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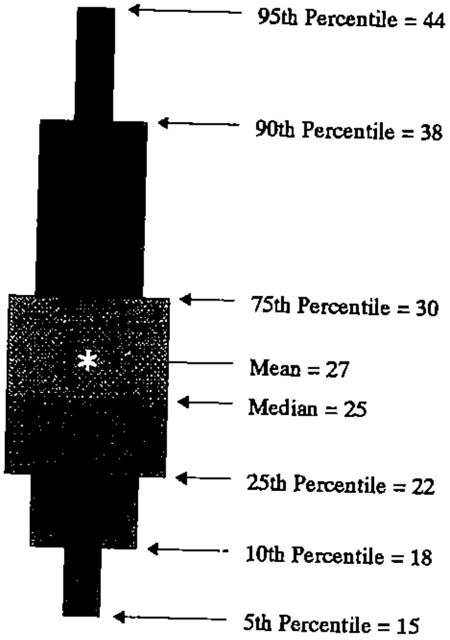
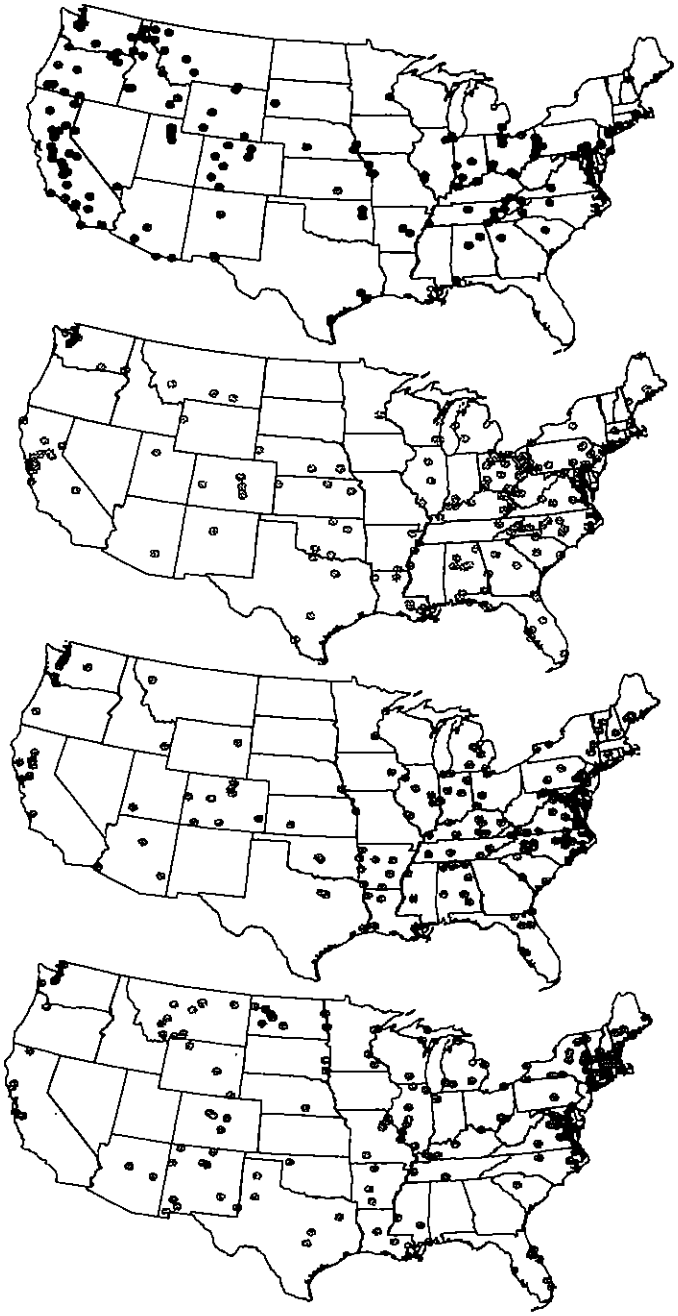
Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA 454/R-94-026
October 1994

Air

National Air Quality and Emissions Trends Report, 1993





-1993 Particulate Matter-
Highest County Annual Mean
(micrograms per cubic meter)

454/R-94-026

National Air Quality and Emissions Trends Report, 1993

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Technical Support Division
Research Triangle Park, North Carolina 27711

October 1994

About the Cover:

The graphical display presents both numerical and geographical distributions of annual mean particulate matter (PM-10) concentrations across the United States for 1993. The boxplot separates the data into quartiles, each represented by a different color. Arrows are drawn to show the annual mean concentration at each quartile and at several other percentiles. The adjacent maps are color-coded to correspond to the quartiles of the boxplot. Each dot on the maps represents the site of the highest annual mean concentration (in ug/m^3*) for that county. This graphical technique helps the reader discern spatial patterns in the particulate matter data. Note that the upper quartiles are dominated by sites located in the western part of the country and the Ohio River Valley, while sites in the eastern United States more frequently occur in the lower quartiles.*

Disclaimer

This report has been reviewed and approved for publication by the Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency. Mention of trade names or commercial products are not intended to constitute endorsement of recommendation for use.

Preface

This is the twenty-first annual report of air pollution trends issued by the U.S. Environmental Protection Agency. The report is prepared by the Technical Support Division and is directed toward both the technical air pollution audience and the interested general public. The Division solicits comments on this report and welcomes suggestions on the trends techniques, interpretations, conclusions, and methods of presentation. Please forward any response to Mr. Warren P. Freas, (MD-14) U.S. Environmental Protection Agency, Technical Support Division, Research Triangle Park, North Carolina, 27711.

For additional air quality data, readers can access the Aerometric Information Retrieval System (AIRS) Executive from the AIRS bulletin board on the Office of Air Quality Planning and Standards (OAQPS) Technology Transfer Network (TTN). To gain access by modem, dial (919) 541-5742. To gain access by internet, telnet ttnbbs.rtpnc.epa.gov. For help in accessing the OAQPS TTN, dial (919) 541-5384.

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Chapter 1: Executive Summary

1.1 Introduction

This is the twenty-first annual report documenting air pollution trends in the United States.[1–20] The primary emphasis of this report is on those pollutants for which the U.S. Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS). EPA set these standards to protect public health and welfare. Primary standards are designed to protect public health, while secondary standards protect public welfare, such as the effects of air pollution on vegetation, materials and visibility. Air toxics, another set of pollutants regulated under the Clean Air Act are also discussed. Air toxics are those pollutants known to cause, or suspected of causing, cancer or other serious health effects, such as reproductive effects or birth defects. Due to the limited availability of ambient data for air toxics, this report focuses on the analysis of trends in hazardous air pollutant emissions and the status of regulatory development for the air toxics provisions of the Clean Air Act Amendments of 1990 (CAAA).

The analyses in this report focus on comparisons with the primary standards in effect in 1993, examines changes in air pollution levels over time, and summarizes the current air pollution status. The six pollutants with National Ambient Air Quality Standards are: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM-10) whose aerodynamic size is equal to or less than 10 microns, and sulfur dioxide (SO_2). It is important to note that the discussions of ozone in this report refer to ground level (tropospheric) ozone and not to stratospheric ozone. Stratospheric ozone, which is miles above the earth, acts as a protective screen from the sun's ultraviolet rays. Ground level ozone, which is in the air we breathe, is a health and environmental concern and is the primary ingredient of what is commonly called smog.

This report tracks two kinds of trends: **air concentrations**, based on actual direct measurements of pollutant concentrations in the air at selected sites throughout the country; and **emissions**, which are estimates of the total tonnage of these pollutants released into the air annually. The emission trends are estimated using best available engineering calculations. These are derived from many factors, including the level of industrial activity, technology changes, fuel consumption, vehicle miles of travel, and other activities that cause air pollution. The trends also reflect changes in air pollution regulations and the installation of emission controls. The estimates of emissions in this report differ from those reported last year because of improvements in emission estimation methodologies. Also note that the 1990 to 1993 emission estimates are preliminary, and will be revised in the next report when final data from ozone State Implementation Plans (SIPs) become available. Additional emission estimates and a more detailed description of the estimation methodology is contained in a companion report, *National Air Pollutant Emission Trends, 1900–1993*.[21]

The first three chapters of this report describe trends in the six NAAQS pollutants. Chapter 3 also contains information on visibility trends throughout the country. Chapter 4 presents information on air toxics. Chapter 5 includes the status of areas with respect to the NAAQS as well as a listing of selected 1993 air quality summary statistics for every metropolitan statistical area (MSA) in the nation. Chapter 6 presents trends in the Pollutant Standards Index (PSI) for 89 cities with populations of at least one-half million. The PSI is widely used in the air pollution field to report daily air quality to the general public. PSI index values are reported in all metropolitan areas of the United States with populations exceeding 200,000. Chapter 7 provides an international air pollution perspective.

1.2 Major Findings

Carbon Monoxide (CO)

CO SUMMARY

- **Air Concentrations**

1984–93:	37 percent decrease	(8-hour second high at 314 sites)
	97 percent decrease	(8-hour exceedances at 314 sites)
1992–93:	5 percent decrease	(8-hour second high at 394 sites)

- **Emissions**

1984–93:	15 percent decrease
1992–93:	1 percent increase

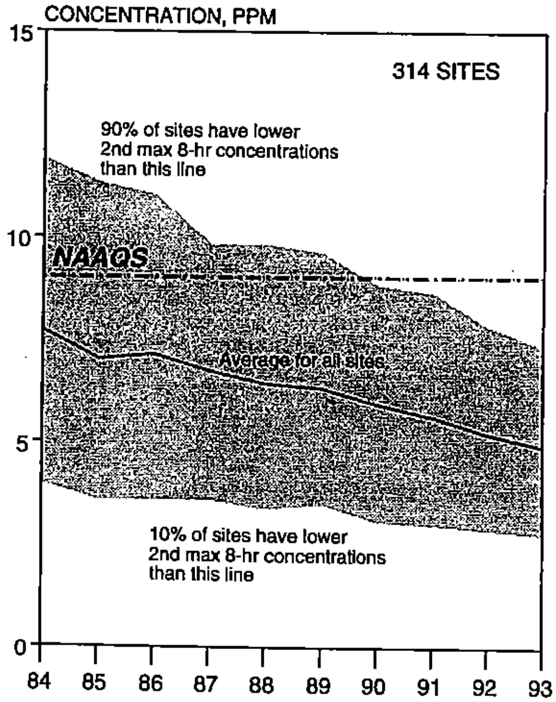
Overview

■ **Trends** — Improvements continued with the 1984–93 10-year period showing a 37-percent decrease in air quality levels and a 15-percent reduction in total emissions. These air quality improvements agree closely with the estimated 24-percent reduction in highway vehicle emissions. This is understandable given the fact the urban CO monitoring network is primarily mobile source oriented. This progress occurred despite the 33-percent increase in miles of travel in the United States during the past 10 years. Transportation sources accounted for 77 percent of the nation's total CO emissions in 1993. Estimated nationwide CO emissions increased one percent between 1992 and 1993. This increase in CO emissions between 1992 and 1993 can be largely attributed to three sources: highway vehicles; off-highway vehicles, and wildfires.

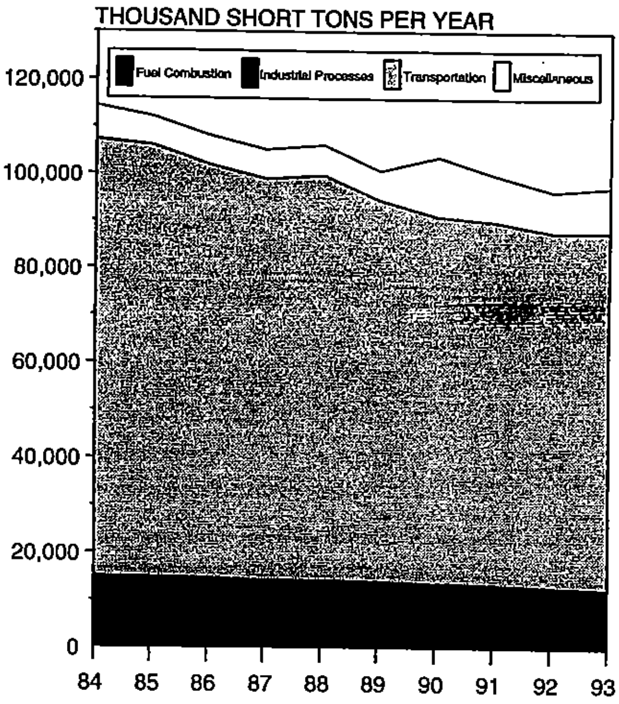
■ **Status** — In November 1991, EPA designated 42 areas as nonattainment for CO. Based on the magnitude of CO concentrations, 41 of these areas were classified as moderate, and only one, Los Angeles, was classified as serious. The 41 moderate areas must meet the NAAQS by December 31, 1995, while Los Angeles has until December 31, 2000. Since the original nonattainment area designations, four areas have been redesignated to attainment for the CO NAAQS: Cleveland, OH; Duluth, MN; Syracuse, NY; and Memphis, TN.

■ **Some Details** — The first major clean fuels program under the 1990 Clean Air Act Amendments is the oxygenated fuel program implemented by state and local agencies following EPA guidelines. Increasing the oxygen content of gasoline reduces CO emissions by improving fuel combustion, which is typically less efficient at cold temperatures. On November 1, 1992, new oxygenated fuel programs began in 28 metropolitan areas. These programs generally run from November through February.

CO TREND, 1984-1993
(ANNUAL 2ND MAX 8-HR AVG)



CO EMISSIONS TREND
(1984 - 1993)



CO EFFECTS

Carbon monoxide enters the bloodstream and reduces oxygen delivery to the body's organs and tissues. The health threat from carbon monoxide is most serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. Healthy individuals also are affected but only at higher levels. Exposure to elevated carbon monoxide levels is associated with impairment of visual perception, work capacity, manual dexterity, learning ability and performance of complex tasks.

Lead (Pb)

Pb SUMMARY

- **Air Concentrations**

  1984–93: 89 percent decrease (maximum quarterly average at 204 sites)

  1992–93: 11 percent decrease (maximum quarterly average at 228 sites)

- **Emissions**

  1984–93: 88 percent decrease in total lead emissions
  (96 percent decrease in lead emissions from transportation sources)

  1992–93: 3 percent increase in total lead emissions
  (3 percent decrease in lead emissions from transportation sources)

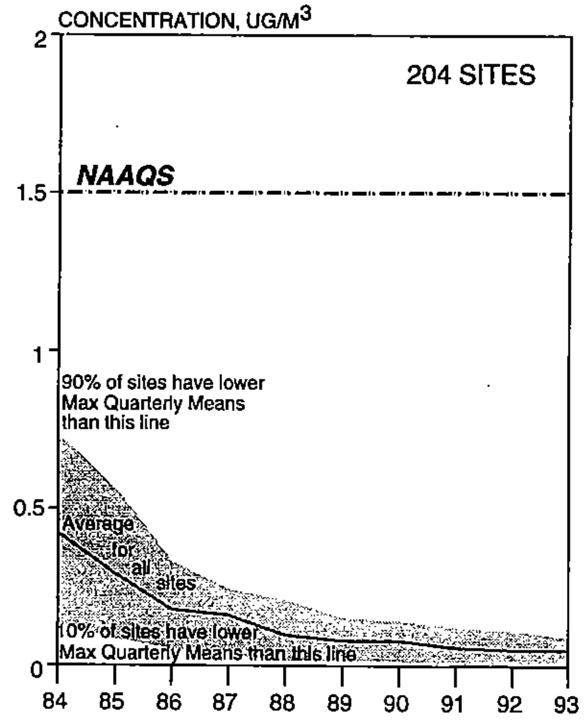
Overview

■ **Trends** — Ambient lead (Pb) concentrations in urban areas throughout the country have decreased 89 percent since 1984. Total Pb emissions have also dropped 88 percent since 1984 due primarily to reductions from automotive sources. The drop in Pb consumption and subsequent Pb emissions was brought about by the increased use of unleaded gasoline in catalyst-equipped cars (99 percent of the total gasoline market in 1993) and the reduced Pb content in leaded gasoline. The three-percent increase in Pb emissions between 1992 and 1993 was due to the increase in emissions from metals processing, incineration operations, and manufacturing. These are offset somewhat by the decreased emissions from highway vehicles.

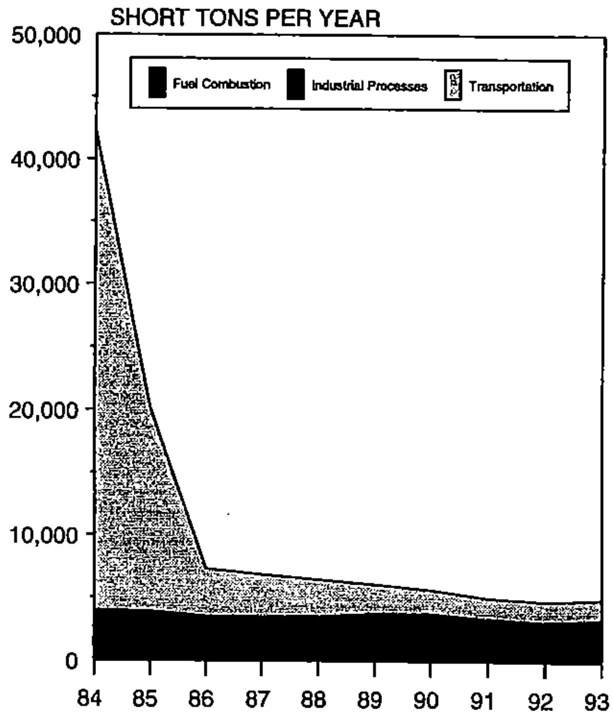
■ **Status** — There are 13 areas that have been designated as nonattainment because of NAAQS violations for lead.

■ **Some Details** — The large reduction in lead emissions from transportation sources has changed the nature of the ambient lead problem in the United States. In 1984, estimated lead emissions were 42,217 tons, and 91 percent was due to transportation sources. By 1993, estimated lead emissions dropped to 4,885 tons, and transportation sources accounted for 31 percent due to the remaining fraction of leaded gasoline sales. Current lead nonattainment problems are associated with point sources, such as smelters, battery plants, and solid waste disposal. Consequently, EPA's lead attainment strategy targets airborne emissions from these stationary sources of lead. Monitoring networks are being expanded around sources of concern, followed by inspections of any facility where violations of the NAAQS are detected. Compliance activities include negotiating consent decrees, agreements, or state orders for individual sources.

PB TREND, 1984-1993
(ANNUAL MAX QRTLY AVG)



PB EMISSIONS TREND
(1984 - 1993)



Pb EFFECTS

Exposure to lead can occur through multiple pathways, including inhalation of air and ingestion of lead in food, water, soil, or dust. Lead accumulates in the body in blood, bone, and soft tissue. Because it is not readily excreted, lead also affects the kidneys, liver, nervous system, and blood-forming organs. Excessive exposure to lead may cause neurological impairments such as seizures, mental retardation, and/or behavioral disorders. Even at low doses, lead exposure is associated with changes in fundamental enzymatic, energy transfer, and homeostatic mechanisms in the body. Fetuses, infants, and children are especially susceptible to low doses of lead, often suffering central nervous system damage. Recent studies have also shown that lead may be a factor in high blood pressure and subsequent heart disease in middle-aged white males.

Nitrogen Dioxide (NO_2)

NO_2 SUMMARY

- **Air Concentrations**

1984–93: 12 percent decrease (annual mean at 201 sites)
1992–93: 2 percent decrease (annual mean at 269 sites)

- **Emissions: Nitrogen Oxides (NO_x)**

1984–93: 1 percent increase
1992–93: 2 percent increase

Overview

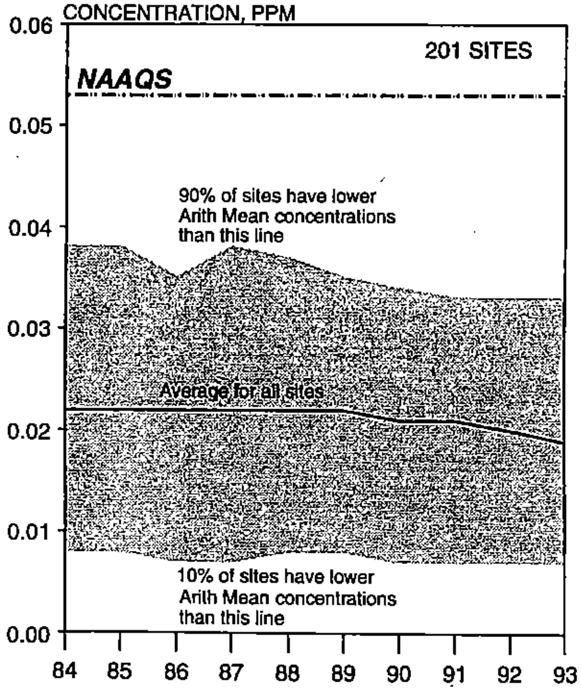
■ **Trends** — Although relatively constant throughout the early 1980s, ambient NO_2 levels have declined steadily since the peak year of 1988. NO_2 air quality has improved 12 percent since 1984. Nitrogen oxides emissions are estimated to have increased one percent since 1984, with a three-percent increase in fuel combustion emissions. The two primary source categories of nitrogen oxide emissions, and their contribution in 1993, are fuel combustion (50 percent) and transportation (45 percent). Since 1984, emissions from highway vehicles are estimated to have decreased 11 percent, while fuel combustion emissions increased three percent. Approximately 76 percent of the increase in NO_x emissions between 1992 and 1993 is attributable to increased emissions from coal-fired electric utilities. The remainder of the increase in emissions this year is due to increased emissions from off-highway sources.

■ **Status** — Currently, Los Angeles is the only area designated as nonattainment for NO_2.

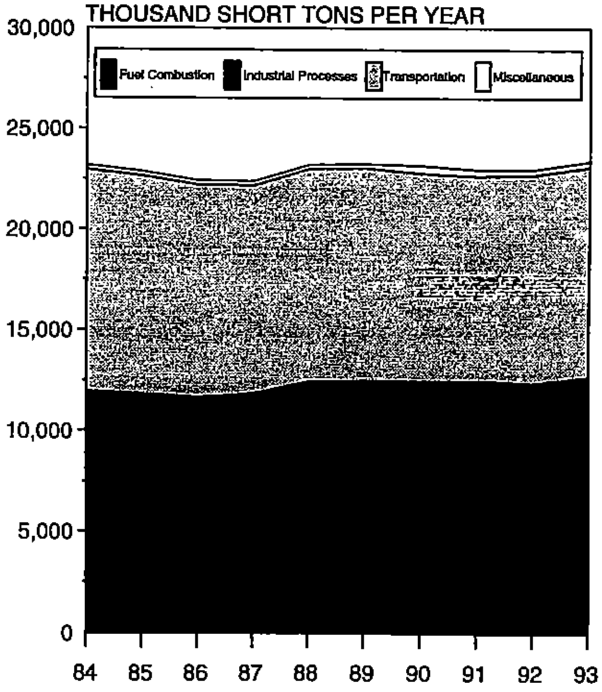
■ **Some Details** — In recent years, Los Angeles was identified as the only location not meeting the National Ambient Air Quality Standard for nitrogen dioxide. However, this is the second year in a row that all monitoring locations in Los Angeles have met the federal NO_2 standard.

State of the art air quality models and improved knowledge of the ambient concentrations of VOCs and NO_x indicate that NO_x control is necessary for effective reduction of ozone in many areas of the United States. Thus, even though the NO_2 standards are now being met at all monitoring locations throughout the country, NO_x emissions and their control are important factors for addressing the current widespread violations of the ozone NAAQS.

NO2 TREND, 1984-1993
(ANNUAL ARITHMETIC MEAN)



NOX EMISSIONS TREND
(1984 - 1993)



NO_2 EFFECTS

Nitrogen dioxide can irritate the lungs and lower the resistance to respiratory infections such as influenza. The effects of short-term exposure are still unclear, but continued or frequent exposure to concentrations higher than those normally found in the ambient air may cause increased incidence of acute respiratory disease in children. Nitrogen oxides are an important precursor to both ozone and acidic precipitation, and may affect both terrestrial and aquatic ecosystems. Atmospheric deposition of NO_x is a potentially significant contributor to ecosystem effects including algal blooms in certain estuaries such as the Chesapeake Bay. In some western areas NO_x is an important precursor to particulate matter concentrations.

Ozone (O_3)

O_3 SUMMARY

- **Air Concentrations**

1984–93	12 percent decrease	(second highest daily max 1-hour at 532 sites)
	60 percent decrease	(exceedance days at 532 sites)
1992–93:	2 percent increase	(second highest daily max 1-hour at 722 sites)

- **Emissions: Volatile Organic Compounds (VOC)**

1984–93:	9 percent decrease	(+1 percent for NO_x)
1992–93:	1 percent increase	(+2 percent for NO_x)

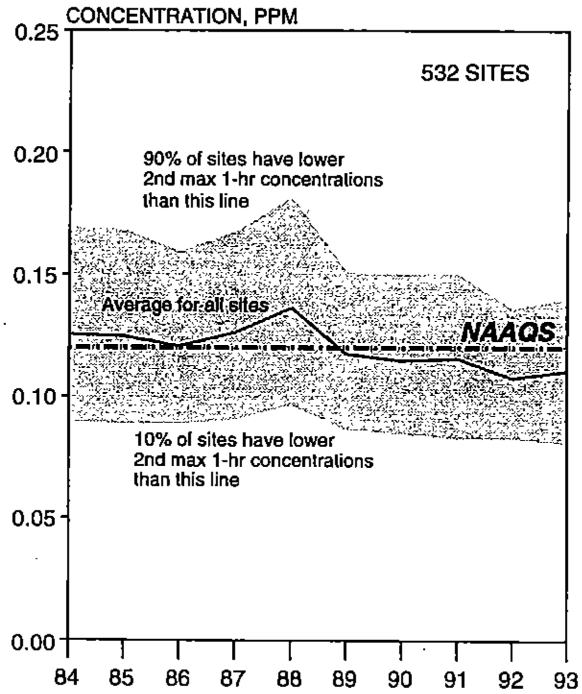
Overview

■ **Trends** — Ground level ozone, the primary constituent of smog, is a pervasive pollution problem for the United States. Ambient trends are influenced by varying meteorological conditions. Although meteorological conditions in the east during 1993 were more conducive to O_3 formation than last year, the composite mean level for 1993 was still the second lowest composite average of the 10-year trend period of 1984–93. The lowest composite mean level was recorded in 1992, and the highest was recorded in 1988. Recent control measures include rules to lower fuel volatility and lower NO_x and VOC emissions from tailpipes. Emission estimates for VOCs, which contribute to ozone formation, are estimated to have improved by nine percent since 1984. However, these VOC emission estimates represent annual totals, while ozone is a warm weather problem. NO_x emissions, the other major precursor factor in ozone formation, increased one percent between 1984 and 1993. Seasonal emissions inventories are being developed for use in future trends assessments.

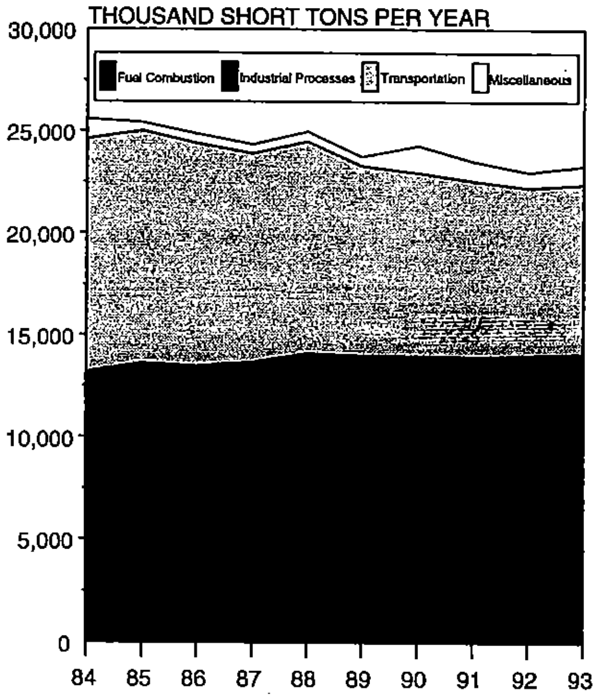
■ **Status** — In November 1991, EPA designated 98 areas as nonattainment for O_3. Since these initial nonattainment designations, seven areas have been redesignated as attainment. EPA has announced plans to review the ozone NAAQS and to examine options for implementing alternative NAAQS to ensure a smooth transition if a decision is made to revise the existing NAAQS. The schedule for this review has been published elsewhere.[23]

■ **Some Details** — Year-to-year O_3 trends are affected by changing meteorological conditions. The larger improvement of 21 percent reported last year between 1983 and 1992 was due in part to 1983 being a relatively high year for ozone, and 1992 being a relatively low year. New statistical techniques accounting for meteorological influences suggest an improvement of 12 percent for the 10-year period. This happens to match the percent change for the ambient trend.

OZONE TREND, 1984-1993
(ANNUAL 2ND DAILY MAX HOUR)



VOC EMISSIONS TREND
(1984 - 1993)



O_3 EFFECTS

The reactivity of ozone with humans causes health problems because it damages lung tissue, reduces lung function, and sensitizes the lungs to other irritants. Scientific evidence indicates that ambient levels of ozone not only affect people with impaired respiratory systems, such as asthmatics, but healthy adults and children as well. Exposure to ozone for six to seven hours at relatively low concentrations has been found to significantly reduce lung function and induce respiratory inflammation in normal, healthy people during periods of moderate exercise. This decrease in lung function often is accompanied by such symptoms as chest pain, coughing, nausea, and pulmonary congestion. Recent studies provide evidence of an association between elevated ambient O_3 levels and increases in hospital admissions for respiratory problems in several U.S. cities. Though less well established in humans, animal studies have demonstrated that repeated exposure to ozone for months to years can produce permanent structural damage in the lungs and accelerate the rate of lung function decline and aging of the lungs. Ozone is responsible for several billion dollars of agricultural crop yield loss in the United States each year. It also causes noticeable foliar damage in many crops and species of trees. Forest and ecosystem studies indicate that damage is resulting from current ambient ozone levels.

Particulate Matter (PM-10)

PM-10 SUMMARY

■ **Air Concentrations: Particulate Matter (PM-10)**

1988–93: 20 percent decrease (based on arithmetic mean at 799 sites)

1992–93: 3 percent decrease (based on arithmetic mean at 799 sites)

■ **Emissions: PM-10**

1988–93: 10 percent decrease (excluding miscellaneous and natural sources)

1992–93: 2 percent decrease (excluding miscellaneous and natural sources)

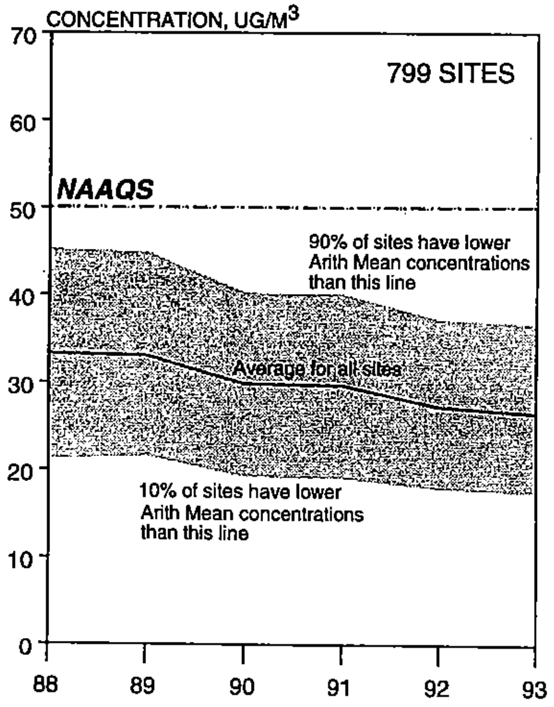
Overview

■ **Trends** — In 1987, EPA replaced the earlier total suspended particulate (TSP) standard with a PM-10 standard. PM-10 focuses on smaller particles that are likely to be responsible for adverse health effects because of their ability to reach the lower regions of the respiratory tract. Ambient monitoring networks have been revised to measure PM-10 rather than TSP. PM-10 ambient levels decreased 20 percent between 1988 and 1993. PM-10 emissions from sources historically included in inventories are estimated to have decreased 10 percent since 1988. Progress in reducing particulate matter emissions is most noticeable in the areas of highway vehicles, particularly diesel vehicles, and residential wood combustion. Nationally, fugitive sources, such as emissions from agricultural tilling, construction, and unpaved roads, contribute six to eight times more PM-10 emissions than sources historically included in emission inventories.

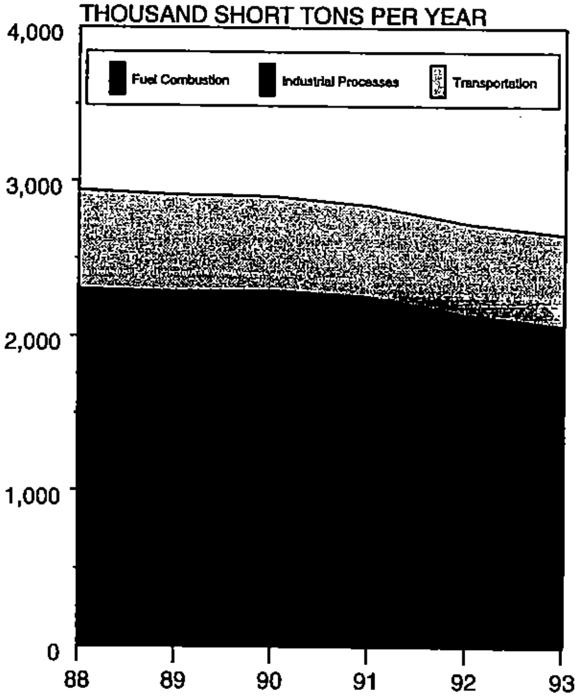
■ **Status** — In November 1991, EPA designated 70 areas as nonattainment for PM-10. During the last two years an additional 13 areas throughout the country have been designated as nonattainment for PM-10.

■ **Some Details** — More and more studies are being conducted across the country to better understand the nature of particulate matter—what it is made up of, the effect of different size particles, which sources it comes from, how it varies in different geographical areas, and its effects on health. Revisions to the ambient standards and changes to the current monitoring network for particulate matter are being considered in light of the new information being discovered.

PM-10 TREND, 1988-1993
(ANNUAL ARITHMETIC MEAN)



PM-10 EMISSIONS TREND
(no miscellaneous emissions)
(1988 - 1993)



PM EFFECTS

Based on studies of human populations exposed to ambient particle pollution (sometimes in the presence of sulfur dioxide) and laboratory studies of both animals and humans, the major areas of concern for human health include: effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis, and premature mortality. The major subgroups of the population that appear likely to be the most sensitive to the effects of particulate matter include individuals with chronic obstructive pulmonary or cardiovascular disease, influenza, and asthma, as well as the elderly and children. Particulate matter causes damage to materials and soiling. It is a major cause of visibility impairment in many parts of the United States.

Sulfur Dioxide (SO_2)

SO_2 SUMMARY

- **Air Concentrations**

1984–93: 26 percent decrease (arithmetic mean at 474 sites)
36 percent decrease (24-hour second high at 469 sites)

1992–93: 1 percent decrease (arithmetic mean at 560 sites)

- **Emissions: Sulfur Oxides (SO_x)**

1984–93: 6 percent decrease

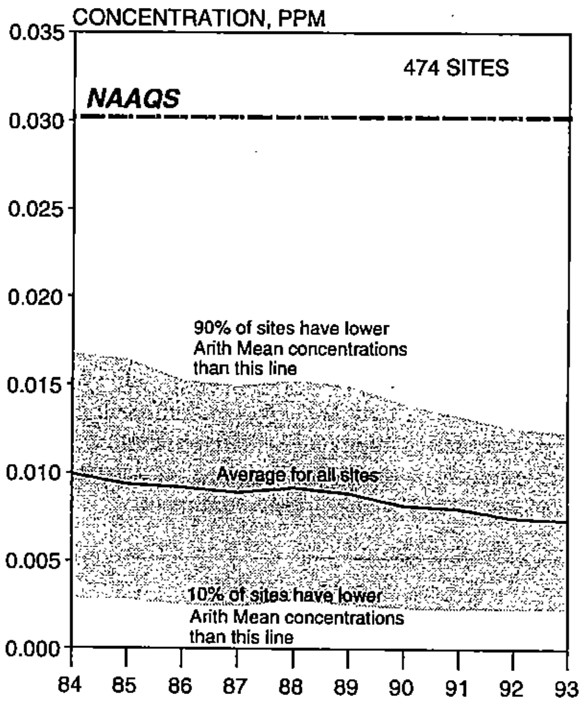
1992–93: 1 percent increase

Overview

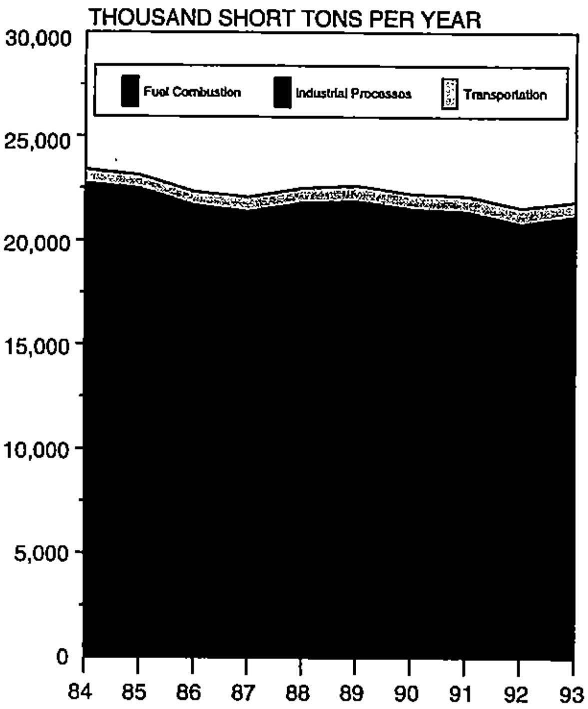
■ **Trends** — Since 1984, SO_x emissions decreased six percent, while average SO_2 air quality improved by 26 percent. This difference occurred because the historical ambient monitoring networks are population-oriented in urban areas while the major emission sources tended to be in less populated areas. The one-percent increase in total SO_x emissions between 1992 and 1993 was the result of increased fuel usage (primarily coal) in the electric utility sector. This increase was largely offset by decreased industrial fuel combustion and highway vehicle emission estimates.

■ **Status** — Almost all monitors in U.S. urban areas meet EPA's ambient air quality standards for SO_2. Dispersion models are commonly used to assess ambient SO_2 problems around point sources because it is frequently impractical to operate enough monitors to provide a complete air quality assessment. Currently, there are 47 areas designated nonattainment for SO_2. New regulations are being considered to target high short-term SO_2 emitters for monitoring.

■ **Some Details** — Four programs make up the EPA's strategy to control the emissions associated with SO_2: (1) the National Ambient Air Quality Program, which sets the primary and secondary standards discussed earlier in this report; (2) the New Source Performance Standards, which set emission limits for new sources; (3) the New Source Review/Prevention of Significant Deterioration Program, which protects air quality from deteriorating in clean areas by requiring new major SO_2 sources to conduct air quality analyses before receiving a permit; and (4) the Acid Rain Program, which is set forth in Title IV of the 1990 Clean Air Act Amendments.



SO2 TREND, 1984-1993
(ANNUAL ARITHMETIC MEAN)



SOX EMISSIONS TREND
(1984 - 1993)

SO$_2$ EFFECTS

The major health effects of concern associated with exposure to high concentrations of sulfur dioxide include effects on breathing, respiratory illness, alterations in the lungs' defenses, and aggravation of existing respiratory and cardiovascular disease. The major subgroups of the population that are most sensitive to sulfur dioxide include asthmatics and individuals with cardiovascular disease or chronic lung disease (such as bronchitis or emphysema), as well as children and the elderly. Sulfur dioxide also can produce foliar damage on trees and agricultural crops. Together, sulfur dioxide and nitrogen oxides are the major precursors to acidic deposition (acid rain). This is associated with a number of effects including acidification of lakes and streams, accelerated corrosion of buildings and monuments, and visibility impairment.

1.3 Some Perspective

A 10-year period is convenient for considering ambient pollution trends. This is because of changes that occurred in monitoring networks during the early 1980s and changes over time that routinely occur in the geographical distribution of monitors. Although it is difficult to provide ambient trends going back more than 10 years, it is important not to overlook some of the earlier control efforts in the air pollution field. While the ambient monitoring trends and the emission trends can be viewed as independent assessments of the underlying pollutant trends, the emission estimates can also be used to provide information on longer time periods. Figure 1-1 provides a convenient summary of the 1970–93 emission changes for all six NAAQS pollutants. Lead emissions clearly recorded the most impressive decrease of 98 percent, but improvements are also seen for emissions of PM-10 (-78 percent), SO_x (-30 percent), CO (-24 percent), and VOCs (-24 percent). Only NO_x emissions showed an increase (14 percent) between 1970 and 1993 levels. It is important to realize that these reductions occurred even during an increase in vehicle miles travelled and industrial output. More detailed information on these emission trends and the updated estimation methodologies are contained in a companion report.[21]

While progress has been made, it is important not to lose sight of the magnitude of the air pollution problem that still remains. Based upon data submitted to EPA's data base, approximately 59 million people in the United States reside in counties which did not meet at least one air quality standard for the single year 1993. Ground level ozone is the most common contributor with 51 million people living in counties that exceeded the ozone standard in 1993. This is the second consecutive year that every monitoring site in the country met the nitrogen dioxide standard. With respect to sulfur dioxide, it is important to note that while almost all monitoring sites are currently meeting the NAAQS, sulfur dioxide problems in the United States are now associated with point sources and are typically identified by modeling rather than by routine ambient monitoring. These population estimates are based on a single year of data, 1993, and only consider counties with monitoring data for that pollutant. Chapter 5 discusses other approaches that would yield different numbers.

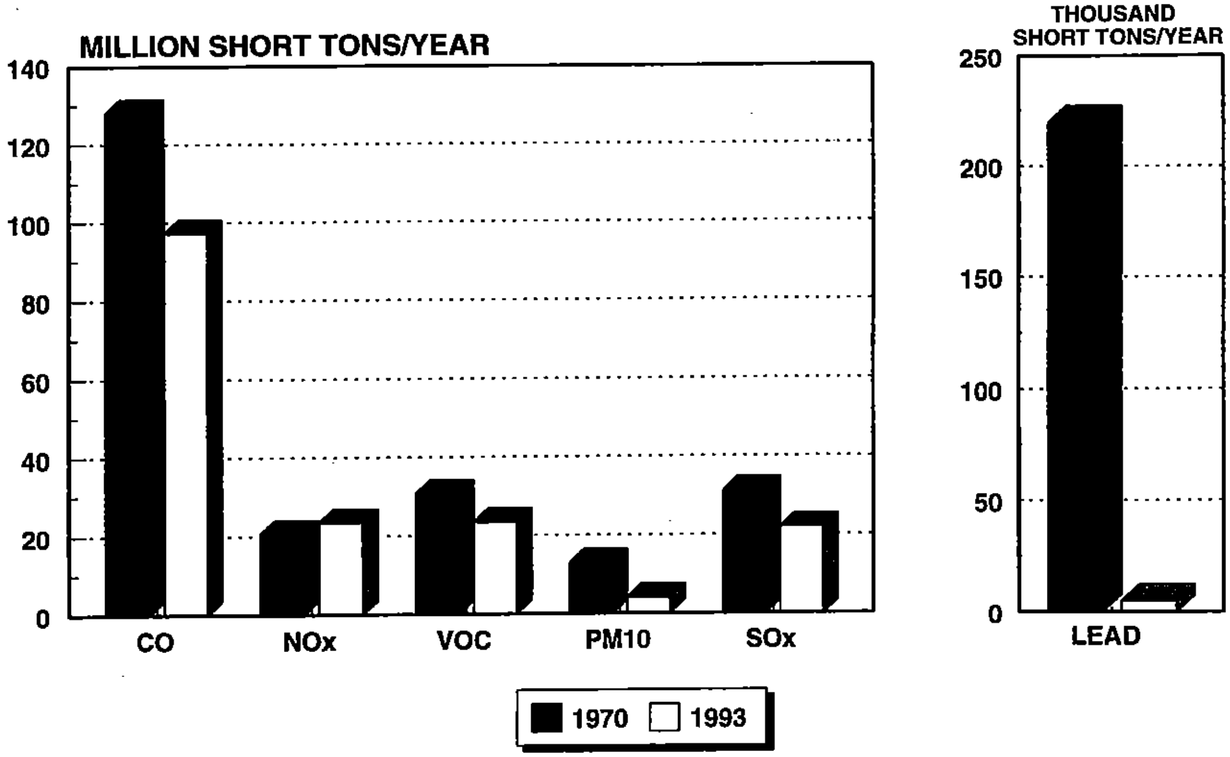


Figure 1-1. Comparison of 1970 and 1993 national total emissions.

In 1991, EPA issued a rule formally designating areas that did not meet air quality standards.[22] Based upon these designations, EPA estimated that 150 million people live in nonattainment areas. This difference between the 150 million and 59 million population figures is because the formal designations are based upon multiple years of data, rather than just one, to reflect a broader range of meteorological conditions. Also, the boundaries used for nonattainment areas may consider other air quality related information, such as emission inventories and modeling. They may extend beyond those counties with monitoring data to more fully characterize the ozone problem and to facilitate the development of an adequate control strategy. For the pollutant lead, EPA's aggressive effort to better characterize lead point sources has resulted in new monitors that have documented additional problem areas. Finally, the designations were generally based on data from the years 1987–1989, which included the peak ozone year of 1988.

Although this report emphasizes those six pollutants for which there are National Ambient Air Quality Standards. There are other air pollutants of concern, as evidenced by the fourth chapter's discussion of air toxics. Air toxics are chemicals known or suspected of causing cancer or other serious health effects (e.g., reproductive effects). According to EPA's Toxic Release Inventory, more than 1.8 billion pounds of toxics were released to the atmosphere in 1992 as compared to 2.0 billion pounds in 1991.[24,25] Further, estimated emissions of hazardous air pollutants (189 compounds identified for regulatory attention by the CAAA) declined from approximately 1.5 billion pounds in 1991 to roughly 1.3 billion pounds in 1992. While control programs are designed to address the criteria pollutants, they are also expected to reduce air toxic releases to some degree by reducing emissions of particulates, volatile organic chemicals and nitrogen oxides. Title III of the CAAA provides specific new tools to directly address releases of hazardous air pollutants. EPA also is implementing programs to reduce emissions of pollutants contributing to depletion of the stratospheric ozone layer and acidic deposition.

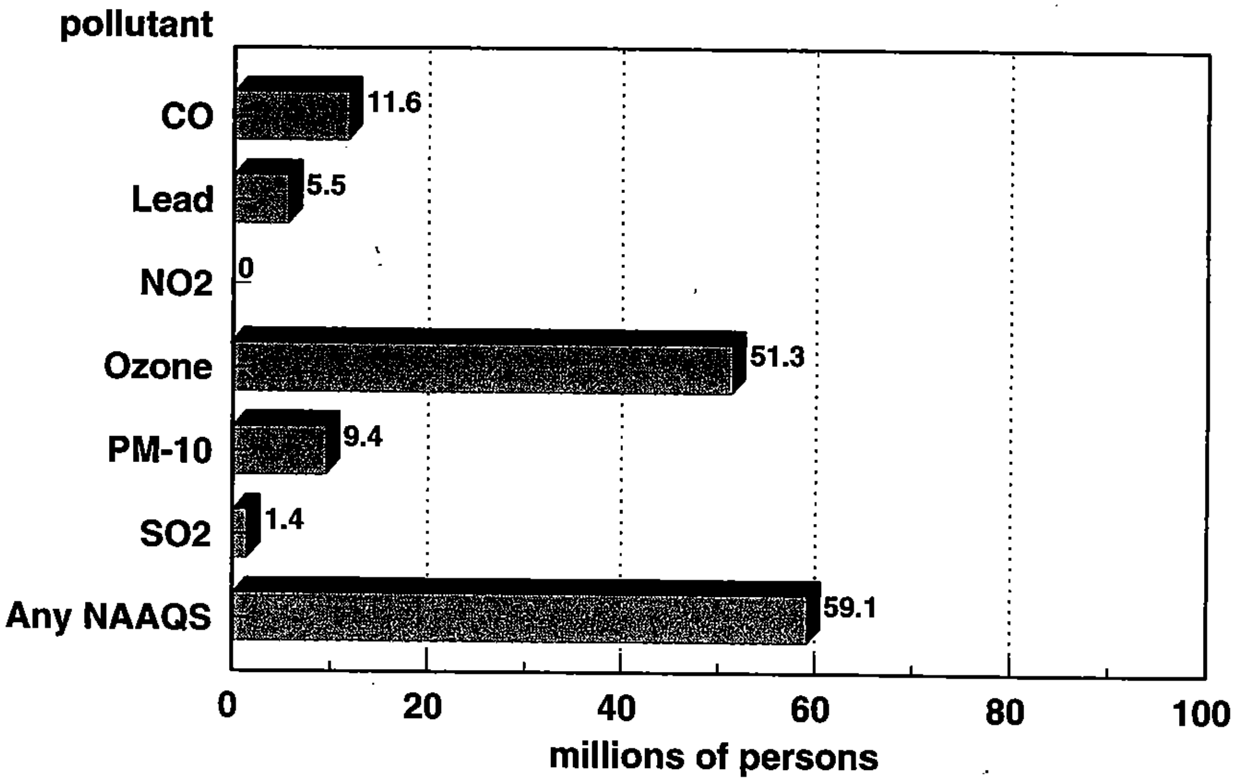


Figure 1-2. Number of persons living in counties with air quality levels not meeting the primary NAAQS in 1993. (Based on 1990 population data and 1993 air quality data.)

1.4 References

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Chapter 2: Methodology

This report focuses on 10-year (1984–93) national air quality trends for each of the major pollutants established by the National Ambient Air Quality Standards (NAAQS). This chapter presents many of the technical details involved in these analyses. Readers familiar with previous reports may prefer initially to proceed directly to the remaining sections. The national analyses are complemented in Chapter 6 with air quality trends of specific metropolitan areas, and in Chapter 7 with a perspective on international air pollution.

The air quality trends statistics displayed for a particular pollutant in this report are closely related to pollutant-specific NAAQS. Trends in other air quality indicators are also discussed for some pollutants. NAAQS are currently in place for the following six pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter whose aerodynamic size is equal to or less than 10 microns (PM-10), and sulfur dioxide (SO_2). There are two types of standards: primary and secondary. Primary standards protect against adverse health effects, whereas secondary standards protect against welfare effects like damage to crops, vegetation, and buildings. Table 2-1 lists the NAAQS for each pollutant in terms of the level of the standard and the averaging time that

Table 2-1. National Ambient Air Quality Standards (NAAQS) in Effect in 1993

Pollutant	Primary (Health Related)		Secondary (Welfare Related)	
	Type of Average	Standard Level Concentration[a]	Type of Average	Standard Level Concentration
CO	8-hour[b]	9 ppm (10 mg/m^3)	No Secondary Standard	
	1-hour[b]	35 ppm (40 mg/m^3)	No Secondary Standard	
Pb	Maximum Quarterly Average	1.5 μg/m^3	Same as Primary Standard	
NO_2	Annual Arithmetic Mean	0.053 ppm (100 μg/m^3)	Same as Primary Standard	
O_3	Maximum Daily 1-hour Average[c]	0.12 ppm (235 μg/m3)	Same as Primary Standard	
PM-10	Annual Arithmetic Mean[d]	50 μg/m^3	Same as Primary Standard	
	24-hour[d]	150 μg/m^3	Same as Primary Standard	
SO_2	Annual Arithmetic Mean	80 μg/m^3 (0.03 ppm)	3-hour[b]	1300 μg/m^3 (0.50 ppm)
	24-hour[b]	365 μg/m^3 0.14 ppm		

[a] Parenthetical value is an approximately equivalent concentration.

[b] Not to be exceeded more than once per year.

[c] The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is equal to or less than one, as determined according to Appendix H of the Ozone NAAQS.

[d] Particulate standards use PM-10 (particles less than 10μ in diameter) as the indicator pollutant. The annual standard is attained when the expected annual arithmetic mean concentration is less than or equal to 50 μg/m^3; the 24-hour standard is attained when the expected number of days per calendar year above 150 μg/m^3 is equal to or less than one; as determined according to Appendix K of the PM NAAQS.

the standard represents. Some pollutants (PM-10 and SO_2) have standards for both long-term (annual average) and short-term (24-hour or less) averaging times. The short-term standards are designed to protect against acute, or short-term health effects, while the long-term standards were established to protect against chronic health effects.

It is important to note that the discussion of ozone in this report refers to ground level (tropospheric) ozone and not to stratospheric ozone. Stratospheric ozone, which is miles above the earth, provides a protective screen from the sun's ultraviolet rays. Ground level ozone, which is in the air we breathe, can cause health and environmental concerns. It also is the primary ingredient of smog.

The ambient air quality data presented in this report were obtained from EPA's Aerometric Information Retrieval System (AIRS). These are actual direct measurements of pollutant concentrations at monitoring stations operated by state and local governments throughout the nation. EPA and other federal agencies operate some air quality monitoring sites on a temporary basis as a part of air pollution research studies. In 1993, more than 4,400 monitoring sites reported air quality data for one or more of the six NAAQS pollutants to AIRS. The vast majority of these measurements represent the heavily populated urban areas of the nation.

The national monitoring network conforms to uniform criteria for monitor siting, instrumentation, and quality assurance.[1] Each monitoring site is classified into one of three specific categories. National Air Monitoring Stations (NAMS) were established to ensure a long-term national network for urban area-oriented ambient monitoring and to provide a systematic, consistent data base for air quality comparisons and trends analysis. The State and Local Air Monitoring Stations (SLAMS) allow state or local governments to develop networks tailored for their immediate monitoring needs. Special Purpose Monitors (SPMs) fulfill very specific or short-term monitoring goals. Often SPMs are used as source-oriented monitors rather than monitors which reflect the overall urban air quality. Data from all three types of monitoring sites are presented in this report.

2.1 Air Quality Data Base

Monitoring sites are included in the national 10-year trend analysis if they have complete data for at least eight of the 10 years 1984 to 1993. For regional comparisons, the site had to report data in each of the last three years to be included in the analysis. Data for each year had to satisfy annual data completeness criteria appropriate to pollutant and measurement methodology. Table 2-2 displays the number of sites meeting the 10-year trend completeness criteria. For PM-10, whose monitoring network has just been initiated over the last few years, analyses are based on sites with data in five of the six years during the 1988–93 period.

The air quality data are divided into two major groupings: 24-hour measurements and continuous one-hour measurements. The 24-hour measurements are obtained from monitoring instruments that produce one measurement per 24-hour period. They typically operate on a systematic sampling schedule of once every six days, or 61 samples per year. Such instruments are used to measure PM-10 and Pb. More frequent sampling of PM-10 such as every other day, or every day, is also common. Only PM-10 weighted annual arithmetic means that met the AIRS annual summary criteria were selected as valid means for trends purposes.[2] The 24-hour Pb data were required to have at least six samples per quarter in at least three of the four calendar quarters. Monthly composite Pb data were used if at least two monthly samples were available for at least three of the four calendar quarters.

One-hour data are obtained from continuously operating monitoring instruments that produce a measurement every hour. This gives a possible total of 8,760 hourly measurements in a year. For continuous hourly data, a valid annual mean for trends requires at least 4,380 hourly observations. The SO_2 standard-related daily statistics required 183 or more daily values. Because of the different selection criteria, the number of sites used to produce daily SO_2 statistics may differ slightly from the number of sites used to produce annual SO_2 statistics. Ozone sites met the annual trends data completeness requirement if they had at least 50 percent of the daily data available for the ozone season, which typically varies by state.[3]

The use of a moving 10-year window for trends yields a data base that is more consistent with the current monitoring network and also reflects the period following promulgation of uniform monitoring requirements. In addition, this procedure increases the total number of trend sites for the 10-year period relative to the data bases used in the last annual report.[4]

2.2 Air Quality Trend Statistics

The air quality statistics presented in this report relate to the pollutant-specific NAAQS and comply with recommendations of the Intra-Agency Task Force on Air Quality Indicators.[5] Although not directly related to the NAAQS, more robust air quality indicators are presented for some pollutants to provide a consistency check.

