United States
Environmental Protection
Agency

# Latest Findings on National Air Quality

2001 STATUS AND TRENDS

Cover Photo of Mount McKinley, Denali National Park, Alaska, by Kim Ferguson, Waynesville, North Carolina

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# Latest Findings on National Air Quality

## 2001 STATUS AND TRENDS

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More detailed information on air pollution trends is available at **www.epa.gov/airtrends**.

Information on global warming and global climate change is available at **www.epa.gov/globalwarming/publications/emissions** and **www.epa.gov/globalwarming/publications/car**.

# National Air Quality

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

EPA tracks air pollution in two ways:

- Air quality measured from over 3,000 locations (over 5,200 monitors) across the nation operated primarily by state, local, and tribal agencies.
- Emissions from all sources going back 30 years.

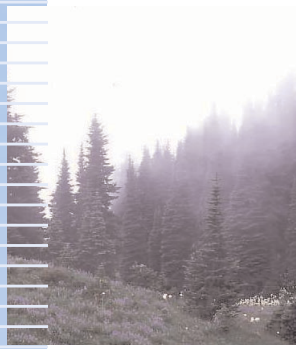
## Highlights

- Since 1970, aggregate emissions of the six principal pollutants tracked nationally have been cut 25 percent. During that same time period, U.S. gross domestic product increased 161 percent, energy consumption increased 42 percent, and vehicle miles traveled increased 149 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, almost 170 million tons of pollution are emitted into the air each year in the United States, and approximately 133 million people live in counties where monitored air in 2001 was unhealthy at times because of high levels of at least one of the six principal air pollutants.
- The vast majority of areas that experienced unhealthy air did so because of one or both of two pollutants—ozone and particulate matter (PM). EPA is focusing its efforts to control these pollutants by implementing more stringent National Ambient Air Quality Standards for ozone and PM and rules reducing emissions from on-road transportation and stationary combustion sources. These rules will bring reductions in emissions over the next few years. Additional reductions will be needed to provide clean air in the future. EPA has submitted to Congress Clear Skies legislation that, if enacted, would mandate reductions of particle- and ozone- forming compounds from power generators by 70 percent from current levels through a nationwide cap and trade program. EPA also expects to propose nonroad vehicle regulations that would help improve ozone and PM air quality.
- EPA, states, and tribes have only recently begun to measure fine particles (known as $PM_{2.5}$) in the air on a broad national basis. In many locations, EPA now has 3 years of air quality monitoring data to use in comparing to the health-based standards for $PM_{2.5}$. Based on those data, areas across the Southeast, Mid-Atlantic, and Midwest regions and California have air quality that is unhealthy due to fine particles. High PM concentrations in the eastern United States are due to regional emissions from power plants and motor vehicles in combination with local emissions from transportation and other sources. In California, high PM concentrations tend to be due to mobile source emissions.
- Of the six tracked pollutants, progress has been slowest for ground-level ozone. The Northeast and West exhibited the greatest improvement, while the South and North Central regions experienced slower progress in lowering ozone concentrations. Despite this progress in most regions of the country, the average ozone (8-hour) levels in 33 of our national parks have increased over the past 10 years.
- Ground-level ozone is not emitted directly into the air but is formed in the atmosphere by the reaction of volatile organic compounds (VOCs) and nitrogen oxides ($NO_x$) in the presence of heat and sunlight. Although emissions of VOCs have decreased 16 percent over the past 20 years, the lack of significant reductions in regional-scale emissions of $NO_x$, a family of chemicals that can contribute to the formation of ozone hundreds of miles downwind, has slowed progress in reducing ozone levels. Between 1982 and 2001, $NO_x$ emissions in the United States increased

**Six Principal Air Pollutants Tracked Nationally**

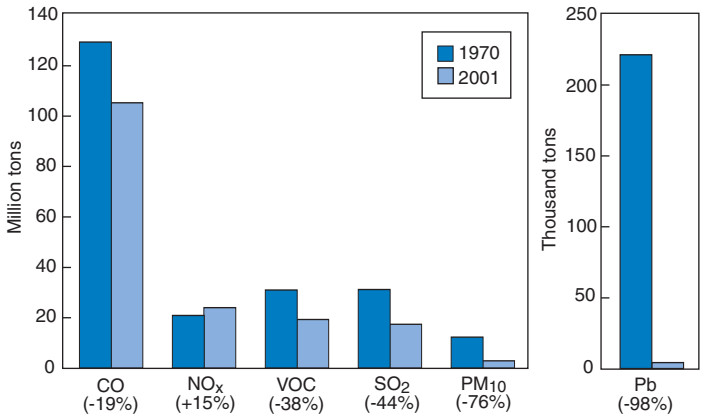
- Nitrogen Dioxide ($NO_2$)
- Ozone ($O_3$) - formed by volatile organic compounds (VOCs) and nitrogen oxides ($NO_x$)
- Sulfur Dioxide ($SO_2$)
- Particulate Matter (PM) - formed by $SO_2$, $NO_x$, ammonia, VOCs, and direct particle emissions
- Carbon Monoxide (CO)
- Lead (Pb)

9 percent (with a 3 percent decrease in the past 10 years). The majority of this increase is attributed to growth in emissions from nonroad engines (like construction and recreation equipment) and diesel vehicles. Emissions of $NO_x$ also contribute to acid rain, haze, particulate matter, and damage to waterbodies like the Chesapeake Bay.



- Sulfates formed primarily from sulfur dioxide ($SO_2$) emissions from coal-fired power plants are a major component of fine particles in the eastern United States. $SO_2$ emissions decreased 25 percent from 1981 to 2001 and 24 percent from 1992 to 2001. Nationally, average $SO_2$ ambient concentrations have been cut 52 percent from 1982 to 2001 and 35 percent over the more recent 10-year period from 1992 to 2001. Reductions in $SO_2$ concentrations and emissions since 1990 are primarily due to controls implemented under EPA's Acid Rain Program.
- Based on EPA's recent National-Scale Air Toxics Assessment for 1996, 3 of 32 urban air toxics (chromium, a metallic compound used in industrial processes such as plating; benzene, primarily emitted by mobile sources such as cars and trucks; and formaldehyde, emitted by mobile sources and formed when other compounds chemically react in sunlight) appear to pose the greatest nationwide cancer risk. One air toxic, acrolein — a by product of combustion in mobile and industrial sources — is estimated to pose the highest potential on a nationwide basis for significant chronic adverse effects other than cancer.
- Scientific evidence shows that the Montreal Protocol has been effective in reducing stratospheric ozone depletion. Measurements have shown that atmospheric concentrations of methyl chloroform are falling, indicating that emissions have been greatly reduced. Concentrations of other ozone-depleting substances in the upper layers of the atmosphere, like chlorofluorocarbons (CFCs), are also beginning to decrease.

**Comparison of 1970 and 2001 Emissions**




## Air Pollution

*The Concern*

The average person breathes 3,400 gallons of air each day. 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. 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 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 $NO_x$ are one of the largest sources of nitrogen pollution in certain water-bodies such as the Chesapeake Bay.

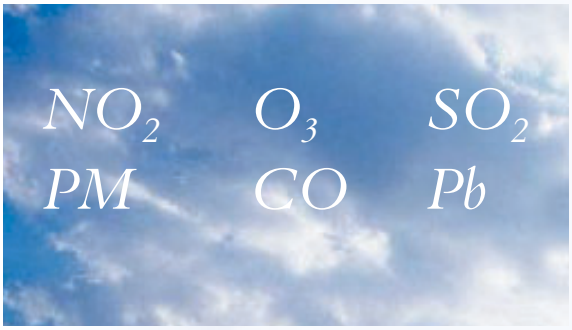
*The Causes*

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 windblown dust and wildfires.

# 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 people with asthma, 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): nitrogen dioxide ($NO_2$), ozone ($O_3$), sulfur dioxide ($SO_2$), particulate matter (PM), carbon monoxide (CO), and lead (Pb). Four of these pollutants (CO, Pb, $NO_2$, and $SO_2$) result primarily from direct emissions from a variety of sources. PM results from direct emissions, but is also commonly formed when emissions of nitrogen oxides ($NO_x$), sulfur oxides ($SO_x$), ammonia, organic compounds, and other gases react in the atmosphere. Ozone is not directly emitted but is formed when $NO_x$ and volatile organic compounds (VOCs) react in the presence of sunlight.




| | Percent Change in Air Quality 1982-2001 | 1992-2001 |
|---|---|---|
| $NO_2$ | -24 | -11 |
| $O_3$ 1-h | -18 | -3 |
| 8-h | -11 | 0 |
| $SO_2$ | -52 | -35 |
| $PM_{10}$ | — | -14 |
| $PM_{2.5}$ | Trend data not available | |
| CO | -62 | -38 |
| Pb | -94 | -25 |

| | Percent Change in Emissions 1982-2001 | 1992-2001 |
|---|---|---|
| $NO_x$ | +9 | -3 |
| VOC | -16 | -8 |
| $SO_2$ | -25 | -24 |
| $PM_{10}$* | -51 | -13 |
| $PM_{2.5}$* | — | -10 |
| CO | 0 | +6 |
| Pb | -93 | -5 |

*Includes only directly emitted particles.

*Negative numbers indicate improvements in air quality or reductions in emissions. Positive numbers show where emissions have increased.*

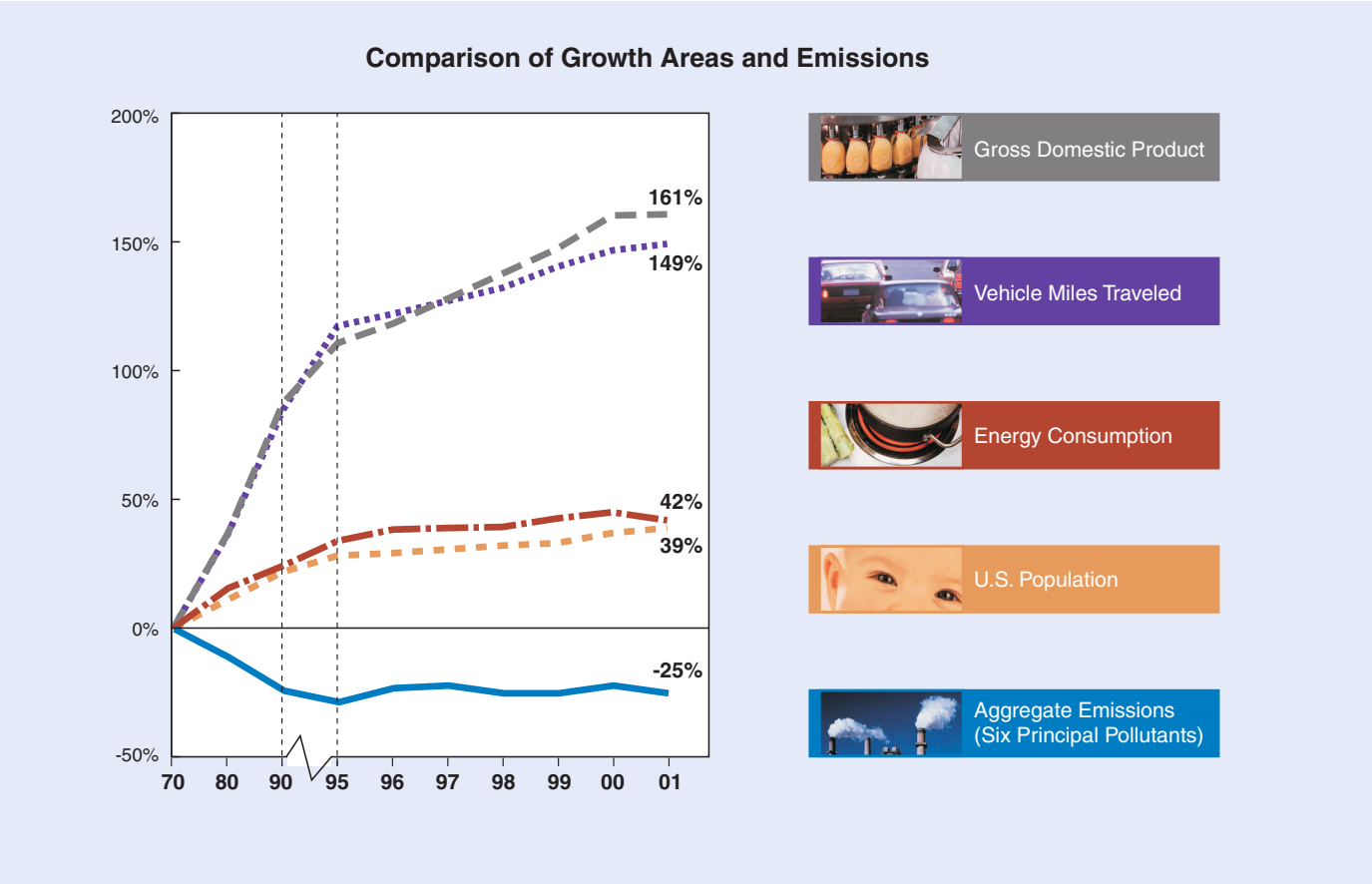
*Air quality concentrations do not always track nationwide emissions. There are several reasons for this. First, most monitors are located in urban areas so air quality is most likely to track changes in urban air emissions rather than in total emissions. Second, not all of the principal pollutants are 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 contribute to the formation and buildup of pollutants in the ambient air. For example, peak ozone concentrations typically occur during hot, dry stagnant summertime conditions.*

