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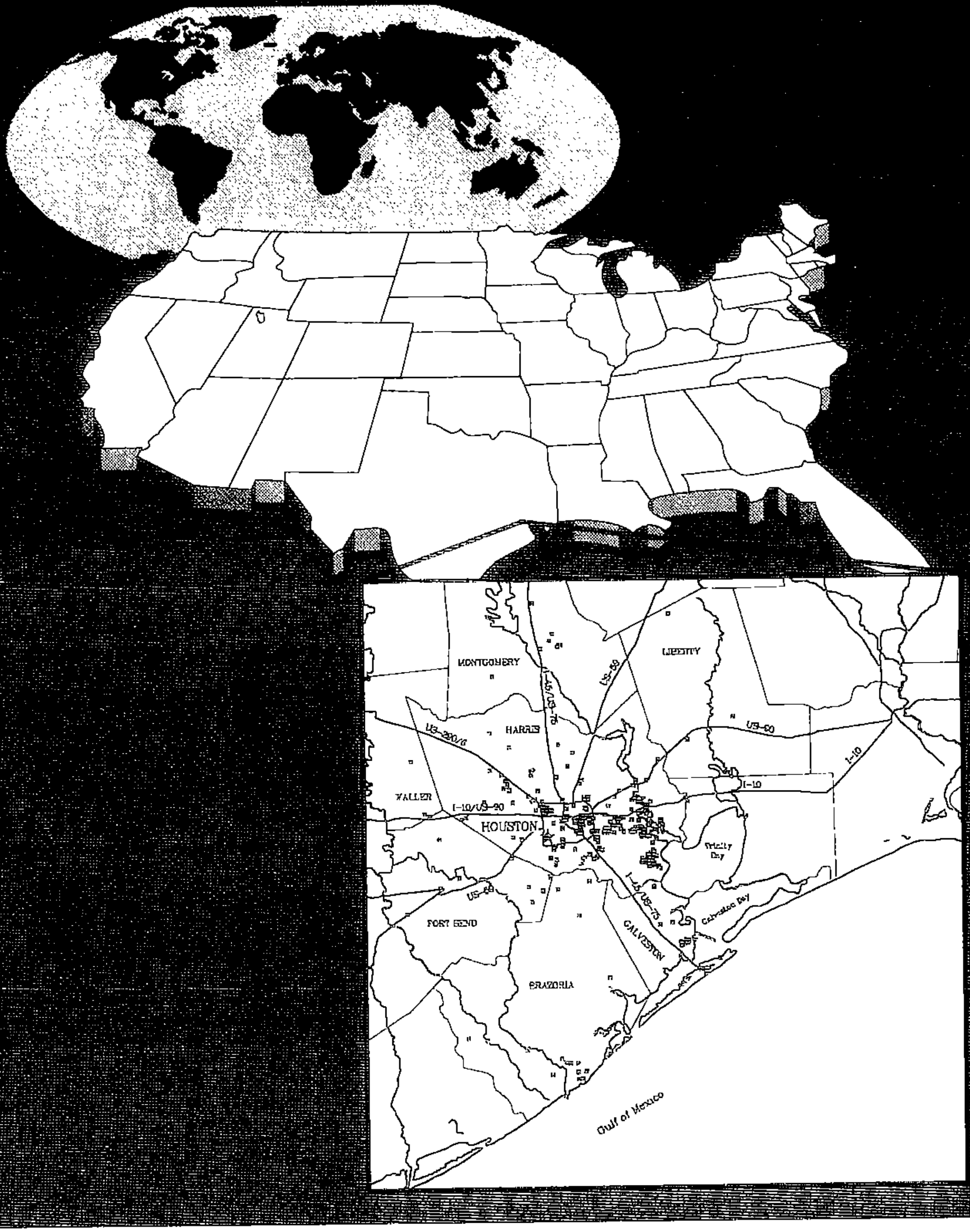

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National Air Quality and Emissions Trends Report, 1992

Technical Support Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711
October 1993

DISCLAIMER

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

PREFACE

This is the twentieth 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 our trend techniques, interpretations, conclusions, and methods of presentation. Please forward any response to Dr. Thomas C. Curran, (MD-14) U. S. Environmental Protection Agency, Technical Support Division, Research Triangle Park, North Carolina 27711.

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Chapter 1: Executive Summary

1.1 Introduction

This is the twentieth annual report[1-19] documenting air pollution trends in the United States. As in previous years, the primary emphasis 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 effects of air pollution on vegetation, materials and visibility. For the first time, this report discusses air toxics, another set of pollutants regulated under the Clean Air Act. Air toxics are those pollutants known to or suspected of causing cancer or other serious health effects, such as reproductive effects or birth defects. Because ambient data on air toxics is limited, this report simply provides an introduction to the subject and an overview of the types of air toxics information that future reports may provide as additional data becomes available.

The analyses in this report focus on comparisons with the primary standards in effect in 1992 to examine changes in air pollution levels over time, and to summarize 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 whose aerodynamic size is equal to or less than 10 microns (PM-10), and sulfur dioxide (SO_2). It is important to note that the discussions of ozone in this report refer to ground level, or tropospheric, ozone and not to stratospheric ozone. Ozone in the stratosphere, miles above the earth, is a beneficial screen from the sun's ultraviolet rays. Ozone at ground level, in the air we breathe, is a health and environmental concern and is the primary ingredient of what is commonly called smog.

The 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 based upon the best available engineering calculations. The estimates of emissions in this report differ from those reported last year. Emissions are now reported in units of short tons per year (2,000 pounds), rather than in metric tons (2,205 pounds) as used in earlier reports. Also, the report reflects a mixture of new estimation methodologies for fuel combustion, industrial, and transportation sources, and includes data obtained from a new model which was used to update mobile source emissions in response to concerns about possible underestimates of the mobile source contribution to total emissions. This is discussed in Chapter 3.

The first three chapters of this report cover trends in the six pollutants with National Ambient Air Quality Standards. Chapter 4 presents the information on air toxics. Chapter 5 includes a detailed listing of selected 1992 air quality summary statistics for every metropolitan statistical area (MSA) in the nation. Chapter 6 presents 1983-92 trends for 23 cities throughout the U.S. Chapter 7 presents summary air pollution statistics from other countries to provide a broader range of air pollution information.

1.2 Major Findings

Carbon Monoxide (CO)

Air Concentrations

1983-92:	34 percent decrease (8-hour second high at 308 sites) 94 percent decrease (8-hour exceedances at 308 sites)
1991-92:	7 percent decrease (8-hour second high at 390 sites)

Emissions

1983-92:	25 percent decrease
1991-92:	4 percent decrease

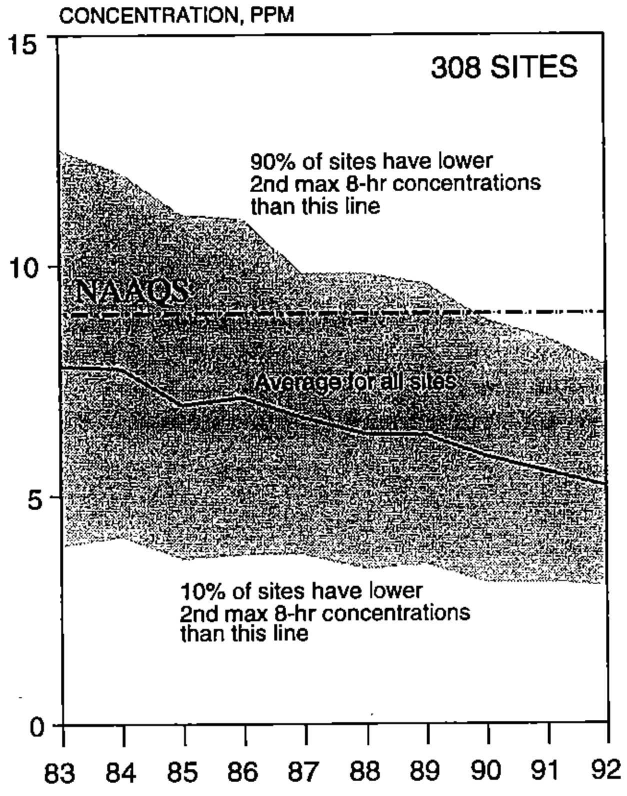
Overview

Trends. Improvements continued with the 1983-92 ten year period showing 34 percent improvement in air quality levels and a 25 percent reduction in total emissions. The air quality improvement agrees more closely with the estimated 30 percent reduction in highway vehicle emissions. This progress occurred despite continued growth in miles of travel in the U.S. Transportation sources account for approximately 80 percent of the nation's CO emissions. The 30 percent decrease in highway vehicle emissions during the 1983-92 period occurred despite a 37 percent increase in vehicle miles of travel. Estimated nationwide CO emissions decreased 4 percent between 1991 and 1992.

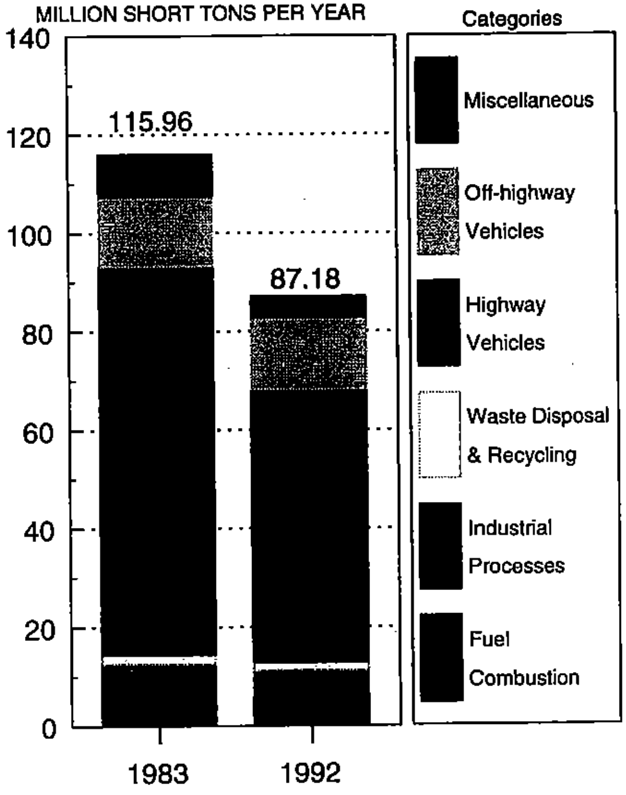
Status. In November 1991, EPA designated 42 areas as nonattainment for CO. Based upon the magnitude of the CO concentrations, 41 of these areas were classified as moderate and 1 (Los Angeles) was classified as serious. In September 1993, Syracuse, NY became the first of these 42 nonattainment areas to be redesignated as an attainment area.

Some Details. The first major clean fuel 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 and preliminary results suggest greater CO air quality improvements, with peak CO levels declining 13 percent in areas with the new oxy-fuel program as compared to a 3 percent decline in non-program areas.

CO TREND, 1983-1992
(ANNUAL 2ND MAX 8-HR AVG)



CO EMISSIONS TREND
(1983 vs. 1992)



CO Effects

Carbon monoxide enters the bloodstream and reduces the delivery of oxygen 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)

Air Concentrations

1983-92: 89 percent decrease (maximum quarterly average at 203 sites)

1991-92: 9 percent decrease (maximum quarterly average at 235 sites)

Emissions

1983-92: 89 percent decrease in total lead emissions
(96 percent decrease in lead emissions from transportation sources)

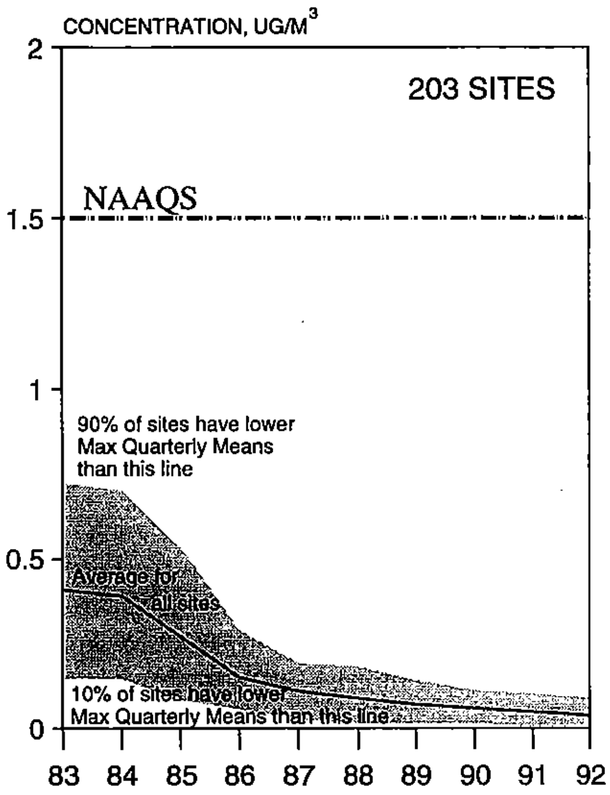
1991-92: 3 percent increase in total lead emissions
(6 percent decrease in lead emissions from transportation sources)

Overview

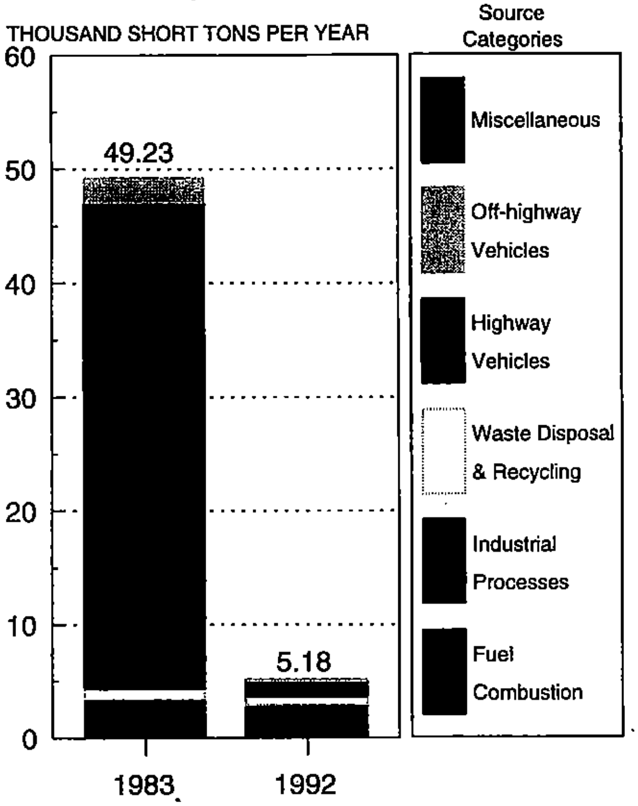
Trends. Ambient lead (Pb) concentrations in urban areas throughout the country have decreased 89 percent since 1983. Total Pb emissions have also dropped 89 percent since 1983 due principally to reductions from automotive sources. The drop in Pb consumption and subsequent Pb emissions was brought about by the increased use of unleaded gasoline in catalyst-equipped cars (99 percent of the total gasoline market in 1992) and the reduced Pb content in leaded gasoline.

