

Outdoor (Ambient) Air Quality

Definition: Outdoor (ambient) air quality is the condition of the air in the environment outside of buildings and accessible to people. Only six air pollutants (particulate matter, ground level ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, and lead) known as Criteria Pollutants are routinely measured. The number of days people are exposed to fine particulate matter above the EPA's standard or an alternative health-based goal is an indicator of the possible health hazard of air pollution. Toxic Air Pollutants are chemicals that are known or suspected of causing serious health problems.

Summary

Air pollution is a major public health concern because it can affect large segments of the population and people do not have a choice about the air they breathe. Most air quality problems in Washington are caused by local sources of air pollution such as cars, diesel vehicles, wood stoves, fireplaces, outdoor burning, wildfires, and industrial facilities. Cars and trucks are the largest source of air pollution, accounting for nearly 60% of the air pollution in Washington. People living closer to sources of air pollution are likely to have higher exposures to pollutants than those who live farther away. Poor air quality in Washington tends to occur most often during the winter months. Some regions of Washington have higher levels of air pollution than other regions. Infants and children, the elderly, and people with lung or cardiovascular disease or diabetes are especially sensitive to air pollution.

Introduction

Air pollution can cause disease or worsen health conditions such as asthma, heart and lung diseases, stroke, and lung cancer. Air pollution can also decrease immunity. Breathing polluted air shortens life expectancy and increases visits to health care providers and hospitals. Infants and children, older adults, and those with lung or cardiovascular disease (heart disease and stroke) or diabetes are more likely than others to develop health symptoms or have diseases worsen with exposure to air pollution. For example, breathing polluted air can cause people with lung or heart disease to have additional health problems such as asthma or heart attacks. As levels of air pollution rise, more people experience health complications or die from breathing polluted air.^{1,2,3,4,5,6,7,8,9,10}

Certain weather or atmospheric conditions can increase air pollution. Air stagnation—when a layer of warm air acts as a lid and traps cold air and pollutants near the ground level—occurs frequently in Washington from November through February. Air quality can also deteriorate during hot and sunny summer weather, especially when these conditions exist for several days. Wildfires often increase air pollution in the summer months. Air pollution in Washington comes primarily from sources of pollution in Washington, not from other states.

This chapter addresses the environmental health indicators that can be used to assess outdoor air quality. It covers four types or categories of air pollution: criteria pollutants, which are regulated by the U.S. Environmental Protection Agency (EPA) under the federal Clean Air Act and the Washington State Department of Ecology and regional clean air agencies under the Washington Clean Air Act; toxic air pollutants, which are also regulated by EPA and the Washington State Department of Ecology; diesel exhaust; and toxic emissions reported as part of the Toxic Release Inventory.

Description of Potential Indicators

Hazard indicators. Outdoor air concentrations of criteria pollutants provide information about potential health impacts in areas where they are measured. The EPA has set national standards for these pollutants. One example of a hazard indicator is the number of days that fine particulate matter (one of the criteria pollutants) exceeds the federal standard or alternative health-based goals.

Exposure indicators. It is difficult to determine exactly how much air pollution people are exposed to. Individual exposure to air pollutants can vary greatly and depends on the quality of the air where people live, work, or play, their activity levels, and their age.

Protective indicators. Because the standards for criteria pollutants are health-based, they can be used as protective indicators. Geographic areas can be defined that are meeting the federal standards for air quality. The number of days the federal standard or alternative health-based goals are met can be used as protective indicators.

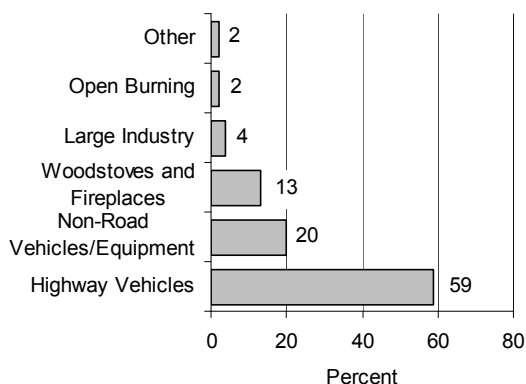
Health outcome indicators. Health outcome indicators associated with air pollution are limited in scope or are not readily available. Statewide disease databases generally record the more severe cases of illness from which people die or require [hospitalization](#). These databases don't record visits to emergency departments or to health care providers where people are most often treated. It can be difficult to link an illness with air pollution because diseases caused by outdoor air pollution can also be caused by other factors.

