



# **EPA Latest Findings on National Air Quality: 2000 Status and Trends**



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# National Air Quality



## Six Principal Air Pollutants Tracked Nationally

- Nitrogen Dioxide ( $\text{NO}_2$ )
- Ozone ( $\text{O}_3$ ) – formed by volatile organic compounds (VOCs) and nitrogen oxides ( $\text{NO}_x$ )
- Sulfur Dioxide ( $\text{SO}_2$ )
- Particulate Matter (PM) – formed by  $\text{SO}_2$ ,  $\text{NO}_x$ , ammonia, VOCs, and direct particle emissions
- Carbon Monoxide (CO)
- Lead (Pb)

## EPA tracks air pollution in two ways:

- Emissions from all sources going back 30 years.
- Air quality measured from monitoring stations around the country going back 20 years.

More detailed information on air pollution trends is available at [www.epa.gov/airtrends](http://www.epa.gov/airtrends).

This summary report highlights the U.S. Environmental Protection Agency's (EPA) most recent evaluation of status and trends in our nation's air quality.

## Highlights

- Since 1970, aggregate emissions of six principal pollutants tracked nationally have been cut 29 percent. During that same time period, U.S. Gross Domestic Product increased 158 percent, energy consumption increased 45 percent, and vehicle miles traveled have increased 143 percent.
- National air quality levels measured at thousands of monitoring stations across the country have shown improvements over the past 20 years for all six principal pollutants.
- Despite this progress, over 160 million tons of pollution are emitted into the air each year in the United States, and approximately 121 million people live in areas where monitored air was unhealthy because of high levels of the six principal air pollutants.
- EPA is increasingly focusing its efforts on tracking and controlling two of these pollutants: ground-level ozone and fine particles, key components of smog and haze.
- Of the six tracked pollutants, progress has been slowest for ground-level ozone. In the southern and north central regions of the United States ozone levels have actually worsened in the past 10 years. Similarly, over the last 10 years, the average ozone levels in 29 of our national parks increased over 4 percent.
- Much of this ozone trend is due to increased emissions in nitrogen oxides ( $\text{NO}_x$ ), a family of chemicals that can spread ozone hundreds of miles downwind. Between 1970 and 2000  $\text{NO}_x$  emissions in the United States have increased almost 20 percent (and 3 percent increase in the last 10 years). The majority of this increase is attributed to growth in emissions from non-road engines (like construction and recreation equipment), diesel vehicles, and power plants. Emissions of  $\text{NO}_x$  also contribute to acid rain, haze, particulate matter, and damage to water bodies, like the Chesapeake Bay.
- EPA, states and tribes have only recently begun to measure fine particles (known as  $\text{PM}_{2.5}$ ) in the air on a broad national basis. EPA will require three years worth of air quality monitoring data before determining whether areas meet the health-based standards for  $\text{PM}_{2.5}$ . However, based on up to two years of data available in most of the country, many areas across the Southeast, Midwest, and Mid-Atlantic regions, and California may have air quality that is unhealthy due to fine particles.
- In late 2001, EPA will release the first in a series of national-scale assessments of the risks associated with 32 toxic air pollutants and diesel PM. Details about this effort conducted under the National Air Toxics Assessment (NATA) program are available at <http://www.epa.gov/ttn/atw/nata>.
- Sulfates formed primarily from  $\text{SO}_2$  emissions from coal-fired power plants are the dominant source of fine particles in the eastern United States.  $\text{SO}_2$  emissions also contribute to the formation of acid rain. EPA's market-based emissions trading program to reduce acid rain has successfully reduced these air pollutants from 16 million tons in 1990 to 11.2 million tons in 2000. One of the many benefits resulting from this reduction is that visibility has improved in the eastern United States. However, measurements show that visibility for the best days in the eastern United States is about the same as the worst days in the West.
- Improvements are being made in the fight to protect the stratospheric ozone layer. Most recent measurements showed that concentrations of the ozone-depleting substance, methyl chloroform, have started to fall, indicating that emissions have been greatly reduced. Concentrations in the upper atmo-

sphere of other ozone-depleting substances, like chlorofluorocarbons, are also beginning to decrease.

- EPA continues to work closely with thousands of companies and other organizations to voluntarily reduce greenhouse gases associated with global climate change. In 2000 alone, EPA's voluntary programs reduced greenhouse gas emissions by 57 million metric tons of carbon equivalent (equal to removing 40 million cars from the road). By investing in products that use energy more efficiently, consumers and businesses have reduced energy consumption by some 75 billion kilowatt hours and saved more than \$5 billion on their 2000 energy bills.

## Air Pollution

### The Concern

Exposure to air pollution is associated with numerous effects on human health, including respiratory problems, hospitalization for heart or lung diseases, and even premature death. The average person breathes 3,400 gallons of air each day. Children are at greater risk because they are generally more active outdoors and their lungs are still developing. The elderly and people with heart or lung diseases are also more sensitive to some types of air pollution.

Air pollution, such as ground-level ozone, and air toxics, can also significantly affect ecosystems. For example, ground-level ozone has been estimated to cause over \$500 million in annual reductions of agricultural and commercial forest yields, and airborne releases of NO<sub>x</sub> are one of the largest sources of nitrogen pollution in certain water bodies such as the Chesapeake Bay.

### The Causes

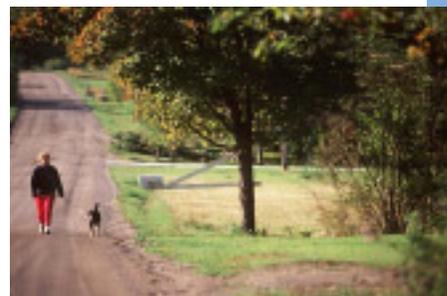
Air pollution comes from many different sources. These include: "stationary sources," such as factories, power plants, and smelters; smaller sources such as dry cleaners and degreasing operations; "mobile sources," such as cars, buses, planes, trucks, and trains; and "natural sources," such as wind-blown dust and wildfires.

### The Law

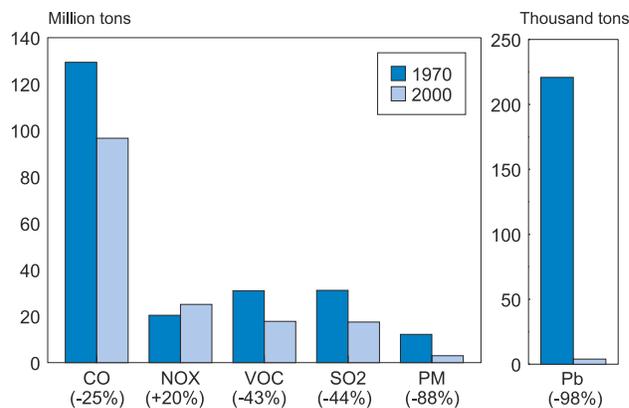
The Clean Air Act provides the principal framework for national, state, tribal, and local efforts to protect air quality. Under the Clean Air Act, EPA has a number of responsibilities, including:

- Setting national ambient air quality standards (NAAQS) for the six principal pollutants that are considered harmful to public health and the environment.
- Ensuring that these air quality standards are met (in cooperation with the state, tribal, and local governments) through national standards and strategies to control air pollutant emissions from vehicles, factories, and other sources.
- Reducing emissions of sulfur dioxide and nitrogen oxides that cause acid rain.
- Reducing air pollutants such as particulate matter, sulfur oxides, and nitrogen oxides that can cause visibility impairment across large regional areas, including many of the nation's most treasured parks and wilderness areas.
- Ensuring that sources of toxic air pollutants that cause or may cause cancer and other adverse human health and environmental effects are well controlled, and that risks to public health and the environment are substantially reduced.
- Limiting the use of chemicals that damage the stratospheric ozone layer in order to prevent increased levels of harmful ultraviolet radiation.

While the focus of this report is on *national* air pollution, *global* air pollution issues such as destruction of the stratospheric ozone layer and the effect of global warming on the Earth's climate are major concerns and are also discussed.



Comparison of 1970 and 2000 Emissions



# Six Principal Pollutants



Under the Clean Air Act, EPA establishes air quality standards to protect public health, including the health of “sensitive” populations such as asthmatics, children, and the elderly. EPA also sets limits to protect public welfare, including protection

against decreased visibility and damage to animals, crops, vegetation, and buildings.

EPA has set national air quality standards for six principal air pollutants (also referred to as criteria pollutants): carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO<sub>2</sub>), ozone (O<sub>3</sub>), particulate matter (PM), and sulfur dioxide (SO<sub>2</sub>). Four of these pollutants (CO, Pb, NO<sub>2</sub>, and SO<sub>2</sub>) result solely from direct emissions from a variety of sources. PM can result from direct emissions also, but is commonly formed when emissions of nitrogen oxides (NO<sub>x</sub>), SO<sub>2</sub>, ammonia, and other gases react in the atmosphere. Ozone is not directly emitted, but is formed when NO<sub>x</sub> and volatile organic compounds (VOCs) react in the presence of sunlight.

Each year EPA examines changes in levels of these ambient pollutants and their precursor emissions over time and summarizes the current air pollution status.

## Summary of Air Quality and Emissions Trends

EPA tracks trends in *air quality* based on actual measurements of pollutant concentrations in the ambient (outside) air at monitoring sites across the country. Monitoring stations are operated by state, tribal, and local government agencies as well as some federal agencies, including EPA. Trends are derived by averaging direct measurements from these monitoring stations on a yearly basis. The tables at left show that the air quality based on concentrations of the principal pollutants has improved nationally over the last 20 years (1981–2000).

EPA estimates nationwide *emissions* of ambient pollutants and their precursors based on actual monitored readings or engineering calculations of the amounts and types of pollutants emitted by vehicles, factories, and other sources. Emission estimates are based on many factors, including the level of industrial activity, technology developments, fuel consumption, vehicle miles traveled, and other activities that cause air pollution. Emissions estimates also reflect changes in air pollution regulations and installation of emissions controls. The 2000 emissions reported in this summary report are projected numbers based on available 1999 information and historical trends. EPA’s emission estimation methods continue to change and improve. As a result, comparisons of the estimates for a given year in this summary to the same year in previous summaries may not be appropriate. Check <http://www.epa.gov/ttn/chief> for updated emissions information. Emissions of the principal pollutants have decreased over the last 20 years (1981–2000), with the exception of NO<sub>x</sub>. While NO<sub>x</sub> emissions have increased, air quality measurements for NO<sub>2</sub> across the country are below the national air quality standards. It is important to note that oxides of nitrogen, including NO<sub>2</sub>, contribute to the formation of ozone, particulate matter, and acid rain. NO<sub>x</sub> also add to poor visibility.

Percent Change in Air Quality  
1981–2000      1991–2000

NO <sub>2</sub>	-14	-11
O <sub>3</sub> 1-hr	-21	-10
8-hr	-12	-7
SO <sub>2</sub>	-50	-37
PM <sub>10</sub>	—	-19
PM <sub>2.5</sub>	Trend data not available	
CO	-61	-41
Pb	-93	-50

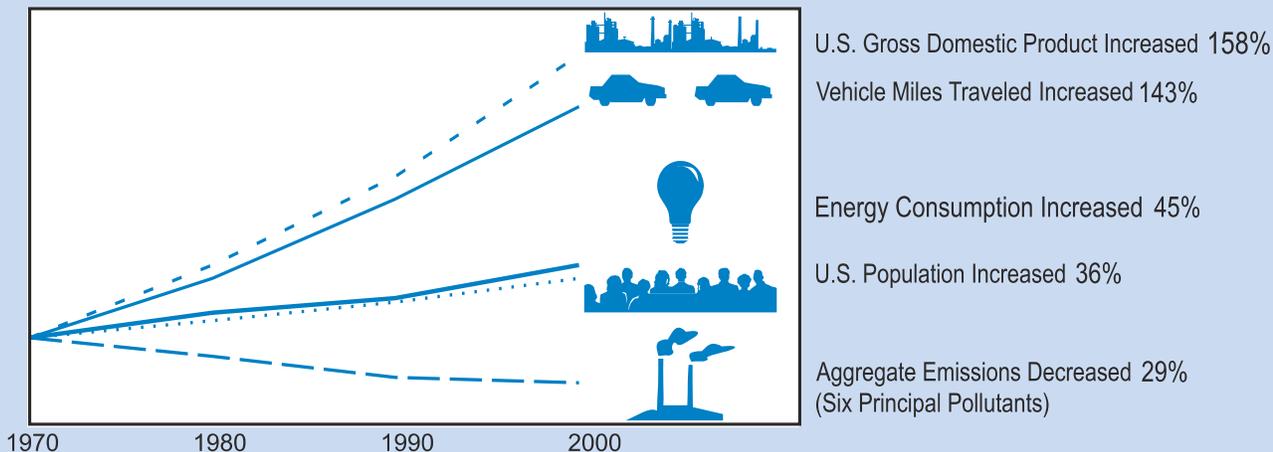
Percent Change in Emissions  
1981–2000      1991–2000

NO <sub>x</sub>	+4	+3
VOC	-32	-16
SO <sub>2</sub>	-31	-24
PM <sub>10</sub> *	-47	-6
PM <sub>2.5</sub> *	—	-5
CO	-18	-5
Pb	-94	-4

*Air quality concentrations do not always track nationwide emissions. There are several reasons for this. First, most monitors are located in urban areas so air quality trends are more likely to track changes in urban emissions rather than changes in total national emissions. Second, not all of the principal pollutants are emitted directly to the air. Ozone and many particles are formed after directly emitted gases react chemically to form them. Third, the amount of some pollutants measured at monitoring locations depends on the chemical reactions that occur in the atmosphere during the time it takes the pollutant to travel from its source to the monitoring station. Finally, weather conditions often control the formation and buildup of pollutants in the ambient air. For example, peak ozone concentrations typically occur during hot, dry, stagnant summertime conditions.*

\* Includes only directly emitted particles.

