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DEGREES OF DANGER

HEALTH EFFECTS OF CLIMATE CHANGE AND ENERGY IN OREGON

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This report was prepared by Physicians for Social Responsibility to alert Oregon 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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The Health Threats of Climate Change in Oregon

Physicians for Social Responsibility

Introduction

Oregon, one of the more topographically diverse states in the nation, sports mountains, valleys, volcanoes, glaciers, forest, farmland, and coastline. This topographic diversity supports economic diversity as well. In fact, many Oregonians enjoy a quality of life unmatched by that found in other states. However, climate change has the potential to threaten this quality of life by fundamentally changing some important aspects of our environment in ways that can affect the health of Oregon residents. Threatened water supplies, droughts, floods, deteriorating air quality, and heat waves could take their toll on the health of Oregon residents.

Changes in climate will certainly affect our health and the environment, but the extents of these effects remain uncertain. This uncertainty makes planning difficult and highlights the most prudent course of action: reduce the rate of climate change. Like other environmental problems that threaten our well-being such as air and water pollution, global climate change is caused, largely, by human activities. When humans burn fossil fuels for energy, carbon dioxide (CO_2) and other greenhouse gases are released into the air. These greenhouse gases accumulate in the atmosphere and act as a blanket, trapping heat under it and raising temperatures on the Earth's surface. Climate change can be slowed and eventually reversed, but there is a narrow window of opportunity in which to act to prevent long-term damage to our health, the health of future generations, and to the Earth itself.

Understanding the potential impacts of climate change will aid the development of solutions. Most importantly, the amount of CO_2 and other greenhouse gases released into the atmosphere must be reduced. Technology already exists to lessen our dependence on fossil fuels, such as coal and oil, which when burned produce CO_2. By demanding that government and industry invest in and use renewable sources of energy, the amount of CO_2 production can be reduced. In addition, putting existing technology to use in cleaning up power plants, such as the Boardman Coal Plant, could immediately reduce CO_2 and other greenhouse gas emissions.

The Oregon population is growing at a rate higher than the national average (*1*). Whether it is the mountains, the Willamette Valley, the coast, or the high desert that is drawing individuals, future increases in the development of Oregon may add to the increasing environmental stresses and the demand for energy. If present patterns of energy production and use are continued, more growth and development will lead to increased CO_2 emissions. For example, cars are responsible for 20% of CO_2 emissions in this country. Technology already exists to produce cars that get greater fuel economy and therefore burn less gasoline, cutting carbon emissions. A limited number of these vehicles are already on the market, but industry and the government must be pressed to continue to invest in these technologies and produce more vehicles that are environmentally responsible.

Oregon residents, along with the rest of Americans, have an opportunity, and a responsibility, to care for the Earth and protect Oregon's natural resources for our children and their children to come. People unknowingly created the problem of pollution and global climate change, and people have the ingenuity and intelligence to create and implement solutions. People in Oregon and all across the country must take action now to learn what can be done, to develop solutions, and to demand that our policy makers put them into action. This report will discuss many of the potential health effects that climate change could cause and many of the solutions that can be implemented today to help slow the rate of climate change and to help residents of Oregon reduce its negative impacts.

Executive Summary: Oregon—A State At Risk

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 published its third report to government officials worldwide stating that by 2100 average global surface temperatures may increase 2.5° to 10.4° F (1.4° to 5.8° C) if countries continue to rely on burning fossil fuels for energy. Rates of warming over land areas are likely to be higher (*2*). The National Academy of Sciences, in a special study recently commissioned by President Bush, provided their best answers to some key questions 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." (3)

The Climate Impacts Group at the University of Washington analyzed seven climate projection models for the Pacific Northwest region and found an average projected increase of 5.3° F from the mid-20th century to the year 2050. The region has already warmed about 1° F since the mid-20th century. These higher temperatures, and the accompanying changes in climate such as precipitation, could affect many aspects of Oregon's environment, perhaps most importantly Oregon's supply and quality of water, which can affect human health.

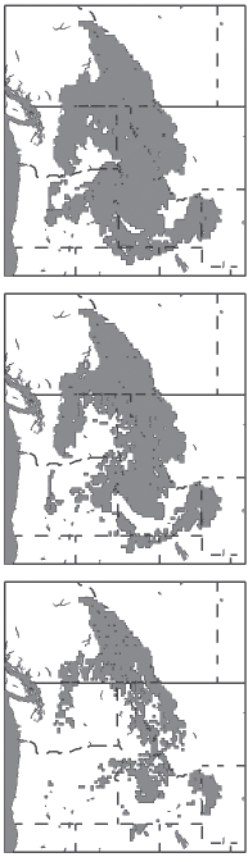
The majority of Oregon's water resources, over 100,000 miles of rivers and streams, are maintained by snowfall and snowmelt (*4*). Water supply is highly sensitive to climate change. A decrease in supply would have detrimental

impacts on agriculture, industry, energy production, and residential use. Some models project an overall increase in precipitation in Oregon, but this precipitation is more likely to come during the fall and winter in the form of rain, rather than snow, in the warmer winter climate. With less snow falling and snowmelt arriving earlier in the year, the snowpack is very likely to diminish, reducing water supplies. Additionally, the change in runoff amounts may cause flooding and affect irrigation and water management (*5*). Less water may be reliably available because of limited storage capabilities and a diminished supply during the warmer seasons (*6*). Oregon's 362 coastal miles may also be affected by rising sea levels and increased erosion of the coastline (*7*). Seawater may contaminate water supplies and estuaries, and wetlands could be unable to shift inland due to development (*7*).

Uncertainty about just how much precipitation will fall and when water will be available makes it difficult for Oregonians to make plans for specific outcomes. Instead, strategies to plan for coming changes should be flexible and nimble. Sometimes these strategies are called "no regrets" plans because they encompass activities that improve the current situation regardless of how much precipitation actually falls in Oregon. Water conservation efforts, for example, reduce the energy required to transport water to where it is needed, reduce the amounts of chemicals needed to treat the water, and allow Oregonians to prepare for the possibility of droughts in the future.

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 (*8*). *Cyclospora* and *Cryptosporidium* are two kinds of germs that can contaminate water and cause disease. Contamination of the water supply, especially with *Cryptosporidium* has tended to occur following episodes of heavy rain and flooding (*9*). Severe flooding also can cause direct injuries and accidents (*2;10*). Technologies already exist that can help conserve water and safeguard the drinking water supply. Putting these technologies to widespread use is the next challenge.

FIGURE 1
Columbia Basin Snow Extent (Washington and Oregon)



Average snow water equivalent on March 1 in the Columbia Basin simulated for 20th century climate ("base") and the future. A detailed hydrology model developed at the University of Washington (called VIC) simulates detailed interactions between air, land, and water at 1/8 degree horizontal resolution and is run for the 20th century and for the climate changes projected for the 2020s and 2090s by the HadCM2 climate model (Hamlet and Lettenmaier, 1999).

Graphics provided by the Climate Impacts Group, University of Washington.

How Climate Change Could Affect Health in Oregon

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

Changes in the quality and supply of water:

- Changes in precipitation amounts and patterns could lead to more flooding in some areas and droughts in others, therefore decreasing supply.
- Water supply may be contaminated due to salt water intrusion caused by rising sea levels.
- Both droughts and floods can impair water quality.

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

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

Increased accidents and injuries:

- A projected increase in sea level of 1 to 3 feet by 2100 could bring flooding and coastal erosion, particularly when complicated by storm surge.
- There could be an increase in injuries from potential extreme weather, including floods.

Greater risk of infectious diseases:

- Water used for drinking and recreation 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.
- Increased risk of mosquito-carried diseases such as malaria and dengue fever.

More 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.

Climate change also is expected to increase air pollution levels in urban areas. For example, small increases in atmospheric temperature will influence winds and storm patterns, which play important roles in the dispersion of pollutants and "washing" of the air with precipitation. Warmer temperatures and sunlight trigger a reaction between nitrogen dioxide and volatile organic compounds (VOCs) that results in the creation of ground-level ozone, the major component of smog (*11*). Particulate matter air pollution is composed of primary particles, or "soot," emitted directly into the atmosphere by pollution sources such as industry, electric power plants, diesel buses, and automobiles, and "secondary particles" formed in the atmosphere from sulfur dioxide and nitrogen oxide gases, emitted by many combustion sources, including coal-burning electric power plants. A large body of research has demonstrated adverse health impacts associated with exposure to particles and ozone air pollution, including: decreased lung function (a measure of our ability to breathe freely); more frequent respiratory symptoms, increased numbers of asthma attacks, more frequent emergency department visits, additional hospital admissions, and increased numbers of daily deaths. These effects have been observed in all regions of the U.S. (*12*). Both nitrogen dioxide and VOCs are pollutants emitted from automobiles, electric power plants, and industry.