Status. In 1991, EPA announced that 12 areas would be designated as nonattainment because of recorded violations of the National Ambient Air Quality Standard for lead. EPA also designated as "unclassifiable" 9 other areas for which existing air quality data are insufficient at this time to designate as either attainment or nonattainment. On April 22, 1993, EPA designated one of the unclassifiable areas as nonattainment.

Some Details. The large reduction in lead emissions from transportation sources has changed the nature of the ambient lead problem in the U.S. In 1983, estimated lead emissions were 49,232 tons and 91 percent was due to transportation sources. In 1992, estimated lead emissions had dropped to 5,176 tons and transportation sources accounted for 31 percent, due to the remaining fraction of leaded gasoline sales. Remaining lead nonattainment problems are associated with point sources, such as smelters, battery plants, and solid waste disposal. Consequently, EPA's current monitoring and control strategies target these kinds of specific sources.



PB TREND, 1983-1992
(ANNUAL MAX QRTLY AVG)



PB EMISSIONS TREND
(1983 vs. 1992)

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)

Air Concentrations

1983-92: 8 percent decrease (annual mean at 183 sites)

1991-92: 3 percent decrease (annual mean at 235 sites)

Emissions: Nitrogen Oxides (NO_x)

1983-92: 5 percent increase

1991-92: 1 percent decrease

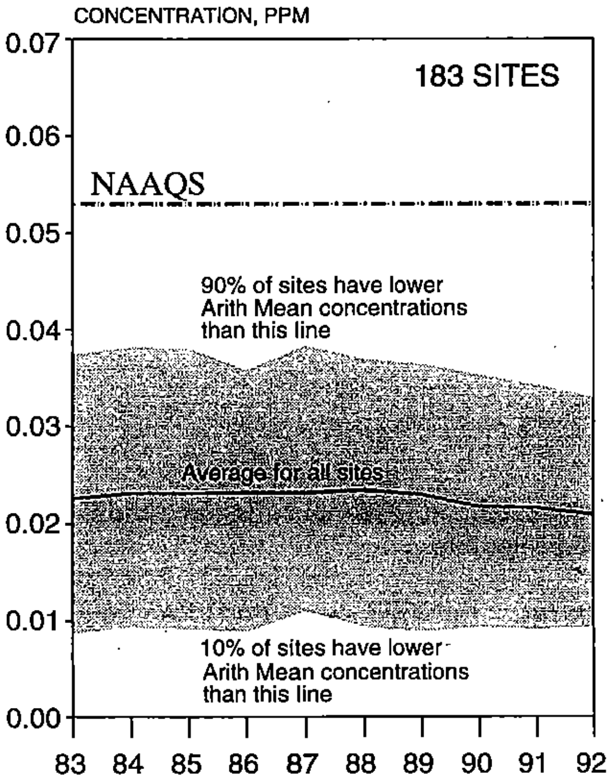
Overview

Trends. Nitrogen oxide emissions are estimated to have increased 5 percent since 1983, with a 9 percent increase in fuel combustion emissions. Air quality improved 8 percent since 1983. The two primary source categories of nitrogen oxide emissions, and their contribution in 1992, are fuel combustion (51 percent) and transportation (45 percent). Since 1983, emissions from highway vehicles have remained relatively constant.

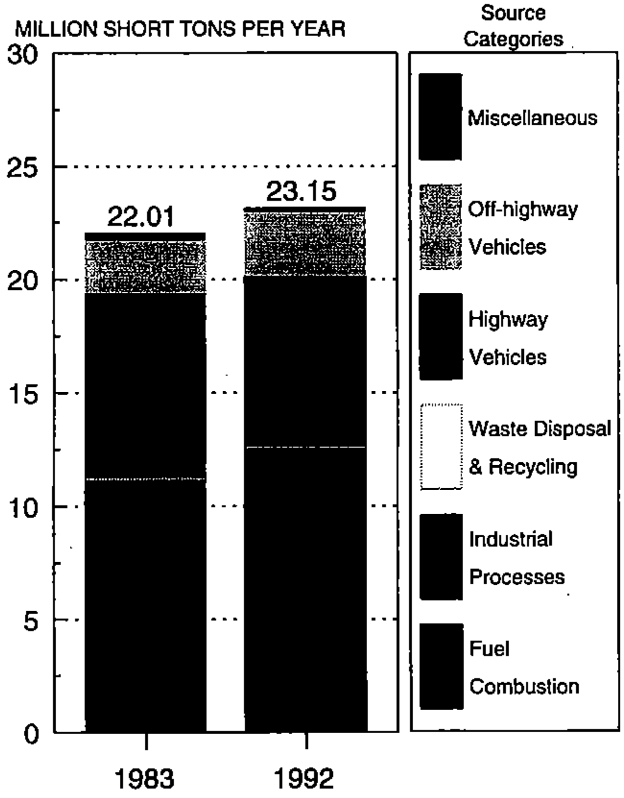
Status. In November 1991, EPA designated Los Angeles as the only nonattainment area for NO_2.

Some Details. In recent years, Los Angeles was identified as the only location not meeting the National Ambient Air Quality Standard for nitrogen dioxide. In 1992, all monitoring locations in Los Angeles reported data meeting the federal standard. This is the first step towards Los Angeles being redesignated as an attainment area for nitrogen dioxide.

The scientific community has expressed concerns that previous EPA emission estimates have underestimated the contribution of transportation sources. An extensive off-highway survey did indeed show marked increases in off-highway emissions from 1983 to 1992. However, highway emissions using a new model (MOBILE5) stayed relatively flat. The major increases, using new methodologies, are from electric utilities, industrial sources, and off-highway mobile sources. Last year's trend from 1982-1991 showed an 8 percent decrease in NO_x, whereas this year's trend shows a 5 percent increase. As methodologies continue to improve, we expect to see variance in the estimates in future years as well.



NO2 TREND, 1983-1992
(ANNUAL ARITHMETIC MEAN)



NOX EMISSIONS TREND
(1983 vs. 1992)

NO_2 Effects

Nitrogen dioxide can irritate the lungs and lower resistance to respiratory infection (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 both to ozone and to 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)

Air Concentrations

1983-92: 21 percent decrease (second highest daily max 1-hour at 509 sites)
65 percent decrease (exceedance days at 509 sites)

1991-92: 7 percent decrease (second highest daily max 1-hour at 672 sites)

Emissions: Volatile Organic Compounds (VOC)

1983-92: 11 percent decrease (+5 percent for NO_x)
1991-92: 3 percent decrease (-1 percent for NO_x)

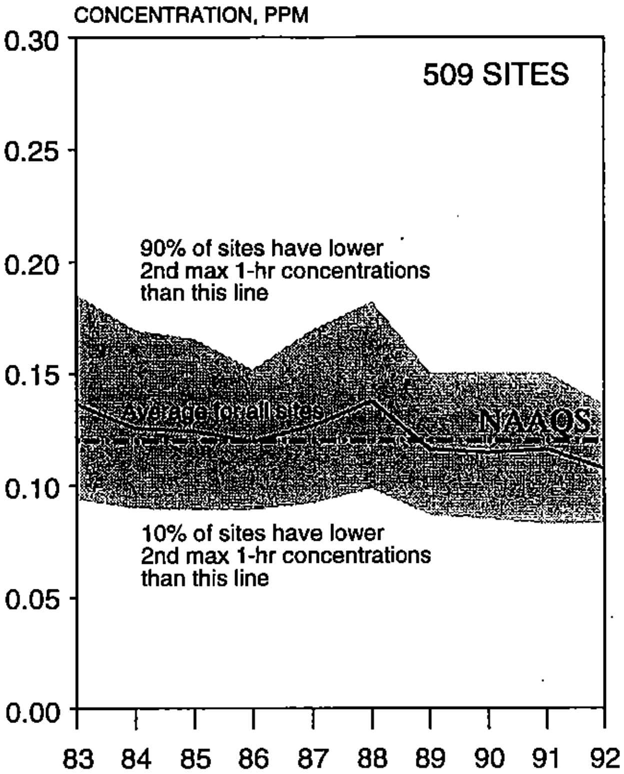
Overview

Trends. Ground level ozone, the primary constituent of smog, has been a pervasive pollution problem for the U.S. Ambient trends during the 1980s were influenced by varying meteorological conditions. Relatively high 1983 and 1988 ozone levels are likely attributable in part to hot, dry, stagnant conditions in some areas of the country. The 1992 levels were the lowest of the 1983-92 period. While the complexity of the ozone problem and the effects of meteorological conditions warrant caution in interpreting the data, there have been recent control measures, such as lower Reid Vapor Pressure for gasoline resulting in lower fuel volatility and lower NO_x and VOC emissions from tailpipes. Emission estimates for volatile organic compounds (VOCs), which contribute to ozone formation, are estimated to have improved by 11 percent since 1983. However, these VOC emission estimates represent annual totals. NO_x emissions, the other major precursor factor in ozone formation, increased 5 percent between 1983 and 1992. While these annual emission totals are the best national numbers now available, seasonal emission trends would be preferable.

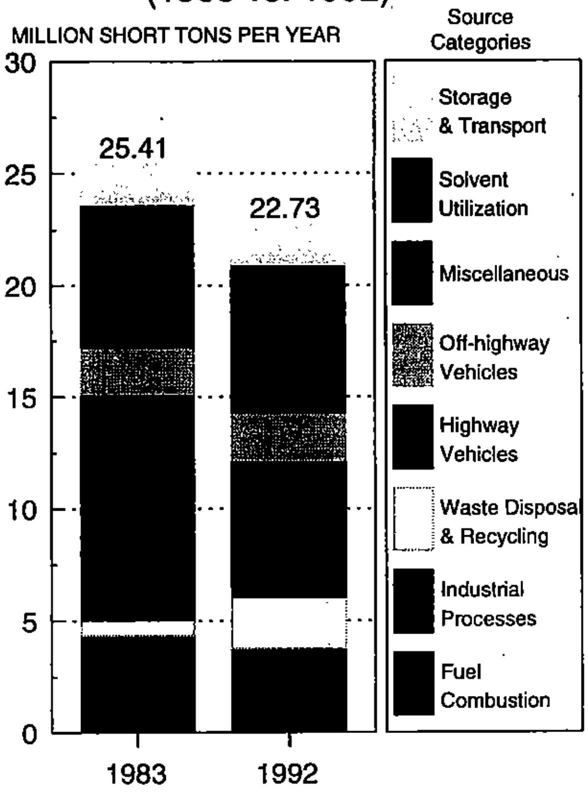
Status. In November 1991, EPA designated 98 nonattainment areas for O_3. Based upon the O_3 concentrations in these areas, EPA classified 43 areas as marginal, 31 as moderate, 14 as serious, 9 as severe, and 1 (Los Angeles) as extreme. In June 1992, Kansas City became the first of these 98 nonattainment areas to be redesignated as an attainment area. In December 1992, Cherokee County, SC became the second. In September 1993, Greensboro, NC and Knoxville, TN were also redesignated as attainment areas for ozone.

Some Details. Year to year ozone trends are affected by changing meteorological conditions. The 21 percent improvement between 1983 and 1992 is in part due to 1983 being a relatively high year for ozone. New statistical techniques to account for meteorological influences suggest an improvement of 10 percent for the 10-year period.

OZONE TREND, 1983-1992
(ANNUAL 2ND DAILY MAX HOUR)



VOC EMISSIONS TREND
(1983 vs. 1992)



O_3 Effects

The reactivity of ozone 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 6 - 7 hours at relatively low concentrations has been found to significantly reduce lung function 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. 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 loss and aging of the lungs. Ozone is responsible each year for agricultural crop yield loss in the U.S. of several billion dollars and 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)

Air Concentrations: Particulate Matter (PM-10)

1988-92: 17 percent decrease (based on arithmetic mean at 652 sites)

1991-92: 9 percent decrease (based on arithmetic mean at 652 sites)

Emissions: PM-10

1983-92: 3 percent decrease

1988-92: 8 percent decrease

1991-92: 2 percent increase

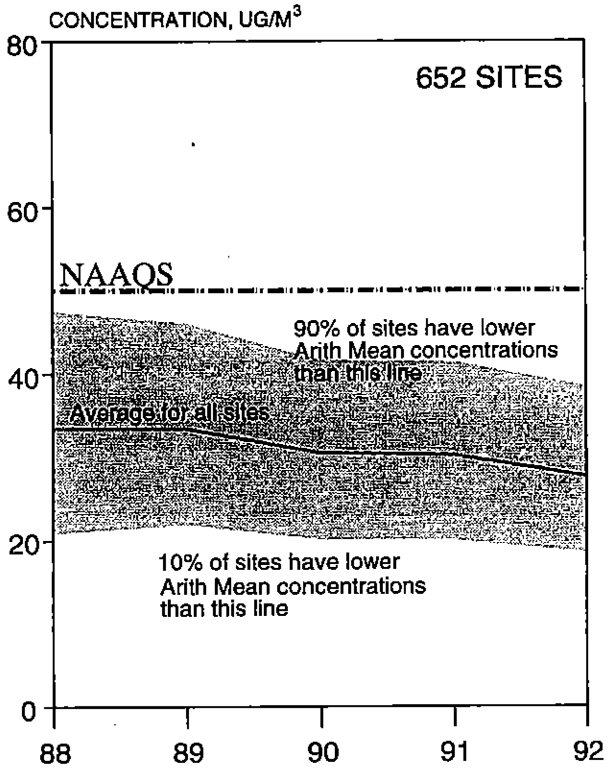
Overview

Trends. In 1987, EPA replaced the earlier total suspended particulate (TSP) standard with a PM-10 standard. PM-10 focuses on the smaller particles 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. Although PM-10 trends data are limited, ambient levels decreased 17 percent between 1988 and 1992. PM-10 emissions from sources historically included in inventories are estimated to have decreased 8 percent since 1988 and 3 percent since 1983. Nationally, fugitive sources (such as emissions from agricultural tilling, construction, and unpaved roads) contribute 6 to 8 times more PM-10 emissions than sources historically included in emission inventories.

