials conduct aerial spraying where mosquitoes and other insects tend to proliferate. A number of pesticides have been used, including organophosphates (e.g. malathion and fenthion) and pyrethroids (e.g. permethrin and resmethrin) (74). All of these insecticides can cause harm to humans and the environment. In 1999, there were almost 60,000 pesticide-related incidents reported to poison control centers nationally; almost half of these were in children less than 6 years old (75).

Pesticides can be absorbed into a person's body by inhalation, ingestion, and skin penetration (76). Malathion does not last in the environment as long as other organophosphates and is therefore thought to be "safe" by some, but in 1975 malathion caused five deaths and 2,800 poisonings in Pakistan during spraying for malaria control (76). Symptoms can range from headache, nausea and dizziness to loss of consciousness, convulsions, and death (76). After malathion was sprayed over two Florida communities in November 1999, 123 human illnesses directly related to the spraying were reported, according to the Centers for Disease Control and Prevention (77).

Pyrethroids are less toxic to humans and the environment than malathion and other organophosphates, but all pesticides are inherently toxic and therefore are not risk-free to humans (76). Signs and symptoms of mild to moderate poisoning include dizziness, headache, nausea, and fatigue. Severe poisoning results in seizures, and evidence is mounting for an association between pesticide exposure and Parkinson's disease (78). Many household pesticide sprays and pet care products contain these compounds (76).

In addition to humans, birds, fish and other aquatic animals, and bees and other beneficial insects are at risk from pesticide poisoning. Fenthion has been used for at least 20 years to kill mosquitoes in Florida (79). In fact, Florida sprays 222,400 to 333,600 pounds of the pesticide over 2 million acres in the state each year (80). Fenthion is especially deadly for birds (81), and thousands of bird deaths, including migratory birds, have been linked to the insecticide (82). Pesticides are harmful to humans, wildlife, and natural ecosystems. Ecosystems that are already stressed by pesticide poisoning and other forms of pollution may be more readily destroyed by the additional stress of climate change.

exacerbate asthma and other respiratory conditions (68). Some pollen-producing plants, such as birch trees, have been found to increase their pollen production and the allergen content of the pollen with increasing temperatures (69). Warmer temperatures may also lengthen the allergy season (70).

How Climate Change Could Affect Diseases Carried by Insects

Changing climate conditions also may affect human health through impacts on terrestrial and marine ecosystems.

—UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (3)

Insects, called "vectors," carry a variety of diseases. These diseases are transmitted when the insect bites a human (or another animal) who is already infected with the disease. The insect itself then becomes infected with the disease, and when it bites another human the disease is passed from the insect to the human. Malaria and dengue fever are two good examples of vector-borne diseases. Although the mosquitoes that carry these diseases already live in Florida, and every year there are a few cases of dengue fever and malaria recorded in Florida (71), the risk of these diseases becoming a big problem in

How Can Insects Be Controlled?

If pesticides aren't used, how can the mosquitoes and the diseases they carry be controlled? In a healthy ecosystem, one that hasn't been poisoned by pesticides, there are many mosquito predators that help to keep the mosquito population (and other insect pests) under control. Fish, frogs and other amphibians, beneficial insects such as dragonflies, bats, and many birds have voracious appetites for mosquitoes and other insects. One bat can eat 3,000 mosquitoes in a single night (83)! Bat populations have declined dramatically and experts suspect this is from a combination of factors including poisoning from pesticides, habitat loss, and destruction of roosting sites (83). Regular "housekeeping" measures can also greatly reduce mosquito populations. Keeping urban drains clean and emptying containers of standing water can help to eliminate mosquito breeding grounds. Naturally occurring bacteria, which kill mosquito larvae but harm no other living creatures, can be used in ponds to keep mosquito populations in check. People can also wear protective clothing and use insect repellents to protect against mosquito bites.

Florida is small (70).