At the present time, air quality is healthful in the majority of the state. The Environmental Protection Agency lists Oregon as having only one area that

has not attained ozone standards (*13*). However, in light of new research, federal air quality standards for particulate matter and ozone are being strengthened, and levels of pollution previously regarded to be "healthful" may be reclassified as unsafe. A federal court ruling halted implementation of new federal standards for particulate matter and ozone in 1997, but if allowed to move forward, other areas in Oregon are likely to be classified as non-attainment.

Other air pollutants that result from burning fossil fuels such as carbon monoxide, sulfur oxides, and nitrogen dioxide all have negative health effects, including toxicity, lung irritation, reduced lung function, and aggravation of existing cardiovascular diseases. In the recognition of air pollution impacts on health caused by climate change, it is important to distinguish the effects of these pollutants from the "greenhouse gases," such as carbon dioxide and methane. Carbon dioxide (CO_2) is emitted by combustion processes, such as the burning of oil and gas in power plants, industry, and motor vehicles. Methane is emitted by microbial activity associated with dairy and beef cattle, sewage treatment, and the decay of household wastes. The staggeringly large amount of these gases emitted by human activities worldwide are disturbing natural balances and causing atmospheric heating. The climatic changes these gases cause will weaken natural processes that reduce air pollution at ground level. Thus the reduction of fossil fuel burning will reduce the amount of CO_2 introduced to the atmosphere and at the same time reduce the levels of air pollutants harmful to health.

Climate change, moreover, could increase the risk of insect-carried (called vector-borne) diseases such as malaria and dengue fever that historically occurred in Oregon. Warmer temperatures can speed maturation of the insect itself, as well as development of the disease within the insect, making it easier for some insects to transmit a disease to humans (*14*). 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 Oregon (*15*). However, if disease surveillance systems are not strengthened and maintained, vector-borne diseases such as dengue fever could become a problem.

While projections look to the future, global and regional warming may be influencing the environment and society now. Numbers of very hot days and nights in Oregon have increased during the past 50 years (*16*). Higher ambient temperatures are associated with heat cramps, heat exhaustion, and heat stroke. Heat stroke can be fatal. Heat waves tend to exacerbate the death rate from other medical conditions. The elderly, chronically ill, and the poor will likely suffer the most (*17*). Oregon is already affected by intermittent heat waves and may become more susceptible with climate change (*6*). Heat related deaths could increase 150% with a summer temperature increase of 4° F (*7*). Reducing CO_2 emissions and slowing global warming and climate change will decrease average temperatures and heat-related deaths. In addition, adaptation strategies can be implemented immediately to reduce the number of heat-related deaths in the short-term.

Climate change could affect agriculture, fisheries, and forests. These sectors can potentially have indirect effects on public health by jeopardizing

economic security and jobs as well as further altering the environment. The production of Oregon's primary crops such as wheat, hay, and potatoes could change. Potato yields are projected to suffer the most, while wheat yields are projected to increase (*6*). One-half of Oregon's cropland is already irrigated; this is expected to increase with drier summers impinging on the already decreasing water resources (*6*). Some technologies for growing crops with less water already exist and focusing additional resources on research and development of additional ways to sustainably increase crop yields should be a priority. Adapting local and regional water management policy to encourage conservation would be an important step in dealing with Oregon's current and future water shortages.

Oregon's fisheries may also be affected by climate change. In addition to contamination of shellfish populations due to algal blooms, fish populations may decrease when fish are unable to find adequate spawning grounds such as cool water estuaries (*18*). Warmer water temperatures may be an important factor in the increase of algal blooms, but algal blooms are also known to occur more commonly in polluted waters (*19*). Therefore, reducing water pollution in important spawning grounds and nursery areas may reduce potential harm to fisheries, marine ecosystems, and humans.

Oregon's forests represent a significant component of land area both east and west of the Cascade Mountains. With increasing CO_2 concentrations, it is possible that some forests will flourish, at least in the short term. However,

The Precautionary Principle

Legislators, physicians, ethicists, and environmentalists often refer to "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" (*98*).

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. There is strong evidence that global warming is occurring and is largely the result of burning fossil fuels and other human activities. No one knows *exactly* how much or how soon temperatures will rise, *exactly* what all the consequences will be, or *at all* how much and in what ways any individual will be affected. It is known, 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 steps are taken to slow global warming and climate change by greatly reducing our consumption of fossil fuels.

many future climate scenarios eventually project reductions in forested area on both sides of the Cascade Mountains. Increased moisture deficits, increased potential for loss from wildfires, increased pest damage, and increased wind damage could take their toll on forest health with projected changes in climate (*10*). Forest management practices may have to be adjusted to accommodate changing growth conditions (*10*).

In summary, climate change could cause changes in Oregon's environment that could have largely negative effects on human health. Climate change can be slowed and eventually reversed by reducing our reliance on fossil fuels to provide energy. 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 climate change 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. Understanding the variety of impacts climate change could have on our environment and our health and well-being is an important first step in developing solutions to the problem. The United States has some ability to adapt to, and prepare for, these changes because of its health care infrastructure and relatively strong economy. However, only by taking action now to decrease CO_2 and other 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. Thus, small changes in average temperatures can produce dramatic changes in climate. Some amount of certain greenhouse gases, such as CO_2, methane, nitrogen dioxide, and water vapor occur naturally, reside in the atmosphere and insulate Earth. These gases retain some heat from the sun's rays and keep Earth's surface about 60° F warmer than it otherwise would be (*20*).

As fossil fuels such as coal and oil are burned to produce energy, greenhouse gases, such as CO_2, accumulate in the atmosphere and act like a blanket trapping heat underneath. Since the beginning of the industrial revolution in the mid-1700s, atmospheric concentrations of greenhouse gases have greatly increased and the rate of temperature increase has greatly accelerated.

- *Carbon dioxide concentrations have increased by 31%.* They are responsible for more than 60% of the "enhanced" greenhouse effect.

Global Warming versus Global Climate Change

Although the average temperature worldwide is increasing, hence the term "global warming," the whole story is even more complex. 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. If this man-made process is allowed to continue, 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 (*2*). Many scientists, therefore, prefer the term "global climate change" to "global warming" because it better describes the bigger picture. In this report, we use the terms "global climate change," "climate change," and "global warming" interchangeably.

- *Methane concentrations have more than doubled*. Methane released from garbage dumps, farm animals, coal mining, melting permafrost in the far North, and natural gas production contributes up to 20% of the enhanced greenhouse effect.
- *Nitrogen dioxide concentrations have risen about 15%*. Nitrogen dioxide results from burning fossil fuels and has a lifespan of about 120 years, meaning that combustion byproducts of fuels burned now may remain in the atmosphere and potentially contribute to climate change until the year 2122 (*21; 22*).

All of these extra human-generated greenhouse gases have combined in the atmosphere to trap heat and warm the Earth. In fact, some researchers believe that methane, black carbon aerosols (soot) and nitrogen dioxide may play an even greater role in global warming (*23*).

Fuel burned to run cars and trucks, heat homes and businesses, and power factories generates approximately 80% of CO_2 emissions in the United States (*24*). Deforestation, livestock production, landfills, industrial production, and mining also add to 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 CO_2 emissions into the atmosphere. In 1999, the United States released 13% more greenhouse gases than in 1990 and the Energy Information Administration projects CO_2 emissions will continue to increase by an average rate of 1.5% per year from 1,562 million metric tons in 2000 to 2,088 million metric tons in 2020 (*25*). If current trends continue, CO_2 concentrations would increase by 30% to 150% by the year 2100 (*20*). One certain way to reduce CO_2 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