Criteria Air Pollutants

Under the federal Clean Air Act, the EPA establishes National Ambient Air Quality Standards for the six criteria pollutants: particulate matter (PM), ground level ozone (ozone), carbon monoxide, nitrogen dioxide, sulfur dioxide, and lead. The EPA sets national standards for these pollutants because historically, they were found in many communities, they can disperse over large areas, and they can be harmful to health.

Sources. The Washington State Department of Ecology estimates that 59% of criteria pollutant emissions come from cars and trucks. Other major sources of these pollutants include non-road vehicles (20%), wood stoves and fireplaces (13%), industrial sources (4%), open burning (2%), and other sources (2%).¹¹

Air Pollution Sources in Washington
WA State Department of Ecology, 2002



Exposure. The state Department of Ecology, in collaboration with regional clean air agencies, monitors levels of PM, ozone, and carbon monoxide. Washington's levels of lead, sulfur dioxide, and nitrogen dioxide have not exceeded EPA's standards for many years, and EPA does not require monitoring of these pollutants.

In 2006, no area in Washington exceeded the EPA's standards for criteria pollutants. But several regions only recently met federal requirements for air quality. Such regions are called "maintenance areas" and must show how they will maintain air quality at or below the standards. Air is monitored in these areas by the state Department of Ecology or the regional clean air agencies to ensure that they continue to comply with standards.

Carbon monoxide. Carbon monoxide interferes with the ability of blood to carry oxygen. Individuals with heart disease are particularly sensitive to carbon monoxide exposures. Carbon monoxide is formed during combustion. Major sources of carbon monoxide include motor vehicles, non-road vehicles and equipment, trains, ships, and wood stoves and fireplaces.

The last region in Washington came into compliance with the carbon monoxide standards in 1996. But the cities of Spokane, Vancouver, and Camas, southwestern Clark County, urbanized regions of King, Pierce, and Snohomish counties, and portions of the city of Yakima continue to be carbon monoxide maintenance areas. In the future, carbon monoxide monitoring might be limited to only three sites in Seattle's Beacon Hill, Bellevue, and Spokane, due to decreases in federal monitoring funding and the recent compliance with the carbon monoxide standards in Washington State.

Ozone. Ozone in the upper atmosphere is beneficial in blocking the sun's ultraviolet rays near the ground, but it can be harmful to breathe at ground level. Ozone is formed in the environment by reactions involving volatile organic compounds such as gasoline, paint thinners, dry cleaning fluids, and nitrogen oxides in the presence of ultra-violet sunlight.

Hot, sunny, and hazy days are times when ozone levels are likely to be elevated. Ozone is a respiratory tract irritant and can cause premature aging of the lung and aggravation and development of asthma.^{12,13} People who spend more time outdoors playing, exercising, or working will breathe more ozone. Major sources for chemicals that lead to ozone air pollution in Washington are cars, light and heavy trucks, buses, ships, trains, non-road equipment, and industry. Ozone pollution can affect large areas because it is transported by winds over long distances.

Pierce and King counties and urbanized Snohomish County, the cities of Vancouver and Camas, and southwestern Clark County have been maintenance areas for ozone for about 10 years. During the hot summer of 2006, the regions of Enumclaw, Pack Forest, and Issaquah all experienced some days where ozone levels exceeded the current standard. The EPA revised the eight-hour standard (based on the average concentration levels in an eight-hour period) for ozone in March 2008 from 84 to 75 parts per billion. In the future, some regions might no longer be in compliance with the standard if Washington's summers are hot and sunny.