A composite average of each of the trend statistics is used in the graphical presentations that follow.

All sites are weighted equally in calculating the composite average trend statistic. Missing annual summary statistics for the second through ninth years for a site are estimated by linear interpolation from the nearest years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since end-point rates of change are dampened by the interpolated estimates.

This report uses statistical confidence intervals around composite averages to make comparisons between years. If the confidence intervals for any two years do not overlap, then the composite averages of the two years are significantly different. Ninety-five percent confidence intervals for composite averages of annual means and of second maxima are calculated from a two-way analysis of variance, followed by an application of the Tukey studentized range.[6] The confidence intervals for composite averages of estimated exceedances are calculated by fitting Poisson distributions[7] to the exceedances each year, and then by applying the Bonferroni multiple comparisons procedure.[8] The utilization of these procedures is explained elsewhere.[9, 10]

Boxplots[11] are used to present air quality trends because they have the advantage of portraying several features of the data simultaneously. Figure 2-1 illustrates the use of this technique by presenting the percentiles of the data as well as the composite average. For example, 90 percent of the sites have concentrations equal to or lower than the 90th percentile.

Bar graphs are introduced for regional comparisons with three-year trend data. These comparisons are based on the 10 EPA regions (Figure 2-2). The composite averages of the appropriate air quality statistic of

Table 2-2. Number of Monitoring Sites

Pollutants 1993	Number of Sites Reporting 1984–93	Number of Trend Sites
CO	537	314
Pb	430	204
NO_2	377	201
O_3	925	532
PM-10	1508	799*
SO2	692	474
Total	**4469**	**2524**

**Number of Trend Sites in 1988–93*

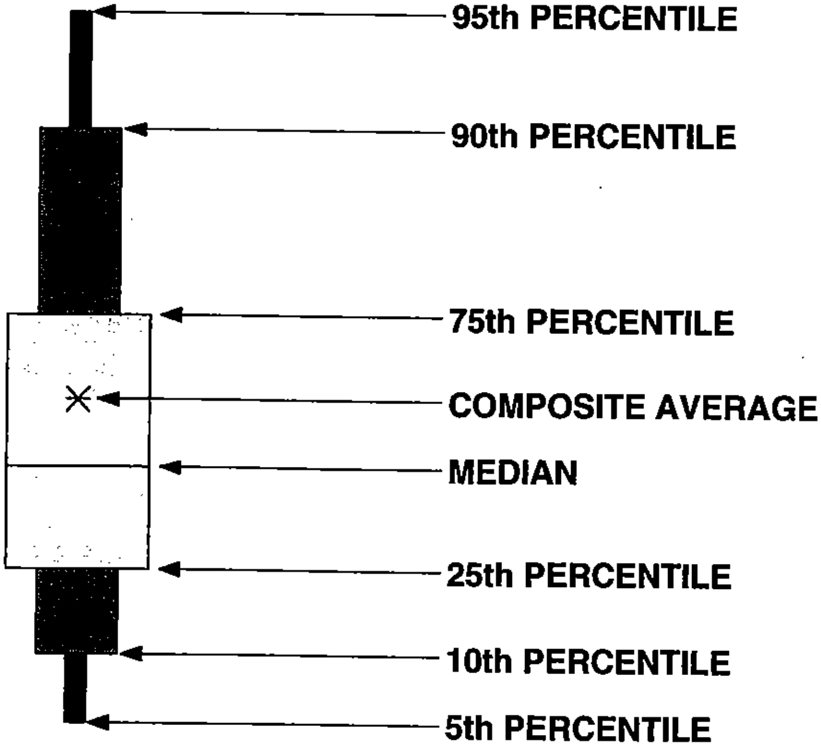

Figure 2-1. Illustration of plotting convention of boxplots.

1991, 1992, and 1993 are presented. The approach is simple, allowing the reader, at a glance, to compare the short-term changes in all 10 EPA regions.

2.3 Emission Estimates Methodology

Trends are also presented for annual nationwide emissions of CO, Pb, nitrogen oxides (NO_x), volatile organic compounds (VOCs), PM-10, and sulfur oxides (SO_x). These are estimates of both the amount and kinds of pollution being emitted by automobiles, factories, and other sources based on best available engineering calculations. Because of changes in the methodology used to obtain these emissions estimates since last year, these estimates have been recomputed for each year. Thus, comparison of the estimates for 1993 in this report with earlier years in previous reports is not appropriate. Also, the 1990 to 1993 emission estimates are preliminary, and may be revised in the next annual report.

Changes have been made in the emissions methodology. Updated methodologies developed for Clean Air Act modeling requirements are used for the 1985 through 1993 emission estimates. The trends methodology from previous trends reports is used for the 1940 through 1984 period. This difference will not be a factor after this report since the 10-year trends time period will begin in post 1984.

Changes since last year include use of the MOBILE5a model, including a version of the model specific to California used to estimate highway vehicle emissions. State and county level estimates for vehicle miles travelled (VMT) mix, in-use Reid vapor pressure (RVP), oxygenated fuels, and inspection/maintenance (I/M) programs were updated. Updates were made to the estimates of forest fire emissions that are included in the miscellaneous category. Also, the methodology for PM-10 emissions estimates has been revised since last year. PM-10 emissions for 1985 to the present are based on a 1990 county-level emission inventory newly developed using methods similar to those developed for Clean Air Act modeling requirements. Years prior to and following 1990 were backcast and forecast using economic growth factors for most source categories. Some additional differences arise from changing the source of growth factors between 1991 and 1992.

All of these changes are part of a broad effort to update and improve emission estimates. Any significant impacts from these changes in methodology on emission estimates are described in the individual pollutant sections that follow in Chapter 3. For more detailed information, the reader should refer to a companion EPA publication, *National Air Pollutant Emission Trends, 1900–1993.*[12]

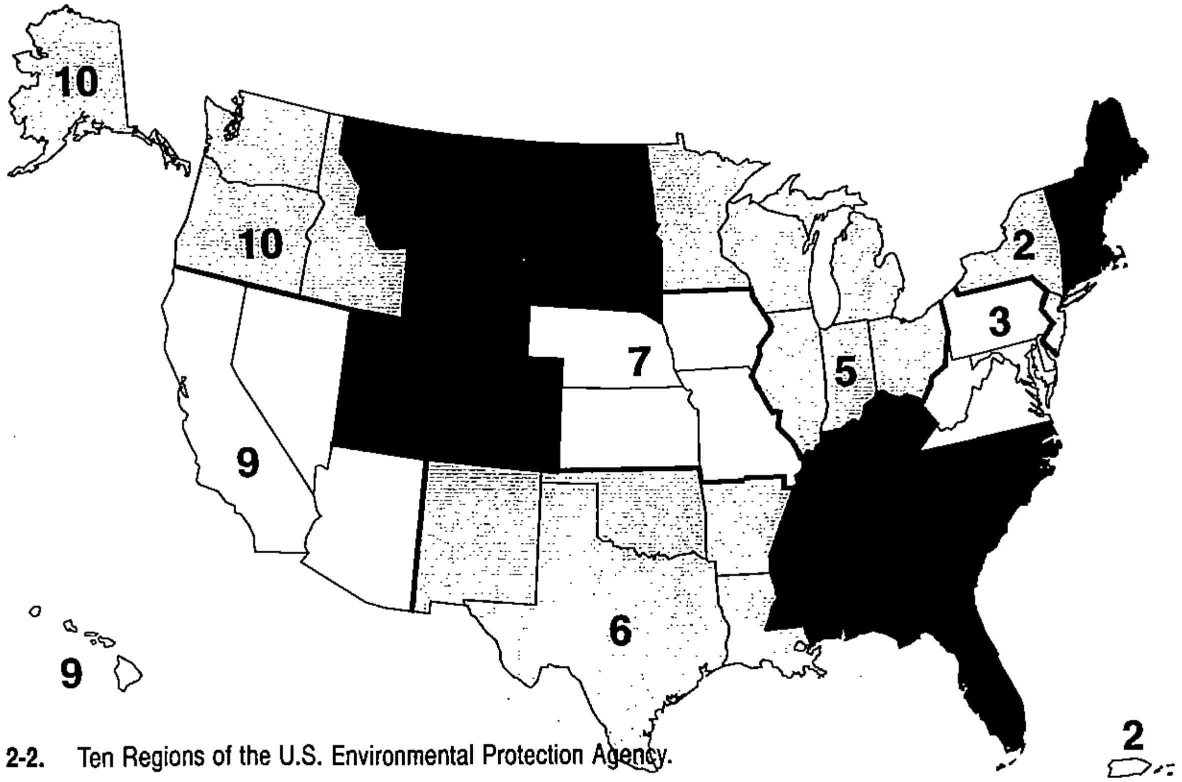

Figure 2-2. Ten Regions of the U.S. Environmental Protection Agency.

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Chapter 3: National and Regional Trends in NAAQS Pollutants

EPA has set National Ambient Air Quality Standards (NAAQS) for six pollutants considered harmful to public health: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM-10), and sulfur dioxide (SO_2). This chapter focuses on both the 10-year (1984–93) trends and the recent changes in air quality and emissions for the six NAAQS pollutants. Changes since 1992, comparisons between all the trend sites, and the subset of National Air Monitoring Stations (NAMS) are highlighted. The NAMS were established to provide a national network of monitoring sites that could provide data for national trends and air quality assessments. The primary objective for the NAMS is to monitor areas where the pollutant concentrations and population exposures are expected to be highest with respect to the NAAQS. Trends are examined for both the nation and the 10 EPA regions. This chapter also presents a section on visibility, a topic related to several of the NAAQS pollutants.

As in previous reports, the air quality trends are presented by using trend lines, confidence intervals, boxplots, and bar graphs. See Chapter 2, Section 2.2 for a detailed description of confidence intervals and boxplot procedures.

These long-term trends have emphasized air quality statistics that are closely related to the NAAQS. For many pollutants this tends to place an emphasis on peak levels since these levels are associated with the health effects of concern. While these peak summary statistics may be more readily understood with respect to the NAAQS, there is concern that they may be too variable to be used as trend indicators. This issue was addressed in an earlier report in response to concerns raised about O_3 trend indicators by a National Academy of Sciences (NAS) report.[1] The concern was whether trend results using a peak value type of summary statistic, such as the annual second maximum, could be overly influenced by data from just a few days and not necessarily be representative of an "overall" trend. Trends in alternative summary statistics were compared with the peak statistics to see if there were sufficient differences to warrant concern. As an example of alternative trends indicators, the NAS report cited earlier EPA analyses which used a comparison of different percentiles and maximum values.[2,3] The concentration percentiles are statistically robust, in the sense that they are less affected by a few extreme values. Trends in various alternative CO, O_3, and NO_2 summary statistics were similar, however, there was a tendency to show less percent improvement (become flatter) for the lower percentile indicators.[4]

Trends are also presented for annual nationwide emissions of CO, Pb, nitrogen oxides (NO_x), volatile organic compounds (VOCs), PM-10, and sulfur oxides (SO_x). These emissions data are estimated using best available engineering calculations. The reader should refer to a companion report for a detailed description of emission trends, source categories and estimation procedures.[5] Because of changes in the methodology used to obtain these emissions estimates since last year, the estimates have been recomputed for each year. Thus, comparison of the 1993 emission estimates in this report to earlier years in previous reports is not appropriate. There have been changes in the emissions methodology as discussed in Chapter 2.

Because of changes that have occurred in ambient monitoring measurement methodology and the change over time in the geographical distribution of monitors, it is difficult to provide ambient trends going back more than 10 years. It is important, however, not to overlook some of the earlier control efforts in the air pollution field. While the ambient monitoring trends and the emission trends can be viewed as independent assessments of underlying pollutant trends, the emission estimates can also be used to provide information on longer time periods. Figure 3-1 provides a convenient summary of the 1970–93 emission changes for all six NAAQS pollutants. Pb emissions clearly recorded the most impressive decrease of 98 percent but improvements are also seen for emissions of PM-10 (-78 percent), SO_x (-30 percent), CO (-24 percent), and VOCs (-24 percent). Only NO_x emissions showed an increase (14 percent) between 1970 and 1993 levels. It is important to realize that these reductions occurred even with an increase in vehicle miles traveled and industrial output.

This chapter covers the six criteria pollutants which have NAAQS. The chapter which follows focuses on the 189 air toxic pollutants established in the 1990 Clean Air Act Amendments. One program within EPA cuts across both sets of air pollutants—the Permit Program.

Title V of the 1990 Clean Air Act Amendments requires states to develop operating permit programs and then submit them to EPA for approval. These operating permit programs require each major stationary source (there are approximately 35,000 major sources) to obtain an operating permit within one year of the approval of the program by EPA. An operating permit for a source will describe each of the federally required air pollution control requirements that apply to the source. The Act requires states to collect fees from Title V sources to cover both the direct and indirect costs of developing and implementing the permit program.

Since the Permit Program is still in the initial stages of approving state programs, there is not much to report at this time. However, look to future reports for information on the success of this program.

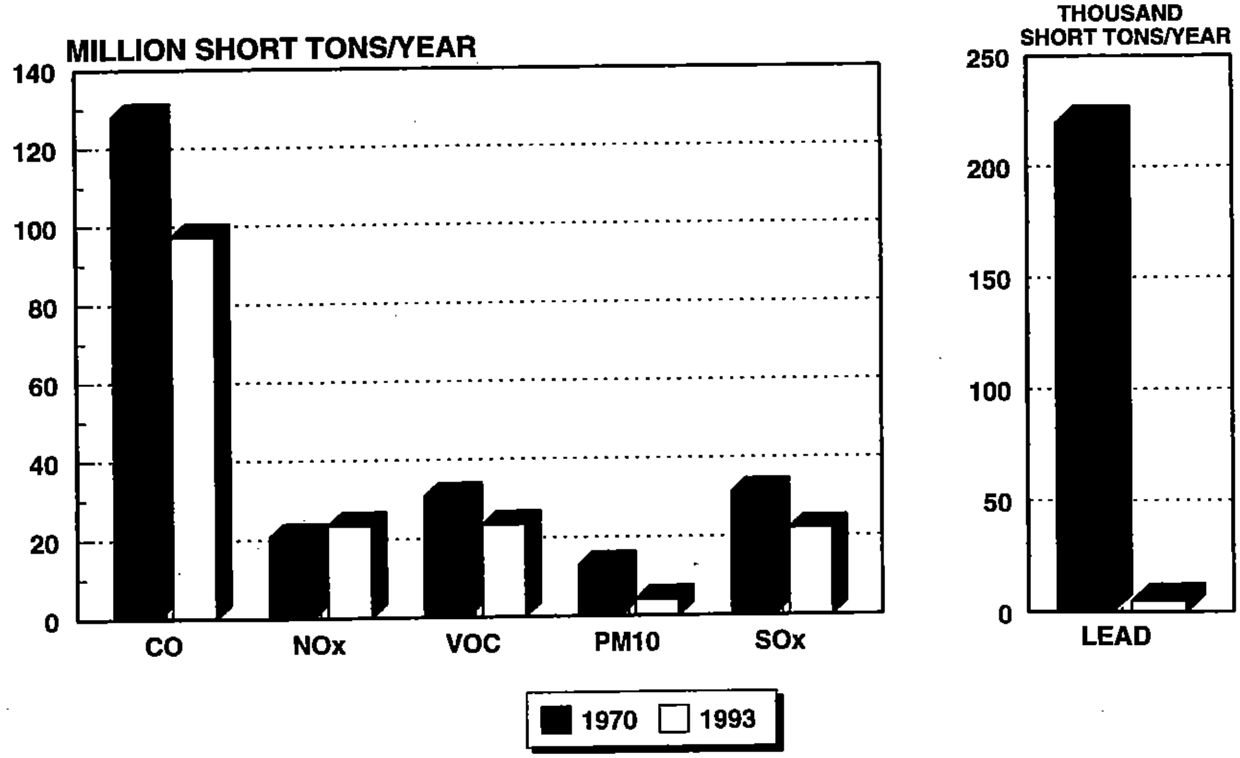

Figure 3-1. Comparison of 1970 and 1993 national total emissions.

3.1 Trends in Carbon Monoxide

Carbon monoxide (CO) is a colorless, odorless and poisonous gas produced by incomplete burning of carbon in fuels. When CO enters the bloodstream, it reduces the delivery of oxygen to the body's organs and tissues. Health threats are most serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. Exposure to elevated CO levels can cause impairment of visual perception, manual dexterity, learning ability, and performance of complex tasks.

The NAAQS for ambient CO specifies upper limits for both one-hour and eight-hour averages that are not to be exceeded more than once per year. The one-hour level is 35 ppm, and the eight-hour level is nine ppm. This trends analysis focuses on eight-hour average results because the eight-hour standard is generally a more restrictive limit. Nationally, there have not been any recorded exceedances of the CO one-hour NAAQS since 1990.

Trend sites were selected by using the criteria presented in Chapter 2, Section 2.1 which yielded a data base of 314 sites for the 10-year 1984–93 period and a data base of 394 sites for the three-year 1991–93 period. Ninety-six NAMS sites were included in the 10-year data base, and 115 in the three-year data base. Seventy-seven percent of the nationwide CO emissions are from transportation sources. The largest emissions contribution comes from highway motor vehicles. Thus, the focus of CO monitoring has been on traffic oriented sites in urban areas where the main source of CO is motor vehicle exhaust. Other major CO sources are wood-burning stoves, incinerators, and industrial sources.

3.1.1 Long-term CO Trends: 1984–1993

The 1984–93 composite national average trend is shown in Figure 3-2 for the second highest non-overlapping eight-hour CO concentration at 314 long-term trend sites. During this 10-year period, the national composite average of the annual second highest eight-hour concentration decreased by 37 percent. The boxplot presentation provides additional information on the year-to-year distribution of ambient CO levels at these long-term trend sites. The general long-term improvement in ambient CO levels is clear for all the percentiles, but is especially notable at the higher percentile concentrations. Although not shown in Figure 3-2, the composite average of the second highest non-overlapping eight-hour concentration at the subset of 96 NAMS decreased by 35 percent. Nationally, the median rate of improvement between 1984 and 1993 is four percent per year for the 314 trend sites, as well as for the subset of 96 NAMS. Following the small upturn between 1985 and 1986, composite average eight-hour CO levels have shown a steady decline during the last seven years. The regional median rates of improvement varied from three to six percent per year. The greatest improvement was seen in the Rocky Mountain states with a decline in CO levels of six percent per year. The northeast states saw median rates of decline of five percent per year, while the Region 6 and 9 states recorded a three percent per year decline in CO levels. The 1993 composite average

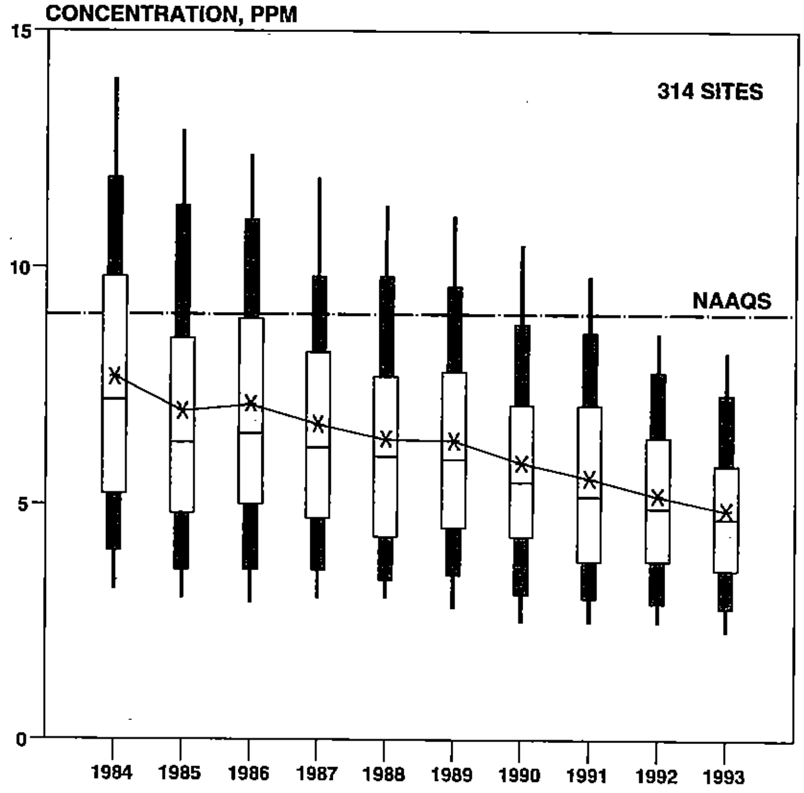

Figure 3-2. Boxplot comparisons of trends in second highest non-overlapping eight-hour average carbon monoxide concentrations at 314 sites, 1984–1993.

is the lowest composite mean recorded since trends have been reported, and is significantly lower than the composite means for 1990 and earlier years.

Figure 3-3 displays the 10-year trend in the composite average of the estimated number of NAAQS exceedances of the eight-hour CO. This exceedance rate was adjusted to account for incomplete sampling. The trend in exceedances shows long-term improvement, but the rates of change are much higher than those for the second maximums. The composite average of estimated exceedances decreased 97 percent between 1984 and 1993 at the 314 long-term trend sites, while the subset of 96 NAMS showed a 95-percent decrease. These percentage changes for exceedances are typically much larger than those found for peak concentrations due to the nature of the exceedance statistic. The trend in annual second maximum eight-hour values is more likely to reflect the change in emission levels than the trend in exceedances. For both curves, the 1993 composite average of the estimated exceedances is significantly lower than levels for 1990 and earlier years. A tabulation of the composite averages for the 314 trend sites and the subset of 96 NAMS sites can be found in the Data Appendix to this report.

The 10-year 1984–93 trend in national CO emission estimates is shown in Table 3-1. These estimates show a 15-percent decrease in total emissions between 1984 and 1993. The estimates in this report differ from those reported last year in several ways. First, the MOBILE5a model was used to estimate highway vehicle emissions, including revised state and county level estimates for vehicle miles traveled (VMT) mix, in-use Reid Vapor Pressure (RVP), oxygenated fuels, and inspection/maintenance (I/M) programs. These changes in methodology yielded higher estimates for highway vehicle CO emissions than reported last year. For example, the revised highway vehicle CO emissions estimate for 1984 is five percent higher, and the revised estimate for 1992 emissions is eight percent higher than reported previously. Updates were also made to the estimates of forest fire emissions that are included in the miscellaneous category. These changes in methodology and data updates yield a revised emissions estimate for 1992 that is 11 percent higher than last year. The estimate for 1984 was revised upward by only one percent. As a result of these revised totals, the 10-year decline in CO emissions is not as large as reported last year.

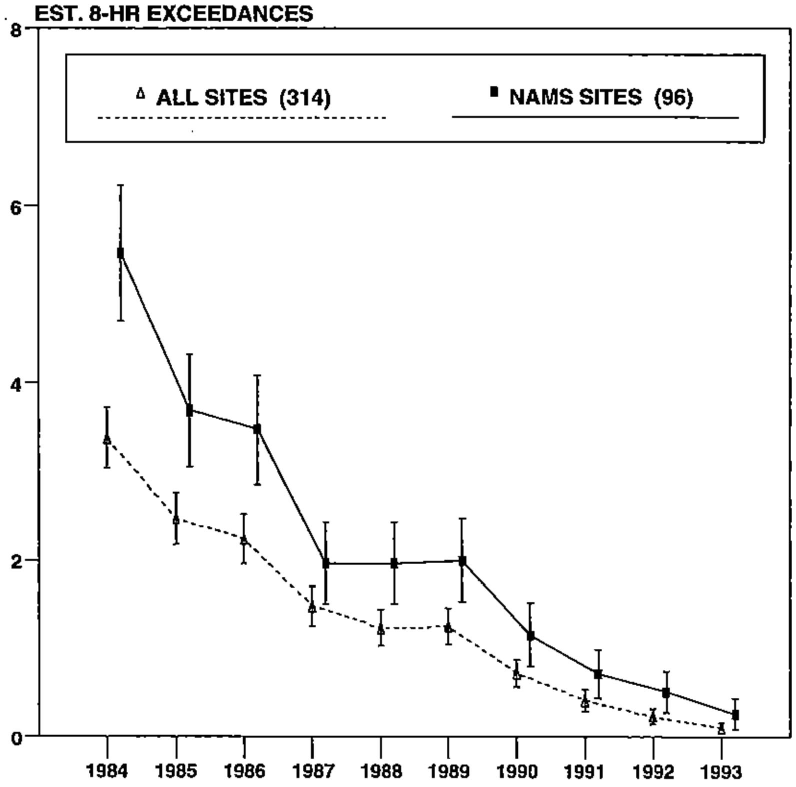

Figure 3-3. National trend in the composite average of the estimated number of exceedances of the eight-hour CO NAAQS, at both NAMS and all sites with 95-percent confidence intervals, 1984–1993.

Table 3-1. National CO Emission Estimates, 1984–1993

(thousand short tons/year)

SOURCE CATEGORY	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Fuel Combustion – Electric Utilities	316	292	291	300	313	319	314	314	313	322
Fuel Combustion – Industrial	732	670	650	649	669	672	677	682	671	667
Fuel Combustion – Other	6,760	6,686	6,571	6,338	6,172	5,942	5,726	5,583	5,033	4,444
Chemical and Allied Product Manufacturing	2,082	1,845	1,853	1,798	1,917	1,925	1,940	1,953	1,964	1,998
Metals Processing	1,734	2,223	2,079	1,984	2,101	2,132	2,080	1,992	2,044	2,091
Petroleum and Related Industries	383	462	451	455	441	436	435	439	410	398
Other Industrial Processes	908	694	715	713	711	716	717	711	719	732
Solvent Utilization	0	2	2	2	2	2	2	2	2	2
Storage and Transport	0	49	51	50	56	55	55	56	55	56
Waste Disposal and Recycling	2,028	1,941	1,916	1,850	1,806	1,747	1,686	1,644	1,717	1,732
Highway Vehicles	78,881	77,387	73,347	70,645	71,081	66,050	62,858	62,074	59,859	59,989
Off-Highway	13,427	13,706	13,984	14,131	14,500	14,518	14,642	14,621	14,904	15,272
Natural Sources	0	0	0	0	0	0	0	0	0	0
Miscellaneous	7,011	6,116	6,161	6,203	6,332	6,290	12,623	9,826	8,679	9,506
Total	**114,262**	**112,072**	**108,070**	**105,117**	**106,100**	**100,806**	**103,753**	**99,898**	**96,368**	**97,208**

NOTE: The sums of sub-categories may not equal total due to rounding.

Figure 3-4 contrasts the 10-year increasing trend in vehicle miles traveled (VMT) with the declining trend in CO emissions from highway vehicles. Emissions from highway vehicles decreased 24 percent during the 1984–93 period, despite a 33-percent increase in VMT.[1] This indicates that the Federal Motor Vehicle Control Program (FMVCP) has been effective on the national scale, with controls more than offsetting growth during this period.

While there is a general agreement between the overall trends in air quality and emissions, it is worth noting that the emission changes reflect estimated national totals, while ambient CO monitors are frequently located to identify local problems. The mix of vehicles and the change in VMT in areas around specific CO monitoring sites may differ from the national averages.

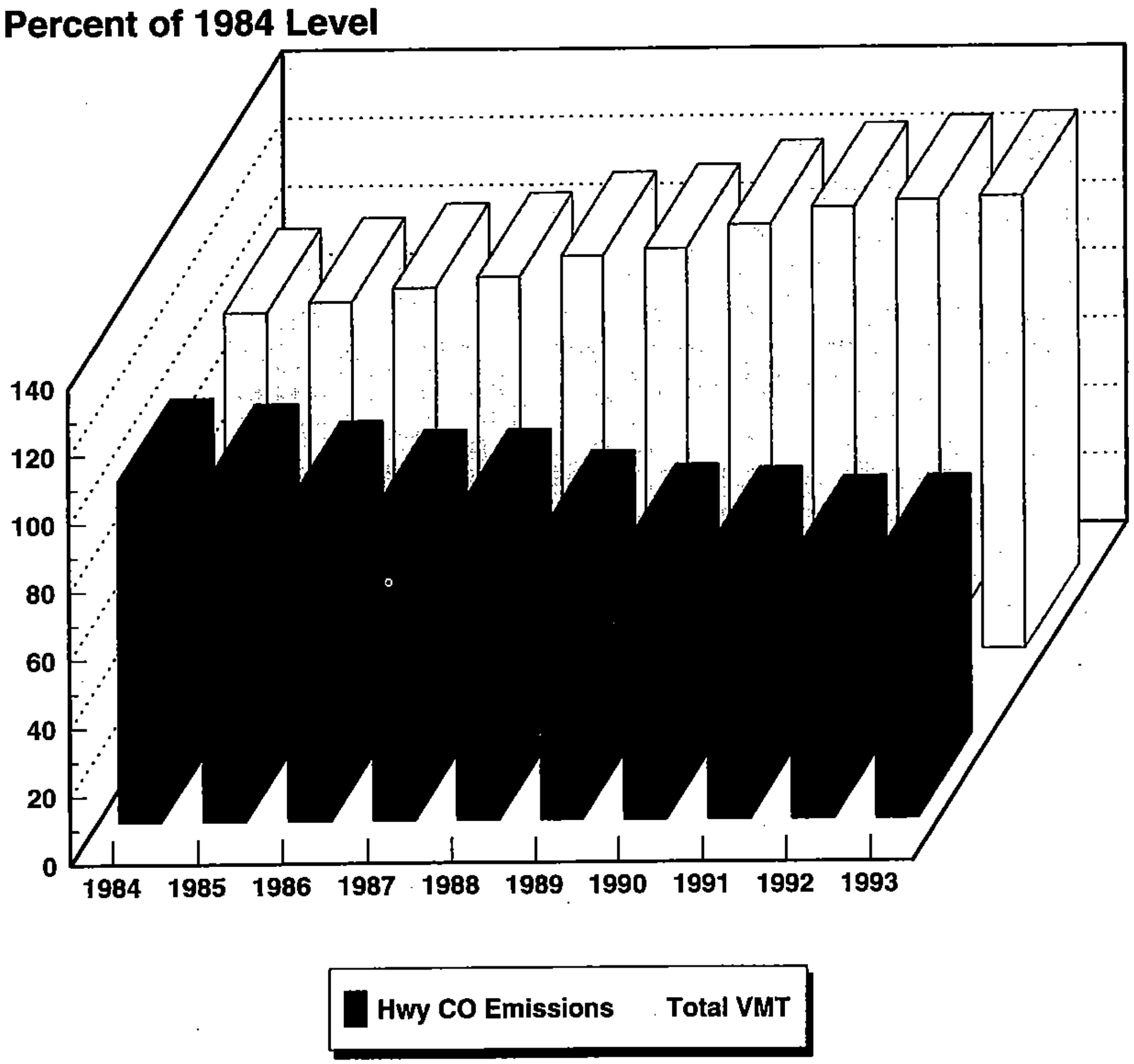

Figure 3-4. Comparison of trends in total national VMT and national highway vehicle carbon monoxide emissions, 1984–1993.

3.1.2 Recent CO Trends: 1991–1993

This section describes ambient CO changes during the last three years (1991, 1992 and 1993) at sites that recorded data in all three years. Between 1991 and 1993, the composite average of the second highest non-overlapping eight-hour average CO concentration at 394 sites decreased by 12 percent, and decreased by seven percent at 115 NAMS sites. Between 1991 and 1993, the composite average of the estimated number of exceedances of the eight-hour CO NAAQS decreased by 55 percent at the 394 trend sites and 63 percent at the subset of 115 NAMS sites. During 1992 and 1993, the composite average of the second highest non-overlapping eight-hour average CO concentration at the 394 trends sites decreased five percent and the composite number of estimated exceedances decreased by 14 percent. Estimated nationwide CO emissions increased one percent between 1992 and 1993. The increase in CO emissions between 1992 and 1993 can be largely attributed to three sources: highway vehicles (+2 percent), off-highway (+2 percent), and wildfires (+10 percent). The latter two categories typically do not impact urban CO levels. These recent changes in emissions should be viewed with caution as the 1990 through 1993 emission estimates are preliminary and subject to revision in subsequent reports.

Figure 3-5 shows the composite regional averages for the 1991–93 time period. Eight of the 10 regions had 1993 composite mean levels that were less than the corresponding 1991 and 1992 values. Increases in composite mean CO levels were seen in Regions 4 and 6. These regional graphs are intended primarily to depict relative change. Because the mix of monitoring sites may vary from one area to another, this graph is not intended to indicate regional differences in concentration levels.

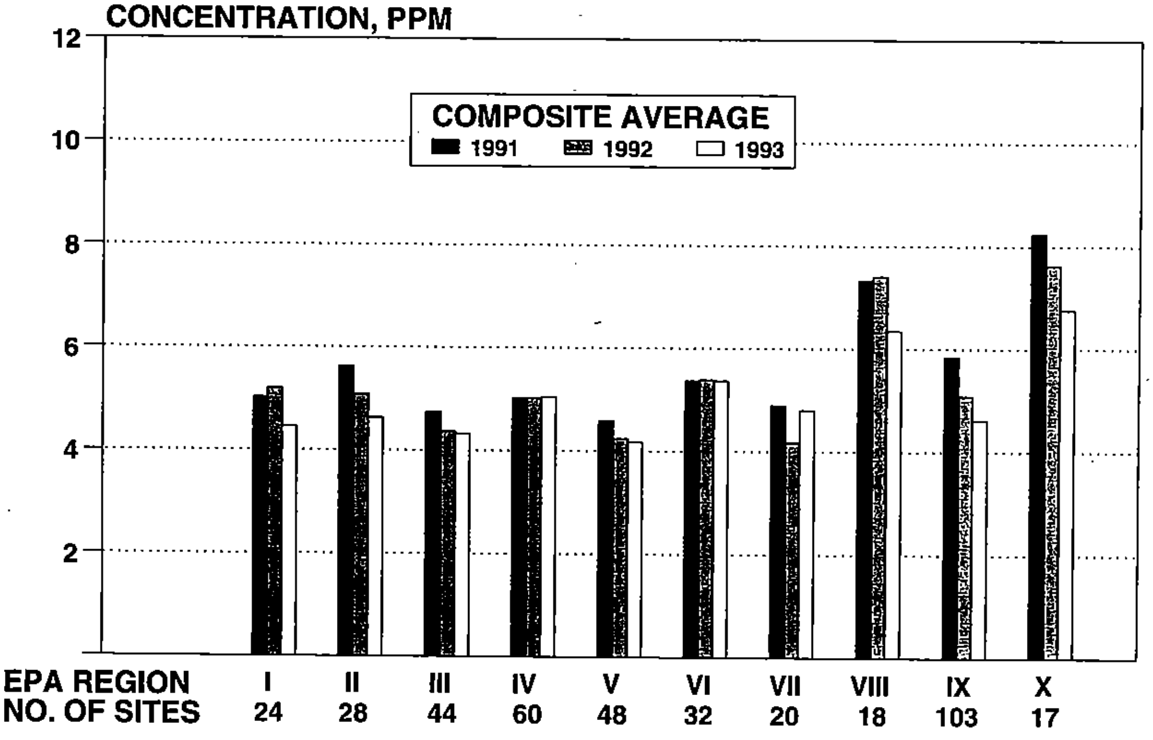

Figure 3-5. Regional comparisons of 1991, 1992, and 1993 composite averages of the second highest non-overlapping eight-hour average carbon monoxide concentrations.

3.2 Trends in Lead

Exposure to Pb can occur through multiple pathways, including inhalation of air and ingestion of Pb in food, water, soil, or dust. Excessive Pb exposure can cause seizures, mental retardation and/or behavioral disorders. A recent National Health and Nutrition Examination Survey reported a 78-percent decrease in blood lead levels from 12.8 to 2.8 μg/dL between 1976 and 1980 and from 1988 to 1991.[6] This dramatic decline can be attributed to the reduction of leaded gasoline and to the removal of lead from soldered cans. Although this study shows great progress, infants and young children are especially susceptible to low doses of Pb, and this age group still shows the highest levels.[6] Low doses of Pb can lead to central nervous system damage. Recent studies have also shown that Pb may be a factor in high blood pressure and in subsequent heart disease in middle-aged white males.

Lead (Pb) gasoline additives, nonferrous smelters, and battery plants are the most significant contributors to atmospheric Pb emissions. In 1993 transportation sources contributed 33 percent of the annual emissions, down substantially from 81 percent in 1985. Total Pb emissions from all sources dropped from 20,100 tons in 1985 to 4,900 tons in 1993. The decrease in Pb emissions from highway vehicles accounts for essentially all of this decline. The reasons for the decrease are noted below.

Two air pollution control programs implemented by EPA before promulgation of the Pb standard[7] in October 1978 have resulted in lower ambient Pb levels. First, regulations issued in the early 1970s required gradual reduction of the Pb content of all gasoline over a period of many years. The Pb content of the leaded gasoline pool was reduced from an average of 1.0 gram/gallon, to 0.5 gram/gallon on July 1, 1985, and still further to 0.1 gram/gallon on January 1, 1986. Second, as part of EPA's overall automotive emission control program, unleaded gasoline was introduced in 1975 for automobiles equipped with catalytic control devices. These devices reduce emissions of CO, VOCs and NO_x. In 1993, unleaded gasoline sales accounted for 99 percent of the total gasoline market. In contrast, the unleaded share of the gasoline market in 1984 was approximately 60 percent. These programs have essentially eliminated violations of the Pb standard in urban areas except those areas with Pb point sources.

Programs are also in place to control Pb emissions from stationary point sources. Lead emissions from stationary sources have been substantially reduced by control programs oriented toward attainment of the PM-10 and Pb ambient standards. However, significant ambient problems still remain around some Pb point sources, which are now the focus of new monitoring initiatives. Pb emissions in 1993 from industrial sources, e.g., primary and secondary Pb smelters, dropped by about 91 percent from levels reported in 1970. Emissions of Pb from solid waste disposal are down about 76 percent since 1970. In 1993, emissions from solid waste disposal, industrial processes and transportation were: 500, 2,300, and 1,600 short tons, respectively. The overall effect of the control programs for these three categories has been a major reduction in the amount of Pb in the ambient air. Additional reductions in Pb are anticipated as a result of the Agency's Multimedia Lead Strategy issued in February, 1991.[8] The goal of the Lead Strategy is to reduce Pb exposures to the fullest extent practicable.

Early trend analyses of ambient Pb data were based almost exclusively on National Air Surveillance Network (NASN) sites.[9,10] These sites were established in the 1960s to monitor ambient air quality levels of total suspended particulate (TSP) and associated trace metals, including Pb. The sites were predominantly located in the central business districts of larger American cities. In September 1981, ambient Pb monitoring regulations were promulgated, which established the current monitoring network.[11]

3.2.1 Long-term Pb Trends: 1984–1993

As with other pollutants, the sites selected for long-term trend analysis had to satisfy annual data completeness criteria of at least eight out of 10 years of data in the 1984 to 1993 period. A year was included as "valid" if at least three of the four quarterly averages were available. As in the 1992 report, composite Pb data, i.e., individual 24-hour observations composited by month or quarter and measured by a single analysis, were used in the trend analysis. Twenty-two sites qualified for the 10-year trend because of the additional composite data.

A total of 204 urban-oriented sites from 37 states and Puerto Rico met the data completeness criteria. Eighty-eight of these sites were NAMS—the largest number of Pb NAMS sites to qualify for the 10-year trends. Twenty-six (13 percent) of the 204 trend sites were located in California. However, the Pb trend at the California sites was identical to the trend at the non-California sites. Therefore, these sites did not distort the overall trends. Other states with 10 or more trend sites included: Texas (17), Illinois (16), Kansas (15), Ohio (14), Pennsylvania (11), and Michigan (10). Again, the Pb trend in each of these states was very similar to the national trend. Sites that were located near Pb point sources, such as primary and secondary Pb smelters, were excluded from the urban trend analysis because the increased levels at these sources could mask the underlying urban trends. Trends at Pb point-source oriented sites are discussed later in this section.

The means of the composite maximum quarterly averages show an 89-percent decrease (1984–93) at 204 urban-oriented sites in Figure 3-6. The boxplot comparison in this figure also shows dramatic improvement in ambient Pb concentrations over the entire distribution of trend sites. Since 1984, the maximum quarterly Pb averages and most of the percentiles show a monotonically decreasing pattern. The 204 urban-oriented sites that qualified for the 1984–93 period is almost the same number of sites (203) that qualified for 1983–92.

Pb emissions over this 10-year period also decreased. There was an 88-percent decrease in total Pb emissions and a 96-percent decrease in Pb emissions from transportation sources.

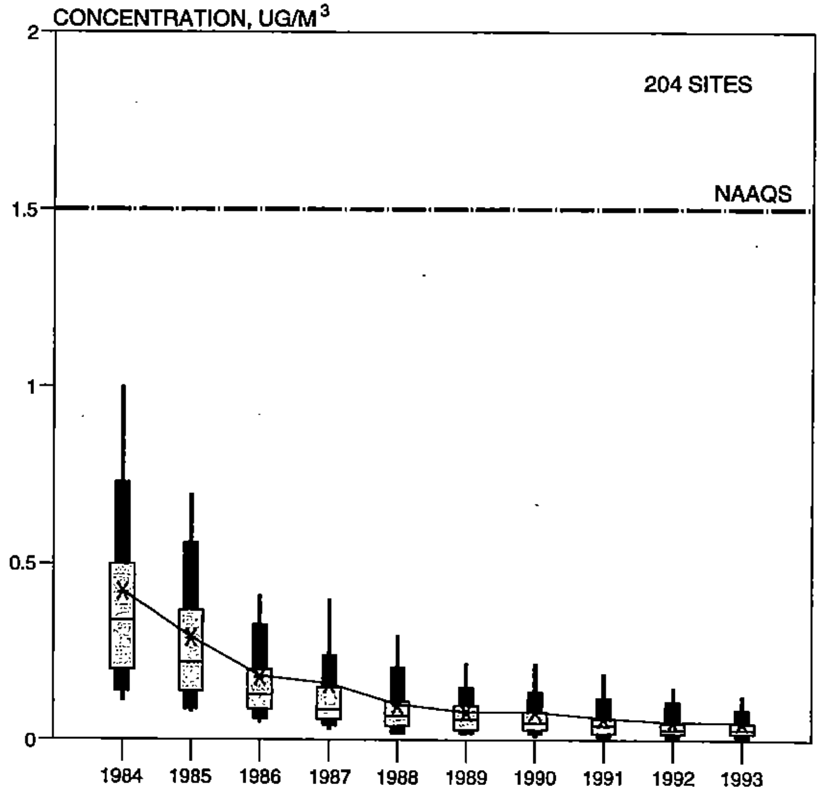

Figure 3-6. Boxplot comparisons of trends in maximum quarterly average lead concentrations at 204 sites, 1984–1993.

Figure 3-7 shows the trend in average Pb concentrations for the urban-oriented sites and for 66 point-source oriented sites that also met the 10-year data completeness criteria. Composite average ambient Pb concentrations at the point-source oriented sites located near industrial sources of Pb, e.g., smelters and battery plants, improved 63 percent compared to 89 percent at the urban-oriented sites. The average at the point-source oriented sites dropped in magnitude from 1.5 to 0.6 μg/m³, a 0.9 μg/m³ difference, whereas the average at the urban sites dropped from 0.4 to 0.05 μg/m³. The improvement at point-source oriented sites reflects both industrial and automotive Pb emission controls. However, some industrial source reductions are due to plant shutdowns. There are still several urban areas where significant Pb problems persist. The six Metropolitan Statistical Areas (MSAs) shown in Table 5-3 that are above the Pb NAAQS in 1993 are all due to Pb point sources. These MSAs are:

- Cleveland, OH;
- Indianapolis, IN;
- Memphis, TN-AL-MS;
- Omaha, NE-IA;
- Philadelphia, PA-NJ; and
- St Louis, MO-IL.

None of the monitoring sites responsible for 1993 Pb concentrations above the NAAQS had sufficient historical data to be included in the point-source oriented trends discussed above. The sites in these MSAs that recorded Pb concentrations above the NAAQS were sites situated near the Pb point sources listed in EPA's Lead Strategy. This strategy has an increased target of 30 primary or secondary Pb smelters and three other stationary sources for more intensive Pb monitoring.

The map in Figure 3-8 shows the highest quarterly average Pb concentrations that were recorded during 1993 in the vicinity of these sources. At present, various types of enforcement and/or regulatory actions are being actively pursued by EPA, with State involvement, for all Pb point sources that have reported Pb levels above the NAAQS. This is especially the case, as indicated on the map in Figure 3-8, where exceptionally high Pb levels have been reported. The Pb sources that reported the highest 1993 quarterly Pb averages in μg/m³ include: ASARCO Glover (23.59), Master Metals (16.13), and Franklin Smelting (11.23). Although significant problems still remain, as indicated by the map, there have been some success stories on point source Pb problems. Two examples are highlighted later in this section.

Table 3-2 summarizes the Pb emissions data. The 1984–93 drop in total Pb emissions was 88 percent. Reduced Pb emissions in the transportation category account for most of this drop. Pb emissions from the other categories show only small changes over the 1984–93 time period. The percent decrease in total Pb emissions (89 percent) is equivalent to the change in the average ambient Pb concentrations. The drop in Pb consumption and subsequent Pb emissions since 1984 was brought about by the increased use of unleaded gasoline in cars equipped with catalytic control devices and the reduced Pb content in leaded gasoline. The results of these actions in 1993 amounted to a 76-percent reduction nationwide in total Pb emissions from 1985 levels. As noted previously, unleaded gasoline represented 99 percent of 1993 total gasoline sales. Although the good agreement among the trends for Pb consumption, emissions, and ambient levels are based upon a limited geographical sample, they do indicate that ambient urban Pb levels are responding to the drop in Pb emissions.

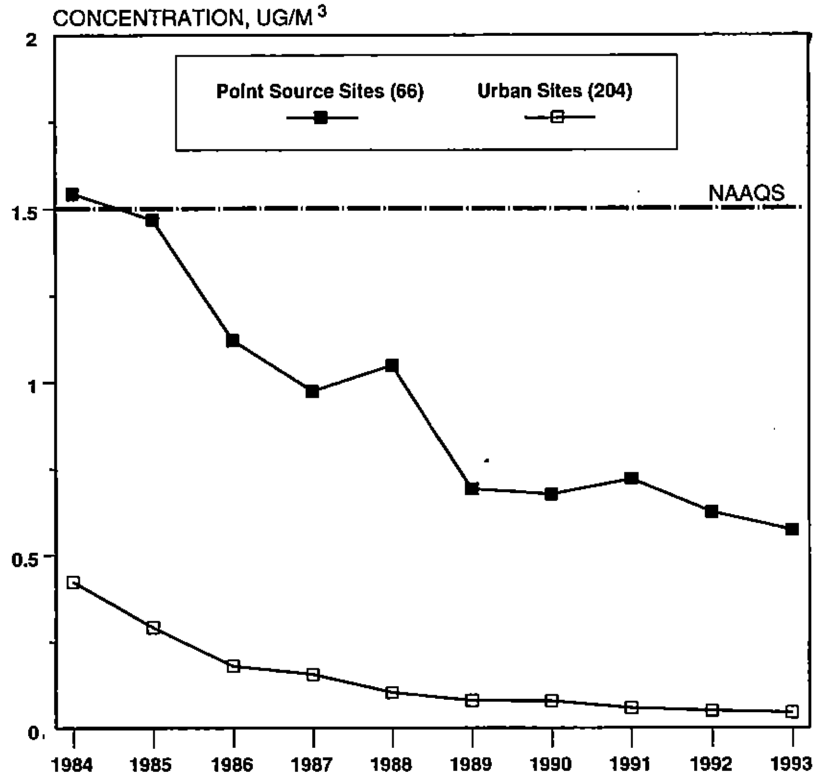

Figure 3-7. Comparison of national trends in the composite average of the maximum quarterly average lead concentrations at urban and point-source oriented sites, 1984–1993.

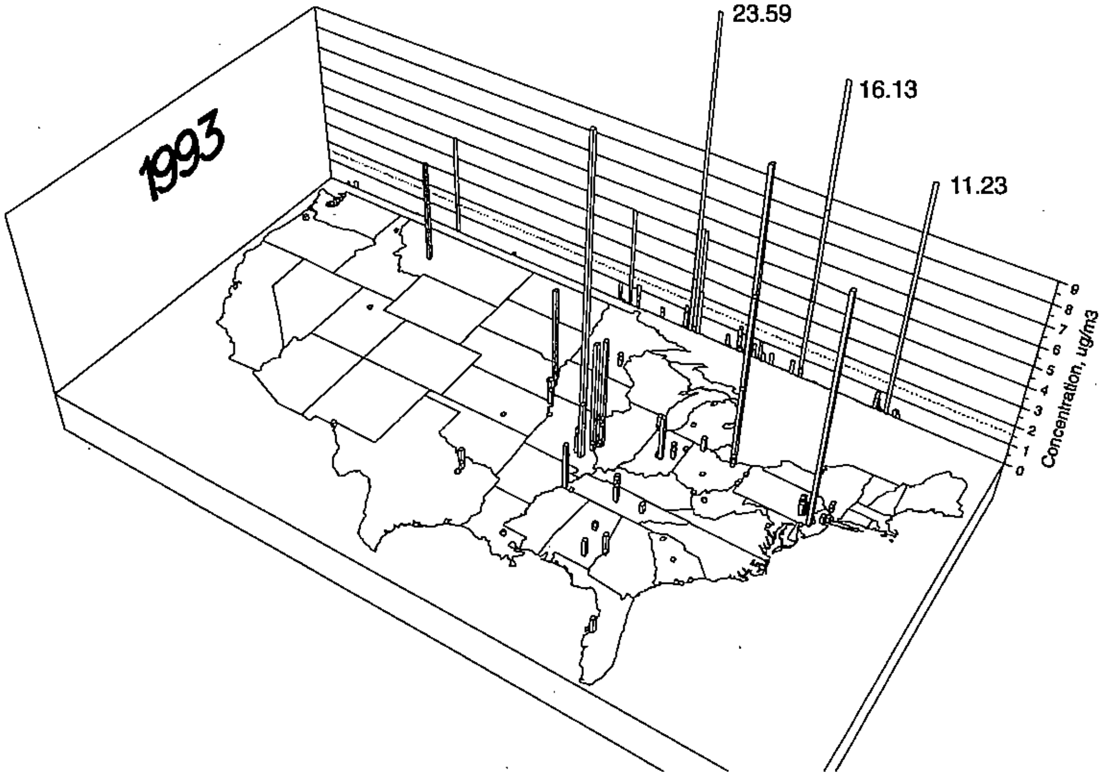

Figure 3-8. Maximum quarterly mean lead concentrations in the vicinity of lead point sources, 1993.

Table 3-2. National Pb Emission Estimates, 1984–1993

(short tons/year)

SOURCE CATEGORY	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Fuel Combustion – Electric Utilities	88	64	69	64	66	67	64	61	59	62
Fuel Combustion – Industrial	29	30	25	22	19	18	18	18	18	18
Fuel Combustion – Other	424	421	422	425	426	420	418	416	414	417
Chemical and Allied Product Manufacturing	133	118	108	123	136	136	136	132	93	109
Metals Processing	1,919	2,097	1,820	1,818	1,917	2,153	2,138	1,939	2,042	2,118
Petroleum and Related Industries	0	0	0	0	0	0	0	0	0	0
Other Industrial Processes	483	316	199	202	172	173	169	167	54	54
Solvent Utilization	0	0	0	0	0	0	0	0	0	0
Storage and Transport	0	0	0	0	0	0	0	0	0	0
Waste Disposal and Recycling	901	871	844	844	817	765	804	582	416	518
Highway Vehicles	35,930	15,978	3,589	3,121	2,700	2,161	1,690	1,519	1,452	1,383
Off-Highway	2,310	229	219	222	211	207	197	186	193	206
Natural Sources	0	0	0	0	0	0	0	0	0	0
Miscellaneous	0	0	0	0	0	0	0	0	0	0
Total	**42,217**	**20,124**	**7,296**	**6,840**	**6,464**	**6,099**	**5,635**	**5,020**	**4,741**	**4,885**

NOTE: The sums of sub-categories may not equal total due to rounding.

The 10-year trend at the 66 point-source oriented sites shows a much larger decline in Pb concentrations (-63 percent) than did Pb emissions from industrial processes (-10 percent). Improvement in Pb concentrations at point-source oriented sites reflects improvement at a relatively small number of Pb sources. The emission figures for industrial processes represent all industrial sources in the nation. It is interesting to note that the Pb emissions from industrial processes are lowest in 1986 (2,127 short tons), but rise slightly to 2,281 short tons in 1993. On the other hand, the trend in point-source oriented sites shows a decline over this period, although there is a small increase in average Pb concentrations in 1988.

3.2.2 Recent Pb Trends: 1991–1993

Ambient Pb trends were also studied over the shorter period 1991–93. A total of 228 urban sites from 37 states met the data requirement that a site have data from all three years. In recent years, the number of Pb sites have dropped because of the elimination of some TSP monitors from state and local air monitoring programs. Pb measurements were obtained from the TSP filters. Some monitors were eliminated because of the change in the particulate matter standard from TSP to PM-10, while others were discontinued because of the very low Pb concentrations measured at or below the minimum detectable level in many urban locations. Although some further attrition may occur, the core network of NAMS Pb sites together with supplementary state and local sites should be sufficient to assess national ambient Pb trends. The three-year data base (1991–93) showed an improvement of 11 percent in composite average urban Pb concentrations. The 1991 and 1993 Pb averages, however, were extremely low: 0.063 and 0.047 $\mu g/m^3$ respectively. Between 1991 and 1993, total Pb emissions decreased three percent and Pb emissions from transportation sources dropped seven percent. Most of this decrease in total nationwide Pb emissions was due once again to the decrease in automotive Pb emissions. Even this larger group of sites was disproportionately weighted by sites in California, Texas, Illinois, Kansas, Ohio, and Pennsylvania. These states had about 47 percent of the 228 sites represented. The percent changes in 1991–93 average Pb concentrations for these six states, however, were very similar to the percent change for the remaining sites. Apparently, the contributions of these sites did not distort the national trends. Although urban Pb concentrations continue to decline consistently, there are indications that the rate of the decline has slowed down. Clearly, in some areas urban Pb levels are so low that further improvements have become difficult.

Indeed, as will be shown later, all sections of the country are showing declines in average Pb concentrations. Ninety-three point-source oriented sites showed a 14-percent decline in average Pb levels over the 1991–93 time period. Thus, Pb concentrations near Pb point sources, unlike the urban sites which showed an 18-percent decrease, have improved to a lesser extent over the last three years. Pb emissions from industrial processes also did not change much during the 1991–93 period. As expected, the average Pb levels at the point-source oriented sites are much higher here than

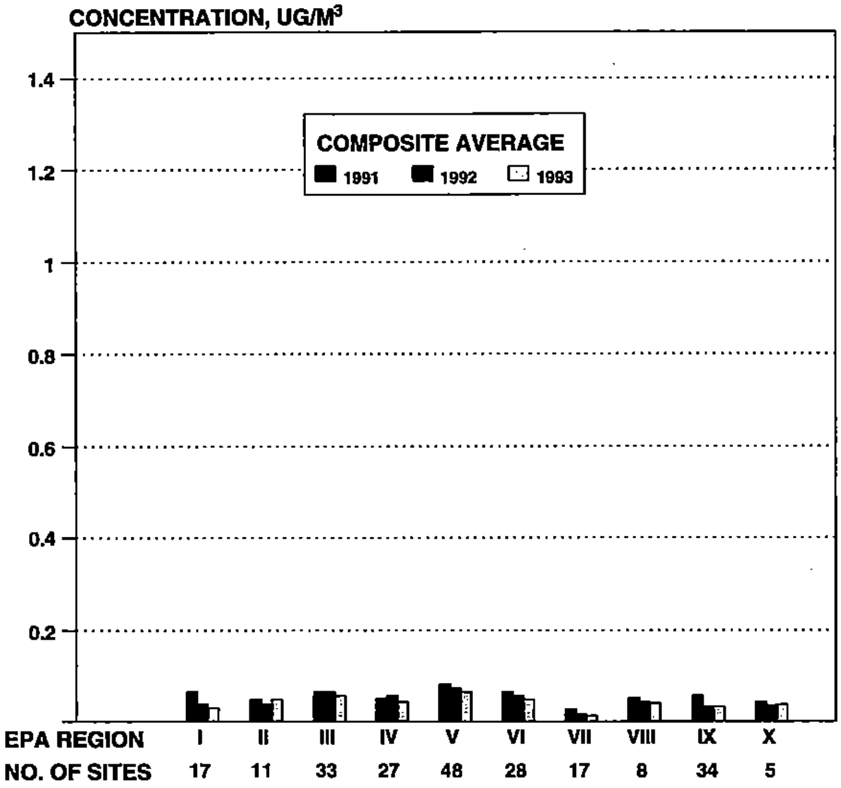

Figure 3-9. Regional comparisons of the 1991, 1992, and 1993 composite average of the maximum quarterly average lead concentrations.

at the urban sites. The 1992 and 1993 Pb point source averages were 0.84 and 0.73 µg/m^3, respectively.