Even though increasing temperatures could expand the mosquito's range and make the mosquito more efficient at transmitting these diseases, many other factors determine whether a disease like malaria will become a problem. For example, temperatures in Florida are already higher than many places in the Caribbean and Central America where there are thousands more cases of malaria every year. Factors such as higher standards of living, less time spent outdoors in the evenings when mosquitoes are more active, window and door screens, air conditioning, better mosquito control, and better public health infrastructure all combine to make epidemics of these diseases unlikely even with rising temperatures (19).

With climate change, vector-borne diseases such as malaria, dengue fever, and yellow fever could become epidemic in many other parts of the world. When this happens the United States, and Florida in particular because of its role as an international gateway, could expect a dramatic increase in imported cases (72;73).

Continued monitoring and vigilance will be needed to ensure that these diseases, or a new disease like West Nile Virus, do not become a problem in Florida.

Although disease surveillance programs and health care infrastructure reduce the risk of epidemics from these diseases in the United States, the risk may increase as the climate warms and changes in precipitation and weather patterns occur. It would be prudent to continue to improve public health infrastructure, surveillance programs, and research into how climate change affects disease.

How Climate Change Could Affect the Supplies and Quality of Water and Food

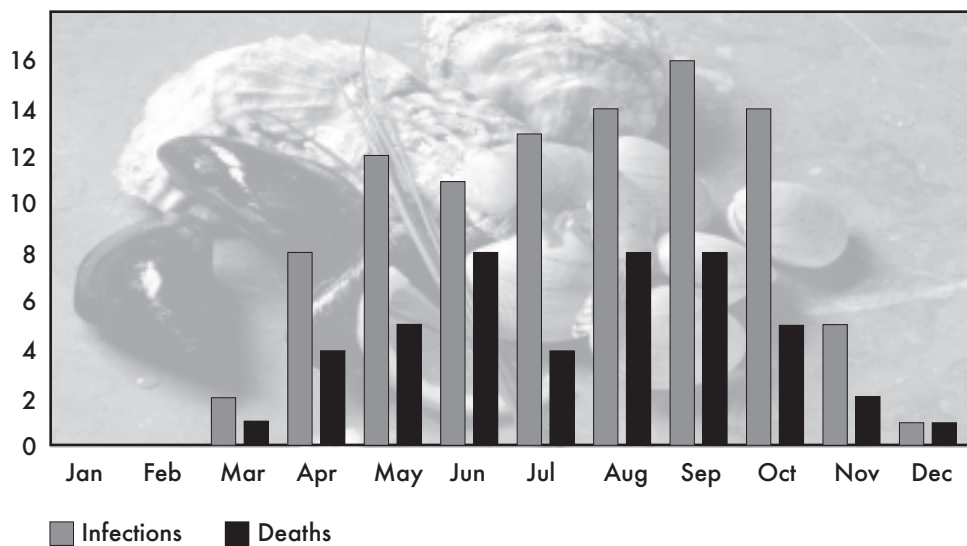
How Climate Change Could Affect Water Supplies

Research shows that climate change could have major effects on precipitation, stream flows, storm surges, runoff, water temperatures, and evaporation, thereby affecting Florida's water supply (3). In addition, increased saltwater intrusion from rising sea levels may contaminate rivers, aquifers (87), and wells, affecting both the quantity and quality of available water.

Considerable uncertainty remains as to specifically how regional precipitation and waterways could be affected by global climate change. There appears to have already been a decrease in surface water flows, at least in some areas of the state. The rivers in the Tampa Bay area, for example, have shown a fairly steady decline in discharge since the 1950s, corresponding fairly closely to increases in population and demand for groundwater to supply them (88). Low stream flows cause substances in water to concentrate, leading to more polluted waters. Virtually all of Florida’s water bodies already are polluted (89).

If water supplies in lakes, rivers, and underground aquifers are further reduced by climate change, there may be an increased likelihood of widespread water shortages for both public and private water users. Areas of the state with rapidly expanding populations, such as southern Florida, would be most affected, since development and loss of forest cover accelerate runoff, preventing groundwater supplies from recharging even when it does rain. As it stands, south Florida receives an average annual rainfall of 60 inches, with annual evaporation rates that can sometimes already exceed this amount. The effects of climate change may further reduce annual rainfall in the central and southern parts of the state and warmer soil temperatures could enhance evaporation. Competition for water among businesses, residences, agriculture, the Everglades, and other natural areas likely will increase (3).