Particulate matter. Studies indicate that air pollution from PM, especially fine particles less than 2.5 microns in diameter ($PM_{2.5}$), is associated with development and worsening of lung and cardiovascular disease. Death rates from these diseases increase as PM levels rise. Even very low levels of $PM_{2.5}$, below the current federal standard, have been linked to health effects in some people.¹

Particulate matter air pollution includes several types of particles with different chemical compositions. Fine particles come from combustion, while the source of coarse particles from 2.5 to 10 microns in diameter ($PM_{2.5-10}$) include wind-blown dust as well as bacteria, pollen, and mold spores. Particles emitted during combustion generally consist of a central carbon core upon which other toxic pollutants

can be attached. Major sources of $PM_{2.5}$ in Washington include wood stoves and fireplaces, dust, agricultural burning, forest fires, non-road vehicles, ships, trains, industry, and motor vehicles—especially diesel-powered ones. In the winter, when $PM_{2.5}$ pollution is highest, wood stoves and fireplaces account for 56% of this pollution.¹⁴

Washington measures both $PM_{2.5}$ and particles less than 10 microns in diameter (PM_{10}). In 2006, however, the EPA lowered the daily standard for $PM_{2.5}$ from 65 to 35 microgram per cubic meter ($\mu\text{g}/\text{m}^3$). Three years of monitoring data are needed to determine if specific regions in Washington will meet the new, more stringent standard.

Compared to the old standard, the more protective standard provides a greater margin of safety from the negative effects of PM on health. But during the standard-setting process, the EPA's scientific advisory committee along with many health researchers recommended that EPA set the standard lower than $35 \mu\text{g}/\text{m}^3$ to protect people most sensitive to air pollution. For example, the Washington State Department of Health recommended that EPA set a daily standard of $30 \mu\text{g}/\text{m}^3$. The World Health Organization has established a daily air quality guideline of $25 \mu\text{g}/\text{m}^3$, which is the same level the Puget Sound Clean Air Agency uses as a daily air quality health goal. The Washington State Department of Ecology has set its health-based goal at $20 \mu\text{g}/\text{m}^3$. Due to the broad-based concern that the $PM_{2.5}$ daily air quality standard of $35 \mu\text{g}/\text{m}^3$ does not sufficiently protect health, the following discussion includes information on exposure levels both above and below the new $PM_{2.5}$ standard.^{15,16,17}

The Department of Ecology and regional clean air agencies monitor $PM_{2.5}$ in 25 Washington counties. They do not monitor levels of $PM_{2.5}$ in the 14 counties that do not have a history of air quality problems. The agencies place monitoring equipment where there are known pollution sources and in maintenance areas. Since 1997, when EPA issued the $PM_{2.5}$ standard, Washington has expanded the number of $PM_{2.5}$ monitors. In 2005, there were 43 $PM_{2.5}$ monitoring sites. Nine counties have multiple monitors, with King County having the most (nine). The remaining 16 counties have only one monitor.