For the 10-year time period, however, the largest single year drop in average Pb concentrations (37 percent) occurred as expected between 1985 and 1986, because of the reduction in the Pb content in leaded gasoline. The 1993 composite average Pb concentrations showed the more modest decline of 11 percent from 1992 levels, while total Pb emissions increased by three percent. There has been a three-percent decrease in estimated Pb emissions for the transportation category between 1992 and 1993, while VMT increased one percent between 1992 and 1993. The Pb emissions trend is expected to continue downward, but at a slower rate, primarily because the leaded gasoline market is almost gone. Some major petroleum companies have discontinued refining leaded gasoline because of the dwindling market.

Figure 3-9 shows 1991, 1992 and 1993 composite average Pb concentrations by EPA region. Once again, the larger three-year data base of 228 sites was used for this comparison. The number of sites varies dramatically by region from five in Region 10, to 48 in Region 5. In all regions except Region 2, there was a decrease in average Pb urban concentrations between 1991 and 1993. These results confirm that average Pb concentrations in urban areas are continuing to decrease throughout the country. This is exactly what is to be expected since the national air pollution control program is now fully in place for Pb.

LEAD SUCCESS STORIES

The phase-out of lead in gasoline has largely addressed high lead concentrations in the air nationwide. However, high lead concentrations still remain around a number of stationary lead sources. In 1990 EPA initiated a lead attainment strategy to address the problems around these sources. The strategy requires air quality monitoring, aggressive enforcement of existing requirements, or modifying source requirements for addressing lead problems. The following are two of several examples on how state environmental agencies, industries, and EPA are working together in partnership to reduce pollution.

■ **Gopher Smelter, Dakota County, Minnesota** — Gopher is one of the few secondary lead smelters where air quality monitors were operated prior to the initiation of the lead attainment strategy. Over the two years prior to initiation of the strategy (1988 and 1989), monitors recorded violations of the lead standards in four different calendar quarters (half of the time monitoring was conducted). On June 4, 1990, EPA conducted an inspection at the source and found that the source was not operating in compliance with their State emissions limits and requirements. On January 6, 1992, the area around the source was designated nonattainment for lead. The EPA Regional Office has worked with the State and the source to develop a consent agreement to address the compliance and air quality problems and to incorporate these new requirements into the permanent attainment plan for the area. The consent agreement was signed on September 25, 1990, and there have been no further violations at the source since the first calendar quarter of 1990. With four years of data showing no further problems at the source, and with the eventual approval of the State's attainment plan for the area, the EPA Regional Office expects to redesignate the area around the Gopher Smelter from nonattainment to attainment.

■ **GNB, Columbus, Georgia** — similar to the Gopher smelter, the GNB facility (formerly Pacific Chloride) operates a secondary lead smelter where air quality was monitored prior to 1990. In this case only one monitor was being operated, and it recorded one violation of the lead standard in the 1988–1989 time frame. After the initiation of the lead attainment strategy, an additional monitor was located at the source, and over the next two years (1990–1991) the lead concentrations exceeded the standards in five different calendar quarters. An inspection of GNB indicated that the source was complying with its State emission limits yet still causing exceedances of the lead standard. So, on January 6, 1992, the area was designated nonattainment for lead. The State has worked with the source in developing and implementing a new control strategy. The EPA Regional Office is currently reviewing this strategy for inclusion in the State's implementation plan. Since there have been no violations of the lead standard since the end of 1991, the Region expects to redesignate the area to attainment soon.

These are two examples from the 21 areas which have had monitored violations since the lead attainment strategy began. In total, 11 areas are now consistently attaining the lead NAAQS, four areas have shown significant improvement but still violate the standard, and six continue to work on the problem. Much of the success of this program results from the cooperation between the EPA, the states, and the sources in addressing lead air quality problems.

3.3 Trends in Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a brownish, highly reactive gas that is present in all urban atmospheres. NO_2 can irritate the lungs, cause bronchitis and pneumonia, and lower resistance to respiratory infections. Nitrogen oxides are an important precursor both to O_3 and acid rain, and may affect both terrestrial and aquatic ecosystems. The major mechanism for the formation of NO_2 in the atmosphere is the oxidation of the primary air pollutant nitric oxide (NO). NO_x plays a major role, together with VOCs, in the atmospheric reactions that produce O_3. NO_x forms when fuel is burned at high temperatures. The two major emissions sources are transportation and stationary fuel combustion sources such as electric utility and industrial boilers.

NO_2 is measured using a continuous monitoring instrument that can collect as many as 8,760 hourly observations per year. Only annual means based on at least 4,380 hourly observations were considered in the trends analyses that follow. A total of 201 sites were selected for the 10-year period, and 269 sites were selected for the three-year data base.

3.3.1 Long-term NO_2 Trends: 1984–1993

Figure 3-10 uses boxplots to display the long-term trend in the annual average NO_2 concentration at 201 trend sites. The 1993 composite average of the NO_2 mean concentrations at the 201 trend sites was at its lowest level in the past 10 years, and was 12 percent lower than the 1984 level. The middle quartiles for the years 1984 to 1989 are similar, followed by a decrease in levels beginning in 1990. The upper percentiles, which generally reflect NO_2 annual mean levels in the Los Angeles metropolitan area, also show improvement during the last four years. The lower percentiles show little change. NO_2 composite average levels for each year from 1984 through 1989 are statistically indistinguishable based on 95-percent confidence intervals about the composite means. The difference between the 1993 and 1984 composite average levels is statistically significant, however. This is the fifth consecutive year of continued improvement in NO_2 levels.

Previous reports have shown that the level of the NO_2 composite means varied by metropolitan area size, with the larger areas recording the higher concentration levels.[12] NAMS sites for NO_2 are located only in large urban areas with populations of one million or greater. Thus, it is not surprising that the composite averages of the NAMS are higher than those of the 201 trend sites. Although the overall trends are similar for both sets of sites, greater improvement has been recorded at the 45 NAMS sites. At the subset of NAMS sites the 1993 composite average of the NO_2 annual mean concentration is 14 percent lower than the composite average in 1984, as compared to the 12-percent improvement for the 201 trend sites. This difference for the NAMS sites also is statistically significant. The composite averages for both the 201 trend sites and the subset of 45 NAMS sites are listed in the Data Appendix.

Table 3-3 presents the trend in estimated nationwide emissions of NO_x. Total 1993 NO_x emissions are one percent higher than 1984 emissions. Table 3-3 shows that the two primary source categories of NO_x emissions are fuel combustion and transportation, composing 50 percent and 45 percent, of total 1993 NO_x emissions, respectively. While fuel combustion emissions (primarily from coal-fired electric utilities) are three percent higher in 1993 than in 1984, NO_x emissions from highway vehicles decreased 11 percent during this 10-hour period. The good agreement between the ambient trends and the changes in NO_x emissions from highway vehicles is expected because the population-oriented urban monitors are more likely to reflect transportation impacts rather than power plant emissions.

The emissions estimates in this report have been recomputed using the MOBILE5a emissions factor model and with updated inputs at the state and county level. The revised 1984 estimate of total NO_x emissions is one percent higher than last year's estimate, while the revised 1992 total is one percent lower.

As noted in a recent report prepared by the National Research Council (NRC), state of the art air quality models and improved knowledge of the ambient concentrations of VOCs and NO_x indicate that NO_x control is necessary for effective reduction of ozone in many areas of the United States.[1] The NRC report recommended that to substantially reduce ozone in many urban/suburban/rural areas of the United States, the control of NO_x emissions will probably be necessary in addition to, or instead of, the control of VOCs. Regional modeling studies performed subsequent to the NRC report have tended to confirm the need to control NO_x emissions to reduce ozone in many areas. Thus, even though the NO_2 standard is currently being met in all locations throughout the country, NO_x emissions and their control are important factors for addressing the current widespread violations of the ozone NAAQS.

3.3.2 Recent NO_2 Trends: 1991–1993

Between 1992 and 1993, the composite annual mean NO_2 concentration, at 269 sites with complete data during the last three years, decreased two percent. This followed a three-percent decrease in the composite mean between 1991 and 1992. At the subset of 53 NAMS, the composite mean concentration decreased three percent between 1992 and 1993. Los Angeles, CA, which met the NO_2 NAAQS for the first time in 1992 continued to show improvement in 1993. Nationwide emissions of NO_x are estimated to have increased two percent between 1992 and 1993. Approximately 76 percent of the increase in NO_x emissions between 1992 and 1993 is attributable to increased emissions from coal fired electric utilities. The remainder of the increase in emissions this year is due to increased emissions from off-highway sources. Highway vehicle emissions were unchanged between 1992 and 1993.

Regional trends in the composite average NO_2 concentrations for the years 1991–93 are displayed by bar graphs in Figure 3-11. Region 10, which did not have any NO_2 sites with data in all three years is not shown. Five of the nine regions had 1993 composite means that were lower than 1991 levels, but higher than 1992 levels. Only Region 2 continued to record progress in reducing NO_2 levels in each of the last two years. In contrast, the 1993 composite mean NO_2 levels in Regions 4 and 5 were higher than both the 1991 and 1992 means. However, all of the annual means are well below the level of the air quality standard.

These regional graphs are intended primarily to depict relative change. Because the mix of monitoring sites may vary from one area to another, this graph is not intended to indicate regional differences in absolute concentration levels.

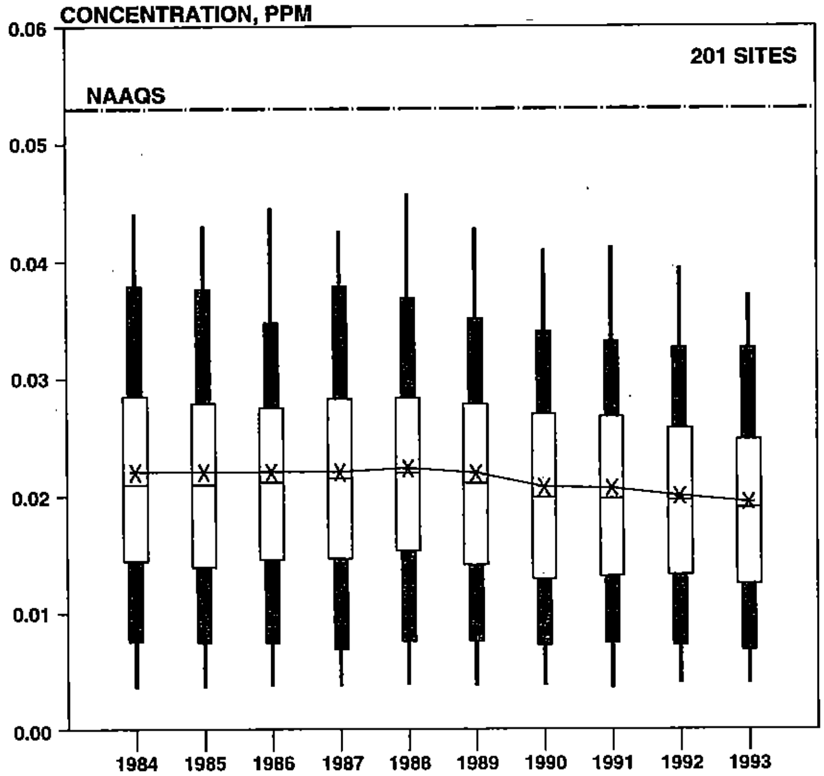

Figure 3-10. Boxplot comparisons of trends in annual mean nitrogen dioxide concentrations at 201 sites, 1984–1993.

Table 3-3. National NO_x Emission Estimates, 1984–1993

(thousand short tons/year)

SOURCE CATEGORY	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Fuel Combustion – Electric Utilities	7,268	6,916	6,909	7,128	7,530	7,607	7,516	7,482	7,473	7,782
Fuel Combustion – Industrial	3,415	3,209	3,065	3,063	3,187	3,209	3,256	3,309	3,206	3,176
Fuel Combustion – Other	670	701	694	710	737	730	732	745	735	732
Chemical and Allied Product Manufacturing	161	374	381	371	398	395	399	401	411	414
Metals Processing	54	87	80	76	82	83	81	79	80	82
Petroleum and Related Industries	70	124	109	101	100	97	100	103	96	95
Other Industrial Processes	203	327	328	320	315	311	306	298	305	314
Solvent Utilization	0	2	3	3	3	3	2	2	3	3
Storage and Transport	0	2	2	2	2	2	2	2	3	3
Waste Disposal and Recycling	90	87	87	85	85	84	82	81	83	84
Highway Vehicles	8,387	8,089	7,773	7,662	7,661	7,682	7,488	7,373	7,440	7,437
Off-Highway	2,644	2,734	2,777	2,664	2,914	2,844	2,843	2,796	2,885	2,986
Natural Sources	0	0	0	0	0	0	0	0	0	0
Miscellaneous	210	201	202	203	206	205	384	305	272	296
Total	**23,172**	**22,853**	**22,409**	**22,386**	**23,221**	**23,250**	**23,192**	**22,977**	**22,991**	**23,402**

NOTE: The sums of sub-categories may not equal total due to rounding.

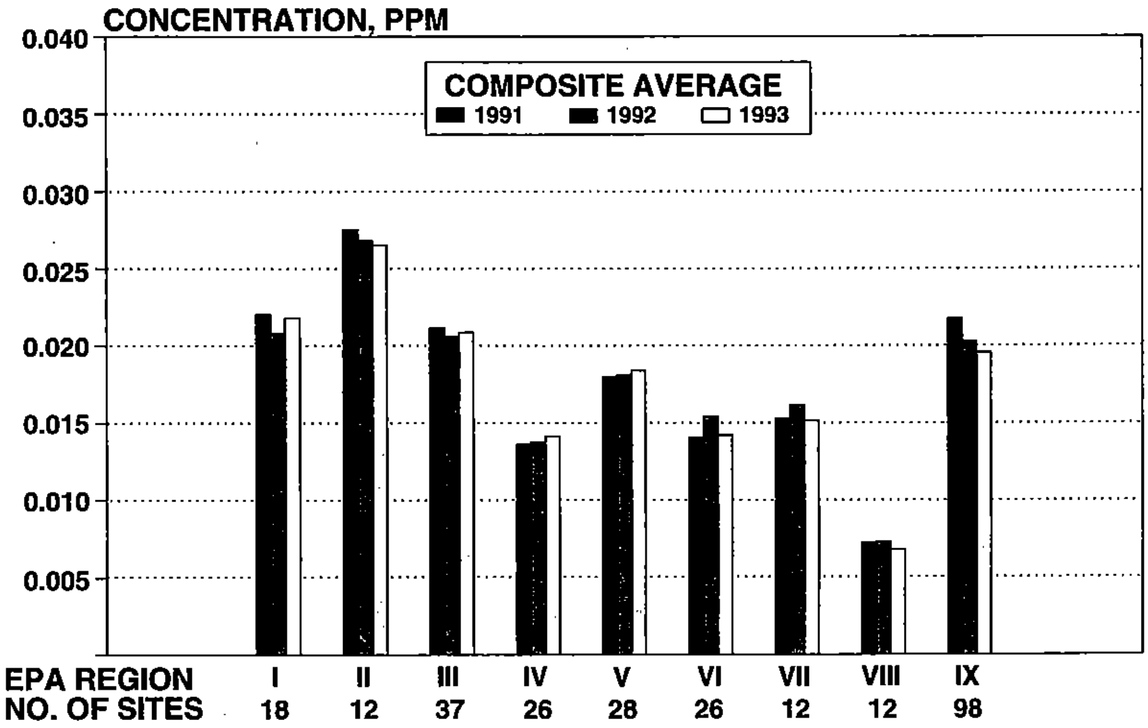

Figure 3-11. Regional comparisons of 1991, 1992, and 1993 composite averages of the annual mean nitrogen dioxide concentrations.

3.4 Trends in Ozone

Ozone (O_3) is a photochemical oxidant and the major component of smog. While O_3 in the upper atmosphere is beneficial to life by shielding the earth from harmful ultraviolet radiation from the sun, high concentrations of O_3 at ground level are a major health and environmental concern. O_3 is not emitted directly into the air but is formed through complex chemical reactions between precursor emissions of VOCs and NO_x in the presence of sunlight. These reactions are stimulated by sunlight and temperature so that peak O_3 levels occur typically during the warmer times of the year. Both VOCs and NO_x are emitted by transportation and industrial sources. VOCs are emitted from sources as diverse as autos, chemical manufacturing and dry cleaners, paint shops, and other sources using solvents. NO_x emissions also were discussed in the previous section.

The reactivity of O_3 causes health problems because it damages lung tissue, reduces lung function, and sensitizes the lungs to other irritants. Scientific evidence indicates that ambient levels of O_3 not only affect people with impaired respiratory systems, such as asthmatics, but healthy adults and children as well. Exposure to O_3 for several hours at relatively low concentrations has been found to significantly reduce lung function and induce respiratory inflammation in normal, healthy people during exercise. This decrease in lung function generally is accompanied by symptoms including chest pain, coughing, sneezing and pulmonary congestion.

The O_3 NAAQS is defined in terms of the daily maximum, that is, the highest hourly average for the day, and it specifies that the expected number of days per year with values greater than 0.12 ppm should not be greater than one. Both the annual second highest daily maximum and the number of daily exceedances during the O_3 season are considered in this analysis. The strong seasonality of O_3 levels makes it possible for areas to limit their O_3 monitoring to a certain portion of the year, termed the O_3 season. Peak O_3 concentrations typically occur during hot, dry, stagnant summertime conditions, i.e., high temperature and strong solar insolation.[13,14] The length of the O_3 season varies from one area of the country to another. May through October is typical, but states in the south and southwest may monitor the entire year. Northern states have shorter O_3 seasons e.g., May through September for North Dakota. This analysis uses these O_3 seasons to ensure that the data completeness requirements apply to the relevant portions of the year.

There are 532 sites in the 1984–93 long-term trends data base, and 722 sites with data in each of the last three years, 1991–93. The NAMS compose 197 of the long-term trends sites and 220 of the sites in the three-year data base.

3.4.1 Long-term O_3 Trends: 1984–1993

Figure 3-12 displays the 10-year composite average and the inter-site variability of the annual second highest daily maximum one-hour concentration during the O_3 season at 532 trend sites. The 1993 composite average for these sites is 12 percent lower than the 1984 level, and 9 percent lower for the subset of 197 NAMS. The 1993 composite average is higher than the 1992 level, which was the lowest composite average of the past 10 years. However, the 1993 composite average is still the second lowest level during the past 10 years. The distribution of second daily maximum one-hour concentrations in 1992

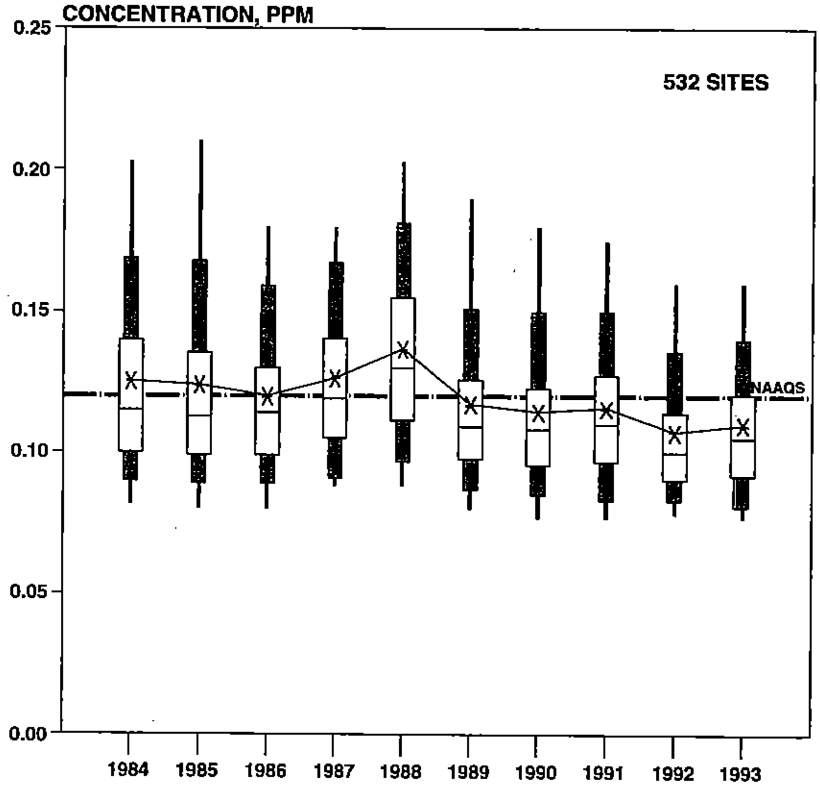

Figure 3-12. Boxplot comparisons of trends in annual second highest daily maximum one-hour ozone concentration at 532 sites, 1984–1993.

is also lower than any other year. The increase in the composite average between 1992 and 1993 is not statistically significant. The composite averages and confidence intervals for the 532 trend sites and the subset of 197 NAMS sites are provided in the Data Appendix.

The interpretation of recent O_3 trends is difficult due to the confounding factors of meteorology and emission changes. Just as the increase in 1988 is attributed in part to meteorological conditions that were more conducive to ozone formation than prior years, the 1992 decrease is due in part, to meteorological conditions being less favorable for O_3 formation in 1992 than in other recent years.[15,16] Meteorological conditions in 1993 were once again more favorable to ozone formation, especially in the east and southeastern areas of the country.[17] Also, since the peak year of 1988, the volatility of gasoline has been reduced by new regulations which lowered national average summertime Reid Vapor Pressure (RVP) in regular unleaded gasoline from 10.0 to 8.9 pounds per square inch (psi) between 1988 and 1989.[18,19,20] RVP was reduced an additional three percent between 1989 and 1990.[21]

Figure 3-13 depicts the 1984–93 trend for the composite average number of O_3 exceedances. This statistic is adjusted for missing data, and it reflects the number of days that the O_3 standard is exceeded during the O_3 season. Since 1984, the expected number of exceedances decreased 60 percent at the 532 long-term trend sites and 57 percent at the subset of 197 NAMS. The composite averages of O_3 estimated exceedances for the last five years (1989–93) are significantly lower than those for the first five years (1984–88) of this 10-year period. Because O_3 trends have not shown a consistent directional pattern, the percent change between the endpoints for the 10-year period of 1984–93 has to be recognized as a simplification. An approach that accounts for meteorological variability in ozone trends assessments is discussed below.

The main focus of this annual report is to track the trends in the quality of air people are breathing when outdoors, therefore, it makes sense to use a summary statistic that clearly relates to the O_3 air quality standard. Nevertheless, as noted in a National Academy of Sciences (NAS) report, it is difficult to assess O_3 trends because the year to year variability in meteorological conditions can greatly influence peak ozone levels.[1]

Last year's report described EPA's ongoing effort to develop techniques for adjusting O_3 trends for meteorological influences. The report featured a statistical model in which the frequency distribution of O_3 concentrations is described as a function of meteorological parameters.[22] The fitted distribution can be used to estimate percentiles and threshold exceedance probabilities for the daily maximum O_3 concentration given a fixed set of meteorological conditions in each modeled city. Cox and Chu test for a statistically significant trend term to determine if an underlying meteorologically adjusted trend can be detected.[22]

The model has been used to calculate "meteorologically adjusted" estimates of the upper percentiles of daily maximum concentrations in each year. Figure 3-14 displays ambient air quality trends, and meteorologically adjusted O_3 trends for 43 metropolitan areas. The "adjusted" trend indicator shown in Figure 3-14 is the composite mean of the meteorologically adjusted 99th percentile daily maximum one-hour concentrations across each of the 43 individual met-

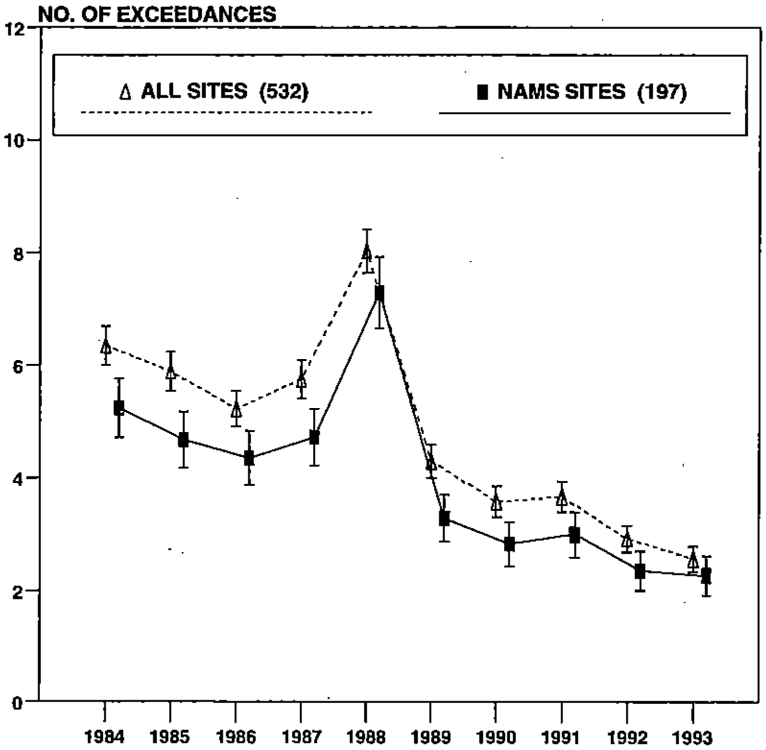

Figure 3-13. National trend in the estimated number of daily exceedances of the ozone NAAQS in the ozone season at both NAMS and all sites with 95-percent confidence intervals, 1984–1993.

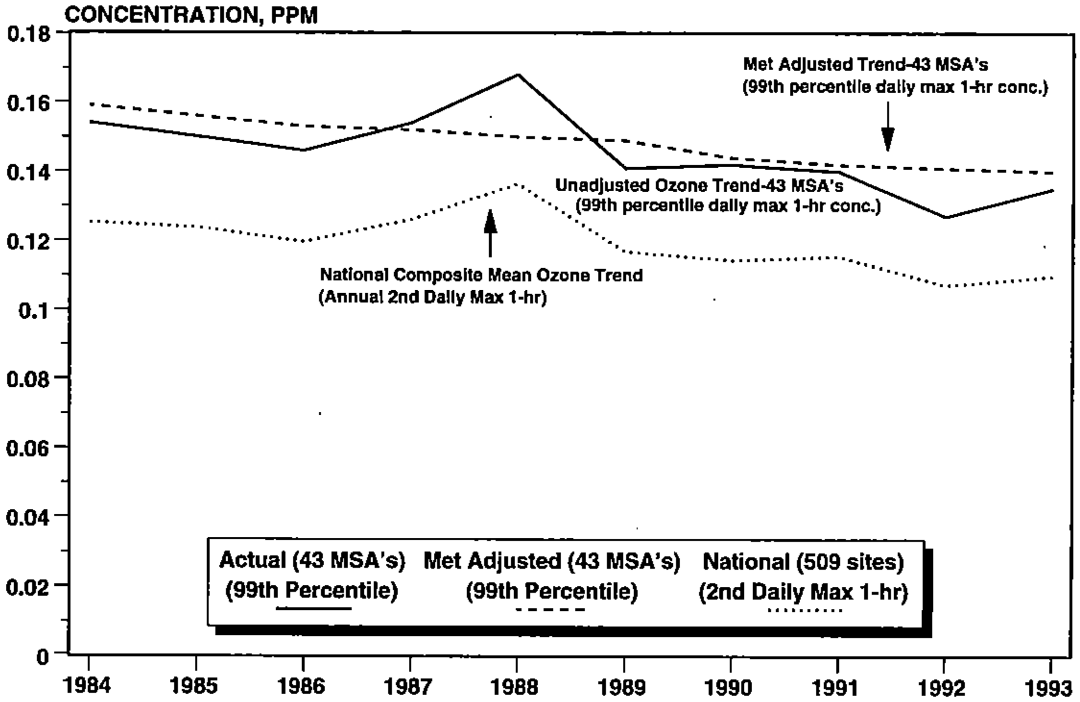

Figure 3-14. Comparison of meteorologically adjusted, and unadjusted, trends in the composite average of the second highest maximum one-hour ozone concentration for 43 MSAs, 1984–1993.

ropolitan areas. The smoothing introduced by the meteorological adjustment is especially evident in the peak O_3 year, 1988, which was followed by years less conducive to O_3 formation. The steady downward trend is clear. The composite average of the 99th percentile daily maximum one-hour concentrations in 1993 is 12 percent lower than the 1984 level. This composite trend captures the spatial and temporal variability in meteorological conditions among these 43 metropolitan areas. As illustrated by this figure, the composite trend in the unadjusted 99th percentile daily maximum one-hour concentration for these 43 metropolitan areas tracks the national composite O_3 trend in the second highest daily maximum one-hour concentration. Thus, the meteorologically adjusted trend is likely to be a reasonable indicator of the composite national O_3 trend. Coincidently, the 10-year percent change in both the adjusted, and unadjusted, composite average of 99th percentile concentration for these 43 cities is exactly the same percentage change as the national second daily maximum one-hour trends statistic. That is, both the meteorologically adjusted 99th percentile concentrations and the standard trends indicator decreased by 12 percent between 1984–93.

Table 3-4 lists the 1984–93 emission estimates for VOCs which, together with NO_x shown earlier in Table 3-3, are involved in the atmospheric chemical and physical processes that result in the formation of O_3. As noted in previous sections, these emissions estimates have been recomputed using new methodologies including the MOBILE5a model and updated inputs at the state and county level. These changes resulted in revised estimates for 1984 total emissions that are two percent lower and 1992 total emissions that are one percent higher than reported last year. Total VOC emissions are estimated to have decreased nine percent between 1984 and 1993. During this same period, NO_x emissions, the other major precursor of O_3 formation, increased one percent. Between 1984 and 1993, VOC emissions from highway vehicles decreased 35 percent, despite a 33-percent increase in VMT. These VOC estimates are annual totals. Because O_3 is predominately a warm weather problem, seasonal emissions inventories are being developed for the current year, thereby enabling seasonal comparisons of emission estimates in future reports.

Table 3-4. National Volatile Organic Compound Emission Estimates, 1984–1993

(thousand short tons/year)

SOURCE CATEGORY	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Fuel Combustion – Electric Utilities	45	32	34	34	37	37	36	36	35	36
Fuel Combustion – Industrial	156	248	254	249	271	266	266	270	271	271
Fuel Combustion – Other	917	508	499	482	470	452	437	426	385	341
Chemical and Allied Product Manufacturing	1,620	1,579	1,640	1,633	1,752	1,748	1,771	1,778	1,799	1,811
Metals Processing	182	76	73	70	74	74	72	69	72	74
Petroleum and Related Industries	1,253	797	764	752	733	731	737	745	729	720
Other Industrial Processes	227	439	445	460	479	476	478	475	482	486
Solvent Utilization	6,309	5,779	5,710	5,828	6,034	6,053	6,063	6,064	6,121	6,249
Storage and Transport	1,810	1,836	1,767	1,893	1,948	1,856	1,861	1,868	1,848	1,861
Waste Disposal and Recycling	687	2,310	2,293	2,256	2,310	2,290	2,262	2,217	2,266	2,271
Highway Vehicles	9,441	9,376	8,874	8,201	8,290	7,192	6,854	6,499	6,072	6,094
Off-Highway	1,973	2,008	2,039	2,038	2,106	2,103	2,120	2,123	2,160	2,207
Natural Sources	0	0	0	0	0	0	0	0	0	0
Miscellaneous	951	428	435	440	458	453	1,320	937	780	893
Total	**25,572**	**25,417**	**24,826**	**24,338**	**24,961**	**23,731**	**24,276**	**23,508**	**23,020**	**23,312**

NOTE: The sums of sub-categories may not equal total due to rounding.

3.4.2 Recent O_3 Trends: 1991–1993

This section discusses ambient O_3 changes during the three-year time period, 1991–93. By focusing on this three-year period, we are able to use a larger data base of 722 sites meeting the trends criteria, compared to 532 sites for the 10-year period.

This three-year period follows the reduction in the volatility of gasoline, RVP, that has occurred since 1988. A recent modeling analysis of New York City conditions estimated that the impact of this RVP reduction was a 25-percent reduction in VOC emissions.[23]

Meteorological conditions in the eastern half of the country were more conducive to ozone formation during Summer 1993 than in 1992. Summer 1993 had a temperature pattern that consisted of unusually warm temperatures over the eastern half of the country and unusually cold temperatures over the western half, divided by a line stretching roughly from the Great Lakes to the southern Rockies.[17] Based on average daily maximum temperatures, the southeast had the hottest July–August on record in 1993.[17] Between 1992 and 1993, composite mean O_3 concentrations increased two percent at the 722 sites and four percent at the subset of 220 NAMS, but both composite means were less than 1991 levels. Between 1992 and 1993, the composite average of the number of estimated exceedances of the O_3 standard decreased by 10 percent at the 722 sites, and 3 percent at the 220 NAMS. Nationwide VOC emissions increased one percent between 1992 and 1993. Beginning with this year's revised estimate for 1992, and the preliminary estimate for 1993, for the first time since 1970, solvent utilization VOC estimates exceed highway emissions. The majority of the increase in 1993 estimates relative to 1992 can be attributed to increased solvent use.

As Figure 3-15 indicates, the composite average of the second daily maximum concentrations decreased in five of the 10 regions between 1992 and 1993, and increased in the other five Regions. The increases were recorded in the northeastern and middle Atlantic states which is consistent with the year-to-year changes in meteorological conditions described above.

Except for the two west coast regions, all the remaining eight regions recorded increases in the composite average of the number of estimated exceedances between 1992 and 1993. However, in six of these eight regions the 1993 composite average number of estimated exceedances was lower than the 1991 level. In the national trend, these regional increases were offset by the 20-percent reduction in exceedances recorded in Region 9 (primarily in southern California).

These regional graphs are intended primarily to depict relative change. Because the mix of monitoring sites may vary from one area to another, this graph is not intended to indicate regional differences in absolute concentration levels.

3.4.3 Clean Air Act Update: 1991–1993

The three-year period that was the focus of the discussion of recent O_3 changes also provides a key milestone for implementation of the Clean Air Act Amendments of 1990. The Act requires that all of the 40 marginal ozone nonattainment areas meet the O_3 NAAQS during the three-year time period, 1991–93. Areas not meeting the standard that have no more than one exceedance of the

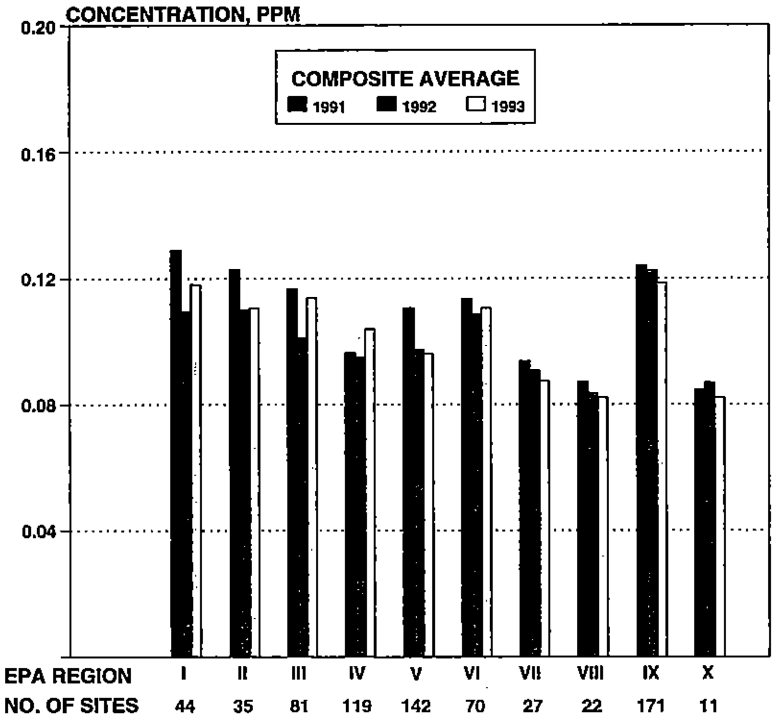

Figure 3-15. Regional comparison of the 1991, 1992, and 1993 composite averages of the second-highest daily one-hour ozone concentrations.

NAAQS during 1993 can request to have this requirement extended for an additional year.

Figure 3-16 displays the location of the 33 marginal areas that had three complete years of ambient monitoring data showing compliance with the standard. Only three of the remaining seven marginal areas did not meet the NAAQS by this date and had more than one exceedance in 1993. The other four areas recorded either less than two exceedances or had incomplete data during this period. The current air quality status of ozone nonattainment areas is listed in the annual air quality update.[24]

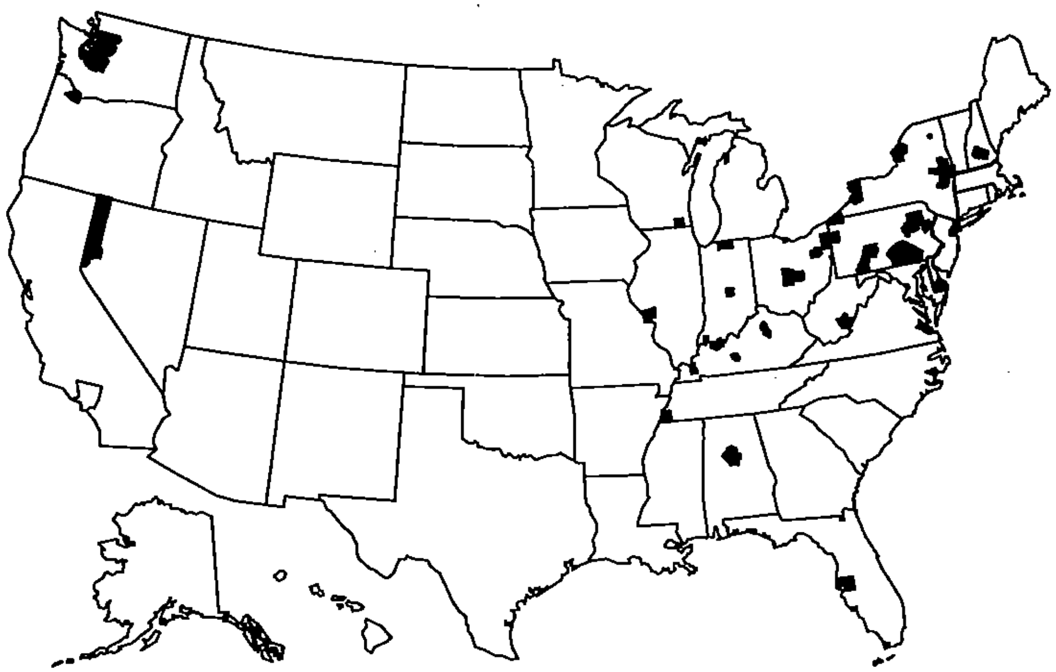

Figure 3-16. Map depicting marginal ozone nonattainment areas meeting the ozone NAAQS during the three-year compliance period, 1991–1993.

3.5 Trends in Particulate Matter

Air pollutants called particulate matter include dust, dirt, soot, smoke and liquid droplets directly emitted into the air by sources such as factories, power plants, cars, construction activity, fires and natural windblown dust. Particles formed in the atmosphere by condensation or the transformation of emitted gases such as SO_2 and VOCs are also considered particulate matter.

Based on studies of human populations exposed to high concentrations of particles (sometimes in the presence of SO_2), and laboratory studies of animals and humans, there are major effects of concern for human health. These include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis and premature death. The major subgroups of the population that appear to be most sensitive to the effects of particulate matter include individuals with chronic obstructive pulmonary or cardiovascular disease or influenza, asthmatics, the elderly and children. Particulate matter also soils and damages materials, and is a major cause of visibility impairment in the United States.

Annual and 24-hour National Ambient Air Quality Standards (NAAQS) for particulate matter were first set in 1971. Total suspended particulate (TSP) was the first indicator used to represent suspended particles in the ambient air. Since July 1, 1987, however, EPA has used the indicator PM-10, which includes only those particles with aerodynamic diameter smaller than 10 micrometers. These smaller particles are likely responsible for most of the adverse health effects of particulate matter because of their ability to reach the thoracic or lower regions of the respiratory tract.

The PM-10 annual and 24-hour standards specify an expected annual arithmetic mean not to exceed 50 $\mu g/m^3$ and an expected number of 24-hour concentrations greater than 150 $\mu g/m^3$ per year not to exceed one. Samples are collected at a frequency of every day, every other day, or every sixth day depending on the conditions in a particular monitoring area.

Several instruments have been approved by EPA for sampling PM-10. The first is a high volume sampler, or Hi-Vol, with a size selective inlet (SSI) that collects suspended particles up to 10 microns in diameter. This sampler uses an inert quartz filter. The second instrument is a "dichotomous" sampler. It uses a different PM-10 inlet, operates at a lower flow rate, and produces two separate samples: 2.5 to 10 microns and less than 2.5 microns, each collected on a teflon filter. There are also some relatively new particulate matter samplers which have the capability of producing hourly values of PM-10 on a continuous basis. These continuous samplers are beginning to be introduced into monitoring networks across the country, but it will be a few more years before they produce enough data to generate trends.

3.5.1 PM-10 Air Quality Trends

Two statistics are used to show PM-10 air quality trends in this report: the weighted annual arithmetic mean and the 90th percentile of 24-hour concentrations. The weighted annual arithmetic mean is used to reflect average air quality over an extended period of time. It is called "weighted" because an average is first taken for each quarter of a year and then the four quarterly averages are averaged. This ensures that each part of the year is weighted equally, even if more measurements are taken during one part of a year than another. The 90th percentile statistic is used because PM-10 sampling frequency varies among sites and may change from one year to the next at some sites. This statistic is less sensitive to changes in sampling frequency than are the maximum or second maximum peak values.

Most monitoring networks have been producing data with approved reference samplers since mid-1987. Thus, the air quality data presented here is for the six-year period from 1988 to 1993, with a sample of 799 trend sites.

Figures 3-17 and 3-18 display boxplots of the concentration distribution for the weighted annual arithmetic mean and the 90th percentile of 24-hour concentrations, respectively. The trend for the annual mean is steadily downward with an overall 20 percent decrease over the six-year period. The 90th percentile trend decreases 19 percent overall, but shows virtually no change between 1992 and 1993.

Annual mean PM-10 concentrations over the last three years for each EPA region are shown in Figure 3-19. Eight of the 10 regions improved in each consecutive year, while Regions 3 and 10 experienced a slight increase in 1993 values over 1992.

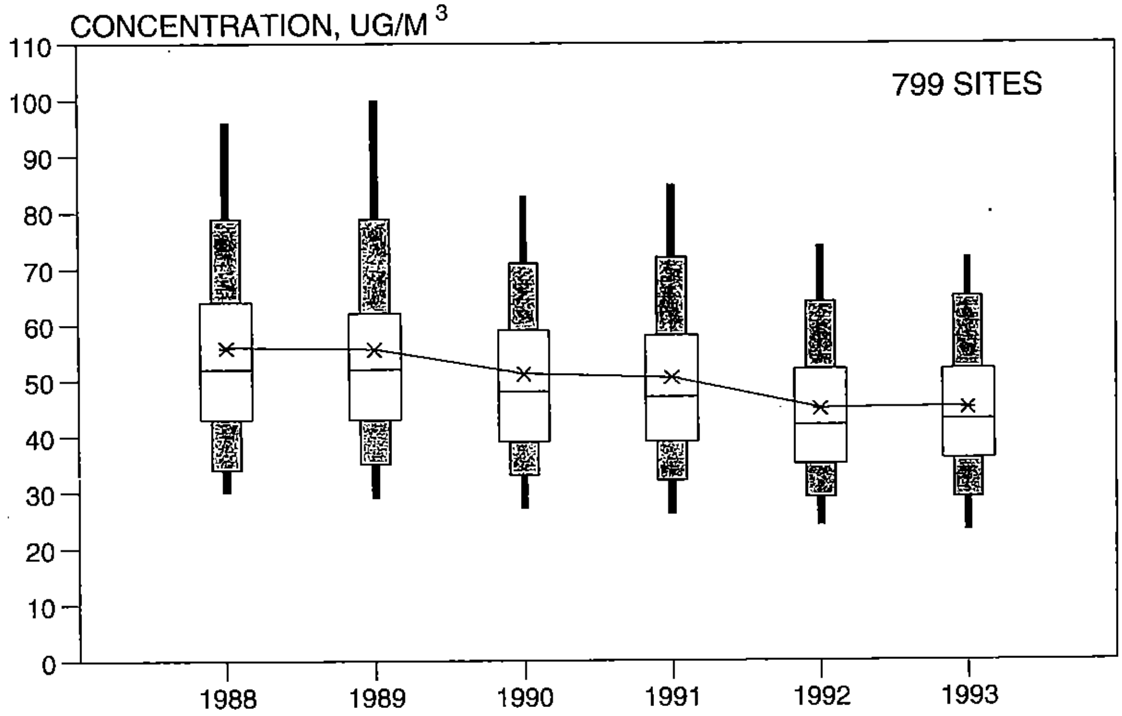

Figure 3-17. Boxplot comparisons of trends in weighted annual mean PM-10 concentrations at 799 sites, 1988–1993.

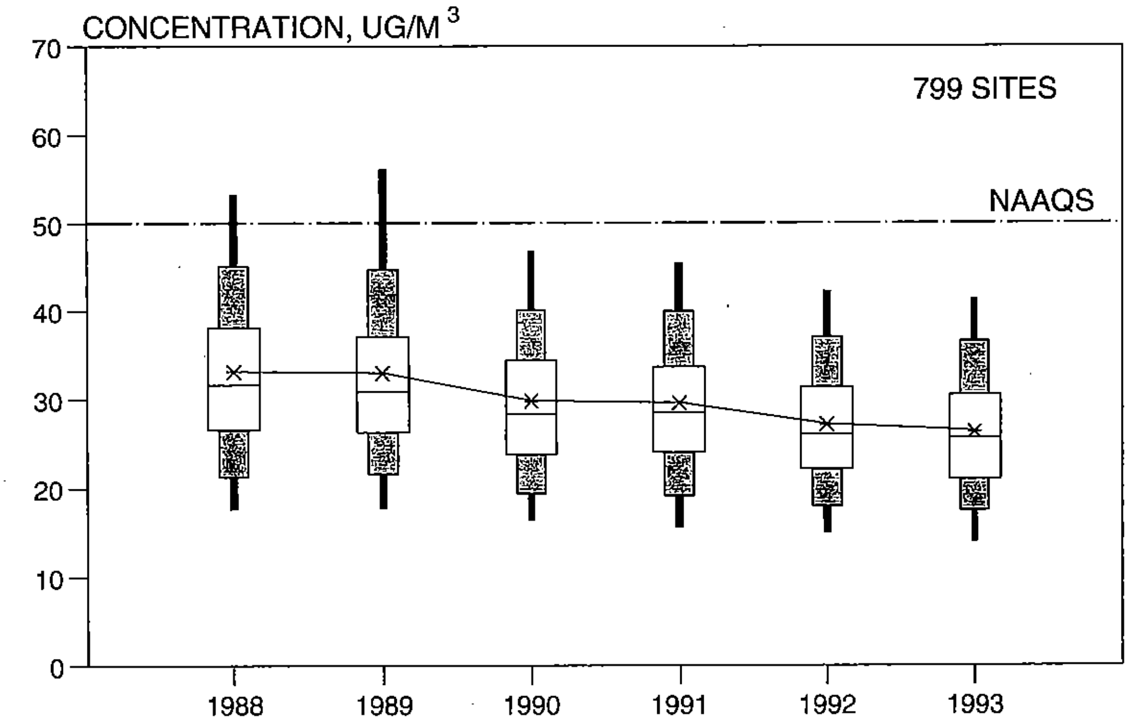

Figure 3-18. Boxplot comparisons of trends in the 90th percentile of 24-hour PM-10 concentrations at 799 sites, 1988–1993.

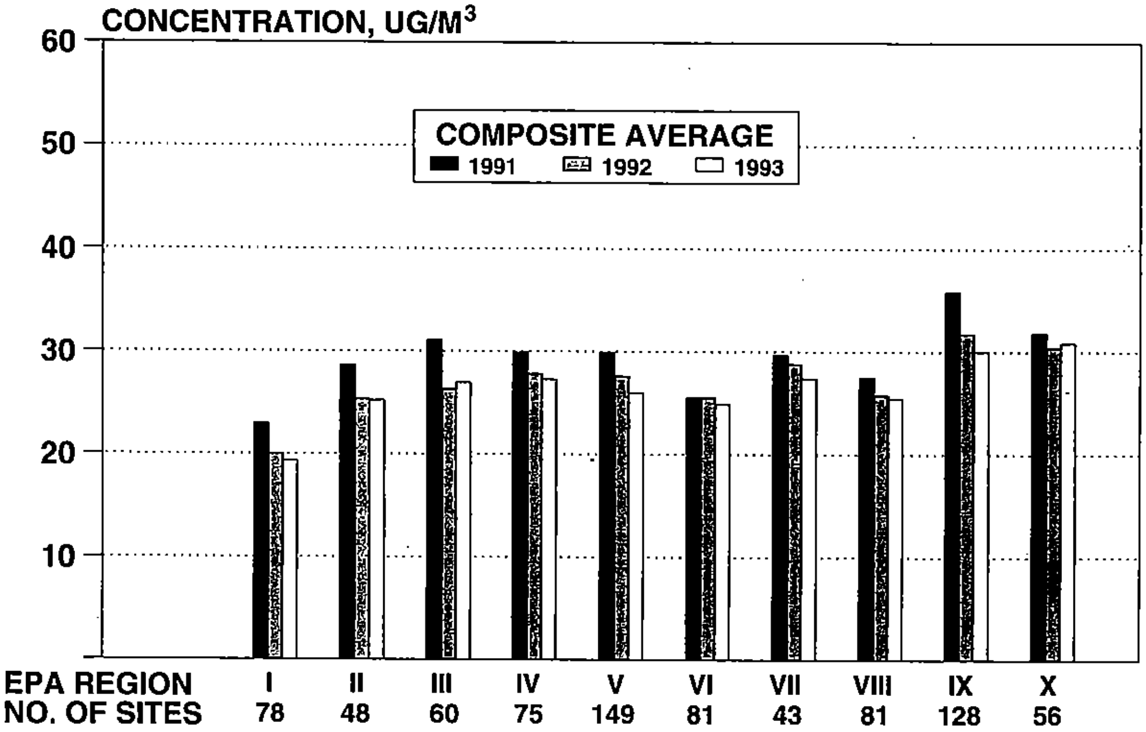

Figure 3-19. Regional comparisons of the 1991, 1992, and 1993 composite averages of the weighted annual mean PM-10 concentrations.

3.5.2 PM-10 Emission Trends

Trends in PM-10 emissions are shown in Table 3-5. The table does not include those emissions in the miscellaneous category such as fugitive dust, wildfires, and agricultural emissions. It also excludes natural emissions such as wind erosion. Miscellaneous and natural emissions are presented separately in Table 3-6.

The numbers in Table 3-5 reflect the new methodology used to compute PM-10 emissions this year. Because the new methods were only applied to data from 1985 on, trends are presented for just the nine-year period from 1985 to 1993. A discussion of the new methodology appears in Chapter 2.

Over the nine-year period from 1985 to 1993, total PM-10 emissions decreased almost 10 percent. Categories which show a significant amount of change are highway vehicles (down 22 percent) and fuel combustion—other (down 19 percent). By far the largest contributor to PM-10 highway vehicle emissions are heavy duty diesel vehicles. Since 1985, emissions from these vehicles have declined 34 percent. Within the fuel combustion—other category, residential wood combustion emissions are down 21 percent due to public educa-

Table 3-5. National PM-10 Emission Estimates, 1985–1993, **No Natural Source or Miscellaneous Emissions**

(thousand short tons/year)

SOURCE CATEGORY	1985	1986	1987	1988	1989	1990	1991	1992	1993
Fuel Combustion - Electric Utilities	284	289	282	278	278	291	253	255	270
Fuel Combustion - Industrial	234	231	226	230	229	228	229	223	219
Fuel Combustion - Other	896	902	910	918	922	930	942	819	723
Chemical and Allied Product Manufacturing	67	68	68	73	74	74	72	75	75
Metals Processing	147	137	131	141	142	140	136	137	141
Petroleum and Related Industries	32	31	30	29	28	28	28	27	26
Other Industrial Processes	317	321	314	314	308	306	300	303	311
Solvent Utilization	2	2	2	2	2	2	2	2	2
Storage and Transport	57	56	54	54	54	54	53	53	55
Waste Disposal and Recycling	279	275	265	259	251	242	245	246	248
Highway Vehicles	271	265	261	256	253	239	223	210	197
Off-Highway	368	372	350	387	372	372	367	379	395
Total	**2,953**	**2,949**	**2,893**	**2,942**	**2,909**	**2,907**	**2,849**	**2,729**	**2,661**

NOTE: The sums of sub-categories may not equal total due to rounding.

tion programs, restrictions on fireplace and woodstove use in the home, and positive incentives to reduce burning.

Table 3-6 shows 1985–93 miscellaneous and natural source PM-10 emissions. Although these categories actually contribute many times more emissions than those listed in the previous table, they are presented in a separate table because the year-to-year variability which some of them exhibit makes them more difficult to use to show trends in PM-10.

Fugitive dust is the major contributor to PM-10 emissions in the miscellaneous category. Among the road types, emissions from unpaved roads have remained fairly steady, while emissions from paved roads are estimated to have increased almost 30 percent since 1985, most likely due to increased vehicle traffic. Emissions in the construction/mining and quarrying category have decreased an estimated 13 percent since 1985.

Agricultural activity is a smaller contributor to the national total, but is estimated to be the major source in specific regions. The same may be said for the categories of wildfires, managed burning, and wind erosion; these may make a significant contribution to PM-10 emissions in certain parts of the country, such as the west. Because PM-10 emissions due to wind erosion are very sensitive to regional soil conditions and year-to-year changes in total precipitation, there can be considerable variability from year to year. Accordingly, estimated emissions from wind erosion were extremely high for the drought year of 1988 and extremely low for the exceptionally wet year of 1993.[17]

Table 3-6. Miscellaneous and Natural Source Particulate Matter Emission Estimates, 1985–1993

(thousand short tons/year)

SOURCE CATEGORY	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Fugitive Dust									
unpaved roads	14,719	14,672	13,960	15,626	15,346	15,661	14,267	14,540	14,404
paved roads	6,299	6,555	6,877	7,365	7,155	7,299	7,437	7,621	8,164
construction/ mining and quarrying	13,009	12,139	12,499	12,008	11,662	10,396	10,042	10,899	11,368
Agriculture & Forestry									
agricultural crops	6,833	6,899	7,008	7,090	6,937	6,999	6,965	6,852	6,842
agricultural livestock	275	285	330	376	397	381	363	386	394
Other Combustion									
wildfires*	142	142	142	142	142	717	457	341	418
managed burning	523	530	536	555	549	546	537	547	549
other	59	59	59	59	59	59	59	59	59
Natural Sources									
wind erosion	3,565	9,390	1,457	17,509	11,826	4,192	10,054	4,655	628
Total	**45,424**	**50,671**	**42,868**	**60,730**	**54,073**	**46,250**	**50,181**	**45,900**	**42,826**

NOTE: The sums of sub-categories may not equal total due to rounding.

* Actual data reflecting acres burned in 1985, 1990, 1991, and 1992. 1993 uses an average of 1990–1992 data.

PM-10 SUCCESS STORY

States have made significant progress in reducing emission levels in moderate PM-10 nonattainment areas since the enactment of the Clean Air Act Amendments of 1990 (CAAA), particularly in urban areas which contain industrial point sources. This success is due largely to State efforts to adopt and implement Reasonably Available Control Technology (RACT) to control point source emissions and Reasonably Available Control Measures (RACM) to control area source emissions.