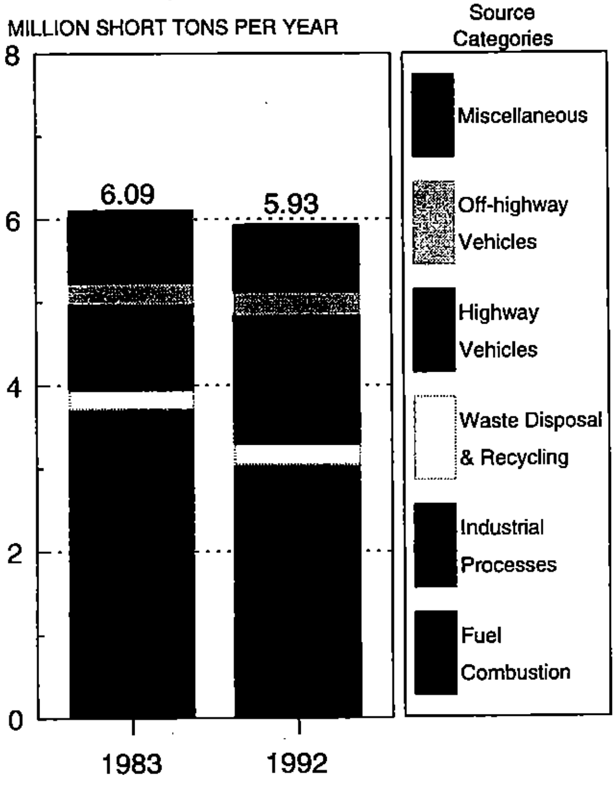
Status. In November 1991, EPA designated 70 areas as nonattainment for PM-10.

Some Details. Because many PM-10 monitoring networks evolved from previously established Total Suspended Particulate networks, emphasis is being placed on evaluating current PM-10 monitoring networks to be certain that they adequately characterize problems from these finer particles. New monitoring techniques, such as low cost portable monitors, are being used as a tool in these evaluations.

PM-10 TREND, 1988-1992
(ANNUAL ARITHMETIC MEAN)



PM-10 EMISSIONS TREND
(1988 vs. 1992)



PM Effects

Based on studies of human populations exposed to high concentrations of particles (often in the presence of sulfur dioxide) and laboratory studies of animals and humans, the major effects 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 most sensitive to the effects of particulate matter include individuals with chronic obstructive pulmonary or cardiovascular disease, individuals with influenza, asthmatics, the elderly and children. Particulate matter causes damage to materials, soiling and is a major cause of substantial visibility impairment in many parts of the United States.

Sulfur Dioxide (SO_2)

Air Concentrations

1983-92:	23 percent decrease (arithmetic mean at 476 sites) 31 percent decrease (24-hour second high at 476 sites)
1991-92:	7 percent decrease (arithmetic mean at 557 sites)

Emissions: Sulfur Oxides (SO_x)

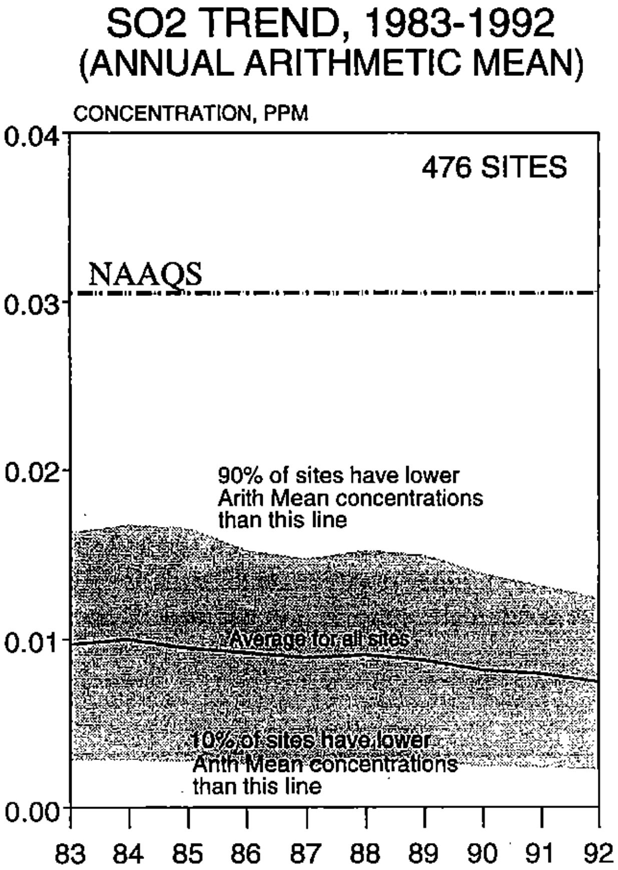
1983-92:	no change
1991-92:	< 1 percent decrease

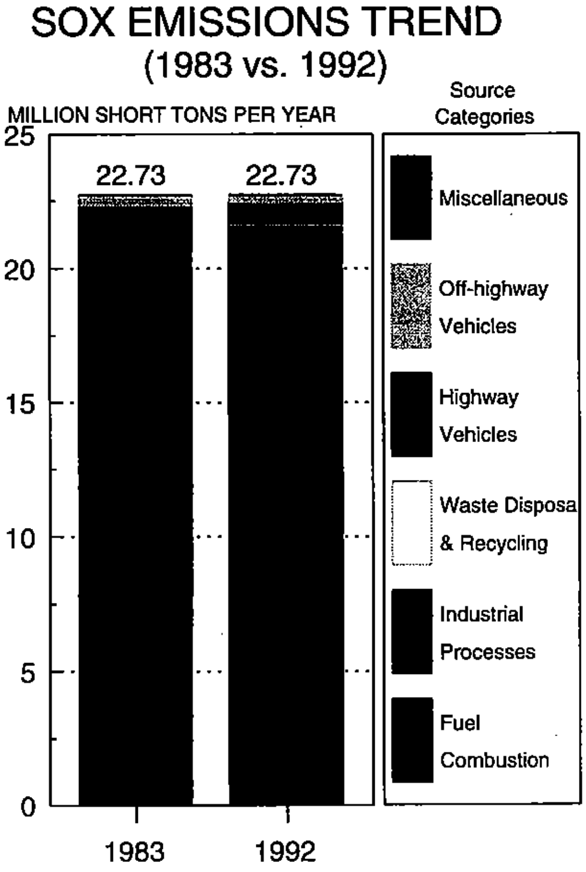
Overview

Trends. Since 1983, SO_x emissions were unchanged while average air quality improved by 23 percent. This difference occurs because the historical ambient monitoring networks are population-oriented while the major emission sources tend to be in less populated areas.

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 46 areas designated nonattainment for SO_2. Current concerns focus on major emitters, total atmospheric loadings and the possible need for a shorter-term standard. Seventy percent of all national SO_x emissions are generated by electric utilities.

Some Details. The Acid Rain provisions of the 1990 Clean Air Act Amendments include a goal of reducing SO_x emissions by 10 million tons relative to 1980 levels. The focus of this control program is an innovative market-based emission allowances trading program which will provide affected sources flexibility in meeting the mandated emission reductions. This is EPA's first large-scale regulatory use of market-based incentives and the first allowance trade was announced in May 1992. This program is coordinated with the air quality standard program to ensure that public health is protected while allowing for cost effective reductions of SO_2.





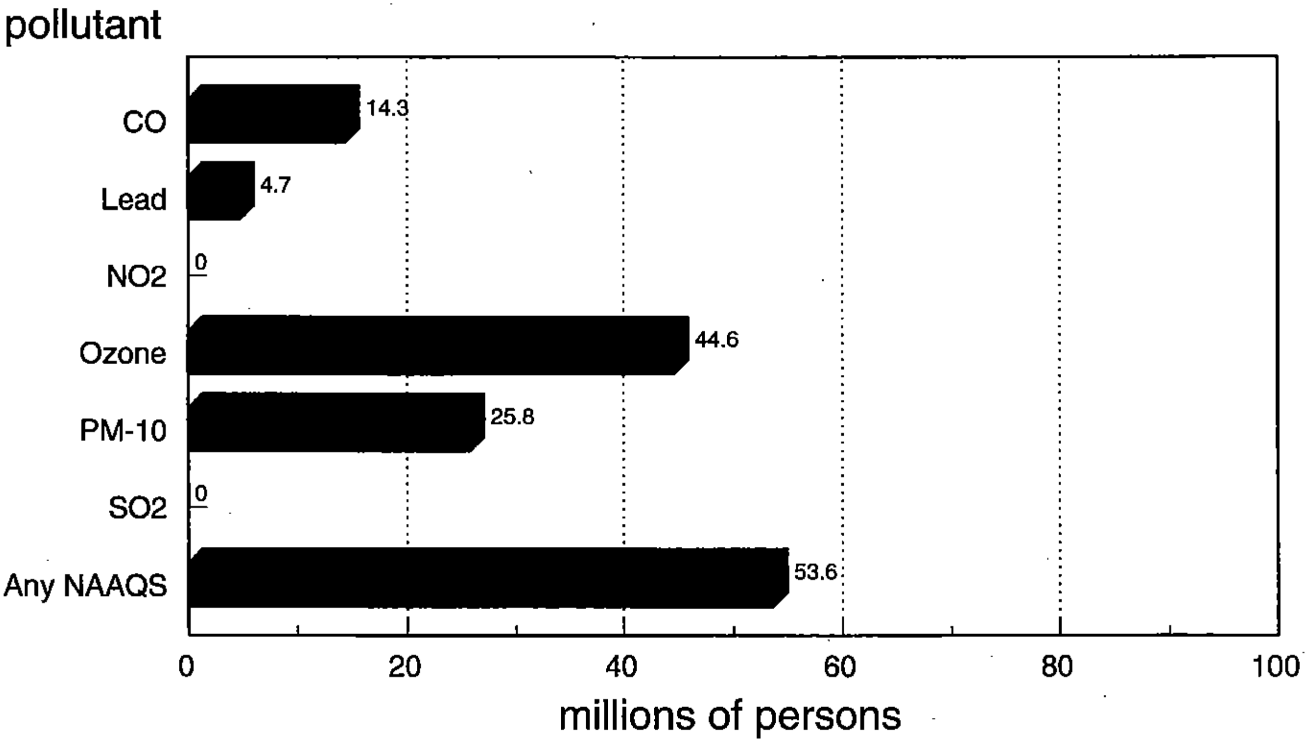
SO_2 Effects

The major health effects of concern associated with high exposures to sulfur dioxide include effects on breathing, respiratory illness and symptoms, alterations in the lungs' defenses, and aggravation of existing respiratory and cardiovascular disease. The major subgroups of the population most sensitive to sulfur dioxide include asthmatics and individuals with chronic lung disease (such as bronchitis or emphysema) or cardiovascular disease. Children and the elderly may also be sensitive. Sulfur dioxide produces foliar damage on trees and agricultural crops. It and nitrogen oxides are major precursors to acidic deposition (acid rain), which 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

It is important to realize that many of these air quality improvements during the past ten years occurred even in the face of growth of emissions sources. More detailed information on these emission trends and the updated estimation methodologies are contained in a companion report.[20]

While progress has been made, it is important not to lose sight of the magnitude of the air pollution problem that still remains. About 54 million people in the U.S. reside in counties which did not meet at least one air quality standard based upon data submitted to EPA's data base for the single year 1992. Ground level ozone is the most common contributor with 45 million people living in counties that exceeded the ozone standard in 1992. This is the first year that no areas had measured values exceeding the nitrogen dioxide standard; previous reports had identified Los Angeles with annual means not meeting the nitrogen dioxide standard. With respect to sulfur dioxide, it is important to note that while no measured data were submitted to EPA's data base showing exceedances in 1992, the current sulfur dioxide problems in the U.S. are associated with point sources and typically identified by modelling rather than by routine ambient monitoring. These statistics, and associated qualifiers and limitations, are discussed in Chapter 5. These population estimates are based only upon a single year of data, 1992, and only consider counties with monitoring data for that pollutant. As noted in Chapter 5, there are other approaches that would yield different numbers. In 1991, EPA issued a rule formally designating areas that did not meet air quality standards.[21] Based upon these designations, EPA estimated that 140 million people live in ozone nonattainment areas. This difference between the 140 million and 54 million population figures is because the formal designations are based upon three



Note: Based on 1990 population data and 1992 air quality data.

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, 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. 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, it should be recognized that this report emphasizes those six pollutants that have National Ambient Air Quality Standards. As discussed in Chapter 4, there are other pollutants of concern. According to industry estimates, more than 2.0 billion pounds of toxic pollutants were emitted into the atmosphere in 1991, compared to 2.2 billion pounds for the previous year.[22,23] They are chemicals known or suspected of causing cancer or other serious health effects (e.g., reproductive effects). Control programs for the pollutants discussed in this report can be expected to reduce these air toxic emissions by controlling particulates, volatile organic compounds and nitrogen oxides. However, Title III of the Clean Air Act Amendments of 1990 provided specific new tools to address routine and accidental releases of these toxic air pollutants. The statute established an initial list of 189 toxic air pollutants. Using this list, EPA published a list of the industry groups (or "source categories") for which EPA will develop emission standards. EPA will issue standards for each listed source category, requiring the maximum degree of emissions reduction that has been demonstrated to be achievable. These are commonly referred to as maximum achievable control technology (MACT) standards. EPA is also implementing other programs to reduce emissions of chlorofluorocarbons, halons, and other pollutants that are depleting the stratospheric ozone layer, and pollutants contributing to acid deposition.