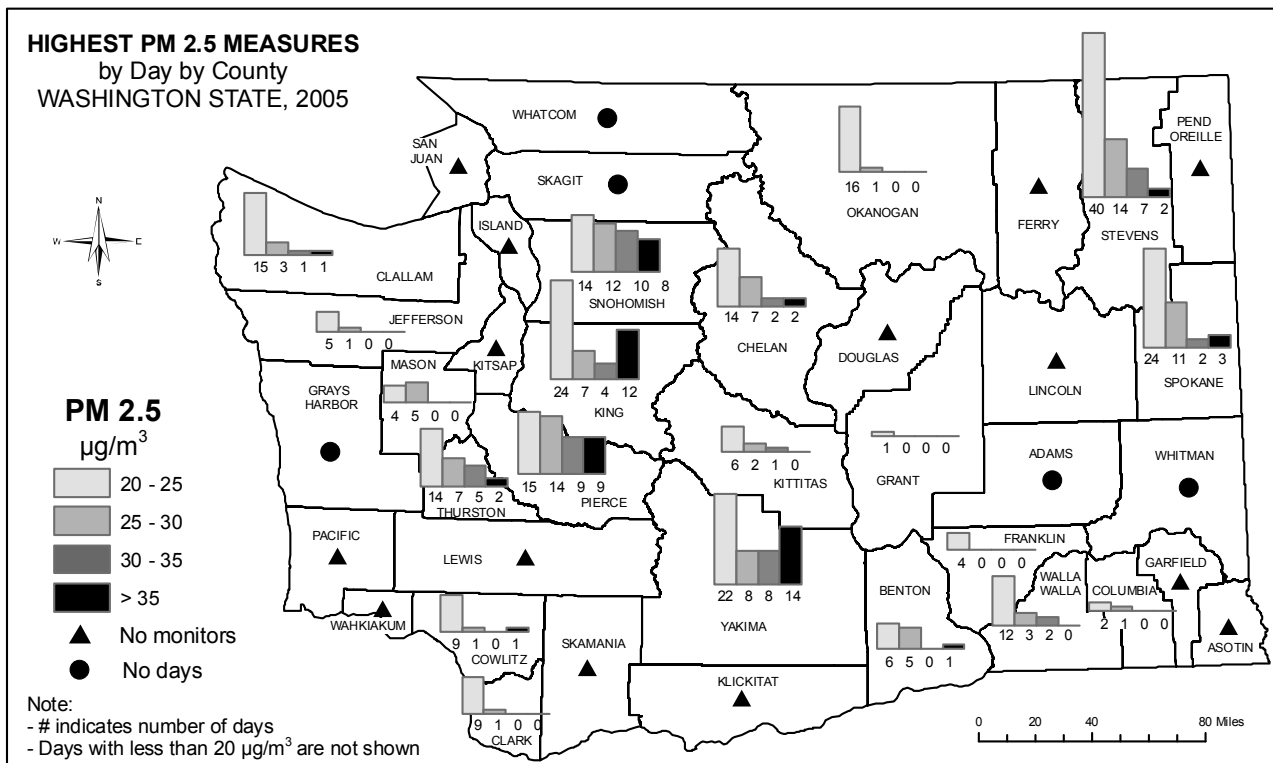
Based on a review of 2005 data, the following map shows that 11 counties (Benton, Clallam, Chelan, Cowlitz, King, Pierce, Snohomish, Spokane, Stevens, Thurston, and Yakima) experienced days in which $PM_{2.5}$ levels in parts of the county were above the new standard of $35 \mu\text{g}/\text{m}^3$. Eleven

counties had days in the 30–35 $\mu\text{g}/\text{m}^3$ range, 18 counties had days in the 25–30 $\mu\text{g}/\text{m}^3$ range, and 20 counties experienced days in the 20–25 $\mu\text{g}/\text{m}^3$ range (see Technical Notes). Areas can have days where the levels of $\text{PM}_{2.5}$ are above $35\mu\text{g}/\text{m}^3$ and still meet the standard. Compliance with the standard is determined by a calculation that looks at three years of daily $\text{PM}_{2.5}$ monitoring values, the number of days these readings are above the standard, and days monitored.

People are more likely to have health symptoms or medical problems on days when $\text{PM}_{2.5}$ levels are elevated. Of about a million Washingtonians

Toxic Air Pollutants

In addition to Criteria Air Pollutants, the EPA regulates emissions of 187 hazardous air pollutants (HAPs) from major industrial operations. These HAPs are listed in the Clean Air Act. They are chemicals that are known or suspected to cause health problems, including cancer. States have the authority to regulate toxic air pollutants from smaller industrial operations. Washington has developed guidelines for limiting emissions of toxic air pollutants from certain small industrial sources. The Washington State Department of Ecology regulates approximately 393 toxic air pollutant chemicals as part of its Controls for New Sources of Toxic Air



living within 2.5 miles of an air monitor, 59% live in an area where $\text{PM}_{2.5}$ measurements were above $35\mu\text{g}/\text{m}^3$ on at least one day in 2005. Currently, the Wapato Hills Puyallup River Valley (including regions in Edgewood, Fife, Fircrest, Lakewood, Milton, Puyallup, Ruston, Sumner, Tacoma, and University Place) is not meeting the standard for $\text{PM}_{2.5}$. The EPA may determine that Vancouver is not meeting the standard as well. Without additional wintertime reductions of $\text{PM}_{2.5}$ emissions, monitoring data suggest that four other communities (Yakima, Marysville, Darrington, and South Park) may come out of compliance with the new daily $\text{PM}_{2.5}$ standard at some time in the future.^{14,18}

Pollutants rule. Most of the federal HAPs are included in the state list of 393 toxic air pollutants.