Two nonattainment areas which have made remarkable progress toward attaining the PM-10 NAAQS are Cuyahoga County and Jefferson County (Steubenville), Ohio. To begin to analyze their problem with particulate matter, the State of Ohio first developed an emissions inventory, which is a listing of major sources along with estimates of how much pollutant they produce. The emissions inventory indicated that the major sources of PM-10 emissions in Cuyahoga and Jefferson Counties were stack emissions from steel mill point sources, fugitive emissions from process sources, and fugitive dust from paved roads, unpaved roads, storage piles, and parking lots.

Next, the State of Ohio adopted and submitted, as a part of the State Implementation Plans (SIPs) for the two areas, regulations which were designed to reduce particulate matter emissions. These regulations (mostly RACT requirements) subjected the steel mills and other major sources to limits on mass emissions and visible emissions. Similarly, RACM requirements were imposed on the area sources at these facilities. As examples, control measures for unpaved roads and parking areas included the use of surface binding agents, and control measures for paved roads and parking areas included frequent flushing and sweeping to remove particulate matter from the road surface. Example control measures for storage piles, such as piles of coal, included wetting them down or enclosing them and venting the emissions via a control device.

Ohio prepared an attainment demonstration using dispersion modeling to demonstrate that the control strategies which they had adopted would enable both Cuyahoga and Jefferson Counties to attain the PM-10 NAAQS by December 31, 1994. Whereas multiple violations were observed in previous years, the data for 1992 to 1994 indicate that both the annual and 24-hour PM-10 standards are being met in these areas.

3.6 Trends in Sulfur Dioxide

Ambient sulfur dioxide (SO_2) results largely from stationary source coal and oil combustion, steel mills, refineries, pulp and paper mills and from nonferrous smelters. There are three NAAQS for SO_2:

- an annual arithmetic mean of 0.03 ppm (80 $\mu g/m^3$);
- a 24-hour level of 0.14 ppm (365 $\mu g/m^3$); and
- a three-hour level of 0.50 ppm (1300 $\mu g/m^3$).

The first two standards are primary (health-related) standards, while the three-hour NAAQS is a secondary (welfare-related) standard. The annual mean standard is not to be exceeded, while the short-term standards are not to be exceeded more than once per year. Trend analyses follow for the primary standards.

High concentrations of SO_2 affect breathing and may aggravate existing respiratory and cardiovascular disease. Sensitive populations include asthmatics, individuals with bronchitis or emphysema, children and the elderly. SO_2 is also a primary contributor to acid deposition, or acid rain, which causes acidification of lakes and streams and can damage trees, crops, historic buildings, and statues. In addition, sulfur compounds in the air contribute to visibility impairment in large parts of the country. This is especially noticeable in national parks.

The trends in ambient concentrations are derived from continuous monitoring instruments which can measure as many as 8,760 hourly values per year. The SO_2 measurements reported in this section are summarized into a variety of statistics which relate to the SO_2 NAAQS. The statistics reported here are for the annual arithmetic mean concentration and the second highest annual 24-hour average (measured midnight to midnight).

3.6.1 Long-term SO_2 Trends: 1984–1993

The long-term trend in ambient SO_2 from 1984 to 1993 is graphically represented in the boxplots of Figures 3-20 and 3-21. In each figure a 10-year downward trend is evident, although the rate of decline has slowed over the last few years. Annual mean SO_2 measured at 474 sites across the United States decreased at a median rate of approximately three percent per year, resulting in an overall decrease of 26 percent since 1984 (Figure 3-20). The annual second highest 24-hour values examined at 469 sites showed a median rate of change of four percent per year, with an overall decline of 36 percent (Figure 3-21).

The 138 NAMS sites, which are a subset of the full set of sites measuring SO_2, recorded higher average concentrations than the full set of all SO_2 monitors, but declined at a faster median rate over the 10-year period. At the NAMS sites, the average annual mean concentration dropped about four percent per year for a total decrease of 33 percent over 10 years, while the second highest 24-hour values decreased five percent per year and 39 percent overall.

The trend in nationwide emissions of sulfur oxides (SO_x), broken down by source category, is shown in Table 3-7. After a 25-percent decrease in total emissions during the 1970s and early 1980s, SO_x emissions have remained relatively unchanged in recent years. The largest contributor to SO_x emissions has consistently been coal burning power plants.

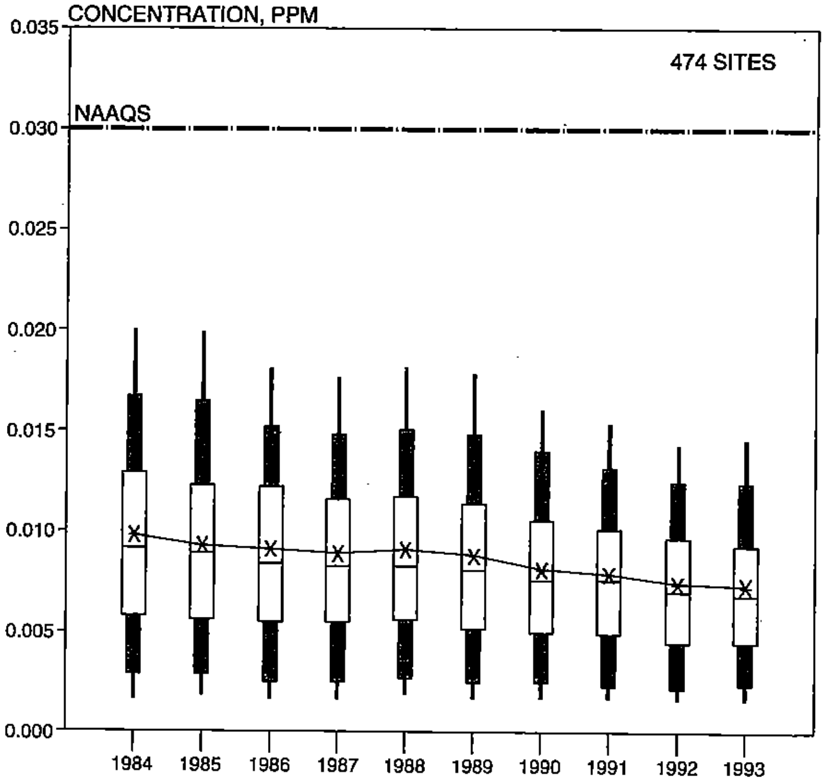

Figure 3-20. Boxplot comparisons of trends in annual mean sulfur dioxide concentrations at 474 sites, 1984–1993.

Four programs make up the EPA's strategy to control the emissions associated with SO_2:

- The National Ambient Air Quality Program, which sets the primary and secondary standards discussed earlier in this report.
- The New Source Review/Prevention of Significant Deterioration Program, which protects air quality from deteriorating in clean areas by requiring new major SO_2 sources to conduct air quality analyses before receiving a permit.
- New Source Performance Standards, which set emission limits for new sources.
- The Acid Rain Program, which is set forth in Title IV of the 1990 Clean Air Act Amendments.

The first three programs protect air quality and public health on a local level, while the Acid Rain Program addresses the regional problem of long range transport of SO_2. The primary goal of the Acid Rain Program is to reduce annual SO_2 emissions by 10 million tons below 1980 levels by setting national emission caps on utility and industrial sources. The focus of this control program is a system which assigns each facility a number of allowances based on historic fuel consumption and a restricted emission rate. Each facility may, if they have reduced their emissions below their allotted number of allowances, sell or trade their extra allowances to other facilities who need them. Or, the facility may bank away any extra allowances they have at the end of the year. Thus, the sources are given a large amount of flexibility in meeting the program's requirements, which should reduce the cost of compliance. This is the first large-scale regulatory use of such a market-based incentive.[25]

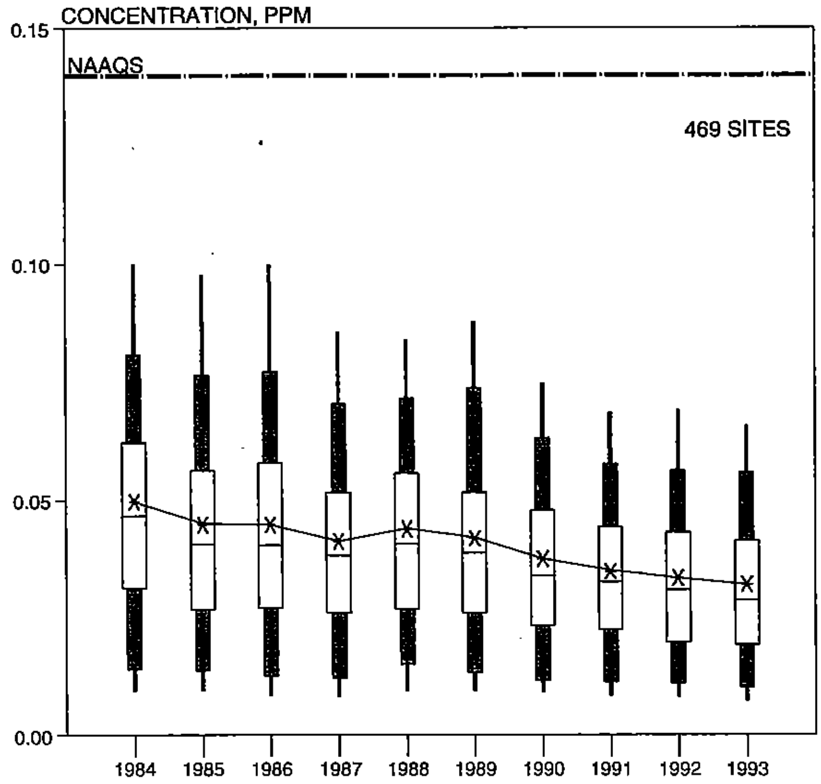

Figure 3-21. Boxplot comparisons of trends in second highest 24-hour average sulfur dioxide concentrations at 469 sites, 1984–1993.

3.6.2 Recent SO_2 Trends: 1991–1993

Nationally, SO_2 measured in the ambient air showed improvement over the last three years in both average and peak 24-hour concentrations. Annual mean concentrations and second highest 24-hour SO_2 concentrations each decreased eight percent between 1991 and 1993. Most recently, the change between 1992 and 1993 showed an average annual mean SO_2 decrease of about one percent and a decrease in second highest 24-hour SO_2 concentrations of five percent.

Figure 3-22 presents the regional changes in composite annual average SO_2 concentrations for the last three years, 1991–1993. Although four of the regions show a slight increase in 1993 values over 1992, the increases are more than offset by decreases in the other six regions.

Table 3-7. National Sulfur Oxides Emission Estimates, 1984–1993

(thousand short tons/year)

SOURCE CATEGORY	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Fuel Combustion – Electric Utilities	16,023	16,273	15,701	15,715	15,990	16,218	15,898	15,784	15,417	15,836
Fuel Combustion – Industrial	2,723	3,169	3,116	3,068	3,111	3,086	3,106	3,139	2,947	2,830
Fuel Combustion – Other	728	578	611	663	660	623	597	608	600	600
Chemical and Allied Product Manufacturing	229	456	432	425	449	440	440	442	447	460
Metals Processing	1,387	1,042	888	616	702	657	578	544	557	580
Petroleum and Related Industries	707	505	469	445	443	429	440	444	417	409
Other Industrial Processes	923	425	427	418	411	405	401	391	401	413
Solvent Utilization	0	1	1	1	1	1	1	1	1	1
Storage and Transport	0	4	4	4	5	5	5	5	5	5
Waste Disposal and Recycling	25	34	35	35	36	36	36	36	37	37
Highway Vehicles	445	446	449	457	468	480	480	478	483	438
Off-Highway	198	208	221	233	253	267	265	266	273	278
Miscellaneous	9	7	7	7	7	7	14	11	10	11
Total	**23,396**	**23,148**	**22,361**	**22,085**	**22,535**	**22,653**	**22,261**	**22,149**	**21,592**	**21,888**

NOTE: The sums of sub-categories may not equal total due to rounding.

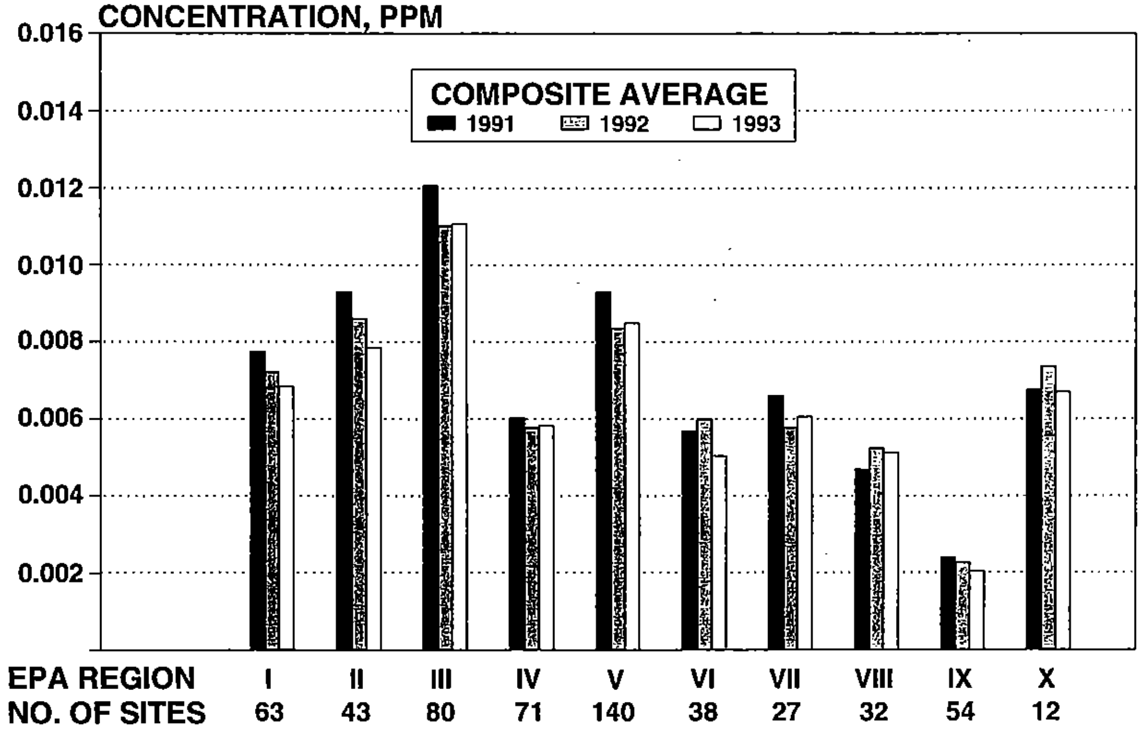

Figure 3-22. Regional comparisons of the 1991, 1992, and 1993 composite averages of the annual sulfur dioxide concentrations.

3.7 Visibility

Visibility impairment, which is most simply described as the haze which obscures the clarity, color, texture, and form of what we see, is actually a complex problem which relates, in part, to several of the pollutants discussed earlier in this report. Because the topic of visibility does not fit completely within the discussion of any one of the NAAQS pollutants, it is included here in its own section.

IMPROVE Monitoring Network

Many parts of the United States are experiencing visibility problems, but perhaps it is most noticeable in our national parks and wilderness areas. Section 169A of the 1977 amendments to the Clean Air Act established as a national goal the protection of visibility in these "Class I" areas. In 1980, the National Park Service (NPS), in cooperation with the EPA, established a long-term visibility monitoring program at remote locations throughout the nation. Since then, the effort has been expanded to incorporate the U.S. Forest Service (USFS), the Fish and Wildlife Service (FWS), the Bureau of Land Management (BLM), the State and Territorial Air Pollution Program Association (STAPPA), the Western States Air Resource Council (WESTAR), and the Northeast States for Coordinated Air Use Management (NESCAUM). Together, this collaborative visibility monitoring effort is called IMPROVE, for Interagency Monitoring of PROtected Visual Environments.

IMPROVE is currently the largest monitoring network in the U.S. that fully characterizes visibility. Cameras and special particulate matter samplers are present at each location to monitor characteristics that will help to describe and define visibility over time. Most sites also directly monitor the optical characteristics of the atmosphere.

Visibility impairment is caused by aerosols, or gas mixtures and suspended particles in the atmosphere that cause light to be scattered or absorbed, thereby reducing visibility. Knowledge of the chemistry and physical properties of the aerosols responsible for visibility impairment can provide insight into the causes of the visibility problem.

As Figure 3-23 shows, the particles in aerosols can be divided into two categories based on size. Coarse particles, with diameters greater than 2.5 micrometers, have little effect on visibility impairment per unit concentration. Wind blown dust is the major contributor of coarse particles. Fine particles, on the other hand, with diameters less than 2.5 micrometers, contribute greatly to the scattering and absorption of light (also called light extinction) and cause poor visibility. The significant chemical species in fine aerosols are sulfates, nitrates, organic carbon, light-absorbing carbon (LAC), and soil dust.

Figure 3-24, which presents data collected by the IMPROVE monitoring network, illustrates the relationship between the type of aerosol and reduction in visibility. The pie charts show the relative contribution of each fine aerosol component to total light extinction, while the size of each pie chart represents the measured amount of light extinction. Sulfates are the largest single contributor to light extinction in all states east of New Mexico and in Hawaii. In the Appalachian Mountains, sulfates account for 68 percent of the visibility reduction. Organic carbon, the next largest contributor, causes 16 percent of the visibility reduction. In most areas of the west and in Alaska, sulfates and

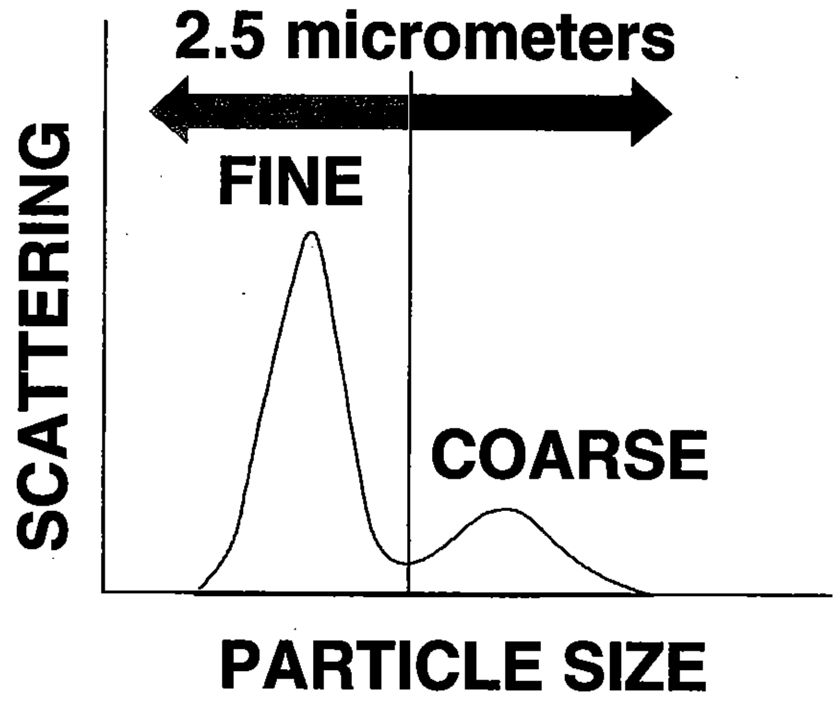

Figure 3-23. Aerosol size distribution.

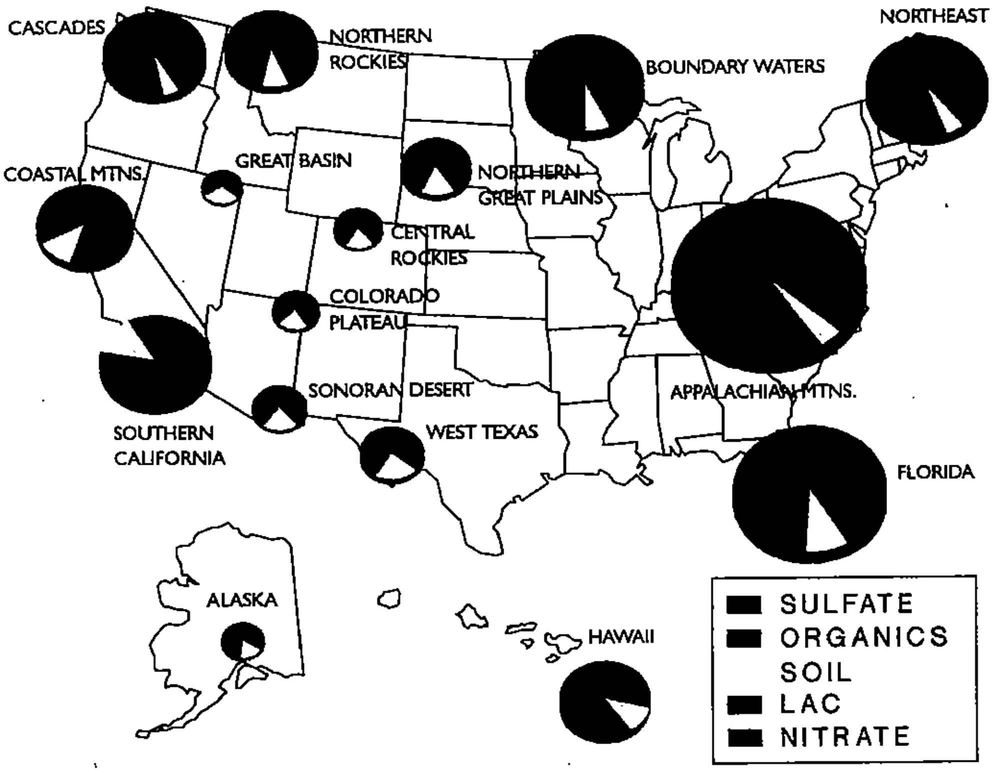

Figure 3-24. Annual average light extinction.

organics are relatively equal in their contributions to light extinction. Nitrate is the single largest contributor to light extinction only in southern California. LAC, which appears in green in the figure, is generally the smallest contributor at all monitoring sites.[26]

The pie charts are scaled to show measured amounts of light extinction. The greater the light extinction, the poorer the visibility. The figure illustrates the difference in visibility between the eastern and the western portions of the United States. The highest extinction and lowest visibility occurs in the east and Great Lakes area, while the west has noticeable lower extinction and higher visibility, with the exceptions of areas near Los Angeles, San Francisco, and the Pacific Northwest. Generally, the best visibility has been reported in a broad region including the Great Basin, most of the Colorado Plateau, deserts of the southwest, portions of the Central Rockies and Great Plains, and in Alaska.[26]

Airport Visual Range Data

Another way to look at visibility impairment is to study the visibility data which has been collected at airports for over 30 years. These data, collected at 280 stations across the United States since 1960, are measurements of visual range, or the maximum distance at which an observer can discern the outline of an object. Visual range is related inversely to light extinction, or haze, and can provide the means to show long-term trends in visibility.

Figure 3-25 shows the location of the airport visual range monitoring sites. Figures 3-26 and 3-27 picture United States haze patterns and trends in 16 maps created from airport visual range data. The maps show the 75th percentile of light extinction, where the cooler colors show better visibility (dark blue being the best visibility) and the warmer colors show poorer visibility (red is the worst visibility). Four separate quarters of data are used to represent seasonal patterns (Q1 is January, February, March; Q2 is April, May, June; and so on). The years shown are five-year averages centered around 1960, 1970, 1980, and 1990. The following analysis of the visibility trends represented by these maps is based largely on a paper by Husar, Elkins, and Wilson titled "U.S. Visibility Trends, 1960–1992."[27]

The overall national view shows two large contiguous haze regions, one over the eastern United States and another over the western Pacific states. The two haze regions are divided by a low-haze territory that spans between the Rocky Mountains and the Sierra-Cascade mountain

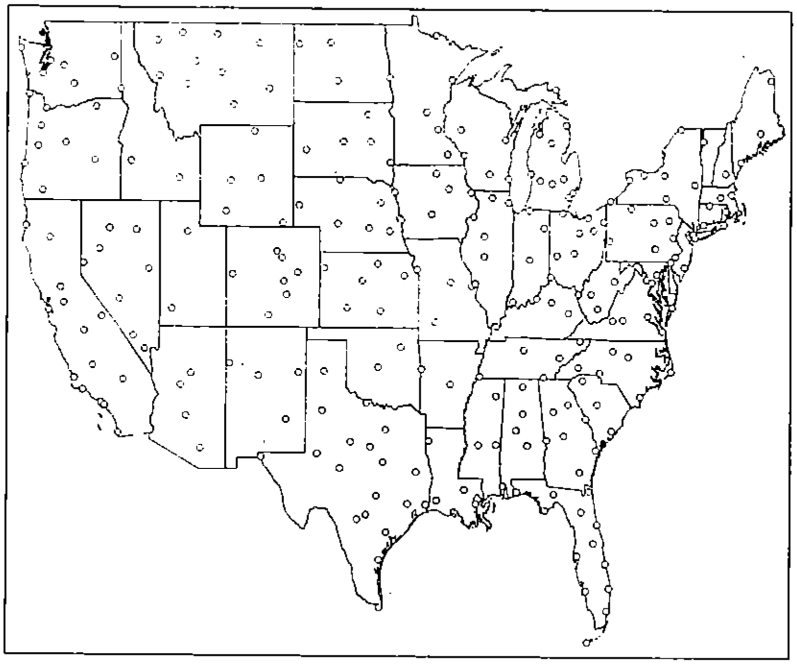

Figure 3-25. Visual range airport data monitoring sites.

ranges. This general pattern is preserved over the 30-year period. However, notable trends have occurred over both the western and the eastern haze regions.

The haziness in the western Pacific states covers all of the coastal states, with California exhibiting the highest values. In the 1960s a large fraction of western California had low visibility particularly during quarters 1 and 4. By the 1990s the magnitude of the Pacific Coast haziness showed a marked decline for all seasons.

The eastern haze region extends from the East Coast to the Rocky Mountains. The western boundary of the eastern haze regions is remarkably constant over both the seasons and the years. In fact, the mid-section of the U.S. extending from the Rocky Mountains to the Mississippi River has changed little over the 30-year history.

The most dynamic pattern can be observed over the eastern United States from the Mississippi River to the East Coast. The eastern United States shows a definitive seasonal variation over the region, and there is also a significant trend over the past 30 years. Furthermore, these seasonal and long-term trends are different for sub-regions within the eastern United States, such as the Northeast, the Mid-Atlantic states and the Gulf states regions.

In the 1960s the highest extinction values were recorded for the cold season, quarters 1 and 4, with significantly lower values for the warm quarters (Q2 and Q3). The remarkable reduction in the cold season haziness and the strong increase during the warm season has shifted the haze peak from winter to summer. Consequently, there was also a regional shift in the highest haze pattern. In the 1960s the worst haziness occurred surrounding Lake Erie and the New York-Washington megalopolis, during the cold season. By the 1990s the worst haziness had drifted southward toward Tennessee and the Carolinas and it now occurs in the summer season.

The decade of the 1980s shows less change than the earlier decades. However, there was a continued haze reduction in the Northeast, north of the Ohio River and east of the Mississippi River. The southeastern United States, as well as the Pacific states, have remained virtually unchanged in the 1980s.[28]

Programs to Improve Visibility

In April of 1994 EPA announced that it will begin work on a Regional Haze Program to address visibility impairment in Class I areas. This program will develop technical approaches to monitoring and modeling regional haze as well as define the policy for achieving "reasonable progress" towards the national goal of eliminating visibility impairment in these areas. The program will be developed in coordination with efforts of the Grand Canyon Visibility Transport Commission, which has been developing recommendations for EPA with respect to protection of the Class I areas on the Colorado Plateau in the southwestern United States.

The Grand Canyon Visibility Transport Commission's recommendations are due to EPA in November, 1995. EPA is planning to respond to those recommendations by proposing its program within 18 months of receipt of the report. Current work on the Regional Haze Program is focussing on development of monitoring and modeling guidance as well as tools for policy assessment.

In addition to the Regional Haze Program, there is a relationship between visibility impairment and the

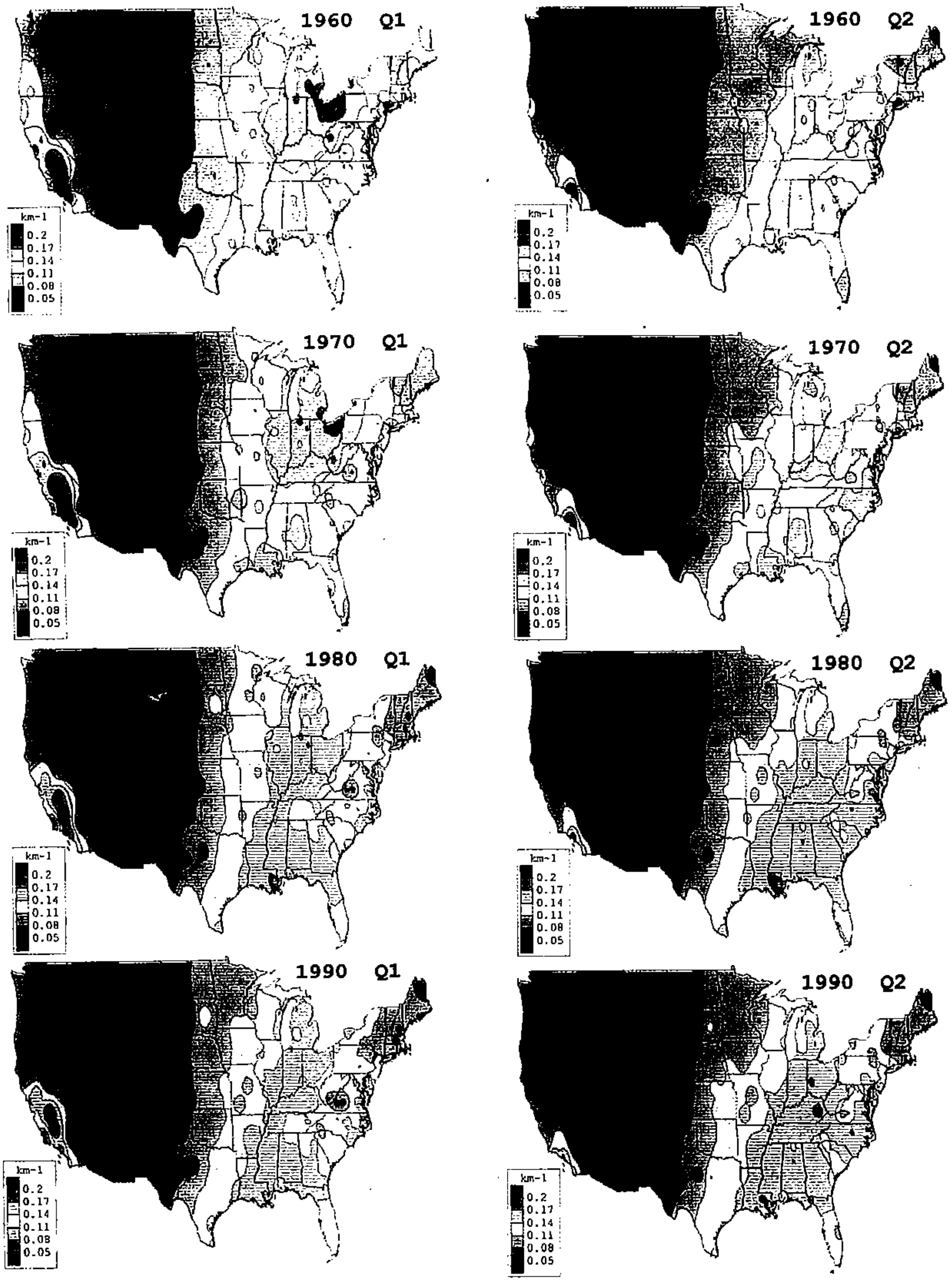

Figure 3-26. United States trends map for the 75th percentile of light extinction derived from airport visual range data. (Q1 = January – March; Q2 = April – June).

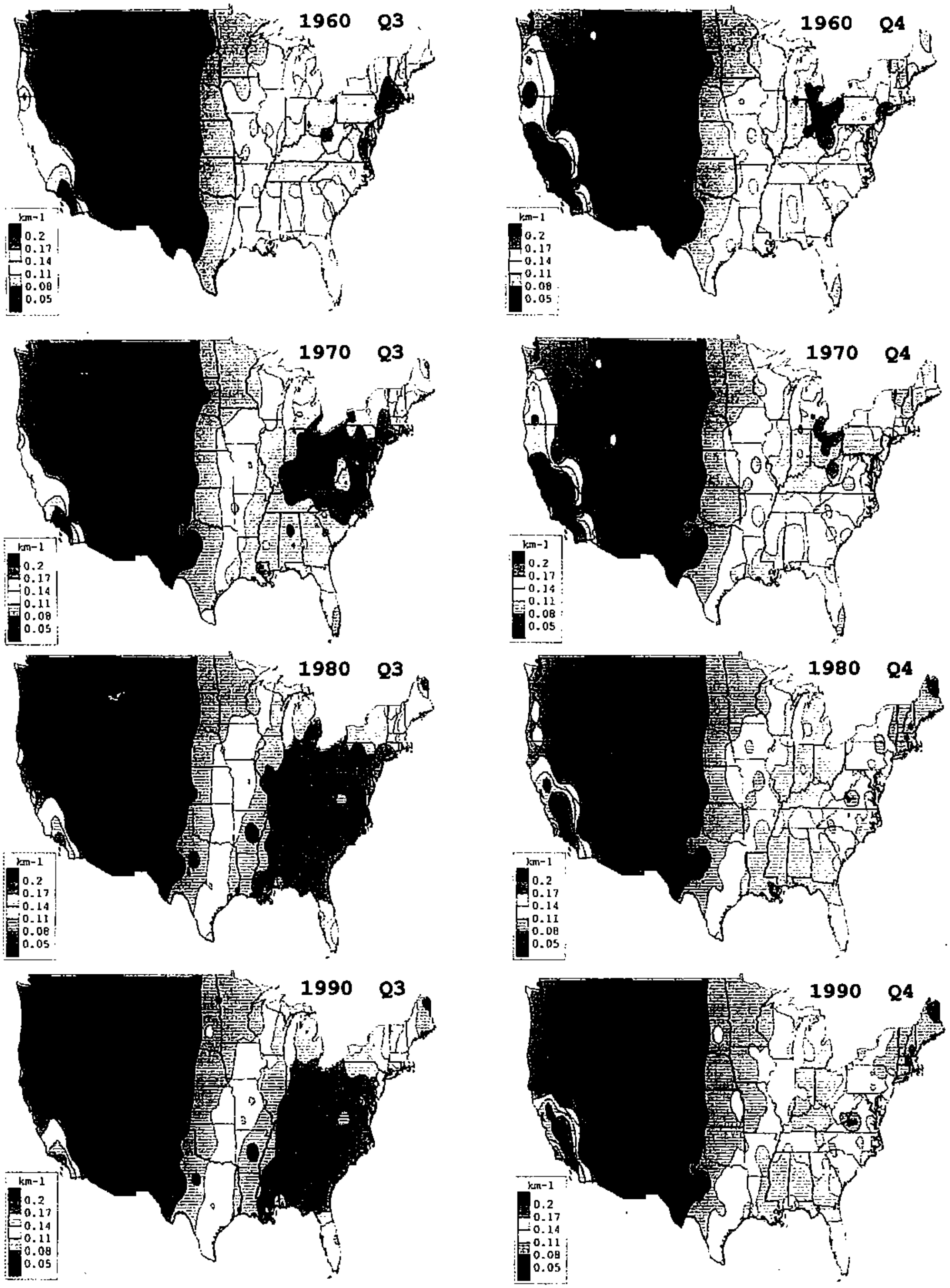

Figure 3-27. United States trends map for the 75th percentile of light extinction derived from airport visual range data. (Q3 = July – September; Q4 = October – December).

NAAQS pollutants which should also lead to improvements in visibility. Controls for sources such as electric utilities, diesel vehicles, petroleum and chemical industries, and residential wood burning may be designed primarily for NAAQS pollutant problems but should also produce better visibility. The Acid Rain provisions resulting from the 1990 Clean Air Act Amendments will reduce SO_x and NO_x. This should result in visibility improvements that can be tracked as these emission reductions take effect in the late 1990s.[28]

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Chapter 4: Air Toxics

Air toxics differ fundamentally from the criteria air pollutants, discussed in the previous chapter, for several principle reasons. First, the term air toxics refers to literally hundreds of pollutants, i.e., 189 compounds according to Clean Air Act Amendments (CAAA) definition, compared to the six criteria pollutants for which there are National Ambient Air Quality Standards. Next, the ambient concentration data for air toxics is significantly limited, both temporally and spatially, relative to that collected by the long-term, nationwide monitoring network for criteria pollutants. In addition, air toxics are generally observed at low ambient concentrations often at or below detection limits for current monitoring instrumentation. Further, air toxics tend to manifest quite localized pollution problems as opposed to the usual urban and regional scale environmental issues associated with many criteria pollutants. Finally, the regulation of hazardous air pollutants (HAPs) is a relatively recent venture in contrast to the level of attention and time commitment dedicated to criteria pollutants.

As a result of these inherent dissimilarities, this chapter is structured differently than that for criteria pollutants. The contents include: (1) an introductory explanation of air toxics and their associated health and ecological effects; (2) a summary and interpretation of current HAP emissions for the United States; and (3) a brief description of air toxics provisions of the CAAA with a report on the status of regulatory development and implementation.

4.1 Air Toxics and Their Effects

For purposes of this report, air toxics are defined as the 189 hazardous air pollutants (HAPs) identified in Title III of the CAAA. The CAAA implies that these compounds were selected for regulation because they

> *"... present, or may present, a threat of adverse human health effects (including, but not limited to, substances which are known to be, or may reasonably be anticipated to be, carcinogenic, mutagenic, teratogenic, neurotoxic, which cause reproductive dysfunction, or which are acutely or chronically toxic) or adverse environmental effects whether through ambient concentrations, bioaccumulation, deposition, or otherwise, ..."*[1]

Exposure to air toxics can result in a variety of severe human health effects as well as impacts to ecosystems. The possible human health effects include cancer and many other chronic and acute effects. Many of the air toxics listed in the CAAA are known to be human carcinogens, and a number of EPA studies have concluded that exposure to air toxics, especially in urban environments, may result in an increased incidence of cancer.

Air toxics can also result in a number of serious non-cancer effects. It is particularly difficult to characterize non-cancer health effects as they may be manifested in many ways: poisoning, or immediate illness; or less-measurable effects such as immunological, neurological, reproductive, developmental, mutagenic, or respiratory effects. These effects in turn exhibit wide ranges of severity and reversibility.

Inhalation is only one of several pathways of human exposure to air toxics. Other pathways, such as bioaccumulation and deposition, may also impose significant risk to the viability of ecological systems as well as serve as alternative routes of exposure to humans. Toxic particulate matter may be deposited onto soil or into water bodies affecting ecological systems as well as human health. For example, deposition to soil may result in exposure to children playing outdoors or in uptake by agricultural crops. Air toxics deposited to surface waters may be taken up by fish which ultimately find their way to the marketplace.

4.2 Emissions Trends: Extent of the Problem

Background—Data Sources and Limitations

As mentioned previously, there is no national air quality monitoring program for air toxics similar to that used to collect data on criteria pollutants. The development of comparable data for air toxics is complicated by a number of factors:

- the number of chemical compounds involved;
- the number and variety of sources emitting the compounds;
- the low concentrations sometimes involved; and
- the potential for secondary formation of one hazardous compound from other, often non-hazardous, compounds.

The limitations of currently available data sources for air toxics impede the Environmental Protection Agency's (EPA's) ability to identify trends in HAP emissions and ambient air concentrations. Therefore, even preliminary assessments of baseline emissions are somewhat tentative.

This chapter utilizes two types of estimates of air toxic emissions: (1) summaries of releases of HAPs as represented in EPA's Toxic Release Inventory (TRI); and (2) engineering estimates of emissions by specific source category. The TRI summaries provide both an indication of the trend in air toxics emissions and an overall picture of the hot spots within the nation. The source-specific inventories were derived, using formal information-gathering letters and meetings with industry, plant visits, and existing state and local information on the sources, as single year estimates to support EPA's rule-making under Title III. Because the source category estimates and the TRI data are not collected in the same manner, these estimates are not directly comparable.

The TRI is currently the primary source of comprehensive information on emissions of air toxics. Authorized by the Emergency Planning and Community Right to Know Act (EPCRA) of 1986, the TRI requires manufacturing facilities with 10 or more employees meeting thresholds for manufacturing, processing or otherwise using listed chemicals (including air toxics) to submit annual reports to EPA on their releases. Data for the TRI has been collected since 1987. The data from TRI are used in this report to provide an indication of trends in toxic emissions, because it is the only air toxics inventory which is regularly updated.

While TRI is the only database available for assessing air toxic emission trends, there are significant limitations in the inventory's portrayal of overall HAP emissions. First, facilities with Standard Industrial Classification (SIC) codes outside the range of 20 to 39 (the manufacturing SIC range) are not required to report. Therefore, HAP emissions from facilities such as mining operations, electric utilities, and oil and gas production operations are not represented in the TRI due to this exemption. In addition, emissions from small manufacturing facilities (those with fewer than 10 employees) as well as mobile, commercial, residential, and consumer sources are not included in the TRI. More comprehensive, single year national inventories for specific pollutants (prepared by EPA to support special studies called for by the CAAA) have demonstrated that emissions from these excluded source categories can be much more significant than those from the manufacturing sector for some toxic air pollutants.[2] Next, TRI data are self-reported by the emitting facilities, and TRI does not require facilities to perform any actual monitoring or testing to develop their TRI estimates. The accuracy of the reported data may vary from facility to facility and year to year. Finally, the original TRI list only required reporting for 173 of the 189 HAPs identified in the CAAA.

Efforts are underway to enhance the TRI database by expanding both the type of facilities which must report their releases and the list of chemicals which must be reported. Two of the sixteen compounds omitted from the original TRI list, acetophenone and ethylidene dichloride, will be added for the 1994 reporting year. On January 12, 1994, the following nine HAPs were proposed for addition to the TRI:

- caprolactam;
- dimethyl formamide;
- hexamethylene-1,6-diisocyanate;
- hexane;
- isophorone;
- mineral fibers;
- phosphine;
- polycyclic organic matter (polycyclic aromatic compounds); and
- triethylamine.

Currently, there are no plans to add the remaining five HAPs to the TRI because they are either produced in quantities too low to meet the reporting thresholds or emitted by sources which currently are not required to report to the Inventory. These five HAPs are:

- 2,2,4-trimethylpentane;
- 2,3,7,8-tetrachlorodibenzo-p-dioxin;
- coke oven emissions;
- p,p'-dichlorodiphenyldichloroethylene (DDE); and
- radionuclides (including radon).

As more information is collected on air toxic emissions, baseline emissions estimates for air toxics will be modified to more accurately gauge the effectiveness of Title III regulations in reducing air toxic emissions.

In summary, 173 of the 189 HAPs (those included in the TRI database) are included in the analyses within this chapter. All references to HAPs emissions in the following section are to the sum of these compounds as reported in the TRI.

Summary of Emissions

In 1992, aggregate HAP emissions in the United States totaled 1.3 billion pounds, down from 1.5 billion pounds in 1991. This total represents a decrease of approximately 600 million pounds (or 31 percent) from 1988 levels and a reduction of 120 million pounds (or eight percent) from 1991 levels. As points of comparison, total TRI air releases declined 32 percent and nine percent, and total TRI releases declined 35 percent and six percent, respectively, during the same time periods.[3,4]

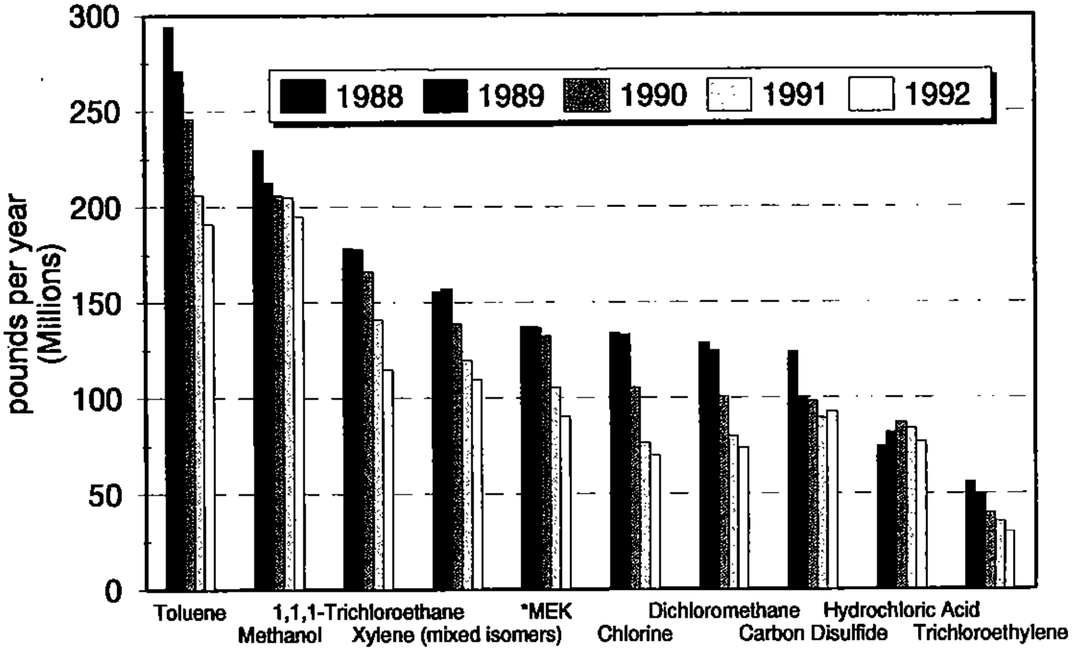
Figure 4-1 compares annual TRI emission estimates from 1988 to 1992 for the top 10 HAPs (based on 1988 levels). The estimates reveal a general downward trend for all, but one (carbon disulfide), of the listed pollutants. In similar fashion, Figure 4-2 presents yearly HAP emissions for the top 10 industry categories based on 1988 releases. All industry categories show a net decline since 1988 and reductions in emissions from 1991 levels as well. The chemical products industry has consistently reported greater aggregate HAP emissions to TRI than any other source category.

Figures 4-3 and 4-4 show reported air toxic emissions by state for 1991 and 1992, respectively. In 1992, three states (New Mexico, North Dakota, and Wyoming) joined the three states from 1991 reporting total HAP emissions less than one million pounds (Hawaii, Nevada, and Vermont). In 1992, five states reported HAP releases greater than 65 million pounds down from seven states in 1991 and thirteen in 1988.

Changes in the TRI estimates of HAP emissions by state for the time periods 1988 to 1992 and 1991 to 1992 are depicted in Figure 4-5 and 4-6, respectively. The total HAP emissions of thirty-one states have declined by greater than 25 percent from 1988 levels. However, five states reported increases in net HAP emission for the same time period, and eight states estimate one year increases in HAP releases since 1991.

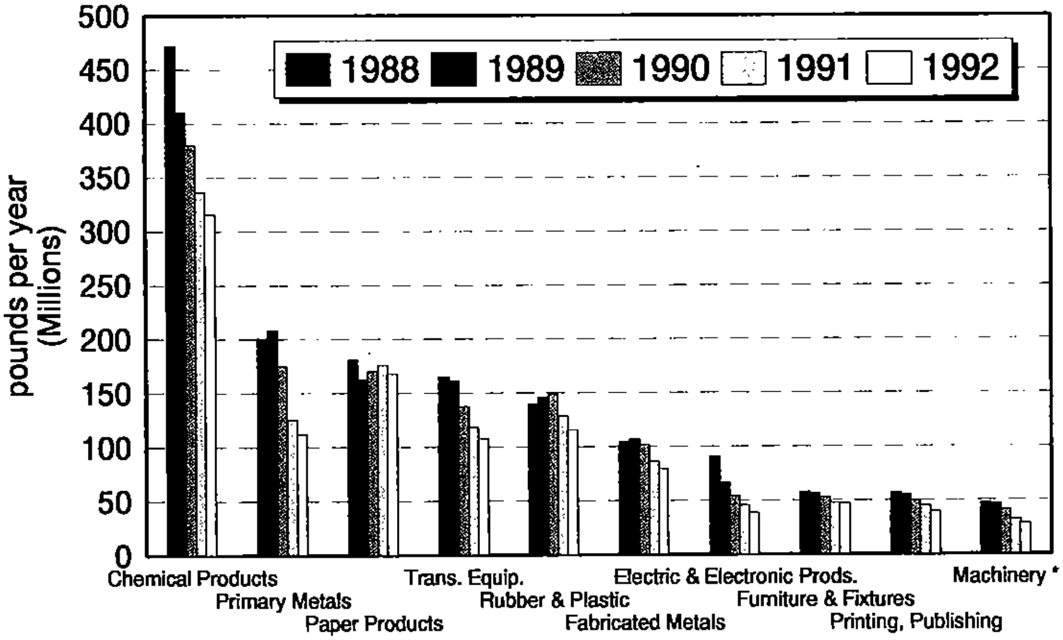
Figure 4-7 illustrates the trend in HAP releases for the five states with the greatest emission levels based on 1988 estimates. All five show a net reduction in HAP emissions over the 1988 to 1992 time period. For all five, except Alabama, the net change was greater than 25 percent from 1988 levels. Virginia reported the largest decline in HAP emissions, 57 percent, for the five year period.

Figure 4-8 presents the same data illustrated in Figure 4-4 (total HAP emissions by state for 1992) but utilizes a smaller grid scale to better resolve the geographic location of these emissions.



*Methyl Ethyl Ketone

Figure 4-1. Top 10 hazardous air pollutants, 1988 basis.



* except Electrical

Figure 4-2. Industry categories reporting highest total HAP releases, 1988 basis.

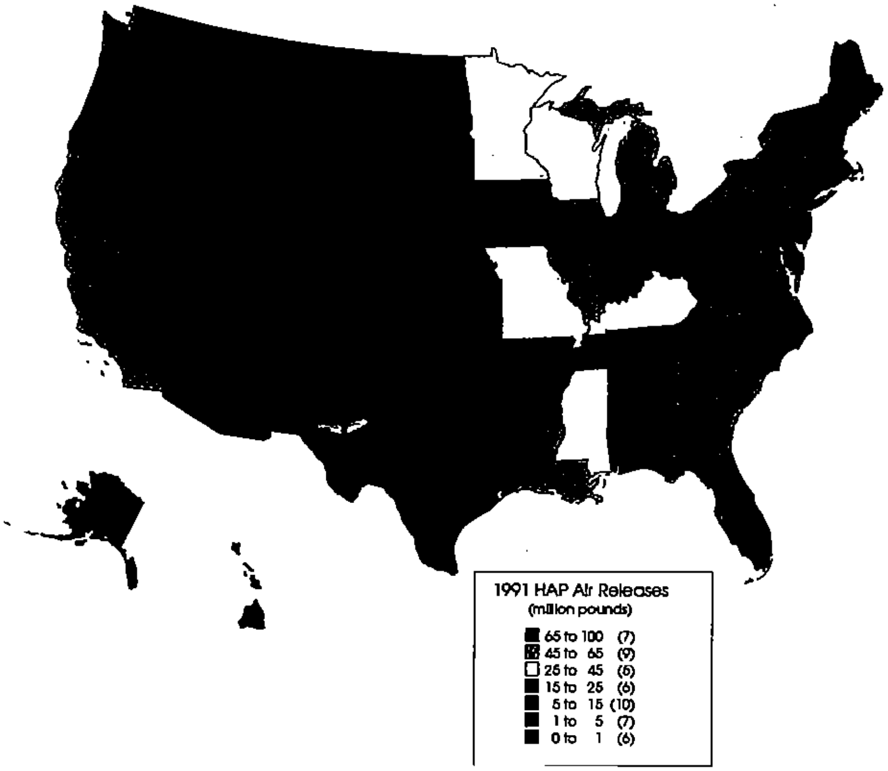


Figure 4-3. 1991 total air releases, HAP species by state, from TRI.

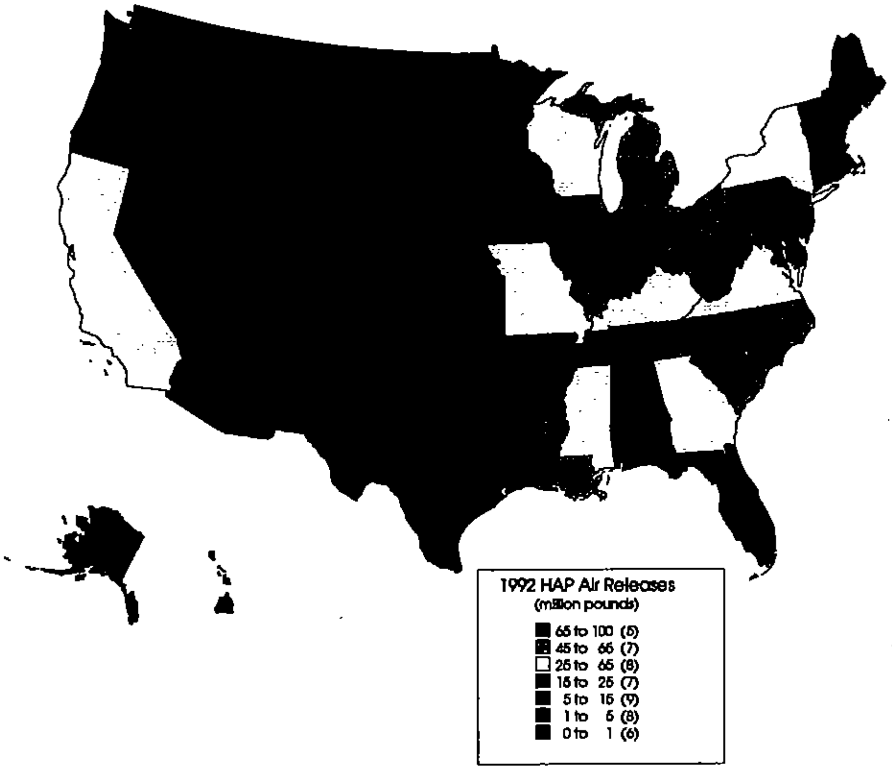


Figure 4-4. 1992 total air releases, HAP species by state, from TRI.

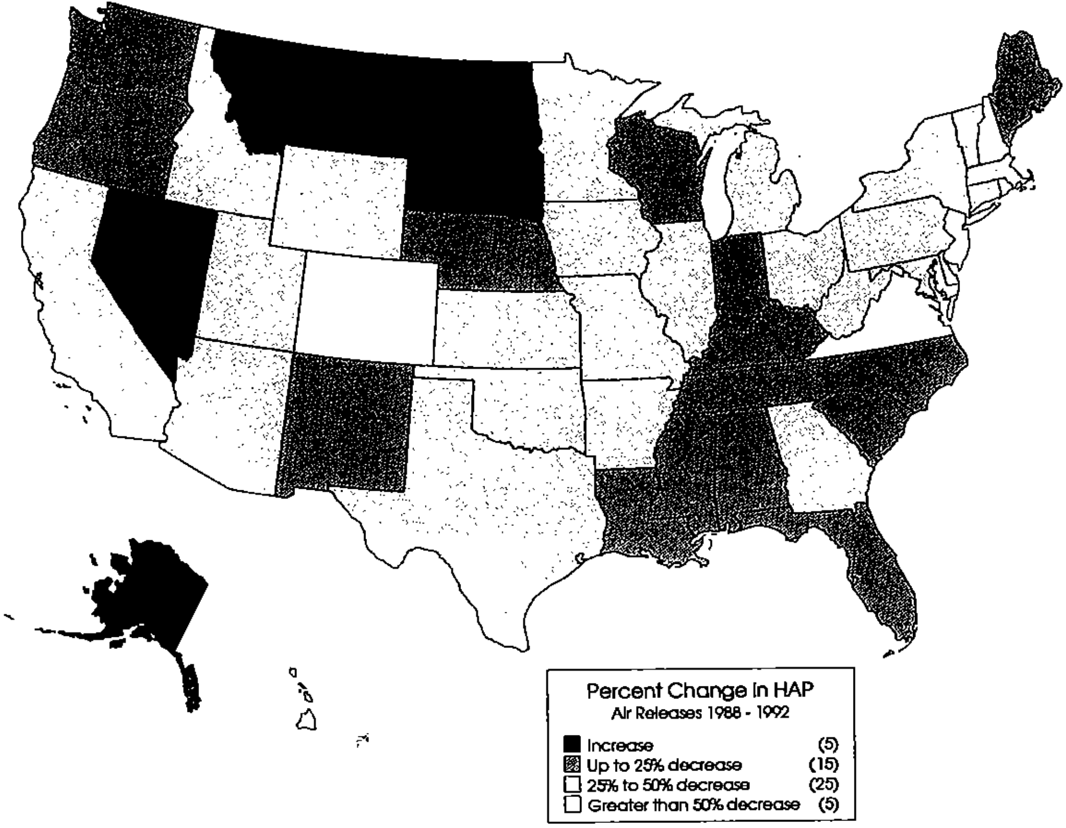


Figure 4-5. Percent change in HAP air releases from 1988 to 1992, from TRI.