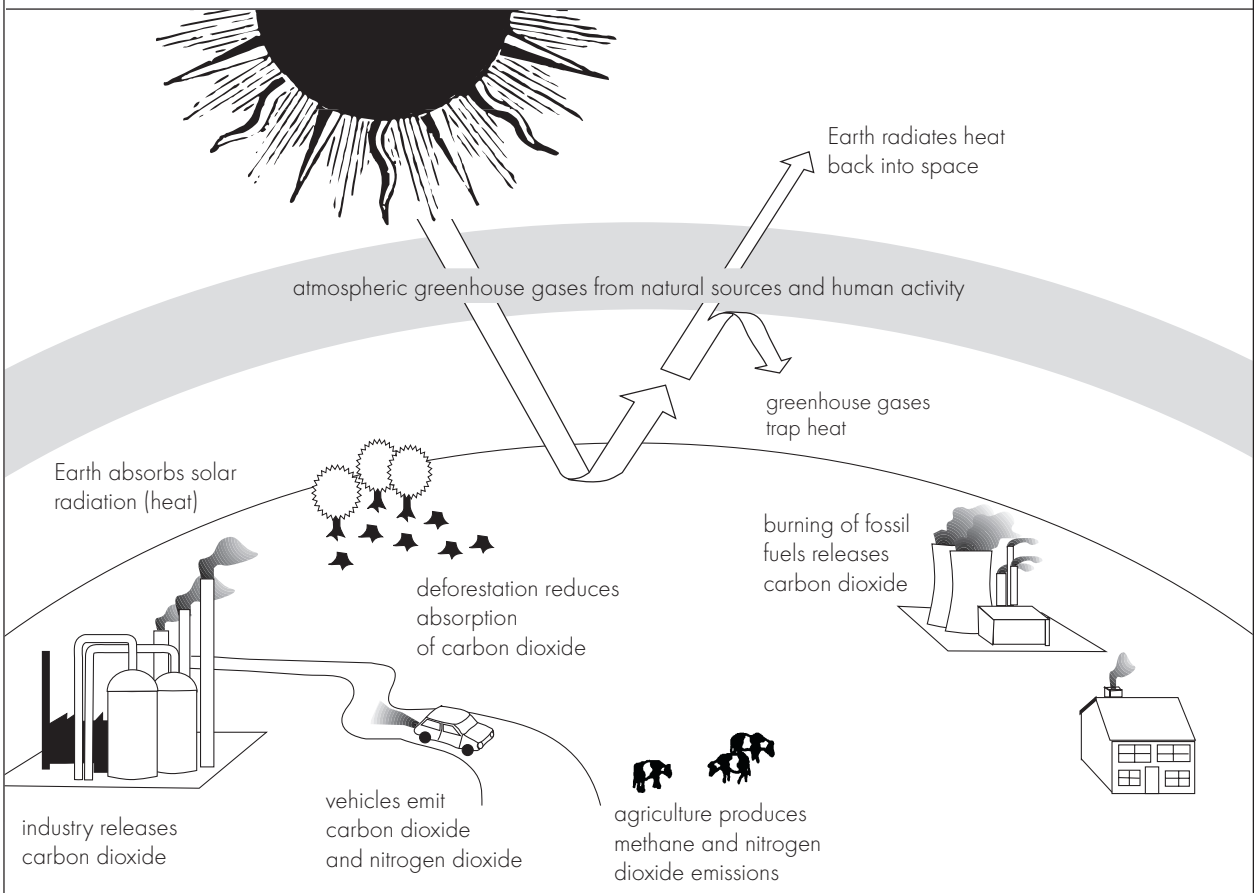
There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.

—INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, 2001 (*2*)

In 1995 the IPCC projected increases in global average temperatures of 1.8° to 6.3° F (1° to 3.5° C) during the next 100 years (*26*). In 2001, the IPCC revised its temperature projections stating that new studies and better methods for analyzing the data have "led to a better understanding of climate change." (2) The IPCC now projects average global temperature increases of 2.5° to 10.4° F (1.4° to 5.8° C) during the next 100 years. Rates of warming over many landmasses are likely to be higher (*2*).

The Intergovernmental Panel on Climate Change (IPCC) is an international organization developed by the United Nation Environment Programme (UNEP) and the World Meteorological Organization (WMO) to address issues of global climate change through an in-depth and continual assessment of climate change research. IPCC does not conduct its own new studies. Instead it assesses all available information and research from around the world and

FIGURE 2
The Greenhouse Effect



Source: Adapted from *The Impact of Climate Change*, United Nations Environment Programme, 1993; Climate Action Network.

synthesizes that information into a single, monumental report. The new Third Assessment Report, released in 2001, is composed of four elements that cover the complete range of scientific, technical, economic, and social issues associated with the climate system and climate change deemed important by the expert and policymaking communities. All together, more than 2,500 of the world's leading climate-related scientists have contributed to this work and the report has undergone extensive scrutiny and peer review.

The evidence that the Earth is warming is now indisputable. While the warming trend needs continued study, it is certain that the Earth will warm, that this warming will affect the population. Action is needed to slow the process. The ensuing section will describe potential health effects of global warming on people and suggest actions that Oregon residents can take now to slow, and eventually reverse, climate change and to help diminish its harmful effects.

How Could Climate Change Affect the Health of Oregon Residents?

The Effects of Climate Change on Oregon's Water Resources

Water Supply Threatened by Climate Change

Oregon has 362 coastal miles, 6,223 lakes and over 100,000 miles of river (*4*). Despite this abundance of seemingly available water, climate change could directly influence water supply. It is likely that the snow pack will decline with more precipitation falling as rain, rather than snow, in the warmer winters. Additionally, warming may cause earlier snowmelt, increasing the likelihood of spring floods and summer droughts (*27*). With a limited storage capacity, even increased winter precipitation resulting from global climate change may not increase supply (*10*). Climate models suggest that in 20 years, severe droughts could be twice as likely as they are now (*28*).

SOLUTIONS

Current studies show that water shortages could be diminished with improved use of water for agriculture. Improved technologies making irrigation more efficient, such as drip and low-energy sprinkler systems, could reduce water use by up to 50%. Additional improvements in irrigation timing adjusted to plant needs, temperature, and precipitation would further reduce water demands (*31*).

Water shortages have already led to competition among various water users. Oregon water law works through "prior appropriation" meaning that the first entity to declare water rights is the last entity to be cut off in times of shortage (*29*). In addition, water rights are reserved for species protection. This law could influence water management when shortages result from climate change. Currently in Oregon, a water use battle ensues in the Klamath Basin. Farmers suffering from drought are demanding use of Upper Klamath Lake water for irrigation. This water, however, is protected for Coho salmon (*30*). These disputes over water resources may continue to grow as water supply becomes scarce, especially if Oregon's population continues to grow at its presently high rate.

Water Quality Threatened by Climate Change

Low stream flows cause substances in water to concentrate, leading to more polluted waters. Decreased stream flow may increase salinity, threatening water quality. Additionally, concentrated pollutants could reduce the ability of rivers and streams to assimilate waste (*7*).

Mercury is one of the most toxic substances known to exist, causing neurological defects, seizures, and even death. Human-made sources of this element include solid waste incineration, fossil fuel combustion, mining, and smelting. Fossil fuel-fired power plants are a major source of mercury. Mercury accumulates in water sources and becomes concentrated in the body tissues of fish, thus becoming a health-hazard for consumers. Concentrations of total mercury in fish such as pike and swordfish can be 10,000 to 100,000 times as great as the ambient concentration in the water. Fish advisories warning against the consumption or handling of fish from contaminated waters have been issued for mercury in 40 states. Since 1993, Oregon has had multiple watersheds listed with fish consumption mercury advisories including

the Columbia and Snake Rivers, with two new advisories listed in 2001 in the Galesville and Cooper Creek Reservoirs (*32*).

Mercury is especially harmful for pregnant women because it crosses the placenta and can cause damage to the developing fetal nervous system. Women who are pregnant, or may become pregnant should check with their doctor about which fish and how much fish is safe to consume.

Pollution is not just a problem for surface waters; groundwater is also at risk. Underground aquifers supply 95% of Oregon's freshwater (*33*). As the population of Oregon grows, further demand may be placed on this valuable resource. Groundwater contaminants include nitrates, pesticides, heavy metals, and bacteria. Sampling of 198 wells in the lower Umatilla Basin found that between 10% and 25% of the wells sampled were above the drinking water standard for nitrates. Nitrates are a particular risk for babies because they cause a condition that prevents the babies' blood from carrying sufficient oxygen. Similar results were found for areas in the Willamette Valley, the South Coast, the North Coast and in Klamath County (*34*). Nitrates are usually washed into the water supply from animal waste and fertilizers applied to farmland. In general, Oregon's water sources are of good quality, but climate change could alter this.

The effects of climate change on precipitation vary from region to region. Though rising temperatures will very likely reduce summer flow in snow-fed streams, a warmer Oregon could also ironically experience higher winter flows and even (in rain-dominated streams) more floods (*10*). As floodwaters wash across farmland, rangeland, industrial sites, and shallow sewage systems, pollutants such as pesticides, chemicals, and animal and human wastes enter surface and ground waters (*35*). Flooding can overload storm and wastewater removal systems increasing the risk of water contamination (*5*). Rising sea levels could also contribute to water contamination, mostly in the form of salination.

Both flooding and drought 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,* and *Cyclospora*) (*14*). 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 (*35*). *Cryptosporidium parvum* is a parasite that completes its life cycle within the intestine of mammals and has caused large outbreaks of diarrhea after flooding contaminated drinking water sources (*9*).

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 (*35*). When foodstuffs such as fresh produce are irrigated or processed with contaminated water, *Cyclospora* can be ingested and can cause diarrhea.