1.4 References

1. *The National Air Monitoring Program: Air Quality and Emissions Trends - Annual Report, EPA-450/1-73-001a and b, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, July 1973.*

2. *Monitoring and Air Quality Trends Report, 1972, EPA-450/1-73-004, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, December 1973.*

3. *Monitoring and Air Quality Trends Report, 1973, EPA-450/1-74-007, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, October 1974.*

4. *Monitoring and Air Quality Trends Report, 1974, EPA-450/1-76-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, February 1976.*

5. *National Air Quality and Emissions Trends Report, 1975, EPA-450/1-76-002, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, November 1976.*

6. *National Air Quality and Emissions Trends Report, 1976, EPA-450/1-77-002, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, December 1977.*

7. *National Air Quality and Emissions Trends Report, 1977, EPA-450/2-78-052, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, December 1978.*

8. *1980 Ambient Assessment - Air Portion, EPA-450/4-81-014, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, February 1981.*

9. *National Air Quality and Emissions Trends Report, 1981, EPA-450/4-83-011, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, April 1983.*

10. *National Air Quality and Emissions Trends Report, 1982, EPA-450/4-84-002, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, March 1984.*

11. *National Air Quality and Emissions Trends Report, 1983, EPA-450/4-84-029, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, April 1985.*

12. *National Air Quality and Emissions Trends Report, 1984, EPA-450/4-86-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, April 1986.*

13. *National Air Quality and Emissions Trends Report, 1985, EPA-450/4-87-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, February 1987.*

14. *National Air Quality and Emissions Trends Report, 1986, EPA-450/4-88-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, February 1988.*

15. *National Air Quality and Emissions Trends Report, 1987, EPA-450/4-89-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, March 1989.*

16. *National Air Quality and Emissions Trends Report, 1988, EPA-450/4-90-002, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, March 1990.*

17. *National Air Quality and Emissions Trends Report, 1989, EPA-450/4-91-003, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, February 1991.*

18. *National Air Quality and Emissions Trends Report, 1990, EPA-450/4-91-023, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, November 1991.*

19. *National Air Quality and Emissions Trends Report, 1991, EPA-450/R-92-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, October 1992.*

20. *National Air Pollutant Emission Estimates, 1900-1992, EPA-454/R-93-032, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, October 1992.*

21. *Federal Register, November 6, 1991.*

22. *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.*

23. *1990 Toxics Release Inventory, EPA 700-S-92-002, U. S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, Washington, D.C. 20460, May 1992.*

Chapter 2: Background

This report focuses on 10-year (1983-92) national air quality trends for each of the major pollutants for which National Ambient Air Quality Standards (NAAQS) have been established. This section 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 in 23 metropolitan areas and in Chapter 7 with an international air pollution perspective.

The air quality trends statistics displayed for a particular pollutant in this report are closely related to the form of the respective air quality standard. Trends in other air quality indicators are also presented for some pollutants. NAAQS are currently in place for 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 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.

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/m^3)	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 1, 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 1; as determined according to Appendix K of the PM NAAQS.

It is important to note that discussions of ozone in this report refer to ground level, or tropospheric, ozone and not stratospheric ozone. Ozone in the stratosphere, miles above the earth, is a beneficial screen from the sun's ultraviolet rays. Ozone at ground level, in the air we breathe, is a health and environmental concern and is the primary ingredient of what is commonly called 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 1992, more than 4,200 monitoring sites reported air quality data for 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 to their immediate monitoring needs. Special Purpose Monitors (SPM) 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.

Trends are also presented for annual nationwide emissions. These are estimates of the amount and kinds of pollution being emitted by automobiles, factories and other sources, based upon best available engineering calculations. The 1992 emission estimates are preliminary and may be revised in the next annual report. Estimates for earlier years have been recomputed using current methodology so that these estimates are comparable over time. The reader is referred to a companion EPA publication, *National Air Pollutant Emission Estimates, 1900-1992*[2], for more detailed information.

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 8 of the 10 years 1983 to 1992. For the 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 1988 through 1992.

Table 2-2. Number of Monitoring Sites.

Pollutant	Number of Sites Reporting in 1992	Number of Trend Sites 1983-92
CO	507	308
Pb	437	203
NO_2	332	183
O_3	853	509
PM-10	1471	652*
SO_2	722	476
Total	4322	2331

* Number of Trend Sites in 1988-92

The air quality data are divided into two major groupings — 24-hour measurements and continuous 1-hour measurements. The 24-hour measurements are obtained from monitoring instruments that produce one measurement per 24-hour period and typically operate on a systematic sampling schedule of once every 6 days, or 61 samples per year. Such instruments are used to measure PM-10 and Pb. For PM-10, more frequent sampling of every other day or everyday is now also common. Only PM-10 sites with weighted annual arithmetic means that met the AIRS annual summary criteria were selected as trends sites. The 24-hour Pb data had to have at least six samples per quarter in at least 3 of the 4 calendar quarters. Monthly composite Pb data were used if at least two monthly samples were available for at least 3 of the 4 calendar quarters.

The 1-hour data are obtained from monitoring instruments that operate continuously, producing a measurement every hour for 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 the daily SO_2 statistics may differ slightly from the number of sites used to produce the 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 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 Trend Statistics

The air quality statistics presented in this report relate to the pollutant-specific NAAQS and comply with the 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 trends statistics is used in the graphical presentations that follow. All sites were 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 surrounding years. Missing end points are replaced with the nearest valid year of data. This procedure results in a statistically balanced data set to which simple statistical procedures and graphics can be applied. The procedure is also conservative, because end-point rates of change are dampened by the interpolated estimates.

This report presents statistical confidence intervals around composite averages. The confidence intervals can be used to make comparisons between years; if the confidence intervals for any 2 years do not overlap, then the composite averages of the 2 years are significantly different. Ninety-five percent confidence intervals for composite averages of annual means and second maxima were 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 were calculated by fitting Poisson distributions[7] to the exceedances each year and then 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 displaying, simultaneously, several features of the data. Figure 2-1 illustrates the use of this technique in presenting the percentiles of the data, as well as the composite average. For example, 90 percent of the sites would have concentrations equal to or lower than the 90th percentile.

Bar graphs are introduced for the Regional comparisons with the 3-year trend data base. These comparisons are based on the ten EPA Regions (Figure 2-2). The composite averages of the appropriate air quality statistic of the years 1990, 1991 and 1992 are presented. The approach is simple, and it allows the reader at a glance to compare the short-term changes in all ten EPA Regions.

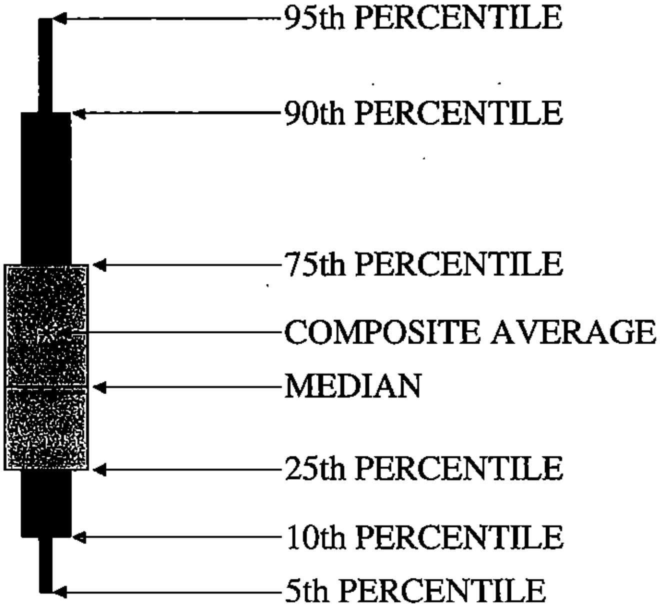


Figure 2-1. Illustration of plotting convention of boxplots.

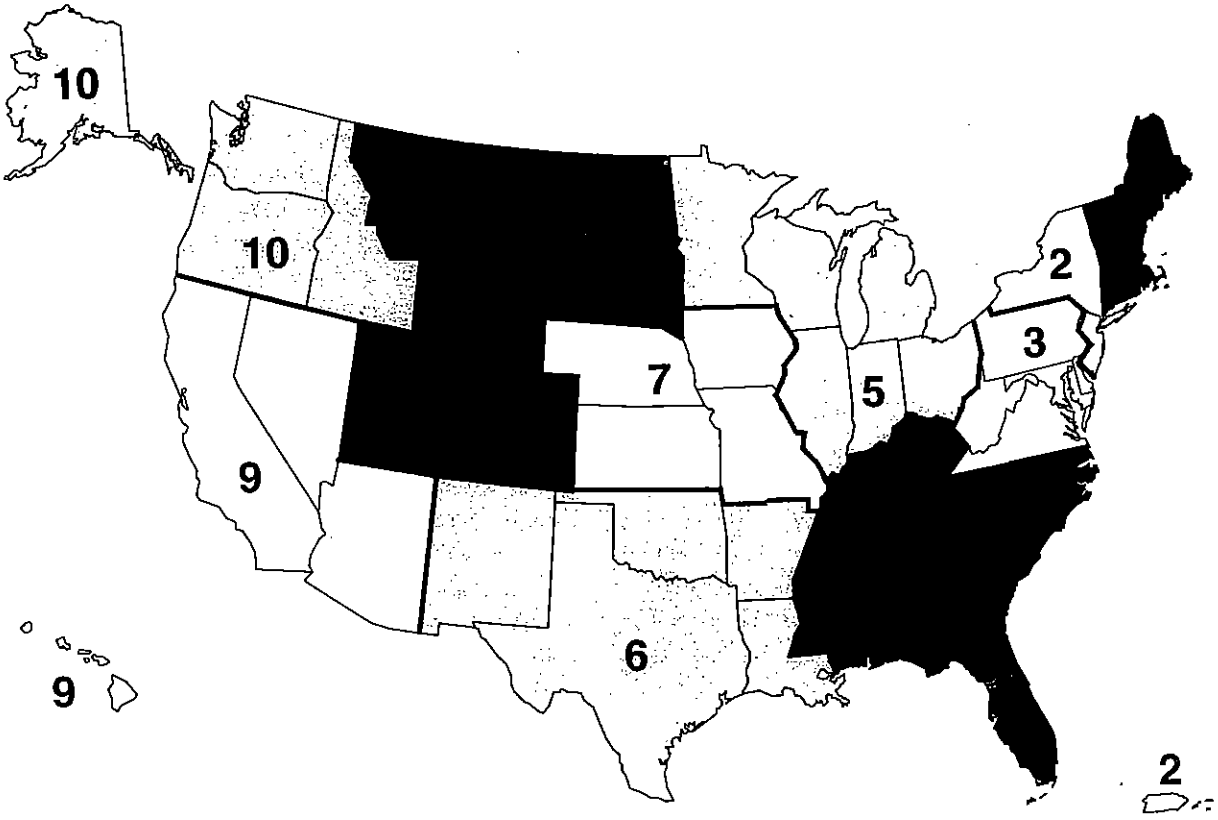


Figure 2-2. Ten regions of the U.S. Environmental Protection Agency.

2.3 References

1. *Ambient Air Quality Surveillance, 44 FR 27558, May 10, 1979.*

2. *National Air Pollutant Emission Estimates, 1900-1992, EPA-454/R-93-032, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, October 1993.*

3. *Ambient Air Quality Surveillance, 51 FR 9597, March 19, 1986.*

4. *National Air Quality and Emissions Trends Report, 1991, EPA-450/R-92-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, October 1992.*

5. *U.S. Environmental Protection Agency Intra-Agency Task Force Report on Air Quality Indicators, EPA-450/4-81-015, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1981.*

6. *B. J. Winer, Statistical Principles in Experimental Design, McGraw-Hill, NY, 1971.*

7. *N. L. Johnson and S. Kotz, Discrete Distributions, Wiley, NY, 1969.*

8. *R. G. Miller, Jr., Simultaneous Statistical Inference, Springer-Verlag, NY, 1981.*

9. *A. K. Pollack, W. F. Hunt, Jr., and T. C. Curran, "Analysis of Variance Applied to National Ozone Air Quality Trends", presented at the 77th Annual Meeting of the Air Pollution Control Association, San Francisco, CA, June 1984.*

10. *A. K. Pollack and W. F. Hunt, Jr., "Analysis of Trends and Variability in Extreme and Annual Average Sulfur Dioxide Concentrations", presented at the Air Pollution Control Association, American Society for Quality Control Specialty Conference on Quality Assurance in Air Pollution Measurements, Boulder, CO, 1985.*

11. *J. W. Tukey, Exploratory Data Analysis, Addison-Wesley Publishing Company, Reading, MA, 1977.*

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 10-year (1983-92) trends and recent changes in air quality and emissions for these six pollutants. Changes since 1991, and comparisons between all the trend sites and the subset of National Air Monitoring Stations (NAMS) are highlighted. Trends are examined for both the nation and the ten EPA Regions. This chapter presents a new section on visibility, a topic which relates to several of the NAAQS pollutants.

As in previous reports, the air quality trends are presented using trend lines, confidence intervals, boxplots and bar graphs. The reader is referred to Section 2.2 for a detailed description of the confidence interval and boxplot procedures.

Trends are also presented for annual nationwide emissions of carbon monoxide, lead, nitrogen oxides (NO_x), volatile organic compounds (VOC), particulate matter, and sulfur oxides (SO_x). These emissions data are estimated using best available engineering calculations. The reader is referred to a companion report for a detailed description of emission trends, source categories and estimation procedures.[1]

The estimates of emissions in this report differ from those reported last year in several ways. First, emissions are now reported in units of short tons per year (a short ton is 2,000 lbs.), rather than the metric tons (2,205 lbs) used in earlier reports. Thus, the numbers shown are about 10 percent higher. Also, mobile source emission estimates have been updated in response to concerns raised in a National Academy of Sciences (NAS) report about possible underestimates in mobile source emissions.[2] Emissions from highway vehicles have been recomputed using the MOBILE5a emission factor model. This model provides a more accurate estimate of motor vehicle emissions, and reflects a number of new requirements for both vehicles and fuels, such as exhaust emission standards and reformulated fuels mandated by the 1990 Clean Air Act Amendments.

Other changes in methodology included in the new mobile model have contributed to the different mobile source emission values in this report. Some of these include an increase from 3 to 9 in the number of speeds entered into the mobile model, a mixture of seasonal and national average temperatures, the use of county-level rather that State-level vehicle mix beginning in 1987, the addition of oxygenated fuel-use data, and new non-road mobile source emission estimates based on an extensive equipment survey.

The most notable difference created by applying the new mobile methodologies to previous years shows up in the recalculated emissions values for 1991. Revised estimates for the off- and on-highway categories increased the total emissions from last year's estimates for CO by 32 percent, for NOx by 13 percent, and for VOC by 26 percent. The addition of data more reflective of actual vehicle operating conditions, and the use of the survey for off-highway data are the primary reasons for the increase. For on-highway sources, the trend continues to show a decrease in overall emissions, even though the decrease is not as large as originally seen using the old methodologies. However, the trend for non-highway values appears to be increasing for all pollutants.