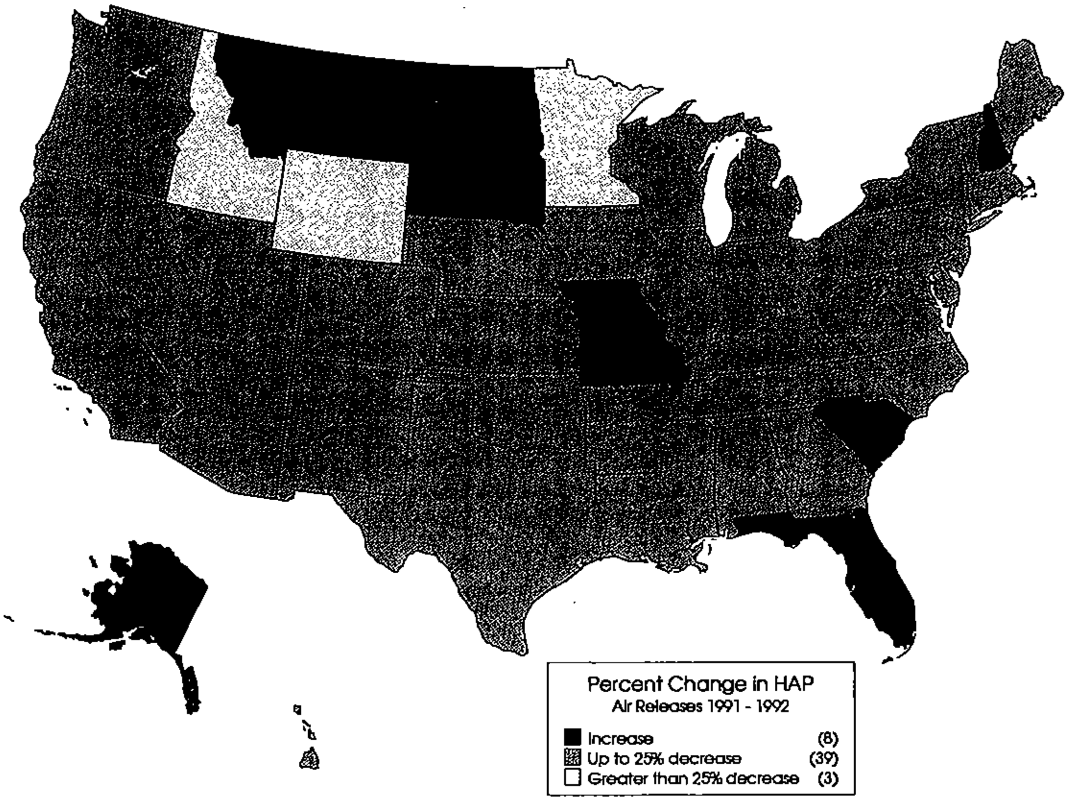


Figure 4-6. Percent change in HAP air releases from 1991 to 1992, from TRI.

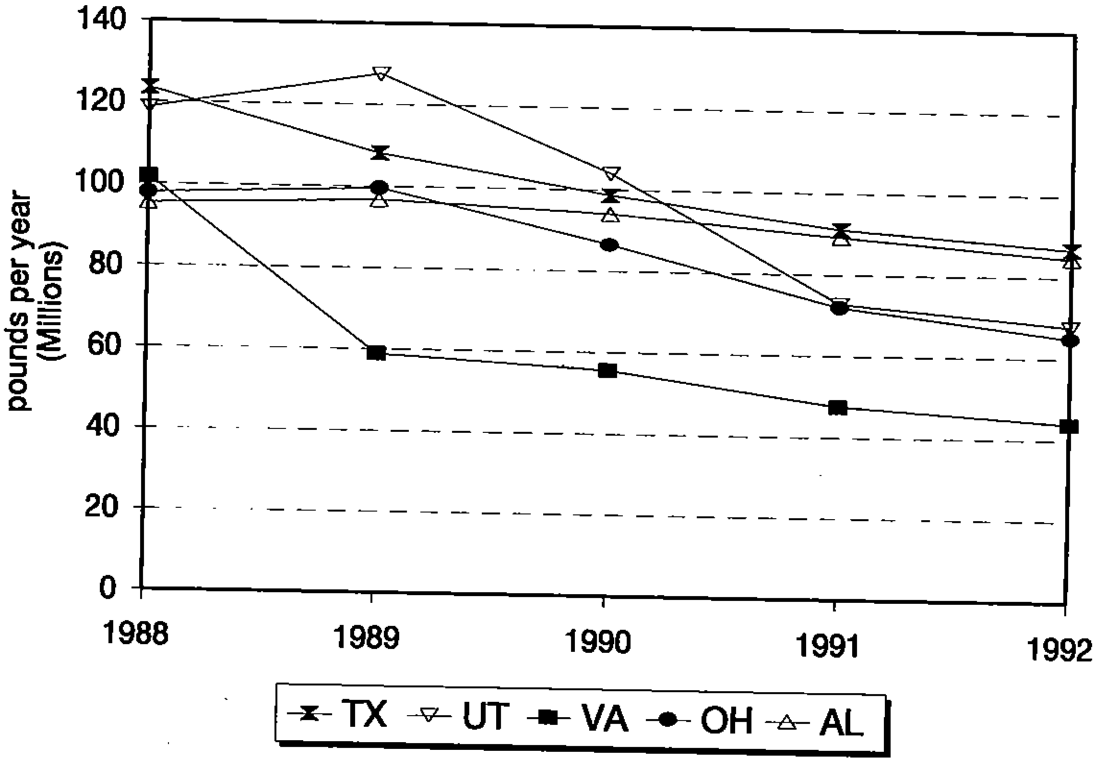


Figure 4-7. Changes in HAP air releases from 1988 to 1992 for top five states from 1988, from TRI.

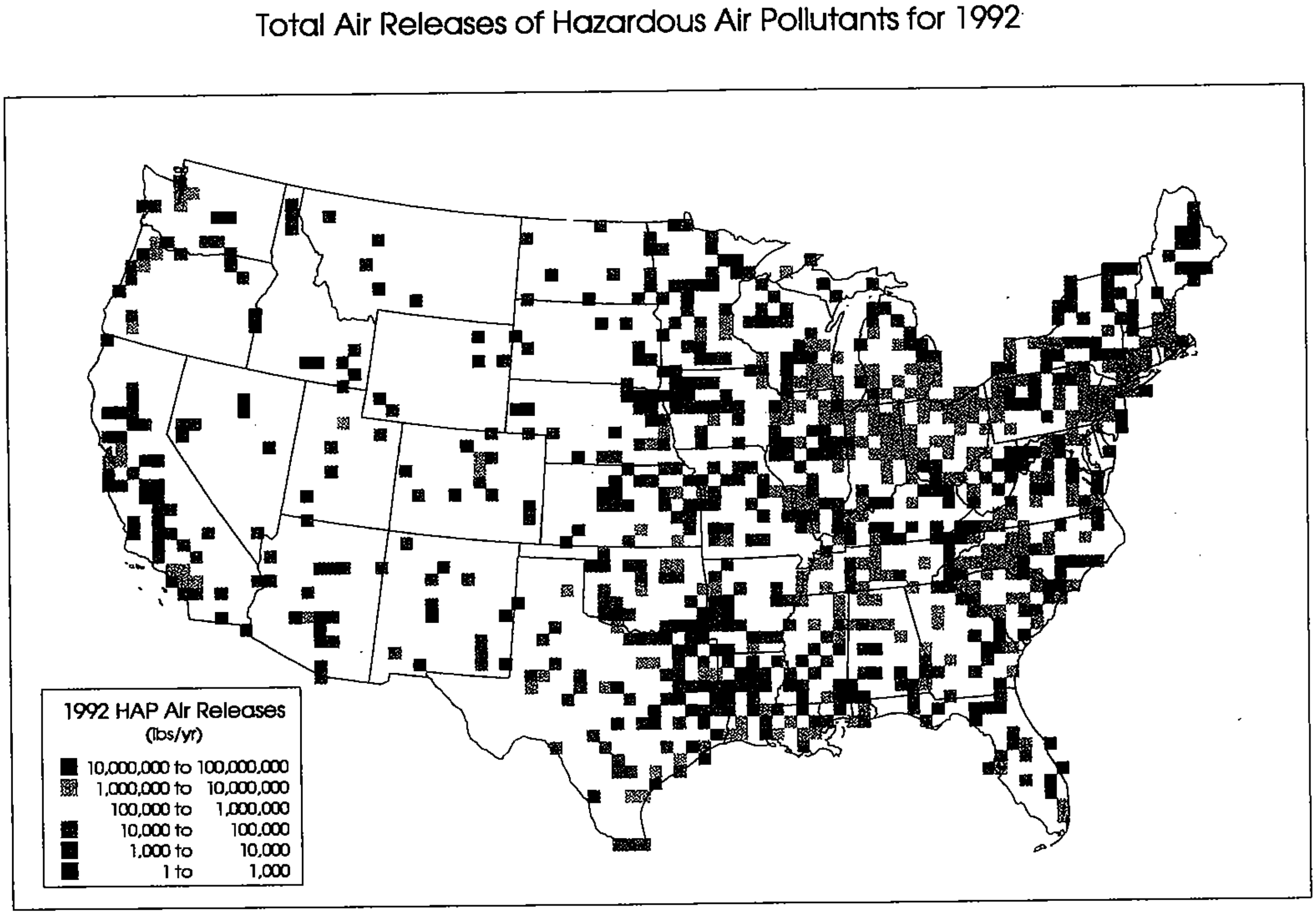


Figure 4-8. Gridded map of TRI total air releases of HAPs, 1992.

4.3 Air Toxics Regulations and Implementation Status

CAAA Requirements

As noted above, the CAAA identified 189 HAPs to be regulated according to a stringent schedule. The process of regulation entails the development of emission standards based upon the Maximum Achievable Control Technology (MACT) for each source category emitting hazardous air pollutants. These emission standards apply to all major sources (defined as sources emitting at least 10 tons per year of any one of the 189 listed HAPs, or at least 25 tons a year of any combination of HAPs).

Regulations must be developed according to the following timetable:

- 25 percent of all source categories by 1994;
- 50 percent of all source categories by 1997; and
- all source categories by the year 2000.

Standards also must be developed for "area sources" (any source that is not defined as a major source), although these can be based on generally available control technologies (GACT). The CAAA also contain incentives to encourage more rapid pollutant reductions through an early reduction program. This program gives a six-year extension on meeting MACT requirements to sources that reduce emissions by 90 percent or more (95 percent for toxic particulates) before the proposal of the applicable standard.

In addition, the CAAA provide for "residual risk" standards to reduce any risk remaining after MACT controls have been implemented. This program entails the development of procedures for assessing residual risk, its public health significance, and uncertainties by 1996. The program also requires EPA to promulgate residual risk standards for each source category within eight years after MACT standards were promulgated if necessary to provide an ample margin of safety to protect the public health.

Additional air toxics provisions include: (1) provisions to provide assistance to states developing their own air toxics programs; (2) an accidental release prevention program; and (3) requirements to establish monitoring stations. (For a complete list, please refer to Section 112 of the CAAA).

Status Report on Air Toxics Regulations

EPA is in the process of meeting the ambitious schedule for implementing the CAAA's air toxics provisions. Infrastructure programs such as defining and classifying major source categories, establishing the priority schedule for MACT phase-in, developing guidance for the accidental release program, and establishing general provisions for record-keeping and reporting requirements, have been completed and are either approved or in various stages of the review/approval process.

Several major regulatory actions in the air toxics program have been finalized or proposed in the past year:

- In February 1994, EPA finalized the standard for the Synthetic Organic Chemical Manufacturing Industry which requires reductions in emissions of 112 HAPs and affects nearly 400 chemical manufacturing plants across the nation. This standard is projected to reduce HAP emissions from existing sources in this industry by 80 percent, or an estimated 440,000 tons per year by 1998, more than any other air toxics rule to be issued under the CAAA. This rule also is projected to reduce volatile organic compounds, which react to form ozone, by 1.1 million tons per year.
- The control technology standards for approximately 3,700 industrial and large commercial dry cleaners were finalized in September 1993. These regulations are projected to decrease emissions of perchloroethylene by approximately 7,300 tons annually by 1996.
- In July 1994, EPA finalized the standards for industrial cooling towers.
- Regulatory negotiations by EPA produced an agreement on regulations to reduce toxic emissions from steel industry coke ovens. These regulations were finalized in October 1993.
- EPA has proposed standards for nine additional source categories, all of which will be finalized next year.
- EPA has initiated work on 77 additional emission standards. These include the emission standards due four years after enactment and several that are due seven years after enactment.
- EPA announced the final rule for the Early Reductions Program in December 1992. By August 1994, EPA had received and initiated review of 95 submittals, 40 of which remain active. If all of these sources follow through, the estimated reductions in HAPs would total over 30 million pounds. The EPA has also received 19 title V specialty permits for early reductions.

Special Studies: The EPA also is conducting special studies assessing the emissions and effects of toxic air pollutants. Several of these programs completed reports to Congress in the past year, including:

- The Hydrogen Fluoride Study, which assessed the potential impacts of accidental releases of hydrogen fluoride at industrial facilities;

- The Hydrogen Sulfide Study, which assessed the impacts of hydrogen sulfide releases from oil and gas wells and pipelines;
- The Atmospheric Deposition to Great Lakes and Coastal Waters (Great Waters) Study, which is the first in a series of reports to Congress, has established the groundwork for considering the regulation of air toxic emissions (this is based on the potential of air toxic emissions to pollute bodies of water, persist in the environment, and bioaccumulate in the food chain, thereby causing deleterious health effects); and
- The National Academy of Sciences Study on Risk Assessment Methodology, a report prepared by eminent scientists outside the EPA in an effort to evaluate the Agency's risk assessment methods.

Other studies, which are continuing in support of Clean Air Act mandates and which may affect the course of further regulatory activity, include:

- the Urban Area Source Program strategy;
- the Electric Utilities Steam Generating Unit study;
- the Mercury Study;
- the Residual Risk Report;
- the Coke Oven Production Technology Study; and
- the Publicly-Owned Treatment Works (POTW) Study.

MACT Standards: Source Category Profiles

As described above, the CAAA air toxics provisions focus on source categories emitting large quantities of various air toxics rather than on particular compounds. Table 4-1 displays a summary of MACT standards proposed in prior years and described in previous Trends reports. Brief profiles of the nine source categories for which regulations were proposed during the past year or are in the final stages of development are presented following the table.

Table 4-1. Summary of Previously Reported MACT Standards

MACT Source Category	HAP Current	Tons/Year After Reg.	Number of Facilities	Date of Proposal	Final	Primary Toxics Emitted
Synthetic Organic Chemical Manufact. Industry	550,000	110,000	370	12/92	04/94	Up to 150 Different HAPs
Perchloroethylene Dry Cleaning Facilities	50,000	42,700	3,700	11/91	09/93	Perchloroethylene
Coke Oven Batteries	1,830	320	30	12/92	10/93	Polycyclic Organic Matter
Ethylene Oxide Sterilization Facilities	1,200	100	200	03/94	11/94	Ethylene Oxide
Chromium Electroplating Operations	175	2	5,000	11/93	11/94	Chromium
Industrial Process Cooling Towers	25	0	300	08/93	07/94	Chromium
Total	**603,230**	**153,122**	**9,600**			

Aerospace Manufacturing and Re-work Industry

Aerospace manufacturing and re-work facilities emit approximately 208,000 tons of HAPs annually from sources including paint and coating operations, chemical stripping, and clean-up solvents. Most of the HAPs emitted by this industry are solvents such as methyl ethyl ketone, 1,1,1-trichloroethane, toluene, and methylene chloride. Many of the primers used for aerospace vehicles also contain heavy metals such as chromium and cadmium. Research indicates that possible health effects of these pollutants include cancer as well as developmental, respiratory, and neurological effects.

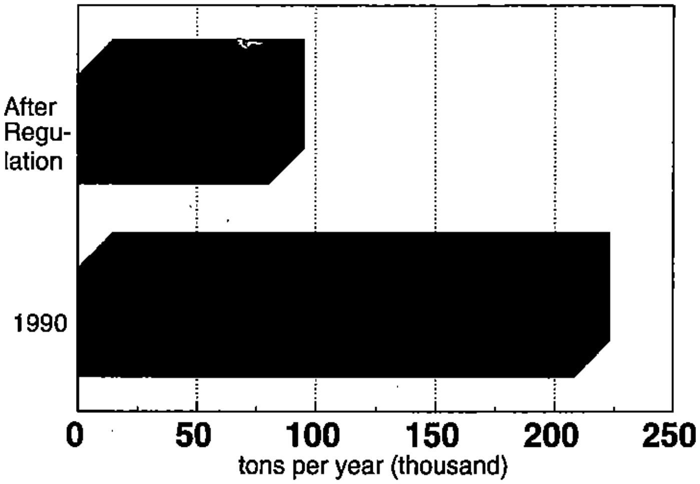
EPA proposed the NESHAP to control HAP emissions from this industry in June 1994. It is estimated that more than 2,800 facilities will be subject to this regulation. Expected emission reductions are projected to lower HAP emissions by approximately 127,800 tons per year (a 60-percent reduction). In addition, emissions of volatile organic compounds (VOCs) will be reduced by 89,000 tons annually.

Petroleum Refinery

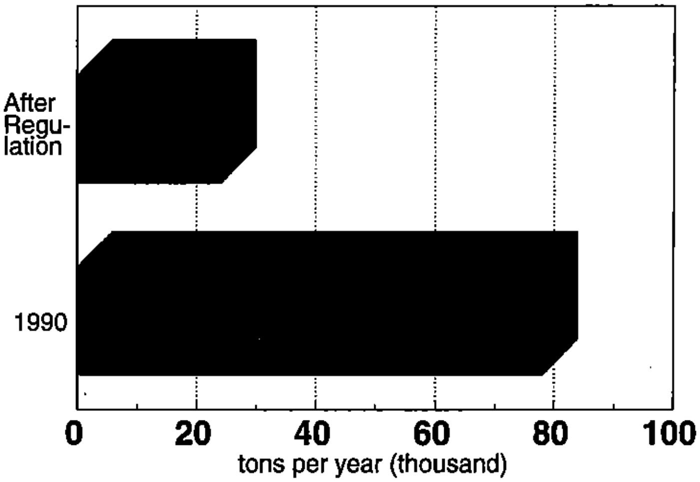
Petroleum refineries annually emit approximately 78,000 tons of HAPs including benzene, toluene, xylene, ethyl benzene, methyl tert-butyl ether, 2,2,4 trimethyl pentane, and hexane. These compounds are thought to contribute to cancer, liver and kidney damage, and neurological and developmental effects. The greatest emission reductions for this source category will result from requiring refiners to implement an effective program of leak detection and repair for pumps, valves, compressors and other equipment. Additional significant reductions will occur by requiring efficient emission controls on storage tanks, process vents and waste water collection and treatment systems.

EPA proposed this NESHAP on June 30, 1994, and expects to promulgate it by June 30, 1995. All 192 petroleum refineries in the United States will be covered by the rule. The regulations will reduce emissions of HAPs from petroleum refineries by 54,000 tons annually, a 69-percent reduction of current emissions. As an additional benefit, VOC emissions will be reduced by 72 percent or 350,000 tons per year.

HAP Emissions from Aerospace Manufacturing



HAP Emissions from Petroleum Refinery

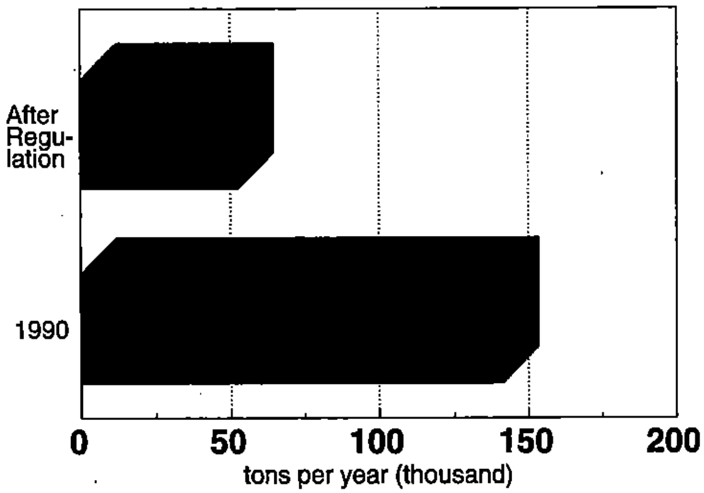


Halogenated Solvent Cleaning

In 1990, the estimated HAP emissions from the halogenated solvent cleaning industry totaled 141,400 tons. These emissions included methylene chloride, perchloroethylene, trichloroethylene, 1,1,1 trichloroethane, carbon tetrachloride, and chloroform. Most of these compounds are suspected carcinogens, as shown in animal studies and some human studies.

The EPA rule proposed in November 1993 is based on equipment and work practices standards with an alternative compliance requirement based on an overall solvent emissions limit. The final rule is scheduled to be promulgated on November 15, 1994. Approximately 25,400 batch vapor and in-line solvent cleaning machines, and 100,000 batch cold cleaning machines are affected by the standards. The rule will reduce annual emissions of the targeted air toxics by 88,400 tons (or 63 percent).

HAP Emissions from Halogenated Solvent Cleaning

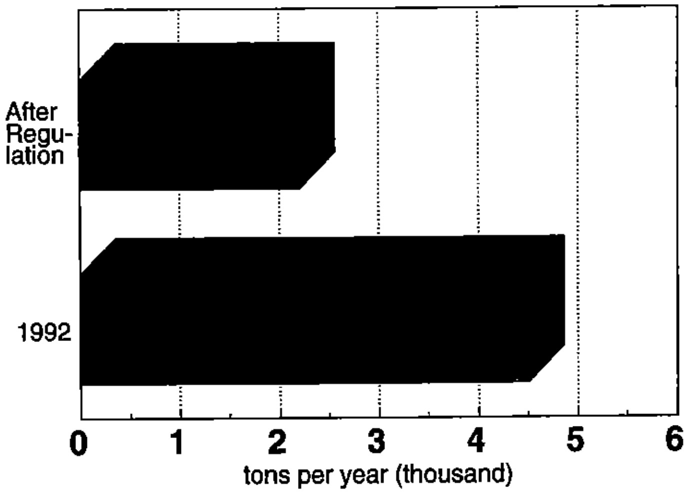


Magnetic Tape Manufacturing

The HAPs emitted from the magnetic tape manufacturing industry are primarily solvents used in the coating process including methyl ethyl ketone, methyl isobutyl ketone, and toluene. These substances can cause developmental, neurological and possibly respiratory effects. Some particulate HAP emissions may also occur during the transfer of magnetic particles to the coating mix. Based on 1992 information, major sources are estimated to emit about 4,500 tons of HAPs annually.

In March 1993, the EPA proposed standards to reduce these emissions. The final rule is scheduled for promulgation in November 1994. For the majority of the emission points in a facility, the proposed rule would require 95 percent control. Most facilities are expected to achieve this with a solvent recovery device, such as a carbon adsorber. Other emission points would be required to meet work practice or equipment specifications. The rule as proposed would reduce HAP emissions to about 2,200 tons per year (an approximate reduction of 50 percent).

HAP Emissions from Magnetic Tape Manufacturing

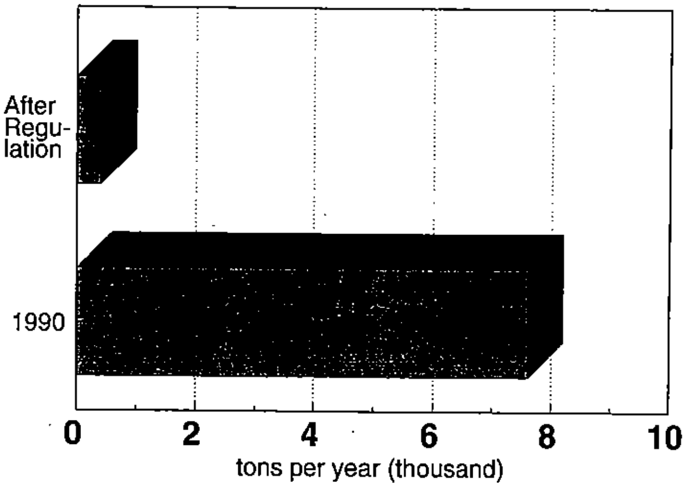


Marine Vessel Loading Operations

Marine vessel loading and unloading operations are believed to emit as many as 60 of the 189 HAPs. Air toxic emissions from this industry include benzene (a known human carcinogen), toluene (a possible contributor to neurological effects), ethyl benzene (a possible contributor to developmental effects), and xylene (a possible contributor to neurological effects). Emissions at marine terminal loading operations result from the displacement of vapors as liquids are loaded into cargo holds either directly through open-hatches or from pipe header systems which collect the vapors and vent to atmosphere.

The EPA proposed the marine vessel rule in May 1994. Approximately 350 facilities emitting 8,000 metric tons of HAPs in 1990 will be affected by the rule. Expected emission reductions resulting from the rule are projected to be 7,600 metric tons per year (or a 95-percent reduction).

HAP Emissions from Marine Vessel Loading

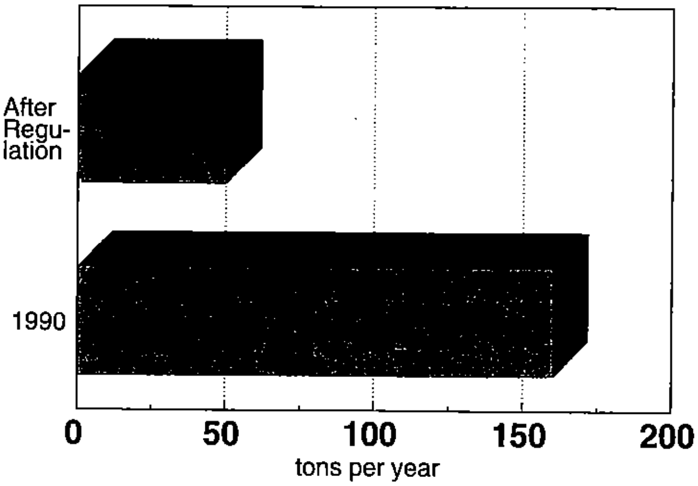


Polymers and Resins II

The EPA proposed the NESHAP for epoxy resin production and non-nylon polyamides production in May 1994. The proposed rules affect manufacturers that produce basic liquid epoxy resin (three facilities) and wet strength resins (17 facilities).

HAPs are emitted at these processes from vents, storage tanks, waste water collection and treatment systems, and equipment leaks. The predominant air toxic emitted is epichlorohydrin which is a suspected carcinogen, based on animal studies and some human studies. Estimated baseline HAP emissions are 160 tons per year. The proposed rules set HAP emissions limitations, which are based on the amount of resin produced, and require operators to implement leak detection and repair programs for control of equipment leaks. The estimated reduction in HAP emissions is 110 tons per year (a reduction of approximately 70 percent).

HAP Emissions from Polymers and Resins II

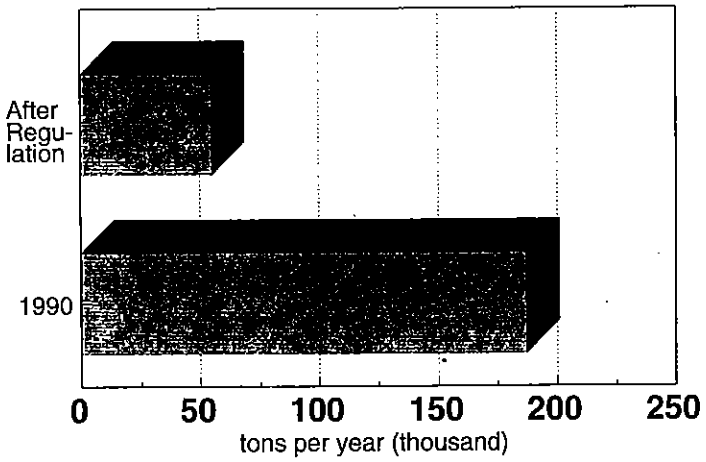


Pulp, Paper, and Paperboard Industry Manufacturing Processes

Pulp and paper mills emit HAPs, most notably chloroform and methanol, to the air as well as discharge toxic and other Clean Water Act pollutants, most notably dioxins and furans, into the nation's waters. Chloroform caused cancer in animal studies, and methanol resulted in reproductive and developmental effects in animal studies. There are about 160 chemical pulping mills contributing approximately 187,000 tons of HAPs per year from process vents and evaporation from waste water units.

The air rule and effluent guidelines were proposed in December 1993 and are estimated to reduce HAP emissions by 132,000 tons per year and VOC emissions by 787,600 tons annually. Air emission reductions are achieved by venting process equipment to combustion devices and steam stripping certain waste water steams. HAP controls for combustion sources at kraft mills will be proposed in early 1994. Both HAP rules are planned to be promulgated together with the effluent guidelines in early 1996.

HAP Emissions from Pulp, Paper, and Paperboard

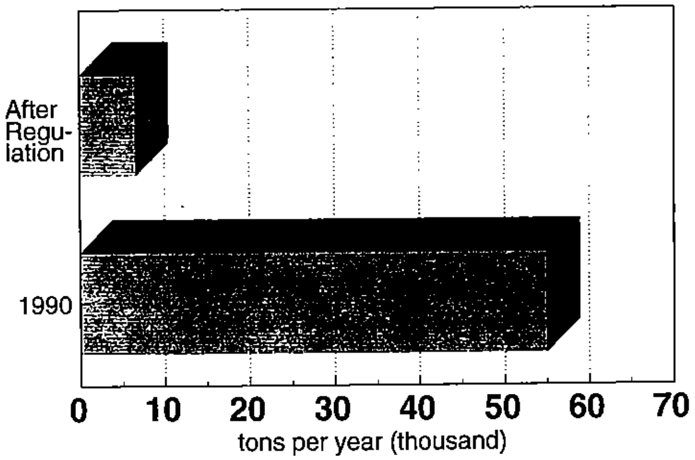


Gasoline Distribution Industry (Stage I)

Gasoline vapor contains up to 11 hazardous air pollutants (HAPs): benzene, toluene, ethylbenzene, naphthalene, cumene, p-xylene, m-xylene, o-xylene, n-hexane, and 2-2-4-trimethylpentane. In addition, methyl tert-butyl ether is in gasolines reformulated and oxygenated to meet the CAAA requirements for non attainment areas. These compounds were found to contribute to cancer, liver and kidney damage, as well as neurological and developmental effects in animal studies and some human studies. Residual HAP and VOC emissions after current VOC control measures are estimated to be 55,000 and 880,000 tons per year, respectively. The potential major sources of HAPs in the gasoline distribution network include about 380 medium and large size gasoline bulk terminals, and about 20 large pipeline breakout stations. Emissions of HAPs from these facilities occur during gasoline tank truck loading, gasoline storage, and from leaking pumps, valves, flanges and other equipment in gasoline service.

The HAP rule for major source terminals and pipeline breakout stations was proposed in February 1994. This regulation is estimated to reduce HAP and VOC emissions by 2,970 and 48,400 tons annually, respectively.

HAP Emissions from Gasoline Distribution Industry (Stage I)

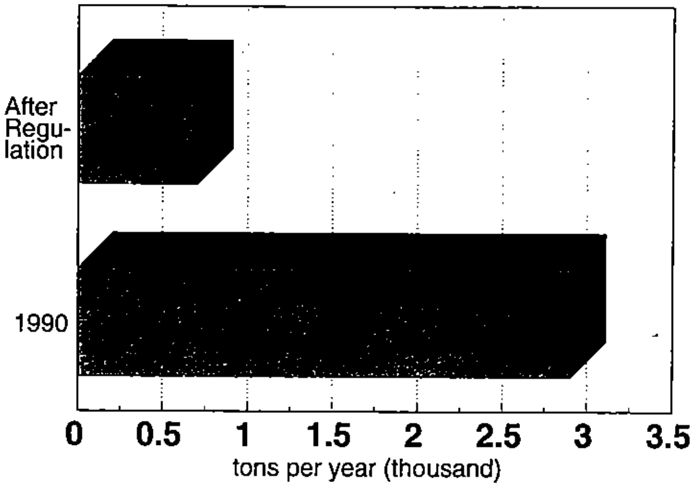


Secondary Lead Smelters

There are about 23 secondary lead smelters in the United States. These facilities provide the domestic capacity for recycling automotive batteries. Secondary lead smelters emit metallic HAPs, organic HAPs, and hydrochloric acid. Some of the HAPs emitted, such as lead compounds, arsenic compounds, and 1,3-butadiene, are known or suspected carcinogens. Total HAP emissions from this source category are estimated at 2,900 tons per year.

National emission standards for these operations were proposed in May 1994, and are expected to be promulgated by May 1995. The regulation would require control of furnace combustion gases; process fugitive emission sources including the furnace charging and tapping locations and emissions of lead fume from refining kettles; and fugitive dust sources which are windblown or vehicular induced emissions from storage piles, roadways, and other areas of the facility. This NESHAP would result in emission reductions of 2,200 tons annually, or 75 percent of the 1990 baseline.

HAP Emissions from Secondary Lead Smelters



4.4 References

1. *Clean Air Act Amendments of 1990, U.S. Code*, vol. 42 sec. 7412(b)(2), 1990.
2. *National Air Pollutant Emission Trends, 1900–1993*, EPA-454-R-94-027, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, N.C. 27711.
3. *1992 Toxics Release Inventory*, EPA-745-R-94-001, U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, Washington, D.C. 20460, April 1994.
4. *1991 Toxics Release Inventory*, EPA-745-R-93-003, U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, Washington, D.C. 20460, May 1993.

Chapter 5: Air Quality Status of Metropolitan Areas

This chapter provides some general information on the current air quality status of U.S. metropolitan areas.[1] Several different summaries are presented. First, a simplified list of areas designated nonattainment for the National Ambient Air Quality Standards (NAAQS) for carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM-10), and sulfur dioxide (SO_2) is given. The list is followed by a set of maps showing the locations of the nonattainment areas for each pollutant. Next, an estimate is provided of the number of people living in counties which did not meet the NAAQS based on a snapshot of 1993 air quality data. Pollutant-specific maps are then presented to provide the reader with a geographical view of how peak 1993 air quality levels varied throughout counties in the United States. Finally, a table is presented that shows peak values for each Metropolitan Statistical Area (MSA) which had 1993 air quality monitoring data.

5.1 Nonattainment Areas

When an area does not meet the air quality standard for one of the criteria pollutants, it may be subject to the formal rule-making process which designates it as nonattainment. The Clean Air Act Amendments (CAAA) of 1990 further classify ozone, carbon monoxide, and some particulate matter nonattainment areas based upon the magnitude of the area's problem. Nonattainment classifications may be used to specify what air pollution reduction measures an area must adopt and when the area must reach attainment. The technical details underlying these classifications are discussed in the *Code of Federal Regulations*.[2]

Table 5-1 lists the number of nonattainment areas for each pollutant as of September 1994. Table 5-2 provides a simplified summary of individual nonattainment areas listed alphabetically by state. A more detailed listing is contained in the *Code of Federal Regulations*, Part 81 (40 CFR 81). The population figures listed with each nonattainment area are based on figures from the 1990 Census. For nonattainment areas defined as only partial counties, population totals for just the nonattainment area were used when available; otherwise, whole county population totals are shown. When a larger nonattainment area encompassed a smaller one, double-counting the population was avoided by only

Table 5-1. Nonattainment Areas for NAAQS Pollutants as of September 1994

Pollutant	Number of Nonattainment Areas*
Carbon Monoxide (CO)	38
Lead (Pb)	13
Nitrogen Dioxide (NO_2)	1
Ozone (O_3)	93
Particulate Matter (PM-10)	83
Sulfur Dioxide (SO_2)	47

* Unclassified areas are not included in the totals.

counting the population of the larger area. Occasionally, two nonattainment areas may only partially overlap. In this case, these areas were counted as two distinct nonattainment areas, and the population was added accordingly (see Figures 5-1 and 5-2).

The total number of nonattainment areas has increased somewhat since Table 5-2 was first published last year. The largest change occurred for PM-10 nonattainment areas, with an increase of 13 areas. SO_2 added three nonattainment areas. Two CO areas and one O_3 area were redesignated to attainment and were dropped from the list. The number of Pb and NO_2 nonattainment areas remained the same. It is worth mentioning that there are several areas, especially for ozone but for other pollutants as well, which have begun the redesignation process but are not included here because their redesignations have not yet been finalized.

Since the original nonattainment designations in 1991, five of the 98 ozone nonattainment areas have been redesignated to attainment:

- Kansas City, KS-MO;
- Cherokee County, SC;
- Greensboro, NC;
- Knoxville, TN; and
- Raleigh-Durham, NC.

Of the 41 original CO nonattainment areas in 1991, four areas have been redesignated to attainment for the CO NAAQS:

- Cleveland, OH;
- Duluth, MN;
- Syracuse, NY; and
- Memphis, TN.

The original number of PM-10 nonattainment areas has increased by the following 13 areas:

- New York, NY;
- Weirton, WV;
- Thompson Falls, MT;
- Steamboat Springs, CO;
- Whitefish, MT (Flathead Co);
- Payson, AZ;
- Bullhead City, AZ;
- Sacramento Co, CA;
- San Bernadino Co, CA;
- Mono Basin, CA;
- Shoshone Co, ID;
- Oakridge, OR; and
- Lakeview, OR (Lake Co).

For SO_2, seven of the original 51 nonattainment areas now meet the NAAQS and have been redesignated to attainment. These include:

- Colbert Co, AL;
- Green Bay, WI;
- Lauderdale Co, AL;
- Dane Co, WI;
- Milwaukee Co, WI;
- Washington Co, OH; and
- Morgan Co, OH..

Three new areas have been designated nonattainment for SO_2:

- Warren, Pleasant, Glade, PA (Warren Co, PA);
- Wierton, Butler, Clay, WV (Hancock Co, WV); and
- Muscatine Co, IA.

The information contained in Table 5-2 is depicted graphically in Figure 5-3 through Figure 5-8. Each map presents the location of the current nonattainment areas for that criteria pollutant. As in the case of the table, this information was current as of the end of September 1994.

Table 5-2. Simplified Nonattainment Areas List[a].

			POLLUTANT(c)						POPULATION(d)	
	STATE	AREA NAME(b)	O3	CO	SO2	PM10	Pb	NO2	(1000s)	
1	AK	Anchorage	.	1	.	1	.	.	130	
2	AK	Fairbanks	.	1	.	.	.	.	41	
3	AK	Juneau	.	.	.	1	.	.	12	
4	AL	Birmingham	1	.	.	.	1 (e)	.	651	
5	AZ	Ajo	.	.	1	1	.	.	6	
6	AZ	Bullhead City				1			5	
7	AZ	Douglas			1	1			13	
8	AZ	Miami-Hayden			2	1			3	
9	AZ	Morenci			1				8	
10	AZ	Nogales				1			19	
11	AZ	Paul Spur	.	.	.	1	.	.	1	
12	AZ	Payson	.	.	.	1	.	.	5	
13	AZ	Phoenix	1	1	.	1	.	.	2092	
14	AZ	Rillito	.	.	.	1	.	.	1	
15	AZ	San Manuel	.	.	1	.	.	.	5	
16	AZ	Yuma				1			55	
17	CA	Chico		1					72	
18	CA	Coachella Valley				1			183	
19	CA	Imperial Valley				1			92	
20	CA	Lake Tahoe South Shore		1					30	
21	CA	Los Angeles-South Coast Air Basin	1	1	.	2	.	1	13513	
22	CA	Mammoth Lakes (In Mono Co.)	.	.	.	1	.	.	10	(Pop Mono Co.)
23	CA	Mono Basin (In Mono Co.)	.	.	.	1	.	.	.	(See Mono Co. above)
24	CA	Monterey Bay	1	.	.	.	.	.	622	
25	CA	Owens Valley	.	.	.	1	.	.	18	
26	CA	Sacramento Metro	1	1		1			1639	
27	CA	San Diego	1	1					2498	
28	CA	San Francisco-Bay Area	1	1					5815	
29	CA	San Joaquin Valley	1	3		1			2742	
30	CA	Santa Barbara-Santa Maria-Lompoc	1						370	
31	CA	Searles Valley	.	.	.	1	.	.	31	
32	CA	Southeast Desert Modified AQMA	1	.	.	.	.	.	384	
33	CA	Ventura Co.	1	.	.	.	.	.	669	
34	CO	Aspen	.	.	.	1	.	.	5	
35	CO	Canon City	.	.	.	1	.	.	13	
36	CO	Colorado Springs		1					359	
37	CO	Denver-Boulder		1		1			1838	
38	CO	Fort Collins		1					106	
39	CO	Lamar				1			8	
40	CO	Longmont		1					62	
41	CO	Pagosa Springs	.	.	.	1	.	.	1	
42	CO	Steamboat Springs	.	.	.	1	.	.	7	
43	CO	Telluride	.	.	.	1	.	.	1	
44	CT	Greater Connecticut	1	1	.	1	.	.	2470	
45	DC-MD-VA	Washington	1	1	.	.	.	.	3924	
46	DE	Sussex Co.	1						113	
47	FL	Miami-Fort Lauderdale-W. PalmBeach	1						4056	
48	FL	Tampa-St. Petersburg-Clearwater	1						1686	
49	GA	Atlanta	1						2653	
50	GA	Muscogee Co.					1		179	
51	GU	Piti Power Plant	.	.	1	.	.	.	145	(Pop Guam)
52	GU	Tanguisson Power Plant	.	.	1	.	.	.	.	(See Guam above)
53	IA	Muscatine Co.	.	.	1	.	.	.	40	
54	ID	Boise	.	.	.	1	.	.	205	
55	ID	Sandpoint (In Bonner Co.)	.	.	.	1	.	.	27	
56	ID	Pinehurst				1			2	
57	ID	Pocatello				1			61	
58	ID	Shoshone				1			1	
59	IL	Groveland			1				124	
60	IL	Hollis Twp.			1				183	(Pop Peoria Co.)
61	IL	Jersey Co.	1	.	.	.	.	.	21	
62	IL	Oglesby	.	.	.	1	.	.	4	
63	IL	Peoria	.	.	1	.	.	.	.	(See Peoria Co. above)
64	IL-IN	Chicago-Gary-Lake County	1	.	1	3	.	.	7886	
65	IN	Evansville	1	.	.	.	.	.	165	
66	IN	Indianapolis	1		1		1 (f)		797	
67	IN	Laporte Co.			1				107	
68	IN	South Bend	1						403	
69	IN	Vermillion Co.				1			17	
70	IN	Vigo Co.			1				106	

Table 5-2. Simplified Nonattainment Areas List[a] (cont.)

	STATE	AREA NAME(b)	POLLUTANT(c) O3	CO	SO2	PM10	Pb	NO2	POPULATION(d) (1000s)
71	IN	Wayne Co.	.	.	1	.	.	.	72
72	KY	Edmonson Co.	1	.	.	.	.	.	10
73	KY	Lexington-Fayette	1	.	.	.	.	.	249
74	KY	Muhlenberg Co.	.	.	1	.	.	.	31
75	KY	Owensboro	1	.	.	.	.	.	88
76	KY	Paducah	1						28
77	KY-IN	Louisville	1						834
78	LA	Baton Rouge	1						582
79	LA	Lake Charles	1						168
80	MA	Springfield (W. Mass)	1						812
81	MA-NH	Boston-Lawrence-Worcester	1	1	.	.	.	.	5500
82	MD	Baltimore	1	1	.	.	.	.	2348
83	MD	Kent and Queen Anne Cos.	1	.	.	.	.	.	52
84	ME	Hancock and Waldo Cos.	1	.	.	.	.	.	80
85	ME	Knox and Lincoln Cos.	1	.	.	.	.	.	67
86	ME	Lewiston-Auburn	1						221
87	ME	Millinocket			1				8
88	ME	Portland	1						441
89	ME	Presque Isle				1			11
90	MI	Detroit-Ann Arbor	1			1			4591
91	MI	Grands Rapids	1	.	.	.	.	.	688
92	MI	Muskegon	1	.	.	.	.	.	159
93	MN	Minneapolis-St. Paul	.	1	1	1	1 (g)	.	2310
94	MN	Olmsted Co.	.	.	1	1	.	.	71
95	MO	Dent	.	.	.	.	1	.	1
96	MO	Liberty-Arcadia					1		6
97	MO-IL	St. Louis	1			1 (h)	1 (i)		2390
98	MT	Butte				1			34
99	MT	Columbia Falls				1			3
100	MT	Kalispell				1			12
101	MT	Lame Deer	.	.	.	1	.	.	1
102	MT	Lewis & Clark	.	.	1	.	1 (j)	.	2
103	MT	Libby	.	.	.	1	.	.	3
104	MT	Missoula	.	1	.	1	.	.	43
105	MT	Polson	.	.	.	1	.	.	3
106	MT	Ronan				1			2
107	MT	Thompson Falls				1			1
108	MT	Whitefish				1			4
109	MT	Yellowstone			1				5
110	NC	Charlotte-Gastonia	1						886
111	NC	Raleigh-Durham	.	1	.	.	.	.	613
112	NC	Winston-Salem	.	1	.	.	.	.	266
113	NE	Douglas	.	.	.	.	1	.	<1
114	NH	Manchester	1	.	.	.	.	.	222
115	NH	Portsmouth-Dover-Rochester	1	.	.	.	.	.	183
116	NJ	Atlantic City	1						319
117	NM	Albuquerque		1					481
118	NM	Anthony				1			2
119	NM	Grant Co.			1				28
120	NV	Central Steptoe Valley			1				9
121	NV	Las Vegas	.	1	.	1	.	.	741
122	NV	Reno	1	1	.	1	.	.	255
123	NY	Albany-Schenectady-Troy	1	.	.	.	.	.	874
124	NY	Buffalo-Niagara Falls	1	.	.	.	.	.	1189
125	NY	Essex Co. (White Mtn.)	1	.	.	.	.	.	<1
126	NY	Jefferson Co.	1						111
127	NY	Poughkeepsie	1						259
128	NY-NJ-CT	New York-N. New Jersey-Long Island	1	1		1			17947
129	OH	Canton	1						368
130	OH	Cleveland-Akron-Lorain	1		2	1			2859
131	OH	Columbus	1	.	.	.	.	.	1157
132	OH	Coshocton Co.	.	.	1	.	.	.	35
133	OH	Dayton-Springfield	1	.	.	.	.	.	951
134	OH	Gallia Co.	.	.	1	.	.	.	31
135	OH	Jefferson Co.	.	.	1	1	.	.	80
136	OH	Lake Co.			1				215
137	OH	Toledo	1		1				575
138	OH-KY	Cincinnati-Hamilton	1						1705
139	OH-PA	Youngstown-Warren-Sharon	1						614
140	OR	Grants Pass		1		1			25

Table 5-2. Simplified Nonattainment Areas List[a] (cont.)

			POLLUTANT(c)						POPULATION(d)
	STATE	AREA NAME(b)	O3	CO	SO2	PM10	Pb	NO2	(1000s)
141	OR	Klamath Falls	.	1	.	1	.	.	37
142	OR	Lakeview	.	.	.	1	.	.	4
143	OR	LaGrande	.	.	.	1	.	.	12
144	OR	Medford	.	1	.	1	.	.	116
145	OR	Oakridge	.	.	.	1	.	.	3
146	OR	Springfield-Eugene	.	.	.	1	.	.	190
147	OR-WA	Portland-Vancouver AQMA	1	1	.	.	.	.	1070
148	PA	Altoona	1	.	.	.	.	.	131
149	PA	Conewango Twp. (In Warren Co, PA)	.	.	1	.	.	.	45 (Pop Warren Co, PA)
150	PA	Erie	1	.	.	.	.	.	276
151	PA	Harrisburg-Lebanon-Carlisle	1	.	.	.	.	.	588
152	PA	Johnstown	1	.	.	.	.	.	241
153	PA	Lancaster	1	.	.	.	.	.	423
154	PA	Pittsburgh-Beaver Valley	1	.	2	1	.	.	2468
155	PA	Reading	1	.	.	.	.	.	337
156	PA	Scranton-Wilkes-Barre	1	.	.	.	.	.	734
157	PA	Warren-Pleas.-Glade (In Warren Co)	.	.	1	.	.	.	. (See Warren Co, PA above)
158	PA	York	1	.	.	.	.	.	418
159	PA-DE-NJ-MD	Philadelphia-Wilmington-Trenton	1	1	.	.	.	.	6010
160	PA-NJ	Allentown-Bethlehem-Easton	1	.	1	.	.	.	687
161	PR	Guaynabo Co.	.	.	.	1	.	.	85
162	RI	Providence (all of RI)	1	.	.	.	.	.	1003
163	TN	Benton Co.	.	.	1	.	.	.	15
164	TN	Fayette Co.	.	.	.	.	1	.	26
165	TN	Humphreys Co.	.	.	1	.	.	.	16
166	TN	Memphis	1	.	.	.	1 (k)	.	826
167	TN	Nashville	1	.	.	.	1 (l)	.	881
168	TN	Polk Co.	.	.	1	.	.	.	14
169	TX	Beaumont-Port Arthur	1	.	.	.	.	.	361
170	TX	Dallas-Fort Worth	1	.	.	.	1 (m)	.	3561
171	TX	El Paso	1	1	.	1	.	.	592
172	TX	Houston-Galveston-Brazoria	1	.	.	.	.	.	3731
173	UT	Ogden	.	1	.	.	.	.	63
174	UT	Salt Lake City	1	.	1	1	.	.	914
175	UT	Tooele Co.	.	.	1	.	.	.	27
176	UT	Utah Co.	.	1	.	1	.	.	264
177	VA	Norfolk-Virg. Beach-Newport News	1	.	.	.	.	.	1366
178	VA	Richmond-Petersburg	1	.	.	.	.	.	738
179	VA	Smyth Co. (White Top Mtn.)	1	.	.	.	.	.	<1
180	WA	Olympia-Tumwater-Lacey	.	.	.	1	.	.	64
181	WA	Seattle-Tacoma	1	1	.	3	.	.	2539
182	WA	Spokane	.	1	.	1	.	.	279
183	WA	Wallula	.	.	.	1	.	.	2
184	WA	Yakima	.	.	.	1	.	.	93
185	WI	Door Co.	1	.	.	.	.	.	26
186	WI	Kewaunee Co.	1	.	.	.	.	.	19
187	WI	Manitowoc Co.	1	.	.	.	.	.	80
188	WI	Marathon Co.	.	.	1	.	.	.	115
189	WI	Milwaukee-Racine	1	.	.	.	.	.	1735
190	WI	Oneida Co.	.	.	1	.	.	.	32
191	WI	Sheboygan	1	.	.	.	.	.	104
192	WI	Walworth Co.	1	.	.	.	.	.	75
193	WV	Follansbee	.	.	.	1	.	.	3
194	WV	Greenbrier Co.	1	.	.	.	.	.	35
195	WV	New Manchester Gr. (In Hancock Co)	.	.	1	.	.	.	35 (Pop Hancock Co.)
196	WV	Wier.-Butler-Clay (In Hancock Co)	.	.	1	1	.	.	(See Hancock Co. above)
197	WV-KY	Huntington-Ashland	1	.	1	.	.	.	206
198	WY	Sheridan	.	.	.	1	.	.	14
			91	38	47	83	13	1	147,952

Table 5-2. Simplified Nonattainment Areas List[a] (cont.)

Notes: (a) This is a simplified listing of Classified Nonattainment areas. Unclassified and transitional nonattainment areas are not included. In certain cases, footnotes are used to clarify the areas involved. For example, the lead nonattainment area listed within the Dallas-Fort Worth ozone nonattainment area is in Frisco, Texas, which is not in Dallas county, but is within the designated boundaries of the ozone nonattainment area. Readers interested in more detailed information should use the official Federal Register citation (40 CFR 81).

(b) Names of nonattainment areas are listed alphabetically within each state. The largest city determines which state is listed first in the case of multiple-city nonattainment areas. When a larger nonattainment area, such as ozone, contains one or more smaller nonattainment areas, such as PM-10 or lead, the common name for the larger nonattainment area is used.

(c) Nonattainment area status as of September, 1994.

(d) Population figures were obtained from 1990 census data. For nonattainment areas defined as only partial counties, population figures for just the nonattainment area were used when these were available. Otherwise, whole county population figures were used. When a larger nonattainment area encompasses a smaller one, double-counting the population is avoided by only counting the population of the larger nonattainment area. Note that several smaller nonattainment areas may be inside one larger nonattainment area, as is the case in Figure 5-1, which is considered 1 nonattainment area. Caution must be used in these cases, as population figures will not be representative of small nonattainment areas for one pollutant inside larger nonattainment areas for another pollutant. Occasionally, two nonattainment areas may only partially overlap, as in Figure 5-2. For the purpose of this table, these are considered two distinct nonattainment areas.

(e) Lead nonattainment area is a portion of Jefferson county, Alabama.

(f) Lead nonattainment area is a portion of Franklin township, Marion county, Indiana.

(g) Lead nonattainment area is a portion of Dakota county, Minnesota.

(h) PM-10 nonattainment area is Granite City, Illinois, in Madison county.

(i) Lead nonattainment area is Herculaneum, Missouri in Jefferson county.

(j) Lead nonattainment area is a portion of Lewis and Clark county, Montana.

(k) Lead nonattainment area is a portion of Shelby county, Tennessee.

(l) Lead nonattainment area is a portion of Williamson county, Tennessee.

(m) Lead nonattainment area is Frisco, Texas, in Collin county.

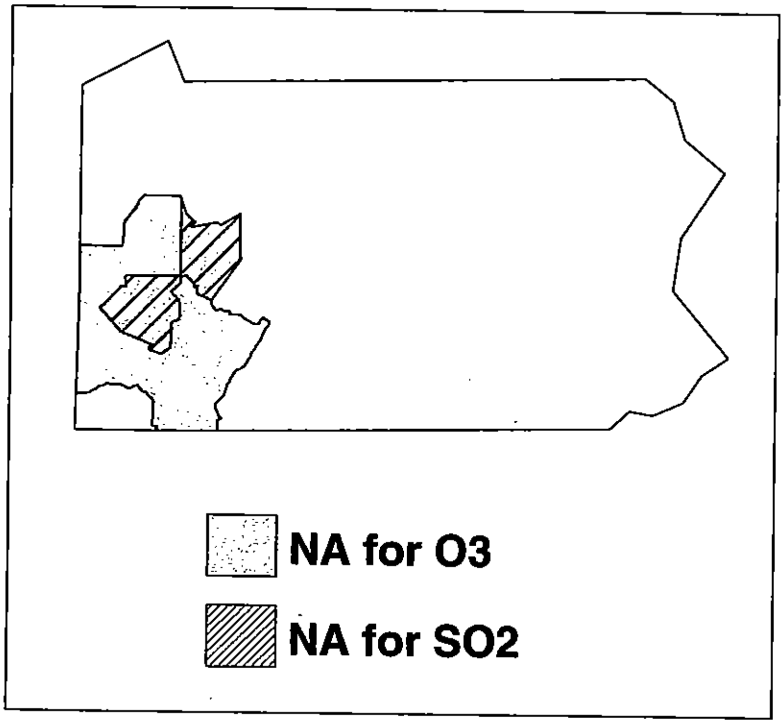


Figure 5-1. Example of multiple nonattainment (NA) areas within a larger NA area (two SO_2 NA areas inside the Pittsburgh-Beaver Valley ozone NA area, counted as one area).

