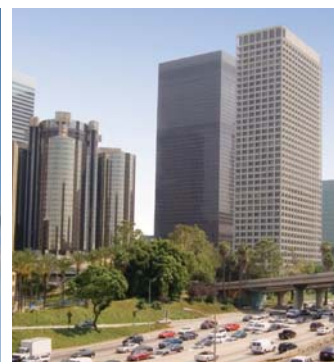


# Latest Findings on National Air Quality

STATUS AND TRENDS THROUGH 2006







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STATUS AND TRENDS THROUGH 2006

Contract No. EP-D-05-004  
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U.S. Environmental Protection Agency  
Office of Air Quality Planning and Standards  
Air Quality Assessment Division  
Research Triangle Park, North Carolina

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# HIGHLIGHTS

For more than 35 years, EPA has been working to reduce pollution and make the nation's air cleaner and healthier to breathe. This summary report highlights the agency's most recent evaluation of status and trends in our nation's air quality.

## LEVELS OF SIX PRINCIPAL POLLUTANTS CONTINUE TO DECLINE

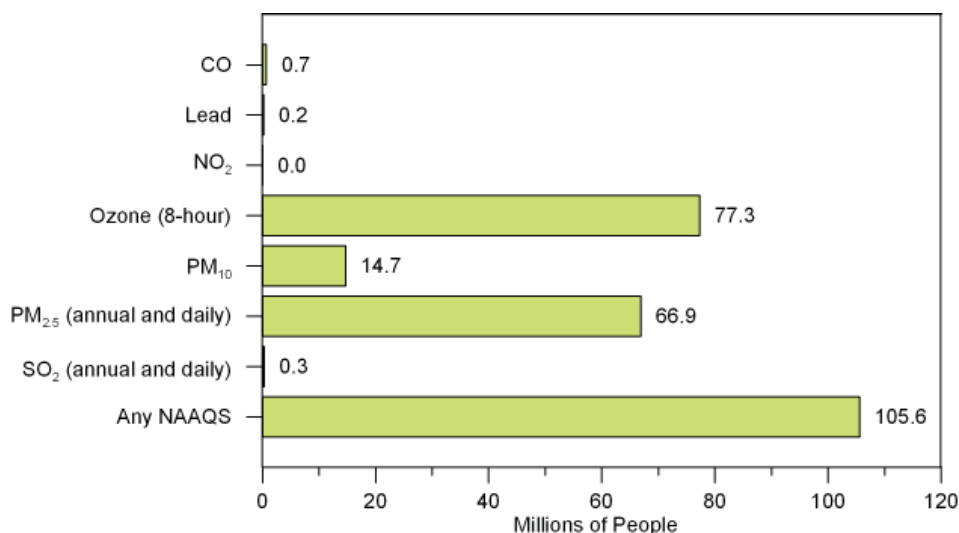
- Cleaner cars, industries, and consumer products have contributed to cleaner air for much of the United States. Since 1980, nationwide air quality, measured at more than a thousand locations across the country, has improved significantly for all six principal pollutants. These common pollutants are ground-level ozone, particle pollution, nitrogen dioxide, carbon monoxide, sulfur dioxide, and lead.
- Despite this progress, ground-level ozone and fine particle pollution (PM<sub>2.5</sub>) continue to present challenges in many areas of the country. Ozone and fine particle levels are continuing to decline. In 2006, 8-hour ozone concentrations were 9 percent lower than in 1990, and annual PM<sub>2.5</sub> concentrations were 14 percent lower than in the year 2000. But that same year, more than 100 million people lived in counties that exceeded national air quality standards for ozone or PM<sub>2.5</sub>.

## AIR TOXICS: MONITORING EXPANDS, BENZENE LEVELS DROP

- Twenty-three National Air Toxics Trends Stations (NATTS) are now fully operational, adding a consistent national network to the existing state and local monitors for toxic air pollutants.
- Benzene, a primary contributor to the cancer risk associated with air toxics exposure, is one of the most routinely and accurately monitored air toxics across the country. Benzene levels in the outdoor air declined about 17 percent between 2000 and 2005.
- Control programs for mobile sources and facilities such as chemical plants, dry cleaners, coke ovens, and incinerators were primarily responsible for reductions of roughly 35 percent in air toxics emissions between 1990 and 2002.

## ACID RAIN AND HAZE DECLINING

- EPA's Acid Rain Program continues to contribute to significant improvements in air quality and environmental health. The program's reductions in sulfur dioxide and nitrogen oxides have led to significant decreases in acid rain, contributing to improved water quality in lakes and streams. For example, between the 1989-1991 and 2004-2006 time periods, sulfate deposition decreased more than 30 percent in the Northeast and Midwest.



*Number of people living in counties with air quality concentrations above the level of the primary National Ambient Air Quality Standards (NAAQS) in 2006.*

Note: Multiple years of data are generally used to determine if an area attains the national standards. The chart above is for one year only.

- Visibility in scenic areas, which can be impaired by particles and gases in the air, has improved throughout the country. Only one location—Petrified Forest, Ariz.—shows degradation in visibility for the worst visibility days between 1996 and 2005.

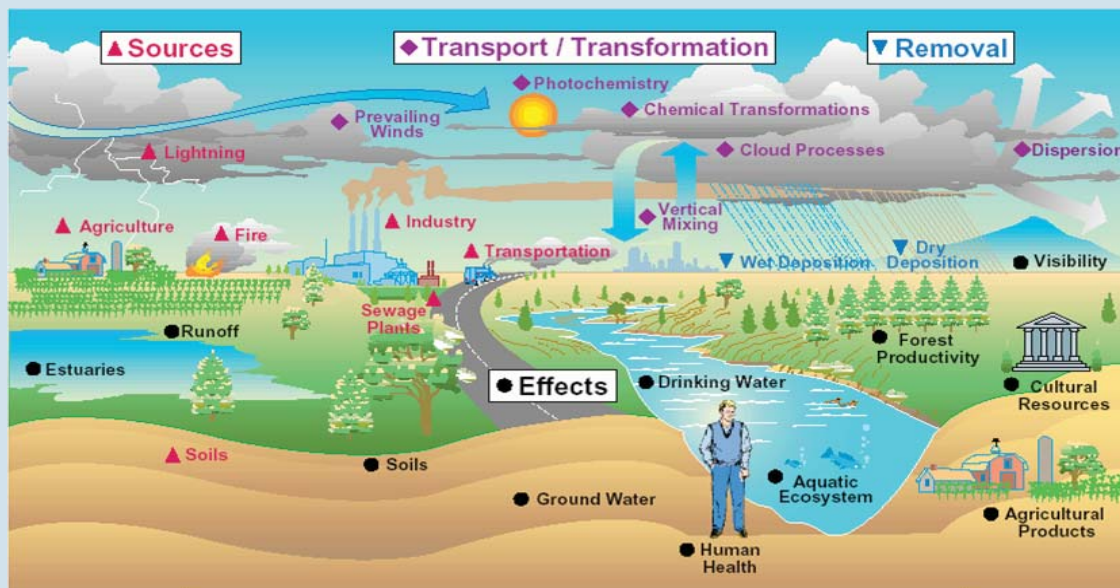
## CLIMATE AND INTERNATIONAL TRANSPORT: IMPROVING OUR UNDERSTANDING

- Research is under way to examine and improve our understanding of the links between air quality and climate: how air quality affects climate and how a warming climate could affect air quality.
- Researchers also are improving our understanding about how pollution moves – not just within North America, but also between continents.

## MORE IMPROVEMENTS ANTICIPATED

- EPA expects the air quality to continue to improve as recent regulations are fully implemented and states work to meet national ambient air quality standards. Among these rules are: the Clean Air Interstate Rule, the Clean Air Mercury Rule, the Tier II Vehicle and Gasoline Sulfur Program, the Heavy-Duty Highway Diesel Rule, the Clean Air Nonroad Diesel Rule, and the Mobile Source Air Toxics Rule.

### Air Pollution Pathways



The interrelationships among pollutants, sources, transport and transformation pathways, and environmental effects are complex. For example,

- Emissions from various sources contribute to ozone, particle pollution, and acid rain formation in the atmosphere.
- The photochemistry involved to form these pollutants is enhanced by sunlight.
- Fires contribute to the build-up of particle pollution.
- Winds disperse and transport pollution over large distances.
- Rain washes particles out of the atmosphere into streams and lakes.

These processes and interrelationships create many pathways and feedback systems through which human health and ecosystems are affected.

(Source: Adapted from National Science and Technology Council Committee on Environment and Natural Resources, Air Quality Research Subcommittee, 1999)

# SIX PRINCIPAL POLLUTANTS

To protect public health and the environment, EPA has established, and regularly reviews, national ambient air quality standards (NAAQS) for six principal air pollutants: ground-level ozone (O<sub>3</sub>), particulate matter (PM), nitrogen dioxide (NO<sub>2</sub>), carbon monoxide (CO), sulfur dioxide (SO<sub>2</sub>), and lead (Pb). Some of these pollutants (CO, SO<sub>2</sub>, and lead) are emitted directly from a variety of sources. Ozone is not directly emitted, but is formed when nitrogen oxides (NO<sub>x</sub>) and volatile organic compounds (VOCs) react in the presence of sunlight. NO<sub>2</sub> is formed in the air through the oxidation of nitric oxide (NO). PM, also known as particle pollution, can be directly emitted or formed when gaseous emissions react in the atmosphere. Particle pollution is regulated as PM<sub>2.5</sub>, or “fine particles” with diameters less than or equal to 2.5 micrometers (µm), and PM<sub>10</sub>, which includes all particles with diameters less than or equal to 10 µm.

This section discusses the six principal pollutants and shows how air quality and emissions have changed over time. Summary information across all six pollutants is presented for the time period 1980 to

2006. Several approaches are used here to look at the pollutants over time, including changes in (1) national air quality concentrations, (2) Air Quality Index “unhealthy” days, (3) air quality in nonattainment areas, and (4) national emissions.

## NATIONAL AIR QUALITY CONCENTRATIONS

Figure 1 shows national trends in the principal pollutants relative to their air quality standards, as measured by monitors located across the country. Most pollutants show a steady decline throughout the time period with a couple of exceptions. For example, lead declined in the 1980s and remained low for the remainder of the time period. Ozone declined in the 1980s, leveled off in the 1990s, and showed a notable decline after 2002. Most of the pollutants show a smooth, gradual trend from year to year, while ozone and PM<sub>2.5</sub> trends are not smooth and show year-to-year influences of weather conditions which contribute to their formation in the air.

All of the six principal pollutants show improvement over the 27-year period. While progress has been made nationally, there are still areas that have local air quality problems caused by one or more pollutants. Ozone and fine particle pollution continue to present air quality concerns throughout much of the U.S., with many monitors measuring concentrations above, or close to, national air quality standards.

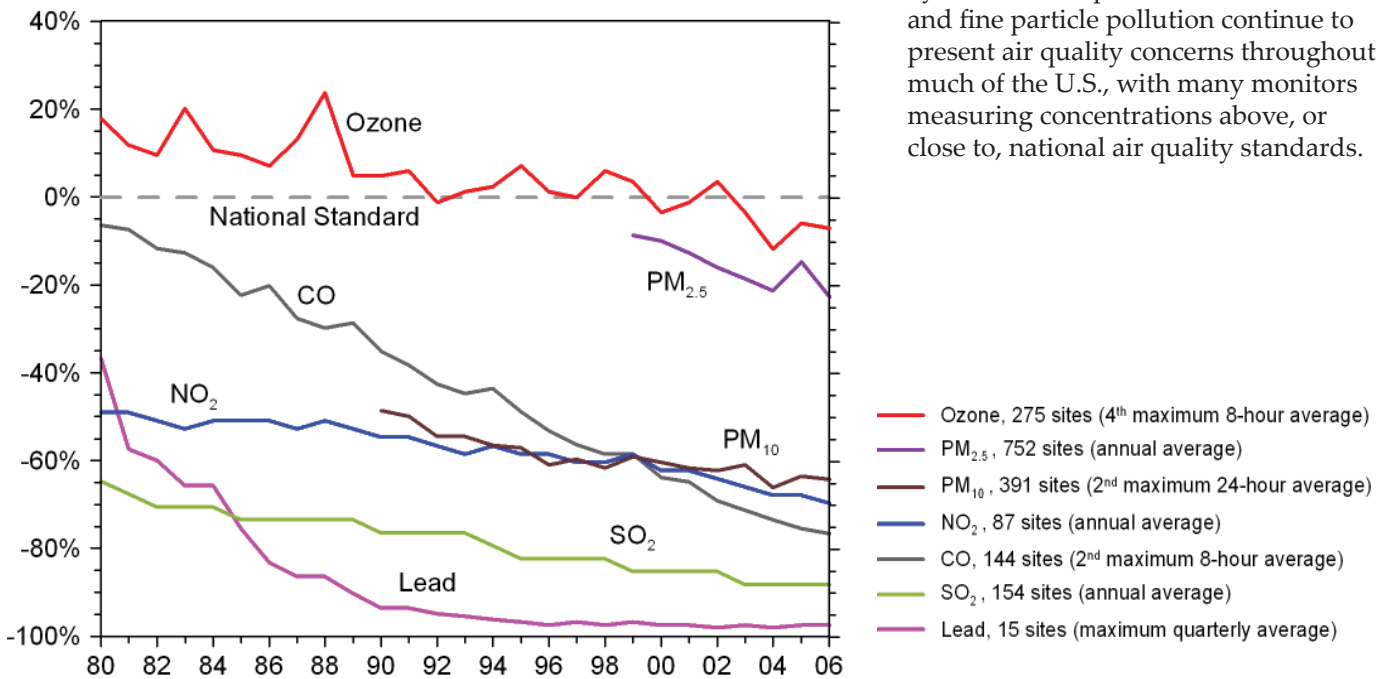


Figure 1. Comparison of national levels of the six principal pollutants to national ambient air quality standards, 1980-2006. National levels are averages across all sites with complete data for the time period.

Note: Air quality data for PM<sub>10</sub> and PM<sub>2.5</sub> start in 1990 and 1999, respectively.

### AIR QUALITY INDEX “UNHEALTHY” DAYS

The Air Quality Index (AQI) relates daily air pollution concentrations for ozone, PM<sub>2.5</sub>, NO<sub>2</sub>, CO, and SO<sub>2</sub> to health concerns for the general public. Daily forecasts allow people to take steps to protect their health when air pollution reaches levels that are unhealthy for them. Figure 2 shows how selected metropolitan areas fared in 2006 relative to previous years. Most areas had fewer unhealthy days in 2006 compared with the previous five years. Notable exceptions were Atlanta and Kansas City, with six more unhealthy days each in 2006 than the average of the previous five years. Most of the unhealthy days are due to ozone and/or particle pollution. Later in this report, the number of unhealthy days for ozone and particle pollution are shown separately.

### EPA’s Air Quality Index (AQI)

EPA provides an AQI based on five of the six principal pollutants: ozone, PM<sub>2.5</sub>, NO<sub>2</sub>, CO, and SO<sub>2</sub>. The AQI indicates a level of health concern. A value of 100 generally corresponds to the national air quality standard for each pollutant. Values below 100 are generally thought of as satisfactory. Values above 100 are considered to be unhealthy—at first for certain sensitive groups of people, then for everyone as the AQI values increase. For more information about the AQI, visit <http://www.airnow.gov>.



Air Quality Index (AQI) Values	Levels of Health Concern
0 to 50	Good
51-100	Moderate
101-150	Unhealthy for Sensitive Groups
151-200	Unhealthy
201-300	Very Unhealthy
301 to 500	Hazardous

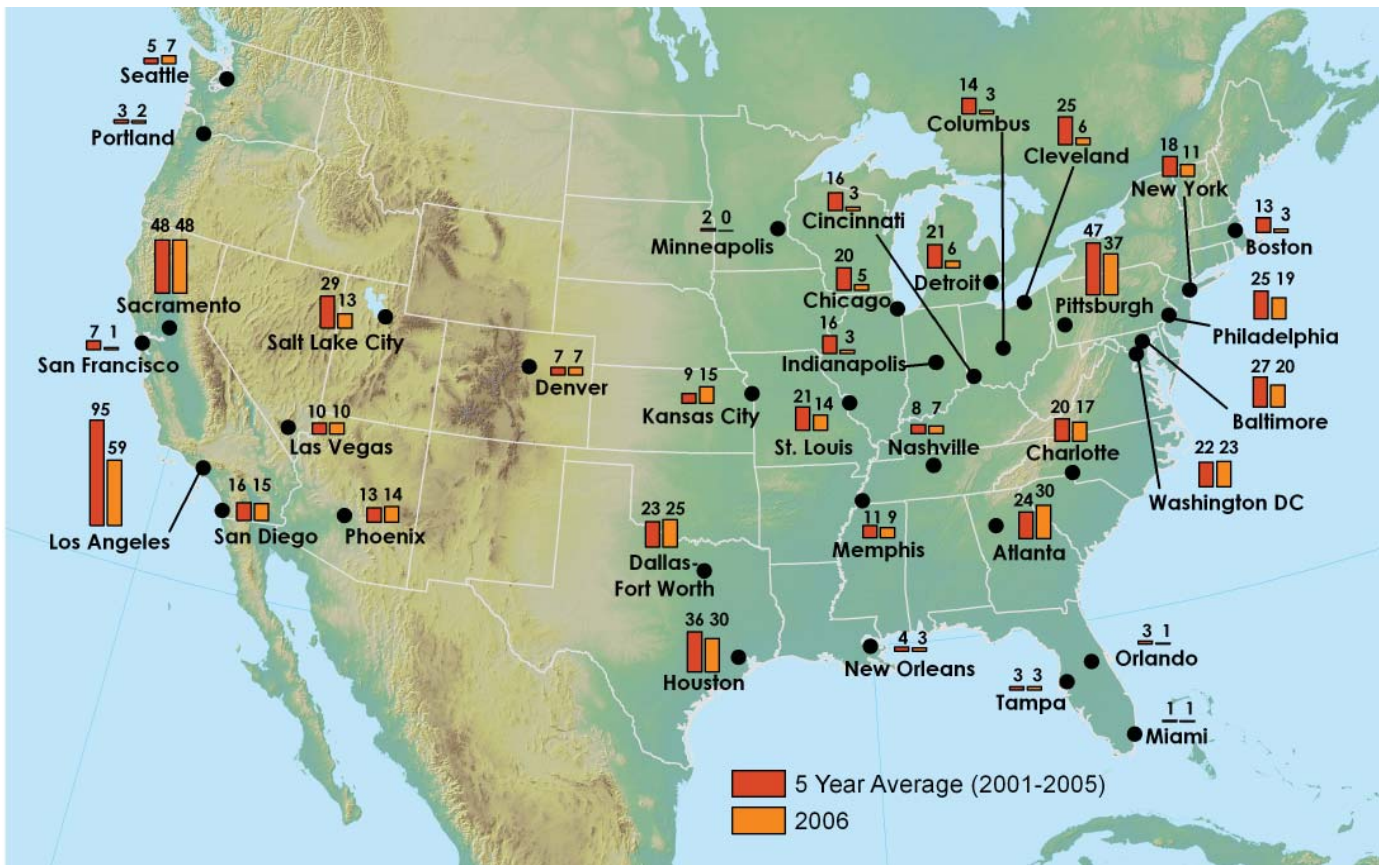


Figure 2. Number of days reaching Unhealthy for Sensitive Groups on the Air Quality Index for five of the six principal pollutants for 2001-2005 (average) vs. 2006.