Wetlands provide a natural method of water clean up and purification, returning less-polluted waters to coastal areas. Climate change has the potential to dry out these wetlands and/or inundate them with seawater as a result of rising sea levels, both weakening nature's way of improving water quality. Oregon's freshwater wetlands are already threatened by encroaching agriculture, eutrophication (when an abundance of nutrients in a body of water causes increased growth of vegetation and depletes the oxygen supply), development, and contamination (*36*). Projected changes in groundwater levels as a result of climate change could also threaten wetlands. Increasing competition over water resources as agriculture and other private and economic forces battle over diminishing supply could also harm wetland health and existence (*36*). Without this natural decontamination process, water quality may be further threatened.

SOLUTIONS

Oregonians can help alleviate water problems in many ways, beginning with the water conservation measures mentioned previously. Strengthening and enforcing clean water regulations that reduce the amounts of pollutants that can be discharged into waterways will help reduce overall stress to these fragile ecosystems. Preserving areas of wetlands will help improve water quality as well as supporting ecosystems that depend on these wetlands for survival.

How Floods Can Affect Public Health

A wet and fairly warm winter from 1995 to 1996 resulted in devastating floods in the Willamette and Columbia River basins. Rising river levels sent major cities like Portland, at the confluence of both rivers, into disaster situations. Houses floated away, car passengers were trapped, horses and cattle had to be rescued, and drowning deaths occurred (*37*). An abundance of rain saturated the ground and filled reservoirs earlier in the season than usual. The mountain snowpack, which had increased to nearly 300% of normal due to heavy snowfall in the mountains, melted rapidly. The combination of these factors brought river levels to similar heights as in the 1964 hundred-year flood. The 1964 flood was the worst flood since Oregon began flood control measures and the 1996 floods nearly matched these levels (*38*).

The Intergovernmental Panel on Climate Change projects extreme weather events likely will become more common during the 21st century (*2*). Flooding, like the unfortunate floods that affected Oregon in 1996, could become more prevalent, especially in predominantly rain-fed rivers such as those in low-lying areas west of the Cascades (*10*).

Nationwide, floods are the leading cause of death from natural disasters and account for 40% of all injuries resulting from natural disasters (*39*). 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 (*39*). Fatalities and property damage from floods have increased in the past 25 years. Studies suggest that this is largely due to increased vulnerability; more people and buildings in higher risk coastal and flood-plain areas subjecting lives and property to greater exposure (*40*).

As temperatures heat up globally, sea levels are rising worldwide. Warmer temperatures cause water expansion in the oceans as well as the melting of polar ice caps. In many coastal areas, rising water levels spell disaster. In Oregon, however, the results of a rise in sea level are much less clear. Much of Oregon's coast is made up of rocky cliffs and increasing rainfall may lead to landslides and flooding, further eroding the cliffs (*41*). Landslides could threaten homes along the Oregon coast and some of the coastal bay areas, such as Coos and Tillamook Bays, could be flooded under a 1 to 3 foot sea level rise (*7*). Uplift, a tectonic phenomenon which results in raising the level of the land, is also occurring along the Oregon and Western coast. This may counteract, to some extent, the effects of sea level rise in Oregon. There is still uncertainty about the relative rates of uplift and sea-level rise and a lack of consensus on the cumulative result. Oregon, however, may not be as vulnerable to inundation as other coastal areas.

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. 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 (*42*). Disaster response plans, especially for floods, should include heightened surveillance for mosquito-carried diseases (*43*).

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 (*44*). 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 (*44*). 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.

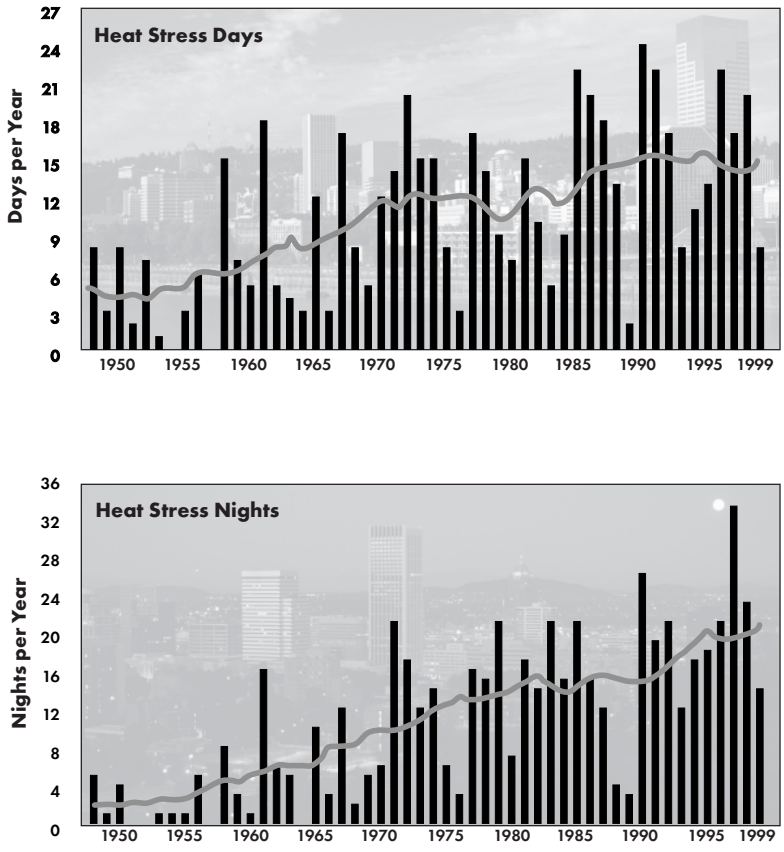
SOLUTIONS

Damage from flooding can be reduced by restricting development in flood-prone areas and replanting deforested hillsides and waterway embankments. Improving public works infrastructure could also be helpful. In some places in Oregon, for example, floodwater and untreated sewer water use the same pipes. During times of flooding, untreated sewage can end up in public waterways further endangering health (*45*). Urge your public officials to update the drainage systems and separate floodwater drainage from wastewater.

Direct Effects of Heat on Health

With a projected increase in average temperature of more than 5° F by the year 2050, Oregon residents will likely experience more extreme heat days. Heat may lead to severe health problems, such as heat cramps, exertional heat injury, heat exhaustion, and heat stroke. 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 an electrolyte (salt) imbalance caused by too much sweating (*17*).

FIGURE 3
Extreme Heat in Portland



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

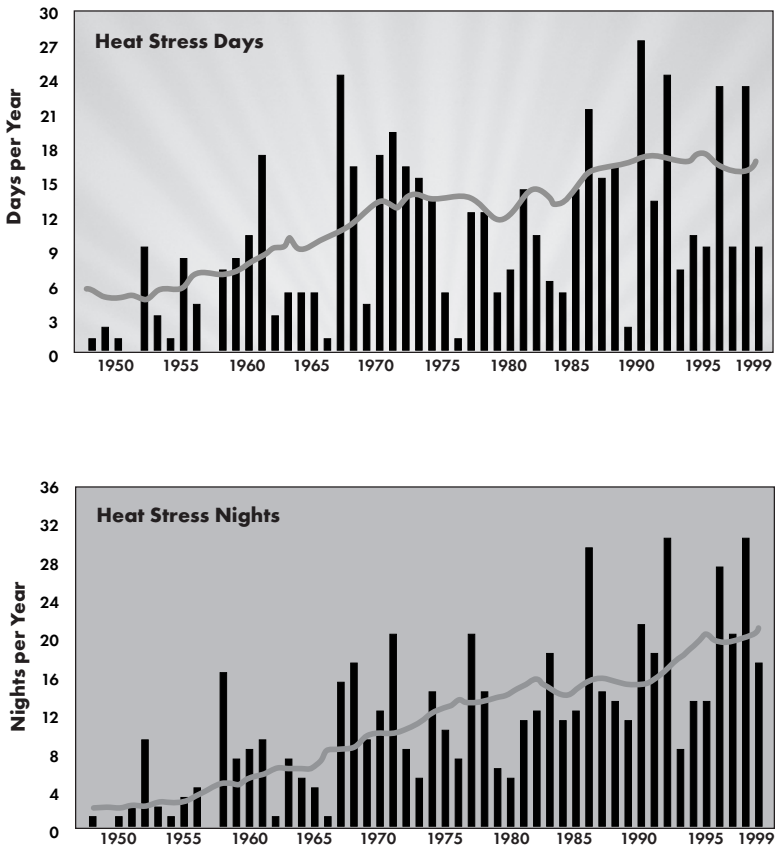
Number of nights with extreme temperatures per year in Portland, 1948–1999

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

Heat cramps are muscle spasms that primarily affect people who exert themselves through strenuous work or exercise in a warm environment. Farmers, construction workers, ranchers, or even tourists may experience heat cramps as a first sign of heat stress. Salt 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 (*17*).

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

FIGURE 4
Extreme Heat in Medford



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

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

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

skin and dilated pupils. The individual may require hospitalization (*17*). 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 (*17*).

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 (*46*). 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 (*17*). In general, hospital admissions and emergency room visits from all causes increase during hotter weather.

