CHAPTER FIVE

Air Quality

Air quality has a variety of significant impacts on both human health and the environment.

In terms of human health, some air pollutants may cause lung cell damage, inflammation, acute changes in lung function and respiratory systems, as well as more long-term lung cell changes. Acute and chronic exposure to air pollutants is also associated with increased mortality and morbidity. Yet much remains to be understood, including, for instance, the role of air pollution in observed increases in asthma cases and deaths from lung disease.

Atmospheric particles may pose major concerns for human health. These include effects on breathing and respiratory systems, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, and carcinogenesis. Some research indicates that particles may contribute to premature death. Hazardous air pollutants, such as benzene and chlorine, also are believed to pose a significant threat to human health.

Air pollutants also have a variety of impacts on environmental quality. For example, atmospheric-borne nitrogen is a major contributor to nitrogen loadings in many estuaries. About 27 percent of the nitrogen in the Chesapeake Bay is from the atmosphere, while the atmospheric contribution to nitrogen levels in the Albemarle/Pamlico Sound is estimated at about 44 percent.

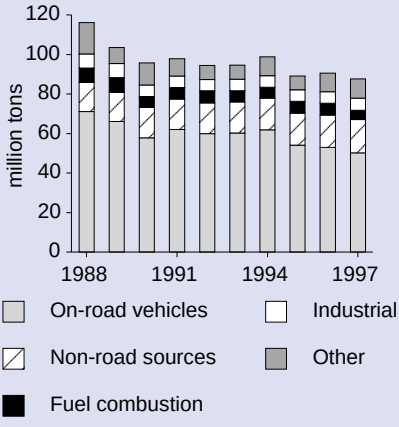
TRENDS FOR CRITERIA POLLUTANTS

Emissions of criteria pollutants and ambient air quality are reported by the Environmental Protection Agency in the *National Air Quality and Emissions Trends Report, 1997*, which describes trends in emissions and air quality during the period from 1988 to 1997. EPA also has recently published *National Air Pollutant Emission Trends, 1970-1997*, which is also available on CD-ROM. (See Selected Resources.)

Carbon Monoxide

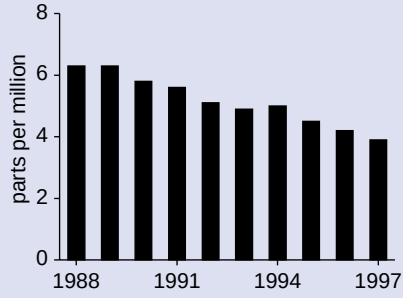
Over the past decade, national emissions of carbon monoxide have declined from 116.08 million tons in 1988 to 87.45 million tons in 1997 (Figure 5.1). More than half of total carbon monoxide emissions are from on-road vehicles. In that category, carbon monoxide emissions have declined from 71.08 million tons in 1988 to 50.26 million tons in 1997, despite a

Figure 5.1 U.S. CO Emissions by Source, 1988-1997



Source: See Part III, Table 5.1.
Notes: CO = carbon monoxide. Non-road sources include non-road gasoline engines (e.g., industrial, lawn and garden, light commercial, and recreational marine vessels), non-road diesel (e.g., construction and farm), aircraft, and railroads. Industrial refers to industrial processes. Other = structural, agricultural, and slash/prescribed fires.

Figure 5.2 U.S. Mean Ambient CO Concentrations, 1988-1997



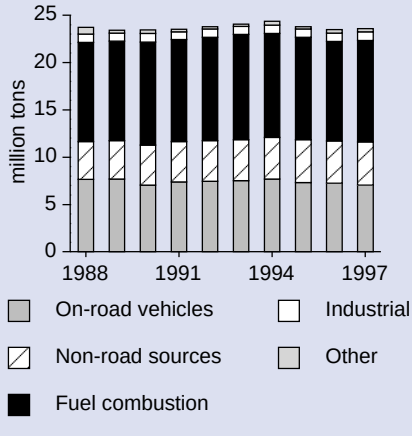
Source: See Part III, Table 5.10.
Note: CO = carbon monoxide.

25-percent increase in vehicle miles traveled over the period.

Among other sources, the most significant increase has occurred in the category of non-road sources, where emissions have increased from 14.70 million tons to 16.76 million tons over the 1988-97 period. Non-road sources include non-road gasoline engines (e.g., industrial, lawn and garden, light commercial, and recreational marine vessels), non-road diesel (e.g., construction and farm), aircraft, and railroads. Fires, including forest wildfires, agricultural fires, and slash/prescribed burning, are an unpredictable but occasionally significant source of carbon monoxide emissions; in 1988, for example, fires accounted for 15.90 million tons of carbon monoxide emissions. For trends in other sources, see Part III, Table 5.1.

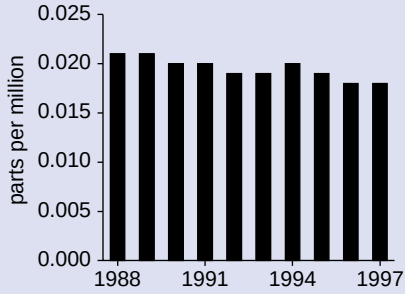
Ambient atmospheric concentrations of carbon monoxide decreased during the decade by 38 percent (Figure 5.2), indi-

Figure 5.3 U.S. NO_x Emissions by Source, 1988-1997



Source: See Part III, Table 5.2.
Notes: NO_x = nitrogen oxides. Non-road sources include non-road gasoline engines, non-road diesel (e.g., construction and farm), aircraft, marine vessels, and railroads. Industrial refers to industrial processes. Other includes other combustion, health services, cooling towers, and fugitive dust.