The majority of toxic air pollutants in Washington are emitted by transportation sources, wood stoves, and industries. The state Department of Ecology and regional clean air agencies regulate facilities that emit toxic air pollutants by specifying the minimum air emission control technology that a source, such as a factory, must have. Because many toxic air pollutants are emitted from the same sources that generate criteria pollutants, a portion of toxic air pollutants emissions are controlled by measures that control criteria pollutants.

A small number of toxic air pollutants have been monitored at sites in Bellingham, Longview, Seattle, Spokane, and Vancouver. Except for one site in Seattle that has operated since 2000, these sites have operated for one-year periods during the past five years.

Diesel Exhaust

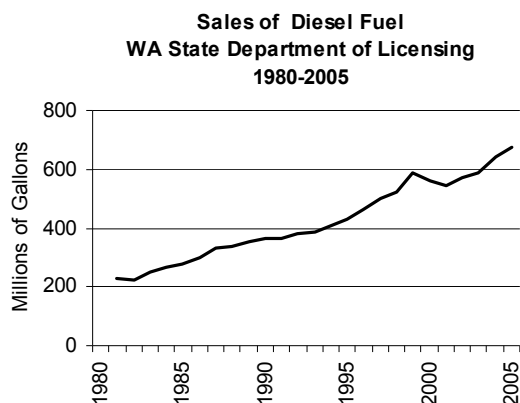
Diesel exhaust contains a mixture of both criteria pollutants and HAPs, including carbon monoxide, carbon dioxide, nitrogen oxides, sulfur oxides, benzene, polycyclic aromatic hydrocarbons, fine particulate matter, and toxic air pollutants such as benzene, 1,3-butadiene, and formaldehyde. Particles in diesel emissions contain carcinogenic and other biologically active contaminants.

Diesel exhaust best described as diesel particulate matter (DPM) is associated with several health effects including lung damage, exacerbation of allergies and asthma, and lung and bladder cancers. The California Environmental Protection Agency (Cal/EPA) assumes that exposure to DPM (which is difficult to study except in occupational settings) has similar effects as PM and would also be linked to an increased risk of heart and lung disease and death.^{19,20,21} The Washington Department of Ecology estimates that at least 70% of the airborne pollutants-associated cancer risk in the state comes from DPM. The risk estimates are based on a method used by Cal/EPA.²²

People who live near major urban roadways can be exposed to higher levels of diesel exhaust, and the Washington State Department of Health estimates that 4.2 million people in Washington live near such roadways. The Washington State Department of Ecology estimates that near these roadways are many facilities that may be used by sensitive populations including 4,000 day care centers, 1,500 schools serving children as young as kindergarten age, 100 hospitals, and 200 nursing homes. The Washington State Department of Ecology and regional air agencies regulate many components of diesel exhaust as HAPs. Major sources of diesel emissions include motor vehicles such as trucks and buses, boats and equipment in ports, trains, construction and agricultural equipment, and stationary sources such as diesel-powered generators. In 2005, DPM made up 7% of the PM_{2.5} emissions in Washington State.

Time Trends

The number of gallons of diesel fuel sold increased by 200% in Washington State from 1981 to 2005. Reasons for this trend include increases in diesel pickup truck use and commercial truck fleets. New federal regulations that went into effect in 2006 required a greater use of ultra low sulfur fuel (ULSF), which is cleaner burning and releases less particulate matter.