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. This phenomenon, known as the "heat island effect," keeps nighttime temperatures high and prevents nighttime relief from the heat (*47*).

The elderly 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 the 13% of Oregon citizens who are over 65 at greater risk of suffering a heat-related illness or death (*1*). Other groups particularly vulnerable to heat stress include babies and young children, socially isolated persons, anyone with serious cardiac or respiratory problems, anyone with limited mobility or other conditions limiting their ability to care for themselves and regulate their fluid intake, and the poor because they often lack the financial resources to adapt to heat (such as air conditioning) (*17*).

Warmer winter temperatures may slightly decrease wintertime mortality. Although daily mortality is usually higher in winter, most winter deaths result from causes that do not vary much with temperature, such as respiratory infections. Thus, even with warmer winter temperatures, overall weather-related mortality is expected to increase (*46*).

SOLUTIONS

Global warming is a direct result of the burning of fossil fuels for energy, thus significantly reducing our reliance on fossil fuels will be the most important action to reduce the number of heat-related illnesses and death. Specific suggestions about ways to reduce our reliance on fossil fuels are included in the "What You Can Do" section, which begins on page 34. For the short term, eliminating dark colored surfaces that absorb heat can decrease the urban heat island effect as can painting roofs a light color to reflect heat, planting more trees and plants, and reducing large expanses of black pavement. In addition, installing early warning systems, which advise the public and public health officials that dangerously hot weather is coming, can allow communities to prepare for coming heat waves. Such systems are already in place in Philadelphia, for example. "When the system predicts a heat wave, Philadelphia officials distribute media advisories, activate telephone hotlines, alert neighborhood volunteers, open air-conditioned shelters, expand outreach to the homeless, and coordinate efforts with local utilities" to protect vulnerable populations (*48*). Similar early warning systems could be set up in Oregon communities.

The Effects of Worsening Air Quality on Human Health

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

—JONATHAN SAMET, PULMONOLOGIST,
JOHNS HOPKINS SCHOOL OF PUBLIC HEALTH (*49*)

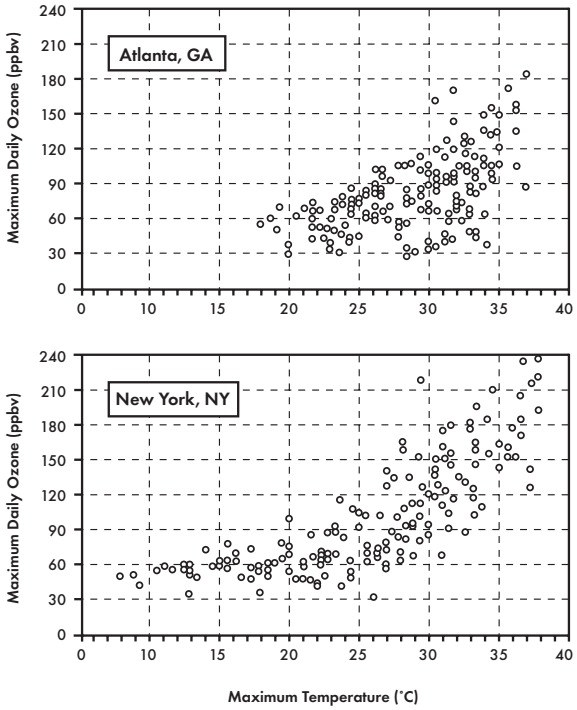
The Climate Change and Air Quality Link

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 CO_2, are not specifically 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, ground level ozone is formed from nitrogen dioxide and volatile organic compounds (both natural and human-made) in the presence of sunlight and heat. As climate change causes temperatures to increase, ground-level ozone formation will increase. 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.

Second, pollutant concentrations in the air of a specific location may be affected by local and regional weather conditions. Still air could allow

FIGURE 5
Maximum Daily Ozone Concentrations versus Maximum Daily Temperature



Maximum daily ozone concentrations in Atlanta, Georgia, and New York, New York, versus maximum daily temperature, May–October, 1988–1990. ppbv, parts per billion volume.

Data from U.S. EPA (*11*)

pollutants to accumulate; wind could blow pollutants to other areas. Climate change could have significant effects on local weather conditions, which then have important effects on local air quality.

Third, concentrations of human-made pollutants could increase as a result of escalating energy demand due to urban growth and development if fossil fuels continue to provide the main energy source. Ground-level ozone, carbon monoxide, particulate matter, nitrogen dioxide, and sulfur dioxides are by-products from burning fossil fuels. All have negative health effects and their concentrations could increase. Climate change can increase concentrations of these pollutants as well as compound effects of these pollutants. Global warming may change some of the factors that influence their atmospheric concentrations including wind speed and direction, precipitation, and other weather patterns.

Fourth, 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. Many of these natural compounds are not harmful by themselves, but combine with nitrogen dioxide to form ground-level ozone.

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 is commonly called smog, the most pervasive outdoor air pollutant in the United States. Ozone concentrations are highest 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 is formed when nitrogen dioxide and volatile organic compounds emitted from motor vehicles, power plants, refineries, factories, and even some natural sources like plants are heated by sunlight (*50*).

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 (*51*). 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 (*51*). For the 55,000 children and 125,000 adults with asthma that live in Oregon, ozone is of special concern (*52*). 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 (*53*). Other sensitive groups include young children, citizens over 65 years of age, anyone with underlying respiratory problems, and healthy adults who work or exercise outside (*54*). If warmer temperatures are coupled with the same or more sunny days, keeping ozone levels low may become even more of a challenge.

Currently, Oregon has only one area that does not meet EPA standards for ozone. This area surrounds a major industrial setting in the northern part of

FIGURE 6
Air Quality Index

CATEGORY	RISK LEVEL	HEALTH ADVICE
Green	No increase in risk	No special actions needed
Yellow	Moderate risk	Children, the elderly, and people with lung problems should **decrease long-term outdoor activity**
Orange	Unhealthy for high risk groups	Children, the elderly, and people with asthma or other lung problems should **limit long-term outdoor activity**
Red	Unhealthy	Everyone should limit outdoor activity. Children, the elderly, and people with asthma or other lung problems should **avoid outdoor activity**

Source: U.S. Environmental Protection Agency

the Willamette Valley and the capitol city, Salem. Colored zones have been developed in order to inform the public what the daily level of ozone is and warn of potential health hazards. Orange and red zones signify that ozone poses a potential danger to health on that day. The orange zone means air is unhealthy for sensitive populations, while the red zone is potentially unhealthy for all populations. Neighboring counties to the Willamette Valley, Clackamas and Marion, registered only one or two days in the orange zone for ozone air quality. Clackamas County had one day in the red zone in 2001. Jackson County in Southern Oregon, the Medford-Ashland metropolitan area, had five days in the orange zone (*54*). Residents of these counties comprise nearly one-quarter of the state population.

Volatile Organic Compounds (VOCs)

Another group of air pollutants consists of VOCs, which are generated by municipal waste combustors, motor vehicles, solvent use, power plants, and the chemical and food industries. VOCs consist of a large group of carbon-based chemicals that evaporate quickly and include a variety of hazardous air toxins, including benzene, butanes, and toluene. VOCs in the atmosphere have two major health impacts: Some VOCs are directly toxic and are associated with cancer, neurological, reproductive, and developmental effects, and VOCs also can combine with nitrogen dioxide to form ozone (*55*). As temperatures increase, more VOCs are emitted when people fuel and operate motor vehicles (*11*). Additionally, VOCs are emitted from vegetation; forest trees such as pines emit more VOCs during periods of warmer temperatures (*56*). Thus, climate change is expected to increase levels of both human-made and natural sources of VOCs, increasing ground level ozone concentrations.

When assessing inventories of air toxic emissions in Oregon, 16 of the 32 toxic air pollutants listed in the National Air Toxics Assessment for the State exceed health guidelines in one or more places at least once per year. Many of

these are VOCs and can cause respiratory irritation and damage or cancer. These toxics are associated with emissions from industrial facilities and mobile sources such as cars, diesel trucks and buses, aircraft, railroad locomotives, motorized watercraft, and farm equipment (*57*).