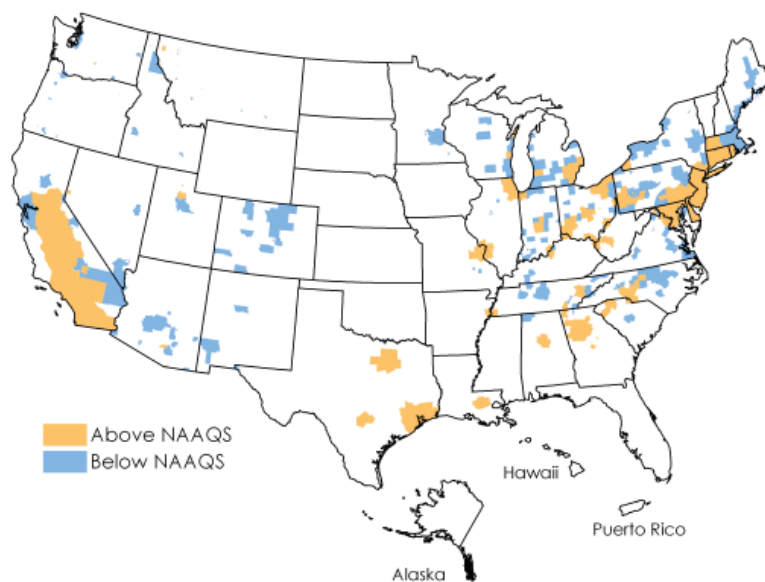


## AIR QUALITY IN NONATTAINMENT AREAS

Many areas of the country where air pollution levels exceeded the NAAQS have been designated “nonattainment.” Under the Clean Air Act, EPA and state, tribal, and local air quality planning agencies work together to develop air quality management plans to address the air pollution in these areas. Each year, EPA tracks air quality progress in areas identified as nonattainment by reviewing changes in measured concentrations with respect to the standards. Figure 3 shows which of these areas are above or below one or more of the standards as of 2006, using the most recent year(s) of data.

Air quality has improved in the areas that were originally designated nonattainment across all six principal pollutants. All of the original areas designated as nonattainment for NO<sub>2</sub>, CO, and SO<sub>2</sub> had air quality levels below their respective standards as of December 2006. Only one area was above the standard for lead, Herculaneum, Mo. For ozone, annual PM<sub>2.5</sub>, and PM<sub>10</sub>, a number of areas were above the standards: 35, 32, and 41 areas, respectively. Even though many areas were above the standard, there have been improvements in the concentration levels in the nonattainment areas. For example, the ozone

areas showed an 11 percent improvement, and the annual PM<sub>2.5</sub> areas showed a 6 percent improvement between the time of designation and 2006.



**Figure 3. Status of original nonattainment areas for one or more standards (i.e., ozone, annual PM<sub>2.5</sub>, PM<sub>10</sub>, NO<sub>2</sub>, CO, SO<sub>2</sub>, and lead) as of 2006.**

Notes: To determine NAAQS attainment, typically an average of multiple years of data is required for comparison with the standard. For information about Air Trends Design Values, visit <http://www.epa.gov/air/airtrends/values.html>.

## Review of the National Ambient Air Quality Standards

The Clean Air Act requires EPA to set two types of NAAQS for the principal air pollutants:

- **primary standards** to protect public health with an adequate margin of safety, including the health of sensitive populations such as asthmatics, children, and the elderly; and
- **secondary standards** to protect public welfare from adverse effects, including visibility impairment and effects on the environment (e.g., vegetation, soils, water, and wildlife).

The Clean Air Act requires periodic review of the science upon which the standards are based and the standards themselves. The current standards and the status of each review are shown below.

Pollutant	Primary Standard(s)	Secondary Standard(s)	Status of Review
PM <sub>2.5</sub>	15 µg/m <sup>3</sup> (annual) 35 µg/m <sup>3</sup> (daily)	Same as Primary	Review completed 2006 (daily PM <sub>2.5</sub> standard strengthened and annual PM <sub>10</sub> standard revoked)
PM <sub>10</sub>	150 µg/m <sup>3</sup> (daily)	Same as Primary	Next review initiated 2007
O <sub>3</sub>	0.08 ppm (8-hour)	Same as Primary	Proposed tightening primary and secondary standards July 2007; final decision March 2008
Pb	1.5 µg/m <sup>3</sup>	Same as Primary	To be completed September 2008
NO <sub>2</sub>	0.053 ppm (annual)	Same as Primary	To be completed 2010
SO <sub>2</sub>	0.03 ppm (annual) 0.14 ppm (daily)	0.5 ppm (3-hour)	To be completed 2010
CO	9 ppm (8-hour) 35 ppm (1-hour)	None	Schedule under development

Units of measure are parts per million (ppm) or micrograms per cubic meter of air (µg/m<sup>3</sup>). For more information about the standards, visit <http://www.epa.gov/ttn/naaqs/>.

## NATIONAL EMISSIONS

EPA tracks direct emissions of air pollutants and emissions that contribute to air pollution formation. Emissions data are compiled from many different sources, including industry and state, tribal, and local agencies. Some emissions data are based on actual measurements, while others are estimates.

Since 1980, emissions of the six principal pollutants have declined significantly, with the greatest drop in lead, as shown in Figure 4. The removal of lead from gasoline is primarily responsible for the 97 percent decrease in lead emissions.

During that same time period, NO<sub>x</sub> emissions have dropped by one third, and VOC, SO<sub>2</sub>, and CO emissions have been cut by roughly one half. Combined, the emissions of the six principal pollutants dropped 49 percent since 1980, as shown in Figure 5.

All of this progress has occurred while the U.S. economy continued to grow, Americans drove more miles, and population and energy use increased. These emission reductions resulted from a variety of control programs, from regulations at the federal, state, local, and regional level to voluntary partnerships between federal, state, local, and tribal governments, academia, industrial groups, and environmental organizations.

The following sections provide more information on each pollutant, including where the pollutant comes from, its health and environmental effects, and more detailed trends in air quality and emissions between 1990 and 2006. The ozone and PM<sub>2.5</sub> sections also show how these two pollutants are affected by weather and the extent to which they contribute to the number of unhealthy days in selected cities. In addition, the PM<sub>2.5</sub> section includes regional trends for the different components of PM<sub>2.5</sub>.

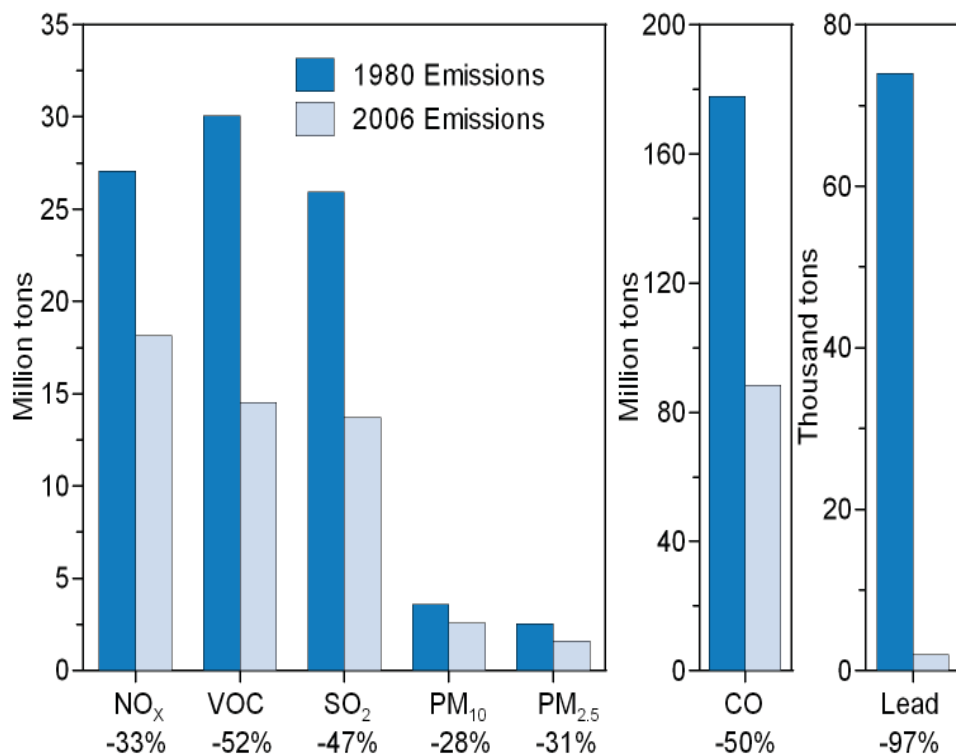


Figure 4. Comparison of national annual emissions, 1980 vs. 2006.

Notes:  
 PM<sub>2.5</sub> estimates are for 1990 vs. 2006.  
 PM<sub>10</sub> estimates are for 1985 vs. 2006.

### Emissions Used in this Report

- PM emissions are direct emissions only.
- PM emissions do not include condensibles, fires, or dust sources.
- VOC and NO<sub>x</sub> emissions are from anthropogenic (human activity) sources only.
- In most cases, emission trends for major sources are shown.
- Emissions were derived from 1996, 1999, and 2002 inventories, except for NO<sub>x</sub> and SO<sub>2</sub> emissions from electric generating units, which come from measured data.
- Emissions inventories are compiled using the best methods and measurements available at the time.

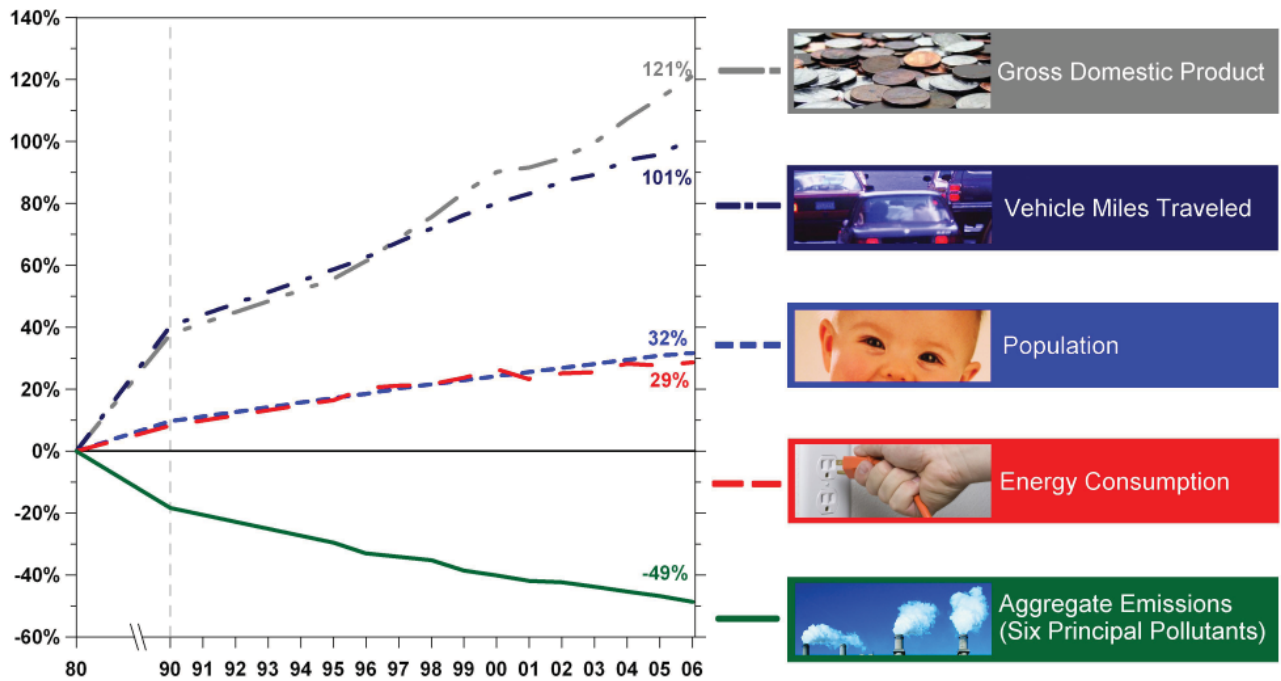
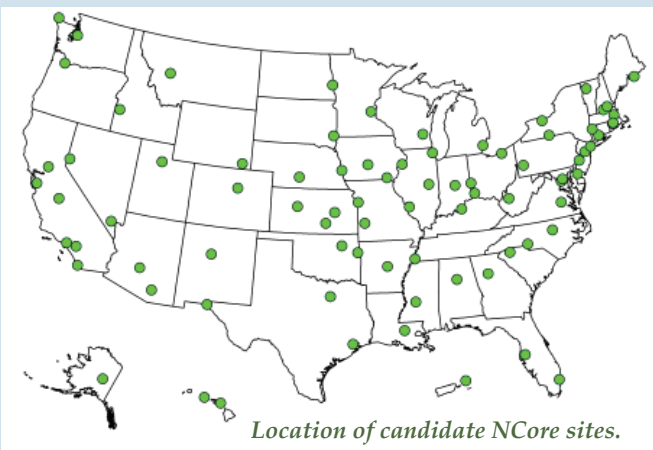


Figure 5. Comparison of growth measures and emissions, 1980-2006.

### New National Monitoring Network



The National Core Monitoring Network (NCore) will provide a network of monitoring sites (owned and operated by cities and states) that measure the principal pollutants (ozone, particles,  $\text{NO}_2$ , CO,  $\text{SO}_2$ , and lead), related gases (like VOCs and  $\text{NO}_x$ ), and basic meteorology. NCore is primarily designed to measure very low-level concentrations to support air quality analyses and health effects studies. Sites will be placed in urban (about 55 sites) and rural (about 20 sites) locations throughout the country to help characterize regional and urban air pollution. Information provided by this network will improve our understanding of the relationships among air quality pollutants and meteorology. For information about the NCore network, visit <http://www.epa.gov/ttn/amtic/files/ambient/monitorstrat/naamstrat2005.pdf>.

# GROUND-LEVEL OZONE (O<sub>3</sub>)

## NATURE AND SOURCES

Ozone can be helpful or harmful, depending on its location. In the stratosphere – 10 to 30 miles above the Earth – a layer of ozone provides protection by filtering the sun’s harmful rays. But at ground level, ozone can harm both human health and the environment.

Ground-level ozone forms when emissions of nitrogen oxides (NO<sub>x</sub>) and volatile organic compounds (VOCs) react in the presence of sunlight. These ingredients come from motor vehicle exhaust, power plant and industrial emissions, gasoline vapors, chemical solvents, and some natural sources. Because ground-level ozone forms more readily in hot, sunny weather, it is known as a summertime air pollutant. High ozone levels can occur anywhere: wind can carry ozone and the pollutants that form it hundreds of miles away from their original sources. Changes in emissions, combined with changing weather patterns, contribute to yearly differences in ozone concentrations from region to region.

## HEALTH AND ENVIRONMENTAL EFFECTS

Breathing ground-level ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, and congestion. It can aggravate bronchitis, emphysema, and asthma. Ozone can also reduce lung function and inflame the lining of the lungs. Repeated exposure may permanently scar lung tissue. People with lung disease, children, older adults, and people who are active outdoors can be affected when ozone levels are unhealthy.

Ground-level ozone can also have detrimental effects on plants and ecosystems. These effects include (1) interfering with the ability of sensitive plants to produce and store food, (2) damaging the leaves trees and other plants, and (3) reducing crop yields and forest growth.

*Figure 6. National 8-hour ozone air quality trend, 1990-2006 (average of annual fourth highest daily maximum 8-hour concentrations).*

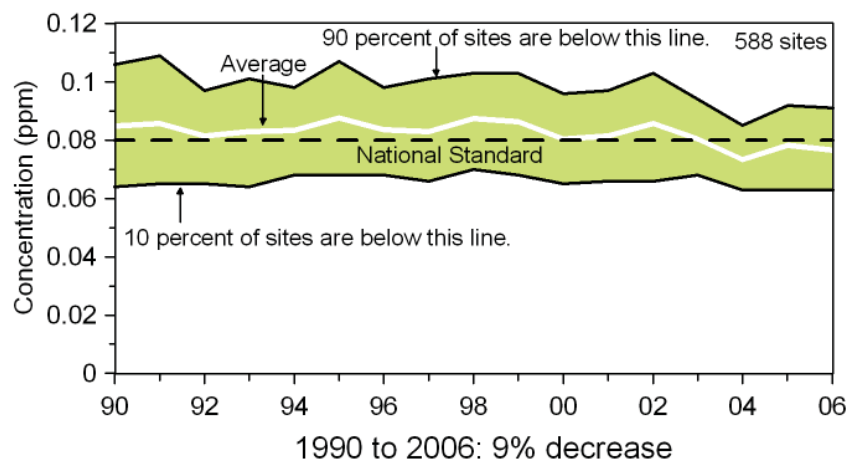
## TRENDS IN OZONE CONCENTRATIONS

Nationally, ozone concentrations were 9 percent lower in 2006 than in 1990, as shown in Figure 6. The trend showed little change throughout the 1990s with a notable decline after 2002. Concentrations in 2006 were the second lowest over the 17-year period.

For each monitoring location, the map in Figure 7 shows whether ozone concentrations increased, decreased, or stayed about the same over the trend period. The sites that showed the greatest improvement were the ones with the highest concentrations in 1990. For example, southern California had some of the highest ozone concentrations in the nation in 1990, but showed more improvement than any other area (a decline of over 0.040 ppm). Other sites in California, plus the Northeast, Midwest, and Texas showed more than 0.021 ppm improvement.

Eleven sites showed an increase of greater than 0.005 ppm. Of the 11 sites that showed an increase, nine had air quality concentrations below the level of the ozone standard (0.08 ppm) for the most recent year of data; only Maricopa County, Ariz., and Clay County, Mo., were above.

Figure 8 shows a snapshot of ozone concentrations in 2006. The highest ozone concentrations were located in California and Texas. Overall, the greatest improvements were in or near urban areas while the greatest increases were in less populated or rural areas. Increases in rural areas raise concerns about ozone’s detrimental effect on plants and ecosystems.



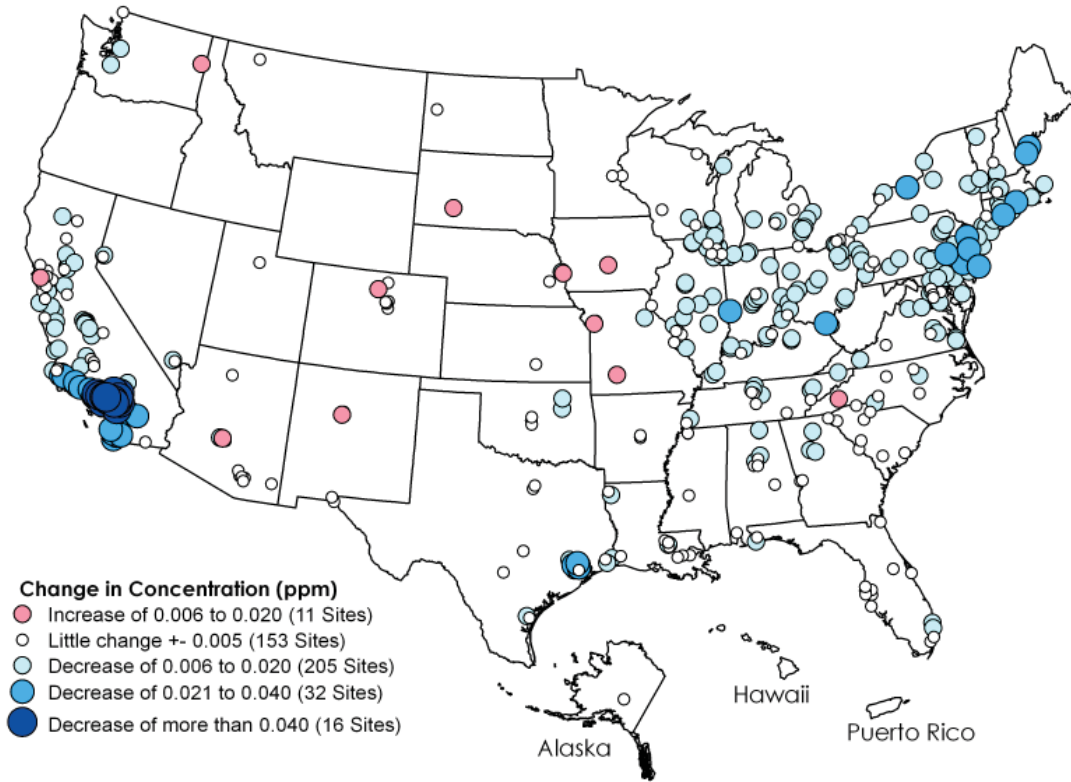


Figure 7. Change in ozone concentrations in ppm, 1990-1992 vs. 2004-2006 (3-year average of annual fourth highest daily maximum 8-hour concentrations).