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

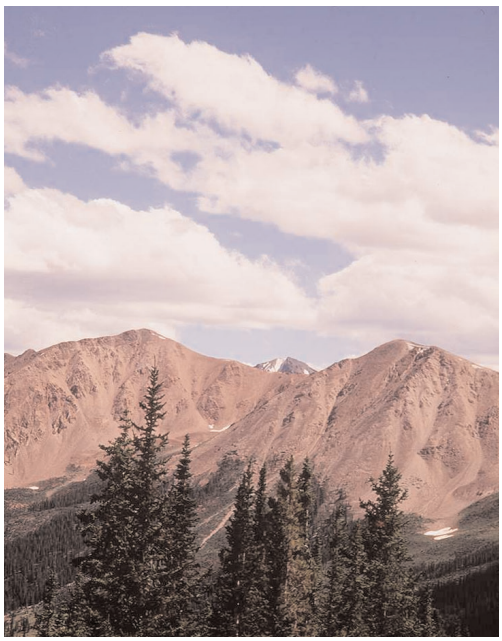
EPA tracks trends in **air quality** based on actual measurements of pollutant concentrations in the ambient (outside) air at monitoring sites across the country. Monitoring stations are operated by state, tribal, and local government agencies as well as some federal agencies, including EPA. Trends are derived by averaging direct measurements from these monitoring stations on a yearly basis. The tables to the left show that the air quality based on concentrations of the principal pollutants has improved nationally over the past 20 years (1982–2001).

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.




*Between 1970 and 2001, gross domestic product increased 161 percent, vehicle miles traveled increased 149 percent, energy consumption increased 42 percent, and U.S. population increased 39 percent. At the same time, total emissions of the six principal air pollutants decreased 25 percent.*

Emission estimates also reflect changes in air pollution regulations and installation of emission controls. The 2001 emissions reported in this summary are projected numbers based on available 2000 information and historical trends. Emission estimation methods continue to evolve and improve over time. Methods have changed for many significant categories beginning with the years 1985, 1990, and 1996, and, consequently, the estimates are not consistently developed across all years in this trend period. Because emissions estimation methods for many significant categories have changed over time, comparisons of the estimates for a given year in this report to the same year in a previous report may not be appropriate. Check **www.epa.gov/ttn/chief** for updated emissions information.

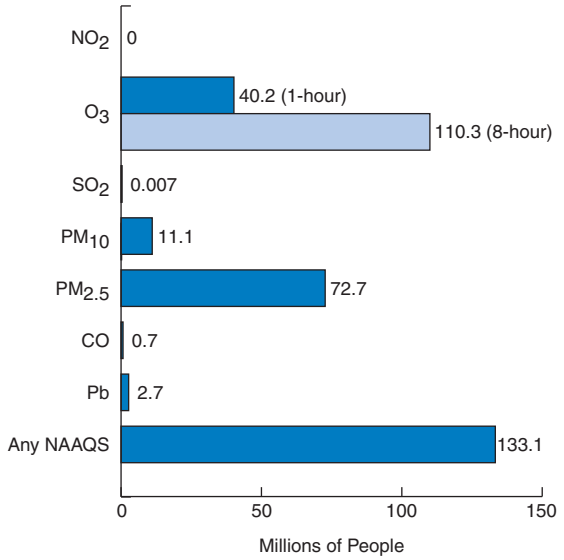


Emissions of all principal pollutants except $NO_x$ have decreased or remained essentially unchanged over the past 20 years (1982–2001), while all air quality measures for the six principal pollutants have gone down. Although $NO_x$ emissions have increased, air quality measurements for $NO_2$ across the country are below the national air quality standards. $NO_x$ plays an important role in a number of air pollution issues. These compounds contribute to the formation of ozone and particles as well as the deposition of acids and nutrients and visibility impairment.

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 133 million people nationwide still lived in counties with pollution levels above the National Ambient Air Quality Standards (NAAQS) in 2001. This annual "snapshot" view of the nation's air quality can be used to show levels that people might currently be experiencing across the county. There are still 130 nonattainment areas out of the 230 originally resulting from the 1990 Clean Air Act Amendments designation process.

**Number of People Living in Counties with Air Quality Concentrations above the Level of the NAAQS in 2001**




*Multiple years of data are generally used to determine if an area attains the NAAQS.*

## The Clean Air Act

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

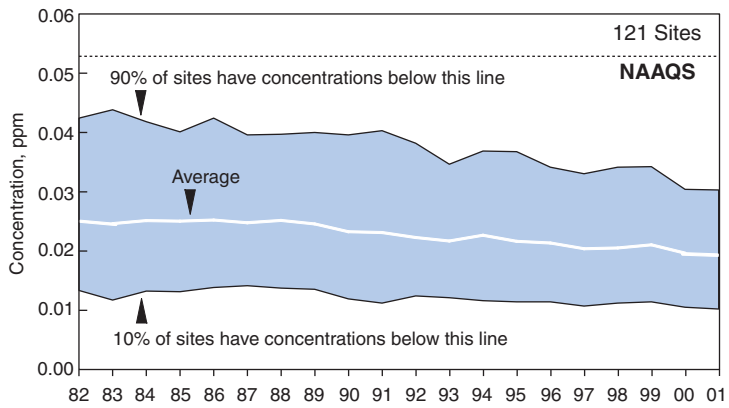
- Setting NAAQS for the six principal pollutants that are considered harmful to public health and the environment.
- Ensuring that these air quality standards are met (in cooperation with the state, tribal, and local governments) through national standards and strategies to control air pollutant emissions from vehicles, factories, and other sources.
- Reducing emissions of $SO_2$ and $NO_x$ that cause acid rain.
- Reducing air pollutants such as PM, $SO_x$, and $NO_x$ 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 may cause cancer and other adverse human health and environmental effects are well controlled and that the 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.

# NITROGEN DIOXIDE ($NO_2$)

## Nature and Sources of the Pollutant

Nitrogen dioxide is a reddish brown, highly reactive gas that is formed in the ambient air through the oxidation of nitric oxide (NO). Nitrogen oxides ($NO_x$), the term used to describe the sum of NO, $NO_2$, and other oxides of nitrogen, play a major role in the formation of ozone, particulate matter, haze, and acid rain. While EPA tracks national emissions of $NO_x$, the national monitoring network measures ambient concentrations of $NO_2$ for comparison to national air quality standards. The major sources of man-made $NO_x$ emissions are high-temperature combustion processes, such as those that occur in automobiles and power plants. Home heaters and gas stoves can also produce substantial amounts of $NO_2$ in indoor settings.

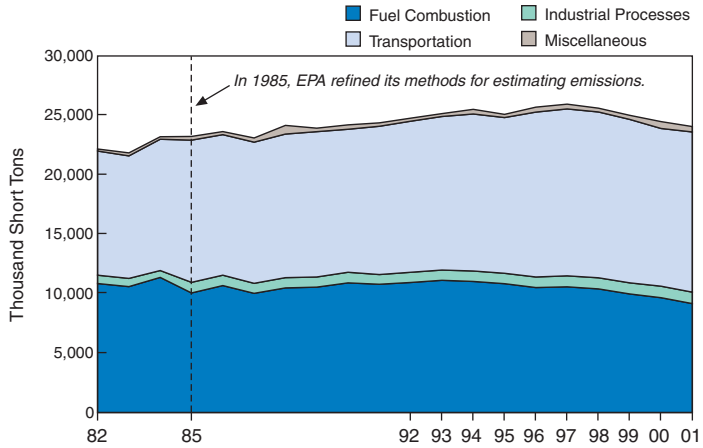
**$NO_2$ Air Quality, 1982–2001**
Based on Annual Arithmetic Average




**1982–01: 24% decrease**
**1992–01: 11% decrease**

*Air quality concentrations do not always track nationwide emissions. For a detailed explanation, see page 3.*

**$NO_x$ Emissions, 1982–2001**




**1982–01: 9% increase**
**1992–01: 3% decrease**

## Health and Environmental Effects

Short-term exposures (e.g., less than 3 hours) to low levels of $NO_2$ may lead to changes in airway responsiveness and lung function in individuals with preexisting respiratory illnesses and increases in respiratory illnesses in children. Long-term exposures to $NO_2$ may lead to increased susceptibility to respiratory infection and may cause irreversible alterations in lung structure. $NO_x$ reacts in the air to form ground-level ozone and fine particle pollution, which are both associated with adverse health effects.

$NO_x$ contributes to a wide range of environmental effects directly and/or when combined with other precursors in acid rain and ozone (see environmental discussion under Ozone and Acid Rain). Nitrogen inputs to terrestrial and wetland systems can alter existing competitive relationships among plant species, leading to changes in community composition and diversity. Similarly, direct nitrogen inputs to aquatic ecosystems such as those found in estuarine and coastal waters (e.g., Chesapeake Bay) can lead to eutrophication (a condition that promotes excessive algae growth, which can lead to a severe depletion of dissolved oxygen and increased levels of toxins harmful to fish and other aquatic life). Nitrogen, alone or in acid rain, also can acidify soils and surface waters. Acidification of soils causes the loss of essential plant nutrients and increased levels of soluble aluminum that are toxic to plants. Acidification of surface waters creates conditions of low pH and levels of aluminum that are toxic to fish and other aquatic organisms. Finally, $NO_x$ is a contributor to visibility impairment.

## Trends in $NO_2$ Levels and $NO_x$ Emissions

Over the past 20 years, monitored levels of $NO_2$ have decreased 24 percent. All areas of the country that once violated the NAAQS for $NO_2$ now meet that standard. While air quality levels of $NO_2$ around urban monitors have fallen, national emissions of $NO_x$ have actually increased over the past 20 years by 9 percent. This increase is the result of a number of factors, the most significant being an increase in $NO_x$ emissions from nonroad engines and diesel vehicles. This increase is of concern because $NO_x$ emissions contribute to the formation of ground-level ozone (smog), but also to other environmental problems like acid rain and nitrogen loadings to waterbodies.