Nitrogen Dioxide

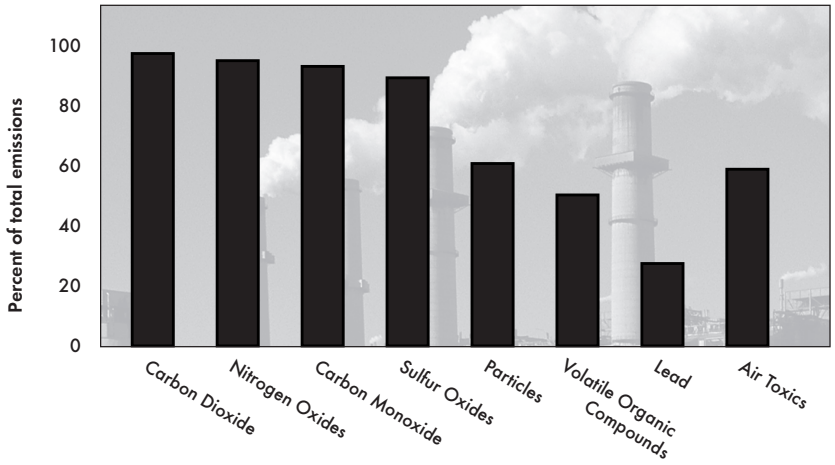
Like VOCs, nitrogen dioxide plays multiple roles in adversely affecting health: nitrogen dioxide can be directly toxic in the lungs and it combines with VOCs to form ozone. In the lungs, nitrogen dioxide combines with moist surfaces lining the airways to form acids that damage lung tissue, potentially worsening asthma and allergic symptoms, and causing increased respiratory infections. Nitrogen dioxide also combines with water vapor in the atmosphere to form nitric and nitrous acids, major components of acid rain (*11*). Higher temperatures accelerate this process, increasing the potential for acid rain as the climate changes (*11*). Nitrogen dioxide also combines with sulfur dioxide to form fine aerosol particles, as discussed in more detail below.

Sulfur Dioxide and Particulate Matter

Sulfur dioxide, like nitrogen dioxide, reacts in the atmosphere to become acid rain and can combine with nitrogen dioxide to form fine particles, which can be inhaled and irritate the respiratory tract (*59; 60*). Sulfur dioxide is formed from the combustion of coal and oil that contains sulfur. While high-sulfur fuels are more commonly burned in the Ohio River Valley and northeast U.S., some sulfur is present in coal and oil burned in power plants in western states and Oregon. Particulate matter can also be emitted directly from the combustion of fossil fuels, industrial processes, and transportation; created by the combination

FIGURE *7*

Emissions of Air Pollutants Associated with Fossil Fuel Combustion



Source: Data from U.S. Environmental Protection Agency (*11*)

of gases such as nitrogen dioxide and sulfur dioxide; produced from mineral dust from roads; and formed from smoke from wildfires (*59; 60*).

According to EPA air quality data, the annual mean concentration of sulfur dioxide in Oregon has decreased since 1996, and no areas within the State are classified as non-attainment by the U.S. EPA. Particulate matter concentrations have also decreased (*61*). However, as of August 2001 Medford, Klamath Falls, Lakeview, Oakridge, Eugene-Springfield, La Grande, and Grant's Pass regions did not meet the federal standard for safe ambient concentrations of particulate matter, representing an unhealthful level of exposure to approximately 600,000 people (*62*).

Several studies document that both the elderly and children show an increase in hospital admissions for respiratory and cardiac causes when concentrations of particulate matter increased (*63–68*). One study conducted by researchers from Harvard discovered that long-term exposure to air pollution significantly increased the risk of death (*63*). Another group of Boston researchers discovered that particulate matter could 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. Significantly, these statistical associations were observed at levels below current federal air quality standards implying that although an area meets Clean Air Act requirements, the particulate matter in the air may still pose a hazard to health (*69*). In 1999, Oregon emitted about 7 million short tons of CO_2, 14 thousand short tons of sulfur dioxide, and 24 thousand short tons of nitrogen dioxide (*25*).

Fine particles may be especially dangerous for babies and young children. Children breathe 50% more air per pound of body weight than adults, thus taking in relatively more pollutants for the body size (*70*). 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 (*71*).

SOLUTIONS

Air pollution contributes to thousands of premature deaths and reduced quality of life in Oregon and the United States. A recent study suggests that adopting "readily available technologies to lessen fossil fuel emissions over the next two decades" in just four major cities (New York City, Santiago, Sao Paulo, and Mexico City) could avoid approximately 64,000 premature deaths, 65,000 chronic bronchitis cases, and 37 million person-days of work loss (*75*). Reducing greenhouse gas emissions would have immediate health benefits by reducing local air pollution.

Carbon Monoxide

Carbon monoxide (CO) is a dangerous air pollutant with severe health effects. The odorless, invisible, poisonous gas is the byproduct of the incomplete combustion of carbon-based fuels. CO itself is not a greenhouse gas, but it can increase the lifespans of other greenhouse gases and worsen climate change. CO can also increase the production and concentration of ground level ozone *(99; 100).*

Carbon monoxide poisoning can be fatal. When inhaled in high concentrations, it binds up the body's oxygen-carrying molecules (hemoglobin) and prevents oxygen from being delivered to the tissues. Low concentrations of carbon monoxide can cause headache, confusion, shortness of breath, and fatigue. Anyone with preexisting heart or lung problems is at higher risk.

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 exacerbate asthma and other respiratory conditions. Warmer temperatures may also lengthen the allergy season (*73*). 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 (*74*).

Climate Change and the Threat of Disease

How Climate Change Could Affect Diseases Carried by Insects

Insects, sometimes called "vectors," can carry a variety of diseases. These diseases are transmitted when the insect bites a human (or another animal) who is already infected with a disease. The insect itself then becomes infected with the disease, and when it bites another human the disease may be passed from the insect to the human. Malaria and dengue fever are two examples of vector-borne diseases.

The increasing temperatures and changes in precipitation that could occur with climate change could also expand the mosquito's range into higher elevations and make the mosquito more efficient at transmitting these diseases. However, many factors determine whether a disease like malaria will become a problem. For example, malaria used to be a common disease in Oregon until the 1930s. 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 large epidemics of these diseases unlikely in Oregon even with rising temperatures (*15*).

SOLUTIONS

Although the standard of living 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, by strengthening and maintaining surveillance programs. Further research into how climate change affects disease is also needed to better understand how to reduce the risk.

With climate change, however, 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 could expect an increase in imported cases (*76;77*). Continued monitoring and vigilance will be essential in order to ensure that these diseases, or a new disease like West Nile Virus, do not become a problem in Oregon.

Pesticides and Health

Milder winters and changes in precipitation may lead to greater insect numbers, tempting some Oregon residents to use more pesticides. Some of the pesticides commonly in use include organophosphates (e.g. malathion and fenthion) and pyrethroids (e.g. permethrin and resmethrin) (*78*). In 1999, there were almost 60,000 pesticide-related incidents reported to poison control centers nationally; almost half of those were in *children less than 6 years old* (*79*).

Pesticides can be absorbed into a person's body by inhalation, ingestion, and skin penetration (*80*). 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 (*80*). Signs and symptoms of mild to moderate poisoning include dizziness, headache, nausea, loss of appetite, allergies, skin irritation, and fatigue. Severe poisoning results in seizures, and evidence is mounting for an association between pesticide exposure and Parkinson's disease (*81*). Many household pesticide sprays and pet care products contain these compounds (*80*).

Pesticides can be harmful to humans, wildlife, and natural ecosystems and should only be used as a last resort, by professionals, and only in limited quantities when public health is threatened. 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. In 1999, Oregon passed legislation calling for a pesticide use-reporting program. Reporting under the system is slated to begin January 2002, although the program has not been fully funded by the Oregon legislature. Currently there are only sporadic estimates of the extent of pesticide application in Oregon (*82*).

SOLUTIONS

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, 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. Backyard containers such as tires, buckets, coolers, cans, or anything that will hold even a few drops of water can be a significant source of mosquito breeding in populated areas. These can be removed or stored under cover to prevent them from collecting rainwater. 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. Educate your neighbors, businesses, and public officials about the hazards of pesticide use to humans and the environment. Urge them to use non-pesticide methods for controlling insects.

How Could Climate Change Affect Oregon's Fisheries, Forests, and Agriculture?

The Effects of Climate Change on Oregon's Fisheries

Climate change could have a devastating impact on fisheries. Some bodies of water may become too warm for the fish and shellfish that have historically inhabited those areas. Some commercially important species, such as Pacific salmon would likely have reduced distribution and productivity in Oregon waters (*45*). 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 (*84*).

SOLUTIONS

Preserving nursery areas, such as wetlands and estuaries, establishing no-take zones and reasonable catch limits based on accurate estimates of fish populations and scientific knowledge of fish life-cycles can allow fish populations to rejuvenate before populations become decimated and the fishery is lost. Eat only sustainably harvested fish and seafood.

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 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 (*85*). Red tides and other HABs impact 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 shellfish poisoning.

There are five principal types of seafood/shellfish poisoning but only two types, amnesic shellfish poisoning and paralytic shellfish poisoning occur along the Oregon coast (*85*).

Amnesic shellfish poisoning is prevalent on the coast of Oregon and Washington, as well as in Canadian waters. Initially, symptoms are analogous to gastroenteritis including vomiting, headache, and diarrhea. Symptoms may progress to confusion, loss of memory, disorientation, and coma. Survivors can be left with permanent dementia (*86*).