Other improvements in the estimation methodologies over last year include using actual fossil-fuel steam utility data, using rule effectiveness factors where applicable, applying earnings data by industry, utilizing emission factor updates for railroads, residential wood combustion and aircraft, and using county-specific information wherever possible. Also, for the first time, this report presents estimates for PM-10 emissions that go back to 1983. These changes are part of a broad effort to update and improve emission estimates. Additional changes are expected in the future, resulting in improved accuracy and reduced uncertainty in the estimates.

This chapter presents 10-year trends for both air quality and emissions in separate sections for each of the 6 NAAQS pollutants. Before these individual discussions, Figure 3-1 provides a convenient summary of the 1983-92 emission changes for all six pollutants. Lead clearly shows the most impressive decrease of 89 percent but improvements are also seen for CO (-25 percent), VOC (-11 percent), and PM-10 (-3 percent). SOx has remained fairly steady, and the only increase (+5 percent) is seen for NO_x, despite an 8 percent decrease in motor vehicle NOx emissions.

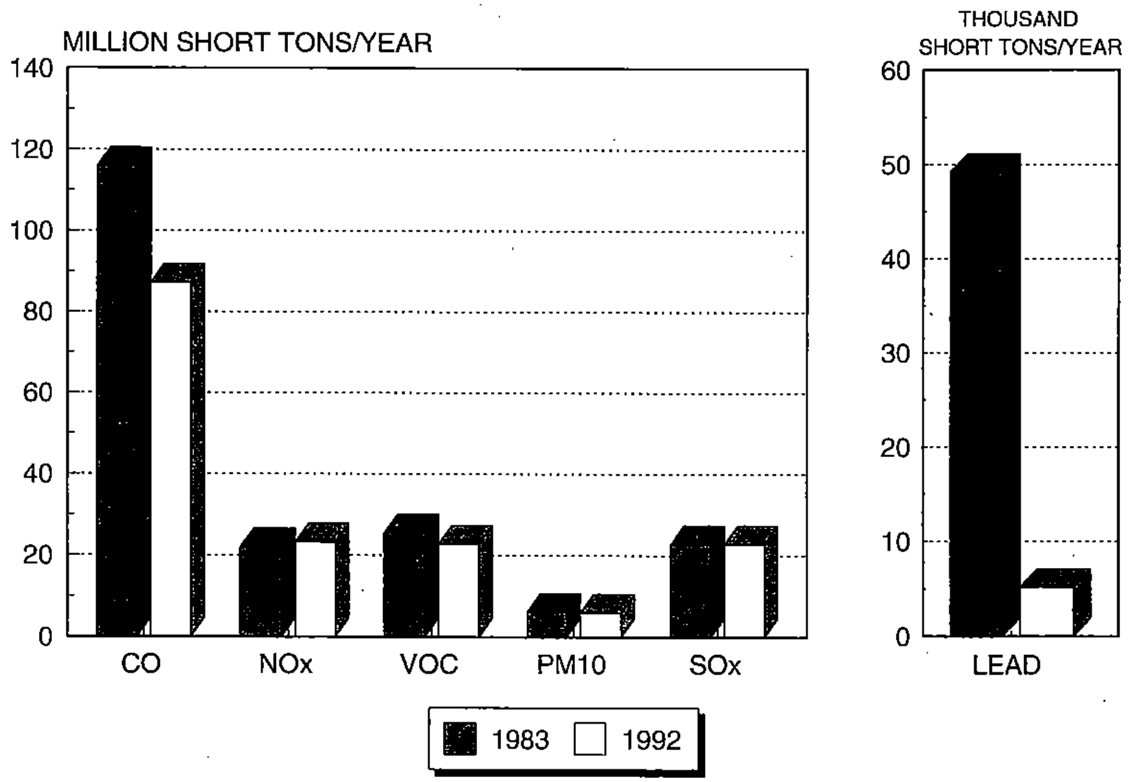


Figure 3-1. Comparison of 1983 and 1992 national total emissions.

3.1 Trends in Carbon Monoxide

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

The NAAQS for ambient CO specify upper limits for both 1-hour and 8-hour averages that are not to be exceeded more than once per year. The 1-hour level is 35 ppm, and the 8-hour level is 9 ppm. This trends analysis focuses on the 8-hour average results because the 8-hour standard is generally the more restrictive limit. Nationally, there have not been any recorded exceedances of the CO 1-hour NAAQS since 1990.

Trends sites were selected using the criteria presented in Section 2.1 which yielded a data base of 308 sites for the 10-year period 1983-92 and a data base of 390 sites for the 3-year 1990-92 period. There were 95 NAMS sites included in the 10-year data base and 115 NAMS sites in the 3-year data base. Eighty percent of the nationwide CO emissions are from transportation sources, with the largest contribution coming from highway motor vehicles. Thus, it is not surprising that most of these trends sites are located in urban areas where the main source of CO is motor vehicle exhaust; other CO sources are wood-burning stoves, incinerators, and industrial sources.

3.1.1 Long-term CO Trends: 1983-92

The 1983-92 composite national average trend is shown in Figure 3-2 for the second highest non-overlapping 8-hour CO concentration for the 308 long-term trend sites and the subset of 95 NAMS sites. During this 10-year period, the national composite average of the annual second highest 8-hour concentration decreased by 34 percent and the subset of NAMS decreased by 33 percent. Both curves show similar trends for the NAMS and the larger group of long-term trend sites. Nationally, the median rate of improvement between 1983 and 1992 is 4 percent per year for the 308 trend sites, and for the subset of 95 NAMS. Except for a small upturn between 1985 and 1986, composite average 8-hour CO levels have shown a steady decline throughout this period. The regional median rates of improvement varied from 2 to 7 percent per year. The greatest improvement was seen in the Rocky Mountain states with a decline in CO levels of 7 percent per year. The Northeast states saw median rates of decline of 5 percent per year, while the Region IX states recorded a 2 percent per year decline in CO levels. The 1992 composite average is the lowest composite mean of the past ten years, and is significantly lower than the composite means for 1990 and earlier years for both the

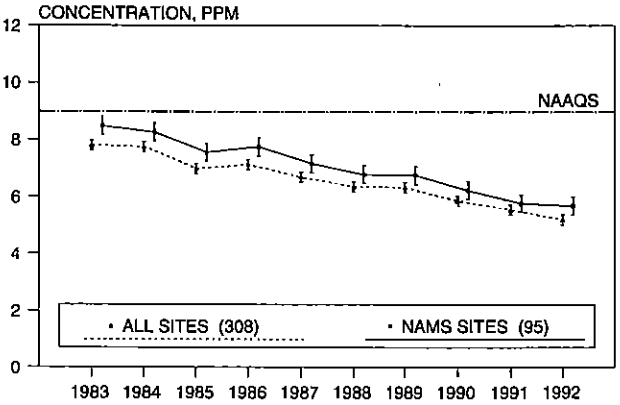


Figure 3-2. National trend in the composite average of the second highest non-overlapping 8-hour average carbon monoxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1983-1992.

308 trend sites, and the subset of 95 NAMS. This same trend is shown in Figure 3-3 for the 308 trend sites by a boxplot presentation which 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 the improvement is especially notable at the higher percentile concentrations.

Figure 3-4 displays the 10-year trend in the composite average of the estimated number of exceedances of the 8-hour CO NAAQS. 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 94 percent between 1983 and 1992 for the 308 long-term trend sites, while the subset of 95 NAMS showed a 90 percent decrease. These percentage changes for exceedances are typically much larger than those found for peak concentrations. The trend in annual second maximum 8-hour values is more likely to reflect the change in emission levels, than the trend in exceedances. For both curves, the 1992 composite average of the estimated exceedances is significantly lower than levels for 1990 and earlier years.

CO levels are the lowest of the past 10 years.

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 values, because these peak values are associated with health effects, and thus are considered in any trends analysis of ambient levels. While these 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

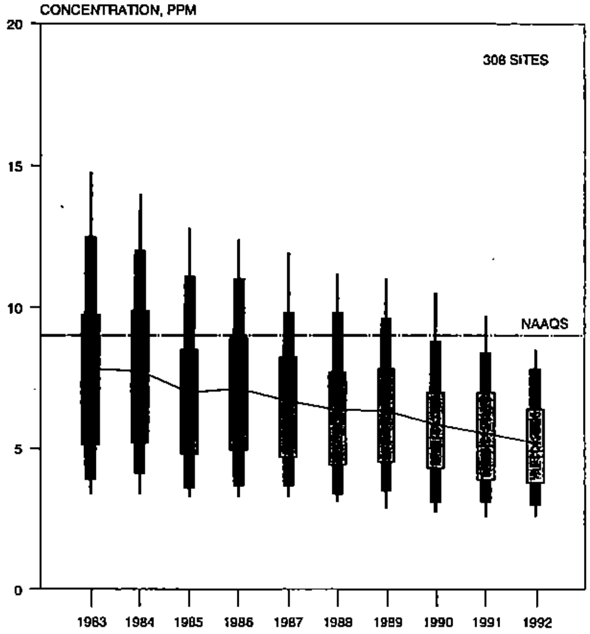


Figure 3-3. Boxplot comparisons of trends in second highest non-overlapping 8-hour average carbon monoxide concentrations at 308 sites, 1983-1992.

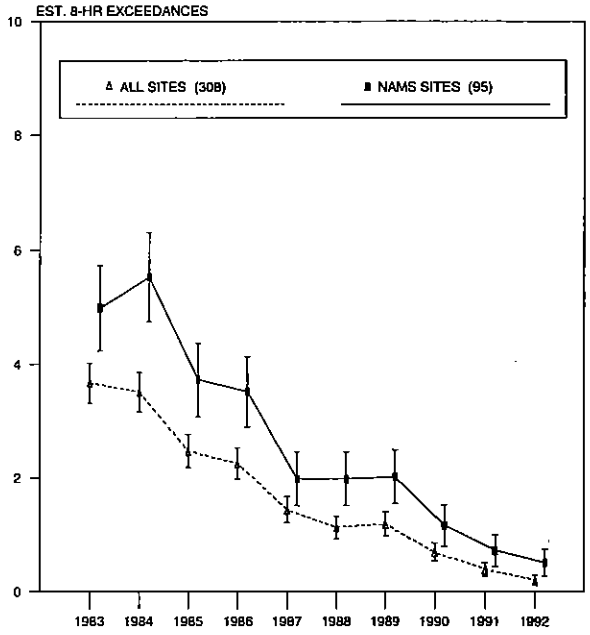


Figure 3-4. National trend in the composite average of the estimated number of exceedances of the 8-hour carbon monoxide NAAQS, at both NAMS and all sites with 95 percent confidence intervals, 1983-1992.

addressed in last year's report in response to concerns raised about ozone trend indicators by a National Academy of Sciences (NAS) report.[2] 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. Last year's report looked at trends in alternative summary 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.[3,4] The concentration percentiles are statistically robust, in the sense that they are less affected by a few extreme values. The trends analysis presented last year showed that the 10-year trends for all these various alternative carbon monoxide summary statistics were similar, however, there was a tendency to show less percent improvement (become flatter) for the lower percentile indicators.[5]

The 10-year 1983-92 trend in national carbon monoxide emission estimates is shown in Table 3-1. These estimates show a 25 percent decrease in total emissions between 1983 and 1992. The estimates in this report differ from those reported last year in several ways. First, the emissions are now reported in units of short tons per year (a short ton is 2,000 lbs.), rather than the metric tons (2,205 lbs) used in earlier reports. Thus, these totals are about 10 percent higher due to the change in reporting units. Also, the emissions from highway vehicles have been recomputed using the MOBILE5 emissions factor model, rather than the MOBILE4.1 model used in last year's report. This second change yielded a revised highway vehicle emissions estimate for 1991 that is 48 percent higher than last year, while the estimate for 1983 was revised upward by only 10 percent. The highway vehicle emissions estimates for the post-1985 period use county level data, e.g., VMT, oxy-fuels, whereas, the earlier years use state level data. This input change alone results in a marked increase in the accuracy of the emission estimates. Finally, the off-highway emissions for the post-1985 period are based on 1990 survey data back projected using Bureau of Economic Analysis (BEA) data.

Figure 3-5 contrasts the 10-year increasing trend in vehicle miles traveled (VMT) with the declining trend in carbon monoxide emissions from highway vehicles. Emissions from highway vehicles decreased 30 percent during the 1983-92 period, despite a 37 percent increase in vehicle miles of travel.[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.

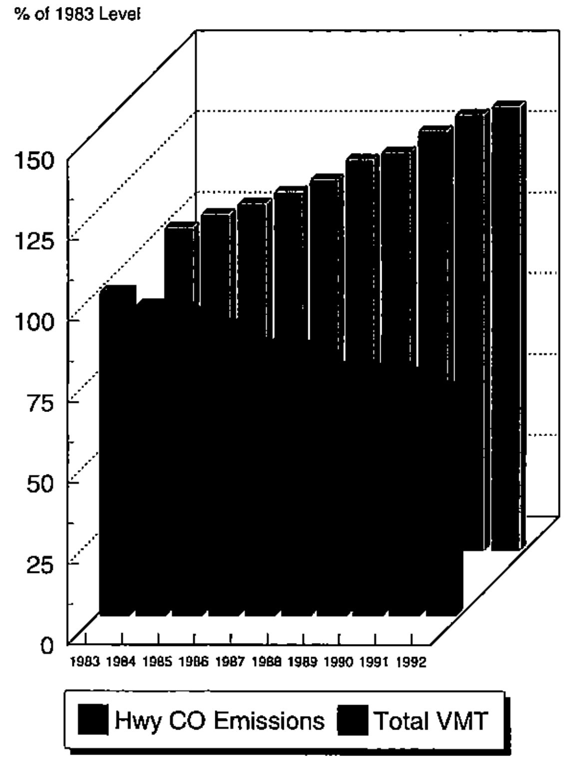


Figure 3-5. Comparison of trends in total national vehicle miles traveled and national highway vehicle carbon monoxide emissions, 1983-92.

While there is general agreement between changes in air quality and emissions over this 10-year period, 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 vehicle miles of travel in the area around a specific CO monitoring site may differ from the national averages.