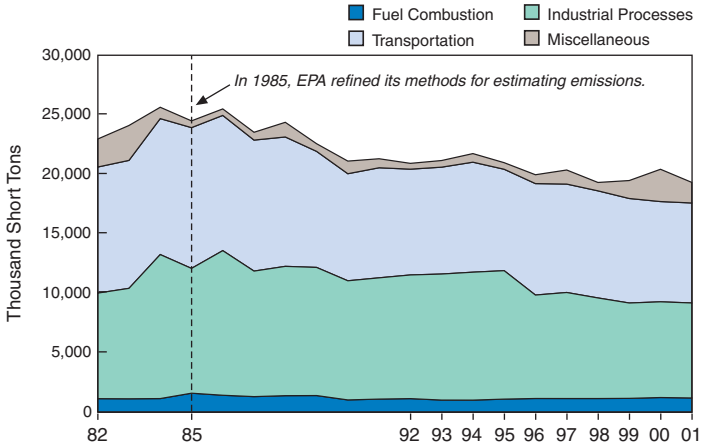
## Nature and Sources of the Pollutant

Ground-level ozone (the primary constituent of smog) continues to be a pollution problem throughout many areas of the United States.

Ozone is not emitted directly into the air but is formed by the reaction of VOCs and $NO_x$ 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. $NO_x$ is 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 pollutants that form ozone also can be transported into an area from pollution sources found hundreds of miles upwind.

Ozone occurs naturally in the stratosphere and provides a protective layer high above the Earth. See page 23 for more information on the stratospheric ozone layer.

VOC Emissions, 1982–2001




**1982–01: 16% decrease**
**1992–01: 8% decrease**

*Air quality concentrations do not always track nationwide emissions. For detailed explanation, see page 3.*

## Health and Environmental Effects

Short-term (1- to 3-hour) and prolonged (6- to 8-hour) exposures to ambient ozone have been linked to a number of health effects of concern. For example, health effects attributed to ozone exposure include significant decreases in lung function and increased respiratory symptoms such as chest pain and cough. Exposures to ozone can make people more susceptible to respiratory infection, result in lung inflammation, and aggravate preexisting respiratory diseases such as asthma. Also, increased hospital admissions and emergency room visits for respiratory problems have been associated with ambient ozone exposures. 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 individuals with preexisting respiratory disease such as asthma and chronic obstructive pulmonary 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 worsening of chronic respiratory illnesses.

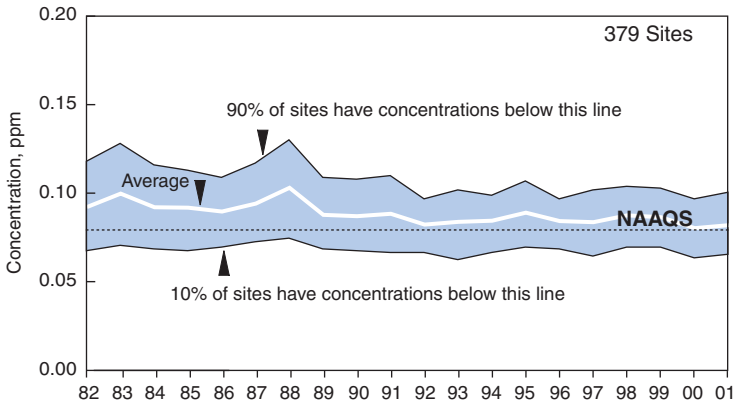
Ozone also affects vegetation and ecosystems, leading to reductions in agricultural crop and commercial forest yields, reduced growth and survivability of tree seedlings, and increased plant susceptibility to disease, pests, and other environmental stresses (e.g., harsh weather). In long-lived species, 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 can also decrease the aesthetic value of ornamental species as well as the natural beauty of our national parks and recreation areas.

## Trends in Ozone Levels and Related Emissions

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

Over the past 20 years, national ambient ozone levels decreased 18 percent based on 1-hour data and 11 percent based on 8-hour data. Between 1982 and 2001, emissions of VOCs decreased 16 percent. During that same time period, emissions of $NO_x$ increased 9 percent.

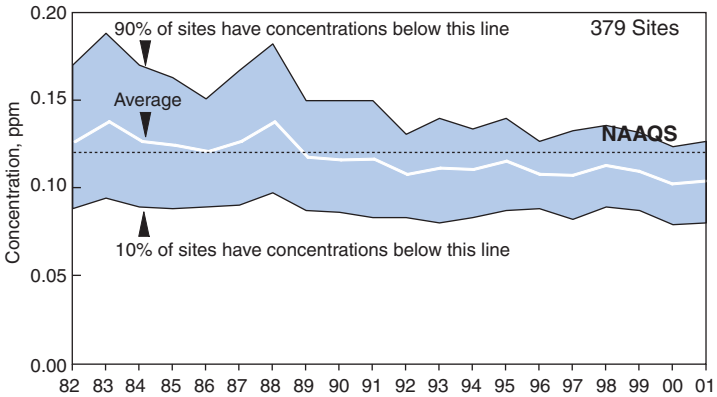
**Ozone Air Quality, 1982–2001**
Based on Annual 4th Maximum 8-Hour Average




**1982–01: 11% decrease**
**1992–01: 0% change**

*Air quality concentrations do not always track nationwide emissions. For a detailed explanation, see page 3.*

**Ozone Air Quality, 1982–2001**
Based on Annual 2nd Maximum 1-Hour Average




**1982–01: 18% decrease**
**1992–01: 3% decrease**

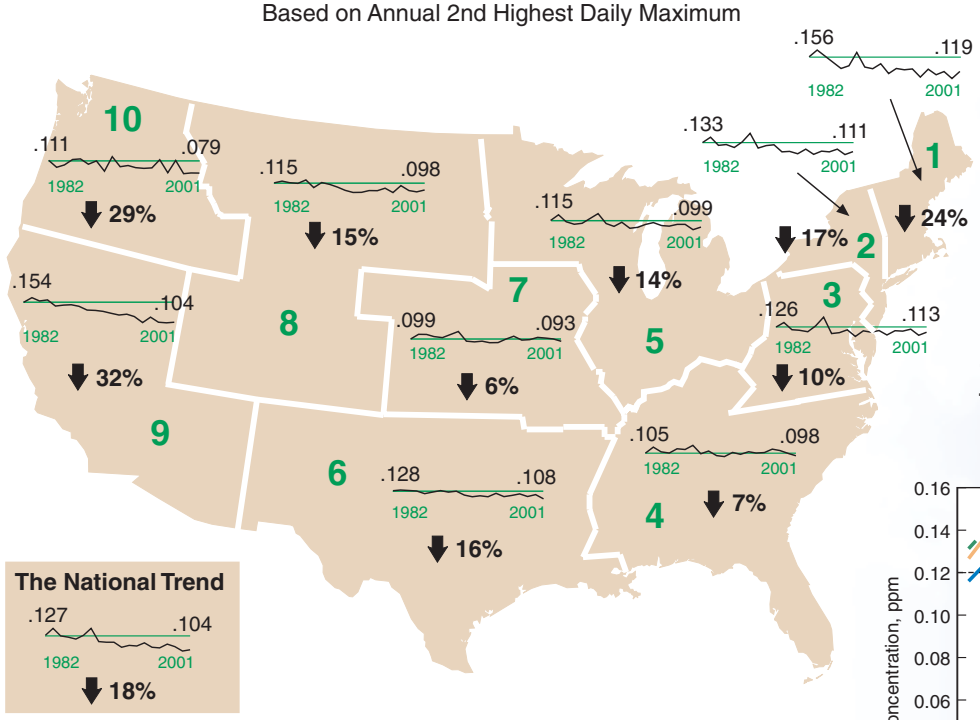
For the period 1982 to 2001, the downward trend in 1-hour ozone levels seen nationally is reflected in every broad geographic area in the country. The Northeast and West exhibited the most substantial improvement, while the South and North Central regions experienced the least rapid progress in lowering ozone concentrations. Similar to the 1-hour ozone trends, all regions experienced improvements in 8-hour ozone levels between 1982 and 2001 except the North Central region, which showed little change during this period. Again, the West and Northeast have exhibited the most substantial reductions in 8-hour ozone levels for the past 20 years.

Across the country, the highest ambient 1-hour 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 approximately 20 percent at urban and suburban sites. In the past 10 years, urban sites show declines of approximately 5 percent and suburban sites show a 6 percent decrease. However, at rural monitoring locations, national improvements have slowed. One-hour ozone levels for 2001 are 11 percent lower than those for 1982 but less than 1 percent below 1992 levels. In 2001, for the sixth consecutive year, rural 1-hour ozone levels, on average, are greater than the levels observed for the urban sites, but they are still generally lower than levels observed at suburban sites.

Over the past 10 years, the average 8-hour ozone level in 33 of our national parks increased almost 4 percent. Six monitoring sites in five of these parks experienced statistically significant upward trends in 8-hour ozone levels: Great Smoky Mountains (Tennessee), Craters of the Moon (Idaho), Mesa Verde (Colorado), Mammoth Cave (Kentucky), and Yellowstone (Wyoming). Monitoring data for two parks showed statistically significant improvements over the same time period: Saguaro (Arizona) and Sequoia (California). For the remaining 26 parks where ozone monitoring takes place, the 8-hour ozone levels at 18 increased only slightly between 1992 and 2001, while 5 showed decreasing levels and 3 were unchanged.

## Trend in 1-Hour Ozone Levels, 1982–2001, Averaged across EPA Regions*

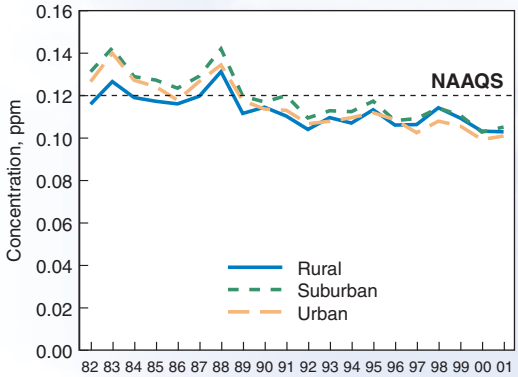
Based on Annual 2nd Highest Daily Maximum




*EPA Regional Office contacts can be found at www.epa.gov/epahome/locate2.htm.*

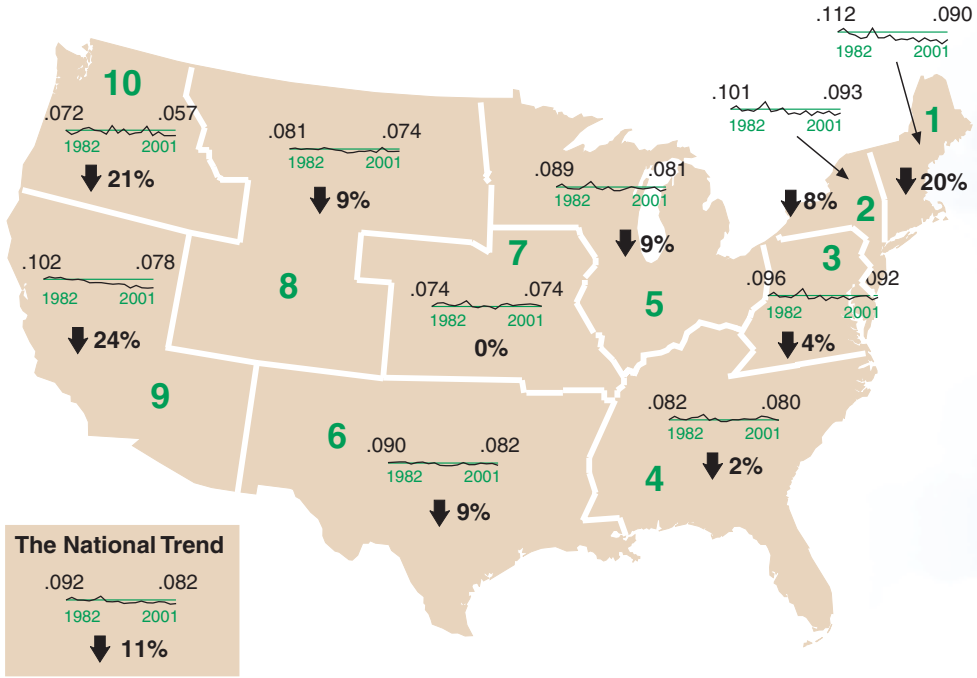
### Trend in 1-hour Ozone Levels, 1982–2001, by Location of Site