FIGURE 5
Seasonality of Shelfish Poisoning in Florida



Source:
*Climate Change
 Impacts on the United
 States*, National
 Assessment Synthesis
 Team.

Florida's Harmful Algal Blooms

Cyanobacteria blooms in Florida represent a major threat to water quality, ecosystem stability, surface drinking water supplies, and possibly public health.

—FLORIDA DEPARTMENT OF HEALTH (93)

Harmful algal blooms (HABs) refer to events where single-celled algae organisms produce toxins in water. Such HAB events can result in massive fish kills. In just one month, January 2000, over 50 incidents of fish with lesions and other skin abnormalities were reported in Florida's waters (94). Human health also is threatened by the dozen or so HAB species that have been identified in waters along Florida's coasts. *Pfiesteria piscicida* has been associated with fish kills in eastern seaboard estuaries as far south as South Carolina. Although no fish kills from *Pfiesteria* have been reported in Florida, *Pfiesteria*-like species have been found in Florida (95).

Fish kills can be impressive events, when hundreds or even thousands of fish covered by large, red, bleeding sores wash up dead along the shores of waters such as the St. Lucie River and the Palm River (94). In 1997, fish kills occurred on the eastern shore of the Chesapeake Bay. People who had had contact with water and fish from affected waterways reported unusual neurological symptoms such as memory loss (96). Soon it was discovered that *Pfiesteria* or *Pfiesteria*-like organisms were causing the symptoms (96). A 1998-2000 surveillance study by Florida's Department of Health and the Centers for Disease Control and Prevention is monitoring human victims of harmful algal blooms that display one or more of the following symptoms: confusion, memory loss, burning skin sensation, skin rash, headache, eye irritation, upper respiratory irritation, muscle cramps, and gastrointestinal distress (95).

Pfiesteria piscicida is actually an organism that can transform itself from a plant alga into an amoeba animal that feeds on fish. Water containing fish affected by *Pfiesteria* can turn an eerie bright red or

maroon-brown, both from the cell's presence and from blood emitted by the fish sores produced by the feeding amoeba. *Pfiesteria* also releases an aerosol that is dangerous for humans to breathe (96).

No one knows for sure what made this ancient cell turn into a mass fish killer, but some scientists theorize that environmental changes are to blame. Warmer water temperatures and greater run-off from farming areas (that can release high levels of animal waste and fertilizer into rivers and lakes) give rise to blooms of algae and bacteria, which in turn can spur a population explosion of *Pfiesteria* (97).

Pfiesteria can change from plant to animal and back under conditions affected by pollution and climate. For example, when the amount of freshwater entering estuaries decreases due to periods of drought and low rainfall, estuaries tend to form stratified layers, with lighter freshwater lying on top of layers of dense, heavy saltwater. When temperatures increase, water becomes less able to hold oxygen. The bottom layer of saltwater is cut-off from almost all oxygen, creating conditions more favorable to *Pfiesteria* development (98).

Sediment pollution primarily resulting from agriculture, livestock grazing, timber cutting, and municipal land use practices also becomes more concentrated during periods of low rainfall and warmer conditions. Extreme weather events, such as Hurricane Floyd, can wash such pollutants into the state's waters, where they concentrate during warm weather months (98).

Until recently, *Pfiesteria* had not been identified in Florida's waters. However, the Department of Health, the Florida Marine Research Institute, and the Florida Fish and Wildlife Conservation Commission have since monitored its prevalence (95). As climate change continues to warm the seas and humans continue to allow large quantities of animal waste and fertilizers to enter surface waters, *Pfiesteria* and other HABs will likely lead to more health risks to fish, shellfish, and humans in the years to come.