Table 3-1. *National Carbon Monoxide Emission Estimates, 1983-1992*

(million short tons/year)

SOURCE CATEGORY	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**
Fuel Combustion - Electric Utilities	0.30	0.32	0.32	0.29	0.30	0.31	0.32	0.31	0.31	0.31
Fuel Combustion - Industrial	0.70	0.73	0.69	0.68	0.68	0.71	0.71	0.72	0.72	0.71
Fuel Combustion - Other	6.72	6.76	7.01	6.57	6.34	6.17	5.94	5.73	5.58	5.15
Chemical and Allied Product Manufacturing	1.84	2.08	1.48	1.81	1.76	1.87	1.88	1.89	1.91	1.87
Metals Processing	1.56	1.73	1.87	2.08	1.98	2.10	2.13	2.08	1.99	1.98
Petroleum and Related Industries	0.48	0.38	0.43	0.45	0.46	0.44	0.44	0.44	0.44	0.40
Other Industrial Processes	0.86	0.91	0.69	0.72	0.71	0.71	0.72	0.72	0.71	0.72
Solvent Utilization	0	0	0	0	0	0	0	0	0	0
Storage and Transport	0	0	0.05	0.09	0.09	0.10	0.10	0.10	0.10	0.10
Waste Disposal and Recycling	2.03	2.03	1.94	1.92	1.85	1.81	1.75	1.69	1.64	1.69
Highway Vehicles	78.67	75.40	73.52	70.47	65.60	65.22	60.13	59.80	58.83	55.29
Off-Highway	14.25	15.62	15.80	15.66	15.33	15.30	15.00	14.64	14.24	14.68
Natural Sources	0	0	0	0	0	0	0	0	0	0
Miscellaneous	8.55	7.01	4.11	4.16	4.20	4.33	4.29	4.27	4.20	4.27
Total	115.96	112.97	107.90	104.89	99.30	99.07	93.39	92.38	90.68	87.18

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

3.1.2 Recent CO Trends: 1990 - 1992

This section examines ambient CO changes during the last 3 years (1990, 1991 and 1992) at sites that recorded data in all three years. Between 1990 and 1992, the composite average of the second highest non-overlapping 8-hour average CO concentration at 390 sites decreased by 11 percent and decreased by 8 percent at the 115 NAMS sites. The composite average of the estimated number of exceedances of the 8-hour CO NAAQS decreased by 68 percent between 1990 and 1992 at both the 390 trend sites and the 115 NAMS sites. During the last two years, 1991-92, at the 390 trends sites the composite average of the second highest non-overlapping 8-hour average CO concentration decreased 7 percent and the composite number of estimated exceedances decreased by 49 percent. Estimated nationwide CO emissions decreased 4 percent between 1991 and 1992, and CO emissions from highway vehicles decreased by 6 percent.

Figure 3-6 shows the composite Regional averages for the 1990-92 time period. Seven of the ten Regions had 1992 composite mean levels less than the corresponding 1990 and 1991 values. Increases in composite mean CO levels were seen in Regions I, VI, and VIII, although 1992 levels still remained less than 1990 for all Regions. The increases in Region VIII are attributed to a higher frequency in 1992 of unfavorable meteorological conditions, i.e., atmospheric inversions, which contributed to increased CO levels in Denver. These Regional graphs are primarily intended 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.

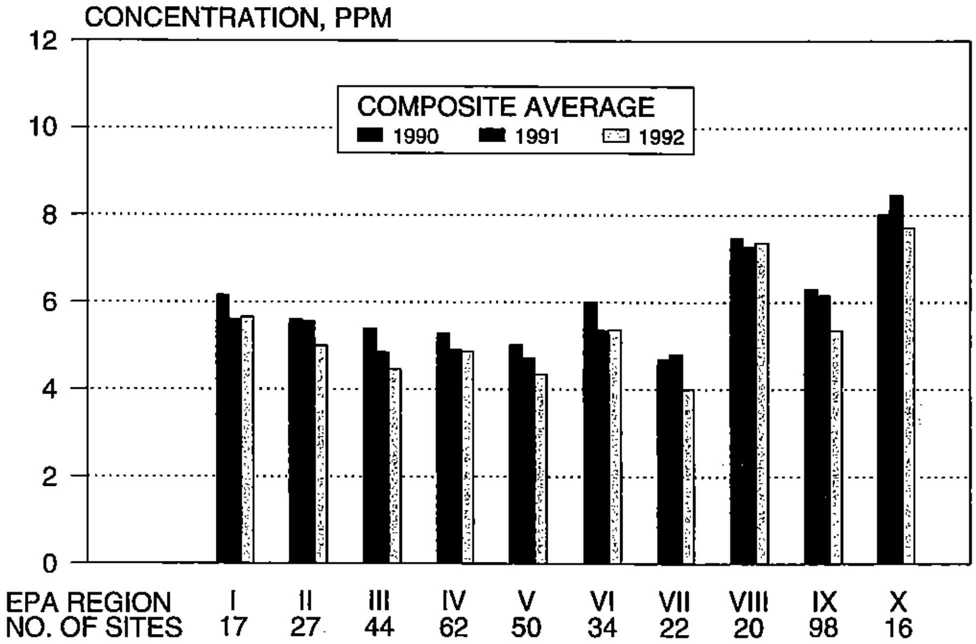


Figure 3-6. Regional comparisons of 1990, 1991, 1992 composite averages of the second highest non-overlapping 8-hour average carbon monoxide concentrations.

Clean Air Act Oxygenated Fuel Program

The first major clean fuel program operating under the 1990 Amendments to the Clean Air Act, the oxygenated fuel program is implemented by state and local air pollution control agencies using guidelines developed by the Environmental Protection Agency. The Clean Air Act requires the fuel in all areas not meeting the National Ambient Air Quality Standard (NAAQS) for carbon monoxide (CO) during the winter months when CO levels are higher. Though the winter season varies, the oxygenated fuel program generally operates from November through February. On November 1, 1992, new oxygenated fuel programs began in 20 metropolitan areas outside of California, and 8 areas within California. The non-California programs require oxygenated fuels to have an oxygen content of 2.7 percent oxygen by weight. The program implemented in California specifies an oxygen content of 1.8 to 2.2 percent oxygen by weight. Eight metropolitan areas located in the western states started oxygenated fuels programs prior to 1992.

Increasing the oxygen content of gasoline reduces CO emissions by improving fuel combustion, which is less efficient at cold temperatures. CO emissions are particularly high during the first few minutes after an engine is started, when it needs extra fuel to warm up.

Although the initial data indicate that CO levels have declined in areas implementing the oxygenated fuel program, there have been some complaints from motorists that pumping the new fuel at self-service pumps has caused dizziness or headaches. EPA is working with the Centers for Disease Control, the state of Alaska and industry to undertake additional research on the effects of the fuel. EPA expects the research to be completed prior to the start of the 1993-94 oxygenated gasoline season.

Comparisons have been made between the peak CO concentrations recorded during the fourth quarter (October through December) of 1991 and 1992 in cities with and without the oxygenated fuels (oxy-fuels) program. Due to the differences in the California program, those cities were not included in the analysis. Figure 3-7 presents boxplots of the differences in the fourth quarter second highest 8-hour concentrations between 1991 and 1992 at all non-California monitoring sites. As these boxplots indicate, larger decreases in peak CO concentrations, on the average, were recorded in those new areas which started the oxygenated fuels program, than in areas that did not implement the fuels program. The median percent changes in the quarterly second highest 8-hour concentrations were a 13 percent decrease in the new areas, a 5 percent decrease in existing oxy-fuels cities, and 3 percent decrease in non-program cities. The differences in both the existing program cities and the non-program cities likely reflect the variation due to changes in meteorological conditions, since these areas did not experience a change in program status.

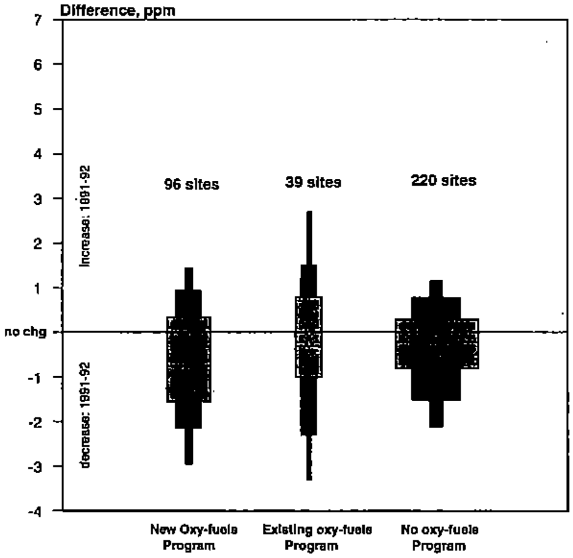


Figure 3-7. Boxplot comparison of differences between 4th quarter second highest 8-hour concentration, 1991-1992.

3.2 Trends in Lead

Lead (Pb) gasoline additives, nonferrous smelters and battery plants are the most significant contributors to atmospheric Pb emissions. Transportation sources in 1992 contributed 31 percent of the annual emissions, down substantially from 81 percent in 1985. Total lead emissions from all sources dropped from 20,100 tons in 1985 to 5,000 and 5,200 tons, respectively in 1991 and 1992. The decrease in lead emissions from highway vehicles accounts for essentially all of this drop. The reasons for this drop are noted below.

Two air pollution control programs implemented by EPA before promulgation of the Pb standard[6] 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 use in automobiles equipped with catalytic control devices. These devices reduce emissions of carbon monoxide, volatile organics and nitrogen oxides. In 1992, unleaded gasoline sales accounted for 99 percent of the total gasoline market. In contrast, the unleaded share of the gasoline market in 1983 was approximately 50 percent. These programs have essentially eliminated violations of the lead standard in urban areas without lead point sources. Programs are also in place to control Pb emissions from stationary point sources. Pb emissions from stationary sources have been substantially reduced by control programs oriented toward attainment of the particulate matter and Pb ambient standards, however, significant ambient problems still remain around some lead point sources, which are the focus of new monitoring initiatives. Lead emissions in 1992 from industrial sources, e.g., primary and secondary lead smelters, dropped by about 91 percent from levels reported in 1970. Emissions of lead from solid waste disposal are down about 66 percent since 1970. In 1992, emissions from solid waste disposal, industrial processes and transportation were respectively: 0.7, 2.3 and 1.6 x 10^3 tons. The overall effect of these three control programs has been a major reduction in the amount of Pb in the ambient air. In addition to the above Pb pollution reduction activities, additional reductions in Pb are anticipated as a result of the Agency's Multi-media Lead Strategy issued in February, 1991.[7] The goal of the Agency's Lead Strategy is to reduce Pb exposures to the fullest extent practicable.

Exposure to lead can occur through multiple pathways, including inhalation of air and ingestion of lead in food, water, soil or dust. Excessive lead exposure can cause seizures, mental retardation and/or behavioral disorders. Fetuses, infants and children are especially susceptible to low doses of lead, resulting in 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.

3.2.1 Long-term Pb Trends: 1983-92

Early trend analyses of ambient Pb data[8,9] were based almost exclusively on National Air Surveillance Network (NASN) sites. 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 and the current monitoring network reflects these requirements.[10]

As with the other pollutants, the sites selected for the long-term trend analysis had to satisfy annual data completeness criteria of at least 8 out of 10 years of data in the 1983 to 1992 period. A year was included as "valid" if at least 3 of the 4 quarterly averages were available. As in last year's report, composite lead data, i.e., individual 24-hour observations composited together by month or quarter and measured by a single analysis, are being used in the trend analysis. Twenty-three sites qualified for the 10-year trend because of the addition of composite data.

A total of 203 urban-oriented sites, from 38 States and Puerto Rico, met the data completeness criteria. Eighty-three of these sites were NAMS, the largest number of lead NAMS sites to qualify for the 10-year trends. Twenty-four (12 percent) of the 203 trend sites were located in the State of California. However, the lead trend at the California sites was identical to the trend at the non-California sites; thus these sites did not distort the overall trends. Other states with 10 or more trend sites included: Illinois (13), Kansas (16), Michigan (10), Pennsylvania (10), and Texas (17). Again, the Pb trend in each of these states was very similar to the national trend. Sites that were located near lead point sources such as primary and secondary lead smelters were excluded from the urban trend analysis, because the magnitude of the levels at these sources could mask the underlying urban trends. Trends at lead point source oriented sites are discussed later in this section.

The means of the composite maximum quarterly averages and their respective 95 percent confidence intervals are shown in Figure 3-8 for both the 203 urban sites and 83 NAMS sites (1983-1992). There was an 89 percent (1983-92) decrease in the average for the 203 urban sites. Lead emissions over this 10-year period also decreased. There was also an 89 percent decrease in total lead emissions and a 96 percent decrease in lead emissions from transportation sources. The confidence intervals for all sites indicate that the 1986-92 averages are significantly less than all averages from preceding years. Because of the smaller number (83) of NAMS sites with at least 8 years of data, the confidence intervals are wider. However, the 1986-92 NAMS averages are still significantly different from all NAMS averages before 1986. It is interesting to note that the composite average lead concentration at the NAMS sites in 1992 is about the same (0.050 µg/m^3) as the "all sites" average; whereas in the early 1980s the averages of the NAMS sites were significantly higher.

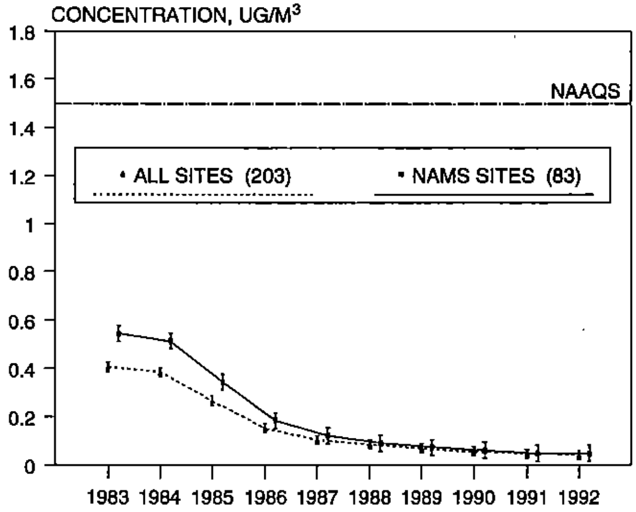


Figure 3-8. National trend in the composite average of the maximum quarterly average lead concentration at both NAMS and all sites with 95 percent confidence intervals, 1983-1992.

Figure 3-9 shows boxplot comparisons of the maximum quarterly average Pb concentrations at the 203 urban-oriented Pb trend sites (1983-92). This figure shows the dramatic improvement in ambient Pb concentrations over the entire distribution of trend sites. As with the composite average concentration since 1983, most of the percentiles also show a monotonically decreasing pattern. The 203 urban-oriented sites that qualified for the 1983-92 period, is slightly less than the 209 sites which qualified for 1982-91 and is almost the same number of sites (202) which qualified for 1981-90.