Based on Annual 2nd Highest Daily Maximum




## Trend in 8-Hour Ozone Levels, 1982–2001, Averaged across EPA Regions

Based on Annual 4th Maximum 8-Hour Average



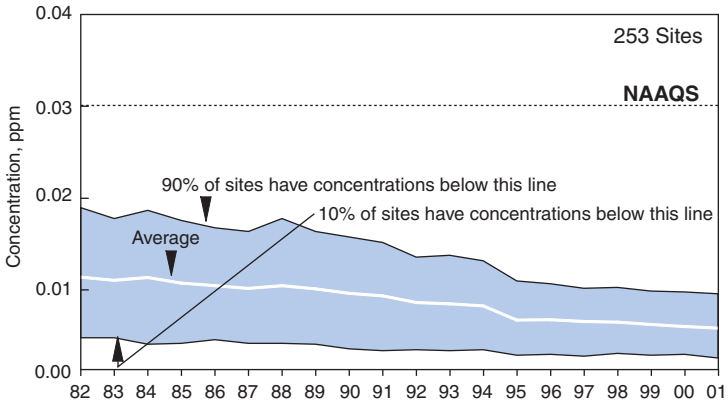

*Concentrations are in parts per million (ppm).*

# SULFUR DIOXIDE ($SO_2$)

## Nature and Sources of the Pollutant

Sulfur dioxide belongs to the family of $SO_x$ gases. These gases are formed when fuel containing sulfur (mainly coal and oil) is burned and during metal smelting and other industrial processes. Most $SO_2$ monitoring stations are located in urban areas. The highest monitored concentrations of $SO_2$ are recorded in the vicinity of large industrial facilities. Fuel combustion, largely from coal-fired power plants, accounts for most of the total $SO_2$ emissions.

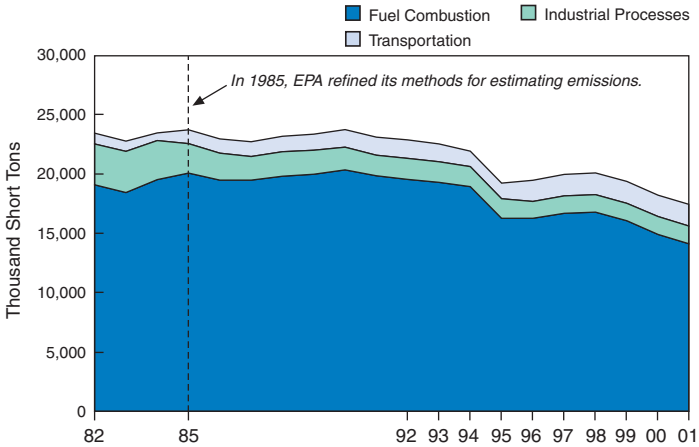
**$SO_2$ Air Quality, 1982–2001**
Based on Annual Arithmetic Average




**1982–01: 52% decrease**
**1992–01: 35% decrease**

*Air quality concentrations do not always track nationwide emissions. For a detailed explanation, see page 3.*

**$SO_2$ Emissions, 1982–2001**




**1982–01: 25% decrease**
**1992–01: 24% decrease**

## Health and Environmental Effects

High concentrations of $SO_2$ can result in temporary breathing impairment for asthmatic children and adults who are active outdoors. Short-term exposures of asthmatic individuals to elevated $SO_2$ levels during moderate activity may result in breathing difficulties that can be accompanied by symptoms such as wheezing, chest tightness, or shortness of breath. Other effects that have been associated with longer-term exposures to high concentrations of $SO_2$, in conjunction with high levels of PM, include aggravation of existing cardiovascular disease, respiratory illness, and alterations in the lungs' defenses. The subgroups of the population that may be affected under these conditions include individuals with heart or lung disease, as well as the elderly and children.

Together, $SO_2$ and $NO_x$ are the major precursors to acidic deposition (acid rain), which is associated with the acidification of soils, lakes, and streams and accelerated corrosion of buildings and monuments. $SO_2$ also is a major precursor to $PM_{2.5}$, which is a significant health concern as well as a main contributor to poor visibility. (See Acid Rain section, page 16, for a more detailed discussion.)

## Trends in $SO_2$ Levels and Emissions

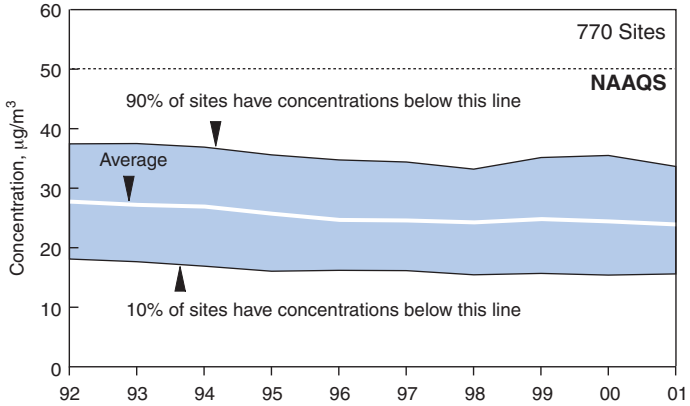
Nationally, average $SO_2$ ambient concentrations have decreased 52 percent from 1982 to 2001 and 35 percent over the more recent 10-year period 1992 to 2001. $SO_2$ emissions decreased 25 percent from 1982 to 2001 and 24 percent from 1992 to 2001. Reductions in $SO_2$ concentrations and emissions since 1990 are due, in large part, to controls implemented under EPA's Acid Rain Program beginning in 1995.

# PARTICULATE MATTER

## Nature and Sources of the Pollutant

Particulate matter is the general term used for a mixture of solid particles and liquid droplets found in the air. Some particles are large enough to be seen as dust or dirt. Others are so small they can be detected only with an electron microscope. $PM_{2.5}$ describes the "fine" particles that are less than or equal to 2.5 µm in diameter. "Coarse fraction" particles are greater than 2.5 µm, but less than or equal to 10 µm in diameter. $PM_{10}$ refers to all particles less than or equal to 10 µm in diameter. A particle 10 µm in diameter is about one-seventh the diameter of a human hair. PM can be emitted directly or form 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 sulfates, formed from $SO_2$ emissions from power plants and industrial facilities, and nitrates, formed from $NO_x$ 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, coarse PM is composed largely of primary particles and fine PM contains many more secondary particles.

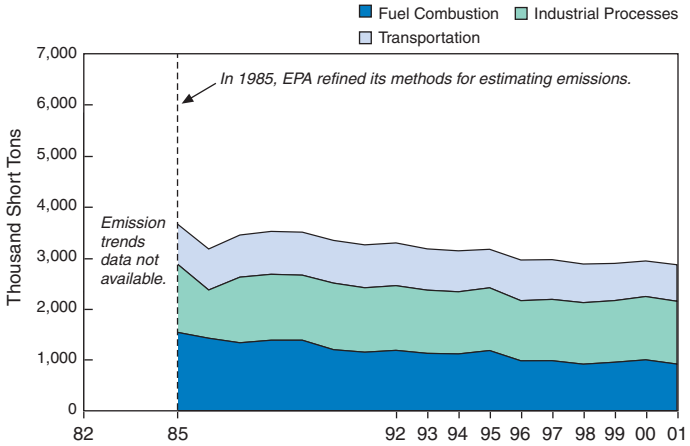
**$PM_{10}$ Air Quality, 1992–2001**
Based on Seasonally Weighted Annual Average




**1992–01: 14% decrease**

*Air quality concentrations do not always track nationwide emissions. For a detailed explanation, see page 3.*

**$PM_{10}$ Emissions, 1982–2001**




**1992–01: 13% decrease**

## Health and Environmental Effects

Particles that are small enough to get into the lungs (those less than or equal to 10 µm in diameter) can cause numerous health problems and have been linked with illnesses and deaths from heart and lung diseases. Various health problems have been associated with long-term (e.g., multi-year) exposures as well as daily and even, potentially, peak (e.g., 1-hour) exposures to particles. Particles can aggravate respiratory conditions such as asthma and bronchitis and have been associated with cardiac arrhythmias (heartbeat irregularities) and heart attacks. Particles of concern can include both fine and coarse-fraction particles, although fine particles have been more clearly linked to the most serious health effects. People with heart or lung disease, the elderly, and children are at highest risk from exposure to particles. 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. (See Acid Rain, $NO_2$, and $SO_2$ sections.)

## Trends in $PM_{10}$ Levels and Direct Emissions

Between 1992 and 2001, average $PM_{10}$ concentrations decreased 14 percent, while direct $PM_{10}$ emissions decreased 13 percent.

If enacted, President Bush's Clear Skies Initiative would decrease PM concentrations by dramatically reducing emissions of $SO_2$ and $NO_x$. This initiative would also reduce mercury emissions (www.epa.gov/clearskies).

## Trends in $PM_{2.5}$ Levels and Direct Emissions

The chart at right shows that direct $PM_{2.5}$ emissions from man-made sources decreased 10 percent nationally between 1992 and 2001. This chart tracks only directly emitted particles and does not account for secondary particles formed when emissions of $NO_x$, $SO_2$, ammonia, and other gases react in the atmosphere. The principal types of secondary particles are sulfates and nitrates, which are formed when $SO_2$ and $NO_x$ react with ammonia.

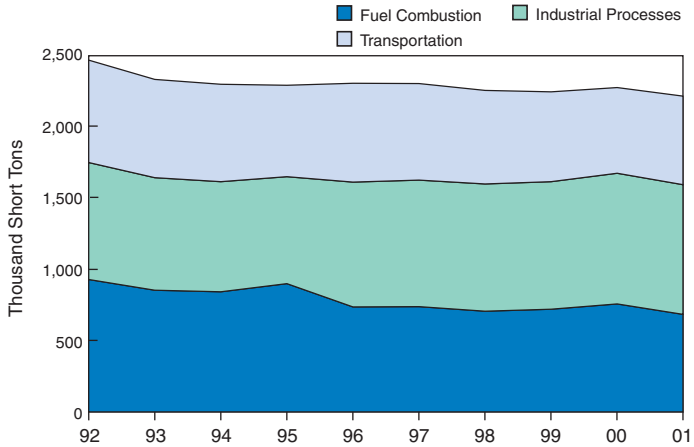
The maps at right show how sulfates and nitrates, along with other components, contribute to $PM_{2.5}$ concentrations. The first map represents the most recent year of data available from the Interagency Monitoring of Protected Visual Environments (IMPROVE) network, which was established in 1987 to track trends in pollutants, such as $PM_{2.5}$, 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 $PM_{2.5}$. The second map represents the most recent year of data from EPA's urban speciation network, which was established in 1999. All of these sites are located in urban areas.

Sites in the rural East typically have higher annual average $PM_{2.5}$ concentrations than those in the rural West, as shown by the larger circles in the East. Most of this regional difference is attributable to higher sulfate concentrations in the eastern United States. Sulfate concentrations in the East largely result from $SO_2$ emissions from coal-fired power plants.