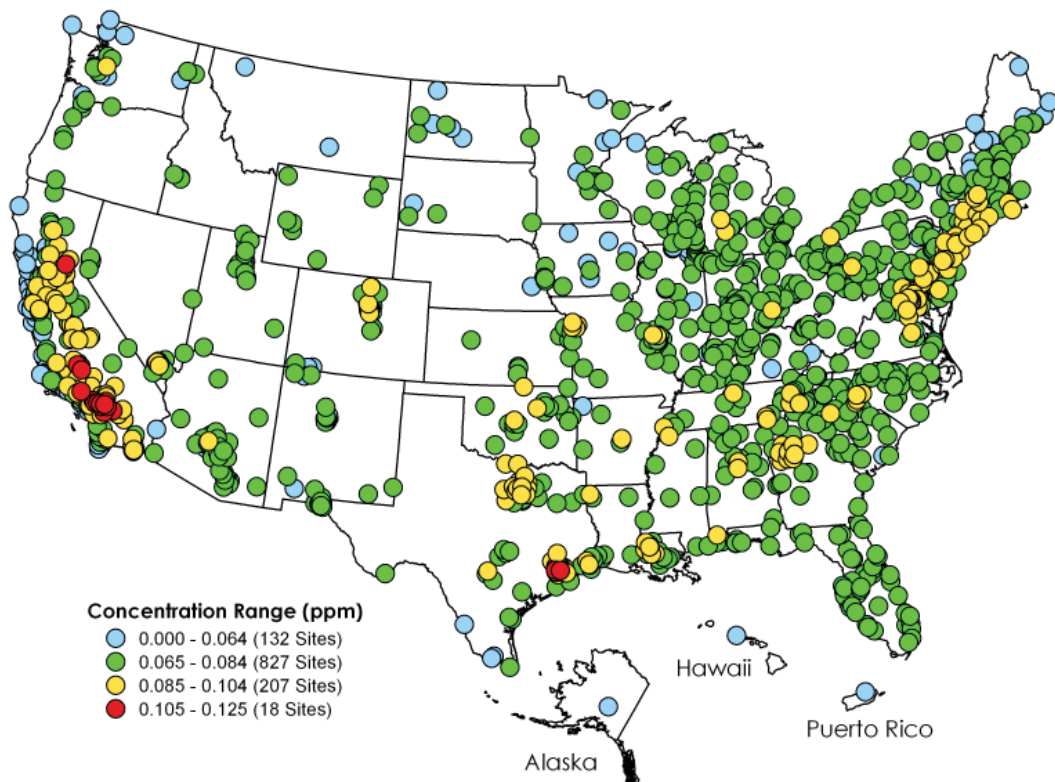


Figure 8. Ozone concentrations in ppm, 2006 (fourth highest daily maximum 8-hour concentrations).

Figure 9 shows that all selected areas in the East had fewer unhealthy ozone days in 2006 compared with the average from the previous five years (2001-2005), with the exception of Atlanta and Kansas City. In the West, Los Angeles and Sacramento had the most unhealthy ozone days in 2006 (over 40 days each), though Los Angeles had fewer unhealthy ozone days in 2006 than its average from the previous five years.

**TRENDS IN OZONE-FORMING EMISSIONS**

Ozone is formed by the reaction of VOCs and NO<sub>x</sub> in the presence of sunlight. Because ozone is mostly a

summer-season pollutant, emissions are shown here for the summer only (May-September). The year 1997 was selected as a base year for these ozone analyses because of the change in methodology for VOC and NO<sub>x</sub> emissions in 1996. Figure 10 shows that during the period 1997 to 2006, summer emissions of VOCs and NO<sub>x</sub> decreased 20 and 30 percent, respectively. The majority of these emission reductions were from transportation and fuel combustion sources. After 2002, the largest reductions were in NO<sub>x</sub> emissions from fuel combustion sources.

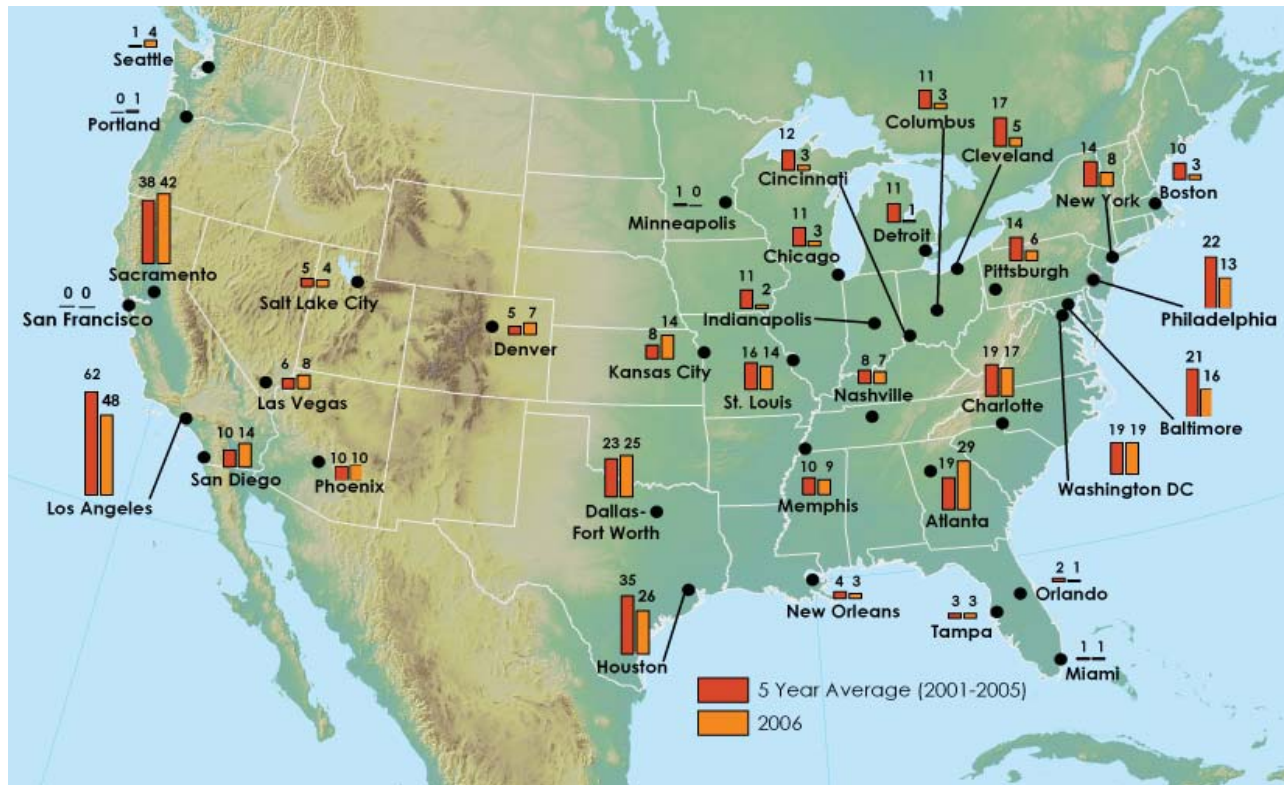


Figure 9. Number of days reaching Unhealthy for Sensitive Groups for ozone on the AQI for 2001-2005 (average) vs. 2006.

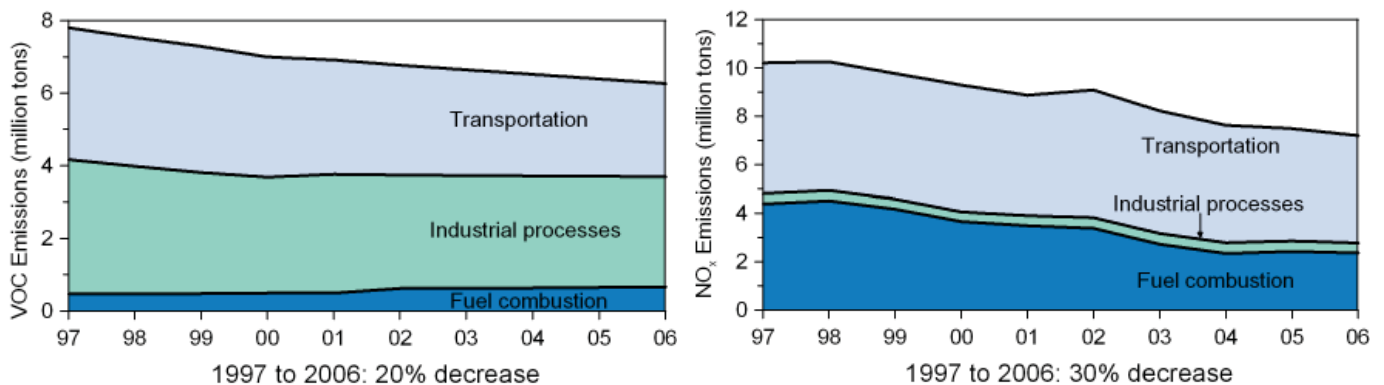


Figure 10. National trends in summertime ozone-forming emissions, 1997-2006.

Notes: Trends do not include miscellaneous emissions. Except for NO<sub>x</sub> emissions from electric generating units, summertime emissions of VOC and NO<sub>x</sub> were estimated using 5/12 of annual emissions.

## WEATHER INFLUENCE ON OZONE

Weather plays an important role in the formation of ozone. A large number of hot, dry days can lead to higher ozone levels in any given year, even if ozone-forming emissions do not increase. Figure 11 shows ozone trends for 1997 through 2006, before and after adjusting for weather at selected sites. The hot, dry summer of 2002 contributed to high concentrations of ozone; after those levels were adjusted to remove the influence of weather, ozone concentrations were much lower. In 2004, the weather was cooler and more humid, so ozone was less likely to form; removing the influence of weather shows higher ozone concentrations that year.

Ozone concentrations decreased 3 percent from 1997 to 2006. When the influence of weather is removed, the effect of changes in emissions on air quality is easier to see, and ozone shows a 7 percent decrease from 1997 to 2006. Much of the improvement occurred in the East.

The average decrease among 79 sites in the East was 10 percent, while the average decrease among 54 sites in the rest of the U.S. was 1 percent.

In Figure 11, both trend lines show a decline in ozone concentrations between 2002 and 2004. This decline is mostly due to reductions in fuel combustion NO<sub>x</sub> emissions under the Acid Rain Program, which began in 1995, and implementation of the NO<sub>x</sub> SIP Call rule, which led to sustained reductions in the East beginning in 2003 and 2004. The weather-adjusted trend line confirms that the decrease in ozone concentrations between 2002 and 2004 was caused by something other than the weather. The weather-adjusted trend line also shows lower ozone concentrations in 2005 and 2006, with concentrations similar to the 2004 levels. Thus, ozone improvements achieved through emission reductions in 2004 were maintained.

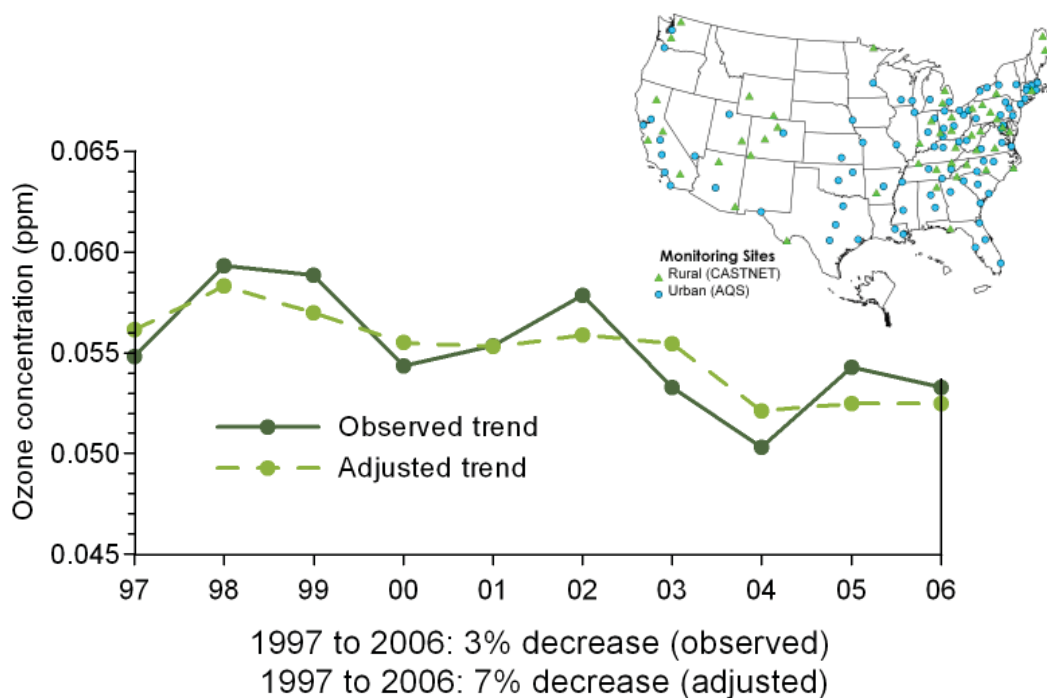


Figure 11. Trends in average summertime daily maximum 8-hour ozone concentrations, before and after adjusting for weather, and the location of urban and rural monitoring sites used in the average.

Notes: Urban areas are represented by multiple monitoring sites. Rural areas are represented by a single monitoring site. For more information about the Air Quality System (AQS), visit <http://www.epa.gov/ttn/airs/airsaqs>. For more information about the Clean Air Status and Trends Network (CASTNET), visit <http://www.epa.gov/castnet>.

### Air Quality, Emissions, and Weather

Ozone and some particles are formed by the reaction of emissions in the presence of sunlight, so both emissions and weather conditions contribute to air pollution levels. As weather conditions vary from year to year, pollutant levels could be higher in years with weather conditions conducive to their formation—even when emission control programs are working as expected.

To better understand how these pollutants are changing, EPA assesses both the changes in emissions as well as weather conditions. EPA uses a statistical model to remove the influence of weather. This provides a clearer picture of the underlying pollutant trend from year to year, making it easier to see the effect of changes in emissions on air quality.

For information on the statistical model, read "The effects of meteorology on ozone in urban areas and their use in assessing ozone trends," by Louise Camalier, William Cox, and Pat Dolwick of the U.S. EPA. *Atmospheric Environment*, In Press, 2007.

Figure 12 shows the effect of the NO<sub>x</sub> SIP Call in the East, where the program was implemented. Weather-adjusted average summertime ozone concentrations were compared between the summers of 2000 and 2001 versus 2005 and 2006 (the years before and after the largest NO<sub>x</sub> reductions). The large declines in ozone occurred throughout the central portions of the region, including North Carolina, Virginia, West Virginia, Pennsylvania, and Ohio. On average, ozone concentrations declined by 0.005 ppm (about 8 to 10 percent) over the region.

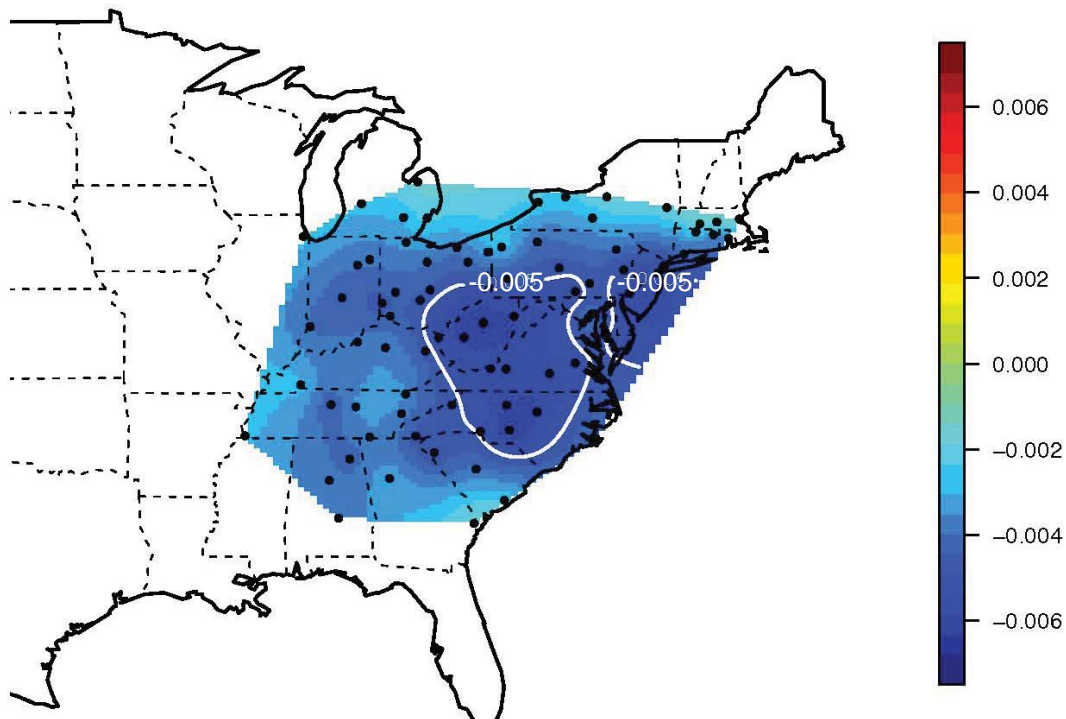


Figure 12. Changes in summertime daily maximum 8-hour ozone concentrations (ppm) between 2000-2001 (average) and 2005-2006 (average). Concentrations have been adjusted using weather variables such as temperature and humidity. Estimated changes for locations farther from monitoring sites (dots on map) have the largest uncertainty.

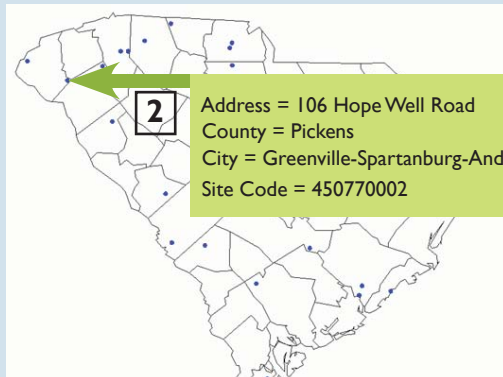
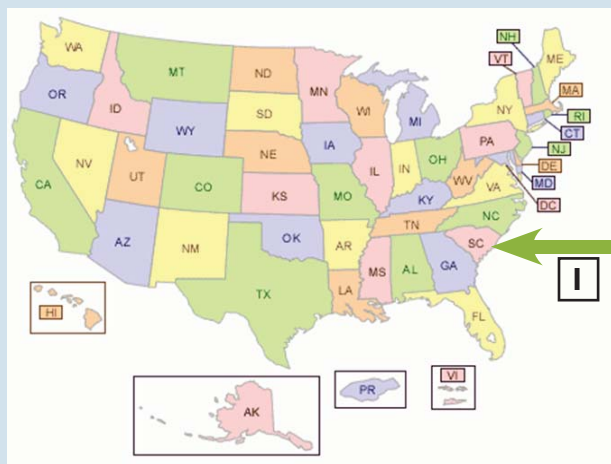
### Future Air Programs Will Bring Cleaner Air to Many Areas

EPA's Clean Air Interstate Rule (CAIR) will help reduce particle pollution and ozone in the East by cutting emissions of SO<sub>2</sub> by 70 percent and NO<sub>x</sub> by 60 percent over 2003 levels. The Clean Air Mercury Rule (CAMR) will build on CAIR to reduce utility emissions of mercury by nearly 70 percent at full implementation. This rule makes the United States the first country to regulate mercury emissions from utilities. In addition, recent national mobile source regulations will help reduce emissions of toxic air pollutants, PM, NO<sub>x</sub>, and VOCs from new passenger vehicles, heavy-duty diesel engines, and other mobile sources. Together, these programs create a strategy to reduce multiple air pollutants throughout the U.S.



## Where You Live

Air quality trends can vary from one area to another. Local trends are available at individual monitoring locations for all pollutants with enough historical data, <http://www.epa.gov/airtrends/where.html>. Trends in ozone adjusted for weather conditions are also available, <http://www.epa.gov/airtrends/weather.html>.