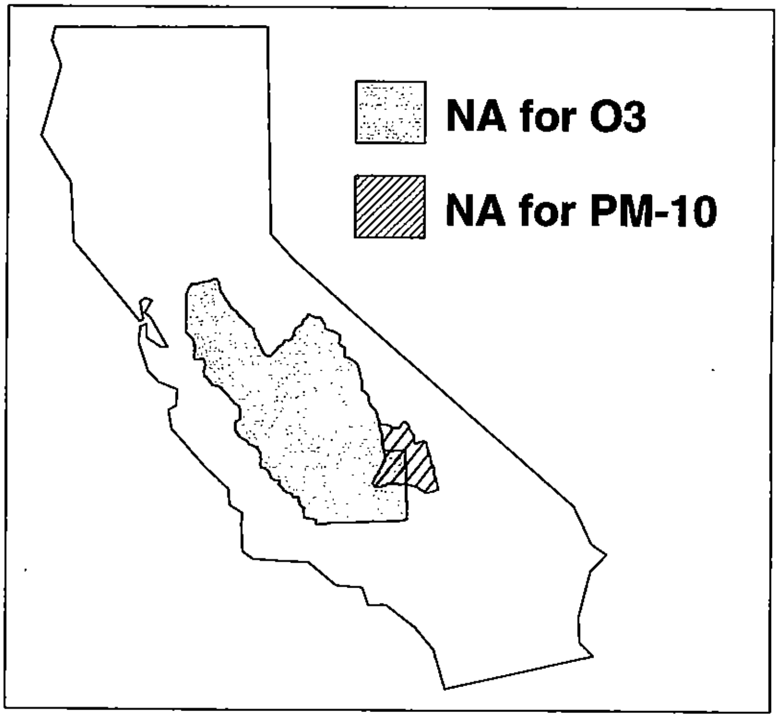
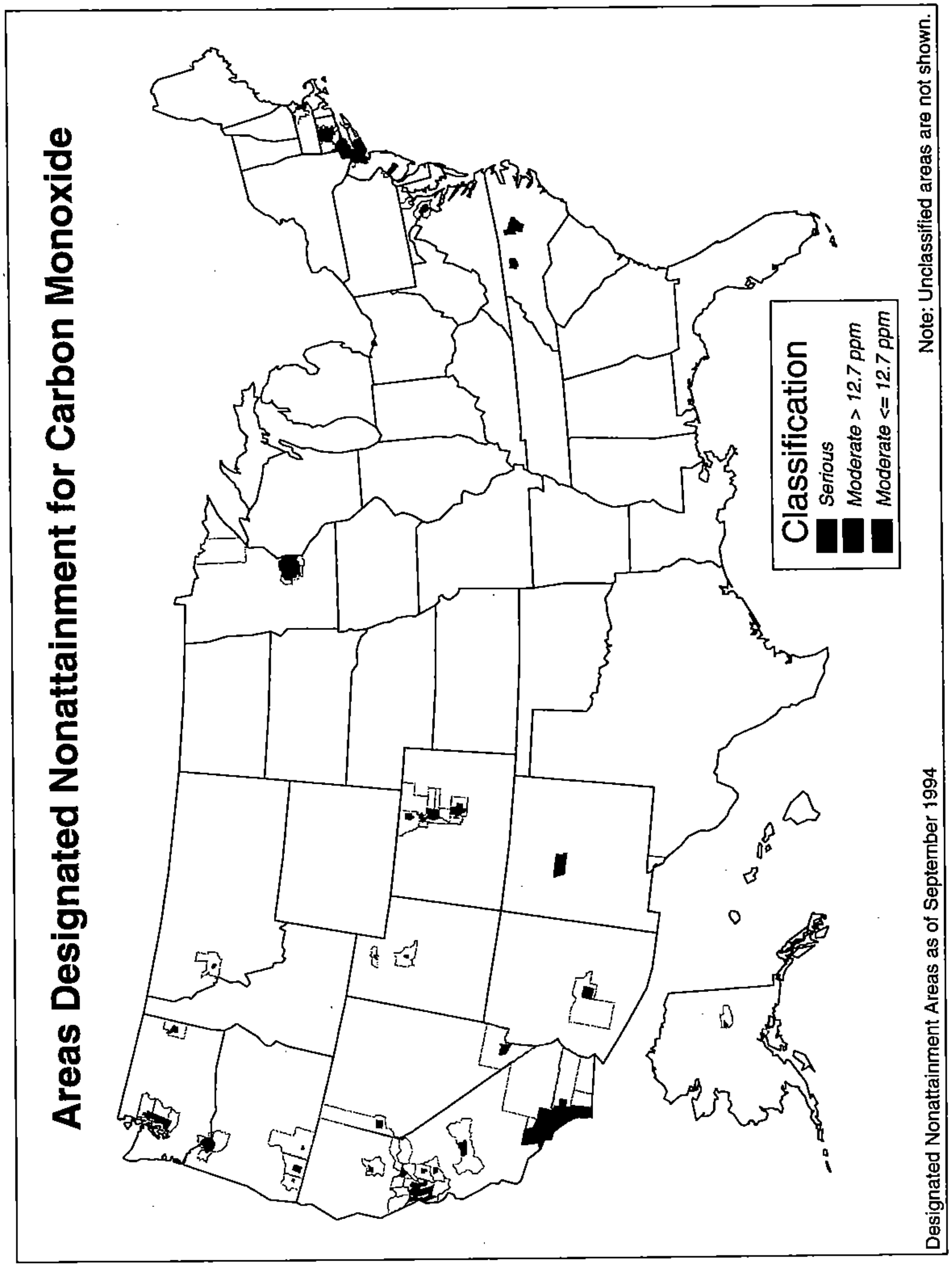


Figure 5-2. Example of overlapping NA areas (Searles Valley PM-10 NA area partially overlaps the San Joaquin Valley ozone NA area, counted as two areas).



Designated Nonattainment Areas as of September 1994

Note: Unclassified areas are not shown.

Figure 5-3. Areas designated nonattainment for carbon monoxide.

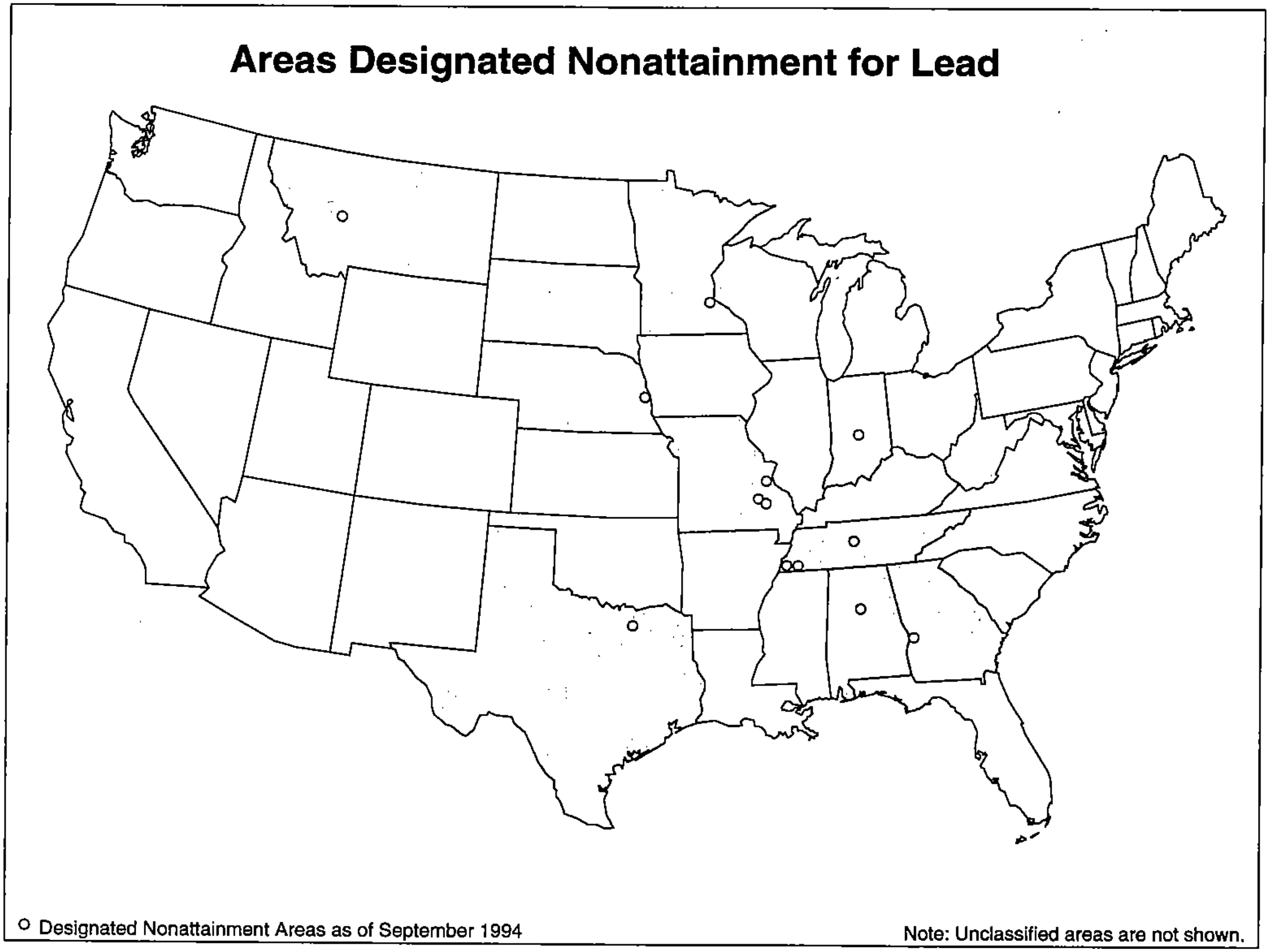
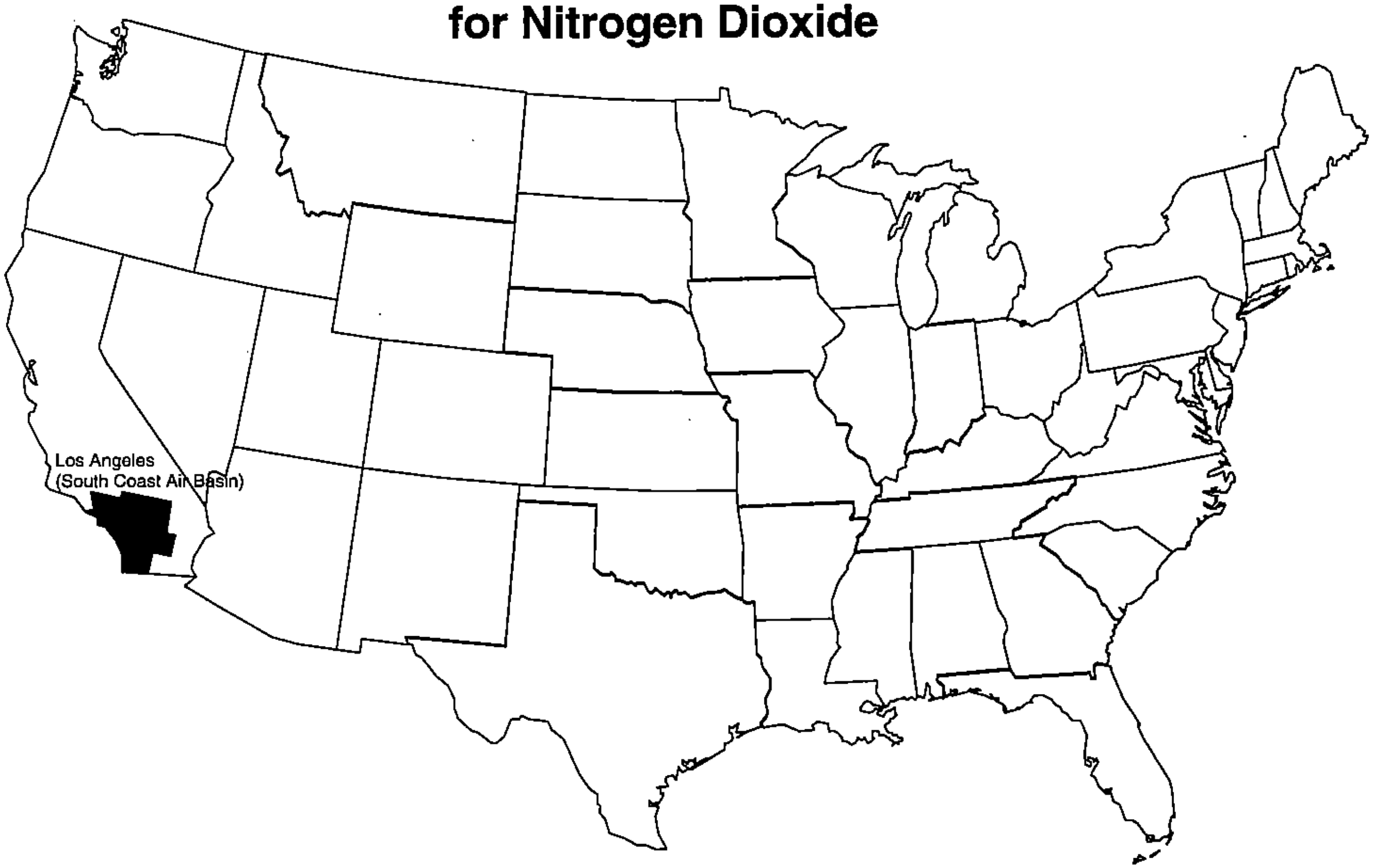


Figure 5-4. Areas designated nonattainment for lead.

Los Angeles is the only Area Designated Nonattainment for Nitrogen Dioxide



Designated Nonattainment Area as of September 1994

Note: Unclassified areas are not shown.

Figure 5-5. Area (Los Angeles) dsignated nonattainment for nitrogen dioxide.

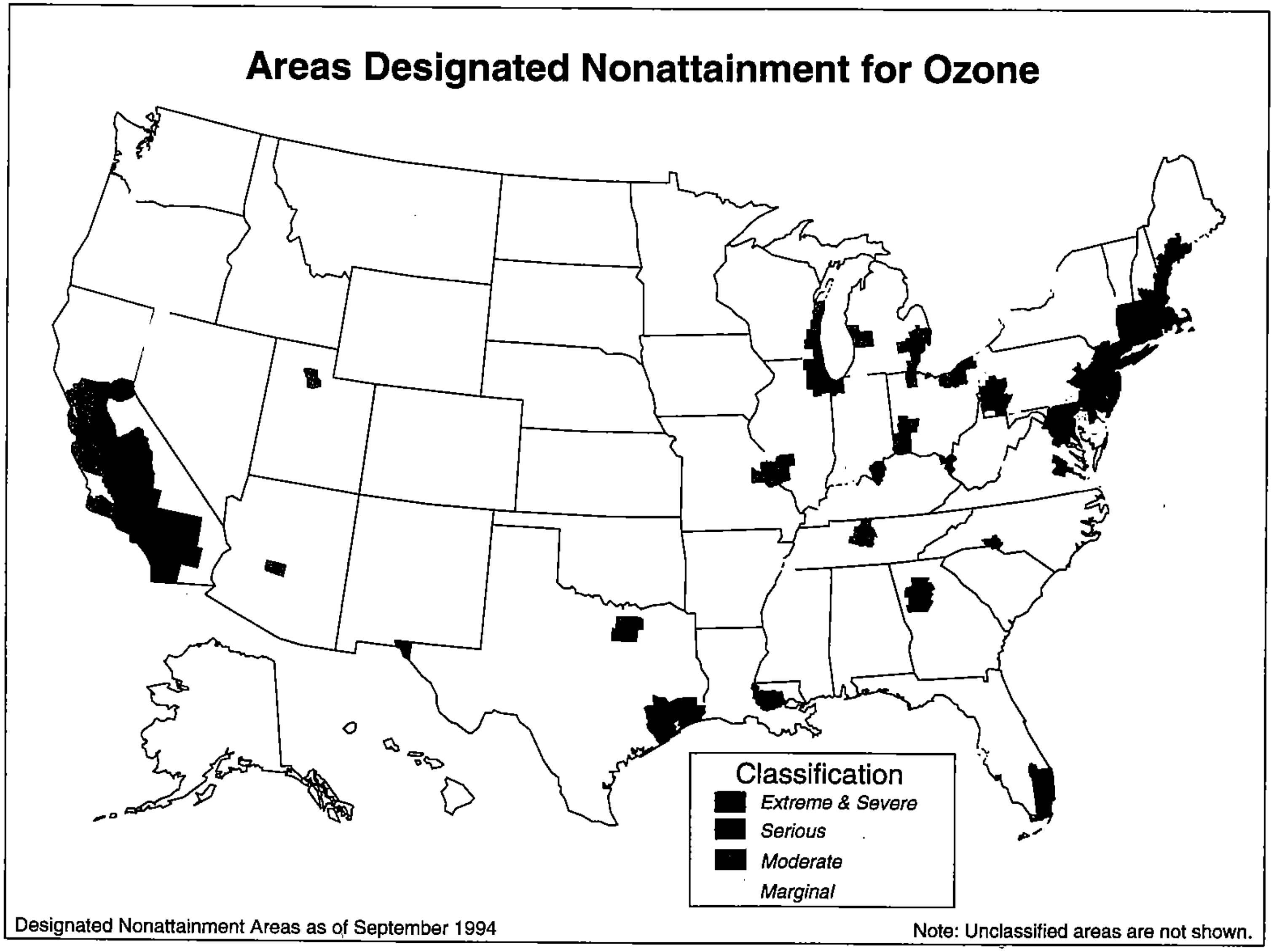


Figure 5-6. Areas designated nonattainment for ozone.

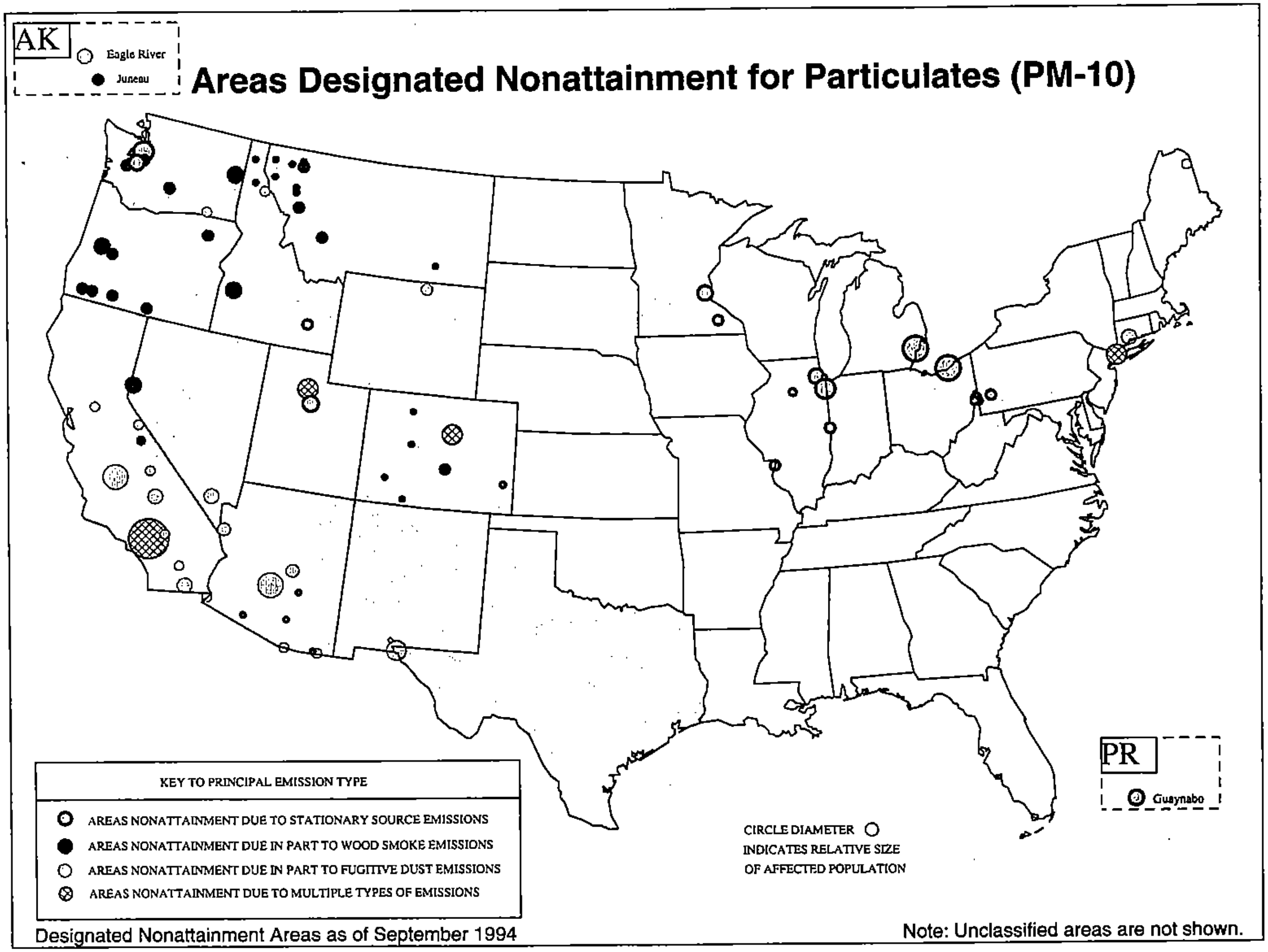
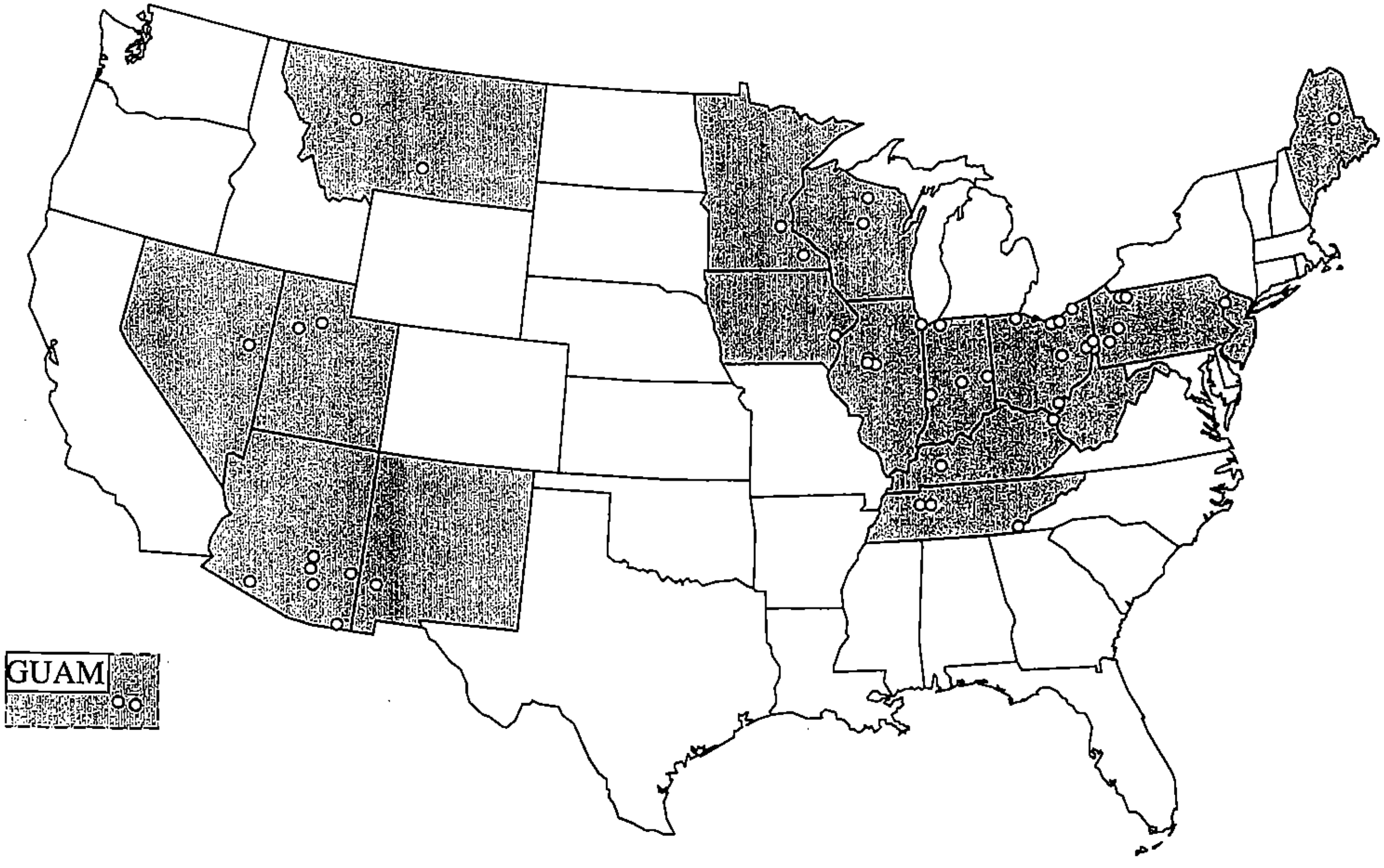


Figure 5-7. Areas designated nonattainment for PM-10 particulates, by emission type.

Areas Designated Nonattainment for Sulfur Dioxide



○ Designated Nonattainment Areas as of September 1994

Note: Unclassified areas are not shown.

Figure 5-8. Areas designated nonattainment for sulfur dioxide.

5.2 Population Estimates for Counties Not Meeting NAAQS, 1993

Figure 5-9 provides an estimate of the number of people living in counties in which the levels of the primary NAAQS were not met during 1993. These estimates use a single-year interpretation of the NAAQS to indicate the current extent of the problem for each pollutant. This single year approach provides a convenient snapshot for the most recent year, but it should be noted that attainment of these standards requires more than just one year of data to fully account for variations in emissions and meteorological conditions. The methodology used to determine the counties not meeting the single-year ozone NAAQS was changed this year to use the second daily maximum concentration rather than the number of estimated exceedances. This change was made in order to employ the same methodology in these estimates as in the county maps that follow. To review the NAAQS for each pollutant, see Chapter 2, Table 2-1.

Figure 5-9 demonstrates that O_3 was the most pervasive air pollution problem in 1993 for the United States with an estimated 51.3 million people living in counties which did not meet the O_3 standard. This estimate is an increase of 8.7 million from last year's revised estimate of 42.6 million people for O_3. Even with this increase, the total is still the second lowest population estimate during this 10-year period and is substantially lower than the 112 million people living in areas which did not meet the ozone NAAQS in 1988. The increase between 1992 and 1993 is likely due in part to meteorological conditions more conducive to O_3 formation in 1993, especially in the eastern half of the country.

Carbon monoxide has the next largest total with 11.6 million, down from last year's estimate of 14.3 million. PM-10 follows with 9.4 million, down significantly from 25.8 million people in 1992. This decrease for PM-10 is due to sixteen counties which met the NAAQS in 1993, six of which had large populations, including Los Angeles, Chicago and Phoenix. Pb is next with 5.5 million and SO_2 with 1.4 million people. Both Pb and SO_2 recorded small increases. Finally, this is the second consecutive year that no monitoring violations of the NO_2 NAAQS were recorded.

A total of 59.1 million persons resided in counties not meeting at least one air quality standard during 1993

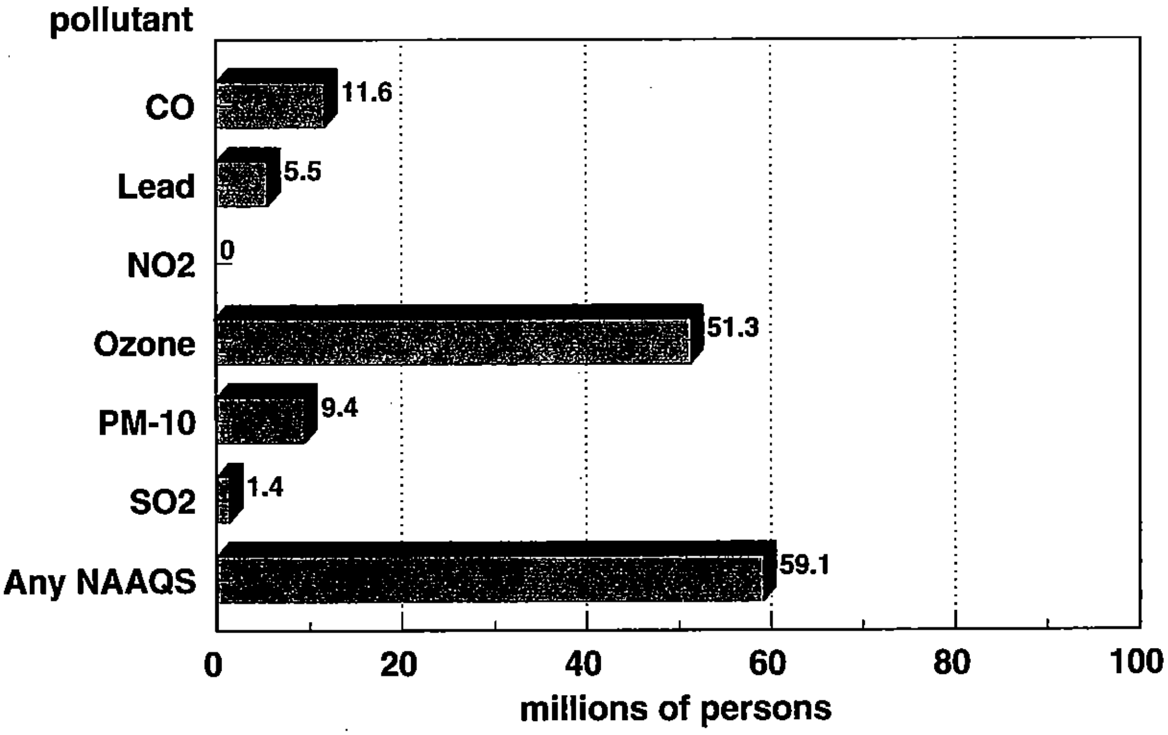


Figure 5-9. Number of persons living in counties with air quality levels not meeting the primary NAAQS in 1993. (Based on 1990 population data and 1993 air quality data.)

(out of a total 1990 population of 249 million). This estimate is up 15 percent from the revised estimate of 51.4 million people for 1992.

These population estimates are intended to provide a relative measure of the extent of the problem for each pollutant in 1993. The limitations of this single-year indicator should be recognized. An individual living in a county that violates an air quality standard may not actually be exposed to unhealthy air. For example, if CO violations were confined to a traffic-congested center city location during evening rush hours in the winter, it is possible that an individual may never be in that area, or may be there only at other times of the day or during other seasons. The lead monitors typically reflect the impact of lead sources in the immediate vicinity of the monitoring location and may not be representative of county-wide air quality. However, it is worth noting that ozone, which appears to be the most pervasive pollution problem by this measure, is also the pollutant most likely to have fairly uniform concentrations throughout an area. The limitations of using only a single year of data were noted previously.

The assumptions and methodology used in any population estimate can, in some cases, yield a wide swing in the estimate. For example, while there are an estimated 51 million people living in counties that had 1993 ozone data not meeting the ozone NAAQS, there are an estimated 140 million people living in EPA designated ozone nonattainment areas, based on air quality data from the years 1987-89. Although these numbers are properly qualified, with such a large difference, it is important to highlight some of the factors involved in these estimates. The estimate of 51 million people only considers data from the single year, 1993, and only considers counties with ozone monitoring data. Presently, counties with ozone monitors contain 66 percent of the total U.S. population (counties with monitors for any pollutant comprise 77 percent). In contrast, designated ozone nonattainment areas are typically based upon three years of data to ensure a broader representation of possible meteorological conditions. This use of multiple years of data, rather than a single year, is based on the procedure for determining attainment of the ozone NAAQS.

Another difference is that the estimate of 51 million people living in counties with air quality levels not meeting the ozone NAAQS only considers counties that had ozone monitoring data for 1993. There were only 925 ozone monitors reporting in 1993. These monitors were located in 538 counties, which clearly falls far short of the more than 3,100 counties in the United States. This shortfall is not as bad as it may initially appear because it is often possible to take advantage of other air quality considerations in interpreting the monitoring data. This, in fact, is why other factors are considered in determining nonattainment areas. Ozone tends to be an area-wide problem with fairly similar levels occurring across broad regions. Because ozone is not simply a localized hot-spot problem, effective ozone control strategies have to incorporate a broad view of the problem. Nonattainment boundaries may consider other air quality related information, such as emission inventories and modeling, and may extend beyond those counties with monitoring data to more fully characterize the ozone problem and to facilitate the development of an adequate control strategy.

Since the early 1970s, there has been a growing awareness that ozone and ozone precursors are transported beyond the political jurisdiction of source areas and affect air quality levels at considerable distances downwind. The transport of ozone concentrations generated from urban man-made emissions of precursors in numerous areas to locations further downwind can result in rather widespread areas of elevated levels of ozone across regional spatial scales.

5.3 Maps of Peak Air Quality Levels by County, 1993

This section presents air quality maps that show how air quality varied across the country during 1993. For each pollutant, the maps display the highest concentration recorded for that air quality indicator among all monitoring sites in the county. The following annual air quality statistics are displayed for each pollutant:

CO – The highest second maximum eight-hour average concentration.

Pb – The highest quarterly average concentration.

NO_2 – The highest annual mean concentration.

O_3 – The highest second daily maximum one-hour concentration.

PM-10 – The highest second maximum 24-hour average concentration.

SO – The highest second maximum 24-hour concentration.

These pollutant concentration maps appear as Figures 5-10 through 5-15.

The bar chart accompanying each map displays the number of people living in counties within each pollutant concentration range. For all of the pollutants except PM-10, the sum of the yellow and red bars equals the height of the population bars in Figure 5-9 for the corresponding pollutant. For PM-10, the map displays the second highest 24-hour concentration in the county, however, there are additional counties not shown on the map that failed to meet the annual mean standard in 1993. Thus, except for PM-10, the reader can use these maps to identify those counties not meeting the NAAQS during 1993 that compose the population estimate for each pollutant.

The Pollutant Standards Index (PSI) colors are employed in the following maps to provide a readily identifiable and consistent color scheme throughout. The PSI is a uniform air quality index used for the daily reporting of air pollution concentrations in most major U.S. cities. The "cooler" PSI colors (blue and green) indicate air quality that is "better" than the level of the corresponding air quality standard. The "warmer" colors (yellow, orange, red) denote air quality levels that do not meet the NAAQS for that pollutant. A complete discussion of the PSI can be found in the following chapter.

Table 5-3. Number of Counties With at Least One Monitoring Site by Pollutant

Pollutant	Number of Counties With at Least One Monitoring Site
Carbon Monoxide	250
Lead	187
Nitrogen Dioxide	213
Ozone	537
Particulate Matter (PM-10)	647
Sulfur Dioxide	359

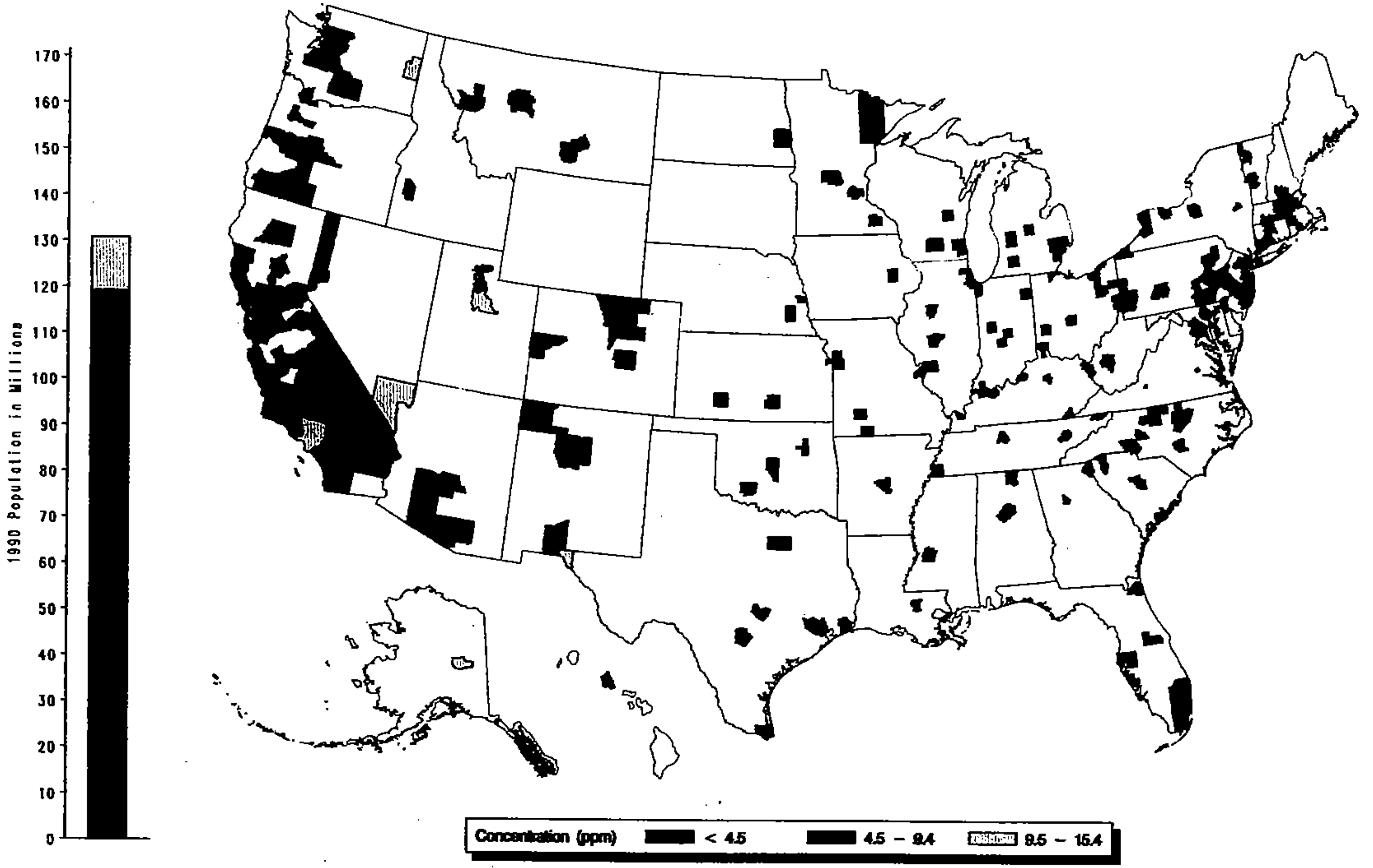


Figure 5-10. Carbon monoxide air quality concentrations, 1993—highest second maximum eight-hour average.

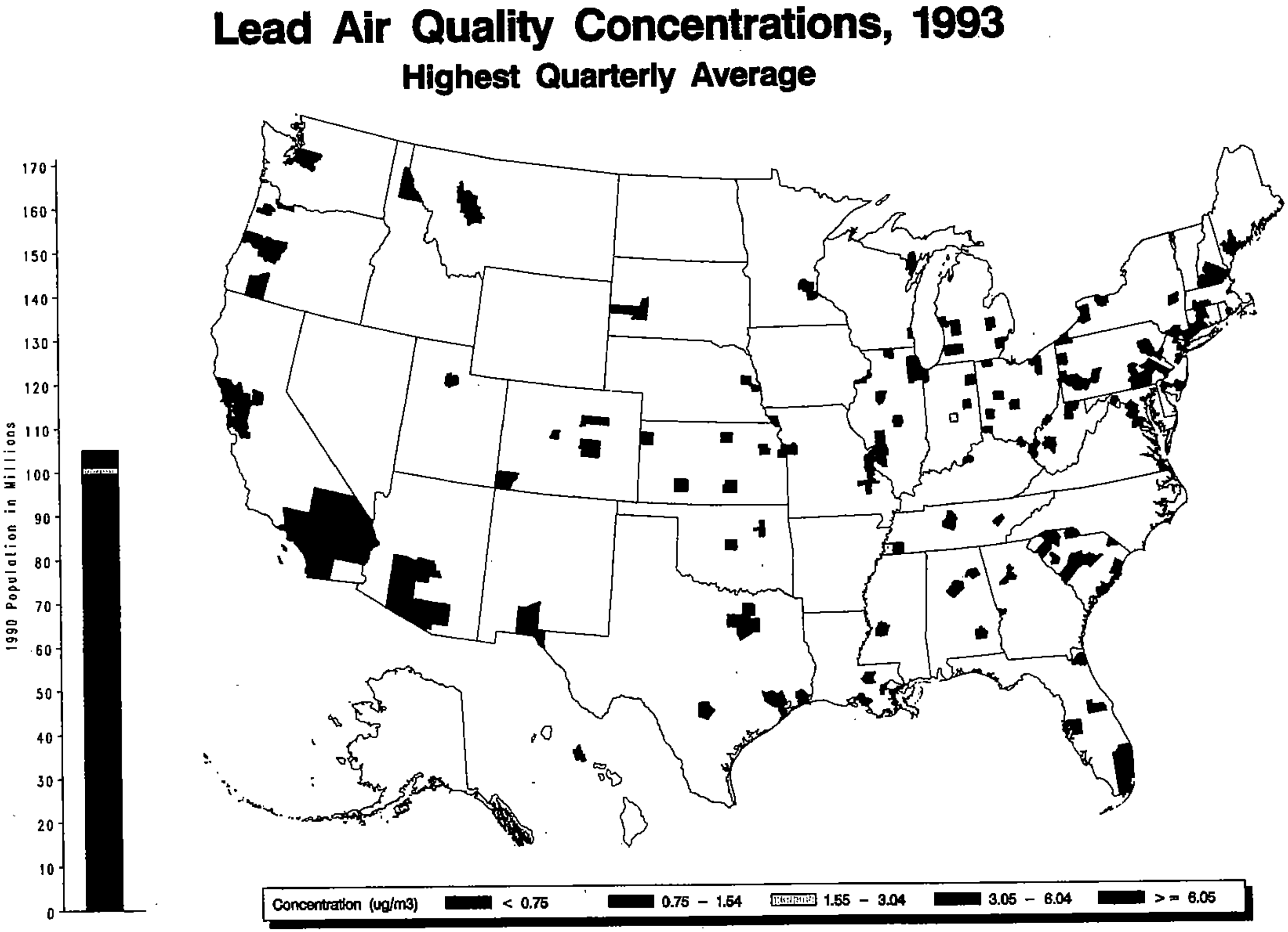
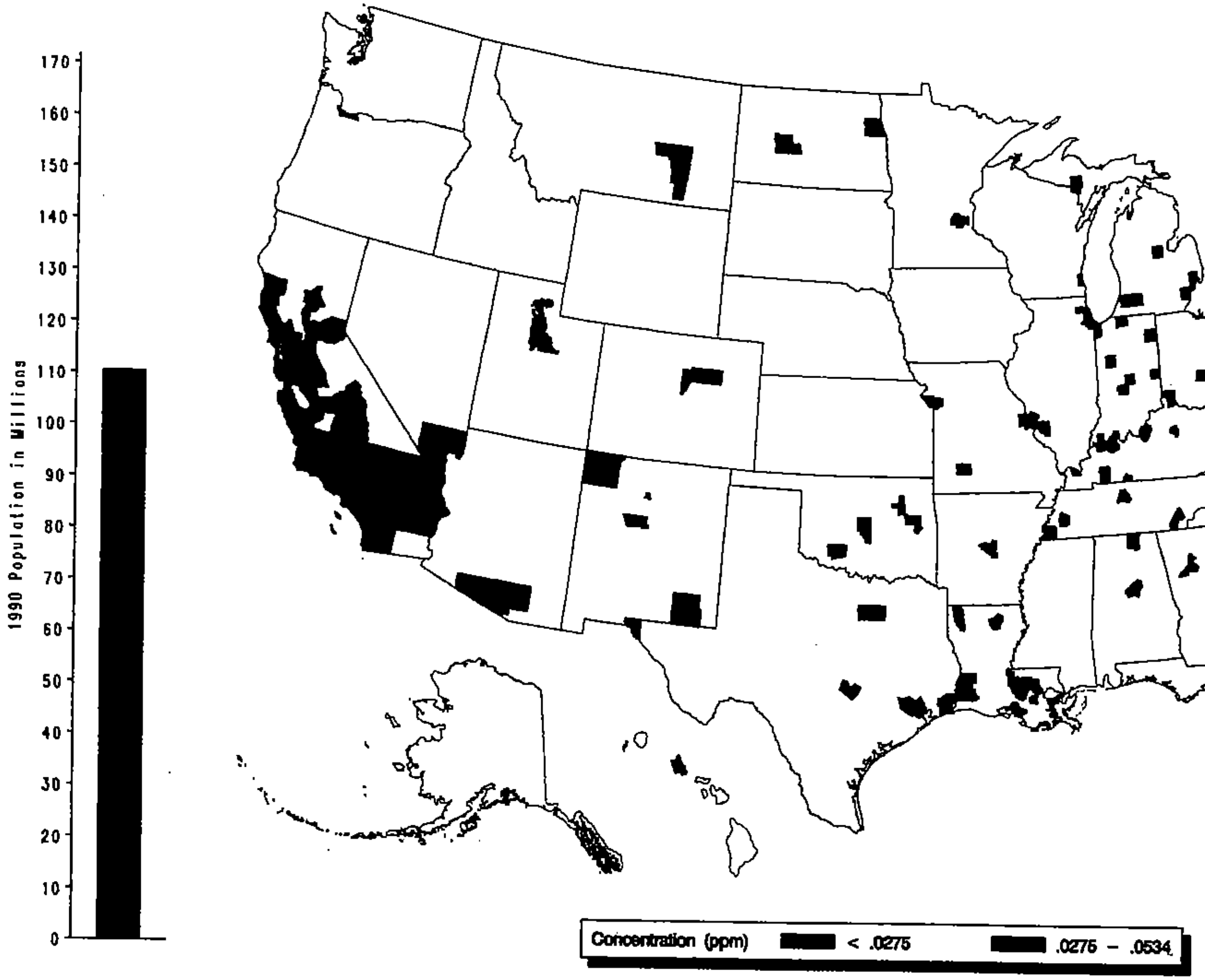


Figure 5-11. Lead air quality concentrations, 1993—highest quarterly average.



Nitrogen Dioxide Air Quality Concentrations, 1993

Highest Arithmetic Mean

Figure 5-12. Nitrogen dioxide air quality concentrations, 1993—highest arithmetic mean.

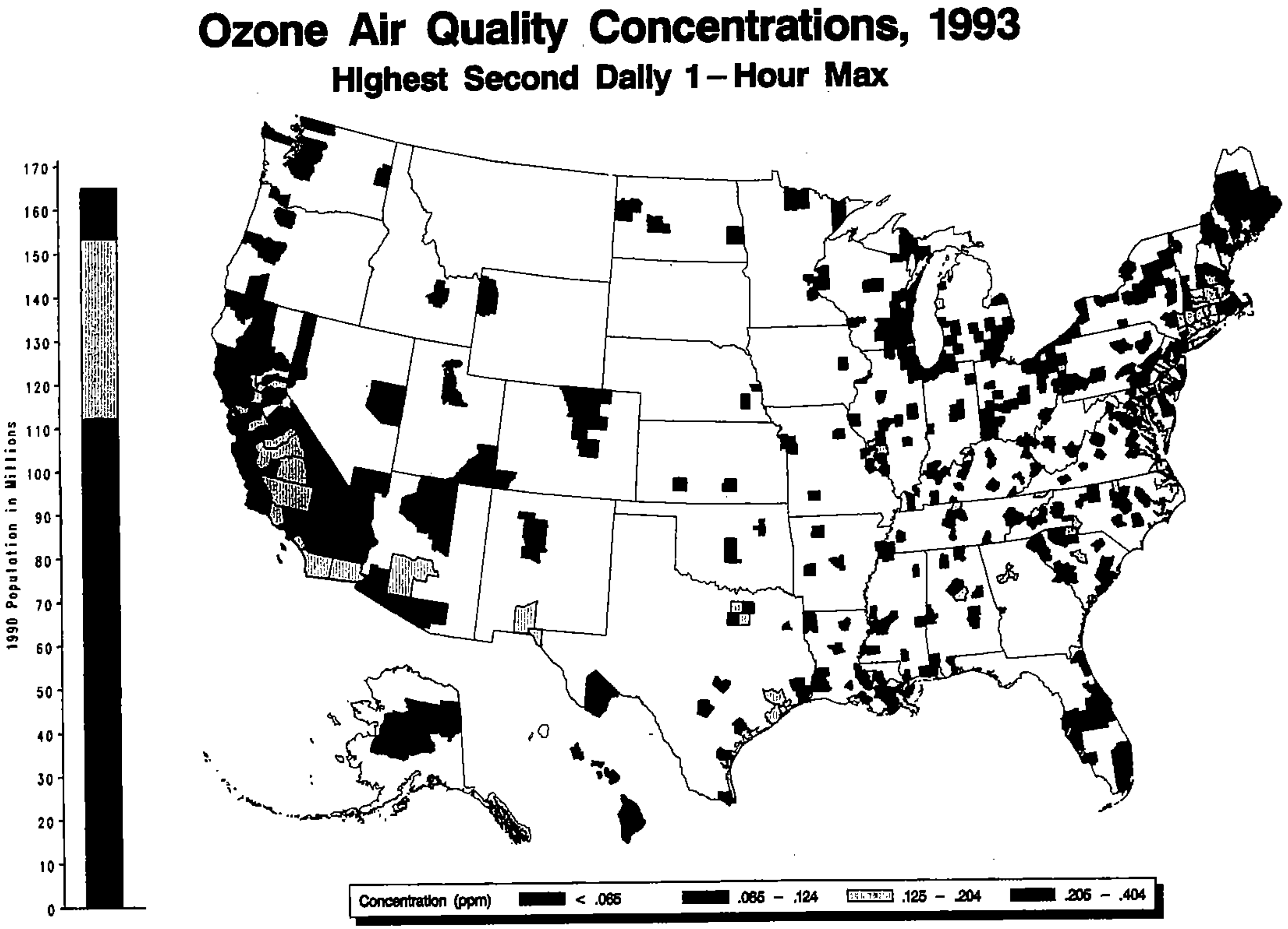


Figure 5-13. Ozone air quality concentrations, 1993—highest second daily one-hour maximum.

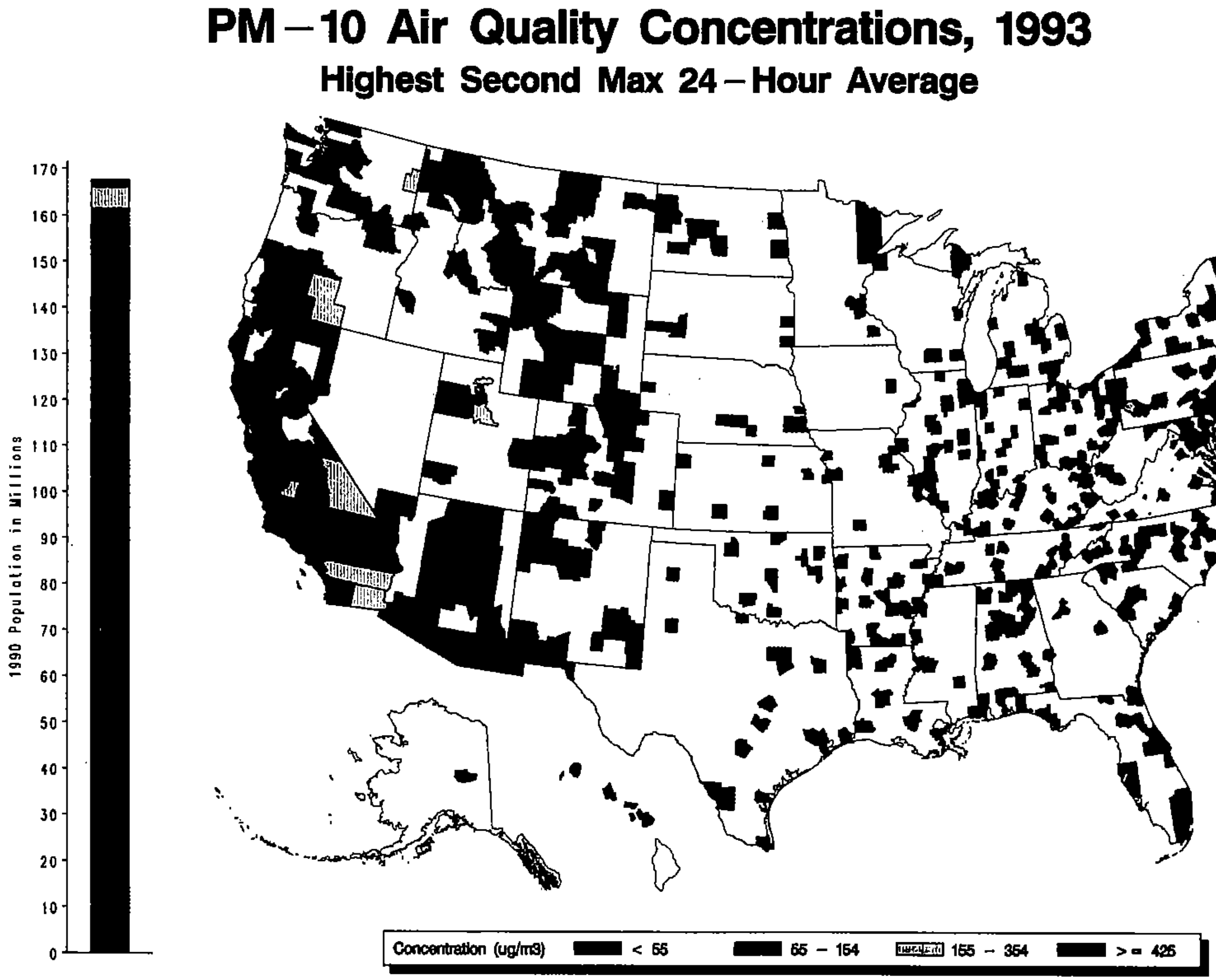


Figure 5-14. PM-10 air quality concentrations, 1993—highest second maximum 24-hour average.

Sulfur Dioxide Air Quality Concentrations, 1993

Highest Second Max 24-Hour Average

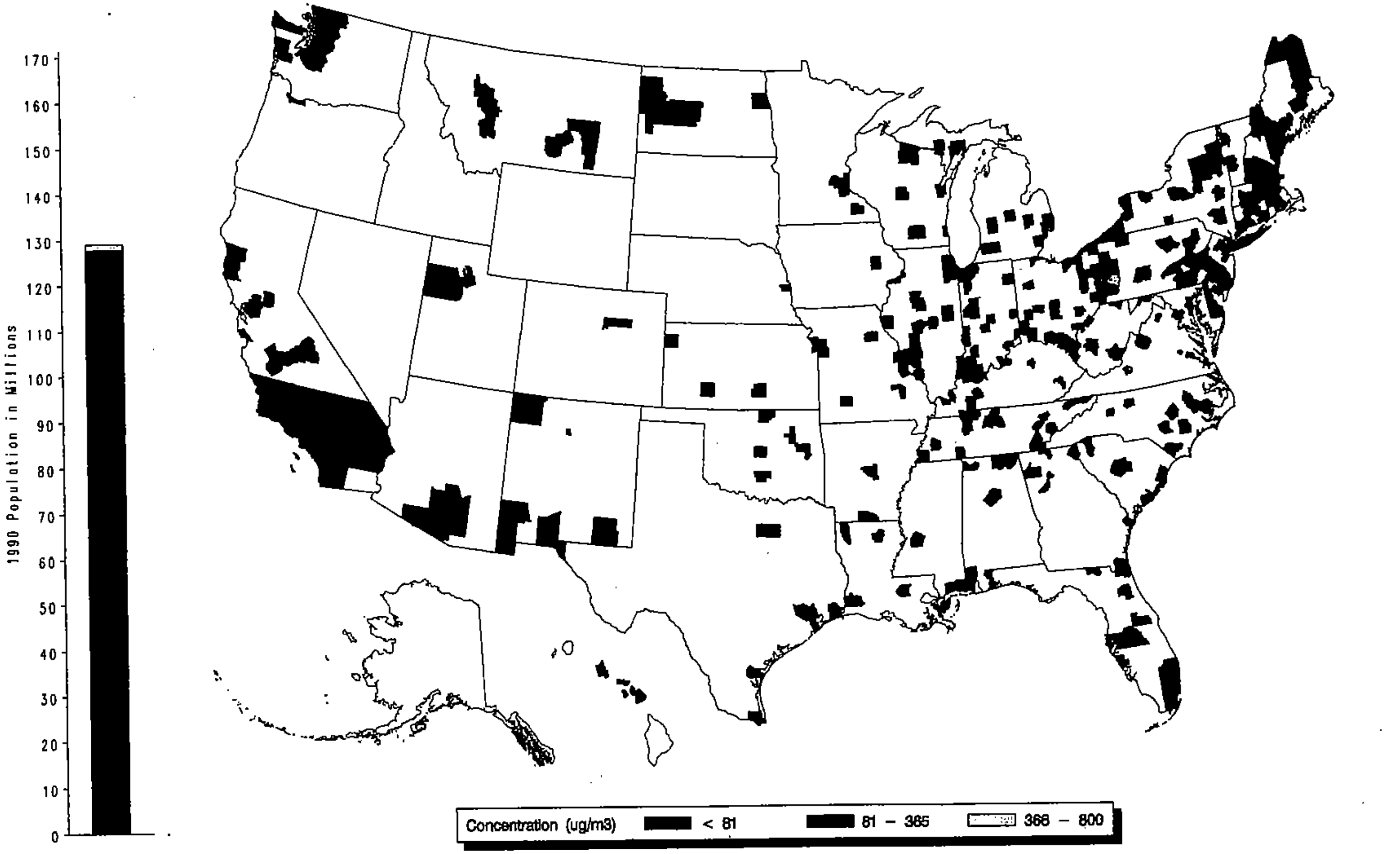


Figure 5-15. Sulfur dioxide air quality concentrations, 1993—highest second maximum 24-hour average.