Sites in urban areas, as shown in the circles in the map at right, generally have higher annual average $PM_{2.5}$ concentrations than nearby rural areas. Carbon from soot and organic compounds accounts for much of the difference, while sulfate concentrations are about the same. Sites in central California show that nitrates, in addition to carbon, are responsible for higher urban concentrations in that region.

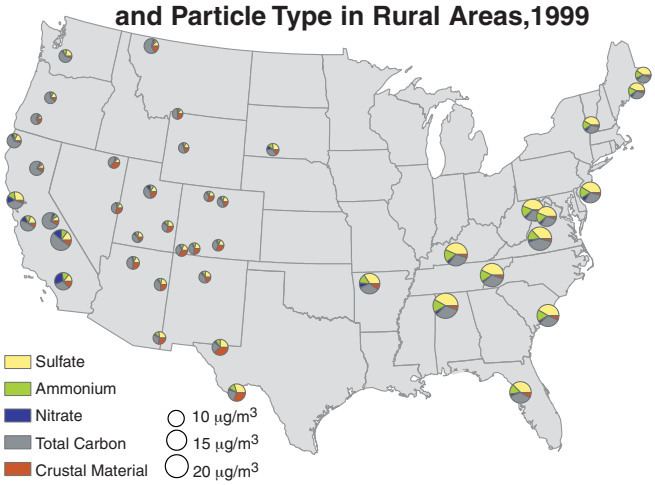
Trends in rural $PM_{2.5}$ concentrations can be examined with data from the IMPROVE network. At the time of this report, 2000 and 2001 data were not available. However, 36 sites have enough data to assess trends from 1992 to 1999. In the East, where sulfates contribute most to rural $PM_{2.5}$, the

**Direct $PM_{2.5}$ Emissions, 1992–2001**




**1992–01: 10% decrease**

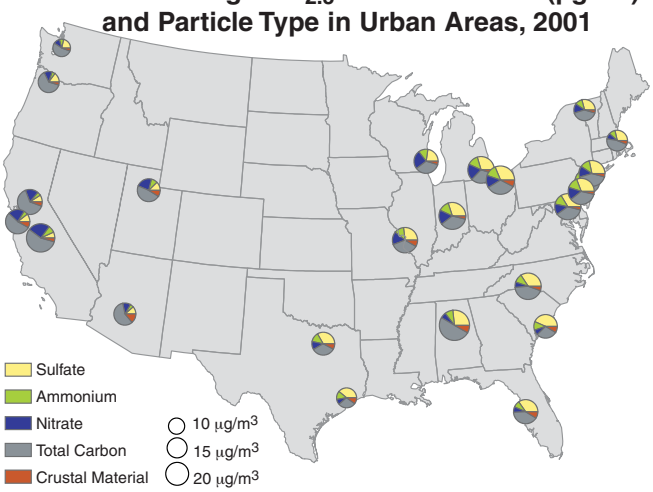
**Annual Average $PM_{2.5}$ Concentrations (µg/m³) and Particle Type in Rural Areas,1999**




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

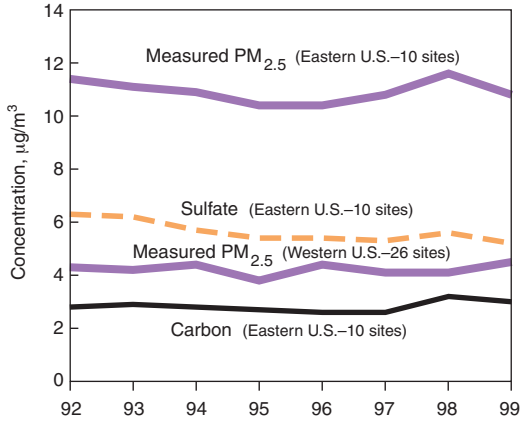
*Note: Direct comparisons of the information in these two maps should take into consideration: the fact that they represent different years; that one is an urban network and the other is a rural network; and that there are also differences in instruments and measurement methods.*

**Annual Average $PM_{2.5}$ Concentrations (µg/m³) and Particle Type in Urban Areas, 2001**



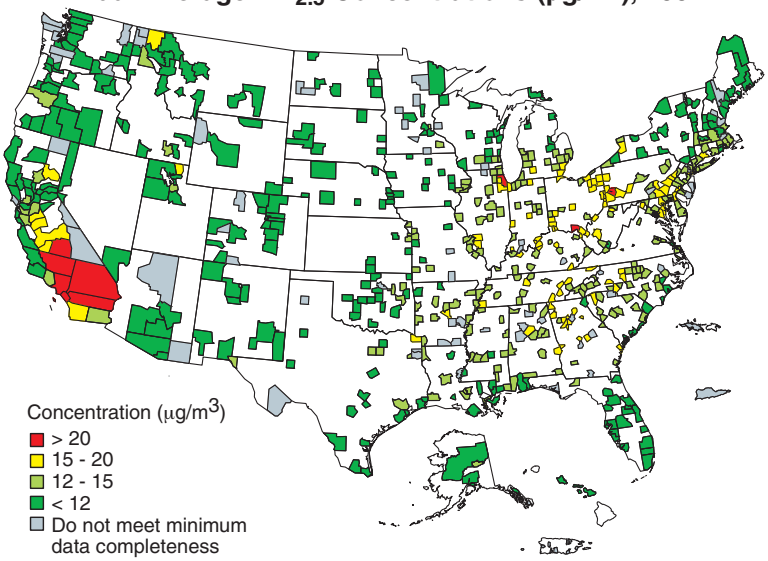

*Source: EPA Speciation Network, 2001.*

## Annual Average $PM_{2.5}$ Concentrations in Rural Areas




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

## Annual Average $PM_{2.5}$ Concentrations (µg/m³), 2001




*Source:* U.S. EPA AIRS databases as of 7/8/02.
Minimum 11 samples per calendar quarter required.

*Note: The NAAQS for $PM_{2.5}$ is 15 µg/m³ but is based on the average of 3 years of monitoring data. In addition, $PM_{2.5}$ 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.*

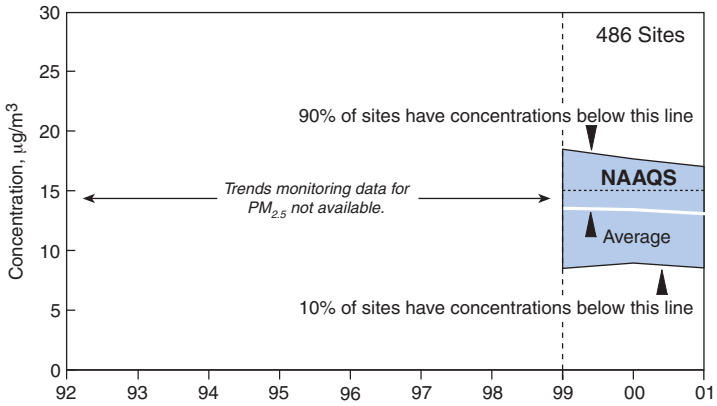
annual average across the 10 sites decreased 5 percent from 1992 to 1999. The peak in 1998 is associated with increases in sulfates and carbon from soot and organic compounds. Average $PM_{2.5}$ concentrations across the 26 sites in the West were less than one-half of the levels measured at eastern sites from 1992 to 1999.

In 1999, EPA and its state, tribal, and local air pollution control partners deployed a monitoring network to begin measuring $PM_{2.5}$ concentrations nationwide. The map at left shows annual average $PM_{2.5}$ concentrations by county. This map also indicates that $PM_{2.5}$ concentrations vary regionally. Based on the monitoring data, parts of 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 orange and red on the map. With few exceptions, the rest of the country generally has annual average concentrations below the level of the annual $PM_{2.5}$ health standard.

Now that there are 3 years of monitoring data available, we have begun to examine trends at the national level. Annual average $PM_{2.5}$ concentrations decreased 5 percent nationally from 1999 to 2001, with much of that decrease occurring between 2000 and 2001. This decrease may or may not represent a trend, given the few years of data available at this time. The Southeast was responsible for most of that reduction, where the monitored levels of $PM_{2.5}$ decreased 10 percent from 2000 to 2001. Lower 2001 annual average concentrations in the Southeast are due, in part, to less demand on utilities during a very warm winter. This is illustrated by the reduction in direct emissions of $SO_2$ and $PM_{2.5}$ from fuel combustion in 2001.

## $PM_{2.5}$ Air Quality, 1999–2001

Based on Seasonally Weighted Annual Average

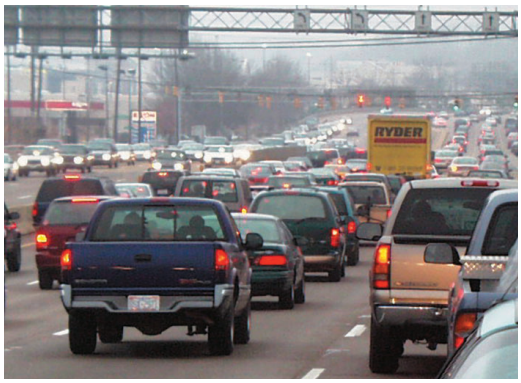



**1999–01: 5% decrease**

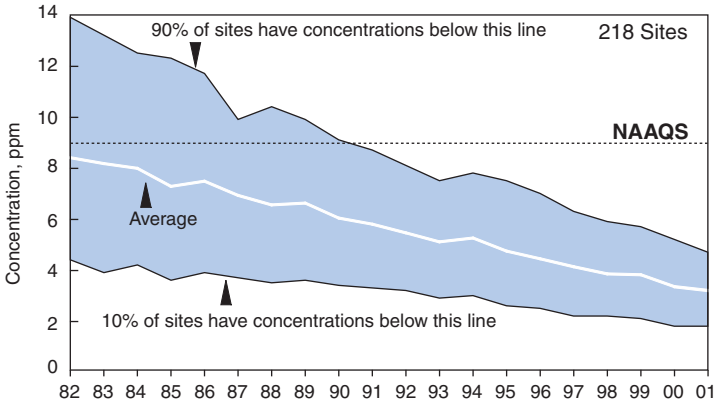
# CARBON MONOXIDE (CO)

## Nature and Sources of the Pollutant

Carbon monoxide 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. Nonroad 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, nontransportation 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.



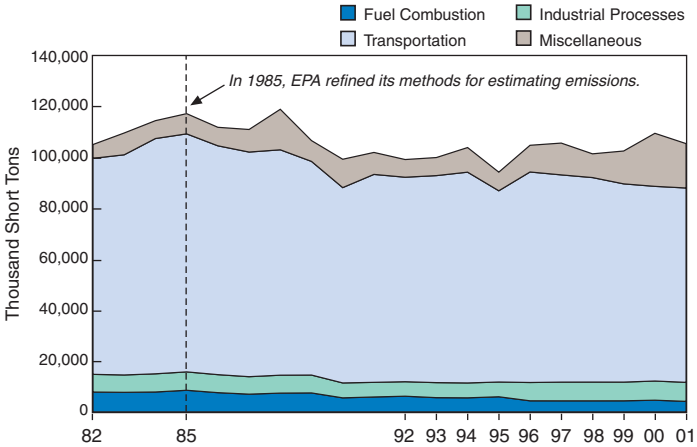

**CO Air Quality, 1982–2001**
Based on Annual 2nd Maximum 8-hour Average




**1982–01: 62% decrease**
**1992–01: 38% decrease**

*Air quality concentrations do not always track nationwide emissions. For a detailed explanation, see page 3.*

**CO Emissions, 1982–2001**




**1982–01: 0% change**
**1992–01: 6% increase**

## Health and Environmental Effects

CO 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 not commonly found in ambient air, 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 and Emissions

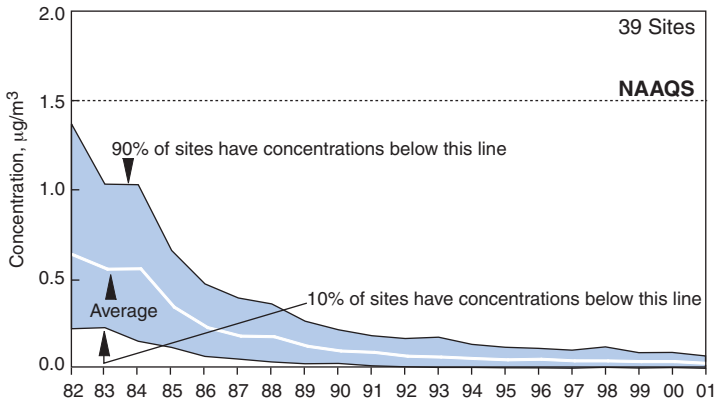
Nationally, the 2001 ambient average CO concentration is almost 62 percent lower than that for 1982 and is the lowest level recorded during the past 20 years. CO emissions from transportation sources, the major contributor to ambient CO concentration, have decreased slightly during this period. Between 1992 and 2001, ambient CO concentrations decreased 38 percent. This air quality improvement occurred despite an approximately 35 percent increase in vehicle miles traveled in the United States during this 10-year period and an increase in total CO emissions of 6 percent. The recent increase in CO emissions was caused by an extremely serious wildfire season in 2000. Nearly twice the number of U.S. acres burned in 2000 compared to the average year since 1982.