**Comparison of Growth Areas and Emission Trends**

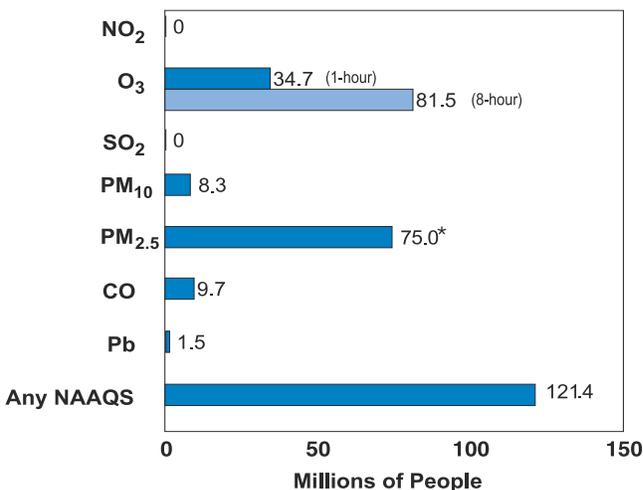


Between 1970 and 2000, gross domestic product increased 158 percent, energy consumption increased 45 percent, vehicle miles traveled increased 143 percent, and U.S. population increased 36 percent. At the same time, total emissions of the six principal air pollutants decreased 29 percent.

The improvements are a result of effective implementation of clean air laws and regulations, as well as improvements in the efficiency of industrial technologies.

Despite great progress in air quality improvement, approximately 121 million people nationwide still lived in counties with pollution levels above the national air quality standards in 2000.

**Number of People Living in Counties with Air Quality Concentrations Above the Level of the NAAQS in 2000**



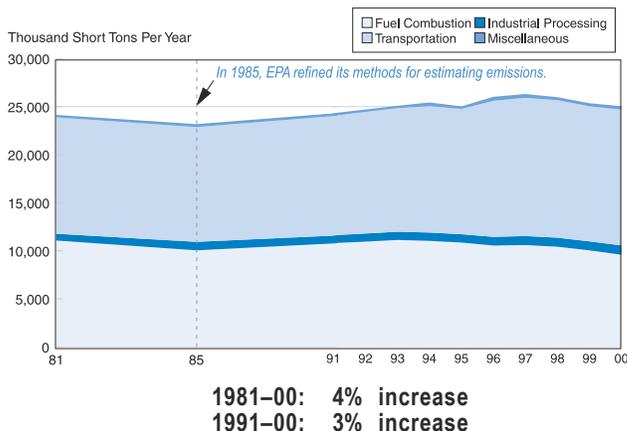
\*This number is based on PM<sub>2.5</sub> monitors with complete data. Because the national PM<sub>2.5</sub> monitoring network was still being deployed in 2000, some counties with PM<sub>2.5</sub> monitors have incomplete data for 2000. Since it is likely that more monitors will have complete data as time goes by, this number may increase as this information becomes available.

**Status of Ozone and Particulate Matter Standards**

In 1997, EPA revised the national ambient air quality standards for ozone and particulate matter. The standards were challenged by several business and state groups who claimed that EPA misinterpreted the Clean Air Act to give itself unlimited discretion to set air standards. On February 27, 2001, the U.S. Supreme Court unanimously upheld the constitutionality of the Clean Air Act as EPA had interpreted it in setting those health-protective air quality standards. The Supreme Court also reaffirmed EPA's long-standing interpretation that it must set these standards based solely on public health considerations without consideration of costs. The case is now back in the U.S. Court of Appeals to decide issues not addressed in their initial opinion. Updates on this action can be found at <http://www.epa.gov/airlinks>.

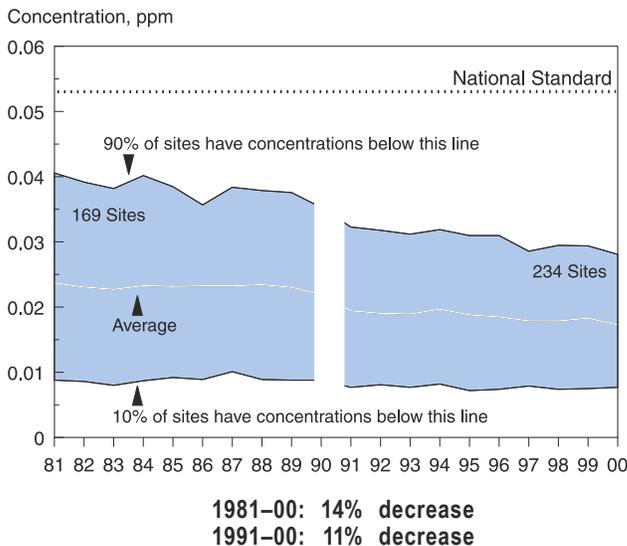
# 1 Nitrogen Dioxide (NO<sub>2</sub>)

**NO<sub>x</sub> Emissions, 1981–2000**



*Air quality concentrations do not always track nationwide emissions. For a detailed explanation, see the caption on page 4.*

**NO<sub>2</sub> Air Quality, 1981–2000**  
(Based on Annual Arithmetic Average)



*Because few sites have 20 years of data, EPA used two consecutive 10-year periods to construct this 20-year trend.*

## Nature and Sources of the Pollutant

Nitrogen dioxide (NO<sub>2</sub>) is a reddish brown, highly reactive gas that is formed in the ambient air through the oxidation of nitric oxide (NO). Nitrogen oxides (NO<sub>x</sub>), the term used to describe the sum of NO, NO<sub>2</sub> and other oxides of nitrogen, play a major role in the formation of ozone, particulate matter, haze and acid rain. The major sources of man-made NO<sub>x</sub> emissions are high-temperature combustion processes, such as those occurring in automobiles and power plants. Home heaters and gas stoves also produce substantial amounts of NO<sub>2</sub> in indoor settings.

## Health and Environmental Effects

Short-term exposures (e.g., less than 3 hours) to low levels of nitrogen dioxide (NO<sub>2</sub>) may lead to changes in airway responsiveness and lung function in individuals with pre-existing respiratory illnesses and increases in respiratory illnesses in children (5–12 years old). Long-term exposures to NO<sub>2</sub> may lead to increased susceptibility to respiratory infection and may cause permanent alterations in the lung. Nitrogen oxides react in the air to form ground-level ozone and fine particle pollution which are both associated with adverse health effects.

Nitrogen oxides contribute to a wide range of environmental effects, including the formation of acid rain and potential changes in the composition and competition of some species of vegetation in wetland and terrestrial systems, visibility impairment, acidification of freshwater bodies, eutrophication (i.e., excessive algae growth leading to a depletion of oxygen in the water) of estuarine and coastal waters (e.g., Chesapeake Bay), and increases in levels of toxins harmful to fish and other aquatic life.

## Trends in NO<sub>2</sub> Levels

Over the past 20 years, monitored levels of NO<sub>2</sub> have decreased 14 percent. All areas of the country that once violated the national air quality standard for NO<sub>2</sub> now meet that standard. While levels around urban monitors have fallen, national emissions of nitrogen oxides have actually increased over the past 20 years by 4 percent. This increase is the result of a number of factors, the largest being an increase in nitrogen oxides emissions from diesel vehicles. This increase is of concern because NO<sub>x</sub> emissions contribute to the formation of ground-level ozone (smog), but also to other environmental problems, like acid rain and nitrogen loadings to water bodies.



# Ground-Level Ozone (O<sub>3</sub>)

# 2



## Nature and Sources of the Pollutant

Ground-level ozone (the primary constituent of smog) continues to be a

pollution problem throughout many areas of the United States.

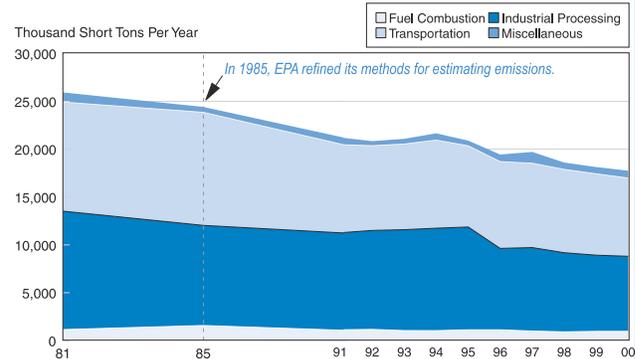
Ozone occurs naturally in the stratosphere and provides a protective layer high above the Earth. See page 22 for more information on the stratospheric ozone layer.

Ozone is not emitted directly into the air but is formed by the reaction of VOCs and NO<sub>x</sub> in the presence of heat and sunlight. Ground-level ozone forms readily in the atmosphere, usually during hot summer weather. VOCs are emitted from a variety of sources, including motor vehicles, chemical plants, refineries, factories, consumer and commercial products, and other industrial sources. Nitrogen oxides are emitted from motor vehicles, power plants, and other sources of combustion. Changing weather patterns contribute to yearly differences in ozone concentrations from region to region. Ozone and the precursor pollutants that form ozone also can be transported into an area from pollution sources found hundreds of miles upwind.

## Health and Environmental Effects

Short-term (1–3 hours) and prolonged (6–8 hours) exposures to ambient ozone have been linked to a number of health effects of concern. For example, increased hospital admissions and emergency room visits for respiratory problems have been associated with ambient ozone exposures. Exposures to ozone can make people more susceptible to respiratory infection, result in lung inflammation, and aggravate pre-existing respiratory diseases such as asthma. Other health effects attributed to ozone exposures include significant decreases in lung function and increased respiratory symptoms such as chest pain and cough. These effects generally occur while individuals are actively exercising, working or playing outdoors. Children, active outdoors during the summer when ozone levels are at their highest, are most at risk of experiencing such effects. Other at-risk groups include adults who are active outdoors (e.g., some outdoor workers) and individu-

VOC Emissions, 1981–2000

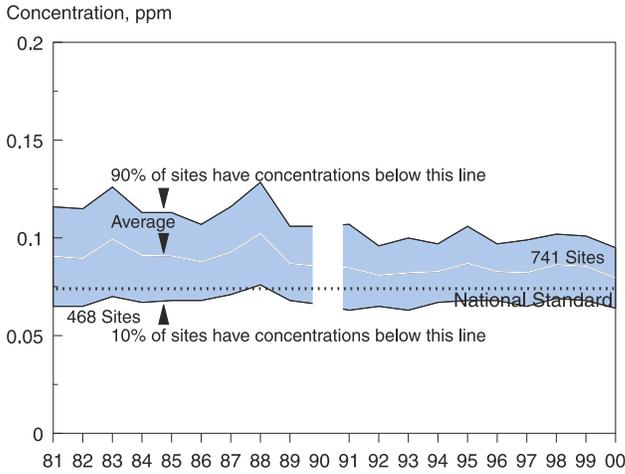


1981–00: 32% decrease  
1991–00: 16% decrease

Air quality concentrations do not always track nationwide emissions. For a detailed explanation, see the caption on page 4.

### Ozone Air Quality, 1981–2000

(Based on Annual 4th Highest Daily Maximum 8-Hour Average)



**1981–00: 12% decrease**  
**1991–00: 7% decrease**

*Because few sites have 20 years of data, EPA used two consecutive 10-year periods to construct this 20-year trend.*

als with pre-existing respiratory disease such as asthma and chronic lung disease. In addition, longer-term exposures to moderate levels of ozone present the possibility of irreversible changes in the lung structure which could lead to premature aging of the lungs and worsen chronic respiratory illnesses.