SOLUTIONS

Harmful algal blooms are more common in waters polluted with large amounts of nutrients that often come from fertilizer runoff or the discharge of inadequately treated sewage (*19*). Reducing the use of excessive fertilizers on farmland and ensuring adequate treatment of sewage will help to reduce the numbers of harmful algal blooms that occur.

Paralytic shellfish poisoning is the second prevalent marine toxin disease along the Oregon coast. It is more potent than amnesic shellfish poisoning. Similar to amnesic shellfish poisoning, paralytic shellfish poisoning has both gastrointestinal and neurological symptoms and can harm fish, birds, and humans. Within thirty minutes of consumption of contaminated shellfish, tingling and then numbness spreads from the mouth to the face and neck. In severe cases, numbness can even reach the extremities. Very severe cases can result in paralysis and death. In general, symptoms begin to diminish after 12 hours and victims tend to recover within a few days (*87*).

The Implications of Climate Change for Oregon's Salmon

Salmon in Oregon have faced repeated threats from human activities over the last few decades, threatening biodiversity and Oregon's economy. Activities such as fishing, urbanization, sedimentation, pollution, and dam building have diminished salmon populations in the Northwest. "Salmon have disappeared from about 40% of their historic range, and are in serious danger of extinction in most of their remaining habitat." (10)

Salmon are sensitive to climate in different ways depending on the stage of their life cycle. Winter flooding, summer droughts, and rising stream and

estuary temperatures could place additional stress on salmon, especially salmon eggs and juveniles (*10*). Climate change also has certain effects that universally threaten salmon, regardless of their life stage. A change in climate may promote habitat loss as well as a reduction of available oxygen in the water (*10*).

The salmon industry brings income into Oregon's economy. If climate change further depletes salmon populations, local fishermen will feel the economic impact. In addition, the loss of salmon populations will have an impact on the economic, cultural, and spiritual well-being of Native American tribes. Native American tribes in the Pacific Northwest are co-managers of salmon resources, having reserved the right to up to 50% of the annual salmon harvest in treaties signed with the U.S. in the mid-1850s (*88*). Further changes to salmon populations brought about by climate change, future development, and use of dams for hydroelectric power generation continue to threaten the well-being of all Oregonians who rely on salmon as a resource (*41*).

The Effects of Climate Change on Oregon's Forests

Forests make up nearly one-half of Oregon's land area and create a significant amount of jobs throughout the state (*36*). Two types of forests dominate the Oregon landscape, split essentially along the Cascades. In the west, wetter forests dominate, while east of the Cascades a drier region prevails. Insects, diseases, wildfire, and wind are all potential disturbances of forests and may all be affected by climate change (*10*).

With moderate warming and increased overall precipitation, the wetter forests of the West will have decreased risk of wildfire and may flourish for the next 30 to 50 years. The drier forests in the East, however, are likely to become woodier with increased precipitation and could be at greater risk of wildfire. The forested areas that don't succumb to wildfire could thrive and prosper for several decades. In the latter half of the century, under the warmest future scenarios, temperature increases will likely result in overall moisture deficits; and forests on both sides of the Cascades could deteriorate (*89*). Researchers warn, though, that the climate changes of increased temperature and precipitation might not occur in an orderly fashion. There will likely be significant variability during the next 100 years and surprises, such as unexpected forest demise, could occur at any time (*89*).

Changes in forest composition, extent, and productivity could further threaten the economic well being of the Oregon citizens employed in the timber industries. Presently, regions of Oregon whose citizens are more likely to work in the timber industry are already suffering poorer economic welfare (*36*).

The lost forestland would likely be replaced by grasslands, shrublands, and savanna (*10*). Much of the

SOLUTIONS

Trees and other plants in the forest absorb CO_2 from the air, sometimes called a "carbon sink", thereby reducing global climate change. Forest removal for development, agriculture, or wood use eliminates or delays this important mechanism for reducing CO_2 in the atmosphere and adds to the global warming problem. Forest managers should consider the implications of climate change when conducting long-range planning. Replanting some areas with trees that are expected to thrive under projected conditions may help forests adapt to climate change. Improved logging techniques and forest management would aid in maintaining forests alive and healthy so that they can absorb more CO_2 and help slow global warming, while providing continued economic support for the region.

reduction in forestland is apt to result from increased likelihood of drought, pests, and wildfires (*10*). Fire, while a natural part of a forest ecosystem cycle, can be dangerous and destructive. Respiratory problems could be caused or exacerbated by smoke inhalation, and even death from fire is a possibility. If fires spread throughout drought-stricken territory, devastation could reach past the forest and into residential communities.

SOLUTIONS

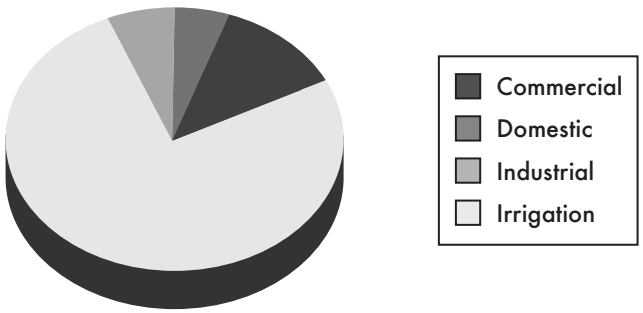
Much of the total current water use is unnecessary and wasteful. By employing water conservation measures for everyone in the state, more can actually be done with less water. Low-pressure drip irrigation, for example, reduces water use by 30 to 70% and increases crop yield by 20 to 90% compared with flooding methods. Traditional high-pressure irrigation sprinklers spray water high into the air to cover as large a land area as possible, but much of the water evaporates or is blown off course before it can reach the plants (*31*). Encourage your state legislators to introduce and support legislation that encourages efficient water use and conservation in all sectors—agriculture, industry, and residential use. Reasonable discussions now about how water will be allocated and used in future times of shortage may help to avoid heated debates, fueled by desperation, in the future.

The Effects of Climate Change on Agriculture

Over one quarter of Oregon is composed of farmland, providing jobs for more than 100,000 people (*36*). Farmland is vulnerable to climate changes, but whether production will increase or decrease depends on climate variability and is specific to each crop. This variability could make adaptation by farmers difficult. Dry-land yields are projected to increase, with the exception of potatoes, while irrigated yields are expected to decrease due to diminishing water resources. The potato yield is predicted to decrease by up to 17% and wheat yields have the potential to increase 2–13% (*6*). Although the national food supply is projected to remain adequate, local and regional shifts in successful crops may provide hardship to farmers.

One half of farms are already irrigated and unfortunately, as conditions create an increased need for irrigation, these same conditions could also decrease the water resources available for irrigation (*10*). Battles for water rights are likely unless water demands are diminished with more efficient irrigation and other water use improvements. Disputes over water rights are already occurring in Oregon and global climate change has barely begun to show its effects. The summer of 2001 marked one of the worst droughts to hit the West Coast in a long time. In the Klamath Basin area, farmers suffering from drought hoped to utilize water resources that the government had designated for endangered fish species. This clash over water rights is merely an example of conflicts to come when summer drought is a much more common occurrence.

FIGURE 8
Water Use in Oregon by Sector (1995)



Source: U.S. Geological Survey (USGS). Water Use in the U.S. http://water.usgs.gov/watuse

Oregon's Progress in Confronting Climate Change

The greater the reductions in emissions and the earlier they are introduced, the smaller and slower the projected warming and the rise in sea levels.

—INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (*91*)

Renewable Energy Sources

Oregon is a leader in taking steps to alleviate greenhouse gas emissions and other contributors to global climate change. Two major power companies serving the area offer many alternatives to fossil fuel power including wind, hydroelectric, solar, and biomass energy. Both Pacific Power and Portland General Electric have alternative energy programs that allow customers to pay a little extra for wind-generated electricity. Portland General Electric charges $3.50 per 100 kilowatt-hour block, which is equivalent to the energy necessary to power a refrigerator for one month (*92*). Pacific Power customers pay only $2.95 for 100 kilowatt-hour blocks (*93*). Thousands of Oregon residents are already taking this step toward a reduction in global climate change. These small investments are used to increase the productivity of, and the construction of, new renewable sources (*92; 93*). Using more of these renewable sources of power could help to diminish dependence on fossil fuels.

Hydroelectric power supplies about 60% of the electricity currently used in Oregon (*94*). Hydroelectric power, although less polluting, can be devastating to ecosystems. One of Portland General Electric's alternative energy programs addresses this issue by devoting funds raised in their Salmon-Friendly Power program for habitat restoration and construction of new renewable resources (*92*). Currently, the Columbia River's flow is managed to optimize and preserve hydropower. Decreases in precipitation and available water will not result in water shortages for power generation. Instead, other water uses such as irrigation and fisheries management will be shortchanged (*10*).