Address = 106 Hope Well Road  
County = Pickens  
City = Greenville-Spartanburg-Anderson, S.C.  
Site Code = 450770002

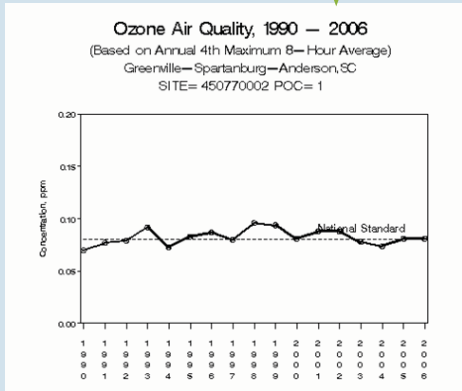


### Local Trends in Ozone Levels

Simple steps to obtain more information

1. Pick the state
2. Pick the site
3. See the trend

<http://www.epa.gov/airtrends/ozone.html>



# PARTICLE POLLUTION

## NATURE AND SOURCES

Particle pollution is a 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 that they can only be detected with an electron microscope. EPA regulates particle pollution as  $PM_{2.5}$  (fine particles) and  $PM_{10}$  (all particles 10 micrometers or less in diameter). The  $PM_{10}$  discussion follows the  $PM_{2.5}$  discussion in this section.

Generally, coarse particles are directly emitted, while fine particles are mostly formed in the atmosphere. Directly emitted particles come from sources such as construction sites, unpaved roads, fields, smokestacks (combustion sources), or fires. Other particles form when gases react in the atmosphere. These are sulfur dioxide ( $SO_2$ ), nitrogen oxides ( $NO_x$ ), and volatile organic compounds (VOCs) emitted mostly from power plants, industries, and automobiles; and ammonia ( $NH_3$ ), mostly from agriculture. Particles formed in the atmosphere make up most of the fine particle pollution in the U.S. The chemical composition of particles depends on location, time of year, and weather. In addition to changes in emissions, weather patterns also contribute to yearly differences in  $PM_{2.5}$  concentrations from region to region.

## HEALTH AND ENVIRONMENTAL EFFECTS

Particle pollution—especially fine particles—contains microscopic solids or liquid droplets that are so small they can get deep into the lungs and cause serious health problems. Numerous scientific studies have linked particle pollution exposure to a variety of health problems including (1) increases in respiratory symptoms such as irritation of the airways, coughing, or difficulty breathing; (2) decreased lung function; (3) aggravated asthma; (4) development of chronic bronchitis; (5) irregular heartbeat; (6) heart attacks; and (7) premature death. People with heart or lung disease, the elderly, and children are at the highest risk from exposure to particles. In addition to health problems, particle pollution is the major cause of reduced visibility and ecosystem damage in many parts of the U.S., including national parks and wilderness areas.

## TRENDS IN $PM_{2.5}$ CONCENTRATIONS

There are two standards for  $PM_{2.5}$ : an annual standard ( $15 \mu\text{g}/\text{m}^3$ ) and a daily standard ( $35 \mu\text{g}/\text{m}^3$ ). The national monitoring network for  $PM_{2.5}$  began in 1999 and was fully implemented in 2000. Nationally, annual  $PM_{2.5}$  concentrations declined by 14 percent between 2000 and 2006, as shown in Figure 13. Daily  $PM_{2.5}$  concentrations have a similar trend with a 15 percent decline.

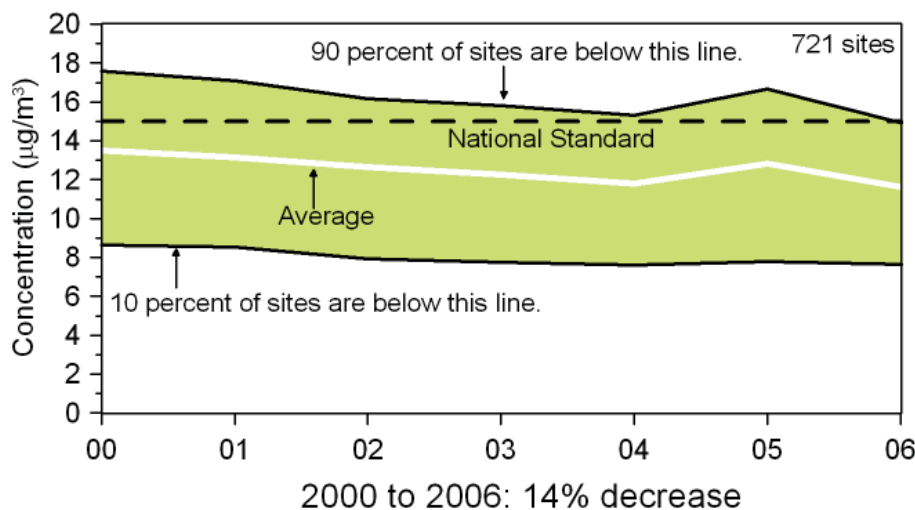


Figure 13. National  $PM_{2.5}$  air quality trend, 2000-2006 (annual average).

Note: Roughly 10 percent of sites are still above the standard in 2006.

The national trend for PM<sub>2.5</sub> shows a steady decline since 2000 with the exception of a temporary increase in 2005, which is discussed on pages 18 and 19.

For each monitoring location, the map in Figure 14 shows whether PM<sub>2.5</sub> increased, decreased, or stayed about the same between 2000 and 2006. Almost all of the sites show a decline in PM<sub>2.5</sub> during this period. The areas that showed the greatest improvement were

the ones that had the highest concentrations in 2000, including Southern California. Eight sites showed an increase greater than 1 µg/m<sup>3</sup> (Juno and Anchorage, Alaska; Nogales, Ariz.; Klamath Falls, Ore.; New Orleans, La.; El Paso and Houston, Texas; Vilas County, Wis.). Of the eight areas that showed an increase, four were below the level of the annual PM<sub>2.5</sub> standard for the most recent year of data and four were above. The four areas above were New Orleans, Nogales, El Paso, and Houston.

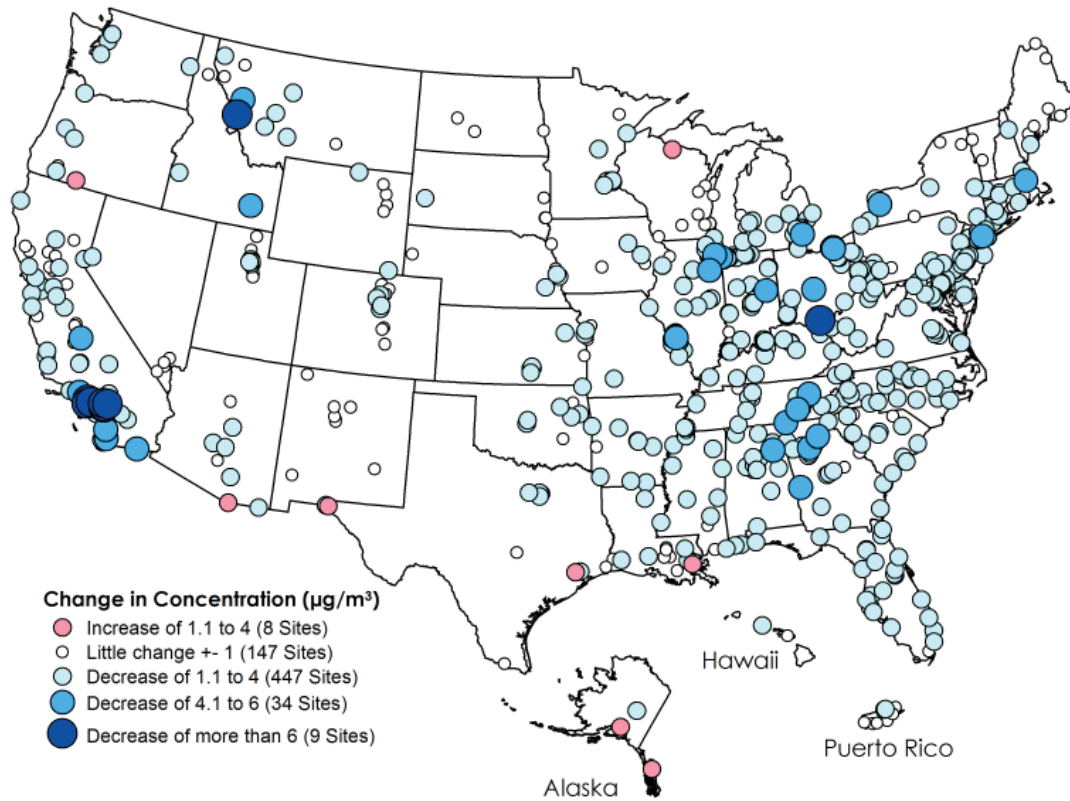


Figure 14. Change in PM<sub>2.5</sub> concentrations in µg/m<sup>3</sup>, 2000 vs. 2006 (annual average).

Note: The national monitoring network for PM<sub>2.5</sub> began in 1999 and was fully implemented in 2000. Three years of data are used to determine if an area meets the annual PM<sub>2.5</sub> national standard. The map above shows the difference between individual years.



In 2006, annual and daily  $PM_{2.5}$  concentrations were generally the lowest of the seven-year period. As shown in Figure 15, the highest annual  $PM_{2.5}$  concentrations were in Alabama, Pennsylvania, and California. The highest daily  $PM_{2.5}$  concentrations were in California, Arizona, and Pennsylvania. Some sites had high daily  $PM_{2.5}$  concentrations but low annual  $PM_{2.5}$  concentrations, and vice versa.

Most of the metropolitan areas displayed in Figure 16 had fewer unhealthy AQI days due to particle pollution in 2006 compared with the average from the previous five years (2001-2005). Los Angeles, Salt Lake City, and Cleveland had the largest decreases in the number of unhealthy days.

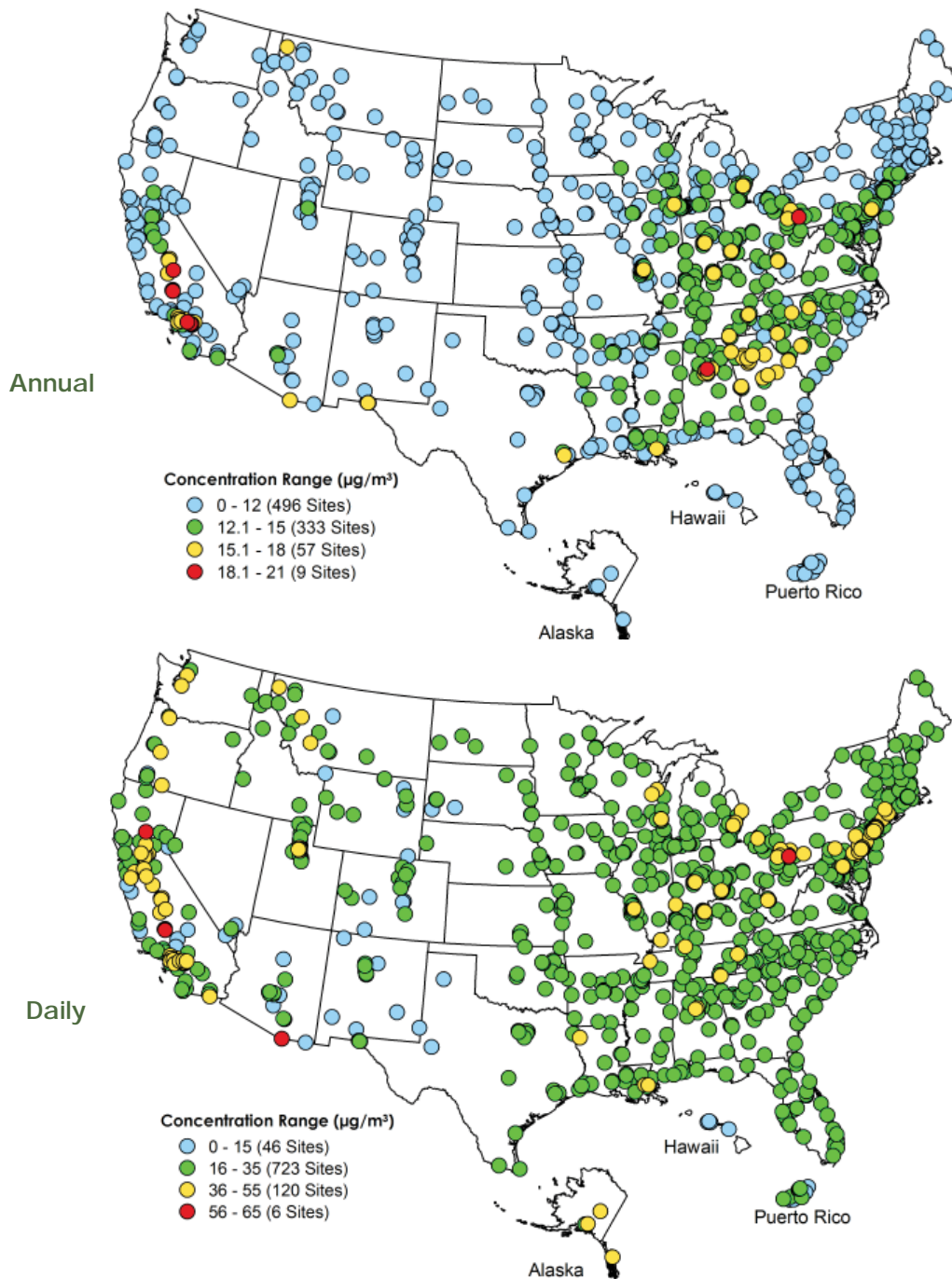


Figure 15. Annual average and daily (98th percentile 24-hour concentrations)  $PM_{2.5}$  concentrations in  $\mu\text{g}/\text{m}^3$ , 2006. Note: In 2006, EPA revised daily  $PM_{2.5}$  standards from 65 to 35  $\mu\text{g}/\text{m}^3$ .

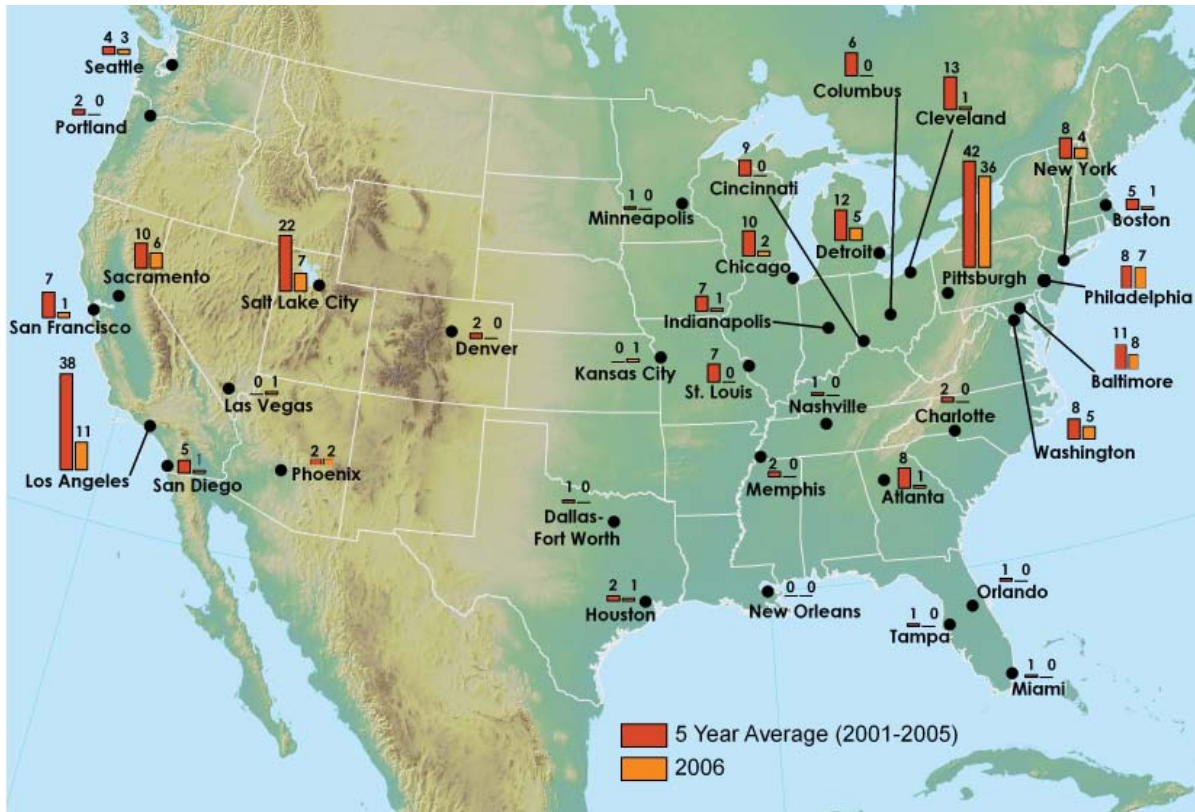
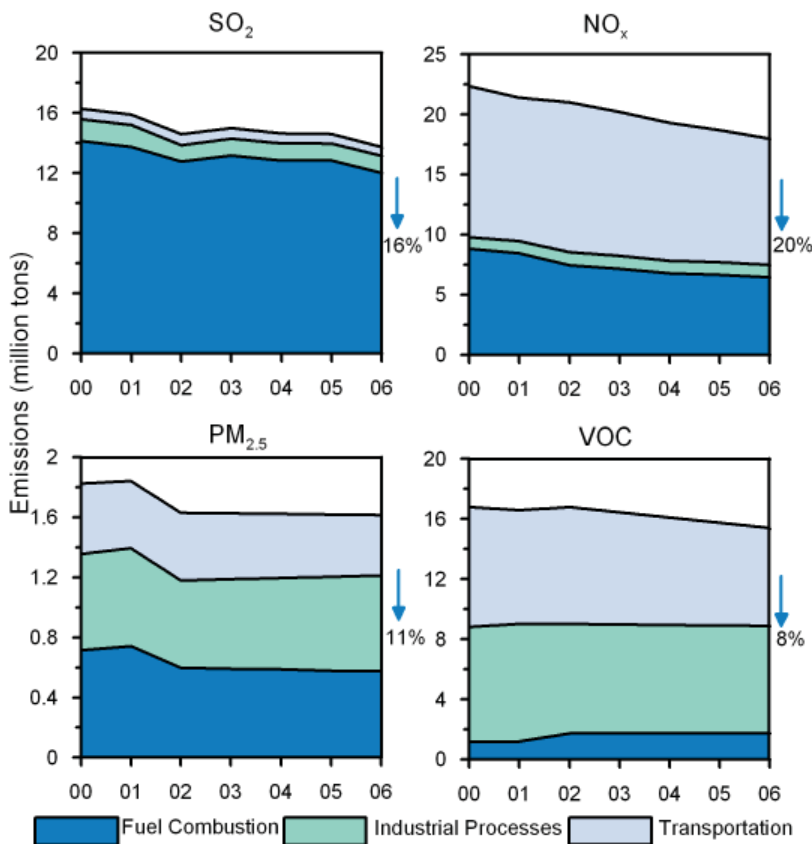


Figure 16. Number of days reaching Unhealthy for Sensitive Groups for PM<sub>2.5</sub> on the AQI for 2001-2005 (average) vs. 2006.



### TRENDS IN PM<sub>2.5</sub>-FORMING EMISSIONS

Nationally, between 2000 and 2006, SO<sub>2</sub>, NO<sub>x</sub>, VOC, and directly emitted PM<sub>2.5</sub> emissions decreased by 16, 20, 8, and 11 percent, respectively, as shown in Figure 17. The contribution of wildfires is not shown here. In fire-conductive years, up to 20 percent of direct PM<sub>2.5</sub> emissions may be from wildfires; normally wildfire emissions are closer to 4 percent.

Figure 17. National trends in annual direct PM<sub>2.5</sub> and PM<sub>2.5</sub>-forming emissions, 2000-2006.