Ozone also affects vegetation and ecosystems, leading to reductions in agricultural and commercial forest yields, reduced growth and survivability of tree seedlings, and increased plant susceptibility to disease, pests, and other environmental stresses (e.g., harsh weather). In long-lived species, these effects may become evident only after several years or even decades, thus having the potential for long-term effects on forest ecosystems. Ground-level ozone damage to the foliage of trees and other plants also can decrease the aesthetic value of ornamental species as well as the natural beauty of our national parks and recreation areas.

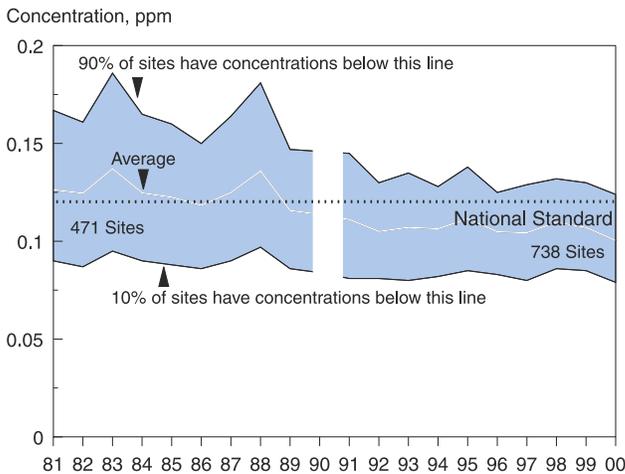
### Trends in Ozone Levels

In 1997, EPA revised the national ambient air quality standards for ozone by setting new 8-hour 0.08 ppm standards. Currently, EPA is tracking trends based on both the 1-hour and 8-hour data.

Over the past 20 years, national ambient ozone levels decreased 21 percent based on 1-hour data, and 10 percent based on 8-hour data. Between 1981 and 2000, emissions of VOCs have decreased 32

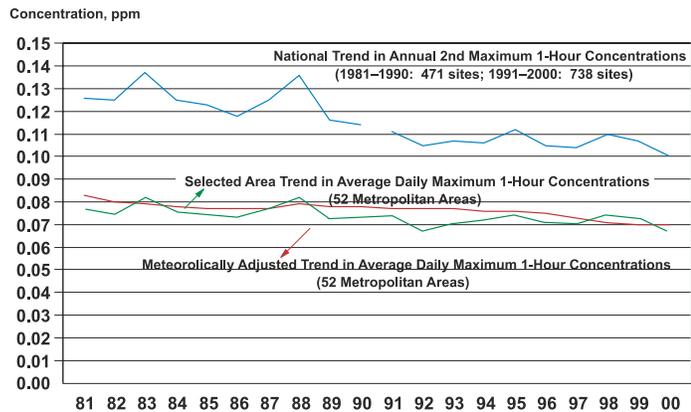
### Ozone Air Quality, 1981–2000

(Based on Annual 2nd Highest Daily Maximum 1-Hour)



**1981–00: 21% decrease**  
**1991–00: 10% decrease**

### Comparison of Actual and Meteorologically Adjusted 1-hour Ozone Trends, 1981–2000



percent. During that same time period, emissions of NO<sub>x</sub> increased 4 percent.

Because sunlight and heat play a major role in ozone formation, changing weather patterns contribute to yearly differences in ozone concentrations. To better reflect the changes that emissions have on measured air quality concentrations, EPA is able to make analytical adjustments to account for this annual variability in meteorology. For 52 metropolitan areas, the adjusted trend for 1-hour ozone levels shows improvement over the 20-year period from 1981–2000. However, beginning in 1994, the rate of improvement appears to level off and the trend in the last 10 years is relatively flat.

For the period 1981–2000, the downward trend in 1-hour ozone levels seen nationally is reflected in every broad geographic area in the country. The Northeast and West exhibit the most substantial improvement while the South and Southwest have experienced the least rapid progress in lowering ozone concentrations. Over the last 10 years, this downward trend continues for the Northeast, Midwest and West coast; however, in the South and North Central regions of the country, ozone levels have actually increased.

Across the country, the highest ambient ozone concentrations are typically found at suburban sites, consistent with the downwind transport of emissions from urban centers. During the past 20 years, ozone concentrations decreased more than 24 percent at urban sites and declined by 21 percent at suburban sites. For the more recent 10-year period, urban sites show decreases of approximately 12 percent and suburban sites show 11 percent decreases. However, at rural monitoring locations national improvements have been slower. One-hour ozone levels for 2000 are 15 percent lower than those in 1981 but only 6 percent below 1991 levels. In 2000, for the third consecutive year, rural 1-hour ozone levels are greater than the levels observed for the urban sites, but they are still lower than levels observed at suburban sites.

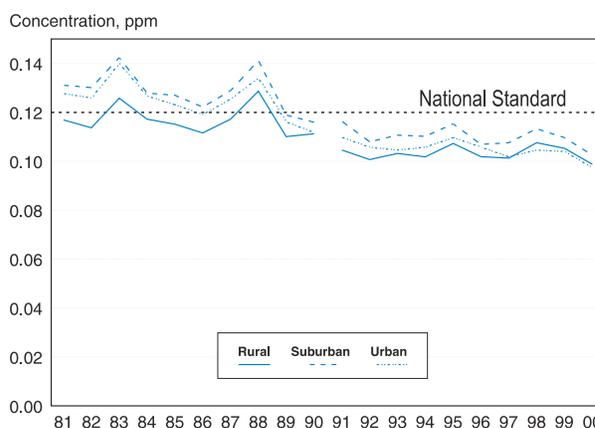
Over the last 10 years, 8-hour ozone levels in 29 of our national parks increased over 4 percent. Thirteen monitoring sites in eleven of these parks experienced statistically significant upward trends in 8-hour ozone levels: Great Smoky Mountains (TN), Cape Romain (SC), Cowpens (SC), Congaree Swamp (SC), Everglades (FL), Mammoth Cave (KY), Voyageurs (MN), Yellowstone (WY), Yosemite (CA), Canyonlands (UT) and Craters of the Moon (ID). For the remaining 18 parks, the 8-hour ozone levels at ten increased only slightly between 1991 and 2000, while seven showed decreasing levels, and one was unchanged.

**Trend in 1-Hour Ozone Levels, 1981–2000**  
**Averaged Across EPA Regions**  
 (Based on Annual Second Highest Daily Maximum)



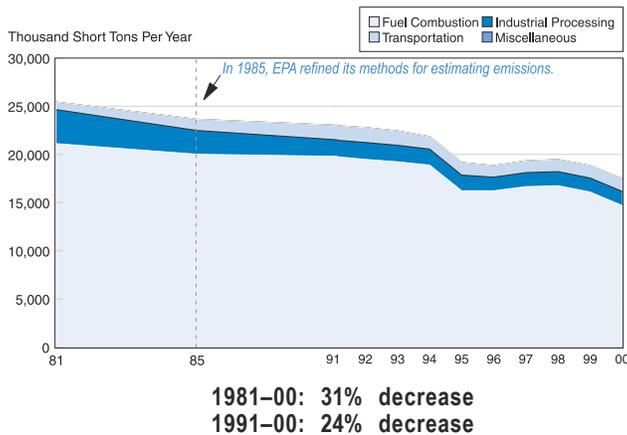
Alaska is in EPA Region 10; Hawaii, EPA Region 9; and Puerto Rico, EPA Region 2. Concentrations are ppm.

**Trend in 1-Hour Ozone Levels, 1981–2000**  
**by Location of Site**  
 (Based on Annual Second Highest Daily Maximum)



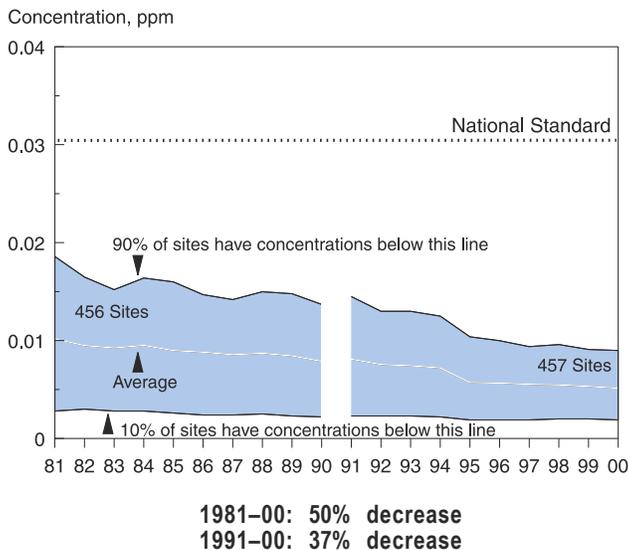
# 3 Sulfur Dioxide (SO<sub>2</sub>)

**SO<sub>2</sub> Emissions, 1981–2000**



*Air quality concentrations do not always track nationwide emissions. For a detailed explanation, see the caption on page 4.*

**SO<sub>2</sub> Air Quality, 1981–2000**  
(Based on Annual Arithmetic Mean)



*Because few sites have 20 years of data, EPA used two consecutive 10-year periods to construct this 20-year trend.*

## Nature and Sources of the Pollutant

Sulfur dioxide belongs to the family of sulfur oxide gases. These gases are formed when fuel containing sulfur (mainly coal and oil) is burned and during metal smelting and other industrial processes. Most SO<sub>2</sub> monitoring stations are located in urban areas. The highest monitored concentrations of SO<sub>2</sub> are recorded in the vicinity of large industrial facilities. Fuel combustion, largely from coal-fired power plants, accounts for most of the total SO<sub>2</sub> emissions.

## Health and Environmental Effects

High concentrations of SO<sub>2</sub> can result in temporary breathing impairment for asthmatic children and adults who are active outdoors. Short-term exposures of asthmatic individuals to elevated SO<sub>2</sub> levels while at moderate exertion may result in breathing difficulties that may be accompanied by such symptoms as wheezing, chest tightness, or shortness of breath. Other effects that have been associated with longer-term exposures to high concentrations of SO<sub>2</sub>, in conjunction with high levels of PM, include respiratory illness, alterations in the lungs' defenses, and aggravation of existing cardiovascular disease. The subgroups of the population that may be affected under these conditions include individuals with cardiovascular disease or chronic lung disease, as well as children and the elderly.

Together, SO<sub>2</sub> and NO<sub>x</sub> are the major precursors to acidic deposition (acid rain), which is associated with the acidification of soils, lakes, and streams, accelerated corrosion of buildings and monuments. Sulfur dioxide also is a major precursor to PM<sub>2.5</sub>, which is a significant health concern as well as a main pollutant that impairs visibility.

## Trends in SO<sub>2</sub> Levels

Nationally, average SO<sub>2</sub> ambient concentrations have decreased 50 percent from 1981–2000 and 37 percent over the more recent 10-year period 1991–2000. SO<sub>2</sub> emissions decreased 31 percent from 1981 to 2000 and 24 percent from 1991–2000. Reductions in SO<sub>2</sub> concentrations and emissions since 1994 are due, in large part, to controls implemented under EPA's Acid Rain Program beginning in 1995.



# Particulate Matter 4



## Nature and Sources of the Pollutant

Particulate matter (PM) is the general term used for a mixture of solid particles and liquid droplets found in the

air. Some particles are large or dark enough to be seen as soot or smoke. Others are so small they can be detected only with an electron microscope. PM<sub>2.5</sub> describes the “fine” particles that are less than or equal to 2.5 micrometers in diameter. “Coarse” particles are greater than 2.5, but less than or equal to 10 micrometers in diameter. PM<sub>10</sub> refers to all particles less than or equal to 10 micrometers in diameter. A particle 10 micrometers in diameter is about one-seventh the diameter of a human hair. PM can be emitted directly or form secondarily in the atmosphere. “Primary” particles, such as dust from roads or elemental carbon (soot) from wood combustion, are emitted directly into the atmosphere. “Secondary” particles are formed in the atmosphere from primary gaseous emissions. Examples include sulfate, formed from SO<sub>2</sub> emissions from power plants and industrial facilities; and nitrates, formed from NO<sub>x</sub> emissions from power plants, automobiles and other types of combustion sources. The chemical composition of particles depends on location, time of year, and weather. Generally, fine PM is composed mostly of secondary particles, and coarse PM is composed largely of primary particles.