Figure 5.4 U.S. Mean Ambient NO_2 Concentrations, 1988-1997



Source: See Part III, Table 5.10.
Note: NO_2 = nitrogen dioxide.

cating that long-term improvements in air quality are continuing.

Nitrogen Oxides

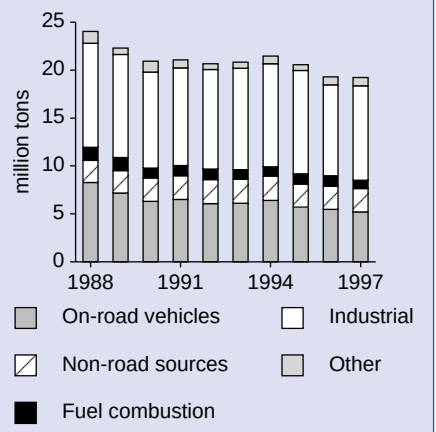
Over the period from 1950 to 1980, national emissions of nitrogen oxides (NOx) rose from 10.09 million to 24.87 million tons. Since 1988, total annual emissions have declined slightly (Figure 5.3). In 1997, emissions were 23.58 million tons, or 1 percent lower than the 1988 total, although changes in data availability and methodology between 1989 and 1990 (in the other combustion category) introduce some uncertainty in this comparison. The principal sources are fuel combustion from electric utilities and industrial processes (10.72 million tons in 1997), on-road vehicles (7.04 million tons in 1997), and non-road sources, which include non-road gasoline engines, non-road diesel (e.g., construction and farm), aircraft, marine vessels, and railroads (4.56 million tons in 1997). For emissions by source, see Part III, Table 5.2.

The trend in atmospheric concentrations of nitrogen dioxide across the country between 1988 and 1997 shows a 14-percent decrease in the national composite mean (Figure 5.4). Since most monitors of nitrogen dioxide are located in urban, population-oriented areas, the trend in ambient concentrations is primarily representative of highway emissions of nitrogen oxides, which decreased 8 percent between 1988 and 1997.

VOCs and Ozone

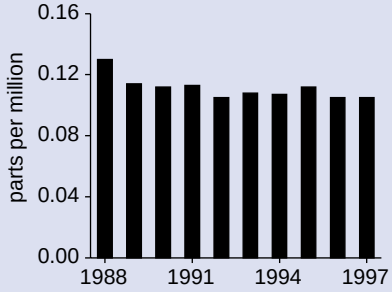
National emissions of volatile organic compounds (VOCs), which along with nitrogen oxides are precursors to ground level ozone formation, peaked at 30.6 million tons in 1970 and have since fallen to 19.21 million tons in 1997 (Figure 5.5).

Figure 5.5 U.S. VOC Emissions by Source, 1988-1997



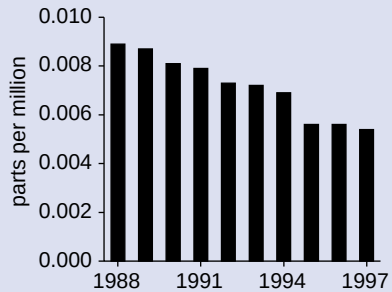
Source: See Part III, Table 5.3.
Notes: VOC = volatile organic compounds. Non-road sources include non-road gasoline engines (e.g., lawn and garden and recreational marine vessels), non-road diesel (e.g., construction and farm), and aircraft. Industrial refers to industrial processes. Other includes fires, other combustion, and natural geogenic sources.

Figure 5.6 U.S. Mean Ambient O_3 Concentrations, 1988-1997



Source: See Part III, Table 5.10.
Note: O_3 = ozone. Data refer to ground-level ozone.

Figure 5.7 U.S. Mean Ambient SO_2 Concentrations, 1988-1997



Source: See Part III, Table 5.10.
Note: SO_2 = sulfur dioxide.

Industrial processes accounted for 9.84 million tons of emissions, on-road vehicles for 5.23 million tons, and non-road sources, which include non-road gasoline engines (e.g., lawn and garden equipment and recreational marine vessels), non-road diesel (e.g., construction and farm), and aircraft, for 2.43 million tons in 1997. For emissions by source, see Part III, Table 5.3.

Ambient atmospheric ozone trends are influenced by year-to-year changes in meteorological conditions, population growth, VOC-to-NOx emissions ratios, and by changes in emissions from ongoing control measures. Hot, dry meteorological conditions, such as occurred in 1988 and 1995, are highly conducive to ozone formation. Despite increases in these years, the 10-year trend shows a 19 percent decline in composite national average daily maximum 1-hour atmospheric ozone concentration (Figure 5.6). Although the general pattern of ozone trends across urban, suburban, and rural areas of the country is similar, the highest concentration levels are typically found at suburban sites. In mid-1997, EPA announced new primary and second 8-hour ozone standards (See Box 5.1).

Sulfur Dioxide

Progress toward reducing ambient atmospheric concentrations of sulfur dioxide during the past 20 years was accom-

Box 5.1
Primary and Secondary 8-hour Ozone Standards

On July 18, 1997, EPA established an 8-hour O_3 primary standard to protect against longer exposure periods that are of concern for both human health and vegetation. The level of the national 8-hour primary and secondary ambient air quality standards for ozone is 0.08 ppm. The standards are met when the 3-year average of the annual fourth-highest daily maximum 8-hour ozone concentration is less than or equal to 0.08 ppm. EPA will designate ozone nonattainment areas for the 8-hour ozone NAAQS by July 2000.

plished by installing flue-gas control equipment in coal-fired electric utilities, reducing emissions from industrial processing facilities, reducing the average sulfur content of fuels burned, switching to low-sulfur coal, and using cleaner fuels in residential and commercial burners. Between 1988 and 1997, annual mean concentrations of sulfur dioxide decreased 39 percent (Figure 5.7), with the largest single-year reduction (19 percent) occurring between 1994 and 1995 (See Box 5.2). The trend has since leveled off, declining only 4 percent from 1996-97.