### WEATHER INFLUENCE ON PM<sub>2.5</sub>

Weather plays an important role in the formation of PM<sub>2.5</sub> (see “Seasonal Influences” below). Figure 18 shows PM<sub>2.5</sub> trends before and after adjusting for weather at selected sites. PM<sub>2.5</sub> concentrations decreased 16 percent from 2000 through 2006. When the influence of weather is removed, the effect of changes in emissions on air quality is easier to see, and

PM<sub>2.5</sub> shows an 11 percent decrease from 2000 through 2006. The observed PM<sub>2.5</sub> levels in 2005 are lower after removing the influence of weather. Without the influence of weather, the underlying national trend in PM<sub>2.5</sub> shows a moderate decline over the past several years and is more consistent with national trends in emissions.

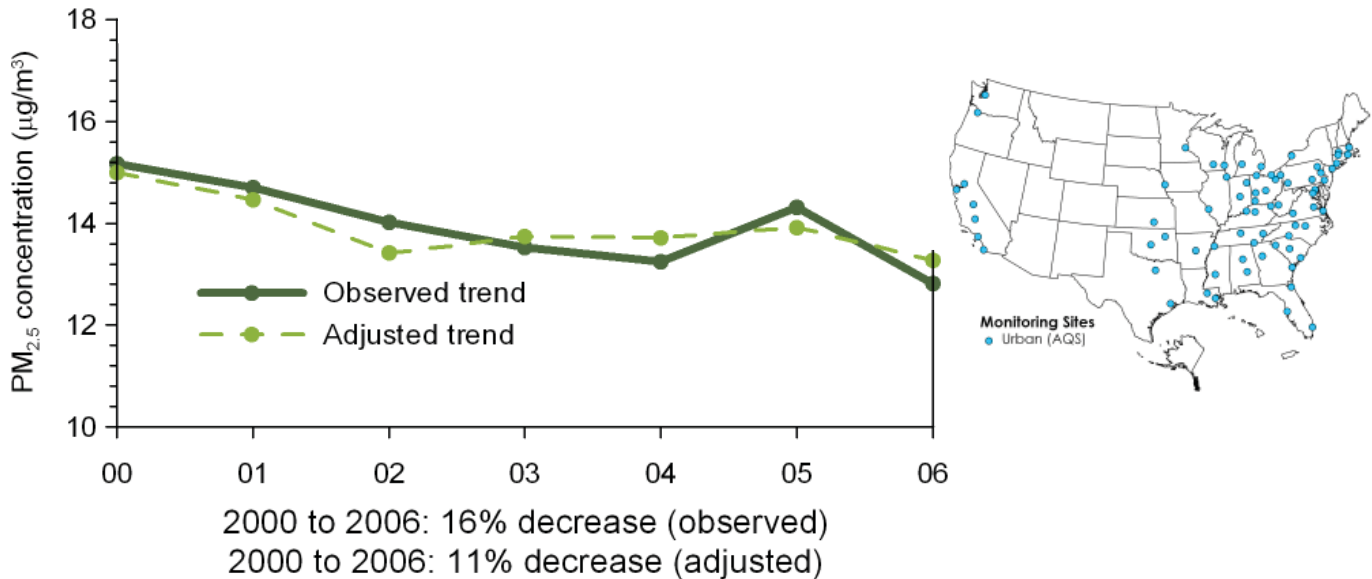
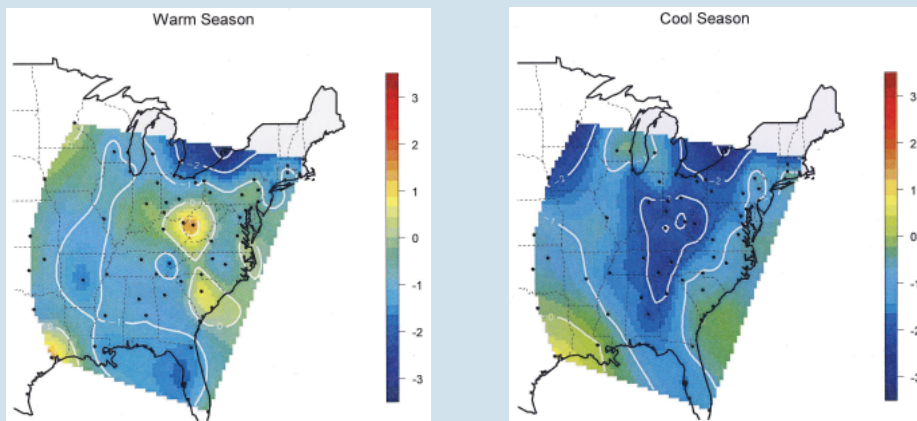


Figure 18. Trends in annual average PM<sub>2.5</sub> concentrations, before and after adjusting for weather, and the location of urban monitoring sites used in the average.

Note: Meteorological adjustment is done on a site-by-site basis, with each of the 72 selected sites shown in this map representing an urban area.

### Seasonal Influences on PM<sub>2.5</sub>

Emissions sources and the composition of PM<sub>2.5</sub> differ by season. For example, in cool months the greater demand for home or office heating (e.g., use of wood stoves or oil furnaces) creates more direct PM<sub>2.5</sub> emissions, while in the warm months, weather conditions more conducive to PM<sub>2.5</sub> formation create more secondary PM<sub>2.5</sub>. To better understand weather influences on annual PM<sub>2.5</sub> concentrations, the data were partitioned into “warm” and “cool” seasons. A statistical model was used to remove the influence of weather, as shown here for the eastern U.S. between 2000 and 2006. For the warm season, PM<sub>2.5</sub> concentrations generally decreased (shown in blue) in the East except for modest increases (shown by yellow, orange, or red) in Houston, Texas, West Virginia, and South Carolina. During the cool season, noticeable decreases occurred across much of the East.



Note: Two-year averages were used to mitigate uncertainty in individual year estimates. Estimated changes for locations that are not near monitoring sites (dots on map) have the largest uncertainty. For PM<sub>2.5</sub> speciation by season, visit [http://epa.gov/ttnnaqs/standards/pm/data/pmstaffpaper\\_20051221.pdf](http://epa.gov/ttnnaqs/standards/pm/data/pmstaffpaper_20051221.pdf) (see Figures 2-23 and 2-24).

Change in warm (April-September) and cool season (October-March) PM<sub>2.5</sub> concentrations in µg/m<sup>3</sup> after removing the influence of weather, 2000-2001 (average) vs. 2005-2006 (average).

## TRENDS IN PM<sub>2.5</sub> COMPOSITION 2002-2006

PM<sub>2.5</sub> is made up of several different chemical components. In urban areas, PM<sub>2.5</sub> is primarily composed of sulfate, nitrate, organic carbon (OC), and, to a lesser degree, elemental carbon (EC) and crustal material. Figure 19 shows regional trends in the composition of PM<sub>2.5</sub> from 2002 to 2006. Decreasing concentrations in southern California from 2002 to 2006 were largely the result of decreasing levels of nitrate; OC levels remained relatively unchanged and have been the largest component of PM<sub>2.5</sub> in the region. The Southeast had little change in PM<sub>2.5</sub> and its two major components—sulfate and OC—over the five-year period. The industrial Midwest and the Northeast showed decreasing concentrations, except for an increased amount of PM<sub>2.5</sub> in 2005. In 2005, the industrial Midwest had a temporary increase in PM<sub>2.5</sub> concentrations, mostly due to more nitrate and sulfate, which was caused by a colder-than-normal winter and a hotter-than-normal summer. The former conditions were more conducive to nitrate formation, while the latter conditions were more conducive to sulfate formation and also caused higher SO<sub>2</sub> emissions due to higher electrical demand.

### Sources of Particle Pollution

Component	Sources
Sulfates	Power generation
Nitrates	Cars, trucks, and power generation
Elemental and organic carbon	Cars, trucks, heavy equipment, wildfires, waste burning, and vegetation
Crustal	Suspended soil and metallurgical operations

Note: Ammonia from sources such as fertilizer and animal feed operations contributes to the formation of sulfates and nitrates that exist in the air as ammonium sulfate and ammonium nitrate. For more information about fine particle sources, visit <http://www.epa.gov/air/airtrends/aqtrnd04/pm.html>.

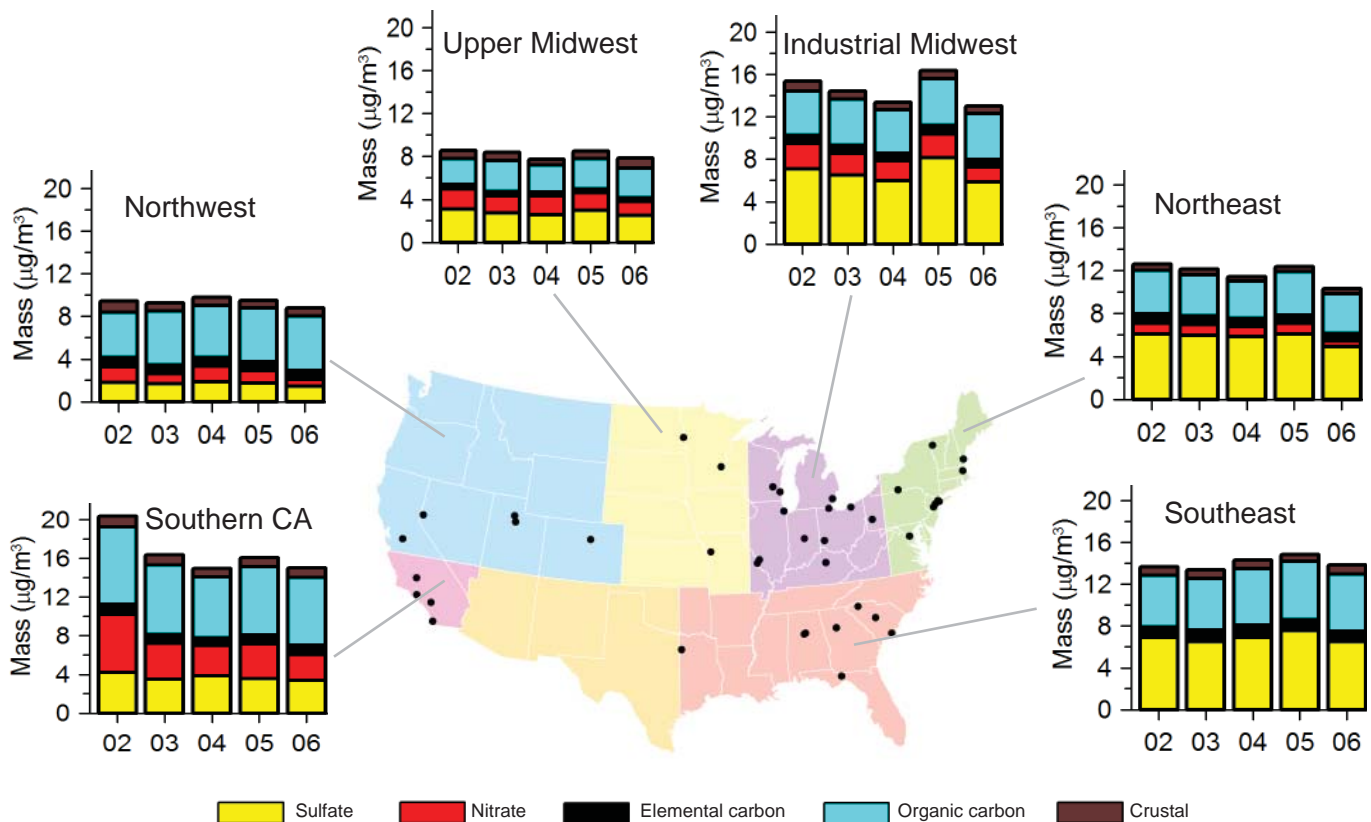


Figure 19. Regional trends in annual PM<sub>2.5</sub> composition in µg/m<sup>3</sup>, 2002-2006.

Note: This figure is based on 41 monitoring locations with the most complete data from the national chemical speciation network for 2002-2006. There were no sites with complete data in the Southwest. These components are presented in terms of their mass as they might have been measured by the PM<sub>2.5</sub> Federal Reference Method (FRM). To characterize these trends, ambient nitrate measurements, and associated ammonium, were adjusted to reflect the lower amount retained on FRM filters. Particle-bound water was included as a mass enhancement to measured sulfate, ammonium, and adjusted nitrate. Organic carbon mass was derived by material balance between measured PM<sub>2.5</sub> and the other components.

### TRENDS IN PM<sub>10</sub> CONCENTRATIONS

Between 1990 and 2006, PM<sub>10</sub> concentrations decreased 30 percent, as shown in Figure 20. The largest decreases were in Spokane, Wash., and Klamath Falls, Ore. Forty-three sites had an increase of more than 5 µg/m<sup>3</sup>. The largest increases were in Houston, Texas; Las Cruces, N.M.; Nogales, Ariz.; Salt Lake City, Utah, and areas of Colorado. Figure 21 shows that in 2006 the highest concentrations were located in Illinois and the Southwest, including parts of California, Nevada, Arizona, New Mexico, and western Texas.

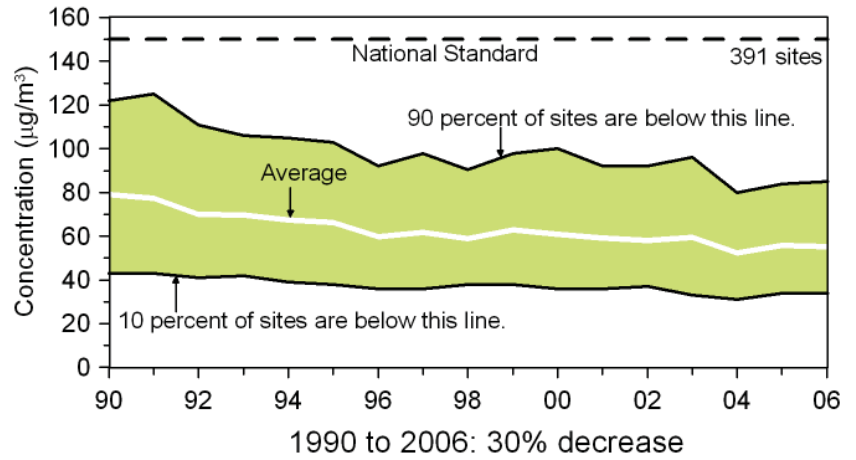


Figure 20. National PM<sub>10</sub> air quality trend, 1990-2006 (second maximum 24-hour concentration).

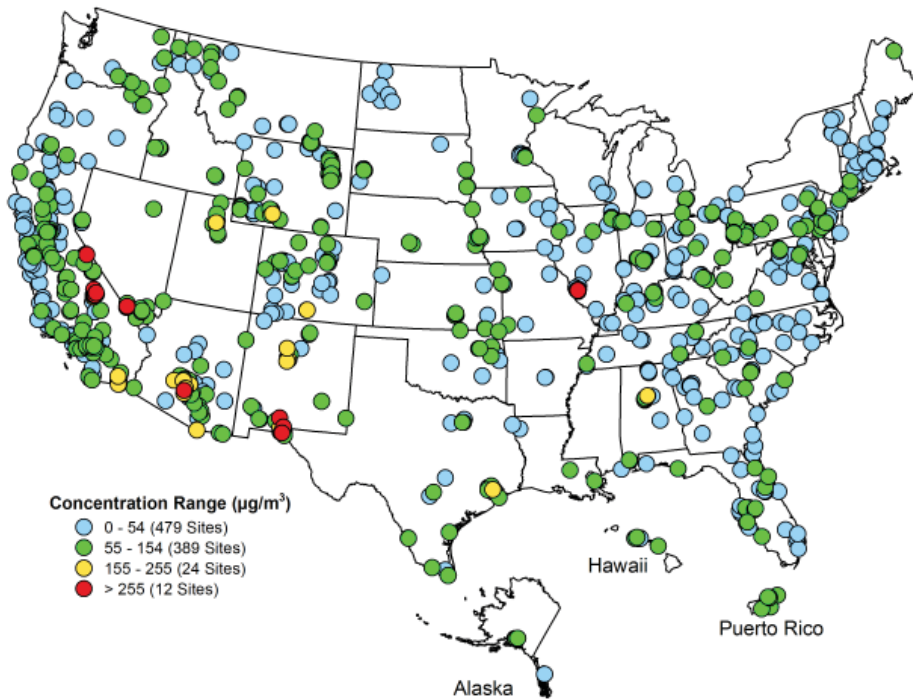


Figure 21. PM<sub>10</sub> concentrations in µg/m<sup>3</sup>, 2006 (second maximum 24-hour concentration).

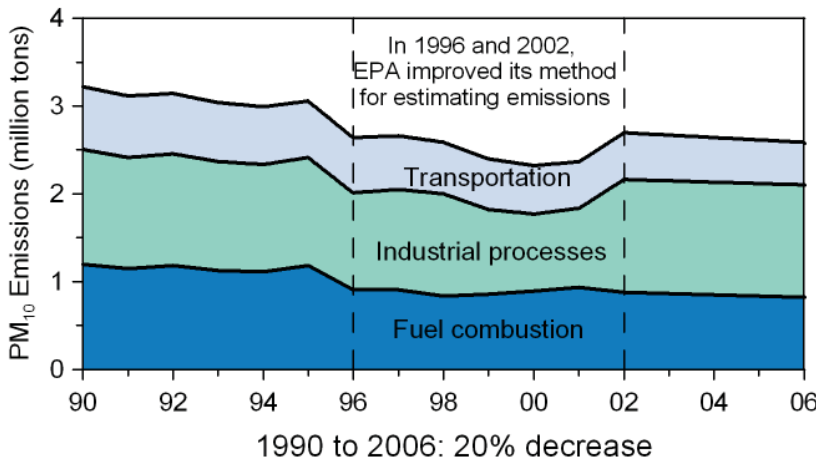


Figure 22. National trends in direct PM<sub>10</sub> emissions, 1990-2006.

### TRENDS IN PM<sub>10</sub> EMISSIONS

Between 1990 and 2006, emissions of directly emitted PM<sub>10</sub> decreased 20 percent, as shown in Figure 22. Changes in how EPA compiled the national inventory over time may account for some differences.



# NITROGEN DIOXIDE (NO<sub>2</sub>)

## NATURE AND SOURCES

Nitrogen dioxide (NO<sub>2</sub>) is a member of the nitrogen oxide (NO<sub>x</sub>) family of gases. It is formed in the air through the oxidation of nitric oxide (NO) emitted when fuel is burned at a high temperature. The monitoring network measures concentrations of NO<sub>2</sub> in the air to compare with national air quality standards, and EPA tracks national emissions of NO<sub>x</sub>. The major sources of NO<sub>x</sub> emissions are automobiles, power plants, and any other industrial, commercial, or residential source that burns fuel.

## HEALTH AND ENVIRONMENTAL EFFECTS

Exposure to NO<sub>2</sub> has been associated with an increased risk of respiratory illness in children. Short-term exposures (e.g., less than three hours) to low levels of NO<sub>2</sub> may decrease lung function in individuals with pre-existing respiratory illnesses. Long-term exposures well above ambient NO<sub>2</sub> levels may cause irreversible changes in lung structure.

NO<sub>x</sub> contributes to other air quality problems that cause a variety of health and environmental impacts. For example, ground-level ozone forms when NO<sub>x</sub> and VOCs react in the presence of sunlight. NO<sub>x</sub> reacts with ammonia and moisture to form nitric acid and particle nitrates. NO<sub>x</sub> reacts with organic chemicals or ozone to form a variety of toxic products including nitrate radicals, nitroarenes, and nitrosamines. NO<sub>x</sub> also contributes to nutrient overloading that deteriorates water quality and plays a major role in visibility impairment and acid rain.

## TRENDS IN NO<sub>2</sub> CONCENTRATIONS

Nationally, concentrations of NO<sub>2</sub> decreased 30 percent between 1990 and 2006, as shown in Figure 23. In 2006, NO<sub>2</sub> concentrations were generally the lowest of the 17-year period. All recorded concentrations were well below the level of the national standard (0.053 ppm).

## TRENDS IN NO<sub>x</sub> EMISSIONS

Between 1990 and 2006, NO<sub>x</sub> emissions decreased 29 percent, as shown in Figure 24. Most NO<sub>x</sub> emissions come from transportation and fuel combustion sources, which decreased by 21 and 41 percent, respectively. Overall, NO<sub>x</sub> emissions did not change much between 1990 and 1998. After 1998, NO<sub>x</sub> emissions showed a decrease similar to the decrease in NO<sub>2</sub> concentrations shown in Figure 23. NO<sub>x</sub> emissions from transportation sources decreased 17 percent, and fuel combustion sources decreased 38 percent between 1998 and 2006. Most of the fuel combustion NO<sub>x</sub> emission reductions were due to the Acid Rain Program, which began in 1995, and implementation of the NO<sub>x</sub> SIP Call, which led to sustained reductions beginning in 2003 and 2004.