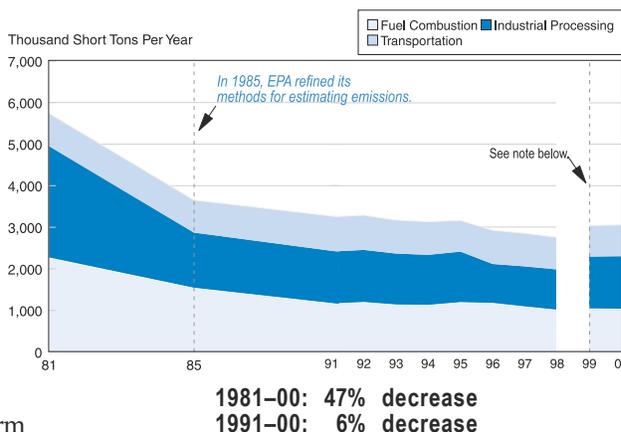
## Health and Environmental Effects

Particulate matter includes both fine and coarse particles. When breathed, particles can accumulate in the respiratory system and are associated with numerous health effects. Exposure to coarse particles is primarily associated with the aggravation of respiratory conditions, such as asthma. Fine particles are most closely associated with such health effects as increased hospital admissions and emergency room visits for heart and lung disease, increased respiratory disease and symptoms such as asthma, decreased lung function, and even premature death. Sensitive groups that appear to be at greatest risk to such effects include the elderly, individuals with cardiopulmonary disease such as asthma, and children. In addition to health problems, PM is the major cause of reduced visibility in many parts of the United States. Airborne particles also can impact vegetation and ecosystems and can cause damage to paints and building materials.

## Trends in PM<sub>10</sub> Levels

Between 1991 and 2000, average PM<sub>10</sub> concentrations decreased 19 percent, while direct PM<sub>10</sub> emissions decreased 6 percent.

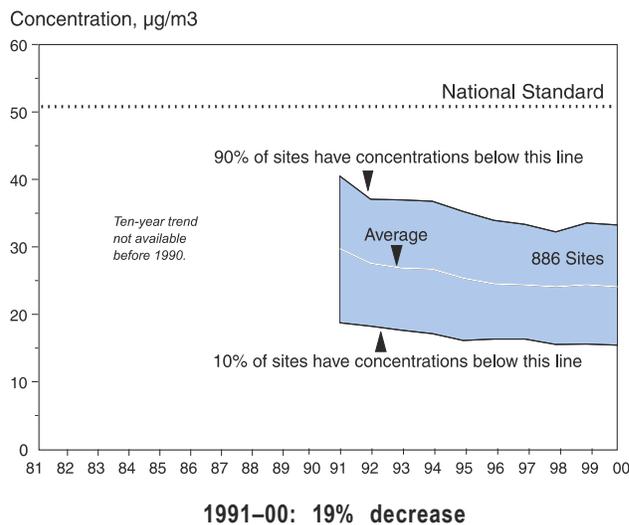
## Direct PM<sub>10</sub> Emissions from Man-Made Sources, 1981–2000



Starting in 1999, PM emissions from certain open burning sources in the “Industrial Processing” category were estimated differently than in previous years. The apparent increase in PM emissions from this category between 1998 and 1999 is the result of this change in estimation methodology.

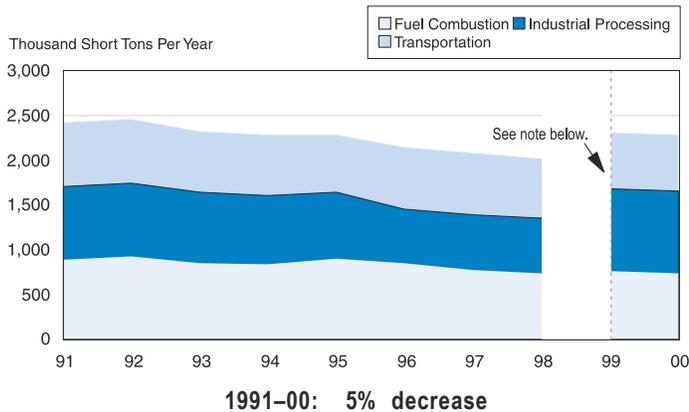
Air quality concentrations do not always track nationwide emissions. For a detailed explanation, see the caption on page 4.

## PM<sub>10</sub> Air Quality, 1991–2000 (Based on Annual Arithmetic Mean)



# Particulate Matter

## Direct PM<sub>2.5</sub> Emissions from Man-Made Sources



*Starting in 1999, PM emissions from certain open burning sources in the "Industrial Processing" category were estimated differently than in previous years. The apparent increase in PM emissions from this category between 1998 and 1999 is the result of this change in estimation methodology.*

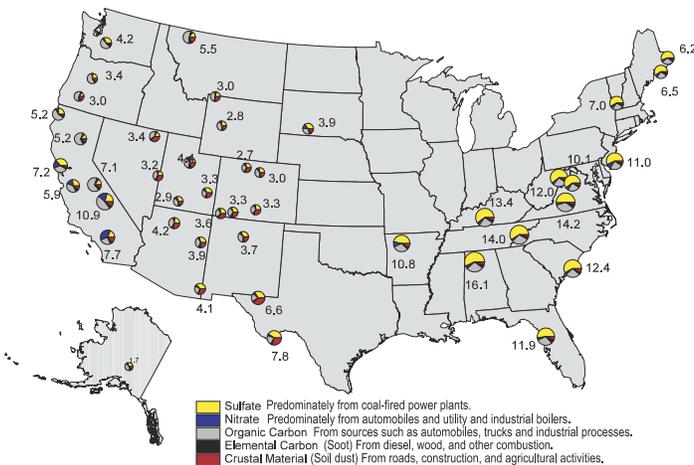
## Trends in PM<sub>2.5</sub> Levels

The chart to the left shows that direct PM<sub>2.5</sub> emissions from man-made sources decreased 5 percent nationally between 1991 and 2000. This chart tracks only directly-emitted particles and does not account for secondary particles formed when emissions of nitrogen oxides (NO<sub>x</sub>), SO<sub>2</sub>, ammonia, and other gases react in the atmosphere. The principal types of secondary particles are sulfates and nitrates, which are formed when SO<sub>2</sub> and NO<sub>x</sub> react with ammonia.

The map (bottom left) shows how sulfates and nitrates, along with three other components (organic carbon, elemental carbon, and crustal material) contribute to PM<sub>2.5</sub> concentrations. This map represents the most recent year of data available from the IMPROVE (Interagency Monitoring of Protected Visual Environments) network. The IMPROVE network was established in 1987 to track trends in visibility and the pollutants, such as PM<sub>2.5</sub>, that contribute to visibility impairment. Because the monitoring sites are located in rural areas throughout the country, the network is a good source for assessing regional differences in PM<sub>2.5</sub>.

Sites in the East typically have higher annual average PM<sub>2.5</sub> concentrations. Most of the regional difference is attributable to higher sulfate concentrations in the eastern United States. Sulfate concentrations in the eastern sites are 4 to 5 times greater than those in the western sites. Sulfate concentrations in the East largely result from sulfur dioxide emissions from coal-fired power plants. EPA's Acid Rain Program, discussed in more detail in the Acid Rain section of this brochure, sets restrictions on these power plants. Within the East, rural PM<sub>2.5</sub> levels are higher in the Southeastern and Mid-Atlantic states. In the West, rural PM<sub>2.5</sub> levels are generally less than one-half of Eastern levels.

## 1999 Annual Average PM<sub>2.5</sub> Concentrations (µg/m<sup>3</sup>) in Rural Areas



Source: Interagency Monitoring of Protected Visual Environments Network, 1999.

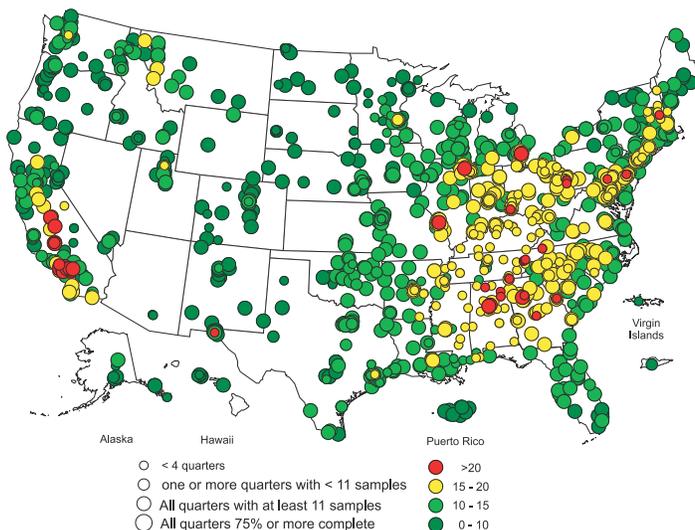
In 1999, EPA and its state, tribal, and local air pollution control partners deployed a monitoring network to begin measuring PM<sub>2.5</sub> concentrations nationwide. The map (top right of page 13) shows annual average PM<sub>2.5</sub> concentrations at the various monitoring locations. Data completeness is illustrated by the size of the circles on the map, with larger circles indicating relatively complete data for the year. This map also indicates that PM<sub>2.5</sub> concentrations vary regionally. Based on the 2000 monitoring data,

California and much of the eastern United States have annual average  $PM_{2.5}$  concentrations above the level of the annual  $PM_{2.5}$  standard, as indicated by the yellow and red on the map. With few exceptions, the rest of the country generally have annual average concentrations below the level of the annual  $PM_{2.5}$  health standard.

**$PM_{2.5}$  Trends in Rural Areas**

Because the national monitoring network started in 1999, there is not enough data to show a national long-term trend in urban  $PM_{2.5}$  air quality concentrations. However, 36 sites in the IMPROVE network (10 in the East, and 26 in the West) have enough data to assess trends in average rural  $PM_{2.5}$  concentrations from 1992–1999. In the East, where sulfates contribute most to  $PM_{2.5}$ , the annual average across the 10 sites decreased 5 percent from 1992–1999. In the West, where sulfates contribute most to  $PM_{2.5}$ , the annual average across the 10 sites decreased 5 percent from 1992–1999. The peak in 1998 is associated with increases in sulfates and organic carbon. Average  $PM_{2.5}$  concentrations across the 26 sites in the West from 1992–1999, were about one-half of the levels measured at Eastern sites.

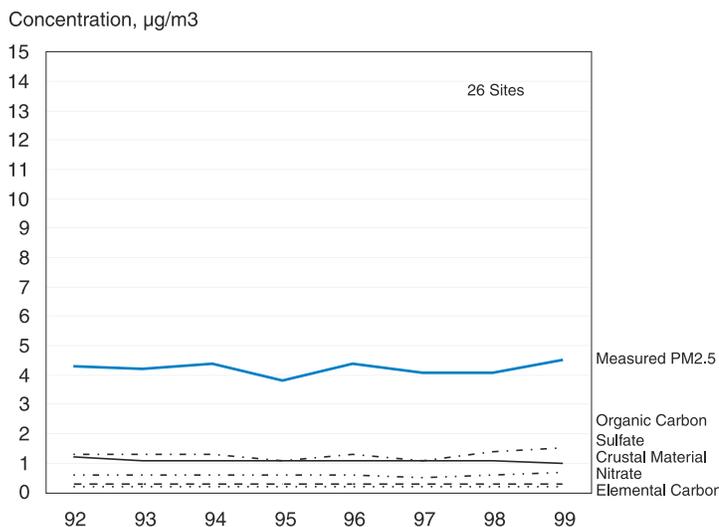
**2000 Annual Average  $PM_{2.5}$  Concentrations ( $\mu g/m^3$ )**



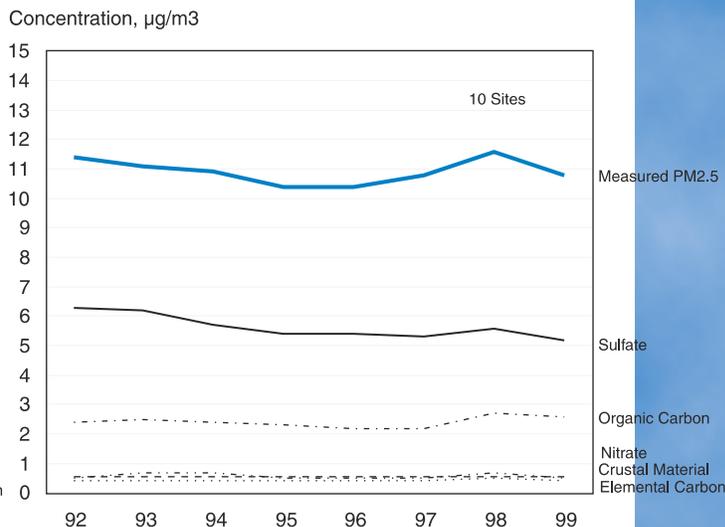
Source: US EPA AIRS Data base as of 7/10/01.