How Climate Change Could Affect Water Quality

On the other end of the spectrum, flooding causes excess water runoff and it can cause pollutants such as pesticides and human wastes to enter surface and ground waters. In 1999, storm water accounted for 80% to 95% of the loadings of heavy metals and coliform bacteria (an indication of fecal contamination) entering Florida's waters (89). It is not surprising that fertilizer and pesticides should wind up in Florida's waters. The citrus industry alone uses 200 to 240 pounds of fertilizer per acre on average (90). Insecticides and fungicides for citrus vary from 5 to 10 gallons of oil-based pesticide per acre (90).

Both flooding and droughts can cause diarrhea from a variety of bacteria (e.g. *Salmonella* and *Shigella*), viruses (e.g. rotavirus), and protozoa (e.g. *Giardia lamblia*, amoebas, *Cryptosporidium*) (18). Most healthy individuals recover, but if not treated appropriately diarrhea can become serious, resulting in dehydration and occasionally death. Children, anyone with a compromised immune system, and the elderly are particularly vulnerable to severe consequences from diarrheal disease (17).

Cyclospora, a parasite that reproduces via an egg-like structure called an oocyst passed from humans in the feces, can get into the water supply. The oocyst matures and becomes infectious in the environment. Warmer temperatures facilitate this process. When foodstuffs such as fresh produce are irrigated or processed with contaminated water, *Cyclospora* can be ingested and can cause diarrhea (17). *Vibrio vulnificus* is a bacteria that naturally occurs in waters around Florida, particularly in the Gulf of Mexico. When shellfish become infected with the bacteria, the infection is passed to humans who eat the shellfish. Warmer temperatures allow the *Vibrio* bacteria to grow faster, and infection rates are higher during the summer (17). (See figure on page 25.)

Harmful algal blooms (HABs) are large increases in algae populations that have negative impacts on the environment, economy, and human health. Most commonly, HABs are discussed with respect to their ability to kill fish and poison humans who eat affected fish and seafood. Recently, however, HABs have been found in fresh water, and low levels of the toxins they produce have been found in Florida's drinking water (91). Multiple environmental changes have been blamed for the increased frequency, duration, and concentration levels of these blooms in freshwater. Changes in land utilization, nutrient runoff, loss of aquatic vegetation, and a climate that has become very conducive to algal growth and proliferation are the main factors involved (91).

Aquatic blue-green algae produce toxins that can attack the nervous system, causing convulsions, paralysis, and respiratory failure. Other toxins can attack the liver, causing damage or liver failure and contributing to cancer. A third type of blue-green algae toxin results in allergic reactions in the skin causing severe itching (91). Humans are exposed to these toxins by ingesting them in drinking water or when pursuing recreational activities in affected surface waters.

Scientists tested 167 water samples from water bodies throughout the state during the summer of 1999. About half of them were found to contain significant levels of toxin-producing blue-green algae, and 80% of these

samples have been shown to be lethally toxic to mice (91). Some of these water bodies are used as drinking water resources. Many of the blooms are easily detected due to the presence of surface scums, discoloration of water, odors, or bad tasting water, but some are more difficult to detect (91). Not just humans are affected; animals such as cattle and sheep have died after drinking water affected by a blue-green algae bloom, as well (92). With warmer temperatures, it is possible that HABs will pose more of a threat to drinking water.

Florida's Fisheries

Scientists have observed an increase in toxic phytoplankton blooms, both in the U.S. and worldwide, since the early 1970s. In the U.S., over the last 25 years we've had more frequent blooms, caused by more different species, and affecting larger geographic areas

—VOLUNTEER WATER QUALITY MONITORING NATIONAL NEWSLETTER (99).

According to the EPA, climate change could have a devastating impact on fisheries. Some bodies of water may become too warm for the fish and shellfish that inhabit those areas. Climate change also may alter the chemical composition of the water that fish inhabit, causing the amount of life-sustaining oxygen in the water to diminish while dangerous pollution and salt levels increase (16).