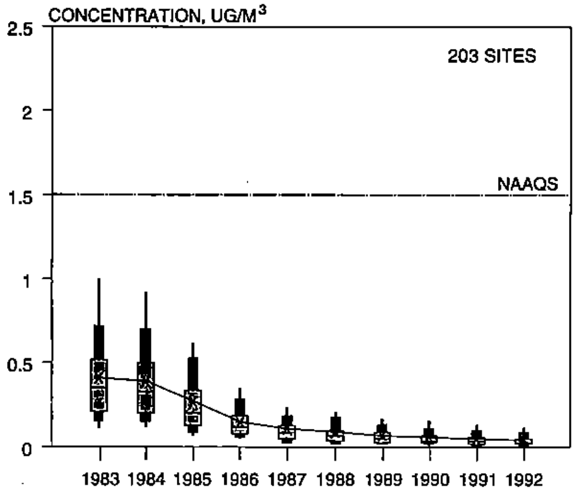


Figure 3-9. Boxplot comparisons of trends in maximum quarterly average lead concentrations at 203 sites, 1983-1992.

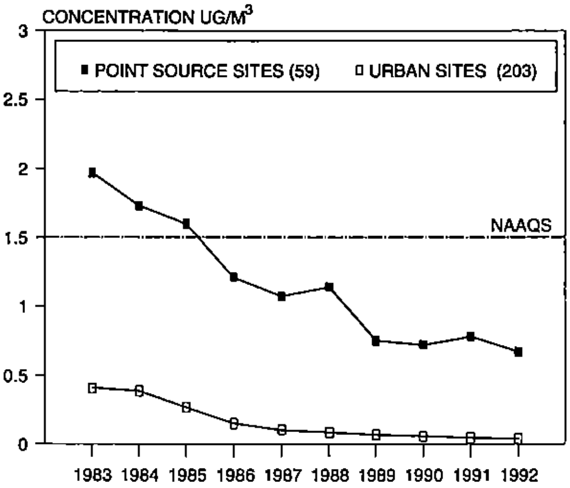


Figure 3-10. Comparison of national trend in the composite average of the maximum quarterly average lead concentrations at urban and point-source oriented sites, 1983-1992.

Figure 3-10 shows the trend in average lead concentrations for the urban-oriented sites and for 59 point-source oriented sites which also met the 10-year data completeness criteria. Composite average ambient lead concentrations at the point-source oriented sites, located near industrial sources of lead, 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 2.0 to 0.7 µg/m^3, a 1.3 µg/m^3 difference; whereas, the average at the urban sites dropped from 0.4 to 0.04 µg/m^3. This improvement at the point-source oriented sites reflects both industrial and automotive lead emission controls, but in some cases, the industrial source reductions are because of plant shutdowns. However, there are still several urban areas where significant Pb problems persist. The 6 MSAs shown in Table 5-6 that are above the lead NAAQS in 1992 are all due to lead point sources. These MSAs are Cleveland, OH; Indianapolis, IN; Memphis, TN-AR-MS; Omaha, NE-IA; Philadelphia, PA-NJ; and St Louis, MO-IL. None of the monitoring sites responsible for 1992 lead concentrations above the NAAQS had sufficient historical data to be included in the point-source oriented trends discussed above. The sites in these MSAs which recorded lead concentrations above the NAAQS were sites situated near the lead point sources listed in EPA's Lead Strategy. This strategy targeted 28 primary or secondary lead smelters and three other stationary sources for more intensive lead monitoring. Figure 3-11 shows the highest quarterly average Pb concentrations recorded during 1992 in the vicinity of these sources. At present, various types of enforcement and/or regulatory actions are being actively pursued by the EPA, with the States involved, for all lead point sources which have reported lead levels above the NAAQS. This is especially the case, as can be seen on the map, where exceptionally high lead levels have been reported. The lead sources reporting the highest 1992 quarterly lead averages in micrograms per cubic meter include: Master Metals (37.4), Franklin Smelter (17.6), Chemetco (11.8), and ASARCO Glover (9.7). Although significant problems still remain as indicated by the map, there have been some success stories on point source lead problems. Two examples appear later in this section.

Table 3-2 summarizes the Pb emissions data. The 1983-92 drop in total Pb emissions was 89 percent. Lead emissions in the transportation category account for most of this drop. Lead emissions from the other categories show only small changes over the 1983-92 time period. The percent decrease (1983-92) in total lead emissions is the same (89 percent) as the change in the average ambient lead concentrations. The drop in Pb consumption and subsequent Pb emissions since 1983 was brought about by the increased use of unleaded gasoline in catalyst-equipped cars and the reduced Pb content in leaded gasoline. The results of these actions in 1992 amounted to a 74 percent reduction nationwide in total Pb emissions from 1985 levels. As noted previously, unleaded gasoline represented 99 percent of 1992 total gasoline sales. Although the good agreement among the trend in lead consumption, emissions and ambient levels is based upon a limited geographical sample, it does show that ambient urban Pb levels are responding to the drop in lead emissions.

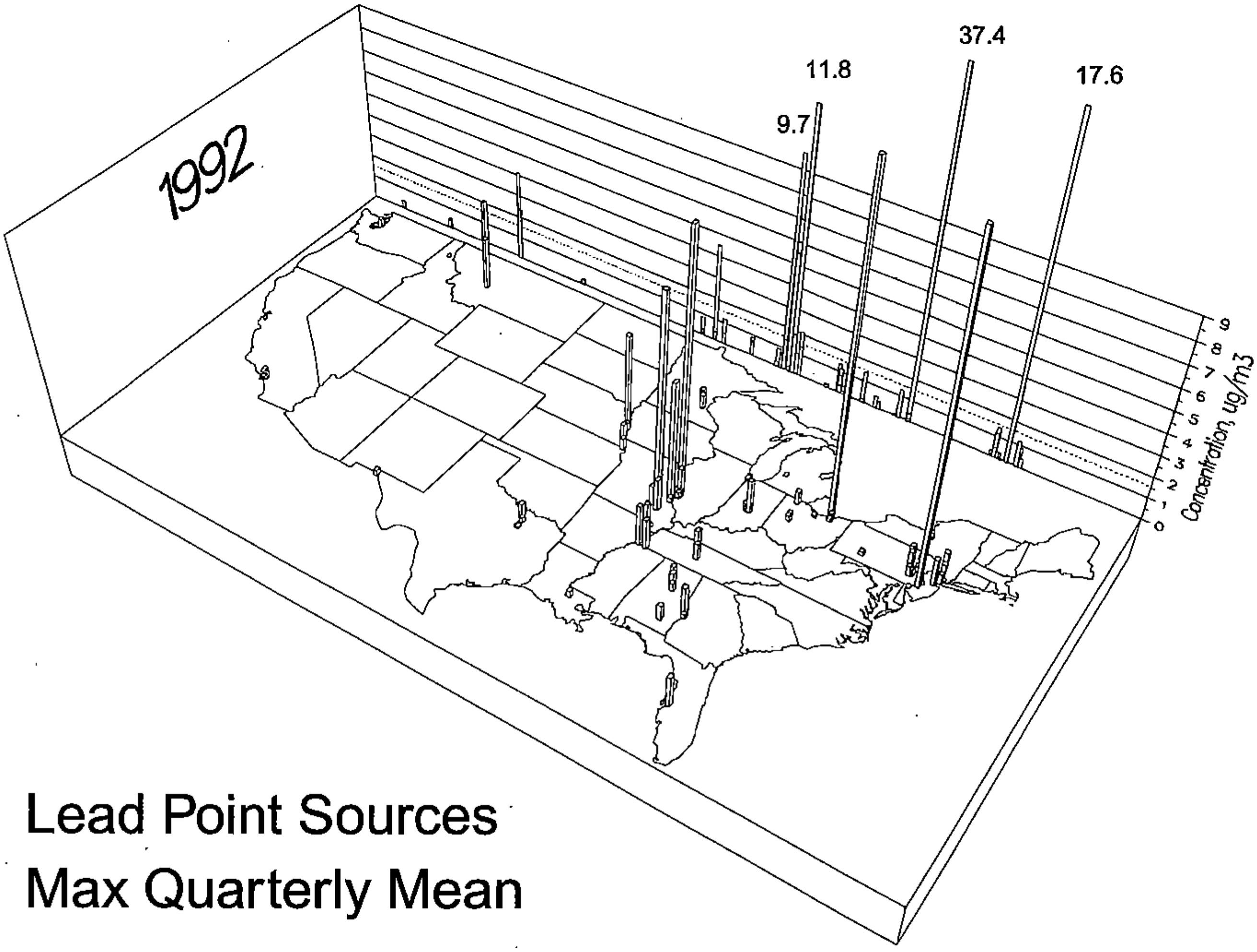


Figure 3-11. Map depicting maximum quarterly mean lead concentrations in the vicinity of lead point sources, 1992.

Table 3-2. National Lead Emission Estimates, 1983-1992

	(thousand short tons/year)									
SOURCE CATEGORY	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**
Fuel Combustion - Electric Utilities	0.09	0.09	0.06	0.07	0.06	0.07	0.07	0.06	0.06	0.06
Fuel Combustion - Industrial	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02
Fuel Combustion - Other	0.55	0.42	0.42	0.42	0.43	0.43	0.42	0.42	0.42	0.42
Chemical and Allied Product Manufacturing	0.14	0.13	0.12	0.11	0.12	0.14	0.14	0.14	0.13	0.14
Metals Processing	2.03	1.92	2.10	1.82	1.82	1.92	2.15	2.14	1.94	2.07
Petroleum and Related Industries	0	0	0	0	0	0	0	0	0	0
Other Industrial Processes	0.53	0.48	0.32	0.20	0.20	0.17	0.17	0.17	0.17	0.14
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	0.91	0.90	0.87	0.84	0.84	0.82	0.77	0.80	0.58	0.74
Highway Vehicles	42.70	35.93	15.98	3.59	3.12	2.70	2.16	1.69	1.52	1.38
Off-Highway	2.27	2.31	0.23	0.22	0.22	0.21	0.21	0.20	0.18	0.21
Natural Sources	0	0	0	0	0	0	0	0	0	0
Miscellaneous	0	0	0	0	0	0	0	0	0	0
Total	49.23	42.22	20.12	7.30	6.84	6.46	6.10	5.63	5.01	5.18

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

The 10-year trend at the 59 point source oriented sites shows a much larger decline in lead concentrations (-63 percent), than did lead emissions from industrial processes (-13 percent). The improvement in lead concentrations at the point source oriented sites reflect improvements at a relatively small number of lead sources. The emission figures for industrial processes represent all industrial sources in the nation. It is interesting to note that the lead emissions from industrial processes are lowest in 1986 ($2.13X10^3$ tons) then rise slightly to $2.35X10^3$ tons in 1992. 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 lead concentrations in 1988.

In Canada a very similar trend in ambient lead concentrations has been observed. Composite average lead concentrations declined over 95 percent for the 1974-90 time period.[11] Also, average ambient Pb concentrations in Tokyo, Japan[12] 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.

3.2.2 Recent Pb Trends: 1990-92

Ambient Pb trends were also studied over the shorter period 1990-92. A total of 235 urban sites from 37 States met the data requirement that a site have all 3 years with data. In recent years, the number of lead sites has dropped because of the elimination of some TSP monitors from state and local air monitoring programs. Lead measurements were obtained from the TSP filters. Some monitors were eliminated due to the change in the particulate matter standard from TSP to PM-10 while others were discontinued because of the very low lead concentrations measured in many urban locations. Although some further attrition may occur, the core network of NAMS lead sites together with supplementary State and local sites should be sufficient to assess national ambient lead trends. The 3-year data base (1990-92) showed an improvement of 25 percent in composite average urban Pb concentrations. However, the 1990 and 1992 lead averages respectively were extremely low 0.059 and 0.044 µg/m^3. Between 1990 and 1992, total Pb emissions decreased 8 percent and lead emissions from transportation sources dropped 16 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, Illinois, Kansas, Pennsylvania and Texas. These States had about 38 percent of the 235 sites represented. However, the percent changes in 1990-92 average Pb concentrations for these five States were very similar to the percent change for the remaining sites, thus the contributions of these sites did not distort the national trends. Although urban lead concentrations continue to decline consistently, there are indications that the rate of the decline has slowed down. Clearly in some areas, urban lead 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 lead concentrations. Eighty (80) point source oriented sites showed a 12 percent decline in average lead levels over the 1990-92 time period. Thus, lead concentrations near lead point sources unlike the urban sites, which showed a 25 percent decrease, have improved to a lesser extent over the last 3 years. Lead emissions from industrial processes also did not change much during the 1990-92 period. As expected, the average lead levels at the point source oriented sites are much higher here than at the urban sites. The 1991 and 1992 lead point source averages were 0.82 and 0.76 µg/m^3 respectively.

The larger sample of sites represented in the 3-year trends database (1990-92) will be used to compare the most recent individual yearly averages. However, for the 10-year time period the largest single year drop in average lead concentrations, 43 percent, occurs as expected between 1985 and 1986, because of the shift of the lead content in leaded gasoline. The 1992 composite average lead concentrations show the more modest decline of 9 percent from 1991 levels. The 10-year data base showed a 12 percent decrease in average lead concentrations from 1991 to 1992, while total lead emissions increased by 3 percent. There has been a 6 percent decrease in estimated Pb emissions for the transportation category between 1991 and 1992, while, VMT increased 2 percent between 1991 and 1992. 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, so that in the future the consumer will find it very difficult to purchase regular leaded gasoline.

Figure 3-12 shows 1990, 1991 and 1992 composite average Pb concentrations, by EPA Region. Once again the larger more representative 3-year data base of 235 sites was used for this comparison. The number of sites varies dramatically by Region from 7 in Region X to 37 in Region V. In all regions, except Region IV, there is a decrease in average Pb urban concentrations between 1990 and 1992. These results confirm that average Pb concentrations in urban areas are continuing to decrease throughout the country, which is exactly what is to be expected because of the national air pollution control program in place for Pb.