*Note:  $PM_{2.5}$  concentration measurements from the new nationwide monitoring network are not directly comparable to the measurements from the IMPROVE network due to differences in instruments and measurement methods.*

**Average  $PM_{2.5}$  Concentrations, 1992–1999 at Rural Western U.S. Sites**



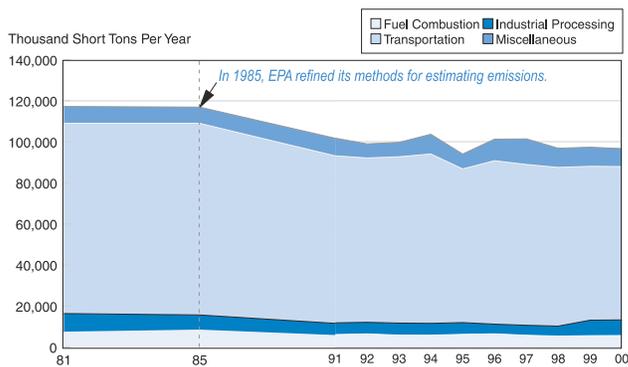
**Average  $PM_{2.5}$  Concentrations, 1992–1999 at Rural Eastern U.S. Sites**



Source: Interagency Monitoring of Protected Visual Environments Network, 1999.

# 5 Carbon Monoxide (CO)

**CO Emissions, 1981–2000**



**1981–00: 18% decrease**  
**1991–00: 5% decrease**

*Air quality concentrations do not always track nationwide emissions. For a detailed explanation, see the caption on page 4.*

## Nature and Sources of the Pollutant

Carbon monoxide (CO) is a colorless and odorless gas, formed when carbon in fuel is not burned completely. It is a component of motor vehicle exhaust, which contributes about 60 percent of all CO emissions nationwide. Non-road vehicles account for the remaining CO emissions from transportation sources. High concentrations of CO generally occur in areas with heavy traffic congestion. In cities, as much as 95 percent of all CO emissions may come from automobile exhaust. Other sources of CO emissions include industrial processes, non-transportation fuel combustion, and natural sources such as wildfires. Peak CO concentrations typically occur during the colder months of the year when CO automotive emissions are greater and nighttime inversion conditions (where air pollutants are trapped near the ground beneath a layer of warm air) are more frequent.

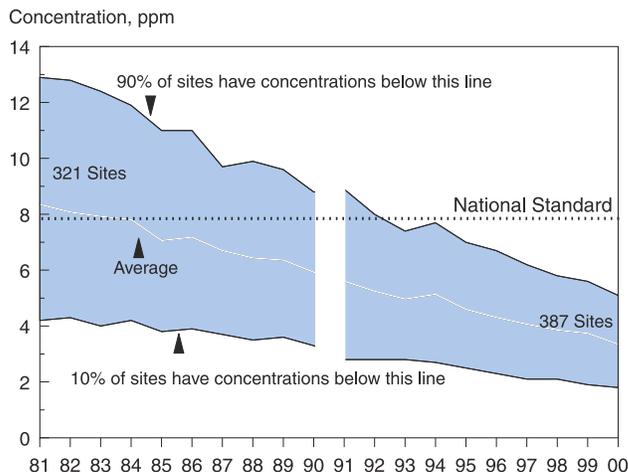
## Health and Environmental Effects

Carbon monoxide enters the bloodstream through the lungs and reduces oxygen delivery to the body's organs and tissues. The health threat from levels of CO sometimes found in the ambient air is most serious for those who suffer from cardiovascular disease, such as angina pectoris. At much higher levels of exposure, CO can be poisonous, and even healthy individuals may be affected. Visual impairment, reduced work capacity, reduced manual dexterity, poor learning ability, and difficulty in performing complex tasks are all associated with exposure to elevated CO levels.

## Trends in CO Levels

Nationally, the 2000 ambient average CO concentration is 61 percent lower than that for 1981 and is the lowest level recorded during the past 20 years. CO emissions levels decreased 18 percent over the same period. Between 1991 and 2000, ambient CO concentrations decreased 41 percent, and the estimated number of exceedances of the national standard decreased 95 percent while CO emissions fell 5 percent. This improvement occurred despite a 24 percent increase in vehicle miles traveled in the United States during this 10-year period.

**CO Air Quality, 1981–2000**  
 (Based on Annual 2nd Maximum 8-hour Average)



**1981–00: 61% decrease**  
**1991–00: 41% decrease**

*Because few sites have 20 years of data, EPA used two consecutive 10-year periods to construct this 20-year trend.*



# Lead (Pb) 6



## Nature and Sources of the Pollutant

In the past, automotive sources were the major contributor of lead emissions to the atmosphere. As a result of EPA's regulatory efforts to reduce the content of lead in gasoline, air emissions of lead from the transportation sector have declined over the past decade.

Today, industrial processes, primarily metals processing, are the major source of lead emissions to the atmosphere. The highest air concentrations of lead are found in the vicinity of smelters, and battery manufacturers.

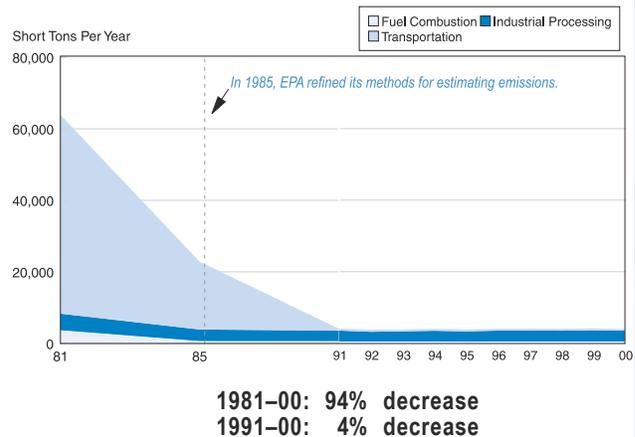
## Health and Environmental Effects

Exposure to lead occurs mainly through inhalation of air and ingestion of lead in food, water, soil, or dust. It accumulates in the blood, bones, and soft tissues. Lead can adversely affect the kidneys, liver, nervous system, and other organs. Excessive exposure to lead may cause neurological impairments such as seizures, mental retardation, and behavioral disorders. Even at low doses, lead exposure is associated with damage to the nervous systems of fetuses and young children, resulting in learning deficits and lowered IQ. Recent studies also show that lead may be a factor in high blood pressure and subsequent heart disease. Lead can also be deposited on the leaves of plants, presenting a hazard to grazing animals.

## Trends in Lead Levels

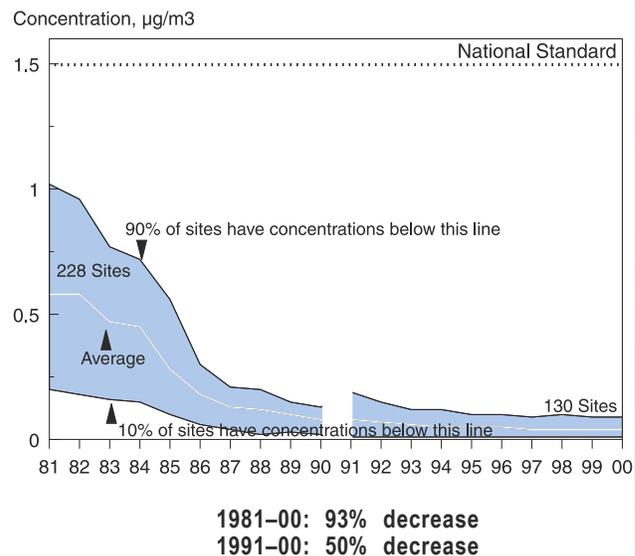
Because of the phase-out of leaded gasoline, lead emissions and concentrations decreased sharply during the 1980s and early 1990s. The 2000 average air quality concentration for lead is 93 percent lower than in 1981. Emissions of lead decreased 94 percent over that same 20-year period. Today, the only violations of the lead national air quality standard occur near large industrial sources such as lead smelters.

Lead Emissions, 1981–2000



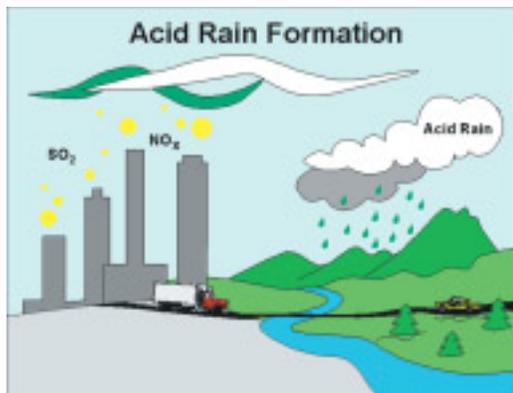
*Air quality concentrations do not always track nationwide emissions. For a detailed explanation, see the caption on page 4.*

Lead Air Quality, 1981–2000  
(Based on Annual Maximum Quarterly Average)



*Because few sites have 20 years of data, EPA used two consecutive 10-year periods to construct this 20-year trend.*

# Acid Rain



Coal-fired electric utilities and other sources that burn fossil fuels emit sulfur dioxide and nitrogen oxides.

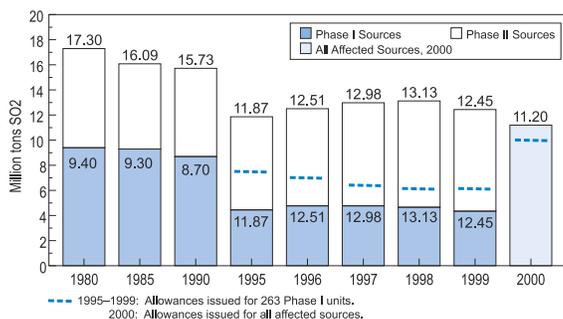
## Nature and Source of the Problem

Acidic deposition or "acid rain" occurs when emissions of sulfur dioxide (SO<sub>2</sub>) and oxides of nitrogen (NO<sub>x</sub>) in the atmosphere react with water, oxygen, and oxidants to form acidic compounds. These compounds fall to the Earth in either dry form (gas and particles) or wet form (rain, snow, and fog). Some are carried by the wind, sometimes hundreds of miles, across state and national borders. In the United States, about 64 percent of annual SO<sub>2</sub> emissions and 26 percent of NO<sub>x</sub> emissions are produced by electric utility plants that burn fossil fuels.

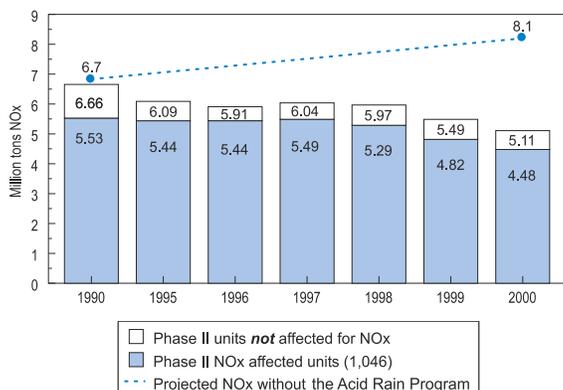
## Health and Environmental Effects

In the environment, acid deposition causes soils and water bodies to acidify (making the water unsuitable for some fish and other wildlife), and damages some trees, particularly at high elevations. It also speeds the decay of buildings, statues, and sculptures that are part of our national heritage. The nitrogen portion of acid deposition contributes to eutrophication in coastal ecosystems, the symptoms of which include algal blooms (some of which may be toxic), fish kills, and loss of plant and animal diversity. Finally, acidification of lakes and streams appears to increase the rate that bacteria living at the bottom of rivers and lakes can convert elemental mercury and mercury salts to highly toxic methyl mercury. The availability of methyl mercury may increase human exposure to mercury from eating contaminated fish. Reductions in SO<sub>2</sub> and NO<sub>x</sub> have begun to reduce some of these negative environmental effects and are leading to significant improvements in public health (described previously).

## SO<sub>2</sub> Emissions Covered Under the Acid Rain Program



## NO<sub>x</sub> Emissions Covered Under the Acid Rain Program



## Program Structure

The goal of EPA's Acid Rain Program, established by the Clean Air Act, is to improve public health and the environment by reducing emissions of SO<sub>2</sub> and NO<sub>x</sub>. The program is being implemented in two phases: Phase I for SO<sub>2</sub> began in 1995 and targeted the largest and highest-emitting coal-fired power plants. Phase I for NO<sub>x</sub> began in 1996. Phase II for both pollutants began in 2000 and sets restrictions on Phase I plants as well as smaller coal-, gas-, and oil-fired plants.

The Acid Rain Program will reduce annual SO<sub>2</sub> emissions by 10 million tons from 1980 levels by 2010. The program sets a permanent cap of 8.95 million tons on the total amount of SO<sub>2</sub> that may be emitted by power plants nationwide, about half of the amount emitted in 1980. It employs an emissions trading program to achieve that emissions cap more cost-effectively. Sources are allocated allowances each year (one allowance equals one ton of SO<sub>2</sub> emissions) which can be bought or sold or banked for future use. This approach gives sources the flexibility and incentive to reduce emissions at the lowest cost while ensuring that the emissions limit is met.

The NO<sub>x</sub> component of the Acid Rain Program limits the emission rate for all affected utilities, resulting in a 2 million ton NO<sub>x</sub> reduction from 1980 levels by 2000. There is no cap on total NO<sub>x</sub> emissions, but under this program a source can choose to overcontrol at units where it is technically easier to control emissions, average these emissions with those at their other units, and thereby achieve overall emissions reductions at lower cost.