National emissions of sulfur dioxide have fallen to about two thirds the 1970 level of 31.16 million tons, reaching 20.37 million tons in 1997 (Figure 5.8). The principal sources of sulfur dioxide emissions are fuel combustion, primarily from electric utilities and industrial processes. Emissions from electric utilities have declined to 13.08 million tons in 1997, about two thirds the 1970 level of 17.40 million tons. National SO_2 emissions decreased 12 percent between 1988 and 1997, with a sharp decline between 1994 and 1995, similar to the decline in the ambient concentrations. Unlike the

Box 5.2
The Acid Rain Program

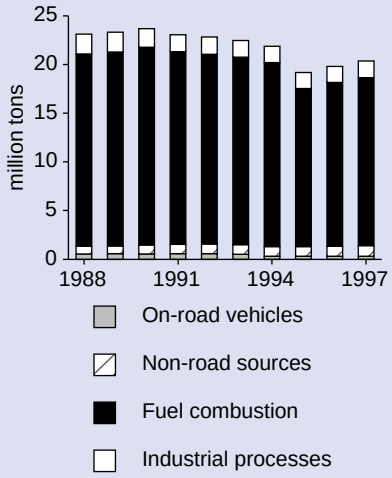
The 1994-95 national reductions in emissions and ambient concentrations of SO_2 are due mainly to Phase I implementation of the Acid Rain Program. Established by EPA under Title IV of the Clean air Act Amendments, the Acid Rain Program's principal goal is to achieve significant reductions in SO_2 and NO_x emissions. Phase I compliance for SO_2 began in 1995 and significantly reduced emissions from the participating electric utilities (See Box Table 5.1). Since 1995, however, total SO_2 emissions from electric utilities have increased. The majority of the increase is attributed to those units not yet participating in the Acid Rain Program. Most of these units will be included in Phase II of the Program, which begins in 2000. The rest of the increase came from some Phase I plants which over-complied in 1995 and were able to use their banked emission allowances in 1996 and 1997. When fully implemented, total SO_2 emissions from electric utilities are capped at 8.9 million tons per year.

Box Table 5.1 Total SO_2 Emissions from Phase I Electric Utility Units and Non-Phase I Electric Utility Units, 1994-1997

Utility Units	1994	1995	1996	1997	1994-95	1995-97
			thousand tons			
Phase I Units	6,915	4,938	5,259	5,304	-1,977	+366
Non-Phase I Units	7,974	7,142	7,373	7,778	-832	+636
All Units	14,889	12,080	12,632	13,082	-2,809	+1,002

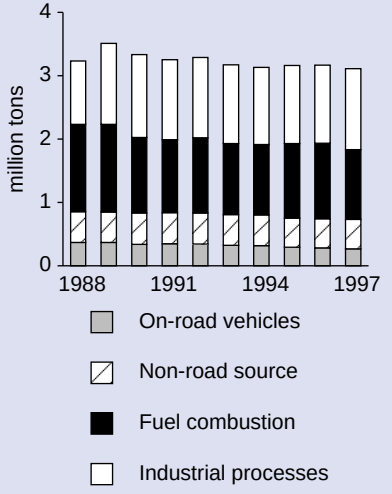
Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *National Air Quality and Emissions Trends Report, 1997,* Table 2.5 (EPA, OAQPS, Research Triangle Park, NC, 1998).

Figure 5.8 U.S. SO_2 Emissions by Source, 1988-1997



Source: See Part III, Table 5.4.
Note: SO_2 = sulfur dioxide. Non-road sources include marine vessels and railroads.

Figure 5.9 U.S. PM-10 Emissions by Source, 1988-1997



Source: See Part III, Table 5.5.
Notes: PM-10 = particulate matter with a diameter 10 micrometers or less. Does not include natural sources or fugitive dust. Non-road sources include non-road diesel (e.g., construction and farm) and railroads.

air quality trend, however, the emissions trend increased from 1995 to 1997, as explained in Box 5.2.

Particulate Matter

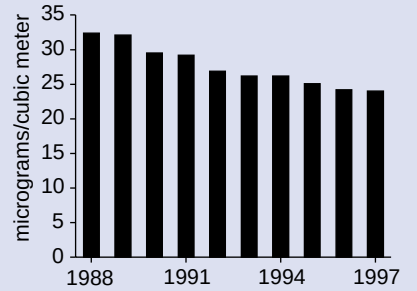
Nationally, PM-10 direct emissions decreased 12 percent between 1988 and 1997. Direct PM-10 emissions are generally examined in two separate groups. Of the more traditionally inventoried sources (fuel combustion, industrial processes, and transportation), the fuel combustion category saw the largest decrease over the 10-year period (Figure 5.9), with most of the decline possibly attributable to a decrease in emissions from residential wood burning. Local control programs to curtail the use of residential wood heaters during times when the air was stagnant and to replace old woodstoves with new, cleaner burning models are responsible for the decrease in residential wood burning, along with lower natural gas and fuel oil prices. Emissions from industrial processes changed very little over the 10-year period, while the on-road vehicles category decreased 27 percent and non-road sources decreased 4 percent.