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

Red Tides And Seafood Poisonings

Certain seafood-related health problems arise when poisonous algae bloom along Florida's shores in the spring or fall. Global warming may increase the occurrence and severity of such blooms. The harmful algae often stain water red—hence the expression “red tides.”

Nationally, such harmful algal blooms (HABs) are on the rise and appear to be expanding throughout the United States (100). Red tides and other HABs such as *Pfiesteria* affect human health when individuals consume or come into contact with fish and shellfish from infected waters. Raw or cooked, these animals can pass the toxins to humans, causing poisoning.

There are five principle types of seafood/shellfish poisoning, but only two types, ciguatera fish poisoning and neurotoxic shellfish poisoning, occur in Florida (98).

Ciguatera fish poisoning may become evident up to 24 hours after an individual consumes toxic fish or 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 (101). Ciguatera may also cause reversal of temperature sensation, muscular aches, anxiety, sweating, and numbness and tingling of the mouth and digits. Paralysis and death have been documented. There is no antidote, but survivors have recovered after taking the drug manitol and undergoing supportive therapy

(101). More than 400 species of fish can cause ciguatera, but the major ones include barracuda, snapper, amberjack, kingfish, mahi mahi, and grouper (101). An outbreak consisting of six cases was reported to the Palm Beach County Health Department in August 2000 (23). Experts report that conditions that favor ciguatera development often follow reef disturbances due to storm damage or human activities such as over-fishing or “nutrient enrichment” from human and animal waste runoff (98).

Neurotoxic shellfish poisoning causes symptoms including tingling and numbness of the tongue, lips, and throat; muscular aches; gastrointestinal distress; and dizziness (101). These can occur within hours or days of consuming infected species. Neurotoxic shellfish poisoning events are associated with fish kills, sea spray aerosol from affected waters, and marine mammal and bird die-offs (101). Seafood associated with the poisoning includes clams, scallops, mussels, and oysters (101).

Another toxin that ends up in water is mercury, which is released in very high levels by power plants and settles into the water where it accumulates in fish. Nearly all fish contain methyl mercury, with large fish and sport fish having the greatest concentrations (102). Mercury is toxic to humans, especially unborn children who can suffer brain damage from exposure. Tuna, sea bass, halibut, marlin, pike, white croaker, shark, swordfish, and mackerel should not be eaten more than once a month, particularly by pregnant women and women of childbearing age who might become pregnant, due to high mercury levels (102).

How Global Warming Could Change Florida's Agriculture and Forests

April through June of 1998 was the driest period in 104 years in Florida, Texas and Louisiana.

—NATURAL RESOURCES DEFENSE COUNCIL (103)

How Climate Change Could Impact Agriculture

Warmer temperatures and changes in precipitation are likely to have significant effects on agriculture in Florida. Whether yields ultimately increase or decrease will depend on many factors, including water availability, changes in climate variability, and the ability and willingness of farmers to adapt to a changing environment. Current earnings from Florida's citrus industry bring \$8 billion annually to the state and employ more than 100,000 people (104). Overall citrus production for the state may not decrease much, but local changes could be devastating. With warmer temperatures, southern Florida could lose a sufficient dormant period causing decreased yields (3). In addition to citrus, major crops in the state include corn, hay, sorghum, cotton, sugarcane, and potatoes (3). Sugarcane yields are projected to drop by 20% to 40%, potatoes by 10% to 30%, and corn yields by 14% (3). Already “unusual climatic conditions,” predicted to occur as a result of climate change, were to blame for a 22% drop in Florida orange production in 1998 (104). Even plants that do survive may become smaller and develop smaller seeds, which could further reduce yields. If summer temperatures rise significantly, livestock may lose weight as forage areas decline, reducing meat and dairy production (3).

Projected Impact On Forests

Global warming also could alter Florida's forests by influencing biological diversity and forest growth (3). Changes in precipitation, higher temperatures, and extreme weather events could wreak havoc on the state's timber stands. For example, the mixed conifer and hardwood forests of Florida's northern and panhandle sections are likely to retreat northward. The movement would be accompanied by a reduction in forest density. Die-backs of forests along the Gulf coast, which already appear to be occurring, could affect commercial timber yields and forest-based recreation and tourism (3).