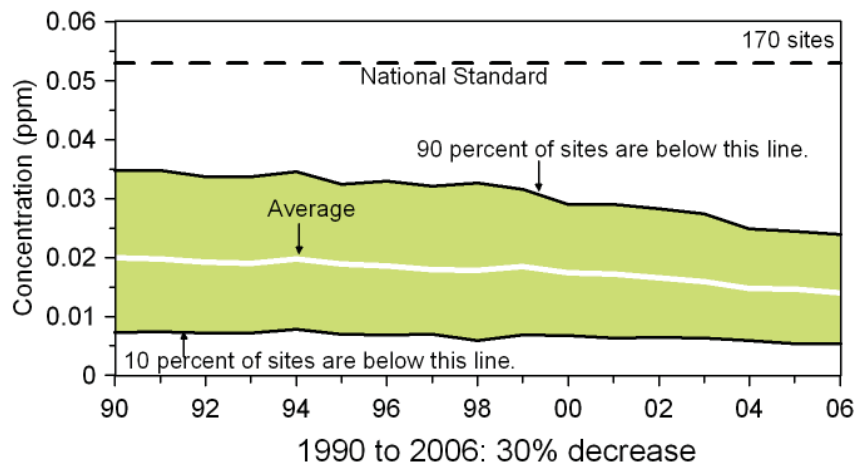


Figure 23. National NO<sub>2</sub> air quality trend, 1990-2006 (annual average).

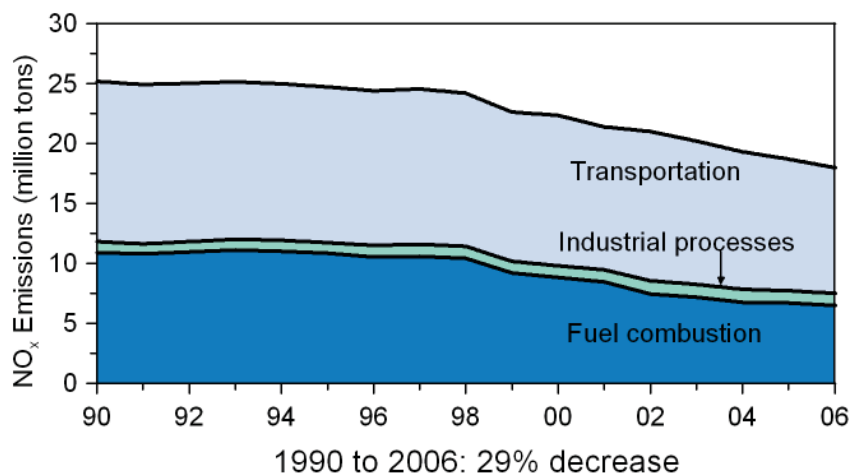


Figure 24. National trends in annual NO<sub>x</sub> emissions, 1990-2006.

# CARBON MONOXIDE (CO)

## NATURE AND SOURCES

Carbon monoxide (CO) is a colorless and odorless gas formed when carbon in fuel is not burned completely. It is a component of on-road vehicle exhaust and other non-road engines and vehicles (such as aircraft, locomotives, and construction equipment). Higher 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 motor vehicle exhaust. Other sources of CO emissions include industrial processes (such as metal processing and chemical manufacturing), residential wood burning, and natural sources such as forest fires. The highest levels of CO typically occur during the colder months of the year when inversion conditions (in which air pollutants are trapped near the ground beneath a layer of warm air) are more frequent.

## HEALTH EFFECTS

CO enters the bloodstream through the lungs and reduces oxygen delivery to the body's organs and other tissues. Higher levels of CO are most serious for those suffering from heart disease such as angina, clogged arteries, or congestive heart failure. For a person with heart disease, a single exposure to CO at high levels may cause chest pain and reduce the person's ability to exercise; repeated exposures may contribute to other cardiovascular effects. People who breathe high levels of CO can develop vision problems, reduced ability to work, reduced manual dexterity, and difficulty performing complex tasks. At even higher levels, CO can cause death.

## TRENDS IN CO CONCENTRATIONS

Nationally, CO concentrations declined 62 percent between 1990 and 2006, as shown in Figure 25. In 2006, CO concentrations were the lowest in the past 17 years. One site in Birmingham, Ala., showed concentrations above 9 ppm, the level of the standard.

## TRENDS IN CO EMISSIONS

Nationally, CO emissions (excluding wildfires and prescribed burning) decreased 38 percent between 1990 and 2006, as shown in Figure 26. Emission reductions from transportation sources, a major contributor to ambient CO concentrations, were responsible for most of this decrease. CO emissions from transportation sources were reduced by more than 52 million tons (or about 40 percent) over the 17-year period.

These improvements in CO concentrations and emissions since 1990 occurred despite a 43 percent increase in vehicle miles traveled during the same 17-year period. Cleaner cars have contributed to cleaner air for much of the U.S.

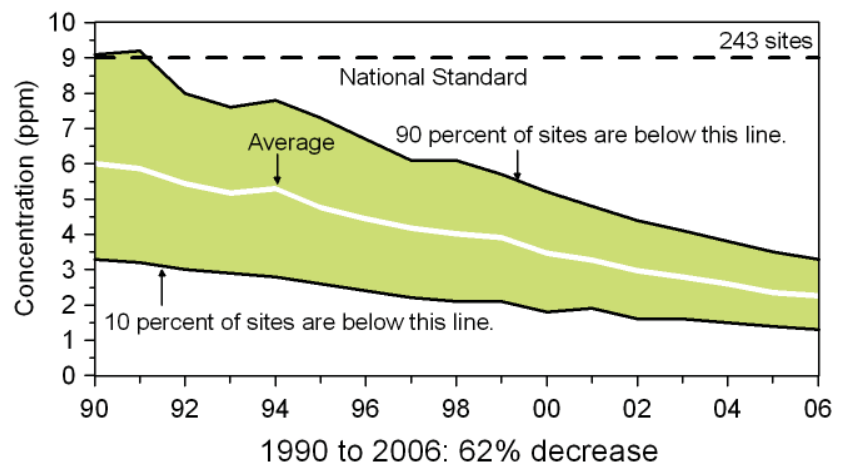


Figure 25. National CO air quality trend, 1990-2006 (second maximum 8-hour average).

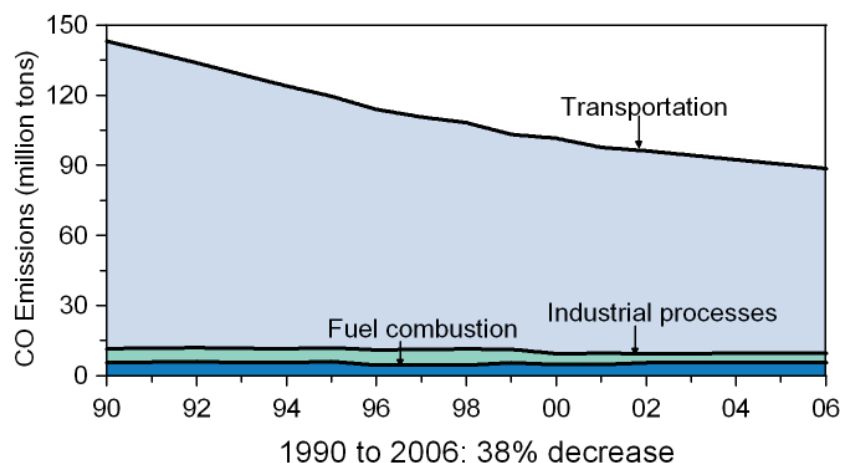


Figure 26. National trends in annual CO emissions, 1990-2006.

# SULFUR DIOXIDE (SO<sub>2</sub>)

## NATURE AND SOURCES

Sulfur dioxide (SO<sub>2</sub>), a member of the sulfur oxide (SO<sub>x</sub>) family of gases, is formed from burning fuels containing sulfur (e.g., coal or oil), extracting gasoline from oil, or extracting metals from ore. SO<sub>2</sub> can also dissolve in water vapor to form acid and can interact with ammonia and particles to form sulfates and other chemical products that can be harmful to people and the environment. The monitoring network measures concentrations of SO<sub>2</sub> in the air to compare with national air quality standards, and EPA tracks national emissions of SO<sub>2</sub>. Eighty-seven percent of the SO<sub>2</sub> released into the air is attributable to fuel combustion. Other sources of SO<sub>2</sub> emissions include industrial facilities such as petroleum refineries, cement manufacturing facilities, and metal processing facilities. Additionally, locomotives, large ships, and some non-road diesel equipment currently burn high sulfur fuels that emit SO<sub>2</sub>.

## HEALTH AND ENVIRONMENTAL EFFECTS

SO<sub>2</sub> causes a wide variety of health and environmental impacts. Particularly sensitive groups include asthmatics who are active outdoors, children, the elderly, and people of any age with heart or lung disease. Longer-term exposures to high levels of SO<sub>2</sub> gases and related particles have been shown to cause respiratory illness and aggravate existing heart disease. Sulfate particles can gather in the lungs, causing respiratory symptoms and disease, difficulty in breathing, and premature death. Sulfate particles are the major cause of reduced visibility in many parts of the U.S., including national parks. SO<sub>2</sub> is also a major contributor to acid rain.

## TRENDS IN SO<sub>2</sub> CONCENTRATIONS

There are two standards for SO<sub>2</sub>: an annual standard (0.03 ppm) and a daily standard (0.14 ppm). The annual standard is the focus in this report. Nationally, concentrations of annual SO<sub>2</sub> decreased 53 percent between 1990 and 2006, as shown in Figure 27. In 2006, annual SO<sub>2</sub> concentrations were generally the lowest of

the 17-year period. All concentrations were below the level of the annual standard. One site in Northampton County, Pa., showed concentrations above the level of the daily standard in 2006.

## TRENDS IN SO<sub>2</sub> EMISSIONS

Since 1990, SO<sub>2</sub> emissions have decreased 38 percent, as shown in Figure 28. Emissions from fuel combustion, industrial processes, and transportation sources decreased 41, 40, and 30 percent, respectively.

The observed reductions in SO<sub>2</sub> concentrations and emissions since 1990 are mainly due to controls implemented under EPA's Acid Rain Program, which began in 1995.

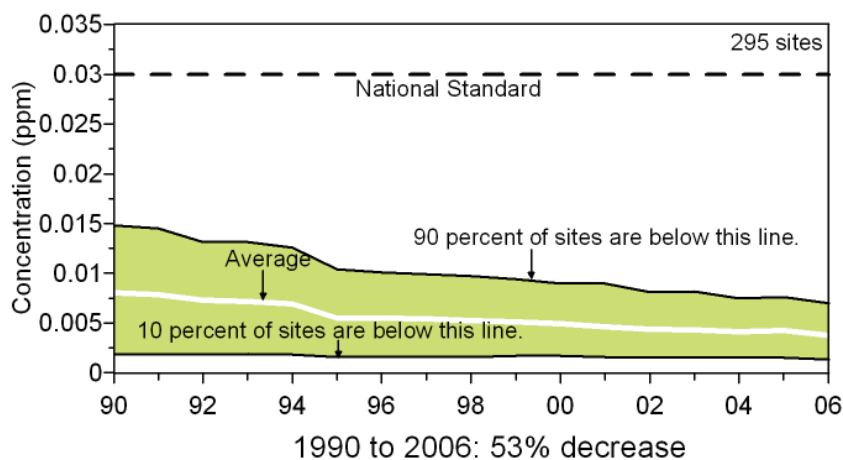


Figure 27. National SO<sub>2</sub> air quality trend, 1990-2006 (annual average).

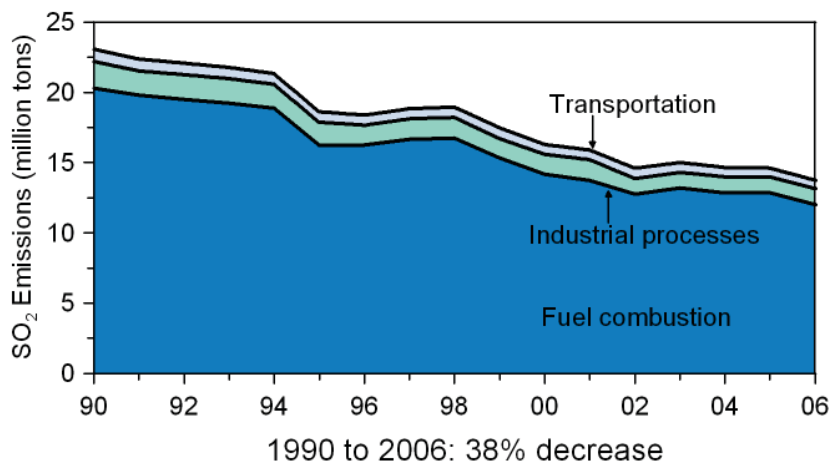


Figure 28. National trends in annual SO<sub>2</sub> emissions, 1990-2006.

# LEAD (Pb)

## NATURE AND SOURCES

Automotive sources are no longer the major contributors of lead emissions to the atmosphere. As a result of EPA's regulatory efforts to reduce the content of lead in gasoline, lead emissions from the automotive sector have greatly declined over the past few decades. Today, industrial processes and combustion of leaded fuel associated with some small planes (piston-engine aircraft) are the major sources of lead emissions to the atmosphere.

## HEALTH AND ENVIRONMENTAL EFFECTS

People can be exposed to lead by inhaling it from the air or by ingesting lead in contaminated drinking water, lead-contaminated food, or lead-contaminated soil and dust. Lead-based paint remains a major exposure pathway in old houses. Depending on the level of exposure, lead can adversely affect the nervous system, kidneys, immune system, reproductive and developmental systems, and the cardiovascular system. Lead exposure also affects the oxygen carrying capacity of the blood. The lead effects of greatest concern from current exposures are neurological effects in children. Infants and young children are especially sensitive to even low levels of lead, which may contribute to

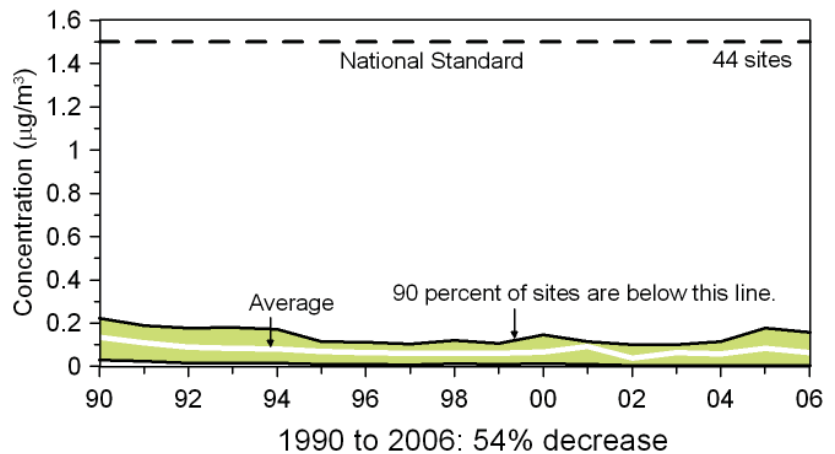
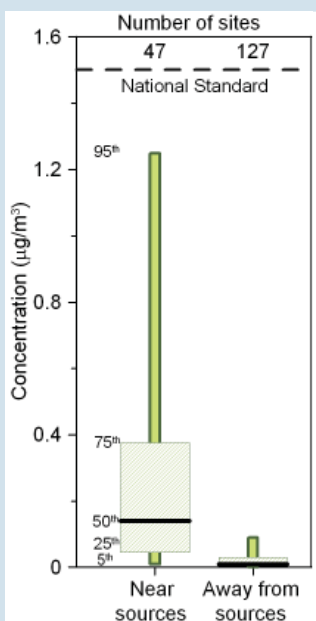


Figure 29. National lead air quality trend, 1990-2006 (maximum quarterly average).

behavioral problems, learning deficits, and lower intelligence quotients.

Lead is persistent in the environment and accumulates in soils and sediments through deposition from air sources, discharge of waste streams to water bodies, mining, and erosion. Ecosystems near point sources of lead demonstrate a wide range of adverse effects including losses in biodiversity, changes in community composition, decreased growth and reproductive rates in plants and animals, and neurological effects in vertebrates.

## New Information on Lead Sources



Large reductions in long-term lead emissions from transportation sources have changed the nature of the lead problem in the United States. Unlike the early 1980s, most of the highest lead concentrations in 2006 are near lead emissions point sources. These point sources include metals processors, battery manufacturers, waste incinerators, mining operations, military installations, and facilities with large boilers (e.g., utility, industrial, and institutional).

Data for all lead monitoring sites with complete data in 2006 shows lead concentrations near point sources are significantly higher than those not near point sources, as shown. The typical concentration near a source is approximately 10 times the typical concentration for sites that are not near a source.

Note: Concentrations shown are maximum quarterly averages using sites with complete data in 2006.

## TRENDS IN LEAD CONCENTRATIONS

Because of the phase-out of leaded gasoline, lead concentrations declined sharply during the 1980s and early 1990s. Between 1980 and 2006, concentrations of lead in the air decreased 95 percent, while emissions of lead decreased 97 percent. From 1990 to 2006, lead concentrations remained low, as shown in Figure 29. In 2006, only two sites had concentrations above the level of the standard ( $1.5 \mu\text{g}/\text{m}^3$ ); both are associated with lead smelting operations in Herculaneum, Mo.

# TOXIC AIR POLLUTANTS

## NATURE AND SOURCES

Hazardous air pollutants, or air toxics, are emitted from thousands of sources across the nation, or they are formed through atmospheric reactions of directly emitted substances. 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. Examples of toxic air pollutants include benzene, found in gasoline; tetrachloroethylene (i.e., perchloroethylene), emitted from some dry cleaning facilities; and dichloromethane (i.e., methylene chloride), used as a solvent by a number of industries. The Clean Air Act regulates 187 air toxics from various sources. EPA has identified 21 pollutants as mobile source air toxics, including diesel particulate matter and diesel exhaust organic gases. In addition, EPA has listed 33 urban hazardous air pollutants that pose the greatest threats to public health in urban areas.

## HEALTH AND ENVIRONMENTAL EFFECTS

People exposed to toxic air pollutants at sufficient concentrations may experience various harmful 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 are also associated with the deposition of certain 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 and plants may be harmed by air toxics exposure. Air toxics also may cause adverse environmental and ecological effects.

## TRENDS IN AIR TOXICS CONCENTRATIONS AND EMISSIONS

The nation's monitoring network for air toxics is not as extensive as that for many of the other pollutants discussed in this report. Figure 30 shows ambient monitoring locations for air toxics sites operating in 2005.

In 2003, working with its state and local partners, EPA launched the implementation of the National Air Toxics Trends Station (NATTS) program, a national monitoring network for toxic air pollutants. The central goal of the NATTS network is to assess trends in high-risk air toxics such as benzene, formaldehyde, 1,3-butadiene, acrolein, and chromium. Fourteen of the 23 sites began operation in 2003 and the remaining nine were established in 2004.