The second group of direct PM-10 emissions is a combination of miscellaneous and natural sources including agriculture and forestry, wildfires and managed burning, fugitive dust from paved and unpaved roads, and wind erosion. These miscellaneous and natural sources actually account for about 90 percent of the total direct PM-10 emissions nationwide, although they can be difficult to quantify compared to the traditionally

inventoried sources. Because the emissions in the miscellaneous/natural group tend to fluctuate a great deal from year to year, the trend from one year to the next or over several years may not be particularly meaningful. See Part III, Table 5.5 for emissions by source and Part III, Table 5.6 for miscellaneous sources.

Mean annual PM-10 concentrations have decreased 26 percent since 1988, which was the first year of PM-10 data for most monitors (Figure 5.10). Urban, suburban, and rural areas have similar trends, although concentrations in rural areas are significantly lower. Several factors have played a role in reducing PM-10 concentrations since 1988. Where appropriate, states required emissions from industrial sources and construction activities to be reduced to meet the PM-10 standards. Measures were also adopted to reduce street dust emissions, including the use of clean anti-skid materials like washed sand, better control of the amount of material used, and removal of the material from the street as soon as the ice and snow melted. In addition, cleaner burning fuels like natural gas and fuel oil have replaced wood and coal as fuels for residential heating and industrial and electric utility furnaces.

Figure 5.10 U.S. Mean Ambient PM-10 Concentrations, 1988-1997



Source: See Part III, Table 5.10.
Note: PM-10 = particulate matter with a diameter 10 micrometers or less.

In July 1997, the standards for PM-10 were revised (See Box 5.3).

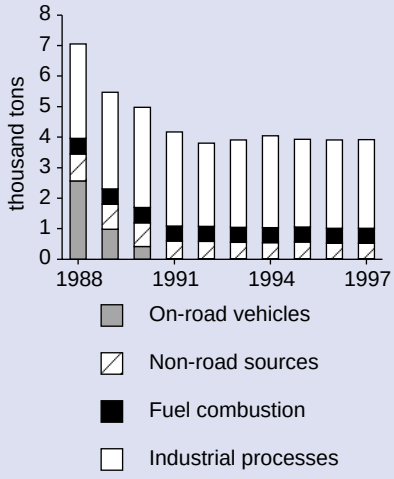
Lead

Annual national emissions of lead have declined spectacularly, dropping from the 1970 level of 221,000 tons to the 1997 level of less than 4,000 tons. Emissions from on-road vehicles, estimated at

Box 5.3
Primary and Secondary PM-10 Standards

The original standards for PM, established in 1971, were for total suspended particulate (TSP) matter. In 1987, EPA replaced the TSP standards with PM-10 standards to focus on smaller particles of aerodynamic diameter less than or equal to 10 micrometers. These smaller particles caused the greatest health concern because of their ability to penetrate into sensitive regions of the respiratory tract. The most recent review of the PM standards concluded that still more protection from adverse health effects was needed. In July 1997, the primary (health-based) PM standards were revised to add two new PM 2.5 standards, set at 15 $\mu g/m^3$ for the annual standard and 65 $\mu g/m^3$ for the 24-hour standard, and to change the form of the 24-hour PM-10 standard. The secondary (welfare-based) standards were revised by making them identical to the primary standards.

Figure 5.11 U.S. Lead Emissions by Source, 1988-1997



Source: See Part III, Table 5.7.
Note: Non-road sources include non-road gasoline engines and aircraft.

172,000 tons in 1970, dropped to about 19 tons in 1997 as a result of the federal phaseout of lead in gasoline. Emissions from metals processing also have dropped sharply, from the 1970 level of 24,000 tons to 2,038 tons in 1997. Over the period 1988-1997, total lead emissions decreased 44 percent (Figure 5.11). Part III, Table 5.7, which lists lead emissions by major source category, shows that on-road vehicles accounted for 82 percent of the 10-year emissions decline.

Over the past 10-year period, atmospheric lead concentrations decreased 67 percent at population-oriented monitoring sites (Figure 5.12). Air quality trends segregated by location (urban, suburban, and rural) show similar declines over the period.

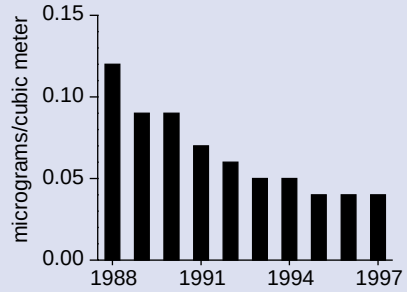
Reductions in lead emissions and atmospheric concentrations are a direct result of the phase-out of leaded gasoline. Because industrial processes are now responsible for all violations of the lead standard and account for 74 percent of total lead emissions, the lead monitoring strategy is now focused on these emissions point sources. On-road vehicles now account for only one-half of a percent of total 1997 lead emissions, while non-road sources account for about 13 percent.

OTHER AIR QUALITY TRENDS

Acid Rain

The National Acid Deposition Program (NADP) monitors wet atmospheric deposition at over 220 National Trends Network (NTN) sites throughout the United States. The program is a partnership between the US Geological Survey and over 100 other federal, state, local and private organizations. USGS supports 72 of the NADP/NTN sites.