Warmer temperatures and climate change can bring on droughts, another effect that appears to already be taking place in the state. During the winter of 2000–2001, the National Oceanic and Atmospheric Administration ranked Florida as the third driest state (105). The year 2000 overall was Florida's driest year on record (106), and 1998 saw the most severe drought in 104 years (103).

Droughts can lead to forest fires, which affect both the health of the public and the health of the ecosystem. Fires can have a devastating effect on current timber production as well as future production by killing young trees (107). Important wildlife habitat can be lost and homes and businesses destroyed. From a human health standpoint, fires may cause injuries and fatalities to firefighters and nearby residents. Smoke, which can cover a wide area, may cause respiratory difficulty and exacerbate existing respiratory conditions such as asthma and chronic obstructive pulmonary disease (108).

Forest fires occur often in the state and have led to numerous deaths and injuries. During just one short period, June–July 1998, a total of 2,277 fires had burned through 499,477 acres in Florida (23). After receiving numerous calls from individuals suffering respiratory problems due to smoke inhalation, the Volusia County Health Department issued a public health alert advising individuals with existing pulmonary or cardiovascular conditions to avoid breathing air outdoors (23). Emergency departments saw high increases of fire-related complaints in fire regions when compared to the previous year: Rates for asthma visits increased by 91%, bronchitis with acute exacerbation by 132%, and chest pain by 37% (23).

Conclusion

This report has reviewed the threats to human health, particularly in Florida, that could result from 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 serious and demand attention. Increased levels of heat, extreme weather events, vector-borne and water-borne diseases, air pollution, and compromised water supplies affect all Americans. The poor, elderly, young, and anyone whose immune system doesn't work well will be the hardest hit.

Many of the effects of climate change will be compounded by other environmental stresses such as pollution, increasing population, over-harvesting of natural resources, and habitat loss. Thus, improving

environmental practices such as decreasing discharges of pollutants into the soil, air, and water may help lessen the harmful effects of climate change on fragile ecosystems.

We must act now to slow and eventually reverse climate change by significantly reducing fossil fuel consumption and greenhouse gas emissions. In addition, we need to invest in strategies that will help us to prepare for what may come. It is essential that we formulate and implement plans to improve our public health infrastructure, including disease surveillance and emergency response capabilities. Continued research is needed to better understand the relationships among climate change, the health of ecosystems, and the health of the public.

What You Can Do

Florida can do its part to begin controlling global warming by implementing common sense measures such as reducing pollution from dirty power plants and inefficient vehicles. These actions protect Florida's environment while saving energy and money.

—ALLIANCE FOR FLORIDA'S FUTURE (109)

What can individual Floridians do to reverse climate change? The number one priority is to lower the use of fossil fuels. Local, state, and federal government representatives should be strongly encouraged to support smart energy policies and the development and use of new technologies to reduce fossil fuel consumption and to reduce greenhouse gas emissions.

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. Reducing greenhouse gas emissions through sound energy policies is a win-win scenario because we will not only prevent the associated health effects of global climate change but also reduce the current threats to health from air pollution. In addition, these policies 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 Florida, starting now, to combat global climate change and bring down consumption of fossil fuels.

1 Contact your local representatives, government officials, and mayor. Find out if your city or county has a plan to reduce carbon dioxide emissions and, if not, encourage them to consider it. Demand user-friendly public transportation. Support efforts to refurbish old wastewater infrastructure in the state. Water systems in Florida are vulnerable to contamination from pollutants and pathogens in untreated sewer water during flood events. Urge officials to continue to update sewer and flood water lines to avoid such problems in the future.