Toxic Release Inventory

The EPA has established the Toxic Release Inventory (TRI) database, which contains industry-reported information on toxic chemicals released into the air. EPA requires reporting if a facility manufactures or processes more than 25,000 pounds of a listed chemical or uses 10,000 pounds of the chemical. The TRI contains information on releases of about 650 hazardous chemicals, including most HAPs.²³ This information is available to the public so that people can know what type of chemical hazards may be present in their communities.²³

Toxics emissions as reported in the TRI decreased in Washington State by 59% over 16 years, from 12,380 tons in 1995 to 5,073 tons in 2005. Emissions decreased by 19% during 1995–2000 and by 40% during 2001–2005. But the TRI does not include diesel particulate matter, which the Department of Ecology considers to be the largest contributor to the potential cancer risk from air toxics in Washington State.²² Additionally, the majority of industry reports on chemical releases are estimates and not actual measurements of releases. This can limit accuracy of some reports.

Disparities

It is not possible to determine the exact amount of air pollution people are exposed to. Monitoring sites

provide information on a few air pollutants and are only highly accurate for short distances. Air pollution tends to be higher in urban areas, where minorities predominately live. In Washington, 81% of Blacks, 79% of Asians, and 69% of Asian Pacific Islanders live in urban areas, while only 59% of whites live in these areas.

Year 2010 Goals

The national *Healthy People 2010* report outlines several goals related to air pollution. Objective 8-1 is to reduce to zero the proportion of people exposed to air that does not meet EPA's standards for criteria pollutants. This objective includes PM₁₀ but not PM_{2.5}. Washington currently meets this goal.

Objective 8-2 is to increase trips made by bicycling, walking, and transit and to increase telecommuting to reduce motor vehicle emissions and improve the nation's air quality. Targets outlined in the *2005 Midcourse Review* are to double the 1995 baselines such that trips made by bicycling increase to 1.8%, walking increases to 10.8%, transit to 3.6%, and persons who telecommute to 4%. Washington State does not have data to assess progress toward this goal, but the Commuter Trip Reduction Program (see Interventions below) indicates that Washington is working toward achieving these targets.

Objective 8-3 is to improve air quality by increasing the use of cleaner alternative fuels. The *2005 Midcourse Review* sets a target of 8%. The Washington Legislature in 2006 passed a law that requires gasoline and diesel fuel sold in the state to contain a minimum of 2% ethanol and biodiesel, respectively, by 2008. Ethanol is manufactured from crops such as corn, wheat, or barley. Ethanol in gasoline reduces carbon monoxide emissions. Biodiesel is made from vegetable oils, animal fats, or recycled restaurant greases. Use of biodiesel decreases emissions of fine particles and carbon monoxide. Combustion of either ethanol or biodiesel can, however, result in increased ozone formation. The new legislation will result in at least 2% of Washington's gasoline and diesel being alternative fuels, but additional changes must be implemented if Washington is going to achieve the goal of 8%.

Objective 8-4 is to reduce air toxic emissions reported to the TRI to two million tons,

representing a 75% decrease compared to 1993. Washington currently contributes less than 2% to the national TRI reports. If the pace of the decrease in reported emissions from 1995 to 2005 continues, Washington will easily achieve a 75% reduction by 2010.

Intervention Strategies

Outdoor air quality regulations, mainly the federal and state Clean Air Acts, have been effective in decreasing the level of many air pollutants. These regulations rely on air pollution monitoring to identify sources of pollution and control of emissions at air pollution sources. State regulations have resulted in a decrease in smoke from agricultural burning. Burn bans and other local regulations have decreased smoke from wood stoves and outdoor burning. Beginning in 2007, outdoor burning is no longer allowed in any urban growth area (areas designated by counties in which urban growth is encouraged) in Washington, and burn bans can now be called at lower levels of PM_{2.5}.

Interventions to reduce emissions from cars, trucks, boats, and trains that are currently being implemented in some regions in Washington include: establishing non-idling areas at schools and ferry terminals, using electrical power to run truck engines at overnight truck stops and ship engines in ports, setting-up programs to help retrofit private and government fleets of trucks and buses, replacing older engines and equipment with cleaner engine technology, and retrofitting locomotives with idle reduction devices.

In 2003 the Washington Legislature passed a law to establish the Washington State Clean Bus Program to help reduce children's exposure to diesel exhaust from school buses. The law provides about \$28 million to retrofit the entire state school bus fleet with emission control technologies. To date, the program has retrofitted more than 5,000 school buses, with another 1,000 buses scheduled to be completed in 2008. About 1,000 buses cannot be retrofit. These buses have been in operation for 20-30 years and produce too much particle pollution to work well with current pollution control technology; the Washington State Department of Ecology recommends that these buses be replaced.