Figure 5.12 U.S. Mean Ambient Lead Concentrations, 1988-1997

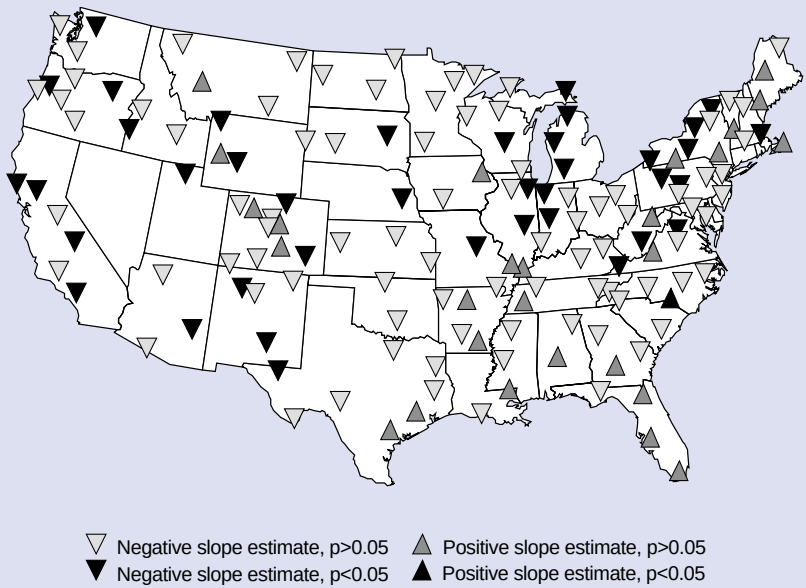


Source: See Part III, Table 5.10.

Based on data collected at NADP/NTN sites, recent studies by Lynch, et al (1996) and other researchers support the conclusion that the Acid Rain Program (Title IV) mandated by the Clean Air Act Amendments of 1990 has, wholly or in part, reduced acid deposition, particularly in the eastern United States. Reductions in the acidity (as represented by hydrogen ion concentration) and sulfate concentration of precipitation occurred in the Ohio River Valley region, where many of the largest emitters of sulfur dioxide targeted by Phase I of Title IV are located, as well as to the east of this region—across the Mid-Atlantic region and north through Maine (Figures 5.13 and 5.14). For example, the average reduction in sulfate concentrations in Ohio was approximately 21 percent, in Maryland, 27 percent, and in Pennsylvania, 15 percent. The largest decrease (32 percent) occurred in the northern portion of West Virginia. Nitrate concentrations at NADP/NTN sites were not appreciably different in 1995–1996 from historical levels. See Part III, Table 5.9.

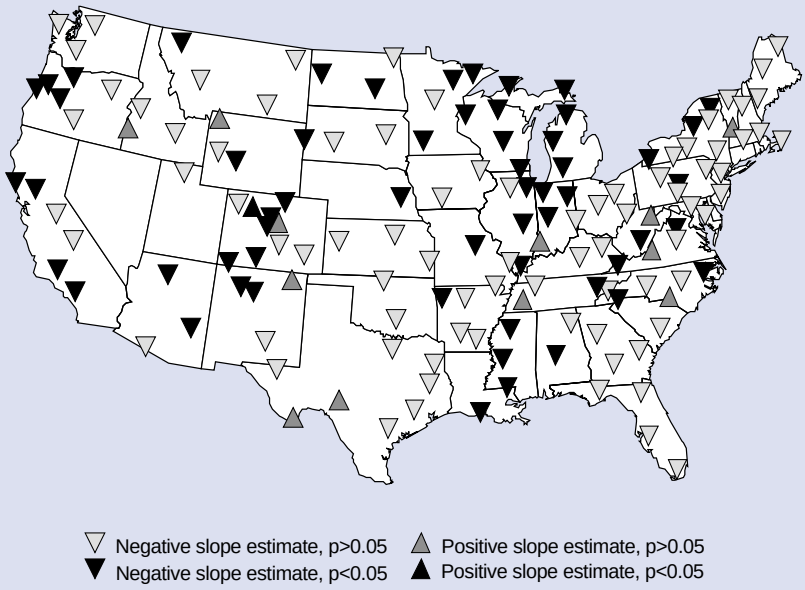
Another important source of information on acid rain is the National Acid Precipitation Assessment Program (NAPAP), an interagency scientific research, monitoring and assessment program on the effects of sulfur and nitrogen oxides on the environment and human health. NAPAP acts as a coordinating office between six Federal agencies. The

Figure 5.13 Trends in Hydrogen Ion Concentrations, 1983-1994



Source: Lynch, J.A., V.C. Bowersox & J.W. Jeffrey. *Trends in Precipitation Chemistry in the United States,1983-94: An Assessment of the Effects in 1995 of Phase I of the Clean Air Act Amendments of 1990, Title IV.* USGS Open File Report 96-0346 (USGS, Reston, VA, 1996).

Figure 5.14 Trends in Sulfate Ion Concentrations, 1983-1994



Source: Lynch, J.A., V.C. Bowersox & J.W. Jeffrey. *Trends in Precipitation Chemistry in the United States, 1983-94: An Assessment of the Effects in 1995 of Phase I of the Clean Air Act Amendments of 1990, Title IV.* USGS Open File Report 96-0346 (USGS, Reston, VA, 1996).

participating agencies are the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, the Department of Energy, the Department of the Interior, the Department of Agriculture, and the National Aeronautics and Space Administration.

In 1996, NAPAP conducted an integrated assessment of the costs, benefits and effectiveness of acid rain controls specified in Title IV of the 1990 Clean Air Act Amendments. The results of the assessment were published in the *NAPAP Biennial Report to Congress: An Integrated Assessment*. The report found that:

- SO_2 emissions have declined since 1980 and especially in 1995, the first year of Title IV.
- The acidity of and sulfate concentrations in precipitation have decreased in the Midwest, Mid-Atlantic, and the Northeast United States.
- Since 1980, lakes and streams throughout many areas of the United States have experienced decreases in sulfate concentrations.
- Although there is evidence of recovery from acidification in New England lakes, additional reductions in sulfur and nitrogen deposition would be required to fully recover sensitive Adirondack lakes.
- Sulfur and nitrogen deposition have caused adverse impacts on certain highly sensitive forest ecosystems in the

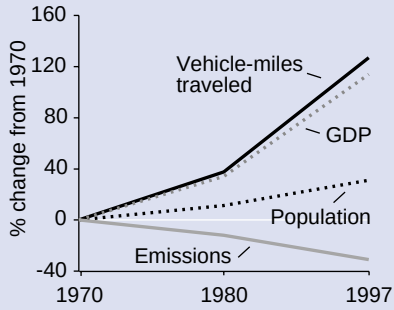
United States, especially high-elevation spruce-fir forests in the eastern United States. Most forest ecosystems are not currently known to be adversely impacted by acid deposition. However, if deposition levels are not reduced in areas where they are presently high, adverse effects may develop in more forests due to chronic, multiple-decade exposure.