## 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, however, the contribution of air emissions of lead from the transportation sector, and particularly the automotive sector, has greatly declined over the past two decades. Today, industrial processes, primarily metals processing, are the major source of lead emissions to the atmosphere. The highest air concentrations of lead are usually found in the vicinity of smelters and battery manufacturers.

**Lead Air Quality, 1982–2001**

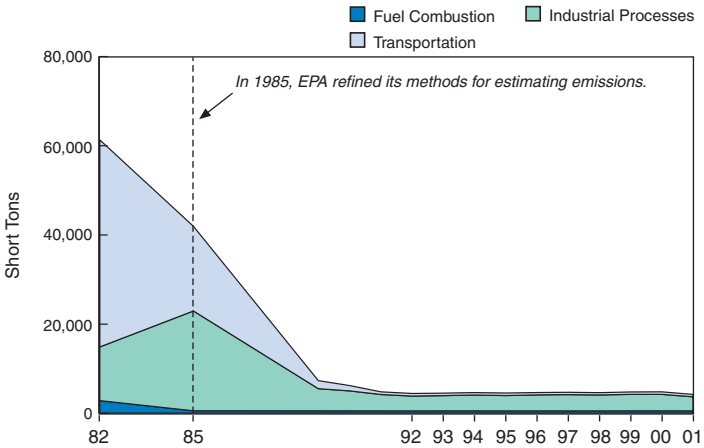
Based on Annual Maximum Quarterly Average




**1982–01: 94% decrease**
**1992–01: 25% decrease**

*Air quality concentrations do not always track nationwide emissions. For a detailed explanation, see page 3.*

**Lead Emissions, 1982–2001**




**1982–01: 93% decrease**

## 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 and 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 and humans through ingestion.

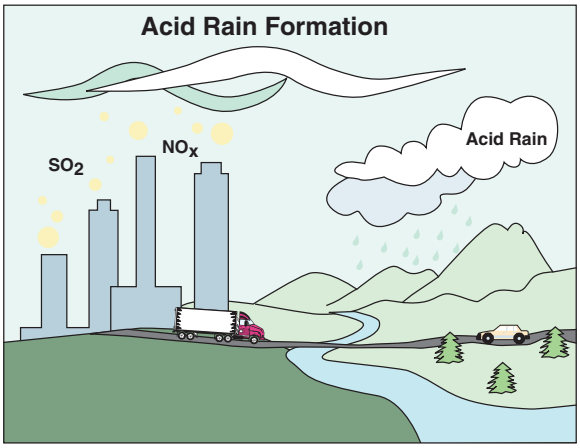
## Trends in Lead Levels and Emissions

Because of the phaseout of leaded gasoline, lead emissions and concentrations decreased sharply during the 1980s and early 1990s. The 2001 average air quality concentration for lead is 94 percent lower than in 1982. Emissions of lead decreased 93 percent over that same 20-year period. Today, the only violations of the lead NAAQS occur near large industrial sources such as lead smelters and battery manufacturers. Various enforcement and regulatory actions are being actively pursued by EPA and the states for cleaning up these sources.

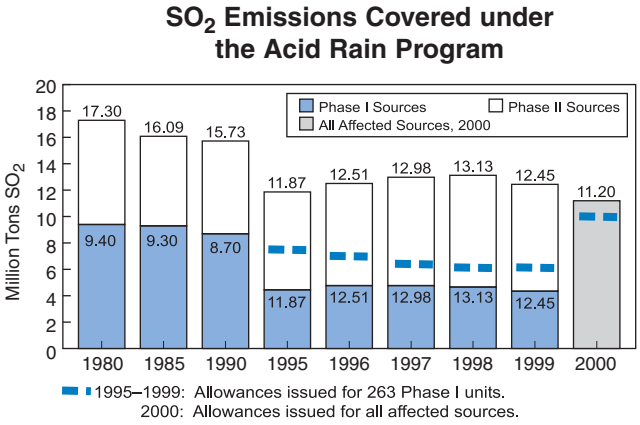
# Acid Rain

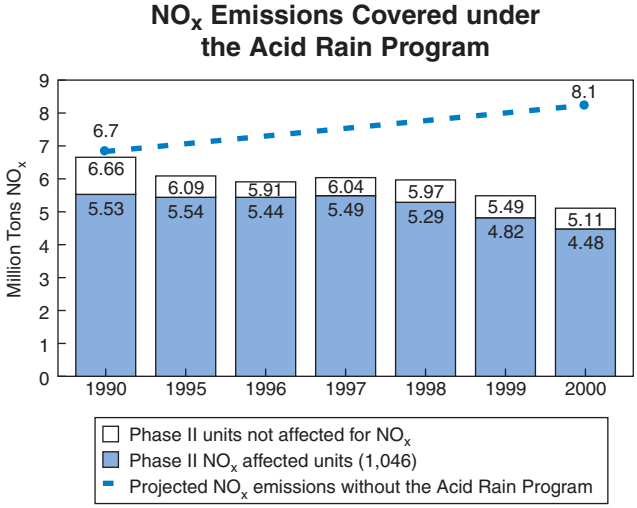
## Nature and Sources of the Problem

Acidic deposition or "acid rain" occurs when emissions of sulfur dioxide and nitrogen oxides 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 $SO_2$ emissions and 26 percent of $NO_x$ emissions are produced by electric utility plants that burn fossil fuels.




*Coal-fired electric utilities and other sources that burn fossil fuels emit $SO_2$ and $NO_x$.*




## Health and Environmental Effects

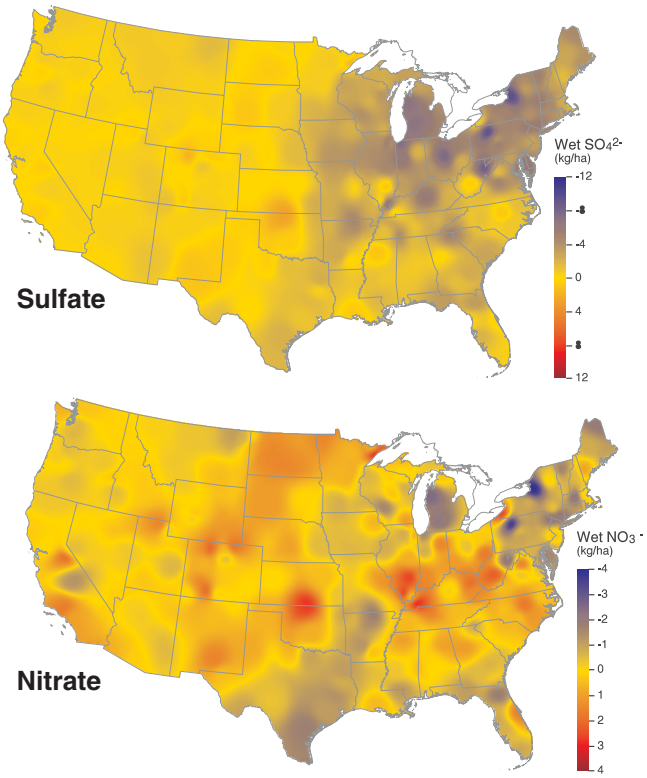
In the environment, acid deposition causes soils and waterbodies to acidify (making the water unsuitable for some fish and other wildlife) and damages some trees, particularly at high elevations. It also speeds the decay of buildings, statues, and sculptures that are part of our national heritage. The 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 can increase the amount of methyl mercury available in aquatic systems. Most exposure to mercury comes from eating contaminated fish. Reductions in $SO_2$ and $NO_x$ have begun to reduce some of these negative environmental effects and are leading to significant improvements in public health (described previously).

## 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 $SO_2$ and $NO_x$. The program was implemented in two phases: Phase I for $SO_2$ began in 1995 and targeted the largest and highest-emitting coal-fired power plants. Phase I for $NO_x$ 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. Over 2,000 sources are now affected by the Acid Rain Program.

The Acid Rain Program will reduce annual $SO_2$ 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 $SO_2$ that may be emitted by power plants nationwide, about half the amount emitted in 1980. It employs an emissions trading program to reach that emissions cap more efficiently and cost-effectively. Sources are allocated allowances efficiently each year (one allowance equals 1 ton of $SO_2$ emissions), which can be bought or sold or banked for future use.

**Change in Deposition from Precipitation 1990–1994 to 1996–2000**




*Source: U.S. EPA analysis of National Atmospheric Deposition Program data.*

This approach gives sources the flexibility and incentive to reduce emissions at the lowest cost while ensuring that the emission cap is met.

The $NO_x$ component of the Acid Rain Program limits the emission rate for all affected utilities, resulting in a 2 million ton $NO_x$ reduction from 1980 levels by 2000. There is no cap on total $NO_x$ emissions, but under this program a source can choose to over-control 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

$SO_2$ emissions reductions have been significant in the first 6 years of EPA's Acid Rain Program. The first year of compliance with Phase II of the Acid Rain Program was 2000. Sources in the Acid Rain Program emitted 11.2 million tons in 2000, down from 16 million tons in 1990. Emissions of $SO_2$ 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 previous year.

Actual $NO_x$ emissions, as shown in the graph on the bottom left of page 16, have also declined since 1990. $NO_x$ emissions decreased steadily from 6 tons in 1997 to just over 5 tons in 2000. The more than 1,000 sources affected by Phase II emitted 4.5 tons in 2000, over 1 million tons (almost 20 percent) less than they did in 1990. $NO_x$ emissions in 2000 were somewhat lower (7 percent) than in 1999 and almost half of what emissions were projected to have been in 2000 without the Acid Rain Program.

For all years from 1995 through 2000, sulfate deposition exhibited dramatic and unprecedented reductions over a large area of the eastern United States. Average sulfate deposition in 1996–2000 compared to 1990-1994 was 10 percent lower 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. Nitrate deposition decreased slightly in some places but increased in others, 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 $SO_2$ and $NO_x$ 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, affect air concentrations and deposition.

# Visibility

In 2000, the IMPROVE Monitoring Network, used to track visibility trends at national parks and wilderness areas, started an expansion from 30 to 110 monitoring sites. The expansion work was completed in the fall of 2001. However, due to the level of resources required to complete the network expansion, reporting of 2000 IMPROVE data will occur while this brochure is being finalized. Therefore, no update is provided for visibility trends reported in the *1999 Status and Trends Brochure*. Reporting of 2000 and 2001 visibility trends are scheduled to be included in U.S. EPA's 2001 *National Air Quality and Emission Trends Report*.