Recently, a group of Pacific Northwest utilities and economic development agencies commissioned a market analysis of clean energy development potential. The analysis concluded that "the Pacific Northwest has the opportunity to be a global leader in the technology-based clean energy industry." (95) Some of the conclusions of the analysis are:

- The expected worldwide market for clean energy technologies is expected to be $180 billion a year over the next 20 years.
- The Pacific Northwest already leads the market in fuel cells and already has a technology-oriented industry base for developing leadership in other clean energy technologies.
- In Oregon, Washington, and British Columbia, clean energy is currently a $1.4 billion a year industry and is projected to grow to at least $2.5 billion a year and provide 12,000 jobs over the next 20 years.
- Public policies to help develop the market and encourage renewable energy use could increase that figure to $6.3 billion a year and 32,000 jobs over the next 20 years (*95*).

FIGURE 9
Location of Wind Resources in the Northwest

Source: from Renewable Northwest Project, http://www.rnp.org/htmls/wind.htm#potent

Renewable energy technology has already successfully been put into use in some areas. This market analysis confirms that tremendous potential exists to develop and expand the renewable energy market making these technologies even more efficient and cost effective and providing economic growth for the Pacific Northwest.

Government Initiatives

In addition to efforts in the private sector, the Oregon government is one of few state governments taking the initiative to offset climate change. Oregon has one of the only mandatory greenhouse gas offset programs, as well as stringent emissions targets for power producers. Oregon House Bill 3283 "requires new energy facilities built in the state to avoid, sequester, or displace a portion of their previously unregulated carbon dioxide emissions" (*96*). The bill also defines a role for a nonprofit organization to implement these laws and The Climate Trust was established to fill this role. In addition to implementing the laws, it also mitigates other emission sources and educates the Oregon public about climate change (*96*).

Another example of Oregon's progressive actions is the City of Portland's Office of Sustainable Development, created by the city council. Portland has a progressive action plan relating to climate change that includes mandatory

green building standards for municipal buildings, light rail, and county land use plans. The city and state offer tax incentives and loan opportunities for green buildings and offer extensive energy efficiency and recycling programs at the residential, government, and commercial levels (*97*). For example, the city of Portland requires businesses to recycle more than 50% of their waste.

Summary

This report reviews some of the threats to human health, particularly in Oregon, that could result from climate change and outlines some actions that need to be taken to slow and eventually reverse climate change as well as soften its blow. 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 relatively 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 with a compromised immune system are at greatest risk.

Many of the effects of climate change will be compounded by other environmental stresses such as pollution, increasing population and development, over-harvesting of natural resources, and habitat loss. Thus, improving environmental practices and policies, such as decreasing discharges of pollutants into the soil, air, and water may help lessen the harmful effects of climate change on fragile ecosystems.

Action is needed now to slow and eventually reverse climate change by significantly reducing fossil fuel consumption and greenhouse gas emissions. The Pacific Northwest is in a position to be a leader in renewable, clean energy sources. Support for the renewable power industry will help Oregon and the Pacific Northwest to capture an even greater share of the market and reduce fossil fuel dependence. Also important is investment in strategies that will help us to prepare for what may come. It is essential that the U.S. and all states 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, but enough is known to support taking action now.

What You Can Do

What can individual Oregonians do to stabilize the climate or 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.

The continued reliance on fossil fuels undermines long-term American interests. Large gas-guzzling SUVs and poorly insulated houses keep us dependent on the importation of foreign oil. Increased domestic supply is also not the answer. Besides destroying America's last pristine areas, domestic drilling cannot replace a significant amount of imported oil. Foreign oil dependence drives our foreign policy. The answer to our energy needs is also not to build more nuclear power facilities, which are potential terrorist targets, but to invest in and develop small renewable energy sources, such as photovoltaic solar collectors and wind generators, which are less vulnerable to terrorist attack.

As an added benefit, the energy conservation techniques and alternative energy sources recommended here to combat global warming will also result in a decrease in air pollution. Reducing greenhouse gas emissions through sound energy policies is a win-win scenario; it prevents global climate change and reduces 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.

To slow global warming, actions need to be taken at many levels: globally, nationally, at the state level, and by industry, businesses, agriculture, and individuals. There is a lot you can do in Oregon, starting now, to combat global climate change and decrease consumption of fossil fuels.

1 Use available public transportation systems (www.tri-met.org/max/maxpage.htm#recognition) and demand support and enhancement of these systems.

2 If offered in your area, subscribe to "green power" (wind and solar generation) options with your electrical power provider.

3 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 the winter and raise it in summer and 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 or remodeling a home, request efficient insulation, and energy efficient appliances, refrigerators, and water heaters.

4 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 create one. Contact your state representatives and Governor John A. Kitzhaber, MD. 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 anyone purchasing newer cars with better gas mileage. Contact information for your state representatives can be found in the blue pages of your phone book and at www.envirohealthaction.org.

5 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 fuel cells, solar, and wind power. This will not only give the existing oil supply a longer life, but will also reduce the unhealthy pollution associated with both the burning of fossil fuels and the recovery of fossil fuels. Demand that current rules aimed at cleaning up modified or new plants, such as New Source Review, be enforced.
- Clean up coal-fired power plants. Require that power plants that were grandfathered under the Clean Air Act be cleaned up or shut down.
- Support "Four-Pollutant" bills regulating carbon dioxide, nitrogen dioxide, sulfur dioxide, and mercury emissions from power plants.
- Support an increase in Corporate Average Fuel Economy (CAFE) standards, or miles per gallon standards, for cars, sport utility vehicles, and light trucks.
- Support commitments made by the U.S. under the Framework Convention on Climate Change in 1992 and made explicit in the 1997 Kyoto Protocol to lower greenhouse gas emissions.
- Help the U.S. to take responsibility for our disproportionate contribution of greenhouse gas emissions to the world's climate change problem. The U.S. has the responsibility to lead the way since we make up 4% of the world's population and produce 25% of the greenhouse emissions.

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: *http://www.senate.gov* and *http://www.house.gov*

6 Urge the businesses you patronize to become energy-efficient and therefore more competitive and profitable. U.S. businesses spend about $100 billion on energy each year to operate commercial and industrial buildings. By using energy efficient products and procedures, organizations

could reduce their energy use by 35%, 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 the Energy Star Buildings program (1-888-STAR-YES, *http://www.epa.gov/greenlights/*).

7 Work with local groups and chapters of national organizations to promote awareness of global climate change and related issues in Oregon. These include:

Alternatives to Growth Oregon
(503) 222-0282
http://www.agoregon.org/

American Lung Association of Oregon
(503) 924-4094
http://www.lungusa.org/oregon/

Climate Solutions
(360) 352-1763
www.climatesolutions.org

For the Sake of Salmon
(503) 223-8511
http://www.4sos.org/

Green House Network
(503) 639-9352
www.greenhousenet.org

Northwest Climate Response
(503) 467-0752
www.climateresponse.org

Northwest Council on Climate Change
1-877-898-7938
http://www.nwclimate.org

Northwest Energy Efficiency Alliance
1-800-411-0834 or (503) 827-8416
http://www.nwalliance.org/

Oregon Chapter Sierra Club
(503) 238-0442
http://www.oregon.sierraclub.org/

Oregon Environmental Council
(503) 222-1963
http://www.orcouncil.org/

Oregon League of Conservation Voters
(503) 224-4011
http://www.olcv.org/

Oregon Natural Resources Council
(503) 283-6343
http://www.onrc.org/

Oregon State Parks Trust
(503) 362-1905
http://www.orparkstrust.org/

Oregon State Public Research Interest Group (OSPIRG)
(503) 231-4181
http://www.ospirg.org/

Renewable Northwest Program
(503) 223-4544
http://www.rnp.org/

The Climate Trust
(503) 238-1915
http://www.climatetrust.org

The Columbia River Inter-Tribal Fish Commission
(503) 238-0667
http://www.critfc.org/

The Nature Conservancy of Oregon
(503) 230-1221
http://nature.org/wherewework/northamerica/states/oregon/

Willamette River Keeper
(503) 223-6418
http://www.willamette-riverkeeper.org/

Where Physicians for Social Responsibility (PSR) Stands

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

While we recognize that uncertainties exist in the measurement of global warming—just as all scientific measurement is uncertain—we are moved to action for several compelling reasons. First, the overwhelming consensus among climate scientists is that the Earth's temperature is increasing and that humans are largely responsible. Human-caused climate change may, in the future, change the environment in ways potentially harmful to human health. Second, just like businesses, governments, and responsible individuals, PSR feels the need to act decisively in the face of uncertainty to protect human welfare.

PSR is working to create a world free of global environmental pollution, weapons of mass destruction, and gun violence. In 1985, PSR shared the Nobel Peace Prize with the International Physicians for the Prevention of Nuclear War.

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