- Reduced SO_2 emissions are expected to reduce sulfate concentrations and, in turn, their contribution to haze.
- Decreased emissions are expected to reduce fine-particulate sulfate and nitrate concentrations in air, possibly leading to reductions in adverse health effects.
- Quantifiable economic benefits could be relatively large in the areas of human health and visibility and exceed the costs of reducing emissions.
- The market-based approach to reducing emissions of SO_2 has reduced compliance costs for utilities below those of a traditional command-and-control approach.

Mobile Sources

Notable reductions in air pollutant emissions and air quality concentrations have occurred since 1970 (Figure 5.15), despite significant increases in population, economic and industrial activity, and vehicle miles traveled. Much of the improvement in air quality is due to reductions in pollutant emissions from mobile sources.

Figure 5.15 U.S. Aggregate Emissions, Demographic, and Economic Trends, 1970-1997



Source: U.S. Environmental Protection Agency, *Air Quality and Emissions Trends Report, 1997* (EPA, Research Triangle Park, NC, 1998).
Note: GDP = Gross Domestic Product.

Visibility

Visibility impairment, as measured by the amount of haze during summer months at 280 monitoring stations located at airports across the country, increased greatly between 1970 and 1980, and decreased slightly between 1980 and 1990. These trends follow overall trends in emissions of sulfur oxides during these periods. In more recent studies, aerosol and light extinction data have been collected for 10 consecutive years (1988-1997) at 29 sites in the Interagency Monitoring of Protected Environments (IMPROVE) network (consisting primarily of national parks and wilderness areas), and for 6 consecutive years (1992-1997) at 8 additional sites. These data show that in the East, the haziest visibility days do not appear to be getting any better and the best visibility days appear to be relatively flat or improving slightly. In contrast,

there appears to be steady visibility improvement in the West.

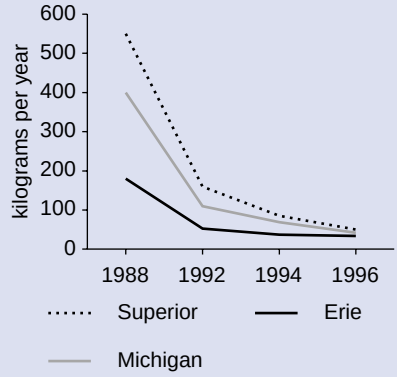
Air Toxics

In 1993, there were approximately 8.1 million tons of hazardous air pollutants (HAPS) released to the air, according to EPA's National Toxics Inventory (NTI). The 1993 NTI includes emissions information for 166 of the 188 HAPs from 958 point-, area-, and mobile-source categories. Emissions data from the Toxic Release Inventory (TRI) were used as the foundation of the 1993 NTI. EPA is currently compiling the 1996 NTI.

Air toxics are emitted from all types of manmade sources, including large point sources such as industrial facilities and utilities, area or smaller stationary sources such as neighborhood dry cleaners, and mobile sources (automobiles and trucks). Point sources that emit more than 10 tons per year of an individual HAP or 25 tons per year of aggregate emissions of HAPs account for approximately 61 percent of the total HAP emissions, nationally, while area sources contribute approximately 18 percent, and mobile sources contribute 21 percent.

People can be exposed to air toxics by breathing contaminated air or ingesting food from contaminated waters where air toxics are deposited. Potential health effects resulting from exposure to hazardous air pollutants include leukemia and other cancers; reproductive and developmental effects such as impaired development in newborns and young children, miscarriage, decreased fertility; and damage to the pulmonary system.

Figure 5.16 PCB Deposition to the Great Lakes, 1988-1996



Source: Intergrated Atmospheric Deposition Network.

The extent to which these effects actually occur in the population depends on a number of factors, including the level and duration of exposure. Air toxics can also adversely impact ecosystems; in some cases, deposited air pollutants can be significant contributors to overall pollutant loadings to waterbodies such as the Great Lakes (See Figure 5.16 for an example). Many of these pollutants are responsible for fish consumption advisories in lakes and inland waterways.

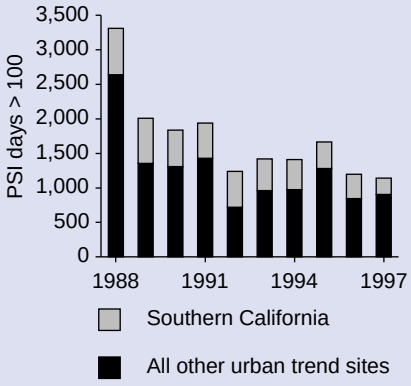
Pollutant Standards Index

The Pollutant Standards Index (PSI) is derived from pollutant concentrations and reported daily in all metropolitan areas of the United States with populations exceeding 200,000. The PSI is reported as a value between zero and 500; these values are associated with general descriptions of air quality. (See Part III, Table 5.11) A PSI value greater than 100

indicates that at least one criteria pollutant (with the exception of NO_2) exceeded the level of the NAAQS, therefore indicating unhealthful air. Relatively high PSI values activate public health warnings. The number of days with PSI values greater than 100 is used as an indicator of urban air quality. Analysis of PSI trends in the nation's 94 largest metropolitan areas over the period 1988 through 1997 show a 56 percent decrease in PSI values greater than 100 in Southern California and 66 percent decrease in the remaining major cities across the United, concomitant with improvements in ambient air (Figure 5.17).