## 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 parks and wilderness areas, such as the Grand Canyon, Yosemite, Yellowstone, Mount Rainier, Shenandoah, and the Great Smoky Mountain National Park, as well as in urban areas.

Visibility impairment results from the scattering and absorption of light by air pollution, including particles and gases. The scattering and absorption by air pollution limits the distance we can see and 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.

Some particles that contribute to visibility impairment are emitted directly into the atmosphere from their sources, such as dust from roads or elemental carbon (soot) from wood combustion. In other cases, particles are formed in the atmosphere from primary gaseous emissions such as $SO_2$ emissions from power plants and other industrial facilities and nitrates formed from $NO_x$ emissions from power plants, automobiles, and other types of combustion sources. These types of particles are referred to as secondarily formed particles. In the eastern United States, reduced visibility is mainly attributable to secondarily formed sulfates. Although these secondarily formed particles still account for a significant amount of particulate loading in the West, primary emissions from sources like wood smoke contribute a larger percentage of the total particulate loading than in the East.

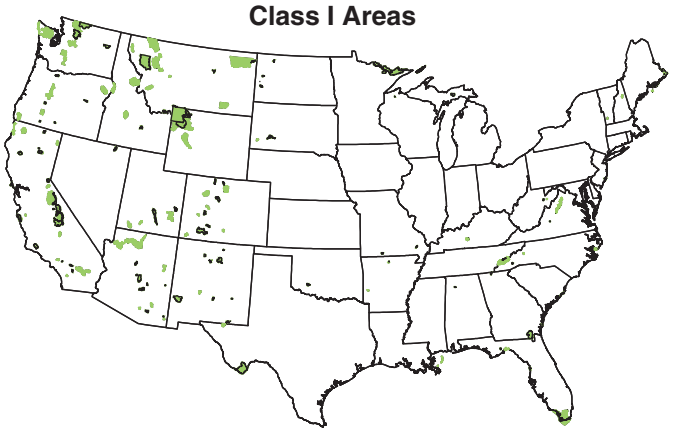
Also, humidity can significantly increase the effect of pollution on visibility, causing some particles to become more efficient at scattering light and causing visibility impairment. Annual average relative humidity levels are 70 to 80 percent in the East as compared to 50 to 60 percent in the West. Poor summer visibility in the eastern United States is primarily the result of high sulfate concentrations combined with high humidity levels.

| | 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% |

*This table shows 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.*

## Program Structure

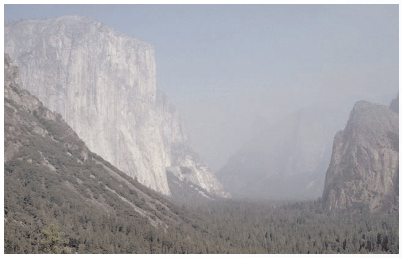
The Clean Air Act provides for the protection of visibility in national parks and wilderness areas, also known as Class I areas. The Clean Air Act's national goal calls for remedying existing visibility impairment and preventing future impairment in these 156 Class I areas across the country.




*The Clean Air Act provides for the protection of visibility in our national parks and wilderness areas, also known as Class I areas. There are 156 Class I areas across the United States as shown.*

In 1987, the IMPROVE visibility network was established as a cooperative effort among EPA, states, National Park Service, U.S. Forest Service, Bureau of Land Management, and U.S. Fish and Wildlife Service. Data are collected and analyzed from this network to determine the type of pollutants primarily responsible for reduced visibility

*Shenandoah National Park under bad and good visibility conditions. The visual range in the top photo is 25 km while the visual range in the bottom photo is 180 km.*



*Yosemite National Park under bad and good visibility conditions. The visual range in the top photo is 111 km while the visual range in the bottom photo is greater than 208 km.*

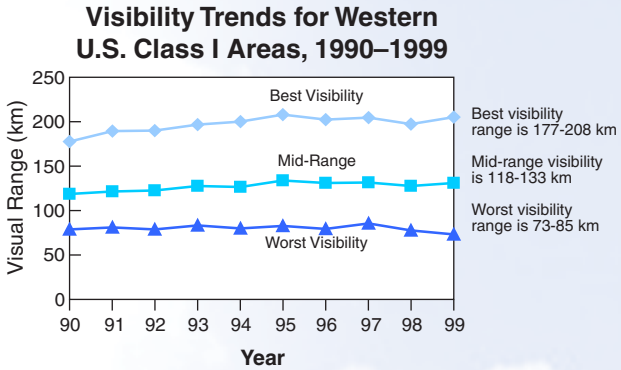
and to track progress toward the Clean Air Act's national goal.

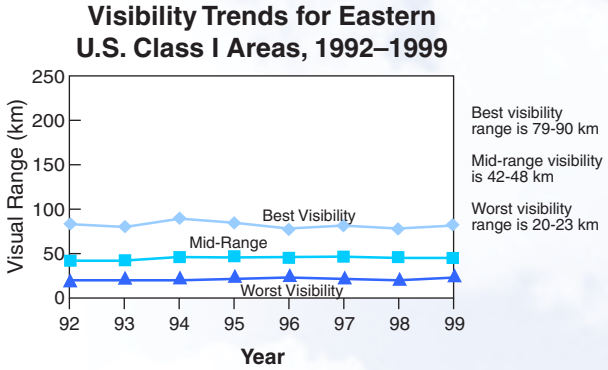
In April 1999, EPA initiated a new regional haze program. The program addresses visibility impairment in national parks and wilderness areas caused by numerous sources located over broad regions. The program sets a framework for states to develop goals for improving visibility on the worst visibility days each year and to adopt emission strategies to meet these goals. 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 encourages states to coordinate through regional planning organizations to develop regional strategies to improve visibility and to reduce pollutants that contribute to fine particles and ground-level ozone. States are also required to review progress every 5 years and revise any strategies as necessary.

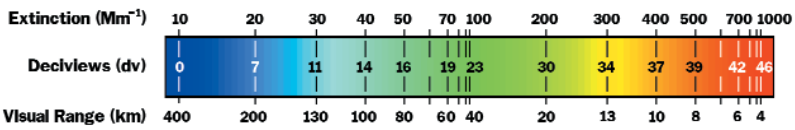
## Visibility Trends

Without the effects of pollution, a natural visual range in the United States is approximately 75 to 150 km (45 to 90 miles) in the East and 200 to 300 km (120 to 180 miles) in the West.

Data collected by the IMPROVE network show visibility impairment for the worst visibility in the West is similar to days with the best visibility in the East. In 1999, mean visual range for the worst days in the East was only 24 km (14.4 miles) compared to 84 km (50.4 miles) for the best visibility. In the West, visibility impairment for the worst days remained relatively unchanged over the 1990s, with the mean visual range for 1999 (80 km) nearly the same as the 1990 level (86 km).




***Visibility Metrics**. Comparisons of extinction ($Mm^{-1}$), deciviews (dv), and visual range (km). Notice the difference in the three scales: 10 $Mm^{-1}$ corresponds to about 400 km visual range and 0.0 dv, while 1,000 $Mm^{-1}$ is about 4 km visual range and 46 dv.*

# Toxic Air Pollutants

## Nature and Sources of the Problem

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. 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. The Clean Air Act identifies 188 air toxics from industrial sources. EPA has identified 20 of these pollutants that are associated with mobile sources and one additional mobile source air toxic designated "diesel particulate matter and diesel exhaust organic gases."

## Health and Environmental Effects

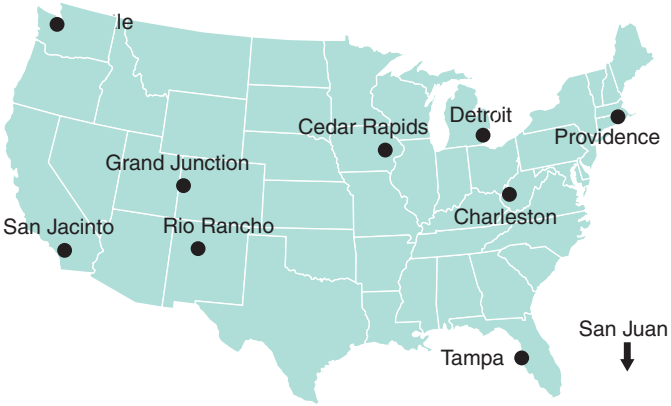
People exposed to toxic air pollutants at sufficient concentrations may experience various health effects, including cancer, damage to the immune system, as well as neurological, reproductive (e.g., reduced fertility), developmental, respiratory, and other health problems. In addition to exposure from 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 an extensive nationwide monitoring network for air toxics as they do for many of the other pollutants discussed in this report. While EPA, states, tribes, and local air regulatory agencies 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. EPA is working with these regulatory partners to build upon the existing monitoring sites to create a national monitoring network for a number of toxic air pollutants. The goal is to ensure that those

compounds that pose the greatest risk are measured. The available monitoring data help air pollution control agencies track trends in toxic air pollutants in various locations around the country. EPA began a pilot city monitoring project in 2001 and is scheduled to include at least 12 months of sampling in four urban areas and six small city/rural areas (see map below). This program is intended to help answer several important national network design questions (e.g., sampling and analysis precision, sources of variability, and minimal detection levels). In addition, an initial 11-city trends network is being established that will help develop national trends for several pollutants of concern. For the latest information on national air toxics monitoring, see **www.epa.gov/ttn/amtic/airtxfil.html**.

EPA also compiles an air toxics inventory as part of the National Emissions Inventory (NEI, formerly the National Toxics Inventory) to estimate and track national emissions trends for the 188 toxic air pollutants regulated under the Clean Air Act. In the NEI, EPA divides emissions into four types of sectors:

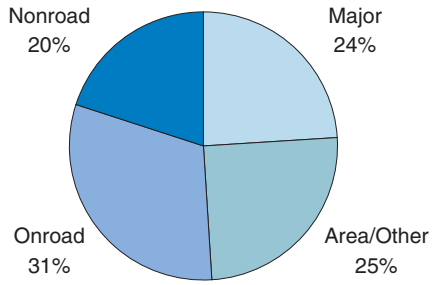



*Map of 10 cities in monitoring pilot project*

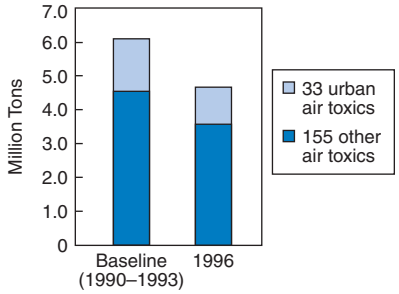
(1) major (large industrial) sources; (2) area and other sources, which include smaller industrial sources like small dry cleaners and gasoline stations, as well as natural sources like wildfires; (3) onroad mobile sources, including highway vehicles; and (4) nonroad mobile sources like aircraft, locomotives, and construction equipment.

As shown in this 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.

**National Air Toxics Emissions, 1996**
4.7M Tons



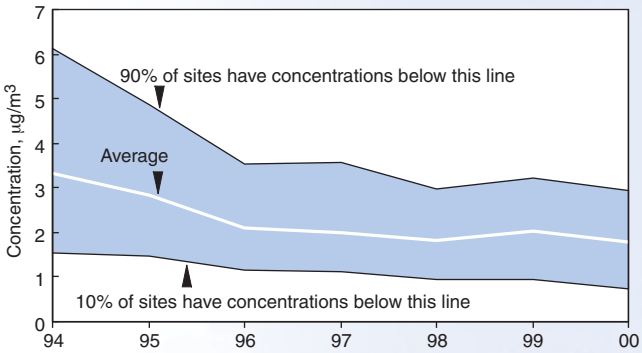

**National Air Toxics Emissions**
Total for 188 Toxic Air Pollutants




Based on the data in the NEI, estimates of nationwide air toxics emissions have dropped approximately 24 percent between baseline (1990–1993) and 1996. Thirty-three of these air toxics, which pose the greatest threat to public health in urban areas, have similarly dropped 31 percent. 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. Benzene, which is the most widely monitored toxic air pollutant, is emitted from cars, trucks, oil refineries, and chemical processes. The graph below shows measurements of benzene taken from 95 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 47 percent drop in benzene levels from 1994 to 2000. 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 20 percent from 1990 to 1996.