### Emissions and Atmospheric Trends

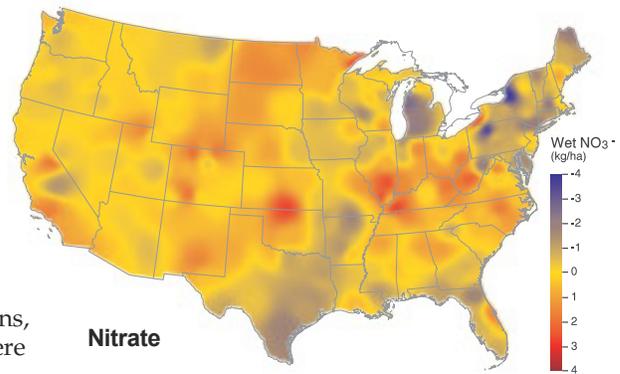
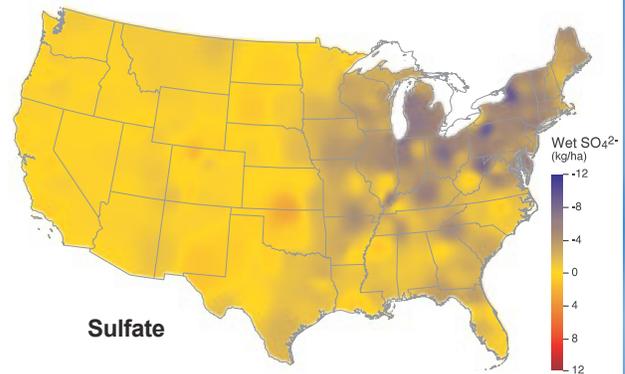
SO<sub>2</sub> emissions reductions have been significant in the first 6 years of compliance with EPA's Acid Rain Program. 2000 was the first year of compliance with Phase II of the Acid Rain Program. Over two thousand sources are now affected by the program. Sources in the Acid Rain Program emitted 11.2 million tons in 2000, down from 16 million tons in 1990. Emissions of SO<sub>2</sub> dropped 1 million tons between 1999 and 2000. Sources began drawing down the bank of unused allowances in 2000, resulting in emissions levels greater than the allowances allocated in 2000 but still lower than emissions during any year of Phase I.

Actual NO<sub>x</sub> emissions, as shown in the graph to the bottom left of page 16, have also declined since 1990. NO<sub>x</sub> emissions decreased steadily from 6 tons in 1997 to just over 5 tons in 2000. The more than 1000 sources affected by Phase II emitted 4.5 tons in 2000, over 1 million tons (almost 20 percent) less than they did in 1990. NO<sub>x</sub> emissions in 2000 were somewhat lower (7 percent) than in 1999 and almost half of what emissions are projected to have been in 2000 without the Acid Rain Program.

For all years from 1995 through 2000, both deposition and concentrations of sulfates in precipitation exhibited dramatic and unprecedented reductions over a large area of the eastern United States. Average sulfate deposition in 1996–2000 is 10 percent lower than in 1990–1994 nationwide, and 15 percent lower in the east. Similarly, sulfate air concentrations, which contribute to human health and visibility problems, were reduced significantly, especially in the east. There was a small decrease in nitrate deposition in some places but in others there were increases, causing an overall average increase in nitrate deposition between 1990–1994 and 1996–2000 of 3 percent.

These reductions in acid precipitation are directly related to the large regional decreases in SO<sub>2</sub> and NO<sub>x</sub> emissions resulting from the Acid Rain Program. The largest reductions in sulfate concentrations occurred along the Ohio River Valley and in states immediately downwind. The largest reductions in wet sulfate deposition occurred across the Mid-Appalachian and Northeast regions of the country. Reductions in the East in hydrogen ion concentrations, the primary indicator of precipitation acidity, were similar to those of sulfate concentrations, both in magnitude and location. The largest reductions in wet nitrate deposition were in the northeastern United States, Michigan, and Texas. The Midwest, the southeast, and California showed the highest increases in deposition even though emissions from acid rain sources have not increased substantially there. Acid rain sources account for only one-third of nationwide nitrogen emissions, so emissions trends in other source categories, especially agriculture and mobile sources, impact air concentrations and deposition.

### Sulfate Deposition in Precipitation



Source: USEPA analysis of National Atmospheric Deposition Program data.

### Deposition vs. Concentration

*Think of putting the same amount of salt into two different glasses of water (one full and one half-full). The total amount (deposition) is the same, but the solution in the half-full glass has a greater concentration.*

# Visibility

Shenandoah National Park under bad and good visibility conditions. The visual range in the top photo is 25 km (28 deciviews) while the visual range in the bottom photo is 180 km (8 deciviews).



A view across the Potomac River at the Lincoln Memorial and the Washington Monument, an urban setting, under bad and good visibility conditions. The visual range in the top photo is 8 km (38 deciviews) while the visual range in the bottom photo is > 150 km (10 deciviews).



## Nature and Sources of the Problem

Visibility impairment is one of the most obvious effects of air pollution and occurs at many of the best known and most treasured natural areas such as the Grand Canyon, Yosemite, Yellowstone, Mount Rainer, Shenandoah, and the Great Smokies as well as in urban areas. Visibility impairment occurs as a result of the scattering and absorption of light by air pollution, including particles and gases. In addition to limiting the distance that we can see, the scattering and absorption of light caused by air pollution can also degrade the color, clarity, and contrast of scenes. The same fine particles that are linked to serious health effects and premature death can also significantly affect our ability to see.

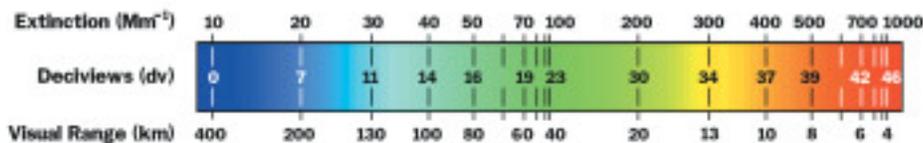
Both primary emissions and secondary formation of particles contribute to visibility impairment. "Primary" particles, such as dust from roads or elemental carbon (soot) from wood combustion, are emitted directly into the atmosphere. "Secondary" particles are formed in the atmosphere from primary gaseous emissions. Examples include sulfate, formed from sulfur dioxide (SO<sub>2</sub>) emissions from power plants and other industrial facilities; and nitrates, formed from nitrogen oxides (NO<sub>x</sub>) emissions from power plants, automobiles, and other types of combustion sources. In the eastern United States, reduced visibility is mainly attributable to secondarily-formed sulfates. While these secondarily-formed particles still account for a significant amount in the West, primary emissions from sources like wood smoke contribute a larger percentage of the total particle loading than in the East.

Humidity can significantly increase the effect of pollution on visibility. Some particles, such as sulfates, accumulate water and grow in size, becoming more efficient at scattering light and causing visibility impairment. Annual average relative humidity levels are 70–80 percent in the East as compared to 50–60 percent in the West. Poor summer visibility in the eastern United States is primarily the result of high sulfate concentrations combined with high humidity levels.

Visibility conditions are commonly expressed in terms of three mathematically related metrics: light extinction, deciviews, and visual range. The graphic at the bottom of the page shows the relationship among the three metrics.

## Program Structure

The Clean Air Act provides for the protection of visibility in national parks and wilderness areas, also known as Class I areas. There are



**Visibility Metrics** Comparisons of extinction (Mm<sup>-1</sup>), deciviews (dv), and visual range (km). Notice the difference in the three scales; 10 Mm<sup>-1</sup> corresponds to about 400 km visual range and 0.0 dv, while 1000 Mm<sup>-1</sup> is about 4 km visual range and 46 dv.

156 Class I areas across the United States. The Clean Air Act's national goal calls for remedying existing visibility impairment and preventing future impairment in these Class I areas.

In 1987, EPA, states, tribes, the National Park Service, the U.S. Forest Service, the Bureau of Land Management, and the U.S. Fish and Wildlife Service cooperatively established the Interagency Monitoring of Protected Visual Environments (IMPROVE) visibility network. In 2000 the IMPROVE network expanded from 30 to 110 sites to collect data and track progress at all federal Class I areas.

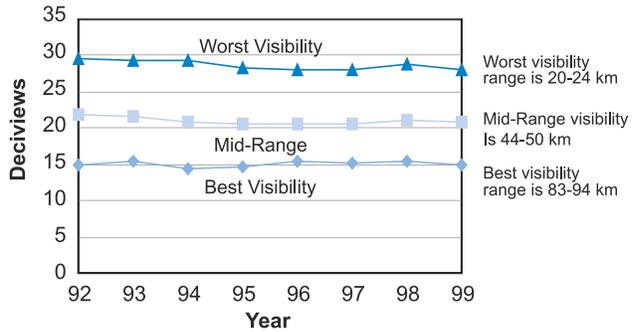
In April 1999, EPA initiated a new regional haze program. The program addresses visibility impairment in national parks and wilderness areas caused by numerous sources located over broad regions. Because fine particles are frequently transported hundreds of miles, pollution that occurs in one state may contribute to the visibility impairment in another state. For this reason, EPA is working with states and tribes to coordinate efforts through regional planning organizations, to develop regional strategies to improve visibility, and to reduce pollutants that contribute to fine particles and ground-level ozone.

Other air quality programs focussing on vehicles, fuels, woodstoves and other sources of pollution, are expected to lead to emission reductions that will improve visibility in certain regions of the country. For example, EPA's acid rain program is designed to achieve significant reductions in SO<sub>x</sub> emissions, which is expected to reduce sulfate haze, particularly in the eastern United States. Additional control programs on sources of NO<sub>x</sub> to reduce the formation of ground-level ozone can also improve regional visibility conditions.

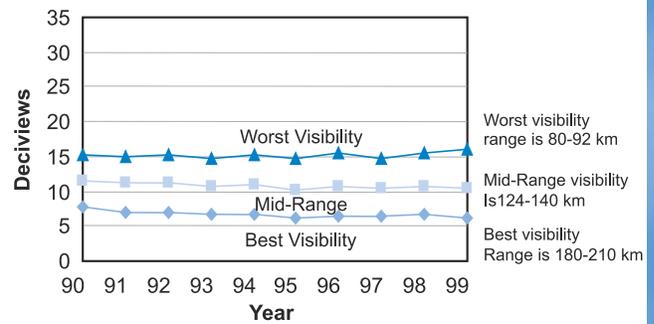
**Recent Trends**

Data collected by the IMPROVE network show visibility for the worst days in the West is similar to days with the best visibility days in the East. In the East, visibility on the worst days has improved by 1.5 deciviews, but visibility remains significantly impaired. In 1999, mean visual range in the East was only 24 km (14.4 miles) compared to 84 km (50.4 miles) for the best visibility days. Without man-made air pollution, visibility in the East would be about 75–150 km (45–90 miles). In the West, visibility impairment for the worst days remains relatively unchanged over the 1990s with the mean visual range for 1999 (80 km/48 miles) nearly the same as the 1990 level (86 km/52 miles). Natural visibility in the West is 200–300 km (120–180 miles).

**Visibility Trends For Eastern U.S. Class 1 Areas, 1992–1999**



**Visibility Trends For Western U.S. Class 1 Areas, 1990–1999**



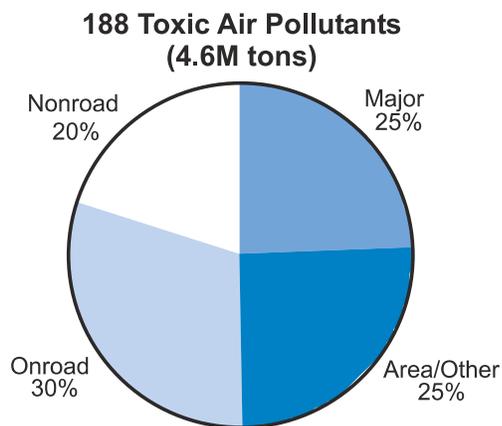
	East	West
Sulfates	60–86%	25–50%
Organic Carbon	10–18%	25–40%
Nitrates	7–16%	5–45%
Elemental Carbon (soot)	5–8%	5–15%
Crustal Material (soil dust)	5–15%	5–25%

*Pollutants that contribute to visibility impairment in the eastern and western parts of the United States. Sulfates are generally the largest contributor in both the East and the West.*

# Toxic Air Pollutants

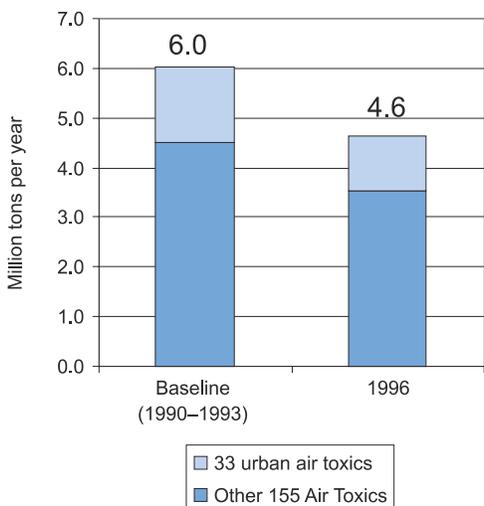


**1996 National Air Toxics Emissions**



*Note: These emissions are from outdoor sources. Also, mobile source emissions do not include diesel particulate matter.*

**National Air Toxics Emissions**  
(Total for 188 Toxic Air Pollutants)



## Nature and Sources

Toxic air pollutants, or air toxics, are those pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects. Air toxics may also cause adverse environmental and ecological effects. EPA is required to reduce air emissions of 188 air toxics listed in the Clean Air Act. Examples of toxic air pollutants include benzene, found in gasoline; perchloroethylene, emitted from some dry cleaning facilities; and methylene chloride, used as a solvent by a number of industries. Most air toxics originate from man-made sources, including mobile sources (e.g., cars, trucks, construction equipment) and stationary sources (e.g., factories, refineries, power plants), as well as indoor sources (e.g., some building materials and cleaning solvents). Some air toxics are also released from natural sources such as volcanic eruptions and forest fires.