2 Contact your state representatives and Governor Bush. Information regarding your state representatives can be found in the blue pages of your phone book. Encourage them to develop and implement state carbon dioxide emission reduction plans and to create incentives for citizens and businesses to make more efficient energy choices. For example, provide tax incentives for families that purchase newer cars with better mileage. Ask Governor Bush to support shutting down or cleaning up old, dirty power plants, like those owned and operated by Southern Company, and to discourage the use and development of nuclear power. At <http://cta.policy.net/cusc/right.vhtm> concerned citizens can send a fax to the CEO of Southern Company urging the utility to reduce pollution emitted from its power plants.

3 Contact your members of Congress and President Bush. Encourage them to adopt a balanced energy policy that promotes efficiency and use of clean, renewable sources of power. Specifically ask them to:

- Fund research and implementation of new next-generation energy technologies such as solar and wind power. This will not only give the oil supply we currently have a longer life, but will also reduce the unhealthy pollution associated with both the burning of fossil fuels and the recovery of fossil fuels.
- Clean up power plants! Require that power plants that were grandfathered under the Clean Air Act be cleaned up or shut down now.
- Support “Four-Pollutant” bills regulating carbon dioxide, nitrogen oxides, sulfur dioxide, and mercury.
- Support an increase in Corporate Average Fuel Economy standards, or minimum miles per gallon standards, for cars, SUVs, and light trucks.
- Support international agreements to lower global carbon emissions, and take responsibility for our disproportionate contribution of greenhouse gas emissions to the world’s climate change problem.

Contact information for your members of Congress and the President can be found in the blue pages of your phone book, or on the following websites: www.senate.gov and www.house.gov

4 Get your own house and business office in order. Use energy-efficient light bulbs such as compact fluorescents. Install a solar system to help provide your hot water (carbon dioxide reduction: 720 pounds per year). Recycle all of your waste newsprint, cardboard, office paper, glass, plastic, and metal (carbon dioxide reduction: 2,480 pounds per year). Lower your thermostat in winter and raise it in summer, or use a thermostat that shuts off when you are not home, 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.

Be conscious of how your actions create carbon emissions. Americans’ love for automobiles contributes 30% of U.S. greenhouse gas emissions. Nearly 10 million cars are registered in Florida. As population increases, so does pollution from cars. From 1990 to 1999, Florida’s population rose 17% to over 15 million. Do your part by carpooling and leaving your car at home as much as possible. When you do have to drive, keep your car’s tires properly inflated at all times. This ensures the maximum efficiency of your car. If your car’s tires are under-inflated by just 4 pounds, it could cost up to a half-mile per gallon of gasoline. When purchasing a new car, buy the most fuel-efficient vehicle you can afford. At a web site launched by the EPA and the U.S. Department of Energy (<http://www.fueleconomy.gov>), you can do a side-by-side comparison and select the right car for your needs.

5 Urge the businesses you patronize to become energy-efficient. United States 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%, or \$35 billion nationally. There are now numerous programs in place to help businesses change their energy use strategies 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 Work with local groups and chapters of national organizations to promote awareness of global climate change and related issues in Florida. These include:

American Lung Association of Florida Affiliate Headquarters for Florida and Puerto Rico (727-570-8809)

Florida Public Interest Research Group (850-224-3321)

Florida Consumer Action Network Foundation (813-286-1226)

Project for an Energy Efficient Florida (850-222-0808)

Legal Environmental Assistance Foundation, Inc. (850-681-2591)

Sierra Club Florida Field Office (727-824-8813)

American Fisheries Society, Florida Chapter (561-465-2400)

American Littoral Society Coral Reef Conservation Center (305-358-4600)

The Conservancy of Southwest Florida (941-262-0304)

Everglades Coordinating Council (305-248-9924)

Florida Defenders of the Environment (352-378-8465)

Florida Forestry Association (904-222-5646)

Florida Wildlife Federation (850-656-7113)

Keep Florida Beautiful, Inc. (850-385-1528)

The Nature Conservancy Southeast Division Office (407-682-3664).

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 climate change—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 climate change. Second, just like businesses, governments, and responsible individuals, PSR feels the need to act decisively to protect the public health and welfare.

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 climate change, one step that we can control. For the sake of our own well-being, and that of future generations, we need to act now.

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

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