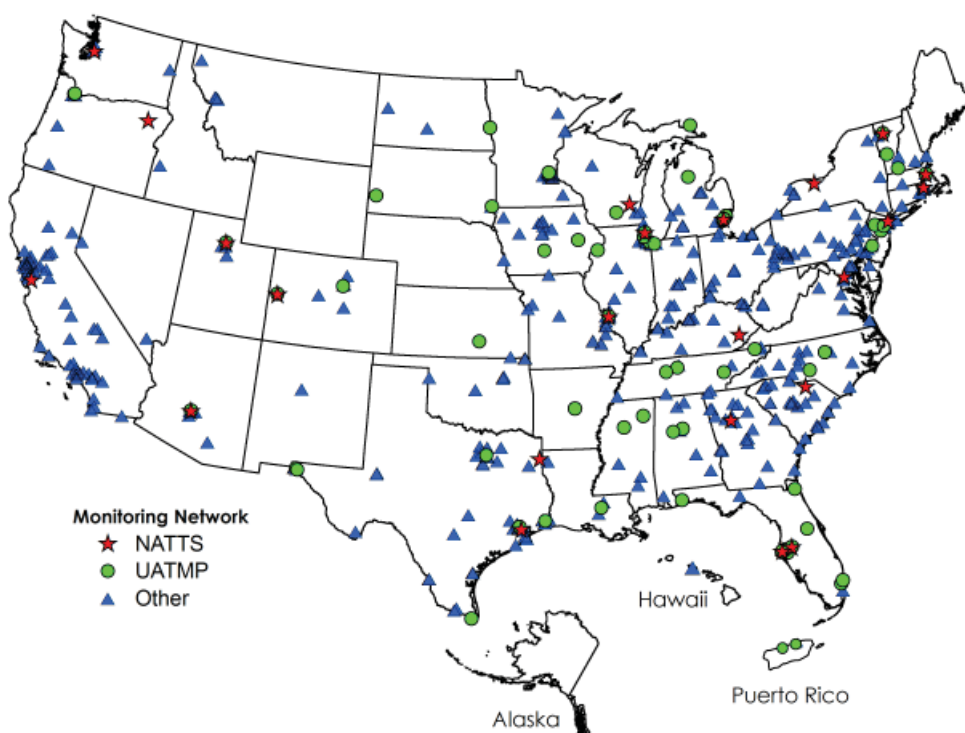


Figure 30. Air toxics monitoring sites operating in 2005 (by monitoring program).

In addition to the NATTS program, about 300 air toxics monitoring sites are currently collecting data to help air pollution control agencies track toxic air pollutant levels in various locations around the country. State and local air quality agencies operate these sites to address specific concerns such as areas of elevated concentrations or “hot spots,” environmental justice concerns, and/or public complaints. Some state and local agencies use EPA sampling and analysis support such as the Urban Air Toxics Monitoring Program (UATMP).

Air toxics monitoring is generally most prevalent in California, Texas, and the eastern U.S. and reflects a tendency to monitor in densely populated areas. Most sampling is conducted on a 1-in-6-day schedule for a 24-hour period. For the latest information about national air toxics monitoring, visit <http://www.epa.gov/ttn/amtic>.

EPA compiles an air toxics inventory as part of the National Emissions Inventory (NEI) to estimate and track national emissions trends for the 187 toxic air pollutants regulated under the Clean Air Act. Figure 31 shows the emissions of toxic air pollutants divided among the four types of sources, based on 2002 estimates (the most recent year of data available).

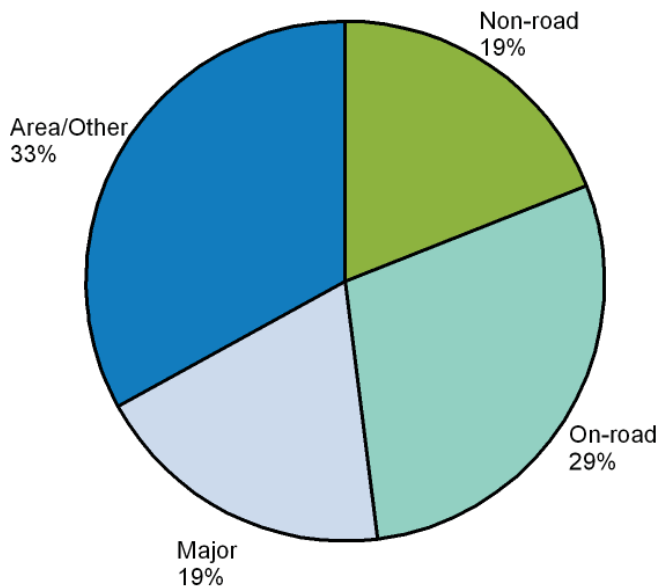


Figure 31. Percent contribution by source sector to national air toxics emissions, 2002.

Note: Emission sectors are (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) on-road mobile sources, including highway vehicles; and (4) non-road mobile sources, such as aircraft, locomotives, and construction equipment.

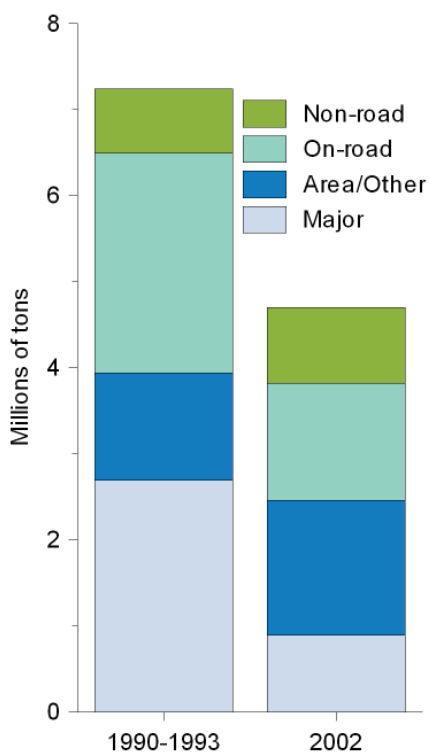


Figure 32. Trends in national air toxics emissions for 1990-1993 vs. 2002.

Nationwide, air toxics emissions decreased approximately 35 percent between the 1990-1993 baseline and 2002 as shown in Figure 32. Major and on-road mobile sources showed the greatest emission reductions (67 and 47 percent, respectively), while emissions from both area and non-road mobile sources increased over this period (26 and 15 percent, respectively).

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 total toxic emissions.



Ambient trends in air toxics vary by pollutant. Benzene, one of the most routinely and accurately monitored air toxics, is also estimated to be the most important at a national level with regard to the average individual cancer risk it poses. Figure 33 shows a national average trend in benzene levels at 107 monitoring sites across the country. These sites are generally in urban areas that have higher levels of benzene than other areas of the country. Data from these sites suggest an average improvement of almost 17 percent between 2000 and 2005.

Figure 34 shows the location and change in benzene concentrations at individual sites used to compile the national trend. While some sites show an increase over the time period of interest, no site shows a significant increase, and most sites indicate improvement from 1990 to 2005.

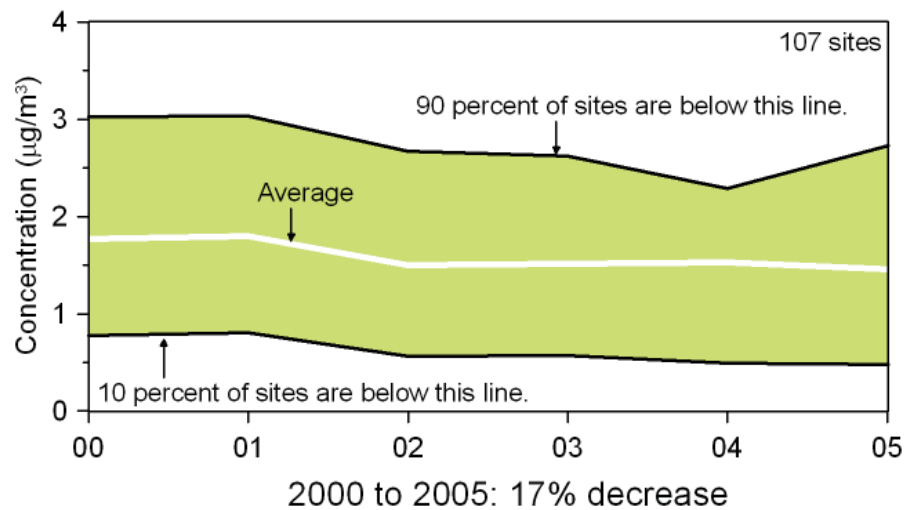


Figure 33. National benzene air quality trend, 2000-2005 (annual average).



Figure 34. Trends in annual average benzene concentrations at individual sites for any period of at least five years within 1990-2005.

**RISK ASSESSMENT**

EPA has developed health risk estimates for 177 toxic air pollutants (a subset of the Clean Air Act's list of 187 air toxics plus diesel particulate matter). Figure 35 shows the estimated lifetime cancer risk across the continental U.S. by county based on 1999 model estimates. More than 270 million people live in census tracts for which the lifetime cancer risk from these compounds exceeds a 10-in-one-million risk. From a national perspective, benzene is the most significant air toxic for which cancer risk could be estimated, contributing 25 percent of the average individual cancer risk identified in the 1999 assessment.

Though not included in the figure, exposure to diesel exhaust is widespread. 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. For more information about EPA's National Air Toxics Assessment, visit <http://www.epa.gov/ttn/atw/nata1999>.

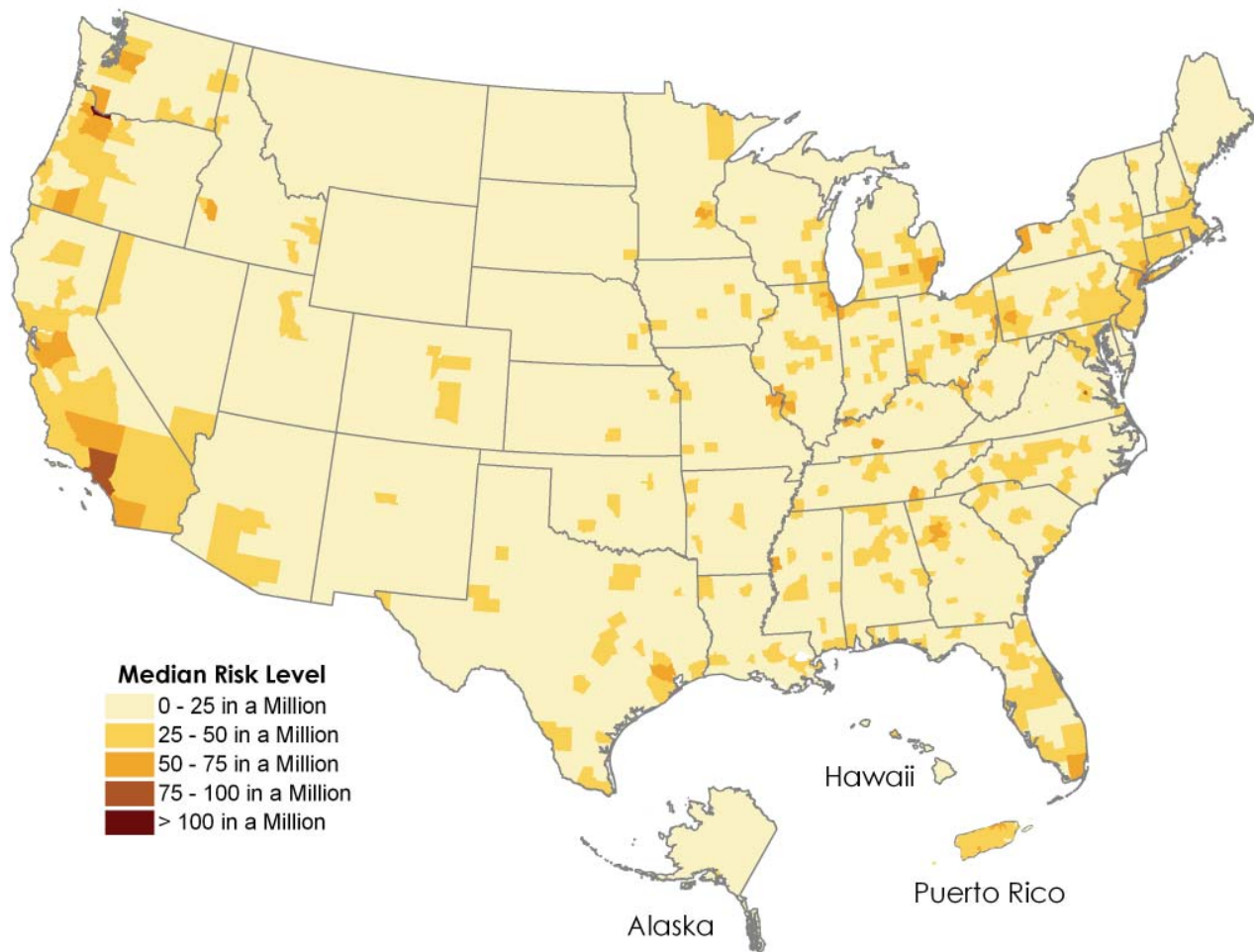


Figure 35. Estimated county-level cancer risk from the 1999 National Air Toxics Assessment (NATA99).



# ACID RAIN

Acid rain occurs when emissions of  $\text{SO}_2$  and  $\text{NO}_x$  react in the atmosphere to form acidic gases. The acidic gases react with water vapor to form acid droplets, which fall to the ground as acid deposition (more commonly known as acid rain), harming sensitive ecosystems in many areas of the country. Acid rain leads to the acidification of lakes and streams, rendering some of them incapable of supporting aquatic life. The electric power industry accounts for about 67 percent of  $\text{SO}_2$  emissions and 19 percent of  $\text{NO}_x$  emissions in the U.S. from man-made sources.

The 1990 Clean Air Act Amendments established the Acid Rain Program to reduce the harmful effects of acid rain through reductions in emissions of  $\text{SO}_2$  and  $\text{NO}_x$ .  $\text{SO}_2$  reductions are achieved by a cap and trade program, which lets sources buy or sell fixed amounts of  $\text{SO}_2$  allowances on the open market while a limit, or cap, is set on the total amount of  $\text{SO}_2$  that can be emitted from all power plants.  $\text{NO}_x$  reductions are achieved through an emissions rate-based program.

Since the start of the Acid Rain Program in 1995, reductions of  $\text{SO}_2$  and  $\text{NO}_x$  emissions from the power industry have contributed to significant improvements in air quality and environmental and human health. As of 2006, the program had

- Reduced  $\text{SO}_2$  emissions by more than 6.3 million tons from 1990 levels, or about 40 percent of total power industry emissions. Compared to 1980 levels,  $\text{SO}_2$  emissions from power plants have dropped by more than 7.9 million tons, or about 46 percent. In 2006, annual  $\text{SO}_2$  emissions fell by over 800,000 tons from 2005 levels.
- Cut  $\text{NO}_x$  emissions by about 3 million tons from 1990 levels, so that emissions in 2006 were less than half the level anticipated without the program. Other efforts, such as the  $\text{NO}_x$  SIP Call in the East, also contributed to this reduction.
- Led to significant decreases in acid rain. For example, between the 1989-1991

and 2004-2006 time periods, sulfate deposition decreased over 30 percent in the Northeast and the Midwest, as shown in Figure 36. These reductions have led to improving water quality in lakes and streams.

- Reduced sulfate concentration in the air by about 30 percent in most regions of the East. Both the size of the affected region and magnitude of the highest concentrations have dramatically declined, with the largest decreases observed along the Ohio River Valley.

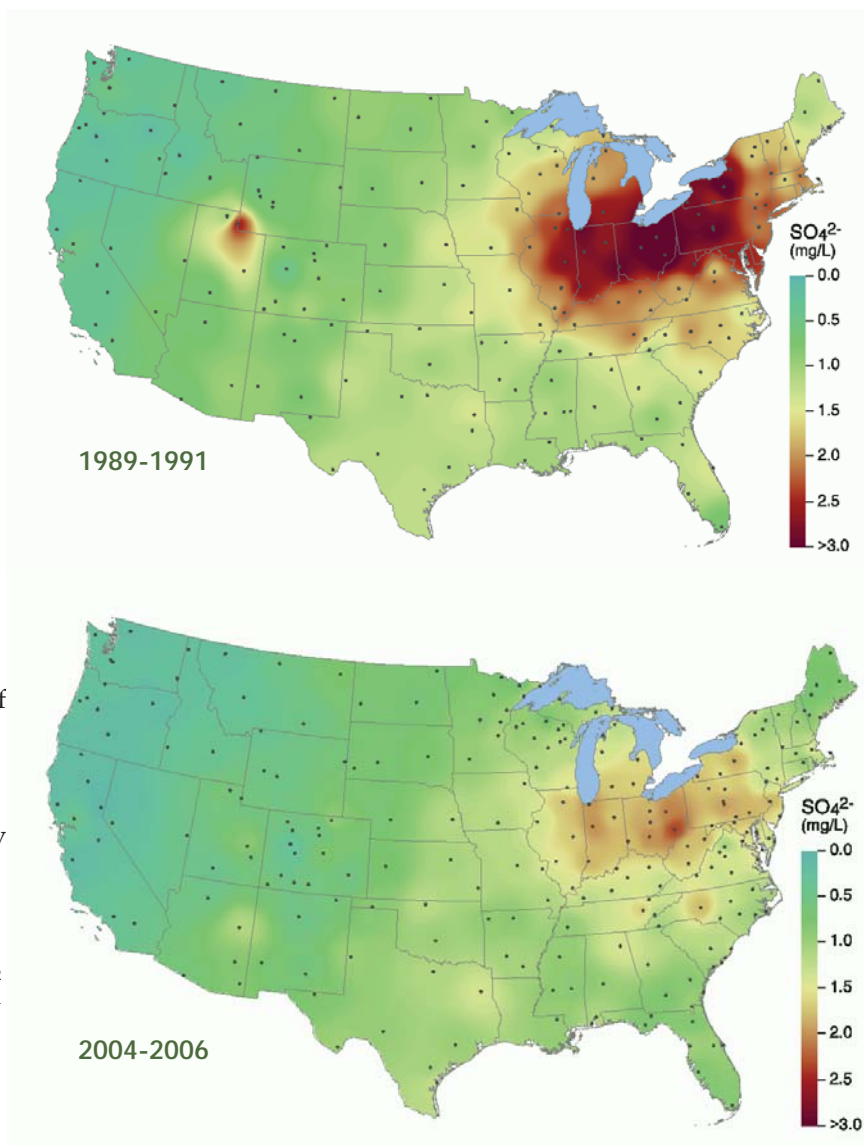


Figure 36. Three-year average precipitation of sulfate concentrations ( $\text{SO}_4^{2-}$ ) in 1989-1991 and 2004-2006. Dots show monitoring locations. (Data source: National Atmospheric Deposition Program, <http://nadp.sws.uiuc.edu/>)

## VISIBILITY IN SCENIC AREAS

Air pollution can impair visibility—and not just in cities. Reduced visibility affects many of our best known and most treasured national parks and wilderness areas, such as Grand Canyon, Yosemite, Yellowstone, Mount Rainier, Shenandoah, and Great Smoky Mountains national parks, and the Mount Hood and Okefenokee wilderness areas, as well as urban areas. Visibility impairment results from the scattering and absorption of light by air pollution, including particles and gases. This limits the distance we can see and can also degrade the color, clarity, and contrast of those views. The same fine particles that are linked to serious health effects and premature death can also significantly affect visibility.

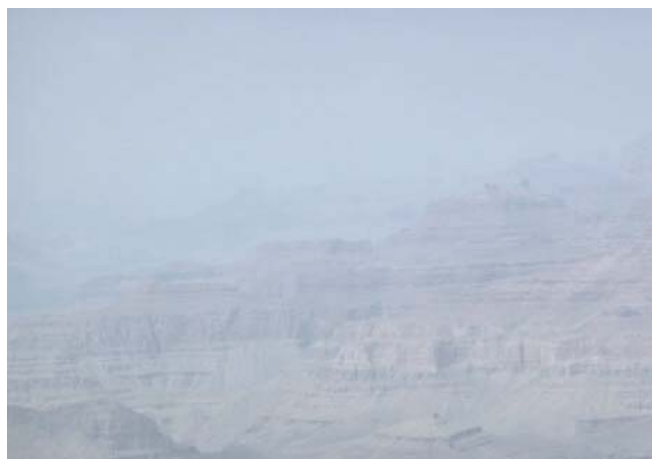
Some particles that contribute to visibility impairment are emitted directly into the atmosphere from their sources, such as dust from roads or elemental carbon (soot) from wood combustion. In other cases, particles form in the atmosphere from primary gaseous emissions such as sulfates (formed from SO<sub>2</sub> emissions from power plants and other industrial facilities) and nitrates (formed from NO<sub>x</sub> emissions from power plants, automobiles, and other types of combustion sources).