## Health and Environmental Effects

People exposed to toxic air pollutants at sufficient concentrations may experience various health effects including cancer, and damage to the immune system, as well as neurological, reproductive (e.g., reduced fertility), developmental, respiratory and other health problems. In addition to exposure from breathing air toxics, risks also are associated with the deposition of toxic pollutants onto soils or surface waters, where they are taken up by plants and ingested by animals and eventually magnified up through the food chain. Like humans, animals may experience health problems due to air toxics exposure.

## Trends in Toxic Air Pollutants

EPA and states do not maintain a nationwide monitoring network for air toxics as they do for many of the other pollutants discussed in this report. Although such a network is under development, EPA has compiled a National Toxics Inventory (NTI) to estimate and track national emissions trends for the 188 toxic air pollutants regulated under the Clean Air Act. In the NTI, EPA divides emissions into four types of sectors: 1) major (large industrial) sources; 2) area and other sources, which include smaller industrial sources, like small dry cleaners and gasoline stations, as well as natural sources, like wildfires; 3) onroad mobile sources, including highway vehicles; and 4) nonroad mobile sources, like aircraft, locomotives, and construction equipment.

As shown in the pie chart, based on 1996 estimates, the most recent year of available data, the emissions of toxic air pollutants are relatively equally divided between the four types of sources. However, this distribution varies from city to city.

While EPA, states and tribes collect monitoring data for a number of toxic air pollutants, both the chemicals monitored and the geographic coverage of the monitors vary from state to state. Together with the emissions data from the NTI, the available monitoring data help air pollution control agencies track trends in toxic air pollutants in various locations around the country. EPA is working with states, tribes and local air monitoring agencies to build upon these monitoring sites to create a national monitoring network for a number of toxic air pollutants.

Based on the data in the NTI, estimates of nationwide air toxics emissions have dropped approximately 23 percent between baseline (1990-1993) and 1996. Although changes in how EPA compiled the national inventory over time may account for some differences, EPA and state regulations, as well as voluntary reductions by industry, have clearly achieved large reductions in overall air toxic emissions.

Trends for individual air toxics vary from pollutant to pollutant. For example, data taken from California's monitoring network for 39 urban sites show an average reduction of 60 percent in measured levels of perchloroethylene for the period 1990–1999. Perchloroethylene is a chemical widely used in the dry cleaning industry. Based on the NTL, EPA estimates that nationwide perchloroethylene emissions dropped 67 percent from 1990–1996. These reductions reflect state and federal efforts to regulate emissions of this pollutant, and industry efforts to move to other processes using less toxic chemicals.

Benzene is another widely monitored toxic air pollutant. It is emitted from cars, trucks, oil refineries, and chemical processes. The graph at the lower right shows measurements of benzene taken from 87 urban monitoring sites around the country. These urban areas generally have higher levels of benzene than other areas of the country. Measurements taken at these sites show, on average, a 40-percent drop in benzene levels from 1994–1999. During this period, EPA phased in new (so-called "tier 1") car emission standards; required many cities to begin using cleaner burning gasoline; and set standards that required significant reductions in benzene and other pollutants emitted from oil refineries and chemical processes. EPA estimates that nationwide benzene emissions from all sources dropped 25 percent from 1990–1996.

### Programs to Reduce Air Toxics

Since 1990, EPA's technology-based emission standards for industrial sources (e.g., chemical plants, oil refineries and dry cleaners) have proven extremely successful in reducing emissions of air toxics. Once fully implemented, these standards will cut emissions of toxic air pollutants by nearly 1.5 million tons per year from 1990 levels. EPA has also put into place important controls for motor vehicles and their fuels and is continuing to take additional steps to reduce air toxics from vehicles. This includes stringent standards for heavy-duty trucks and buses and diesel fuel that will lead to a reduction in emissions of diesel particulate matter by over 90 percent between 1996 and 2020.

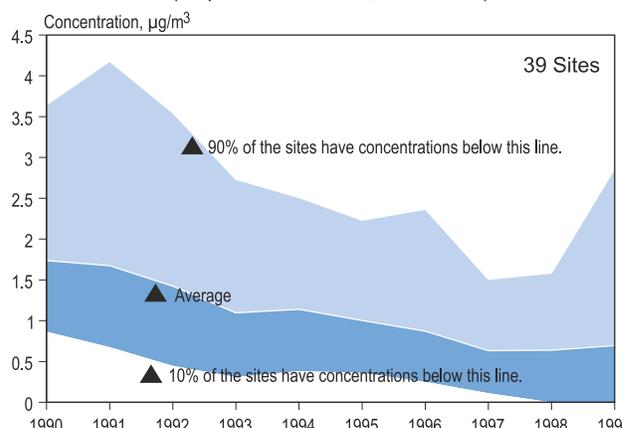
EPA has begun to look at the risk remaining (i.e., the residual risk) after emission reductions for industrial sources take effect and is also investigating new standards for nonroad engines such as construction equipment. In addition, by 2004, EPA plans to regulate air toxic emissions, including mercury from power plants.

In addition to national regulatory efforts, EPA's program includes work with communities on comprehensive local assessments, as well as federal and regional activities associated with protecting water bodies from air toxics deposition (e.g., the Great Waters program which includes the Great Lakes, Lake Champlain, Chesapeake Bay, and many coastal estuaries) and Agency initiatives concerning mercury and other persistent and bioaccumulative toxics. For indoor air toxics, EPA's program has relied on education and outreach to achieve reductions. Information about indoor air activities is available at: [www.epa.gov/iaq/pubs/index.html](http://www.epa.gov/iaq/pubs/index.html).

In late 2001, EPA will release the first in a series of national-scale assessments of the risks associated with 32 toxic air pollutants and diesel PM. Details about this effort conducted under the National Air Toxics Assessment (NATA) program are available at <http://www.epa.gov/ttn/atw/nata>. EPA, states, and others are continuing to gather data to improve knowledge about the risks from air toxics both nationally and locally.

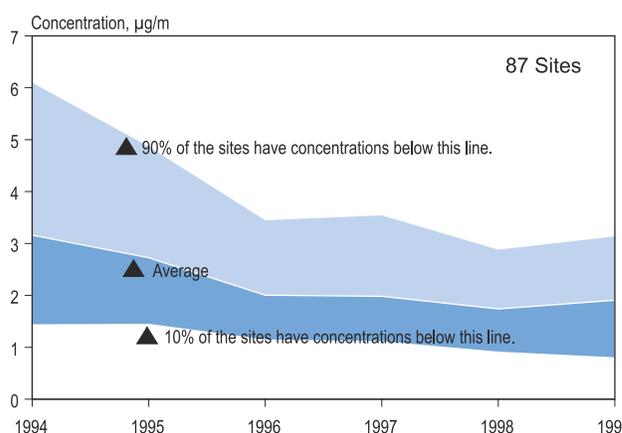
### Ambient Perchloroethylene Annual Average Urban Concentrations in California

(60-percent reduction, 1990–1999)



### Ambient Benzene Annual Average Urban Concentrations, Nationwide

(40-percent reduction, 1994–1999)



For more information about EPA's air toxics program, visit the Agency's website at <http://www.epa.gov/ttn/atw>.

# Stratospheric Ozone

## Nature and Sources of the Problem

The stratosphere, located about 6 to 30 miles above the Earth, contains a layer of ozone gas that protects living organisms from harmful ultraviolet radiation (UV-b) from the sun. Over the past two decades, however, this protective shield has been damaged. Each year, an “ozone hole” forms over the Antarctic, and ozone levels can fall to 60 percent below normal. Even over the United States, ozone levels are about 5 percent below normal in the summer and 10 percent below normal in the winter.

As the ozone layer thins, more UV-b radiation reaches the Earth. In 1996, scientists demonstrated for the first time that UV-b levels over most populated areas have increased. In the 1970s, scientists had linked several substances associated with human activities to ozone depletion, including the use of chlorofluorocarbons (CFCs), halons, carbon tetrachloride, methyl bromide, and methyl chloroform. These chemicals are emitted from commercial air conditioners, refrigerators, insulating foam, and some industrial processes. Strong winds carry them through the lower part of the atmosphere, called the tropo-

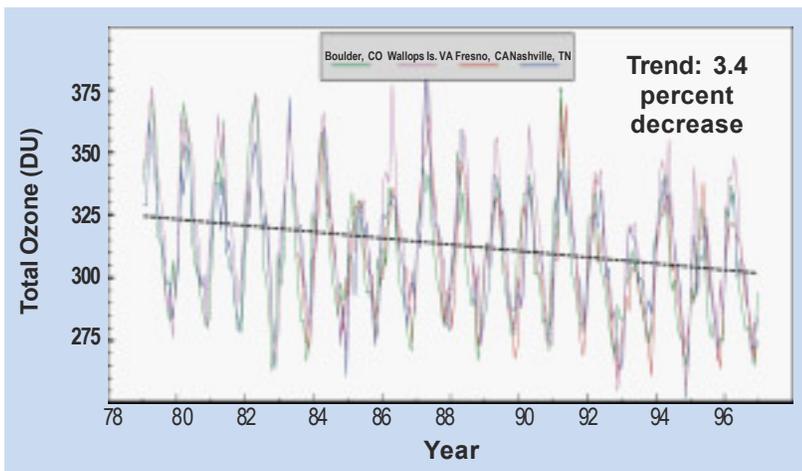
sphere, and into the stratosphere. There, strong solar radiation releases chlorine and bromine atoms that attack protective ozone molecules. Scientists estimate that one chlorine atom can destroy 100,000 ozone molecules.

## Health and Environmental Effects

Some UV-b radiation reaches the Earth’s surface even with normal ozone levels. However, because the ozone layer normally absorbs most UV-b radiation from the sun, ozone depletion is expected to lead to increases in harmful effects associated with UV-b radiation. In humans, UV-b radiation is linked to skin cancer, including melanoma,

the form of skin cancer with the highest fatality rate. It also causes cataracts and suppression of the immune system.

The effects of UV-b radiation on plant and aquatic ecosystems are not well understood. However, the growth of certain food plants can be slowed by excessive UV-b radiation. In addition, some scientists suggest that marine phytoplankton, which are the base of the ocean food chain, are already under stress from UV-b radiation. This stress could have adverse consequences for human food supplies from the oceans. Because they absorb CO<sub>2</sub> from the atmosphere, significant harm to phytoplankton populations could increase global warming (see following section on Global Warming and Climate Change).



Source: National Oceanic and Atmospheric Administration, 1998.

*Monthly average total ozone measured in Dobson Units (DU) at four mid-latitude stations across the United States from 1979 to 1997. The trend line shows a 3.4 percent decrease in average total ozone over mid-latitudes in the United States since 1979. The large annual variation shown in each of the four cities is a result of ozone transport processes which cause increased levels in the winter and spring and lower ozone levels in the summer and fall at these latitudes.*

## Programs to Restore the Stratospheric Ozone Layer

In 1987, 27 countries signed the Montreal Protocol, a treaty that recognized the international nature of ozone depletion and committed the world to limiting the production of ozone-depleting substances. Today, more than 175 nations have signed the Protocol, which has been strengthened five times and now calls for the elimination of those chemicals that deplete stratospheric ozone.