While progress has been made, it is important not to lose sight of the air pollution problems that still remain. Though air quality trends are improving nationally, there are still areas, both urban and rural, with concentrations above the level of the national standard and even areas with worsening trends. Based upon monitoring data submitted to EPA's Aerometric Information Retrieval System (AIRS) data base, approximately 107 million people in the United States reside in counties with air quality concentrations above the level of the NAAQS in 1997. (Note: Population estimates are intended to provide a relative measure of the extent of the problem for each pollutant in a single year. An individual living in a county that had a measured concentration above the the level of the NAAQS may not actually be exposed to unhealthy air.) See Part III, Table 5.12.

Figure 5.17 U.S. Urban Air Quality, 1988-1997



Source: See Part III, Table 5.11.
Notes: PSI = Pollutant Standards Index. PSI days > 100 are within the unhealthy range. See notes for Table 5.11. Because of their magnitude, PSI totals for Los Angeles, CA, Riverside, CA, Bekersfield, CA, and San Diego, CA are shown separately as Southern California.

Nonattainment Areas

When an area does not meet the air quality standard for one of the criteria pollutants it may be subject to EPA's formal rule-making process that designates it as nonattainment. As of September 1998, there were a total of 130 nonattainment areas on EPA's condensed nonattainment list. The areas on the condensed list are on the Internet (http://www.epa.gov/airs/nonattn.html). The list is updated as areas are redesignated.

There are approximately 113 million people living in areas currently designated as nonattainment. (Note: These population estimates differ from those presented in the previous paragraph because formal nonattainment designations are based on multiple years data rather than a single year and generally do not follow county boundaries. For example, ozone nonattainment areas typically compose

the entire metropolitan area, which may include additional counties that do not contain air quality monitors.) See Part III, Table 5.13.

Indoor Air Quality

Research indicates that air in homes, schools, and workplaces can have higher levels of pollution than outdoor air. Common indoor pollutants include radon, lead, environmental tobacco smoke (ETS), household chemicals and pesticides, and biological pollutants such as bacteria, viruses, mold, dust mites, and animal dander.

Radon, a naturally occurring gas, is the country's second leading cause of lung cancer, accounting for 15,000-22,000 deaths per year. Radon can be managed with readily available technology.

ETS is responsible for approximately 3,000 lung cancer deaths in nonsmokers annually, as well as 150,000 to 300,000 lower respiratory tract infections in infants, resulting in up to 15,000 hospitalizations per year. It also affects from 200,000—1,000,000 asthmatic children per year. Levels of asthma appear to have increased in the past decade or more.

ONLINE RESOURCES

The Environmental Protection Agency maintains a vast quantity of material on its website. Many of these resources are listed in the sections on selected resources below. Other federal agencies with air-quality-related material include the Department of Energy's Energy Information Administration, the Department of Transportation's Bureau of Transportation Statistics, the Department of Interior's National Park Service, and the Department of Labor's Occupational Safety and Health Administration (OSHA).

Many other websites provide valuable information about air quality. For example, the site maintained by the State and Territorial Air Pollution Program Administrators (STAPPA) and the Association of Local Air Pollution Control Officials (ALAPCO) offers a wealth of information (http://www.4cleanair.org/links.html). STAPPA/ALAPCO's "Air Links" site includes links to local, state, and federal agencies, and other organizations. It also includes information by topic. The topics include acid rain, the Clean Air Act, climate change, enforcement, motor vehicles, particulate matter, permits, pollution prevention, smog, stratospheric ozone, toxics, and training.

The Air and Waste Management Association's (A &WMA) online publications provide information on environmental science, research, and policy issues (http://www.awma.org). The *Journal of the Air and Waste Management Association* site contains hundreds of peer-reviewed technical articles on environmental science and research.

Acid Rain

EPA's Acid Rain Program is online (http://www.epa.gov/docs/acidrain/ardhome.html). The program's system of tradable SO_2 allowances is a landmark use of market incentives in environmen-

tal protection. The site includes information on SO_2 emissions trading and allowance data, on EPA's NOx reduction program, and on emissions monitoring and reporting.

The Department of Energy's Clean Coal Technology Program began in 1986 with a mandate to expand the list of innovative pollution control options to curb the release of acid rain pollutants. The program has sponsored 45 first-of-a-kind projects, which are underway in 21 states (http://www.doe.gov/html/fe/cct.html).

The National Atmospheric Deposition Program, which is housed at the Illinois State Water Survey at the University of Illinois, operates a nation-wide atmospheric deposition monitoring network through collaborative relationships with federal, state, academic, and private organizations. The website offers information on the program as well as access to acid rain data and isopleth maps (http://nadp.sws.uiuc.edu). The National Acid Precipitation Assessment Program (NAPAP) also is online (http://www.oar.noaa.gov/admin/napap.html).

Environment Canada (http://www.ec.gc.ca/envhome.html) provides a wide range of information on acid rain. For example, the *1996 Annual Report on the Federal-Provincial Agreements for the Eastern Canada Acid Rain Program* is available in PDF format (http://www.ec.gc.ca/pdb/can_us/easteg96.pdf). Environment Canada's National Environmental Indicator Series includes data on emissions of sulfur dioxide, emissions of nitrogen oxides, wet sulphate deposition, and trends in lake acidity in southeastern Canada (http://199.212.18.79/~ind/english/AcidRain/default.cfm).