5.4 Metropolitan Statistical Area (MSA) Air Quality Summary, 1993

This section provides information for general air pollution audiences on 1993 air quality levels in each MSA in the United States. Generally, an MSA is an area comprising a large population center with adjacent communities that have a high degree of economic and social integration with the urban center. MSAs contain a central county(ies), and any adjacent counties with at least 50 percent of their population in the urbanized area.[1] Although MSAs compose only 19 percent of the land area in the United States, they account for 79 percent of the total population of 249 million in 1990.

At the end of this chapter, Table 5-4 presents a summary of the highest air quality levels measured in each MSA during 1993. Individual MSAs are listed to provide more extensive spatial coverage for large metropolitan complexes. The MSA names and population estimates have been revised this year to reflect the 1993 revisions based on the most recent census data. The 330 MSAs are listed alphabetically, with the 1990 population estimate and air quality statistics for each pollutant. Concentrations above the level of the respective NAAQS are shown in ***bold italic*** type.

In the case of O_3, the problem is regional in scale, and the high values associated with the pollutant can reflect a large part of the MSA. However in many cases, peak ozone concentrations occur downwind of major urban areas, e.g., peak ozone levels attributed to the Chicago metropolitan area are recorded in and near Kenosha, Wisconsin. In contrast, high CO values generally are localized and reflect areas with heavy traffic. The scale of measurement for the pollutants — PM-10, SO_2 and NO_2 — falls somewhere in between. Finally, while Pb measurements generally reflect Pb concentrations near roadways in the MSA, if a monitor is located near a point source of lead emissions it can produce readings substantially higher. Such is the case in several MSAs. Lead monitors located near a point source are footnoted accordingly in Table 5-4.

The pollutant-specific statistics reported in this section are for a single year of data. For example, if an MSA has three ozone monitors in 1993 with second highest daily hourly maxima of 0.15 ppm, 0.14 ppm and 0.12 ppm, the highest of these, 0.15 ppm, would be reported for that MSA. The associated primary NAAQS concentrations for each pollutant are summarized in Table 2-1.

The same annual data completeness criteria used in the air quality trends data base for continuous data were used here for the calculation of annual means, i.e., 50 percent of the required samples for SO_2 and NO_2. If some data have been collected at one or more sites, but none of these sites meet the annual data completeness criteria, then the reader will be advised that there are insufficient data to calculate the annual mean. With respect to the summary statistics on air quality levels with averaging times less than or equal to 24 hours, all sites are included, even if they do not meet the annual data completeness requirement.

For PM-10 and Pb, the arithmetic mean statistics are based on 24-hour measurements, which are typically obtained from a systematic sampling schedule. In contrast to the trends analyses in Chapter 3 which used a more relaxed indicator, only maximum quarterly average Pb concentrations meeting the AIRS validity criteria are displayed in Table 5-4.

5.5 References

1. *Statistical Abstract of the United States*, 1993, U.S. Department of Commerce, U.S. Bureau of the Census, Appendix II.
2. *Code of Federal Regulations*, 40 CFR Part 81.

The reader is cautioned that this summary is not adequate in itself to numerically rank MSAs according to their air quality. The monitoring data represent the quality of the air in the vicinity of the monitoring site but may not necessarily represent urban-wide air quality.

Table 5-4. 1993 Metropolitan Statistical Area Air Quality Factbook Peak Statistics for Selected Pollutants by MSA

METROPOLITAN STATISTICAL AREA	1990 POPULATION	CO 8-HR (PPM)	PB QMAX (UGM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PM10 WTD AM (UGM)	PM10 2ND MAX (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)
ABILENE, TX	119,655	ND	ND	ND	ND	ND	ND	ND	ND
AGUADILLA, PR	156,000	ND	ND	ND	ND	ND	ND	ND	ND
AKRON, OH	436,905	4	0.08	ND	0.11	27	69	0.015	0.056
ALBANY, GA	112,561	ND	ND	ND	ND	ND	ND	ND	ND
ALBANY-SCHENECTADY-TROY, NY	874,304	4	0.03	ND	0.11	23	57	0.006	0.028
ALBUQUERQUE, NM	480,577	9	ND	0.024	0.09	35	72	ND	ND
ALEXANDRIA, LA	131,556	ND	ND	ND	ND	ND	ND	ND	ND
ALLENTOWN-BETHLEHEM-EASTON, PA	686,688	4	0.18	0.021	0.11	28	71	0.009	0.034
ALTOONA, PA	130,542	2	ND	0.015	0.10	23	62	0.009	0.052
AMARILLO, TX	187,547	ND	ND	ND	ND	16	29	ND	ND
ANCHORAGE, AK	226,338	***10***	ND	ND	ND	39	***174*** (a)	ND	ND
ANN ARBOR, MI	282,937	ND	ND	ND	0.10	IN	48	ND	ND
ANNISTON, AL	116,034	ND	ND	ND	ND	25	69	ND	ND
APPLETON-OSHKOSH-NEENAH, WI	315,121	3	ND	ND	0.08	ND	ND	ND	ND
ARECIBO, PR	140,608	ND	ND	ND	ND	ND	ND	0.005	0.019
ASHEVILLE, NC	174,821	ND	ND	ND	0.08	22	68	ND	ND
ATHENS, GA	156,267	ND	ND	ND	ND	ND	ND	ND	ND
ATLANTA, GA	2,833,511	5	0.02	0.025	***0.16***	28	77	0.007	0.044
ATLANTIC-CAPE MAY, NJ	319,416	5	0.03	ND	0.12	30	58	0.003	0.014
AUGUSTA-AIKEN, GA-SC	396,809	ND	0.01	ND	0.10	22	51	ND	ND
AURORA-ELGIN, IL	356,884	ND	ND	ND	ND	ND	ND	ND	ND
AUSTIN-SAN MARCOS, TX	781,572	3	ND	0.017	0.09	20	52	ND	ND
BAKERSFIELD, CA	543,477	5	ND	0.027	***0.16***	***54***	128	0.002	0.010
BALTIMORE, MD	2,382,172	7	0.04	0.033	***0.15***	35	70	0.009	0.031
BANGOR, ME	88,745	ND	ND	ND	0.10	22	68	ND	ND
BARNSTABLE-YARMOUTH, MA	94,132	ND	ND	ND	ND	ND	ND	ND	ND
BATON ROUGE, LA	528,264	9	0.08	0.018	***0.13***	26	52	0.006	0.025
BEAUMONT-PORT ARTHUR, TX	361,226	3	0.03	0.010	0.12	22	56	0.008	0.059
BELLINGHAM, WA	127,780	ND	ND	ND	0.08	21	51	0.005	0.017
BENTON HARBOR, MI	161,378	ND	ND	ND	0.09	ND	ND	ND	ND
BERGEN-PASSAIC, NJ	1,278,440	6	0.03	0.029	0.11	37	80	0.009	0.028
BILLINGS, MT	113,419	7	ND	ND	ND	26	57	0.026	0.116
BILOXI-GULFPORT-PASCAGOULA, MS	197,125	ND	ND	ND	0.09	20	50	0.006	0.029
BINGHAMTON, NY	264,497	ND	ND	ND	ND	20	55	ND	ND
BIRMINGHAM, AL	907,810	8	0.30 (b)	0.012	***0.13***	36	85	0.009	0.050
BISMARCK, ND	83,831	ND	ND	ND	ND	19	45	ND	ND
BLOOMINGTON, IN	108,978	ND	ND	ND	ND	ND	ND	ND	ND
BLOOMINGTON-NORMAL, IL	129,180	ND	ND	ND	ND	ND	ND	ND	ND
BOISE CITY, ID	205,775	7	ND	ND	ND	39	91	ND	ND
BOSTON, MA-NH	2,870,669	5	0.03	0.034	***0.13***	21	86	0.011	0.044

BOULDER-LONGMONT, CO	225,339	6	ND	ND	0.10	25	81	ND	ND
BRAZORIA, TX	391,707	ND	ND	ND	***0.13***	ND	ND	ND	ND
BREMERTON, WA	189,731	ND	ND	ND	ND	ND	ND	ND	ND
BRIDGEPORT, CT	443,722	4	0.02	0.024	***0.17***	21	50	0.010	0.035
BROCKTON, MA	189,478	ND	ND	ND	0.11	ND	ND	ND	ND
BROWNSVILLE-HARLINGEN-SAN BENITO, TX	260,120	4	ND	ND	0.03	27	67	IN	0.004
BRYAN-COLLEGE STATION, TX	121,862	ND	ND	ND	ND	ND	ND	ND	ND
BUFFALO-NIAGARA FALLS, NY	1,189,288	4	0.05	0.019	0.09	23	69	0.011	0.049
BURLINGTON, VT	131,439	4	ND	0.017	ND	20	46	0.003	0.011
CAGUAS, PR	173,961	ND	ND	ND	ND	ND	ND	ND	ND
CANTON-MASSILLON, OH	394,106	3	ND	ND	0.11	29	66	0.010	0.046
CASPER, WY	61,226	ND	ND	ND	ND	18	41	ND	ND
CEDAR RAPIDS, IA	168,767	4	ND	ND	0.07	22	49	0.005	0.066
CHAMPAIGN-URBANA, IL	173,025	ND	ND	ND	0.07	22	50	0.004	0.016
CHARLESTON-NORTH CHARLESTON, SC	506,875	6	0.02	0.012	0.11	26	58	0.004	0.025
CHARLESTON, WV	250,454	2	0.02	IN	0.08	29	62	0.009	0.041
CHARLOTTE-GASTONIA-ROCK HILL, NC-SC	1,162,093	7	0.01	0.017	***0.14***	30	54	ND	ND
CHARLOTTESVILLE, VA	131,107	ND	ND	ND	ND	24	54	ND	ND
CHATTANOOGA, TN-GA	433,210	ND	ND	ND	0.11	32	63	ND	ND
CHEYENNE, WY	73,142	ND	ND	ND	ND	25	49	ND	ND
CHICAGO, IL	6,069,974	6	0.65 (c)	0.031	0.11	47	147	0.009	0.065
CHICO-PARADISE, CA	182,120	5	ND	0.016	0.09	27	78	ND	ND
CINCINNATI, OH-KY-IN	1,452,645	5	0.05	0.026	0.11	35	90	0.015	0.065
CLARKSVILLE-HOPKINSVILLE, TN-KY	169,439	ND	ND	ND	ND	ND	ND	0.010	0.058
CLEVELAND-LORAIN-ELYRIA, OH	2,202,069	5	***16.10*** (d)	0.028	0.12	48	154	0.015	0.072

CO = HIGHEST SECOND MAXIMUM NON-OVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.5 ug/m3)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PM10 = HIGHEST WEIGHTED ANNUAL MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m3)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 150 ug/m3)
SO2 = HIGHEST ANNUAL MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

WTD = WEIGHTED
AM = ANNUAL MEAN
UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

(a) - Includes data flagged as a possible exceptional event.

(b) - Impact from an industrial source in Leeds, AL. Highest population oriented site in Birmingham, AL is 0.07 ug/m3.

(c) - Impact from an industrial source in Chicago, IL. Highest population oriented site in Chicago, IL is 0.10 ug/m3.

(d) - Impact from an industrial source in Cleveland, OH. This facility has been shutdown. Highest site in Cleveland, OH is 0.10 ug/m3.

Table 5-4. 1993 Metropolitan Statistical Area Air Quality Factbook Peak Statistics for Selected Pollutants by MSA (cont.)

METROPOLITAN STATISTICAL AREA	1990 POPULATION	CO 8-HR (PPM)	PB QMAX (UGM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PM10 WTD AM (UGM)	PM10 2ND MAX (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)
COLORADO SPRINGS, CO	397,014	6	0.02	ND	0.07	30	113	ND	ND
COLUMBIA, MO	112,379	ND	ND	ND	ND	ND	ND	ND	ND
COLUMBIA, SC	453,331	6	0.03	0.013	***0.13***	41	125	0.003	0.016
COLUMBUS, GA-AL	243,072	ND	1.01 (e)	ND	0.09	25	50	ND	ND
COLUMBUS, OH	1,377,419	5	0.04	0.012	0.11	29	74	0.007	0.034
CORPUS CHRISTI, TX	349,894	ND	ND	ND	0.12	31	78	0.003	0.035
CUMBERLAND, MD-WV	101,643	ND	ND	ND	ND	ND	ND	0.008	0.027
DALLAS, TX	2,553,362	5	0.99 (f)	0.017	***0.14***	30	74	0.002	0.011
DANBURY, CT	187,867	ND	ND	ND	***0.14***	19	46	0.006	0.024
DANVILLE, VA	108,711	ND	ND	ND	ND	ND	ND	ND	ND
DAVENPORT-MOLINE-ROCK ISLAND, IA-IL	350,861	ND	0.02	ND	0.08	23	44	0.004	0.018
DAYTON-SPRINGFIELD, OH	951,270	4	0.06	ND	0.12	27	60	0.006	0.035
DAYTONA BEACH, FL	370,712	ND	ND	ND	0.09	20	50	ND	ND
DECATUR, AL	131,556	ND	ND	ND	ND	25	60	ND	ND
DECATUR, IL	117,206	ND	0.03	ND	0.08	28	64	0.006	0.024
DENVER, CO	1,622,980	***10***	0.11	0.034	0.11	41	142	0.008	0.035
DES MOINES, IA	392,928	ND	ND	ND	ND	ND	ND	ND	ND
DETROIT, MI	4,382,299	6	0.05	0.022	0.12	42	113	0.010	0.045
DOTHAN, AL	130,964	ND	ND	ND	ND	26	59	ND	ND
DOVER, DE	110,993	ND	ND	ND	ND	ND	ND	ND	ND
DUBUQUE, IA	86,403	ND	ND	ND	ND	ND	ND	ND	ND
DULUTH-SUPERIOR, MN-WI	239,971	4	ND	ND	ND	22	47	ND	ND
DUTCHESS COUNTY, NY	640,220	ND	ND	IN	***0.14***	ND	ND	ND	ND
EAU CLAIRE, WI	137,543	ND	ND	ND	ND	ND	ND	ND	ND
EL PASO, TX	591,610	***11***	0.23	0.031	***0.14***	37	106	0.009	0.065
ELKHART-GOSHEN, IN	156,198	ND	ND	ND	0.09	ND	ND	ND	ND
ELMIRA, NY	95,195	ND	ND	ND	0.09	20	66	0.005	0.019
ENID, OK	56,735	ND	ND	ND	ND	ND	ND	ND	ND
ERIE, PA	275,572	4	0.05	0.014	0.11	IN	59	0.011	0.072
EUGENE-SPRINGFIELD, OR	282,912	6	0.02	ND	0.08	28	151	ND	ND
EVANSVILLE-HENDERSON, IN-KY	278,990	6	ND	0.017	0.11	32	81	0.015	0.082
FARGO-MOORHEAD, ND-MN	153,296	3	ND	ND	0.06	18	39	ND	ND
FAYETTEVILLE, NC	274,566	6	ND	ND	0.12	27	55	0.003	0.010
FAYETTEVILLE-SPRINGDALE-ROGERS, AR	113,409	ND	ND	ND	ND	IN	58	ND	ND
FITCHBURG-LEOMINSTER, MA	102,797	ND	ND	ND	ND	ND	ND	ND	ND
FLINT, MI	430,459	ND	0.02	ND	0.11	24	127	0.005	0.018
FLORENCE, AL	131,327	ND	ND	ND	ND	23	52	0.004	0.022
FLORENCE, SC	114,344	ND	ND	ND	ND	ND	ND	ND	ND
FORT COLLINS-LOVELAND, CO	186,136	7	ND	ND	0.09	22	54	ND	ND
FORT LAUDERDALE, FL	1,255,488	5	0.03	0.010	0.10	21	71	0.002	0.011

FORT MYERS-CAPE CORAL, FL	335,113	ND	ND	ND	0.08	ND	ND	ND	ND
FORT PIERCE-PORT ST. LUCIE, FL	251,071	ND	ND	ND	ND	ND	ND	ND	ND
FORT SMITH, AR-OK	175,911	ND	ND	ND	ND	25	60	ND	ND
FORT WALTON BEACH, FL	143,776	ND	ND	ND	ND	IN	60	ND	ND
FORT WAYNE, IN	363,811	1	0.08	0.011	0.10	20	61	0.005	0.021
FORT WORTH-ARLINGTON, TX	1,332,053	4	0.04	0.013	0.12	24	60	0.001	0.005
FRESNO, CA	667,490	7	ND	0.023	***0.14***	***53***	131	0.003	0.010
GADSDEN, AL	99,840	ND	0.06	ND	ND	35	84	ND	ND
GAINESVILLE, FL	204,111	ND	ND	ND	ND	IN	50	ND	ND
GALVESTON-TEXAS CITY, TX	217,399	ND	0.02	ND	***0.18***	IN	67	0.005	0.056
GARY, IN	604,526	5	0.11	0.021	0.10	34	122	0.009	0.044
GLENS FALLS, NY	118,539	ND	ND	ND	ND	19	44	0.004	0.018
GOLDSBORO, NC	78,143	ND	ND	ND	ND	ND	ND	ND	ND
GRAND FORKS, ND-MN	70,683	ND	ND	IN	ND	17	46	IN	0.008
GRAND RAPIDS-MUSKEGON-HOLLAND, MI	688,399	3	0.02	ND	0.10	22	80	0.003	0.012
GREAT FALLS, MT	77,691	7	ND	ND	ND	21	61	ND	ND
GREELEY, CO	131,821	6	ND	ND	0.09	31	99	ND	ND
GREEN BAY, WI	194,594	ND	ND	ND	0.08	IN	44	0.003	0.019
GREENSBORO--WINSTON-SALEM--HIGH POINT	942,091	6	ND	0.017	0.12	31	82	0.006	0.022
GREENVILLE, NC	88,741	ND	ND	ND	ND	ND	ND	ND	ND
GREENVILLE-SPARTANBURG-ANDERSON, SC	640,861	5	0.03	0.018	0.12	27	69	0.003	0.012
HAGERSTOWN, MD	121,393	ND	ND	ND	ND	26	59	ND	ND
HAMILTON-MIDDLETOWN, OH	291,479	ND	ND	ND	0.12	33	82	0.008	0.042
HARRISBURG-LEBANON-CARLISLE, PA	587,986	4	0.04	0.015	0.12	21	65	0.006	0.025
HARTFORD, CT	767,841	7	0.02	0.018	***0.15***	23	52	0.007	0.023

CO = HIGHEST SECOND MAXIMUM NON-OVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.5 ug/m3)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PM10 = HIGHEST WEIGHTED ANNUAL MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m3)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 150 ug/m3)
SO2 = HIGHEST ANNUAL MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

WTD = WEIGHTED
AM = ANNUAL MEAN
UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

(e) - Impact from an Industrial source in Columbus, GA.

(f) - Impact from an Industrial source in Collin Co., TX. Highest site in Dallas, TX is 0.14 ug/m3.

Table 5-4. 1993 Metropolitan Statistical Area Air Quality Factbook Peak Statistics for Selected Pollutants by MSA (cont.)

METROPOLITAN STATISTICAL AREA	1990 POPULATION	CO 8-HR (PPM)	PB QMAX (UGM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PM10 WTD AM (UGM)	PM10 2ND MAX (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)
HICKORY-MORGANTON, NC	221,700	ND	ND	ND	0.09	23	53	0.004	0.017
HONOLULU, HI	836,231	4	0.01	0.004	0.06	24	58	0.002	0.017
HOUMA, LA	182,842	ND	ND	ND	0.10	ND	ND	ND	ND
HOUSTON, TX	3,301,937	7	0.02	0.024	***0.20***	32	89	0.006	0.036
HUNTINGTON-ASHLAND, WV-KY-OH	312,529	4	0.05	0.016	0.12	33	79	0.014	0.093
HUNTSVILLE, AL	238,912	4	ND	0.013	0.11	25	56	IN	0.011
INDIANAPOLIS, IN	1,249,822	4	***2.19*** (g)	0.018	0.11	37	91	0.015	0.055
IOWA CITY, IA	96,119	ND	ND	ND	ND	ND	ND	ND	ND
JACKSON, MI	149,756	ND	ND	ND	ND	ND	ND	ND	ND
JACKSON, MS	395,398	6	0.02	ND	0.10	23	61	0.003	0.010
JACKSON, TN	77,982	ND	ND	ND	ND	24	56	ND	ND
JACKSONVILLE, FL	906,727	6	0.07	0.015	0.12	28	61	0.004	0.047
JACKSONVILLE, NC	149,838	ND	ND	ND	ND	23	43	ND	ND
JAMESTOWN, NY	141,895	ND	ND	ND	0.10	IN	52	0.011	0.049
JANESVILLE-BELOIT, WI	139,510	ND	ND	ND	0.08	ND	ND	ND	ND
JERSEY CITY, NJ	553,099	8	0.05	0.027	***0.13***	34	85	0.011	0.035
JOHNSON CITY-KINGSPORT-BRISTOL, TN-VA	436,047	7	ND	0.017	***0.13***	25	97	0.010	0.047
JOHNSTOWN, PA	241,247	4	0.06	0.017	0.10	27	63	0.015	0.049
JOPLIN, MO	134,910	ND	ND	ND	ND	ND	ND	ND	ND
KALAMAZOO-BATTLE CREEK, MI	223,411	2	0.02	0.015	0.10	24	59	0.004	0.024
KANKAKEE, IL	516,418	ND	ND	ND	ND	ND	ND	ND	ND
KANSAS CITY, MO-KS	1,566,280	5	0.03	0.012	0.11	44	97	0.005	0.040
KENOSHA, WI	128,181	ND	ND	ND	***0.13***	ND	ND	ND	ND
KILLEEN-TEMPLE, TX	255,301	ND	ND	ND	ND	16	43	ND	ND
KNOXVILLE, TN	604,816	5	ND	ND	0.12	40	80	0.009	0.063
KOKOMO, IN	96,225	ND	ND	ND	ND	ND	ND	ND	ND
LA CROSSE, WI-MN	97,904	ND	ND	ND	ND	ND	ND	ND	ND
LAFAYETTE, LA	208,740	ND	ND	ND	0.09	ND	ND	ND	ND
LAFAYETTE, IN	130,598	ND	ND	0.011	ND	IN	54	0.005	0.041
LAKE CHARLES, LA	168,134	ND	ND	0.007	0.11	IN	51	0.005	0.019
LAKELAND-WINTER HAVEN, FL	405,382	ND	ND	ND	0.11	ND	ND	0.004	0.019
LANCASTER, PA	422,822	3	0.04	0.015	0.12	IN	68	0.007	0.026
LANSING-EAST LANSING, MI	432,674	ND	ND	ND	0.10	ND	ND	ND	ND
LAREDO, TX	133,239	ND	ND	ND	ND	30	58	ND	ND
LAS CRUCES, NM	135,510	9	0.13	ND	***0.13***	37	98	0.011	0.097
LAS VEGAS, NV-AZ	741,459	***10***	ND	0.030	0.11	44	110	ND	ND
LAWRENCE, KS	81,798	ND	ND	ND	ND	ND	ND	ND	ND
LAWRENCE, MA-NH	393,516	ND	ND	ND	0.12	IN	46	0.008	0.027
LAWTON, OK	111,486	3	ND	0.008	ND	IN	55	ND	ND
LEWISTON-AUBURN, ME	88,141	ND	0.02	ND	ND	24	68	0.007	0.028

LEXINGTON, KY	348,428	7	ND	0.017	0.10	25	67	0.007	0.026
LIMA, OH	154,340	ND	ND	ND	0.10	27	46	0.005	0.023
LINCOLN, NE	213,641	5	ND	ND	0.06	26	52	ND	ND
LITTLE ROCK-NORTH LITTLE ROCK, AR	513,117	4	ND	0.009	0.10	30	60	0.006	0.017
LONGVIEW-MARSHALL, TX	162,431	ND	ND	ND	0.11	ND	ND	ND	ND
LOS ANGELES-LONG BEACH, CA	8,863,164	*14*	0.11	0.050	*0.25*	47	102	0.004	0.014
LOUISVILLE, KY-IN	952,662	8	0.05	0.014	*0.14*	33	73	0.014	0.041
LOWELL, MA-NH	273,067	5	ND	ND	ND	ND	ND	ND	ND
LUBBOCK, TX	222,636	ND	ND	ND	ND	20	56	ND	ND
LYNCHBURG, VA	142,199	ND	ND	ND	0.11	26	63	ND	ND
MACON, GA	281,103	ND	ND	ND	ND	ND	ND	ND	ND
MADISON, WI	367,085	5	ND	ND	0.08	21	50	0.003	0.018
MANCHESTER, NH	147,809	5	0.01	0.016	0.10	19	43	0.009	0.056
MANSFIELD, OH	126,137	ND	ND	ND	ND	IN	66	ND	ND
MAYAGUEZ, PR	133,497	ND	ND	ND	ND	ND	ND	ND	ND
MCALLEN-EDINBURG-MISSION, TX	383,545	ND	ND	ND	ND	ND	ND	ND	ND
MEDFORD-ASHLAND, OR	146,389	8	0.02	ND	ND	41	106	ND	ND
MELBOURNE-TITUSVILLE-PALM BAY, FL	398,978	ND	ND	ND	0.09	19	57	ND	ND
MEMPHIS, TN-AR-MS	981,747	9	*2.26* (h)	0.026	0.12	33	75	0.007	0.031
MERCED, CA	178,403	ND	ND	0.015	0.12	43	118	ND	ND
MIAMI, FL	3,192,582	6	0.01	0.016	0.11	30	90	0.001	0.004
MIDDLESEX-SOMERSET-HUNTERDON, NJ	1,019,835	4	0.33	ND	0.12	25	60	0.005	0.018
MILWAUKEE-WAUKESHA, WI	1,432,149	6	0.05	0.024	0.11	30	75	0.004	0.030
MINNEAPOLIS-ST. PAUL, MN-WI	2,464,124	7	0.57	0.024	0.09	27	96	0.007	0.053
MOBILE, AL	476,923	ND	ND	ND	0.10	38	71	0.010	0.066

CO = HIGHEST SECOND MAXIMUM NON-OVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.5 ug/m3)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PM10 = HIGHEST WEIGHTED ANNUAL MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m3)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 150 ug/m3)
SO2 = HIGHEST ANNUAL MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

WTD = WEIGHTED
AM = ANNUAL MEAN
UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

(g) - Impact from an industrial source in Indianapolis, IN. Highest population oriented site in Indianapolis, IN is 0.04 ug/m3.

(h) - Impact from an industrial source in Memphis, TN. Highest population oriented site in Memphis, TN is 0.12 ug/m3.

Table 5-4. 1993 Metropolitan Statistical Area Air Quality Factbook Peak Statistics for Selected Pollutants by MSA (cont.)

METROPOLITAN STATISTICAL AREA	1990 POPULATION	CO 8-HR (PPM)	PB QMAX (UGM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PM10 WTD AM (UGM)	PM10 2ND MAX (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)
MODESTO, CA	370,522	7	ND	0.024	***0.13***	IN	123	ND	ND
MONMOUTH-OCEAN, NJ	986,327	6	ND	ND	***0.13***	ND	ND	ND	ND
MONROE, LA	142,191	ND	ND	0.009	0.10	27	81	0.004	0.011
MONTGOMERY, AL	292,517	ND	ND	ND	0.12	23	48	ND	ND
MUNCIE, IN	119,659	ND	0.74	ND	ND	ND	ND	ND	ND
MYRTLE BEACH, SC	144,053	ND	ND	ND	ND	ND	ND	ND	ND
NAPLES, FL	152,099	ND	ND	ND	ND	ND	ND	ND	ND
NASHUA, NH	180,557	6	0.01	ND	***0.13***	17	38	0.005	0.019
NASHVILLE, TN	985,026	7	1.32 (l)	0.012	***0.13***	36	136	0.011	0.101
NASSAU-SUFFOLK, NY	2,609,212	6	ND	0.026	***0.13***	19	77	0.008	0.032
NEW BEDFORD, MA	175,641	ND	ND	ND	0.09	17	44	ND	ND
NEW HAVEN-MERIDEN, CT	638,220	5	0.26	0.027	***0.15***	***53***	***178***	0.009	0.044
NEW LONDON-NORWICH, CT-RI	266,819	ND	ND	ND	***0.13***	19	41	0.006	0.019
NEW ORLEANS, LA	1,238,816	5	0.07	0.019	0.11	26	81	0.006	0.025
NEW YORK, NY	8,546,846	7	0.16	0.043	0.12	47	86	0.019	0.052
NEWARK, NJ	1,824,321	6	0.23	0.034	0.12	34	78	0.009	0.026
NEWBURGH, NY-PA	307,647	ND	0.41	ND	ND	ND	ND	ND	ND
NORFOLK-VIRGINIA BEACH-NEWPORT NEWS,V	1,396,107	7	0.03	0.021	***0.13***	25	74	0.007	0.027
OAKLAND, CA	2,082,914	5	0.03	0.020	***0.13***	26	71	0.002	0.011
OCALA, FL	194,833	ND	ND	ND	ND	ND	ND	ND	ND
ODESSA-MIDLAND, TX	118,934	ND	ND	ND	ND	ND	ND	ND	ND
OKLAHOMA CITY, OK	958,839	8	0.02	0.013	0.10	21	49	0.003	0.008
OLYMPIA, WA	161,238	5	ND	ND	ND	IN	78	ND	ND
OMAHA, NE-IA	618,262	7	***5.01*** (j)	ND	0.07	38	93	0.002	0.008
ORANGE COUNTY, CA	2,410,556	7	0.05	0.039	***0.17***	38	80	0.002	0.008
ORLANDO, FL	1,072,748	4	0.00	0.012	0.10	27	48	0.002	0.011
OWENSBORO, KY	87,189	6	ND	0.012	0.11	26	75	0.009	0.050
PANAMA CITY, FL	126,994	ND	ND	ND	ND	IN	50	ND	ND
PARKERSBURG-MARIETTA, WV-OH	149,169	ND	0.02	IN	0.12	IN	54	0.014	0.065
PENSACOLA, FL	344,406	ND	ND	ND	0.11	IN	57	0.006	0.063
PEORIA-PEKIN, IL	339,172	7	0.03	ND	0.08	24	49	0.007	0.042
PHILADELPHIA, PA-NJ	4,856,881	7	***11.20*** (k)	0.035	***0.14***	34	***531***	0.012	0.044
PHOENIX-MESA, AZ	2,122,101	9	0.06	ND	***0.13***	44	92	0.007	0.034
PINE BLUFF, AR	85,487	ND	ND	ND	ND	23	55	ND	ND
PITTSBURGH, PA	2,056,705	5	0.13	0.031	0.12	38	***167***	0.021	***0.155*** (l)
PITTSFIELD, MA	79,250	ND	ND	ND	0.11	ND	ND	ND	ND
PONCE, PR	253,285	ND	ND	ND	ND	30	86	ND	ND
PORTLAND, ME	215,281	ND	0.03	IN	0.11	29	91	0.009	0.032
PORTLAND-VANCOUVER, OR-WA	1,239,842	8	0.21	IN	0.10	34	99	0.006	0.028
PORTSMOUTH-ROCHESTER, NH-ME	223,578	ND	0.02	0.014	0.11	19	39	0.006	0.019

PROVIDENCE-FALL RIVER-WARWICK, RI-MA	1,141,510	5	ND	0.022	0.12	34	68	0.010	0.042
PROVO-OREM, UT	263,590	*10*	ND	0.026	0.09	40	*209*	ND	ND
PUEBLO, CO	123,051	ND	ND	ND	ND	26	51	ND	ND
PUNTA GORDA, FL	110,975	ND	ND	ND	ND	ND	ND	ND	ND
RACINE, WI	175,034	4	ND	ND	0.10	ND	ND	ND	ND
RALEIGH-DURHAM-CHAPEL HILL, NC	735,480	7	ND	0.015	0.11	24	50	0.003	0.010
RAPID CITY, SD	81,343	ND	0.10	ND	ND	42	130	ND	ND
READING, PA	336,523	4	0.95 (m)	0.021	0.11	26	55	0.010	0.038
REDDING, CA	147,036	2	ND	ND	0.09	20	63	ND	ND
RENO, NV	254,667	7	ND	ND	0.09	45	148	ND	ND
RICHLAND-KENNEWICK-PASCO, WA	150,033	ND	ND	ND	ND	IN	136	ND	ND
RICHMOND-PETERSBURG, VA	865,640	5	ND	0.024	*0.13*	26	60	0.007	0.032
RIVERSIDE-SAN BERNARDINO, CA	2,588,793	6	0.04	0.042	*0.23*	*73*	*172*	0.002	0.010
ROANOKE, VA	224,477	5	ND	0.014	0.10	32	72	0.004	0.018
ROCHESTER, MN	106,470	5	ND	ND	ND	20	38	0.002	0.010
ROCHESTER, NY	1,002,410	4	0.04	ND	0.10	20	73	0.011	0.051
ROCKFORD, IL	283,719	ND	0.03	ND	0.08	16	42	ND	ND
ROCKY MOUNT, NC	133,235	ND	ND	ND	ND	ND	ND	ND	ND
SACRAMENTO, CA	1,481,102	9	0.02	0.022	*0.15*	29	78	0.001	0.005
SAGINAW-BAY CITY-MIDLAND, MI	399,320	ND	ND	0.009	ND	23	85	ND	ND
ST. CLOUD, MN	190,921	5	ND	ND	ND	ND	ND	ND	ND
ST. JOSEPH, MO	83,083	ND	ND	ND	ND	32	100	ND	ND
ST. LOUIS, MO-IL	2,444,099	5	*5.45* (n)	0.024	*0.13*	44	101	0.013	0.081
SALEM, OR	278,024	9	ND	ND	ND	ND	ND	ND	ND
SALINAS, CA	355,660	2	ND	0.012	0.09	IN	55	ND	ND

CO = HIGHEST SECOND MAXIMUM NON-OVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.5 ug/m3)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PM10 = HIGHEST WEIGHTED ANNUAL MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m3)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 150 ug/m3)
SO2 = HIGHEST ANNUAL MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

WTD = WEIGHTED
AM = ANNUAL MEAN
UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

(i) - Impact from an industrial source in Williamston Co., TN. Highest population oriented site in Nashville, TN is 0.10 ug/m3.

(j) - Impact from an industrial source in Omaha, NE. Highest population oriented site in Omaha, AL is 0.02 ug/m3.

(k) - Impact from an industrial source in Philadelphia, PA. Highest population oriented site in Philadelphia, PA is 0.47 ug/m3.

(l) - Impact from an industrial source.

(m) - Impact from an industrial source in Reading, PA. Highest population oriented site in Reading, PA is 0.12 ug/m3.

(n) - Impact from an industrial source in Herculaneum, MO. Highest population oriented site in St. Louis, MO is 0.05 ug/m3.

Table 5-4. 1993 Metropolitan Statistical Area Air Quality Factbook Peak Statistics for Selected Pollutants by MSA (cont.)

METROPOLITAN STATISTICAL AREA	1990 POPULATION	CO 8-HR (PPM)	PB QMAX (UGM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PM10 WTD AM (UGM)	PM10 2ND MAX (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)
SALT LAKE CITY-OGDEN, UT	1,072,227	7	0.09	0.033	0.10	42	***156***	0.013	0.058
SAN ANGELO, TX	98,485	ND	ND	ND	ND	ND	ND	ND	ND
SAN ANTONIO, TX	1,302,099	5	0.03	ND	0.11	27	63	ND	ND
SAN DIEGO, CA	2,498,016	7	0.01	0.024	***0.16***	34	105	0.002	0.011
SAN FRANCISCO, CA	1,603,678	6	0.03	0.024	0.09	29	72	0.002	0.010
SAN JOSE, CA	1,497,577	6	0.03	0.025	0.12	28	94	ND	ND
SAN JUAN-BAYAMON, PR	1,086,376	5	ND	ND	0.01	42	95	0.012	0.052
SAN LUIS OBISPO-ATASCADERO-PASO ROBLE	217,162	ND	ND	ND	ND	ND	ND	ND	ND
SANTA BARBARA-SANTA MARIA-LOMPOC, CA	369,608	3	ND	0.013	0.11	29	88	0.002	0.012
SANTA CRUZ-WATSONVILLE, CA	229,734	1	ND	0.006	0.08	22	49	0.001	0.007
SANTA FE, NM	117,043	3	ND	0.003	0.07	15	35	0.002	0.005
SANTA ROSA, CA	388,222	4	0.01	0.016	0.08	18	52	ND	ND
SARASOTA-BRADENTON, FL	277,776	7	ND	ND	0.10	29	100	0.003	0.018
SAVANNAH, GA	242,622	ND	ND	ND	ND	ND	ND	0.003	0.011
SCRANTON--WILKES-BARRE--HAZLETON, PA	734,175	3	0.04	0.018	0.11	28	72	0.008	0.026
SEATTLE-BELLEVUE-EVERETT, WA	1,972,961	7	0.37	ND	0.10	35	119	0.009	0.022
SHARON, PA	121,003	ND	0.05	ND	0.11	IN	56	0.008	0.029
SHEBOYGAN, WI	103,877	ND	ND	ND	0.10	ND	ND	ND	ND
SHERMAN-DENISON, TX	95,021	ND	ND	ND	ND	ND	ND	ND	ND
SHREVEPORT-BOSSIER CITY, LA	334,341	ND	ND	0.008	0.12	25	75	0.004	0.011
SIOUX CITY, IA-NE	115,018	ND	ND	ND	ND	ND	ND	ND	ND
SIOUX FALLS, SD	123,809	ND	ND	ND	ND	19	49	ND	ND
SOUTH BEND, IN	247,052	ND	ND	IN	0.10	23	60	ND	ND
SPOKANE, WA	361,364	***12***	ND	ND	0.07	46	***166*** (o)	ND	ND
SPRINGFIELD, IL	189,550	4	ND	ND	0.11	19	42	0.006	0.040
SPRINGFIELD, MO	239,971	5	ND	0.011	0.08	18	39	0.009	0.061
SPRINGFIELD, MA	529,519	7	0.02	0.025	***0.13***	30	74	0.009	0.029
STAMFORD-NORWALK, CT	127,378	5	ND	ND	***0.15***	30	61	0.007	0.032
STATE COLLEGE, PA	123,786	ND	ND	ND	ND	ND	ND	ND	ND
STEUBENVILLE-WEIRTON, OH-WV	142,523	9	0.07	0.017	0.11	40	***177*** (p)	***0.043***	***0.244*** (p)
STOCKTON-LODI, CA	480,628	7	ND	0.024	0.12	IN	103	ND	ND
SUMTER, SC	102,637	ND	ND	ND	ND	ND	ND	ND	ND
SYRACUSE, NY	659,864	6	ND	ND	0.10	27	72	0.004	0.019
TACOMA, WA	586,203	6	ND	ND	0.10	33	96	0.009	0.027
TALLAHASSEE, FL	233,598	ND	ND	ND	ND	ND	ND	ND	ND
TAMPA-ST. PETERSBURG-CLEARWATER, FL	2,067,959	4	0.89 (q)	0.012	0.10	30	79	0.008	0.058
TERRE HAUTE, IN	130,812	ND	ND	ND	0.09	30	74	0.010	0.042
TEXARKANA, TX-TEXARKANA, AR	120,132	ND	ND	ND	ND	22	44	ND	ND
TOLEDO, OH	614,128	4	0.63 (r)	ND	0.12	27	66	0.007	0.031
TOPEKA, KS	160,976	ND	0.01	ND	ND	IN	48	ND	ND

TRENTON, NJ	325,824	ND	ND	ND	***0.14***	27	66	ND	ND
TUSCON, AZ	666,880	6	0.03	0.028	0.10	28	73	0.003	0.006
TULSA, OK	708,954	5	0.20	0.017	0.12	29	67	0.006	0.044
TUSCALOOSA, AL	150,522	ND	ND	ND	ND	26	66	ND	ND
TYLER, TX	151,309	ND	ND	ND	ND	IN	53	ND	ND
UTICA-ROME, NY	316,633	ND	ND	ND	0.09	21	54	ND	ND
VALLEJO-FAIRFIELD-NAPA, CA	451,186	7	0.02	0.014	0.10	26	63	0.002	0.008
VENTURA, CA	669,016	4	ND	0.023	***0.14***	29	65	0.002	0.007
VICTORIA, TX	74,361	ND	ND	ND	0.10	ND	ND	ND	ND
VINELAND-MILLVILLE-BRIDGETON, NJ	138,053	ND	ND	ND	0.12	ND	ND	0.006	0.019
VISALIA-TULARE-PORTERVILLE, CA	311,921	4	ND	0.023	***0.15***	***53***	107	ND	ND
WACO, TX	189,731	ND	ND	ND	ND	ND	ND	ND	ND
WASHINGTON, DC-MD-VA-WV	3,000,504	8	0.03	0.029	***0.13***	31	66	0.011	0.029
WATERBURY, CT	221,629	ND	0.02	ND	ND	25	57	0.006	0.021
WATERLOO-CEDAR FALLS, IA	146,611	ND	ND	ND	ND	ND	ND	ND	ND
WAUSAU, WI	115,400	ND	ND	ND	0.08	ND	ND	ND	ND
WEST PALM BEACH-BOCA RATON, FL	863,518	4	0.10	0.013	0.12	21	52	0.004	0.028
WHEELING, WV-OH	159,301	4	ND	ND	0.11	29	81	0.020	0.098
WICHITA, KS	485,270	6	0.02	ND	0.08	39	125	0.005	0.022
WICHITA FALLS, TX	122,378	ND	ND	ND	ND	IN	62	ND	ND
WILLIAMSPORT, PA	118,710	ND	ND	ND	0.09	24	58	0.006	0.025
WILMINGTON-NEWARK, DE-MD	578,587	4	0.02	0.019	***0.15***	29	67	0.015	0.060
WILMINGTON, NC	120,284	ND	ND	ND	0.10	22	45	0.003	0.008
WORCESTER, MA-CT	320,006	6	ND	0.028	***0.16***	20	44	0.007	0.026
YAKIMA, WA	188,823	8	ND	ND	ND	38	90	ND	ND
YOLO, CA	381,288	ND	ND	ND	ND	ND	ND	ND	ND
YORK, PA	417,848	3	0.04	0.022	0.11	31	77	0.008	0.032
YOUNGSTOWN-WARREN, OH	492,619	2	ND	0.024	0.12	36	84	0.012	0.091
YUBA CITY, CA	122,643	5	ND	0.018	***0.13***	IN	69	ND	ND
YUMA, AZ	106,895	ND	ND	ND	0.00	IN	36	ND	ND

CO = HIGHEST SECOND MAXIMUM NON-OVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.5 ug/m3)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PM10 = HIGHEST WEIGHTED ANNUAL MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m3)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 150 ug/m3)
SO2 = HIGHEST ANNUAL MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
ND = INDICATES DATA NOT AVAILABLE
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WTD = WEIGHTED
AM = ANNUAL MEAN
UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

(o) - Includes data flagged as a possible exceptional event.

(p) - Impact from an industrial source.

(q) - Impact from an industrial source in Tampa, FL.

(r) - Impact from an industrial source in Toledo, OH.

Chapter 6: Selected Metropolitan Area Trends

While most of this report discusses trends on a national scale, great interest exists in trends of air pollutants in more localized areas. This chapter presents 1984–93 air quality trends in major urban areas. The areas selected are the Primary Metropolitan Statistical Areas (PMSA or MSA) with populations of at least 500,000.

Urban area trends in the number of unhealthy days as measured by the Pollutant Standards Index (PSI) are examined for all large metropolitan areas. The air quality data used for the trend statistics were obtained from the EPA Aerometric Information Retrieval System (AIRS). This is the fourth year that this report has presented trends in the PSI, which is used locally in many areas to characterize and publicly report air quality. Because the focus of this analysis is on examining 10-year trends in the number of unhealthy days, the PSI values are based on daily maximum pollutant concentrations from the subset of ambient monitoring sites that met the 10-year trends criteria of Chapter 2. Thus, only sites which met the completeness criteria in at least eight of the last 10 years are included in the trends comparisons. It should also be noted that no interpolation for missing data is used in this chapter; this corresponds with typical PSI reporting.

6.1 The Pollutant Standards Index

The number of days when the PSI is greater than 100 (the unhealthy range) is used in this section as an air quality indicator for describing urban area trends. The PSI is widely used in the air pollution field to report daily air quality to the general public. PSI index values are reported in all metropolitan areas of the United States with populations exceeding 200,000. The index provides a uniform system of measuring pollution levels for the major air pollutants regulated under the Clean Air Act. In addition, the PSI advises the public about general health effects associated with different pollution levels, and describes precautionary steps that may need to be taken if levels rise into the unhealthy range.[1] The index integrates information from five major pollutants across an entire monitoring network into a single number that represents the worst daily air quality experienced in an urban area. This is accomplished by first computing a separate sub-index for each pollutant with data for the day. The daily PSI value is determined by the pollutant having the highest sub-index value from all the monitoring values used for that day. The index numbers are on a scale of zero to 500. The most important number on the scale is 100, since this number corresponds to the standard established under the Clean Air Act. On days when two or more pollutants exceed the standard (PSI greater than 100), the pollutant with the highest index is reported as the PSI. Therefore, the PSI does not take into account the possible adverse effects associated with combinations of pollutants (synergism).[1,2]

The PSI places the maximum emphasis on acute health effects occurring over very short time periods (24 hours or less) rather than chronic effects occurring over months or years. It does not specifically account for damage air pollutants can do to animals, vegetation, and materials such as building surfaces and statues. However, increased PSI levels generally reflect increased damage to the environment.

The PSI is computed for PM-10, SO_2, CO, O_3 and NO_2 based on their short-term National Ambient Air Quality Standards (NAAQS), Federal Episode Criteria and Significant Harm Levels. Lead is the only major pollutant not included in the index because it does not have a short-term NAAQS, a Federal Episode Criteria or a Significant Harm Level.

PSI estimates depend upon the number of pollutants monitored and the number of monitoring sites collecting data. The more pollutants and sites that are available in an area, the better the estimate of the maximum PSI for that day is likely to be. However, O_3 accounts for most of the days with a PSI above 100 and O_3 air quality is relatively uniform over large areas so that a small number of sites can still estimate maximum pollutant concentrations. All of the included cities had at least one CO trend site or one O_3 trend site. The typical one in six day sampling schedule for most PM-10 sites limits the number of days that PM-10 can factor into the PSI determination. Results for individual years could be somewhat different if data from all monitoring sites and all pollutants were considered in an area. This is illustrated for 1993, where the number of PSI days from all monitoring sites is compared to the results for the subset of trend sites. Local agencies may use only selected monitoring sites to determine the PSI value so that differences are possible between the PSI values reported here and those reported by the local agencies.

The PSI simplifies the presentation of air quality data by producing a single dimensionless number ranging from zero to 500. The PSI uses data from all selected sites in the PMSA or Consolidated Metropolitan Statistical Area (CMSA) and combines different air pollutants with different averaging times, different units of concentration, and more importantly, with different NAAQS, Federal Episode Criteria and Significant Harm Levels. Table 6-1 shows the five PSI categories and health effect descriptor words. The PSI is primarily used to report the daily air quality of a large urban area as a single number or descriptor word. Frequently, the index is reported as a regular feature on local TV or radio news programs or in newspapers.

Throughout this section, emphasis is placed on CO and O_3 which cause most of the NAAQS violations in urban areas. Ozone presents unique problems in summarizing values across areas. The O_3 pollution problem is regional in scale. High values can represent an ozone problem over a large area. Since it is a secondary pollutant, peak O_3 values can occur downwind of the sources of precursor pollutants.

Table 6-1. Comparison of Pollutant Standards Index (PSI) Values with Pollutant Concentrations, Health Descriptions, and PSI Colors

INDEX VALUE	AIR QUALITY LEVEL	POLLUTANT LEVELS					HEALTH EFFECT DESCRIPTOR	PSI COLORS
		PM_{10} (24-hour) ug/m3	SO_2 (24-hour) ug/m3	CO (8-hour) ppm	O_3 (1-hour) ppm	NO_2 (1-hour) ppm		
500	SIGNIFICANT HARM	600	2620	50	0.6	2.0	HAZARDOUS	RED
400	EMERGENCY	500	2100	40	0.5	1.6		
300	WARNING	420	1600	30	0.4	1.2	VERY UNHEALTHFUL	ORANGE
200	ALERT	350	800	15	0.2	0.6	UNHEALTHFUL	YELLOW
100	NAAQS	150	365	9	0.12	a	MODERATE	GREEN
50	50% OF NAAQS	50	80 [b]	4.5	0.06	a	GOOD	BLUE
0		0	0	0	0	a		

[a] No index values reported at concentration levels below those specified by "Alert Level" criteria.

[b] Annual primary NAAQS.

6.2 Summary of PSI Analyses

Table 6-2 displays the number of PSI days greater than 100 (unhealthful or worse days) for the 10-year period, 1984–93, in 89 large metropolitan areas. For all practical purposes CO, O_3, PM-10 and SO_2 are the only pollutants that contribute to the PSI in Table 6-2. NO_2 rarely is a factor because it does not have a short-term NAAQS and can only be included when concentrations exceed one of the Federal Episode Criteria or Significant Harm Levels. Total suspended particulates (TSP) is not included in the index because the revised particulate matter NAAQS is for PM-10, not TSP. As noted above, lead is not included in the index because it does not have a short-term NAAQS or Federal Episode Criteria and Significant Harm Levels.

Bakersfield, Pittsburgh, Riverside and Salt Lake City are the only cities where PSI days greater than 100 are due to pollutants other than CO or O_3. For Pittsburgh, SO_2 and PM-10 account for the additional days, while PM-10 accounts for the additional days in the other cities.

The first column in the table lists the number of sites in each metropolitan area that meet the 10-year trends completeness criteria (eight of the last 10 years have valid data). The following 10 columns display the number of unhealthy days determined by the subset of trends sites in each metropolitan area. The two right most columns show the number of corresponding PSI days greater than 100, using *all* active monitoring sites in 1993; not just the subset of 10-year trend sites. Note that for all urban areas there is close agreement between the two totals for 1993 of the number of days when the PSI is greater than 100 except in El Paso, Fresno, Monmouth, and Wilmington-Newark. The differences are attributed to currently active sites without sufficient historical data to be used for trends.

During the past decade, more than half of the cities listed in Table 6-2 had days where O_3 did not account for all of the PSI greater than 100 days. However, in 1993 only 13 cities had days where the PSI was over 100 and not due to ozone. These were: Chicago, Denver, El Paso, Kansas City, Las Vegas, Los Angeles, Nashville, Omaha, Phoenix, Pittsburgh, Riverside-San Bernardino, Sacramento and Salt Lake City. In most cases, CO or PM-10 were the pollutants causing high PSI with the exception noted above for Pittsburgh. Also these instances amounted to one to three days with the exception of Los Angeles. Because of the overall improvement in CO levels (see Chapter 3, Section 3.1 in this report), CO accounts for far less of these days in the latter half of the 10-year period. In 1993, 90 percent of the days with PSI greater than 100 days were due to O_3.

As noted above, although the PSI is based on five pollutants, ozone tends to dominate the number of days greater than 100 during the period 1984–93. This can be clearly seen in Table 6-3 which presents the trend in the number of PSI days greater than 100 based only on O_3 monitoring data. The two right most columns in this table display the number of ozone sites reporting data in 1993 and the corresponding number of days with the PSI greater than 100 based only on 1993 O_3 data. In this table, the impact of the very hot and dry summer of 1988 in the eastern United States on O_3 concentrations can clearly be seen.

There are several assumptions that are implicit in this PSI analysis. Probably the most important is that the monitoring data available for a given area provide a reasonable estimate of maximum short-term concentration levels. The PSI procedure uses the maximum concentration which may not represent the air pollution exposure for the entire area. If the downwind maximum concentration site for ozone is outside the PMSA, these data are not used in this analysis.