In 2006, the EPA began to require that 80% of highway diesel fuel produced or imported be ULSF. The combination of ULSF and new emission control technology will reduce particulate matter and nitrogen oxides emissions in new heavy-duty highway vehicles by 90%. This allows new vehicles to meet stricter emissions standards. These

standards, however, will not apply to older vehicles that can stay on the road for many years.

Washington State has a Commute Trip Reduction (CTR) law. This law requires employers with more than 100 employees in the nine counties with the largest number of people to set up a CTR program. Twenty-five percent of employees in these counties are covered by a CTR program. The program works with employers to encourage workers who commute to reduce commute trips and not drive alone. The goal of the program is to reduce air pollution, traffic congestion, and fuel consumption. From 1993 to 2005, there was a 7% reduction in drive-alone trips at CTR sites. In 2005, the CTR program succeeded in reducing air pollution from motor vehicle exhaust by about 1% or 3,700 tons of carbon monoxide, volatile organic compounds, and nitrogen oxides combined. Among the CTR sites, 34% of employees in 2005 participated in CTR. Participating workers used various means to reduce commuting including 14% car or vanpool, 12% bus or rail, 3% condensed work week, 2% walk, 1% bike, 1% telecommute, and 1% other.²⁴

People can take steps to reduce air pollution by reducing or changing the fuel they use. Ways to limit or change fuel use include: combining car trips, carpooling, taking public transportation, not idling, not burning wood or switching to a certified wood stove or pellet stove and using correct burning practices, substituting electrical for gas-powered yard equipment, and composting instead of burning yard waste.

People can reduce their exposure to outdoor air pollution by limiting the time they spend outdoors, especially exercising, on days when air quality is poor. Information on current air quality conditions can be obtained from the Washington State Department of Ecology's Washington Air Quality Advisory or from local clean air agencies.^{25,26}

See Related Chapters: [Asthma](#), [Indoor Air Quality](#), [Children's Environmental Health](#)

Data Sources

Daily PM_{2.5} monitoring data: Washington State Department of Ecology data from 2005. PM_{2.5} monitoring-level data and population estimates in urban areas prepared by the Washington State Department of Health, Office of Environmental Health Assessments.

Estimates of population and facilities near major urban roadways: Washington State Department of Ecology

Diesel gallons sold data: Washington Department of Licensing

CTR data for 2005: Washington State Department of Transportation

For More Information

Washington State Department of Health, Office of Environmental Health Assessments: (360) 236-3200

Washington State Department of Ecology, Air Quality Program: (360) 407-6800, and <http://ecy.wa.gov/programs/air/airhome.html>

Technical Notes

Counties that do not have a PM monitoring site include: Asotin, Douglas, Ferry, Garfield, Island, Kitsap, Klickitat, Lewis, Lincoln, Pacific, Pend Oreille, San Juan, Skamania, and Wahkiakum.

The Department of Health reviewed monitoring information from 2005 to evaluate PM_{2.5} levels in the various counties on all days in the year where data for PM_{2.5} levels were available. The 24-hour average daily level of PM_{2.5} monitoring site information was examined in each county. In counties where there was more than one monitor, the highest monitor reading for that day was used. That monitoring value was assigned to one of four categories: >35 µg/m³ (i.e., above the current EPA standard); 30-35 µg/m³; 25-30 µg/m³; and 20-25 µg/m³ (i.e., all below the current EPA standard). The number of days that PM_{2.5} levels fell in these four categories can be found in the chart "Highest PM 2.5 Measures by Day by County Washington State, 2005." Most monitors provide measurements that cover a radius of only 2.5 miles. Monitors therefore give only an approximate level for a county. Levels may vary depending on local pollution sources, land characteristics, and weather conditions.

Endnotes

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²⁶ Information on local clean air agencies available at <http://www.ecy.wa.gov/programs/air/local.html>.