**Ambient Benzene, Annual Average Urban Concentrations, Nationwide, 1994–2000**




**1994–00: 47% decrease**

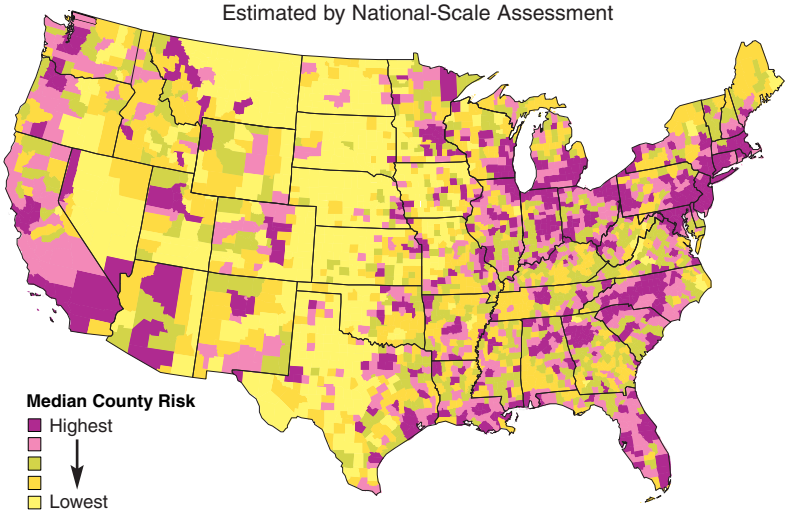
## Risk Assessment

EPA has developed a National-Scale Air Toxics Assessment, which is a nationwide analysis of air toxics. It uses computer modeling of the 1996 NEI air toxics data as the basis for developing health risk estimates for 33 toxic air pollutants (a subset of the Clean Air Act's list of 188 air toxics plus diesel PM). The national-scale assessment is intended to provide state, local, and tribal agencies and others with a better understanding of the risks from inhalation exposure to toxic air pollutants from outdoor sources. It will help EPA and states prioritize data and research needs to better assess risk in the future and will provide a baseline to help measure future trends in estimated health risks. The next national-scale analysis will focus on 1999 data and will be released by the end of 2003.

The following map shows a pattern of the distribution of relative cancer risk across the continental United States as estimated by the national-scale assessment. The highest ranking 20 percent of counties in terms of risk (622 counties) contain almost three-fourths of the U.S. population. Three air toxics (chromium, benzene, and formaldehyde) appear to pose the greatest nationwide carcinogenic risk. This map does not include the potential risk from diesel exhaust emissions. This is because existing health data are not sufficient to develop a numerical estimate of cancer risk for this pollutant. However, exposure to diesel exhaust is widespread and EPA has concluded that diesel exhaust is a likely human carcinogen and ranks with the other substances that the national-scale assessment suggests pose the greatest relative risk. One air toxic, acrolein, is estimated to pose the highest potential nationwide for significant chronic adverse effects other than cancer. For more information, visit **www.epa.gov/ttn/atw/nata**.

**County Risk Comparison**

Estimated by National-Scale Assessment




This technical assessment represents an important step toward characterizing air toxics nationwide. It is designed to help identify general patterns in air toxics exposure and risk across the country and is not recommended as a tool to characterize or compare risk at local levels (e.g., to compare risks from one part of a city to another). More localized assessments, including monitoring and modeling, are under way to help characterize local-level risk.

## 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 annual emissions of toxic air pollutants by nearly 1.5 million tons from 1990 levels. EPA has also put into place important controls for motor vehicles and their fuels, including introduction of reformulated gasoline and low sulfur diesel fuel, and is continuing to take additional steps to reduce air toxics from vehicles. Furthermore, air toxics emissions will further decline as the motor vehicle fleet turns over, with newer vehicles replacing older higher emitting vehicles. By the year 2020, these requirements are expected to reduce emissions of a number of air toxics (benzene, formaldehyde, acetaldehyde, and 1,3-butadiene) from highway motor vehicles by about 75 percent and diesel PM by over 90 percent from 1990 levels.

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 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 waterbodies from air toxics deposition (e.g., the Great Waters program, which includes the Great Lakes, Lake Champlain, Chesapeake Bay, and many coastal estuaries) and EPA 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/**.

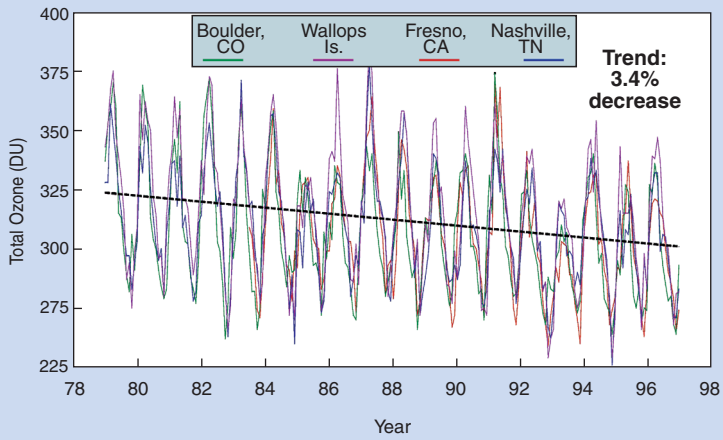
For more information about EPA's air toxics program, visit the Agency's Web site at **www.epa.gov/ttn/atw**.

# 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 three decades, however, it has become clear that this protective shield has been damaged. Each year, an "ozone hole" forms over the Antarctic, and ozone levels there can fall to 60 percent below normal. Even over the United States, ozone levels are about 3 percent below normal in the summer and 5 percent below normal in the winter.

As the ozone layer thins, more UV-b radiation reaches the Earth. The 1998 Scientific Assessment of Stratospheric Ozone firmly established the link between decreased ozone and increased UV-b radiation. 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 troposphere, 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.




*Source: National Oceanic and Atmospheric Administration (NOAA), 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 that cause increased levels in the winter and spring and lower ozone levels in the summer and fall at these latitudes.*

## 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.

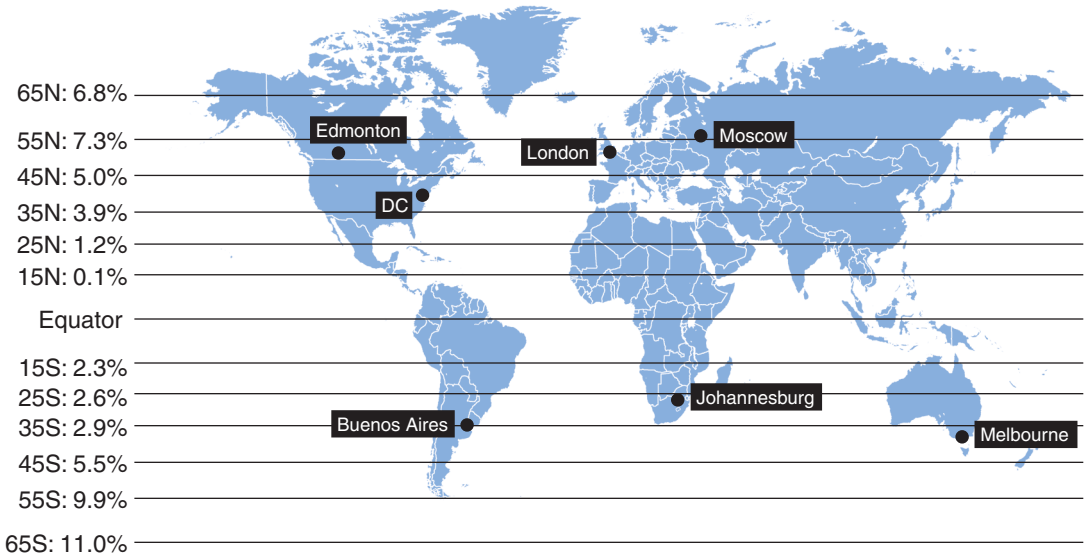
The effects of UV-b radiation on plant and aquatic ecosystems are not well understood. However, the growth of certain food plants can be slowed by excessive UV-b radiation. In addition, some scientists suggest that marine phytoplankton, which are the base of the ocean food chain, are already under stress from UV-b radiation. This stress could have adverse consequences for human food supplies from the oceans.

## Programs to Restore the Stratospheric Ozone Layer

In 1987, 27 countries, including the United States, 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 180 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

**UV-b Radiation Increases by Latitude**




*A 1996 study using satellite-based 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 to 1996. UV-b incidence is strongly dependent on latitude. At latitudes that cover the United States, UV-b levels are 4 to 5 percent higher than they were in 1986.*

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 to which people may be exposed 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. Measurements have shown that atmospheric concentrations of methyl chloroform are falling, indicating that emissions have 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 the second half of this century. All nations that signed the Protocol must complete implementation of ozone protection programs if full repair of the ozone layer is to happen.

# Conclusions

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.

## Acronyms

| | |
|---|---|
| CFCs | chlorofluorocarbons |
| $CO_2$ | carbon dioxide |
| CO | carbon monoxide |
| DU | Dobson units |
| EPA | U.S. Environmental Protection Agency |
| FCCC | Framework Convention on Climate Change |
| IMPROVE | Interagency Monitoring of Protected Visual Environments |
| IPCC | Intergovernmental Panel on Climate Change |
| km | kilometers |
| NAAQS | National Ambient Air Quality Standards |
| NAS | National Academy of Sciences |
| NCDC | National Climatic Data Center |
| NEI | National Emissions Inventory |
| NESDIS | National Environmental Satellite Data and Information Service |
| $NO_2$, $NO_x$ | nitrogen dioxide, nitrogen oxides |
| NO | nitric oxide |
| NOAA | National Oceanic and Atmospheric Administration |
| $O_3$ | ozone |
| Pb | lead |
| $PM_{10}$, $PM_{2.5}$ | particulate matter (10 μm or less, 2.5 μm or less in diameter) |
| ppm | parts per million |
| $SO_2$, $SO_x$ | sulfur dioxide, sulfur oxides |
| VOCs | volatile organic compounds |
| UV | ultraviolet |

## For Further information

Detailed information on Air Pollution Trends: **www.epa.gov/airtrends**

Real-Time Air Quality Maps and Forecasts: **www.epa.gov/airnow**

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

Office of Air and Radiation: **www.epa.gov/oar**

Office of Air Toxics: **www.epa.gov/ttn/atw**

Office of Air Quality Planning and Standards: **www.epa.gov/oar/oaqps**

Office of Transportation and Air Quality: **www.epa.gov/otaq**

Office of Atmospheric Programs: **www.epa.gov/air/oap.html**

Office of Radiation and Indoor Air: **www.epa.gov/air/oria.html**

Global Warming Emissions Information: **www.epa.gov/globalwarming/index.html**

Acid Rain Web site: **www.epa.gov/airmarkets/arplindex.html**

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**

Ozone Depletion Web site: **www.epa.gov/ozone/**

**United States Environmental Protection Agency**

Office of Air Quality and Standards
Air Quality Strategies and Standards Division
Research Triangle Park, NC

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