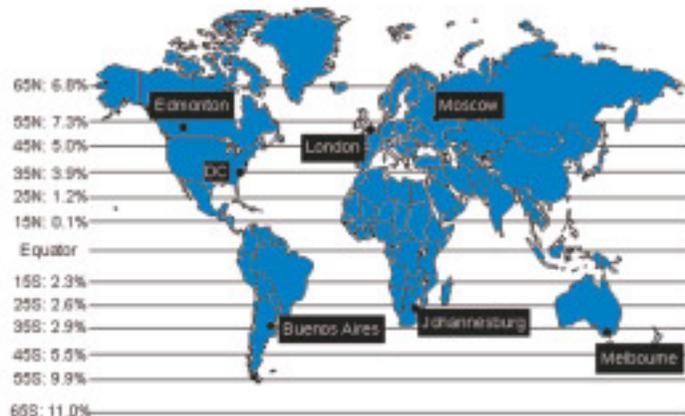
The 1990 Clean Air Act Amendments established a U.S. regulatory program to protect the stratospheric ozone layer. In January 1996, U.S. production of many ozone-depleting substances virtually ended, including CFCs, carbon tetrachloride, and methyl chloroform. Production of halons ended in January 1994. Many new products that either do not affect or are less damaging to the ozone layer are now gaining popularity. For example, computer-makers are using ozone-safe solvents to clean circuit boards, and automobile manufacturers are using HFC-134a, an ozone-safe refrigerant, in new motor vehicle air conditioners. In some industries, the transition away from ozone-depleting substances has already been completed. EPA is also emphasizing new efforts like the UV Index, a daily forecast of the strength of UV radiation people may be exposed to outdoors, to educate the public about the health risks of overexposure to UV radiation and the steps they can take to reduce those risks.

### Trends in Stratospheric Ozone Depletion

Scientific evidence shows that the approach taken under the Montreal Protocol has been effective to date. In 1996, measurements showed that the concentrations of methyl chloroform had started to fall, indicating that emissions had been greatly reduced. Concentrations of other ozone-depleting substances in the upper layers of the atmosphere, like CFCs, are also beginning to decrease. It takes several years for these substances to reach the stratosphere and release chlorine and bromine. For this reason, stratospheric chlorine levels are currently peaking and are expected to slowly decline in the years to come. Because of the stability of most ozone-depleting substances, chlorine will be released into the stratosphere for many years, and the ozone layer will not fully recover until around 2050. All nations that signed the Protocol must complete implementation of ozone protection programs if full repair of the ozone layer is to happen.

In 1996, scientists developed a new technique allowing them to draw conclusions about UV-b radiation at ground level. According to satellite-based trend analyses, major populated areas have experienced increasing UV-b levels over the past 15 years. As shown by the figure above, at latitudes that cover the United States, UV-b levels are 4–5 percent higher than they were in 1986.

UV-b Radiation Increases by Latitude



*A 1996 study using satellite-base analyses of UV-b trends demonstrated that UV-b level had increased at ground level. This figure shows the percent increases in average annual UV-b reaching the surface from 1986–1996. UV-b incidence is strongly dependent on latitude. At latitudes that cover the United States, UV-b levels are 4–5 percent higher than they were in 1986.*

# Global Warming & Climate Change

## Nature and Sources

The Earth's climate is fueled by the Sun. Most of the Sun's energy, called solar radiation, is absorbed by the Earth, but some is reflected back into space. Clouds and a natural layer of atmospheric gases absorb a portion of Earth's heat and prevent it from escaping to space. This keeps our planet warm enough for life and is known as the natural "greenhouse effect," as illustrated in the diagram below. Without the natural greenhouse effect, the Earth's average temperature would be much colder, and the planet would be uninhabitable.

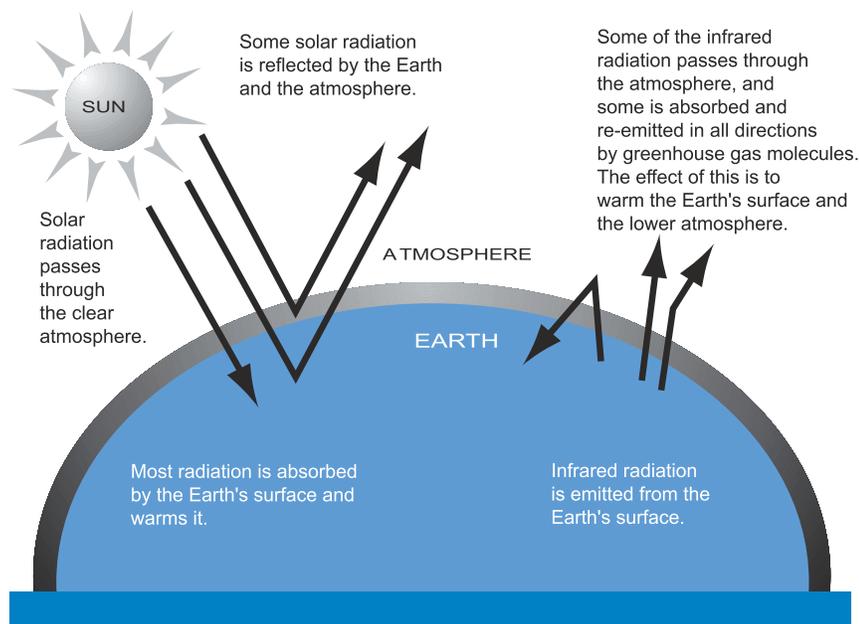
Recent scientific evidence shows that the greenhouse effect is being increased by release of certain gases to the atmosphere that cause the Earth's temperature to rise. This is called "global warming." Carbon dioxide, methane, particulate matter (especially black carbon or soot), nitrous oxide, fluorinated compounds, and ozone, are some of the compounds contributing to global warming. Carbon dioxide accounts for about 81 percent of greenhouse gases released in the United States. Carbon dioxide emissions are largely due to the combustion of fossil fuels in electric power generation, motor vehicles, and industries. Methane emissions, which result from agricultural activities, landfills, and other sources, are the next largest contributors to greenhouse gas emissions in the United States and worldwide.

Industrial processes such as foam production, refrigeration, dry cleaning, chemical manufacturing, and semiconductor manufacturing produce other greenhouse gas emissions, such as hydrofluorocarbons. Smelting of aluminum produces another greenhouse gas called perfluorinated compounds. Emissions of  $\text{NO}_x$  and VOCs from automobile exhaust and industrial processes contribute to the formation of ground-level ozone or smog, also a greenhouse gas.

Health and Environmental Effects

In 1988, the Intergovernmental Panel on Climate Change (IPCC) was formed to assess the available scientific and economic information on climate change. IPCC recently published its Third Assessment Report representing the work of more than 2,000 of the world's leading scientists. The IPCC concluded that humans are changing the Earth's climate, and that "there is new and stronger evidence that

## The Greenhouse Effect



*The greenhouse effect is being accelerated by releases of certain gases to the atmosphere that are causing the Earth's temperature to rise.*

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most of the warming observed over the last 50 years is attributable to human activities.”

According to the IPCC, continued emissions of greenhouse gases could cause a 2.5° to 10° Fahrenheit rise in temperature during the next century. Although this change may appear small, it would be an unprecedented temperature change relative to the past 10,000 years. This could lead to more extreme weather events such as droughts and floods, threaten coastal resources and wetlands by raising sea level, and increase the risk of certain diseases by producing new breeding sites for pests and pathogens. Agricultural regions and woodlands are also susceptible to changes in climate that could result in increased insect populations and plant disease. This degradation of natural ecosystems could lead to reduced biological diversity.

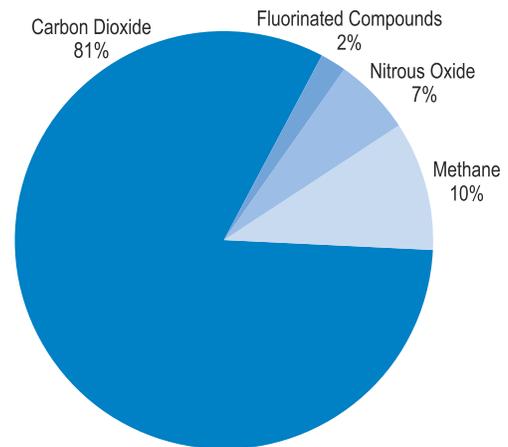
### International Developments

In 1992, over 150 countries signed the Framework Convention on Climate Change (FCCC), which has the objective of stabilizing the concentration of greenhouse gases in the atmosphere at levels that would prevent dangerous interference with the climate system. Under the FCCC, industrialized countries agreed to aim to reduce greenhouse gas emissions to 1990 levels by the year 2000. Most industrialized countries, including the United States, have not been able to meet this target. In light of this, the United States and the rest of the international community continue to work towards ways of achieving the FCCC's ultimate objective.

### U.S. Programs to Mitigate Climate Change

The United States implemented a Climate Change Action Plan in 1993 to reduce greenhouse gas emissions and help achieve the goals of the FCCC. Thousands of companies and other organizations are working in partnership with the Federal government to effectively reduce their emissions. The Plan involves more than 40 programs implemented by EPA, the Department of Energy, the Department of Agriculture, and other government agencies. In 2000 alone, EPA's voluntary climate protection programs reduced greenhouse gas emissions by 58.5 million metric tons of carbon equivalent (MMTCE), the same as eliminating the greenhouse gas emissions from about 40 million cars. By investing in products that use energy more efficiently, consumers and businesses have also reduced energy consumption by an estimated 75 billion kilowatt hours and netted savings of more than \$5 billion on their 2000 energy bills while achieving these environmental benefits.

**1998 Greenhouse Gas Emissions  
in the United States**



*1998 total greenhouse gas emissions rose 11 percent from 1990 baseline levels. The major contributor to these emissions is carbon dioxide from fossil fuel combustion. Other contributors include methane gas from landfills, fermentation, natural gas systems, and coal mining; nitrous oxide from agricultural management and mobile sources, and fluorinated compounds from such processes as aluminum and magnesium production and electrical transmission and distribution systems.*

# Conclusion

The Clean Air Act has resulted in many improvements in the quality of the air in the United States. Scientific and international developments continue to have an effect on the air pollution programs that are implemented by the U.S. Environmental Protection Agency and state, local, and tribal agencies. New data help identify sources of pollutants and the properties of these pollutants. Although much progress has been made to clean up our air,

work must continue to ensure steady improvements in air quality, especially because our lifestyles create more pollution sources. Many of the strategies for air quality improvement will continue to be developed through coordinated efforts with EPA, state, local and tribal governments, as well as industry and other environmental organizations.

## For Further Information

Detailed information on Air Pollution Trends:  
<http://www.epa.gov/airtrends>

Real-Time Air Quality Maps and Forecasts:  
<http://www.epa.gov/airnow>

On-line Air Quality Data:  
<http://www.epa.gov/air/data/index.html>

Office of Air and Radiation:  
<http://www.epa.gov/oar>

Office of Air Toxics:  
<http://www.epa.gov/ttn/atw>

Office of Air Quality Planning and Standards:  
<http://www.epa.gov/oar/oaqps>

Office of Transportation and Air Quality:  
<http://www.epa.gov/otaq>

Office of Atmospheric Programs:  
<http://www.epa.gov/air/oap.html>

Office of Radiation and Indoor Air:  
<http://www.epa.gov/air/oria.html>

Global Warming Emissions Information:  
<http://www.epa.gov/globalwarming/emissions/national/index.html>

Acid Rain Website: <http://www.epa.gov/airmarkets/>

Acid Rain Hotline: (202) 564-9620

Energy Star (Climate Change) Hotline:  
(888) STAR-YES

Mobile Sources National Vehicles and Fuel Emissions Lab: (734) 214-4200

Stratospheric Ozone Hotline: (800) 296-1996

## Acronyms

CO	Carbon Monoxide
Pb	Lead
NO <sub>2</sub> , NO <sub>x</sub>	Nitrogen Dioxide, Nitrogen Oxides
O <sub>3</sub>	Ozone
PM <sub>10</sub>	Particulate Matter (10 micrometers in diameter or less)
PM <sub>2.5</sub>	Particulate Matter (2.5 micrometers in diameter or less)
SO <sub>2</sub> , SO <sub>x</sub>	Sulfur Dioxide, Sulfur Oxides

## Other Pollutants

CFCs	Chlorofluorocarbons
CH <sub>4</sub>	Methane
CO <sub>2</sub>	Carbon Dioxide
HFCs	Hydrofluorocarbons
N <sub>2</sub> O	Nitrous Oxide
PCBs	Polychlorinated Biphenyls
PFCs	Perfluorinated Carbons
VOCs	Volatile Organic Compounds

## Other Acronyms

CCAP	Climate Change Action Plan
DU	Dobson Unit(s)
EPA	Environmental Protection Agency
FCCC	Framework Convention on Climate Change
IPCC	Intergovernmental Panel on Climate Change
NAAQS	National Ambient Air Quality Standards
NTI	National Toxics Inventory