EPA monitors visibility trends, defined by the Regional Haze Rule, in 155 of the 156 mandatory Class I areas (certain national parks and wilderness areas meeting the criteria established in the 1977 Clean Air Act amendments). The Regional Haze Rule requires states to identify the most effective means of preserving conditions in Class I areas when visibility is at its

best—based on the best 20 percent visibility days—and to gradually improve visibility when it is most impaired—based on the worst 20 percent visibility days. Trends in visibility for the annual 20 percent best and worst visibility days are shown in Figure 37. Several locations showed improving visibility (decreasing haze) for the best visibility days at eastern national park and wilderness monitoring sites (Acadia, Moosehorn, Lye Brook, Dolly Sods, and Shenandoah), and one location showed improvement for the worst visibility days (Great Smoky Mountains). The western U.S., which has most of the Class I areas, showed improvement at 24 locations for the best visibility days. Mount Rainer and Redwoods also showed improvement on the worst visibility days. Only one location—Petrified Forest, Ariz.—showed a notable degradation in visibility (increasing haze) for the worst days.

In 2001, EPA promoted the establishment of five Regional Planning Organizations (RPOs) to serve as centers for conducting the coordinated Regional Haze Rule technical assessments and policy development required of states and tribes in concert with federal land managers and other stakeholders in five regions of the U.S. More detailed information concerning measured visibility levels, as well as links to all five RPOs, are available at the Visibility Information Exchange Web Site (VIEWS) at <http://vista.cira.colostate.edu/views/>.

For more information about EPA's Regional Haze Program, visit <http://www.epa.gov/visibility>.



These photographs taken at Grand Canyon National Park show how visibility can differ. PM<sub>2.5</sub> concentrations were 0.2 µg/m<sup>3</sup> (left) and 37.3 µg/m<sup>3</sup> (right).

(Source: <http://vista.cira.colostate.edu/improve/Publications/GrayLit/NPSSpecialImages/Updated%20NPS%20Special%20Images.pdf>)

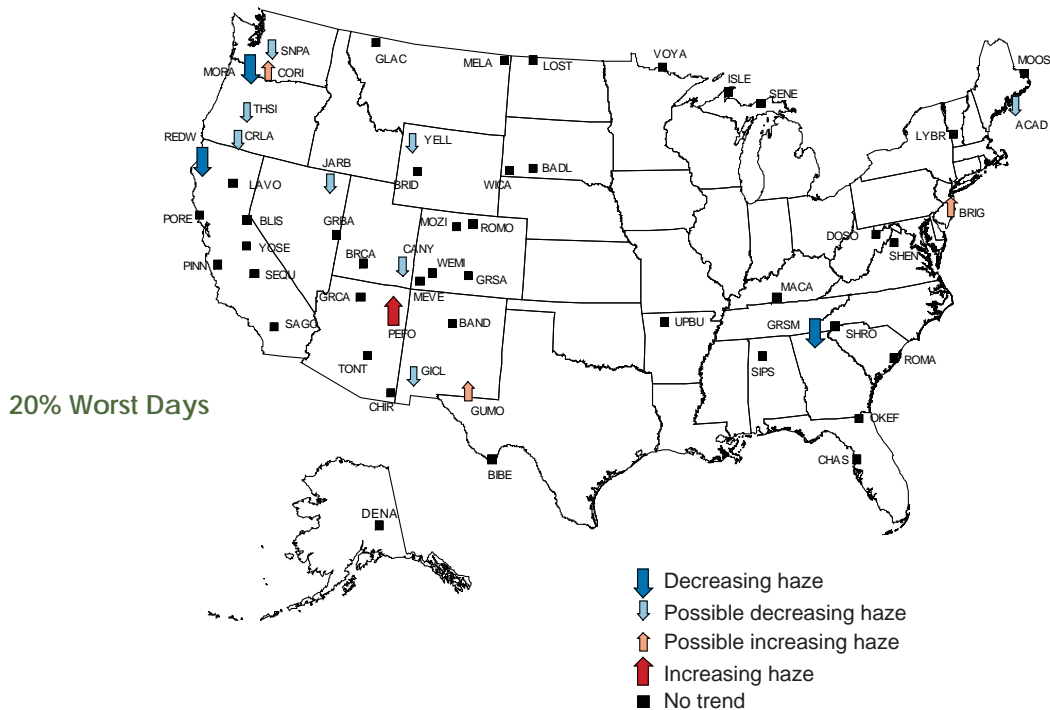
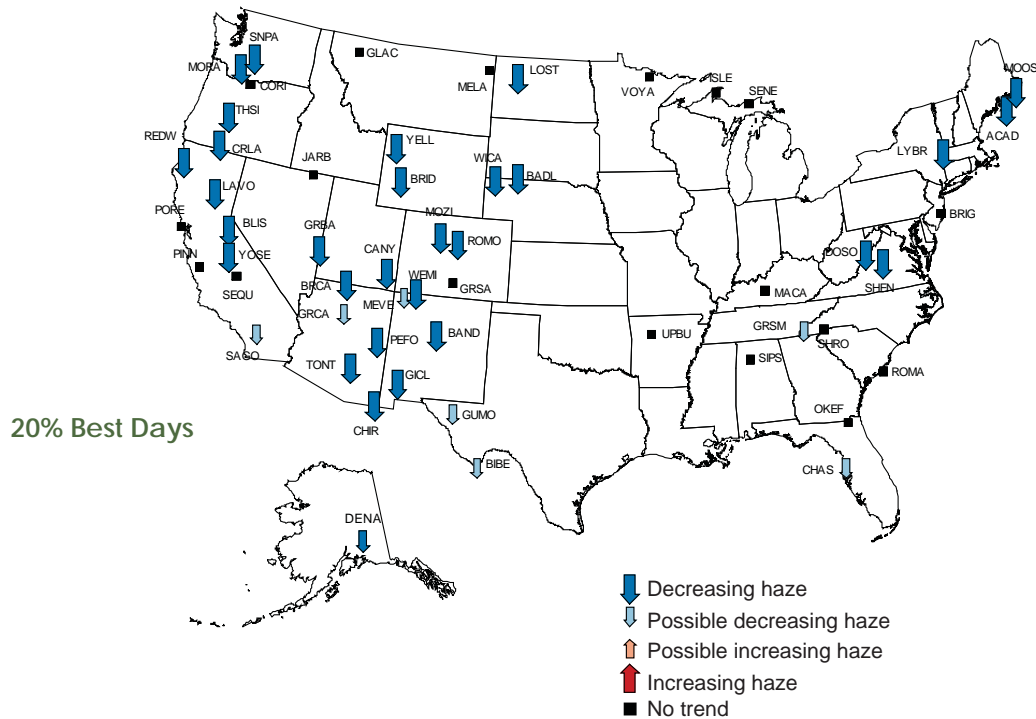


Figure 37. Trends in visibility (haze index in deciviews) on the 20 percent best and worst visibility days, 1996-2005. (Source: <http://www.nature.nps.gov/air>)

Note: Visibility trends using a haze index for the annual average for the 20 percent best and worst visibility days are based on aerosol measurements collected at Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. The haze index is measured in deciviews (dv), a visibility metric based on the light extinction coefficient that expresses incremental changes in perceived visibility. Sites having at least six years of complete data were used.

# CLIMATE CHANGE

Climate and ground-level air quality are closely coupled within the atmosphere and Earth system. For example, ground-level ozone is a greenhouse gas (GHG). Particle pollution can influence global and regional climate by scattering or absorbing incoming solar radiation, and by changing cloud formation processes and cloud cover. And climate changes have effects on air quality. For example, warming of the atmosphere increases the formation of ground-level ozone, while increases in cloud cover tend to decrease ozone formation.

Figure 38 shows the trends in domestic GHG emissions over time in the U.S. The dominant gas emitted is carbon dioxide (mostly from fossil fuel combustion). Total U.S. GHG emissions increased 16 percent between 1990 and 2005. The Intergovernmental Panel on Climate Change has concluded that the Earth's climate will continue to warm as global GHG emissions increase.

Research is under way that will provide an improved understanding of the connections between air quality and climate change. Using estimates from a computer model that assumes continued growth in global GHG emissions, Figure 39 shows how ground-level ozone in the eastern U.S. may increase from current levels given future climate change. For particle pollution, the interrelationships of climate and concentrations are more complex.

For more information about emissions and trends in GHGs, visit <http://www.ipcc.ch/> and <http://www.epa.gov/climatechange/emissions/usinventoryreport.html>. For information about what EPA is doing to address climate change, visit <http://www.epa.gov/climatechange/>.

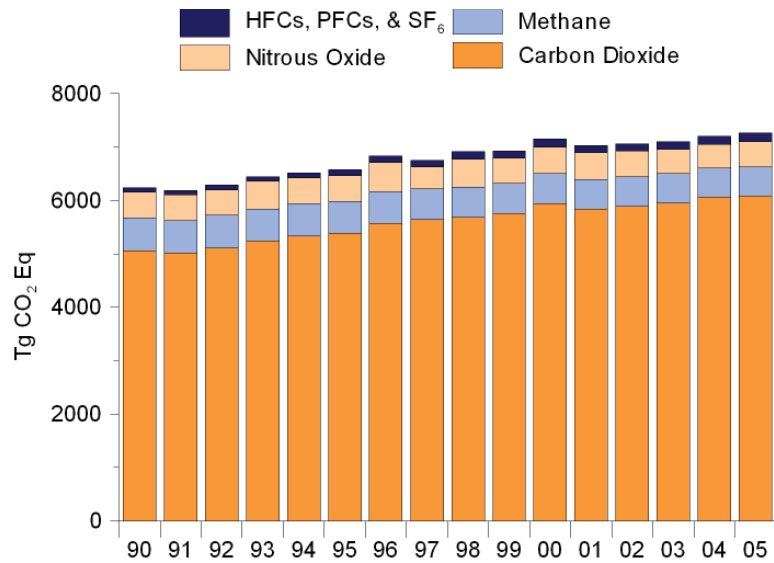


Figure 38. Domestic greenhouse gas emissions in teragrams of carbon dioxide equivalents (Tg CO<sub>2</sub> eq), 1990-2005. (Source: <http://epa.gov/climatechange/emissions/usinventoryreport.html>)

Notes: A teragram is equal to 1 million metric tons. Emissions in the figure include fluorocarbons (HFCs, PFCs) and sulfur hexafluoride (SF<sub>6</sub>).

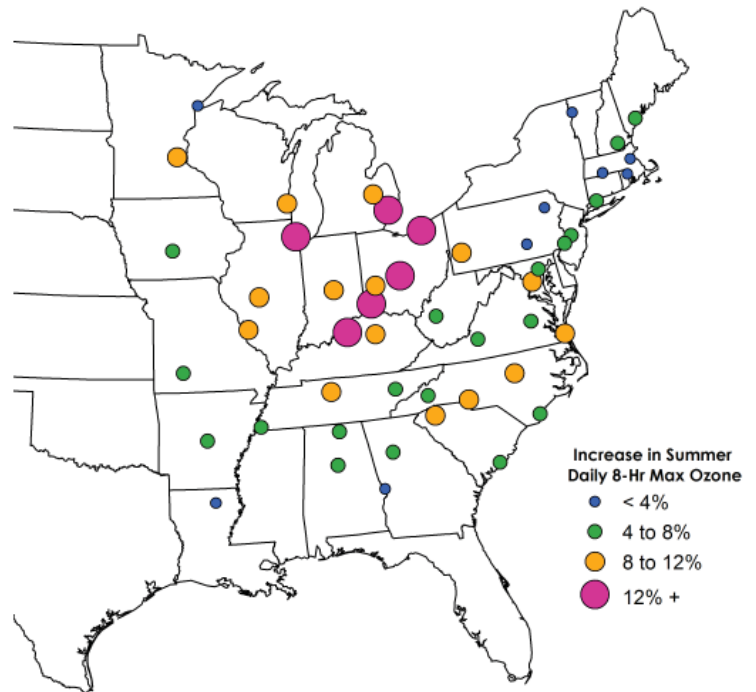


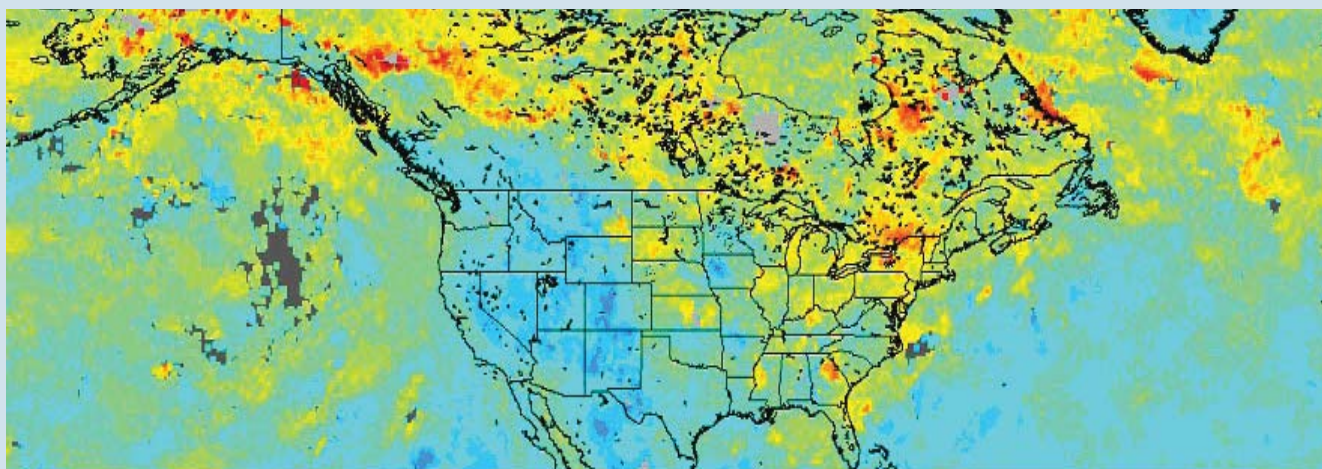
Figure 39. Predicted increases in summertime daily maximum 8-hour ozone concentrations between the 1990s and 2050s. (Source: Bell, M., et al. *Climate change, ambient ozone, and health in 50 U.S. cities*. Climatic Change, Vol. 82, Numbers 1-2, May 2007, pp. 61-76)

## International Transport of Air Pollution

While domestic sources of emissions are the primary cause of air pollution in our country, the U.S. is both an importer and exporter of air pollution. Air pollution flows across boundaries — not only between the U.S. and our closest neighbors, Canada and Mexico, but also between North America, Europe, and Asia, and to some extent, between North America, Africa, and Central and South America.

Economic growth, in conjunction with increased emissions of particle pollution, mercury, and ozone precursors in developing countries, may increase background levels of these pollutants in the U.S. EPA and other agencies are working via treaties and international cooperative efforts to address the international transport of air pollution. For information about the Task Force on Hemispheric Transport of Air Pollution, an international panel on which EPA serves, visit <http://www.htap.org/>.

The figure below illustrates how pollution can move. In the summer of 2004, NASA researchers sampled a variety of trace gases and aerosols (tiny particles suspended in the air) across North America. During this time, wildfires in western Canada and eastern Alaska were burning more acres than at any time in the previous 50 years. Smoke from these fires traveled eastward and southward, reaching as far as the U.S. Gulf Coast.



*This figure shows, for July 12-26, 2004, the total amount of carbon monoxide, one of the pollutants emitted by wildfires, as measured by the Measurements of Pollution in the Troposphere (MOPITT) instrument aboard NASA's Terra Satellite. High levels of pollution are indicated by yellow and red colors, and blue indicates low pollution levels. (Source: National Center for Atmospheric Research/NASA)*



## TERMINOLOGY

AQI	Air Quality Index
AQS	Air Quality System
CAA	Clean Air Act
CAIR	Clean Air Interstate Rule
CASTNET	Clean Air Status and Trends Network
CO	carbon monoxide
dv	deciviews
EC	elemental carbon
EPA	U.S. Environmental Protection Agency
FRM	Federal Reference Method
GHG	greenhouse gas
HFCs	hydrofluorocarbons
IMPROVE	Interagency Monitoring of Protected Visual Environments
MOPITT	Measurements of Pollution in the Troposphere
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NATTS	National Air Toxics Trends Stations
NCAR	National Center for Atmospheric Research
NCORE	National Core Monitoring Network
NEI	National Emissions Inventory
NH <sub>3</sub>	ammonia
NO	nitric oxide
NO <sub>x</sub>	oxides of nitrogen
NO <sub>2</sub>	nitrogen dioxide
O <sub>3</sub>	ground-level ozone
OCM	organic carbon mass
Pb	lead
PFCs	perfluorinated compounds
PM	particulate matter
PM <sub>2.5</sub>	particulate matter (fine) 2.5 μm or less in size
PM <sub>10</sub>	particulate matter 10 μm or less in size
ppm	parts per million
SF <sub>6</sub>	sulfur hexafluoride
SIP	state implementation plan
SO <sub>x</sub>	sulfur oxides
SO <sub>2</sub>	sulfur dioxide
UATMP	Urban Air Toxics Monitoring Program
μm	micrometers
μg/m <sup>3</sup>	micrograms per cubic meter
VOC	volatile organic compound

## WEB SITES

1999 National-Scale Air Toxics Assessment: <http://www.epa.gov/ttn/atw/nata1999>

Acid Rain Program: <http://www.epa.gov/airmarkets/progsregs/arp/index.html>

Acid Rain Program 2006 Progress Report: <http://www.epa.gov/airmarket/progress/arp06.html>

Air Quality Index: <http://www.airnow.gov>

Air Quality System: <http://www.epa.gov/ttn/airs/airsaqs>

Air Quality Trends: <http://www.epa.gov/airtrends>

Air Toxics Monitoring: <http://www.epa.gov/ttn/amtic>

Air Trends Design Values: <http://www.epa.gov/air/airtrends/values.html>

Clean Air Status and Trends Network (CASTNET): <http://www.epa.gov/castnet>

Clean Air Interstate Rule: <http://www.epa.gov/cair>

Climate change: <http://www.epa.gov/climatechange/>

Emissions: <http://www.epa.gov/ttn/chief/>

Emissions and trends in greenhouse gases:  
<http://www.ipcc.ch>  
<http://www.epa.gov/climatechange/emissions/usinventoryreport.html>

EPA Monitoring Network: <http://www.epa.gov/ttn/amtic>

Health and Ecological Effects: <http://www.epa.gov/air/urbanair>

Local air quality trends: <http://www.epa.gov/airtrends/where.html>

Local trends in ozone levels: <http://www.epa.gov/airtrends/ozone.html>

National Air Monitoring Strategy Information:  
<http://www.epa.gov/ttn/amtic/monstratdoc.html>

National Ambient Air Quality Standards:  
<http://www.epa.gov/ttn/naaqs/>  
<http://www.epa.gov/air/criteria.html>

National Atmospheric Deposition Program: <http://nadp.sws.uiuc.edu/>

National Core Monitoring Network, "DRAFT National Ambient Air Monitoring Strategy":  
<http://www.epa.gov/ttn/amtic/files/ambient/monitorstrat/naamstrat2005.pdf>

National Park Service: <http://www.nature.nps.gov/air>

NO<sub>x</sub> Budget Program Under the NO<sub>x</sub> SIP Call: <http://www.epa.gov/airmarkets/progsregs/nox/sip.html>

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

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

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

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

Regional Haze Program: <http://www.epa.gov/visibility>

Review of the National Ambient Air Quality Standards for Particulate Matter:  
[http://epa.gov/ttnnaaqs/standards/pm/data/pmstaffpaper\\_20051221.pdf](http://epa.gov/ttnnaaqs/standards/pm/data/pmstaffpaper_20051221.pdf)

Task Force on Hemispheric Transport of Air Pollution: <http://www.htap.org>

The Particle Pollution Report - Current Understanding of Air Quality and Emissions Through 2003:  
<http://www.epa.gov/air/airtrends/aqtrnd04/pm.html>

Trends in ozone adjusted for weather conditions: <http://www.epa.gov/airtrends/weather.html>

Visibility Information Exchange Web Site (VIEWS): <http://vista.cira.colostate.edu/views/>



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

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