Note: *Urban lead concentrations have dropped dramatically over the past 15 or so years. As a result, lead violations now occur typically in the vicinity of lead point sources (see Chapter 3).*

Table 6-2. Number of PSI Days Greater Than 100 at Trend Sites, 1984–93, and All Sites in 1993

MSA	# trend sites	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Total # sites	PSI > 100 1993
ALBANY-SCHENECTADY-TROY, NY	3	1	2	0	0	1	0	0	0	0	0	10	0
ALLENTOWN-BETHLEHEM-EASTON, PA	9	6	2	2	5	16	0	0	2	0	0	12	0
ATLANTA, GA	7	8	9	17	19	15	3	16	5	4	14	10	16
AUSTIN-SAN MARCOS, TX	5	0	2	0	0	0	0	0	0	0	0	5	0
BAKERSFIELD, CA	6	26	29	36	46	59	34	29	30	5	28	10	37
BALTIMORE, MD	13	46	21	24	28	41	7	12	20	4	12	20	14
BATON ROUGE, LA	6	11	8	5	10	10	9	18	6	2	3	13	8
BERGEN-PASSAIC, NJ	8	12	8	5	13	19	4	4	3	0	0	8	0
BIRMINGHAM, AL	13	5	3	7	10	16	2	5	0	2	5	16	5
BOSTON, MA-NH	19	7	3	2	5	12	2	1	3	1	3	22	3
BUFFALO-NIAGARA FALLS, NY	9	0	2	1	2	15	1	2	0	0	0	10	0
CHARLESTON-NORTH CHARLESTON, SC	6	0	0	2	0	0	0	0	0	0	0	7	0
CHARLOTTE-GASTONIA-ROCK HILL, NC-SC	8	19	6	10	10	17	3	4	2	0	4	15	6
CHICAGO, IL	30	12	8	9	15	21	3	3	8	6	1	36	1
CINCINNATI, OH-KY-IN	18	4	4	6	10	23	2	6	7	0	1	21	1
CLEVELAND-LORAIN-ELYRIA, OH	20	4	1	2	7	20	4	1	5	0	1	27	4
COLUMBUS, OH	9	0	0	1	1	4	0	1	3	1	0	12	1
DALLAS, TX	9	11	15	5	8	3	3	5	0	2	4	15	5
DAYTON-SPRINGFIELD, OH	11	2	0	2	2	14	3	1	1	0	2	12	2
DENVER, CO	14	62	38	47	36	19	11	7	7	7	3	23	3
DETROIT, MI	24	7	2	5	9	17	10	3	7	0	2	26	2
EL PASO, TX	14	20	24	34	27	13	29	20	8	11	5	16	10
FORT LAUDERDALE, FL	4	0	0	0	0	0	1	0	0	0	0	10	1
FORT WORTH-ARLINGTON, TX	5	12	8	5	2	4	2	4	7	2	1	5	1
FRESNO, CA	4	18	21	24	28	12	21	12	18	16	13	12	21
GARY, IN	15	10	10	9	10	14	2	4	5	3	0	20	0
GRAND RAPIDS-MUSKEGON-HOLLAND, MI	6	2	4	4	9	18	8	5	6	3	1	9	1
GREENSBORO--WINSTON-SALEM--HIGH POINT, NC	7	2	0	3	1	11	0	1	0	0	2	15	2
HARRISBURG-LEBANON-CARLISLE, PA	8	1	1	0	4	13	0	2	0	0	1	8	1
HARTFORD, CT	9	31	17	7	18	26	8	7	14	9	9	9	9
HONOLULU, HI	6	1	0	0	0	0	0	0	0	0	0	7	0
HOUSTON, TX	22	49	48	45	55	48	34	48	40	30	26	23	26
INDIANAPOLIS, IN	15	5	2	2	1	7	2	1	0	1	0	24	0
JACKSONVILLE, FL	9	0	2	0	1	2	0	1	0	0	1	12	1
JERSEY CITY, NJ	6	43	21	8	12	17	2	7	7	1	5	7	5
KANSAS CITY, MO-KS	14	12	3	4	3	3	2	2	1	1	2	18	2
KNOXVILLE, TN	9	0	0	0	0	5	0	2	0	0	1	13	1
LAS VEGAS, NV-AZ	9	37	55	40	7	30	44	21	14	5	8	9	6
LITTLE ROCK-NORTH LITTLE ROCK, AR	4	0	0	1	1	0	0	1	0	0	0	6	0
LOS ANGELES-LONG BEACH, CA	17	204	194	211	184	226	212	163	157	169	131	21	131
LOUISVILLE, KY-IN	13	14	4	9	3	20	3	4	5	0	5	26	6
MEMPHIS, TN-AR-MS	10	18	11	12	10	8	4	6	1	1	4	12	4
MIAMI, FL	7	2	5	4	4	4	4	1	2	0	0	9	0
MIDDLESEX-SOMERSET-HUNTERDON, NJ	5	14	15	7	9	24	7	10	8	3	1	7	1
MILWAUKEE-WAUKESHA, WI	13	11	5	9	12	19	8	2	10	0	0	19	0

Table 6-2. Number of PSI Days Greater Than 100 at Trend Sites, 1984–93, and All Sites in 1993

MSA	# trend sites	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Total # sites	PSI > 100 1993
MINNEAPOLIS-ST. PAUL, MN-WI	11	21	21	13	7	1	5	1	0	1	0	18	0
MONMOUTH-OCEAN, NJ	2	2	2	0	0	0	0	0	0	0	0	4	9
NASHVILLE, TN	11	27	3	9	4	15	4	8	1	1	3	16	3
NASSAU-SUFFOLK, NY	4	2	3	8	14	10	6	6	12	2	4	8	6
NEW HAVEN-MERIDEN, CT	8	24	10	6	17	16	7	8	19	2	7	8	11
NEW ORLEANS, LA	9	8	1	3	4	2	1	0	0	1	2	13	2
NEW YORK, NY	12	98	61	53	41	43	16	17	22	4	6	16	6
NEWARK, NJ	11	20	21	19	22	32	4	8	10	5	2	13	2
NORFOLK-VIRGINIA BEACH-NEWPORT NEWS,VA-NC	7	0	1	1	2	3	0	0	1	2	3	13	4
OAKLAND, CA	17	12	7	5	9	4	2	2	2	1	3	19	3
OKLAHOMA CITY, OK	8	14	6	4	6	0	2	1	0	0	0	10	0
OMAHA, NE-IA	9	1	3	1	0	1	1	0	0	0	1	11	1
ORANGE COUNTY, CA	8	69	69	54	46	54	53	39	32	37	17	9	17
ORLANDO, FL	4	0	0	0	0	0	0	2	0	0	0	8	0
PHILADELPHIA, PA-NJ	29	31	25	21	36	34	19	11	24	3	20	29	31
PHOENIX-MESA, AZ	16	107	84	85	40	22	30	8	4	8	6	23	7
PITTSBURGH, PA	23	15	9	8	13	23	9	11	3	1	5	38	9
PORTLAND-VANCOUVER, OR-WA	9	4	3	6	2	2	0	4	3	2	0	15	0
PROVIDENCE-FALL RIVER-WARWICK, RI-MA	12	26	12	7	10	8	2	7	10	2	1	12	1
RALEIGH-DURHAM-CHAPEL HILL, NC	4	29	8	11	7	14	2	3	0	0	0	11	0
RICHMOND-PETERSBURG, VA	9	2	3	0	6	18	0	1	1	2	4	10	8
RIVERSIDE-SAN BERNARDINO, CA	22	164	152	156	152	165	155	128	122	128	115	29	123
ROCHESTER, NY	7	0	0	1	1	4	0	1	0	0	0	7	0
SACRAMENTO, CA	14	70	67	58	44	58	45	39	27	12	6	25	9
ST. LOUIS, MO-IL	34	22	10	13	14	17	12	8	6	2	5	42	6
SALT LAKE CITY-OGDEN, UT	15	20	20	36	7	10	15	6	18	9	3	17	3
SAN ANTONIO, TX	7	2	0	1	1	1	0	0	0	0	0	7	0
SAN DIEGO, CA	12	51	54	45	41	49	61	39	25	19	14	16	14
SAN FRANCISCO, CA	10	2	5	4	1	1	0	1	0	0	0	10	0
SAN JOSE, CA	8	25	27	8	9	7	13	5	9	1	1	11	1
SAN JUAN-BAYAMON, PR	5	0	0	0	2	0	0	0	0	0	0	11	0
SCRANTON--WILKES-BARRE--HAZLETON, PA	10	1	1	0	1	12	1	0	2	0	0	11	0
SEATTLE-BELLEVUE-EVERETT, WA	10	4	24	10	10	6	4	2	0	0	0	13	0
SPRINGFIELD, MA	10	14	11	4	3	15	2	2	3	2	7	13	7
SYRACUSE, NY	3	8	17	9	4	2	2	1	2	0	0	6	0
TACOMA, WA	5	0	12	3	8	9	4	1	1	1	0	8	0
TAMPA-ST. PETERSBURG-CLEARWATER, FL	13	3	5	5	5	0	1	3	0	1	0	19	0
TOLEDO, OH	7	3	0	1	2	6	1	0	1	0	2	10	2
TUSCON, AZ	10	7	3	1	4	6	2	0	0	0	0	15	0
TULSA, OK	10	10	5	4	2	2	2	2	2	1	1	11	1
VENTURA, CA	11	23	19	60	31	55	46	18	39	10	16	11	18
WASHINGTON, DC-MD-VA-WV	26	30	15	12	25	36	7	5	16	2	12	32	14
WEST PALM BEACH-BOCA RATON, FL	2	0	0	0	0	0	0	0	0	0	0	6	2
WILMINGTON-NEWARK, DE-MD	9	5	8	6	9	23	4	5	9	2	3	13	9

Table 6-3. (Ozone Only) Number of PSI Days Greater Than 100 at Trend Sites, 1984–93, and All Sites in 1993

MSA	# trend sites	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Total # sites	PSI > 100 1993
ALBANY–SCHENECTADY–TROY, NY	1	1	2	0	0	1	0	0	0	0	0	3	0
ALLENTOWN–BETHLEHEM–EASTON, PA	3	5	2	2	5	15	0	0	2	0	0	3	0
ATLANTA, GA	2	8	9	17	19	15	3	16	5	4	14	4	16
AUSTIN–SAN MARCOS, TX	2	0	2	0	0	0	0	0	0	0	0	2	0
BAKERSFIELD, CA	3	26	27	33	45	54	28	22	23	4	28	6	37
BALTIMORE, MD	6	19	13	19	26	38	7	11	20	4	12	7	14
BATON ROUGE, LA	3	11	8	5	10	10	9	18	6	2	3	7	7
BERGEN–PASSAIC, NJ	1	4	6	2	12	18	2	3	3	0	0	1	0
BIRMINGHAM, AL	4	2	3	5	6	15	0	5	0	2	5	6	5
BOSTON, MA–NH	2	7	3	2	4	12	2	1	3	1	3	5	3
BUFFALO–NIAGARA FALLS, NY	1	0	2	0	2	14	1	1	0	0	0	1	0
CHARLESTON–NORTH CHARLESTON, SC	2	0	0	2	0	0	0	0	0	0	0	2	0
CHARLOTTE–GASTONIA–ROCK HILL, NC–SC	4	5	1	9	10	17	2	3	2	0	4	6	6
CHICAGO, IL	13	9	8	6	14	20	2	0	7	3	0	17	0
CINCINNATI, OH–KY–IN	7	2	2	6	10	23	2	6	7	0	1	7	1
CLEVELAND–LORAIN–ELYRIA, OH	6	3	1	2	7	20	2	1	5	0	1	7	1
COLUMBUS, OH	2	0	0	1	1	4	0	1	3	0	0	4	1
DALLAS, TX	3	11	14	5	8	3	3	5	0	2	4	6	5
DAYTON–SPRINGFIELD, OH	3	1	0	2	2	14	3	1	1	0	2	4	2
DENVER, CO	5	2	1	3	4	4	0	0	0	0	0	10	0
DETROIT, MI	7	4	1	3	6	16	10	3	7	0	2	10	2
EL PASO, TX	3	9	10	11	12	3	10	4	5	6	4	4	4
FORT LAUDERDALE, FL	1	0	0	0	0	0	1	0	0	0	0	3	1
FORT WORTH–ARLINGTON, TX	2	12	8	5	2	4	2	4	7	2	1	2	1
FRESNO, CA	2	18	21	24	28	11	21	12	18	16	13	6	20
GARY, IN	4	9	2	5	6	12	0	2	3	1	0	4	0
GRAND RAPIDS–MUSKEGON–HOLLAND, MI	2	2	4	4	9	18	8	5	6	0	1	4	1
GREENSBORO––WINSTON–SALEM––HIGH POINT, NC	2	0	0	3	1	11	0	1	0	0	2	6	2
HARRISBURG–LEBANON–CARLISLE, PA	3	1	1	0	4	13	0	2	0	0	1	3	1
HARTFORD, CT	3	19	11	2	8	23	7	7	12	8	9	3	9
HONOLULU, HI	1	1	0	0	0	0	0	0	0	0	0	1	0
HOUSTON, TX	11	49	48	43	52	48	34	48	40	30	26	11	26
INDIANAPOLIS, IN	3	1	2	0	1	7	2	1	0	0	0	8	0
JACKSONVILLE, FL	2	0	2	0	1	2	0	0	0	0	1	3	1
JERSEY CITY, NJ	1	7	13	4	12	17	2	7	7	1	5	1	5
KANSAS CITY, MO–KS	5	11	3	3	2	3	1	2	1	1	1	6	1
KNOXVILLE, TN	3	0	0	0	0	5	0	2	0	0	1	5	1
LAS VEGAS, NV–AZ	2	0	1	0	0	2	1	0	0	0	0	4	0
LITTLE ROCK–NORTH LITTLE ROCK, AR	1	0	0	1	1	0	0	1	0	0	0	2	0
LOS ANGELES–LONG BEACH, CA	8	152	154	159	145	165	138	118	111	130	102	10	102
LOUISVILLE, KY–IN	4	13	4	9	3	20	1	4	5	0	5	6	5
MEMPHIS, TN–AR–MS	3	2	4	6	5	8	2	4	0	0	1	4	1
MIAMI, FL	3	0	3	4	4	4	3	1	2	0	0	4	0
MIDDLESEX–SOMERSET–HUNTERDON, NJ	2	14	15	7	9	24	7	10	8	3	1	2	1
MILWAUKEE–WAUKESHA, WI	4	7	5	9	12	19	8	2	10	0	0	7	0

Table 6-3. (Ozone Only) Number of PSI Days Greater Than 100 at Trend Sites, 1984–93, and All Sites in 1993

MSA	# trend sites	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Total # sites	PSI > 100 1993
MINNEAPOLIS–ST. PAUL, MN–WI	3	2	0	1	1	1	0	0	0	0	0	5	0
NASHVILLE, TN	3	6	3	3	3	15	2	7	1	1	2	6	2
NASSAU–SUFFOLK, NY	1	0	3	7	10	8	6	6	12	2	4	3	6
NEW HAVEN–MERIDEN, CT	2	24	10	6	17	16	7	8	19	2	7	2	7
NEW ORLEANS, LA	4	7	1	2	4	2	1	0	0	1	2	6	2
NEW YORK, NY	4	17	19	7	15	32	10	13	19	3	6	5	6
NEWARK, NJ	3	2	10	12	21	30	3	7	7	5	2	3	2
NORFOLK–VIRGINIA BEACH–NEWPORT NEWS,VA–NC	1	0	1	1	2	3	0	0	1	2	3	3	4
OAKLAND, CA	7	12	7	5	9	4	2	2	1	1	3	9	3
OKLAHOMA CITY, OK	3	1	1	0	1	0	0	1	0	0	0	4	0
OMAHA, NE–IA	3	1	0	0	0	0	0	0	0	0	0	3	0
ORANGE COUNTY, CA	4	62	61	51	42	45	38	36	32	35	17	4	17
ORLANDO, FL	2	0	0	0	0	0	0	2	0	0	0	4	0
PHILADELPHIA, PA–NJ	8	22	25	19	32	34	17	11	24	3	20	8	20
PHOENIX–MESA, AZ	7	11	9	0	2	2	0	2	0	4	5	11	6
PITTSBURGH, PA	6	0	2	1	5	14	2	0	1	0	3	9	4
PORTLAND–VANCOUVER, OR–WA	3	2	2	4	2	2	0	4	1	2	0	4	0
PROVIDENCE–FALL RIVER–WARWICK, RI–MA	2	18	9	6	10	8	2	7	10	2	1	2	1
RALEIGH–DURHAM–CHAPEL HILL, NC	1	0	0	0	2	11	0	0	0	0	0	5	0
RICHMOND–PETERSBURG, VA	3	2	3	0	5	18	0	1	1	2	4	4	8
RIVERSIDE–SAN BERNARDINO, CA	13	164	142	151	149	163	146	121	119	126	112	20	120
ROCHESTER, NY	2	0	0	1	1	4	0	1	0	0	0	2	0
SACRAMENTO, CA	6	23	19	22	22	35	9	14	14	11	5	15	7
ST. LOUIS, MO–IL	10	20	10	11	12	17	7	8	6	2	5	13	6
SALT LAKE CITY–OGDEN, UT	4	8	13	9	1	7	5	2	1	0	0	4	0
SAN ANTONIO, TX	2	1	0	1	1	1	0	0	0	0	0	2	0
SAN DIEGO, CA	7	51	50	42	40	45	54	39	25	19	14	9	14
SAN FRANCISCO, CA	3	0	1	0	0	0	0	0	0	0	0	3	0
SAN JOSE, CA	4	18	7	1	9	2	3	0	1	1	1	6	1
SCRANTON––WILKES–BARRE––HAZLETON, PA	4	1	1	0	1	12	1	0	2	0	0	5	0
SEATTLE–BELLEVUE–EVERETT, WA	1	0	0	1	0	1	0	2	0	0	0	3	0
SPRINGFIELD, MA	2	9	11	2	2	15	2	2	3	2	7	2	7
TAMPA–ST. PETERSBURG–CLEARWATER, FL	5	3	5	5	5	0	1	3	0	1	0	7	0
TOLEDO, OH	2	0	0	1	2	6	1	0	1	0	2	4	2
TUSCON, AZ	3	0	0	0	0	0	0	0	0	0	0	7	0
TULSA, OK	3	10	5	4	1	2	2	2	2	0	1	3	1
VENTURA, CA	6	23	19	59	31	55	46	18	39	10	16	7	18
WASHINGTON, DC–MD–VA–WV	12	12	12	10	20	35	4	5	16	2	12	15	14
WEST PALM BEACH–BOCA RATON, FL	1	0	0	0	0	0	0	0	0	0	0	2	2
WILMINGTON–NEWARK, DE–MD	2	5	8	6	9	23	4	5	9	2	9	4	9

6.3 References

1. *Measuring Air Quality, The Pollutant Standards Index*, EPA-451/K-94-001, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1994.
2. *Code of Federal Regulations*, 40 CFR Part 58, Appendix G.

Chapter 7: International Air Pollution Perspective

This chapter discusses air pollution emissions, trend patterns, levels for selected countries and cities around the world, and ambient concentration regulations for international and national entities. Because the form of air quality standards and goals may differ among countries, common air quality statistics have been selected for comparison purposes. Definitions and monitoring methods may vary from country to country; therefore, comparisons among nations are subject to caution. *Trends observed within each country may be more reliable than comparisons between countries.*

7.1 Emissions

As a result of human activities involving stationary and mobile sources, world-wide anthropogenic emissions of SO_x (reported as SO_2) are currently estimated to be approximately 99 million metric tons.[1] Fossil fuel combustion accounts for approximately 90 percent of the global human-induced SO_x emissions.[2] Over the past few decades, global SO_x emissions have increased by approximately four percent per year, corresponding to the increase in world energy consumption.

Recent data indicate that emissions of SO_x have been significantly reduced in many developed countries (Figure 7-1). Table 7-1 provides additional comparative information on SO_2 emissions. The table describes the emissions of SO_x from anthropogenic sources in selected countries in 1980 and 1990; the total emissions are reported as 10^3 metric tons per year as SO_2. Because the manner in which emission estimates were generated may vary from country to country, comparisons among nations are subject to caution.

About 90 percent of the human-induced emissions originate in the Northern Hemisphere. The United States and countries within the former Soviet Union are the two biggest sources.[3] For example, in 1970, the United States emitted approximately 28 million metric tons of SO_2, which had been reduced to approximately 20 million metric tons by 1993.[4], Countries within the former Soviet Union emitted approximately 20 million metric tons in 1981 compared to approximately 17 million metric tons in 1990.[5] Much less information is available for emission trends in developing countries. However, there are indications that SO_x emissions are increasing in these developing areas and SO_x pollution is evident in countries such as China, India (see Table 7-1) and Mexico.[2,3,5,6]

In 1990, it was estimated that, worldwide, 68 million metric tons of nitrogen oxides (reported as NO_2)

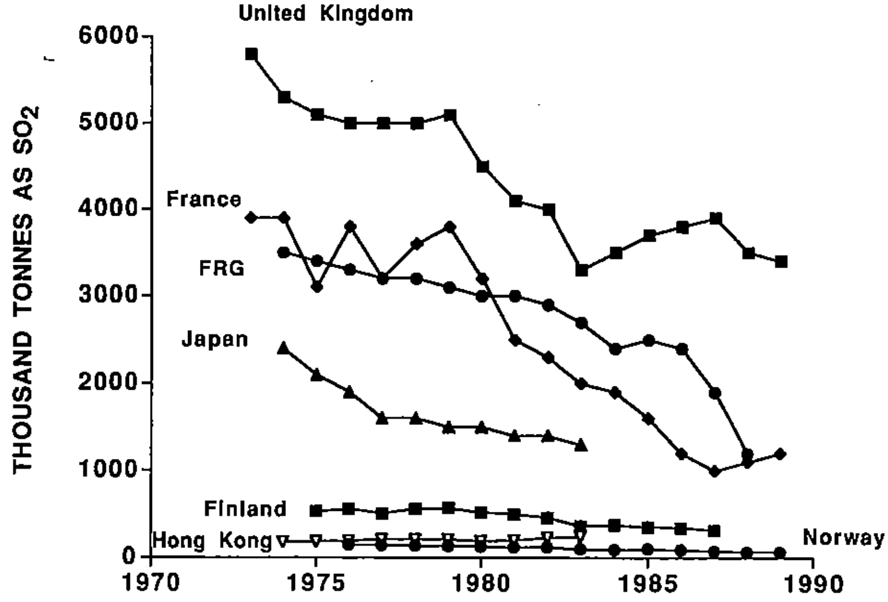

Figure 7-1. SO_x emissions in 1000 metric tons/year for selected countries. *Source: UNEP 1991a.*

Table 7-1. Emissions of sulfur dioxide from anthropogenic sources in selected countries, 1980 and 1990. Total emissions (10^3 metric tons per year as SO_2)

Region/Country	1980	1990	Per capita 1990 (kg $year^{-1}$)	% Change 1980–1990
NORTH AMERICA				
Canada	4,643	3,800	143.3	-18
USA	21,256	18,321	84.7	-13
ASIA[1]				
Afghanistan	8.5	11	3.9	29
Bangladesh	57	49	0.5	-14
Brunei	0.9	1.1	4.4	22
Cambodia	1.3	2.9	0.3	123
China	13,370	19,990	17.7	50
China, Taiwan	1,040	605	29.8	-42
Hong Kong	166	150	25.9	-10
India	2,010	3,070	3.7	53
Indonesia	329	485	2.7	47
Israel	308	273	58.6	-11
Japan	1,600	1,140	9.2	-29
Korea	271	333	7.9	23
Korea, Dem.	1,920	1,290	59.3	-33
Kuwait	450	465	222.5	3
Laos	1.4	1.7	0.4	21
Macao	3.0	8.4	18.9	180
Malaysia	272	263	14.7	-3
Maldives	–	0.3	1.5	–
Mongolia	65	101	49.4	55
Myanmar	31	30	0.7	-3
Nepal	4.9	11	0.6	124
Pakistan	198	381	3.4	92
Philippines	1,040	370	6.0	-64
Qatar		159	430.8	
Singapore	122	155	51.7	27
Sri Lanka	30	28	1.7	-7
Thailand	420	612	11.2	46
Turkey	276	398	7.2	44
Viet Nam	34	39	0.6	15
EUROPE				
Albania	50	50	0	
Austria	390	98	13.1	-75
Belgium	828	420	42.3	-49
Bulgaria	1,034	1,030	114.6	0
Czechoslovakia	3,100	2,564	177.1	-17

Table 7-1. Emissions of sulfur dioxide from anthropogenic sources in selected countries, 1980 and 1990. Total emissions (10^3 metric tons per year as SO_2) (cont.)

Region/country	1980	1990	Per capita 1990 (kg year^{-1})	% Change 1980–1990
Denmark	448	266	52.0	-41
Finland	584	256	51.5	-56
France	3,338	1,206	21.5	-64
German. Dem. Rep.	4,264	5,242	314.9	23
Germany, Fed. Rep.	3,194	1,002	16.6	-69
Greece	400	500	50.3	25
Hungary	1,632	1,010	95.7	-38
Iceland	6	6	24.8	0
Ireland	222	168	45.2	-24
Italy	3,800	2,406	42.0	-37
Luxembourg	24	10	32.7	-58
Netherlands	466	238	16.1	-49
Norway	142	60	14.2	-58
Poland	4,100	3,210	83.5	-22
Portugal	266	212	20.6	-20
Romania	1,800	1,800	45.6	0
Spain	3,250	2,190	56.7	-33
Sweden	514	204	24.5	-60
Switzerland	126	62	9.5	-51
UK	4,898	3,774	66.3	-23
Yugoslavia	1,300	1,480	62.1	14
USSR				
Armenia	141	73	20.9	-48
Azerbaijan	119	90	12.4	-24
Belarus	740	562	54.6	-24
Estonia	462	192	121.3	-58
Georgia	59	76	13.9	29
Kazakhstan	1,607	1,484	87.0	-8
Kyrgyzstan	62	56	12.4	-10
Latvia	60	54	20.0	-10
Lithuania	228	143	38.0	-37
Moldova	289	231	52.9	-20
Russia	12,123	10,166	68.2	-16
Tajikistan	7	17	3.0	143
Turkmenistan	5	22	5.8	340
Ukraine	3,850	2,782	53.3	-28
Uzbekistan	298	542	25.2	82

Source: UNEP (1993) except for USA data (U.S. EPA, 1993).

[1] In Asia, 1987 data were reported for all countries except for Turkey.

were emitted into the atmosphere as a result of human activities.[1] Nitrogen oxides are primarily emitted by fossil fuel combustion, with the transport sector typically accounting for between one-third and one-half of national emissions.[7] During the past 20 years, trends in natural emissions have been mixed. Table 7-2 summarizes the emissions of NO_x from anthropogenic sources in selected countries.

In 1990, global emissions of suspended particulate matter were estimated to be approximately 57 million metric tons per year.[7] However, estimates vary widely. The United Nations Environment Program (UNEP) has estimated the global total to be closer to 135 million metric tons.[3] Despite increased coal combustion, in many industrialized countries, particulate emissions have decreased because of cleaner burning techniques.[3] Table 7-3 provides additional information on particulate emissions to allow for comparisons among countries. Although, as already noted, the percent change within each country may be more reliable than comparisons between countries. For Eastern Europe and other developing countries, although information is scarce, particulate emissions appear to be increasing.[3]

For more information on emission estimates for Europe, Canada and Mexico, the reader is directed to the report, *National Air Pollutant Emission Trends, 1900–1993*.[4] This companion report summarizes emissions estimates prepared by the European Communities, European Environment Agency Task Force that are broken down by emission category. The report also contains international greenhouse gas emission estimates.

Table 7-2. Emissions of nitrogen oxides from anthropogenic sources in selected countries, 1980 and 1990. Total emissions (10^3 metric tons per year at NO_2).

Region/Country	1980	1990	Per capita 1990 (kg year^{-1})	% Change 1980–1990
NORTH AMERICA				
Canada	1,959	1,943	73.3	-1
USA	19,160	19,087	79.8	0
ASIA[1]				
Afghanistan	22	30	1.8	36
Bangladesh	58	66	0.6	14
Brunei	4	11	44.2	175
Cambodia	9	12	1.4	33
China	4,910	7,370	6.5	50
China, Taiwan	225	325	16.0	44
Hong Kong	88	99	17.1	12
India	1,670	2,560	3.1	53
Indonesia	465	639	3.6	37
Israel	80	148	31.8	85
Japan	2,130	1,940	15.7	-9
Korea	365	555	13.1	52
Korea, Dem.	383	468	21.5	22
Laos	8	9	2.2	12
Macao	3	5	11.3	67
Malaysia	126	177	9.9	40
Mongolia	49	72	35.3	47
Myanmar	47	45	1.1	-4
Nepal	21	50	2.6	138
Pakistan	164	231	2.1	41
Philippines	184	184	3.0	0
Singapore	67	88	29.3	31
Sri Lanka	31	37	2.2	19
Thailand	255	384	7.0	51
Turkey	175	175	3.0	0
Viet Nam	88	99	1.5	12

Table 7-2. Emissions of nitrogen oxides from anthropogenic sources in selected countries, 1980 and 1990. Total emissions (10^3 metric tons per year at NO_2). (cont.)

Region/Country	1980	1990	Per capita 1990 (kg year^{-1})	% Change 1980–1990
EUROPE				
Albania	9	9	2.8	0
Austria	233	209	27.9	-10
Belgium	317	300	30.2	-5
Bulgaria	150	150	16.8	0
Czechoslovakia[2]	1,204	1,122	71.3	-7
Denmark	245	254	49.6	4
Finland	264	290	58.3	10
France	1,823	1,742	31.0	-4
German. Dem. Rep.[2]	630	705	42.3	12
Germany, Fed. Rep.[2]	2,980	2,707	44.7	-9
Greece	746	746	75.1	0
Hungary	273	238	22.6	-13
Iceland	13	12	49.8	-8
Ireland	73	135	36.3	85
Italy	1,480	1,755	30.6	19
Luxembourg	23	15	40.9	-35
Netherlands	553	529	35.9	-4
Norway	185	212	50.1	15
Poland	1,500	1,280	33.3	-15
Portugal	166	142	13.8	-14
Romania	390	390	16.8	0
Spain	950	950	24.2	0
Sweden	398	373	23.2	-6
Switzerland	196	184	28.2	-6
UK	2,422	2,690	47.3	11
Yugoslavia	350	420	17.6	20
USSR				
Armenia	16	23	6.5	44
Azerbaijan	50	59	8.1	18
Belarus	98	101	9.8	3
Estonia	46	20	12.6	-56
Georgia	40	24	4.3	-40
Kazakhstan	169	330	19.4	95
Kyrgyzstan	11	12	2.7	9
Latvia	10	14	5.3	40
Lithuania	30	35	9.4	17
Moldova	51	39	8.9	-24
Russia	2,578	3,050	20.5	18
Tajikistan	6	8	1.5	33
Turkmenistan	15	35	9.0	133
Ukraine	841	761	14.6	-10
Uzbekistan	80	117	5.5	46

Source: UNEP (1993) except for USA data (U.S. EPA, 1993).

[1] In Asia, 1987 data were reported for all countries except for Turkey.

[2] 1989 data used.

Table 7-3. Emissions of particulates from anthropogenic sources in selected countries, 1980 and 1990. Total emissions (10^3 metric tons per year).

Region/Country	1980	1990	% Change 1980–1990
NORTH AMERICA			
Canada	1,907	1,855[a]	-3
USA[b]	5,512	2,637	-18
EUROPE			
Austria	79	39	-51
France	427	276	-35
Germany	3,190	2,275	-29
Hungary	576	343[c]	-40
Ireland	94	105	-12
Italy	433	501[c]	16
Netherlands	158	72	-54
Norway	24	21	-12
Switzerland	28	20	-29
UK	560	473	-16

[a] *Source: M. Deslauriers, Environment Canada, Ottawa.*

[b] EPA's National Air Pollutant Emissions Trends, 1993; PM-10 total emissions excluding miscellaneous and natural sources.

[c] 1989 data cited.

Source: Except where noted, OECD (1993).

7.2 Ambient Concentrations

On a global scale, in general, declining annual average SO_2 levels over time correspond with declining emission trends (Figure 7-1). Trends in SO_2 annual average concentration levels for selected cities are displayed in Table 7-4.[8] Again, the focus should be more on the direction of change, rather than on a comparison of absolute levels, because monitoring methods and siting objectives may vary among countries. Figure 7-2 presents a comparison of SO_2 annual average concentrations in selected cities in the world. Figure 7-3 compares the second-highest 24-hour sulfur dioxide concentrations at two sites in the United States, a site in New York and one in Chicago, with concentrations experienced at sites in Montreal (Quebec), Toronto (Ontario), and Winnipeg (Manitoba), Canada.[9]

Similar to trend estimates for SO_2 concentrations, suspended particulate matter annual average concentrations in cities are declining in many of the world's industrialized cities. Urban particulate matter concentrations have declined in the Organization for Economic Cooperation and Development (OECD) countries from annual average concentrations of between 50 and 100 µg/m^3 in the early 1970s, to levels between 20 and 60 µg/m^3 on an annual basis.[1] However, suspended particulate matter concentrations in many of the developing countries are high when compared to some of the more industrialized cities (Figure 7-4). A comparison of the annual geometric mean suspended particulate matter concentrations between New York and Chicago in the United States and Hamilton (Ontario), Montreal (Quebec), and Vancouver (British Columbia) in Canada is illustrated in Figure 7-5.

Hourly average values of O_3 vary from year to year, depending on factors such as precursor emissions and meteorological conditions. Although surface O_3 measurements are made in many countries, O_3 has not been routinely summarized on an international basis. In many OECD countries, O_3 levels exceed the recommended standards. In Japan, hourly average concentrations of 235 µg/m^3 (0.12 ppm) are exceeded on a few days of the year, mostly in the Tokyo and Osaka areas[8]. Mexico City has experienced some of the highest O_3 hourly average concentrations in the world. For the period 1986–1991, at some locations in Mexico City, maximum hourly average concentrations have at times

Table 7-4. Urban Trends in Annual Average Sulfur Dioxide Concentrations (μg/m³).

Country	City	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
USA	New York	51.7	47.8	50.4	47.4	47.8	42.7	41.0	41.4	45.3	40.6	36.3	36.7
Japan	Tokyo	48.0	43.0	42.0	30.0	27.0	25.0	24.0	23.0	20.0	25.0	26.0	–
New Zealand	Auckland	23.0	15.7	7.9	7.3	4.4	–	3.2	2.5	3.0	2.0	1.9	2.0
Austria	Vienna	69.0	57.0	52.0	41.9	39.1	46.0	39.1	36.8	23.0	22.1	–	–
Belgium	Brussels	42.9	46.0	32.0	35.1	44.9	39.0	37.1	26.1	26.9	–	26.9	25.0
Denmark	Copenhagen	30.9	17.9	22.9	25.0	26.0	26.0	19.0	–	21.1	20.0	17.2	18.7
Finland	Helsinki	–	29.4	21.8	24.4	24.9	28.0	23.0	23.0	21.0	15.1	12.9	12.0
France	Paris	89.1	70.7	68.0	61.0	57.2	54.0	50.2	47.0	36.2	43.7	38.3	–
Germany	Frankfurt	70.8	75.0	72.0	56.7	51.2	61.0	54.9	62.8	34.2	26.8	20.7	23.2
The Netherlands	Amsterdam	25.1	25.8	21.3	19.6	19.6	15.8	13.6	13.6	14.1	11.1	10.0	–
Norway	Oslo	35.6	31.5	20.3	15.5	16.2	15.0	12.5	12.8	–	–	7.2	–
Portugal	Lisbon	44.0	34.1	34.1	35.0	31.9	31.0	27.0	31.0	43.1	30.1	20.2	45.0
Sweden	Gothenberg	24.0	33.0	18.9	18.3	25.1	22.0	16.9	18.9	13.0	11.0	12.1	-
Switzerland	Zurich	–	43.0	49.0	48.0	46.0	50.0	38.0	30.0	27.0	23.0	18.0	19.0
Turkey	Ankara	208.6	219.1	257.4	154.4	139.9	132.0	122.8	157.1	260.0	154.4	155.8	122.8
United Kingdom	London	70.1	68.0	60.9	49.1	50.0	42.0	44.9	39.1	39.1	37.0	39.1	31.9
Czech. Republic	Prague	74.0	–	–	–	–	86.0	69.7	78.3	43.0	65.4	44.7	62.8
Slovak	Prievidza-Dist.	85.2	109.9	80.0	59.8	59.8	65.0	68.3	72.8	55.3	42.3	31.9	33.2
Poland	Warsaw47.0	51.8	45.9	41.0	31.9	54.0	29.2	27.0	23.2	23.8	–	–	

Source: OECD (1993).

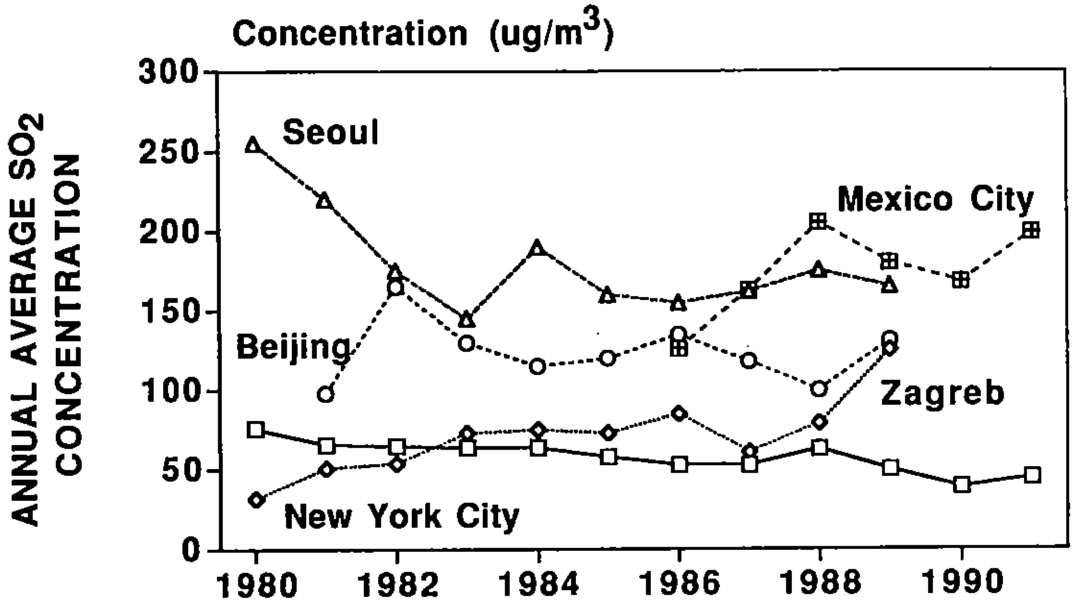

Figure 7-2. Trend in annual average sulfur dioxide concentrations in selected cities of the world. *Source: UNEP, 1992; UNEP/WHO, 1992a; UNEP/WHO, 1992b.*

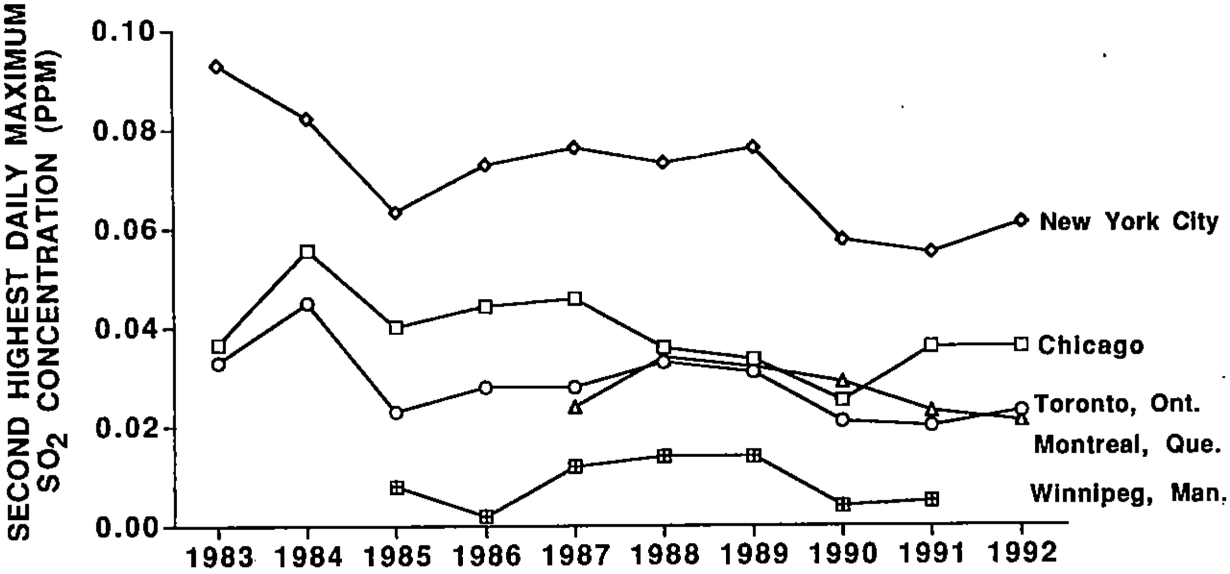

Figure 7-3. Trend in annual second highest 24-hour sulfur dioxide concentrations in selected U.S. cities and Canadian cites, 1983–1991. *Source: T. Dann, Environment Canada; AIRS database.*

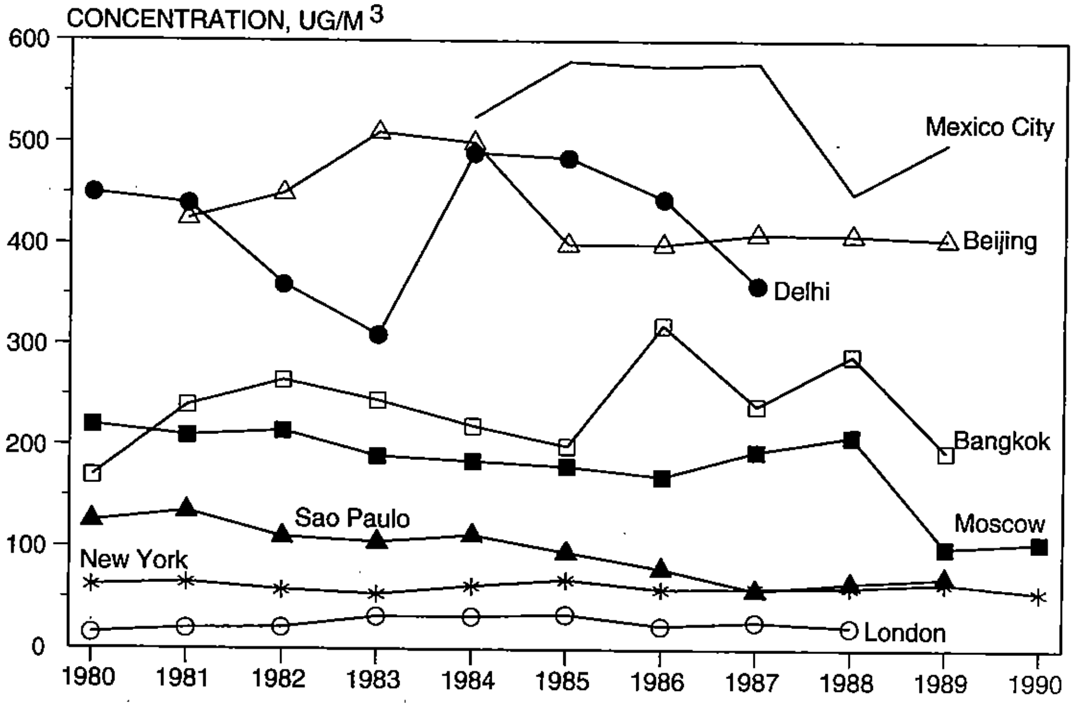

Figure 7-4. Trend in annual average suspended particulate concentrations of selected cities of the world. *Source: UNEP/WHO, 1992a; UNEP/WHO, 1992b.*

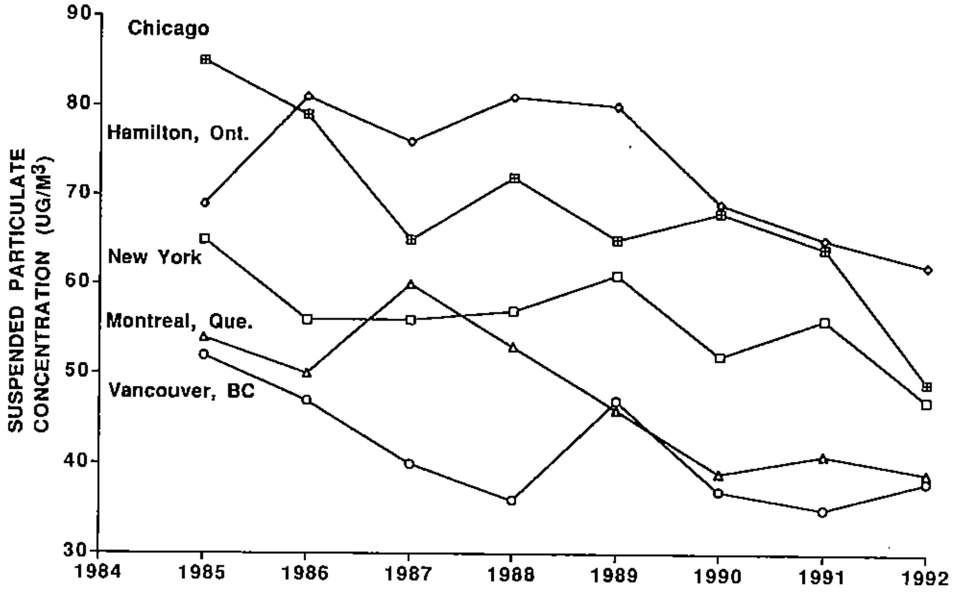

Figure 7-5. Trend in annual geometric mean total suspended particulate concentrations in selected U.S. cities and Canadian cites, 1985–1991. *Source: T. Dann, Environment Canada; AIRS database.*

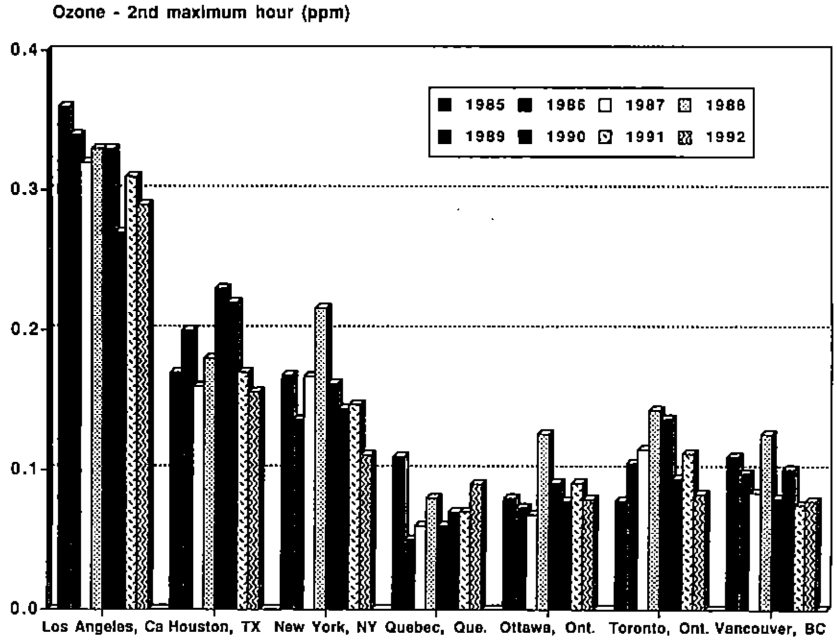

Figure 7-6. Trend in annual second highest one-hour ozone concentrations in selected U.S. cities and Canadian cites, 1983–1991. *Source: T. Dann. Environment Canada; AIRS database.*

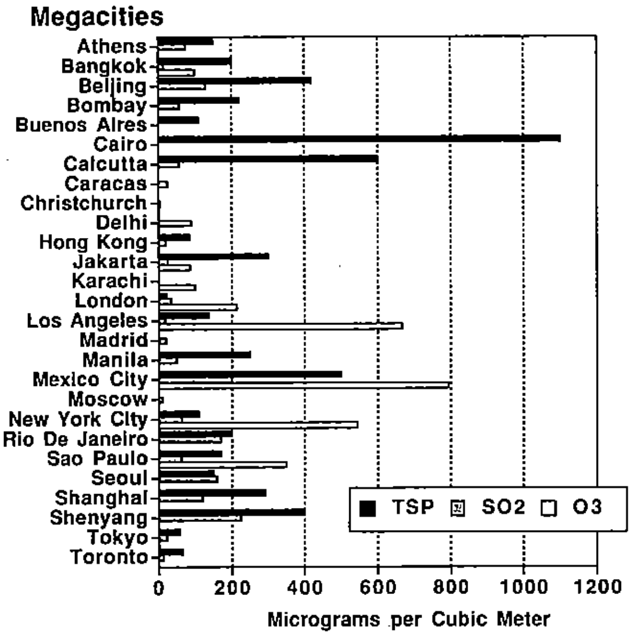

Figure 7-7. Comparison of ambient levels of annual second daily maximum one-hour ozone, annual average total suspended particulate matter and sulfur dioxide concentrations among selected cities.
Source: UNEP/WHO, 1992a; UNEP/WHO, 1992b; Varshney and Aggarwal, 1992; UNEP/WHO, 1993; AIRS database.

exceeded 0.450 ppm.[10] In March 1992, similar high hourly average values were reported. These values are higher than those that normally occur in Los Angeles, California. In general, O_3 levels at urban locations are lower in Canada than in the United States. The lower O_3 levels in Canada may be associated with the country's geographical location, i.e., lower temperature and solar radiation. Figure 7-6 shows a comparison of the second highest daily maximum O_3 levels between some selected sites in the United States and in Canada. The year 1988 was conducive for high O_3 concentrations in the eastern and midwestern United States and parts of Canada.

Concentrations for suspended particulate matter, sulfur dioxide, and ozone vary substantially among cities in the world. Figure 7-7 presents a summary of the extent of these variations. The concentration information presented in the figure was derived from several sources.[1,2,3,9,11,12,13,14,18]

Ambient Pb levels have shown a significant decline in the past decade. Between 1984 and 1993, the composite average of the maximum quarterly mean concentration decreased by 89 percent in the United States, with even larger reductions in the early 1980s. In Canada, a very similar trend in ambient Pb concentrations has been observed. Composite average Pb concentrations declined over 95 percent for the 1974–1990 time period.[15] Also, average ambient Pb concentrations in Tokyo, Japan[16] have dropped from around 1.0 $\mu g/m^3$ in 1967 to approximately 0.1 $\mu g/m^3$ in 1985 a 90-percent improvement.

7.3 Ambient Concentration Regulations

Most countries regulate ambient concentration of pollutants to protect its citizens and their environment. The averaging times, number of exceedances, and units for these regulations vary across countries. For purposes of comparisons, a sampling of national regulations is summarized in Table 7-5. The table lists selected standards from certain countries. The most common pollutants having ambient air quality standards worldwide are presented for each country. However, these countries may have other standards for pollutants that are particular to their dominant industries that are not presented here. It should also be pointed out that different countries treat standards very differently.[17] In some cases, the standards are a legislated requirement in which specific steps must be taken when the standards are not met. In other cases, the standards serve as guidelines or goals which put ambient monitoring data into a perspective relative to health risks or environmental degradation. However, no specific steps are taken when these limits are not met. The regulations described are subject to change and the information in the tables was available at time of publication by the sources cited. The World Health Organization guidelines are listed in the table. No entries are provided in the TSP columns for the United States because the current form of the standard is PM-10.

Table 7-5. Selected International Air Quality Standards and Guidelines (units in µg/m^3)

Country	SO_2 Annual Average	SO_2 Daily Average	TSP Annual Average	TSP Daily Average	Ozone Hourly Average
Australia	60		90		240*
Belgium	40–60	100–150	40–60	100–150	
Brazil	80	365*		240*	160*
Canada	30	150		120	100
Finland	40		60		
France	40–60	100–150			
Germany	140		150		
Israel	60	280	75	200	
Italy	40–60	100–150			
Japan		105			118
Kuwait	79	157*	90	350*	157
Malaysia		105	90	260	200
Mexico		350		275	220
Netherlands		500			120
Saudi Arabia	80	400			290
South Africa	80	265		150	240
United Kingdom	40–60	100–150			
United States	80	365*			235**
WHO	40–60	100–150	60–90	150–230	100–200

* Allowable exceedance: One per year

** The standard is attained when the expected number of days per year with maximum hourly average concentrations above 0.12 ppm (235 ug m^{-3}) is equal to or less than one.

Source: International Union of Air Pollution Prevention Associations, 1991; Cochran et al., 1992; UNEP/WHO, 1992a.

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Data Appendix

TREND STATISTICS USED IN THE 1993 TRENDS REPORT - MEANS
DATA TAKEN OFF OF AIRS ON JULY 8, 1994

Pollutant	Statistic	Units	# of Sites	Sites Type	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	% CHANGE 1984-93	% CHANGE 1992-93
Carbon Monoxide	2nd.Max.8hr.	PPM	314	ALL	7.69	6.97	7.11	6.69	6.38	6.34	5.87	5.55	5.18	4.88	-37%	
"	"	"	96	NAMS	8.27	7.57	7.76	7.17	6.79	6.76	6.23	5.77	5.68	5.34	-35%	
"	"	"	394	ALL								5.46	5.09	4.82		-5%
"	8hr. Exceed.	8hrs.	314	ALL	3.38	2.47	2.24	1.48	1.23	1.25	0.72	0.42	0.24	0.11	-97%	
"	"	"	96	NAMS	5.46	3.69	3.47	1.96	1.96	2.00	1.16	0.72	0.51	0.27	-95%	
"	"	"	394	ALL								0.40	0.21	0.18		-14%
Lead	Max.Qtr	UG/M3	204	ALL	0.423	0.291	0.180	0.156	0.103	0.080	0.079	0.058	0.050	0.045	-89%	
"	"	"	88	NAMS	0.514	0.346	0.191	0.129	0.098	0.079	0.066	0.054	0.053	0.046	-91%	
"	"	"	228	ALL								0.063	0.053	0.047		-11%
"	"	"	66	PBPT**	1.543	1.468	1.119	0.973	1.048	0.691	0.675	0.720	0.622	0.569	-63%	
"	"	"	93	PBPT**								0.843	0.795	0.726		-9%
Nitrogen Dioxide	Arith.Mean	PPM	201	ALL	0.0220	0.0220	0.0220	0.0220	0.0223	0.0219	0.0207	0.0206	0.0199	0.0194	-12%	
"	"	"	45	NAMS	0.0272	0.0270	0.0272	0.0273	0.0270	0.0266	0.0254	0.0250	0.0241	0.0234	-14%	
"	"	"	269	ALL								0.0191	0.0186	0.0183		-2%
Ozone	2nd.Max.Day	PPM	532	ALL	0.1252	0.1237	0.1197	0.1261	0.1364	0.1169	0.1143	0.1155	0.1071	0.1097	-12%	
"	"	"	197	NAMS	0.1219	0.1199	0.1188	0.1232	0.1352	0.1142	0.1136	0.1139	0.1063	0.1104	-9%	
"	"	"	722	ALL								0.1123	0.1049	0.1072		2%
"	Exceed.Days	DAYS	532	ALL	6.35	5.89	5.22	5.75	8.02	4.29	3.57	3.66	2.91	2.55	-60%	
"	"	"	197	NAMS	5.23	4.67	4.34	4.71	7.28	3.27	2.82	2.99	2.34	2.26	-57%	
"	"	"	722	ALL								3.35	2.64	2.38		-10%
PM10	Wgt Arith. Mean	UG/M3	799	All					33.2	33.0	29.8	29.6	27.2	26.4	-20% *	-3%
	"	"	255	NAMS					36.9	36.6	33.4	33.1	30.2	29.6	-20% *	-2%
"	2nd Max 24-Hr	"	799	ALL					79.7	81.9	75.5	72.4	65.4	65.0	-18% *	-1%
	"	"	255	NAMS					84.7	87.3	82.3	77.6	71.5	71.2	-16% *	-0%
"	90th %tile	"	799	ALL					55.8	55.5	51.1	50.3	44.8	45.0	-19% *	0%
Sulfur Dioxide	Arith. Mean	PPM	474	ALL	0.0098	0.0093	0.0091	0.0089	0.0091	0.0088	0.0081	0.0079	0.0074	0.0073	-26%	
"	"	"	138	NAMS	0.0117	0.0109	0.0106	0.0101	0.0104	0.0100	0.0092	0.0089	0.0081	0.0078	-33%	
"	"	"	560	ALL								0.0077	0.0072	0.0071		-1%
"	2nd.Max.24hr.	PPM	469	ALL	0.0496	0.0448	0.0447	0.0412	0.0438	0.0418	0.0374	0.0346	0.0333	0.0319	-36%	
"	"	"	138	NAMS	0.0517	0.0463	0.0457	0.0431	0.0454	0.0426	0.0389	0.0355	0.0350	0.0316	-39%	
	"	"	552	ALL								0.0343	0.0333	0.0317		-5%

* FOR PM10 THE % CHANGE REFERS TO THE 1988-93 TIME PERIOD
** SITES LOCATED IN THE VICINITY OF LEAD POINT SOURCES

EMISSIONS STATISTICS USED IN THE 1993 TRENDS REPORT
NATIONAL EMISSION ESTIMATES (MILLION SHORT TONS/YEAR)**

Pollutant	1970	1984	1992	1993	1970-93	1984-93	1992-93
Carbon Monoxide	128.079	114.262	96.368	97.208	-24%	-15%	1%
Lead**	219.471	42.217	4.741	4.885	-98%	-88%	3%
Nitrogen Oxides	20.625	23.172	22.991	23.402	13%	1%	2%
VOC	30.646	25.572	23.020	23.312	-24%	-9%	1%
PM10 ***	11.999	2.942 *	2.729	2.661	-78%	-10% *	-2%
Sulfur Oxides	31.096	23.396	21.592	21.888	-30%	-6%	1%

* 1988 TOTAL EMISSIONS ESTIMATE (TO COINCIDE WITH THE AIR QUALITY PERCENT CHANGE)
** LEAD EMISSIONS ARE IN THOUSANDS OF SHORT TONS/YEAR
*** PM10 EMISSIONS ESTIMATES EXCLUDE THE MISCELLANEOUS CATEGORY

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16. ABSTRACT

This report presents national and regional trends in air quality from 1984 through 1993 for particulate matter, sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone and lead. Air quality trends are also presented for 89 metropolitan areas. Both national and regional trends in each of these pollutants are examined. National air quality trends are also presented for both the National Air Monitoring Sites (NAMS) and other site categories. In addition to ambient air quality, trends are also presented for annual nationwide emissions. These emissions are estimated using the best available engineering calculations; the ambient levels presented are averages of direct measurements. International comparisons of air quality and emissions are contained in this report. The topics of air toxics and visibility are also addressed.

This report also includes a section called Air Quality Status of Metropolitan Areas. Its purpose is to provide interested members of the air pollution control community, the private sector and the general public with greatly simplified air pollution information for the single year 1993. Air quality statistics are presented for each of the pollutants for all MSAs with data in 1993.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Lead Air Pollution Trends Emission Trends Carbon Monoxide Nitrogen Dioxide Ozone Sulfur Dioxide Total Suspended Particulates Visibility Particulate Matter Air Pollution Air Quality Standards National Air Monitoring Stations (NAMS) Air Toxics Pollutant Standards Index		

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