Mobile Sources

EPA's Office of Mobile Sources site (http://www.epa.gov/omswww) contains information on mobile vehicles, fuels, and nonroad engines. The site includes information on transportation/air quality planning, including material on trading and market incentives. The Department of Transportation's Bureau of Transportation Statistics (http://www.bts.gov) also provides a variety of statistical and research materials on transportation and clean air issues. For information specifically about highways, the Federal Highway Administration's Office of Highway Information Management (http://www.fhwa.dot.gov/ohim/) includes selected documents, periodicals, and highway-related data from federal, state, and local sources.

California, one of the most active states on transportation and air quality, has several valuable sites. The California Air Resources Board (http://www.arb.ca.gov/homepage.htm), a department of the California Environmental Protection Agency, includes a buyer's guide to cleaner cars that can help consumers identify new or used vehicles that produce particularly low levels of emissions.

The South Coast Air Quality Management District (http://www.aqmd.gov/) is the smog control agency for all or portions of Los Angeles, Orange, Riverside, and San Bernardino counties in the Los Angeles area, where 14 million people breathe the dirtiest air in the nation.

The site includes information on smog levels, compliance programs, clean air plans, rules and regulations, business assistance, transportation programs, the permitting process, and clean air technologies. The site includes a table showing historic ozone air quality trends in the South Coast Air Basin from 1976 to 1996. The table shows a significant reduction in the number of days ozone levels exceeded health standards in the basin area over the two-decade period.

Visibility

The National Park Service's NatureNet (http://www.aqd.nps.gov) provides information about environmental and other issues related to the National Park System. The site includes the "AIR-Web" (http://www.aqd.nps.gov/ard), which includes information on air quality in parks and refuges and air quality legal mandates. NPS also has devised a prototype park.

The NPS Visibility Monitoring Program includes information about visibility monitoring, visibility impairment photos, and related resources (http://www.aqd.nps.gov/ard/vis/vishp.html).

Indoor Air Quality

Information on indoor air quality is available at EPA's indoor air homepage (http://www.epa.gov/iaq) and on OSHA's homepage (http://www.oshaslc.gov/SLTC/indoorairquality/index.html).

OTHER WEBSITES OF INTEREST

AirNow - real-time air pollution data, information about the public health and environmental effects of air pollution, and information about ways to protect public health and reduce air pollution. This website, which is also known as the Ozone Mapping Project, currently focuses on ground-level ozone (smog). Future plans for this website are to expand the geographic coverage of the current ozone maps and to include other pollutants (http://www.epa.gov/airnow/).

AIRSData - access to key measures of air pollution that EPA uses to assess the Nation's air quality; measurements of ambient air quality for the past five years from 4,000 air monitoring sites across the nation; air pollutant emissions and regulatory compliance status for 9,000 point sources regulated by EPA. Reports and maps are generated on demand from a database refreshed monthly with the latest information from AIRS (http://www.epa.gov/airsweb/).

Atmospheric Integrated Research Monitoring Network (AIRMoN) - an array of stations maintained by the National Oceanic and Atmospheric Administration (NOAA) designed to provide a research-based foundation for the routine operations of the nation's deposition monitoring networks—the National Atmospheric Deposition Program (NADP) for wet deposition, and the Clean Air Status and Trends Network (CASTNet) for dry. A subprogram is specifically designed to

detect the benefits of emissions controls mandated by the Clean Air Act Amendments of 1990, and to quantify these benefits in terms of deposition to sensitive areas (http://www.arl.noaa.gov/research/programs/airmon.html).

Environmental Radiation Ambient Monitoring System (ERAMS) - a national network of monitoring stations that regularly collect air, water, precipitation, and milk samples for analysis of radioactivity (http://www.epa.gov/narel/erams.html).

Green Book: Nonattainment Areas for Criteria Pollutants - extensive information about nonattainment areas and National Ambient Air Quality Standards for the six criteria pollutants. Updated lists identify areas of the country where air pollution levels persistently exceed the national ambient air quality standards and are designated "nonattainment" (http://www.epa.gov/oar/oaqps/greenbk/).

Mercury Deposition Network - a subnetwork in NADP with 30 sites in operation to collect weekly concentrations of total mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition. The data will be used to develop information on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors (http://nadp.sws.uiuc.edu/mdn/).

NOAA/EPA UltraViolet Index (UVI) - access to daily, annual, and archived bulletins, graphs, and maps of UVI (http://nic.fb4.noaa.gov/products/stratosphere/uv_index/index.html).

Ozone Depletion - information about the science of ozone depletion, regulations in the U.S. designed to protect the ozone layer, information on methyl bromide, and flyers about the UV index (http://www.epa.gov/ozone/index.html).

Technology Transfer Network (TTNWeb) - a collection of related websites containing information about many areas of air pollution science, technology, regulation, measurement, and prevention. In addition, the TTNWeb serves as a public forum for the exchange of technical information and ideas among participants and EPA staff (http://www.epa.gov./ttn).

Toxics Release Inventory - access to data from EPA's Toxics Release Inventory (http://www.epa.gov/opptintr/tri/index.html).

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CORE DATA

Table 5.1 U.S. Emissions of Carbon Monoxide by Source, Ten-Year Intervals, 1940-1980, and Annually, 1988-1997

Table 5.2 U.S. Emissions of Nitrogen Oxides by Source, Ten-Year Intervals, 1940-1980, and Annually, 1988-1997

Table 5.3 U.S. Emissions of Volatile Organic Compounds by Source, Ten-Year Intervals, 1940-1980, and Annually, 1988-1997