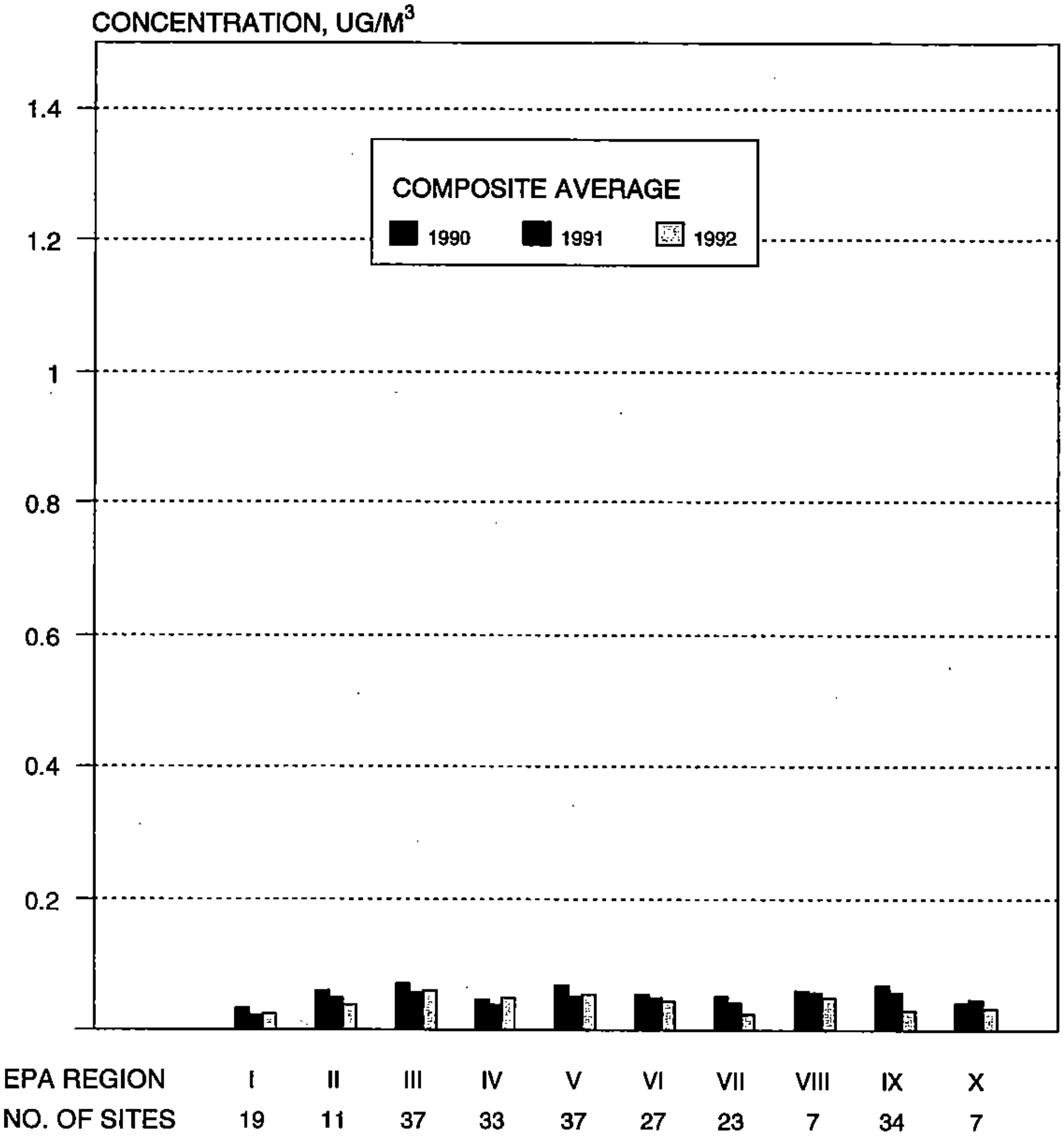


Figure 3-12. Regional comparisons of the 1990, 1991, 1992 composite average of the maximum quarterly average lead concentrations.

Lead Sources: Two Examples

The phase-out of lead in gasoline has largely addressed high lead concentrations in the air nationwide. However, high lead concentrations still remain around some stationary lead sources. In 1990, EPA initiated a lead attainment strategy to address the problems around these sources. Two of several examples of how the State environmental agencies, industry and EPA are working together in partnership to reduce pollution follow.

Doe Run, Herculaneum, Missouri **– In 1988 the Doe Run smelter in Herculaneum Missouri was one of the few industrial sources in the country that was being monitored for lead. The lead concentrations at this smelter in that year were as high as 8.59 micrograms per cubic meter ($\mu g/m^3$) averaged over a calendar quarter (almost six times the standard).**

In October of 1988, EPA, the State and the company began to address these high concentrations by revising the operating requirements for the source. Changes made by the plant resulted in reductions in the concentration of lead around the facility. However, from 1989 to 1991 the concentration remained above the standard. As a result, the area was designated as nonattainment for lead effective January 6, 1992.

Even though the concentrations of lead in the atmosphere remain above the health based standard, the efforts have been successful in dropping the lead concentrations from the high level in the eighties to the current average concentrations of 2.4 $\mu g/m^3$ for 1992. The plant is continuing to implement the new requirements established in their implementation plans and should continue to make progress in lowering the lead concentrations at the source.

Sanders Lead, Troy, Alabama **– In 1988 and 1989, 5 violations of the national ambient air quality standards were recorded at this secondary lead smelter. As a result of the violations EPA requested the Governor of Alabama to designate Pike County as "nonattainment" for lead. In lieu of the nonattainment designation, the company installed new control measures which addressed the air quality problems. Also, the State developed federally enforceable permit requirements for these new control measures to ensure that as long as the source complied with those requirements the lead concentration will be maintained below the standard. As of the end of 1992 there have been no further violations of the air quality standards at the facility.**

These are two examples of different approaches to addressing lead air quality problems. In the first case, EPA and the State employed the more formal regulatory process of nonattainment designation. In the second, reductions were achieved without requiring this formal procedure. The success at these and other sources is achieved because EPA and the States are working together to evaluate the most appropriate method to deal with the specific problem.

3.3 Trends in Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a brownish, highly reactive gas which is present in urban atmospheres. Nitrogen dioxide can irritate the lungs, cause bronchitis and pneumonia, and lower resistance to respiratory infections. Nitrogen oxides are an important precursor both to ozone and acidic precipitation 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). Nitrogen oxides play a major role, together with volatile organic compounds, in the atmospheric reactions that produce ozone. Nitrogen oxides form 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 which 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 which follow. A total of 183 sites were selected for the 10-year period and 236 sites were selected for the 3-year data base.

3.3.1 Long-term NO_2 Trends: 1983-92

The composite average long-term trend for the nitrogen dioxide mean concentrations at the 183 trend sites and the 43 NAMS sites, is shown in Figure 3-13. The 95 percent confidence intervals about the composite means reveal that the 1983-89 NO_2 levels are statistically indistinguishable. The 1992 composite average NO_2 level, which is the smallest mean of the past ten years, is 8 percent lower than the 1983 level, and the difference is statistically significant. A similar trend is seen for the NAMS sites which, for NO_2, are located only in large urban areas with populations of one million or greater. As expected, the composite averages of the NAMS are higher than those of all sites. The

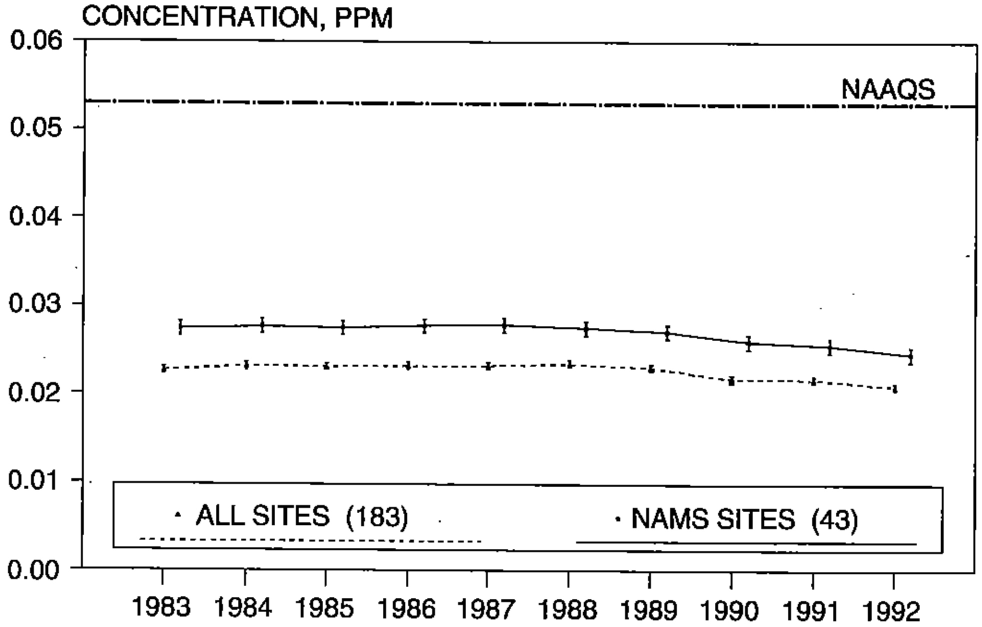


Figure 3-13. National trend in the composite annual average nitrogen dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1983-1992.

1992 composite average of the NO_2 annual mean concentration at the 43 NAMS is 11 percent lower than the composite average in 1983. This difference is statistically significant.

Long-term trends in NO_2 annual average concentrations are also displayed in Figure 3-14 with the use of boxplots. The middle quartiles for the years 1983 through 1990 are similar, while a decrease in levels can be seen 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 three years. The lower percentiles show little change. Long-term NO_2 annual mean trends vary with population size among metropolitan areas. 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.[13]

Last year's report presented a comparison of the 10-year trend in the annual arithmetic mean NO_2 concentration with the 10-year trends in various alternative NO_2 air quality indicators. The trends in the peak indicators, both the annual maximum and the second maximum 1-hour NO_2 concentrations, showed a much steeper decline than for the annual arithmetic mean concentrations.[5] The reductions in the various percentiles of the hourly NO_2 concentrations were similar to that observed in the annual arithmetic mean concentration.

Table 3-3 presents the trend in estimated nationwide emissions of nitrogen oxides (NO_x). Total 1992 nitrogen oxides emissions are 5 percent higher than 1983 emissions. Fuel combustion emissions, which are 9 percent higher in 1992 than in 1983, have remained relatively constant during the last 5 years. Most of the decreases in mobile source

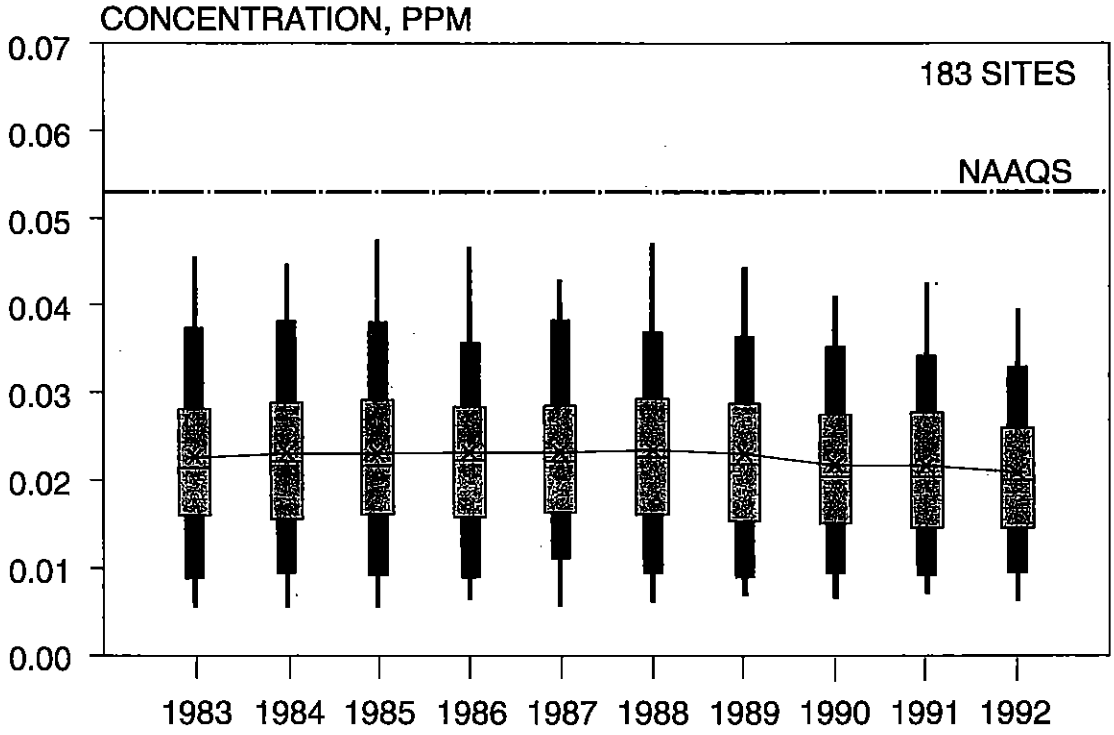


Figure 3-14. Boxplot comparisons of trends in annual mean nitrogen dioxide concentrations at 183 sites, 1983-1992.

emissions occurred in urban areas. Table 3-3 shows that the two primary source categories of nitrogen oxides emissions are fuel combustion and transportation, composing 51 percent and 45 percent, respectively, of total 1992 nitrogen oxides emissions. As noted in previous sections, the emissions estimates in this report have been recomputed using the MOBILE5 emissions factor model, rather than the MOBILE4.1 model used in the last annual report. This change yielded a revised estimate for 1991 highway emissions that is 30 percent higher than last year's estimate. The reporting units have also been changed since last year, from metric tons to short tons.

Table 3-3. National Nitrogen Oxides Emission Estimates, 1983-1992

(million short tons/year)										
SOURCE CATEGORY	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**
Fuel Combustion - Electric Utilities	6.92	7.27	6.68	6.91	7.13	7.53	7.61	7.53	7.48	7.47
Fuel Combustion - Industrial	3.16	3.41	3.42	3.28	3.29	3.44	3.48	3.54	3.60	3.52
Fuel Combustion - Other	0.65	0.67	0.70	0.69	0.71	0.74	0.73	0.73	0.75	0.73
Chemical and Allied Product Manufacturing	0.15	0.16	0.16	0.38	0.37	0.40	0.39	0.40	0.40	0.40
Metals Processing	0.05	0.05	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Petroleum and Related Industries	0.07	0.07	0.12	0.11	0.10	0.10	0.10	0.10	0.10	0.09
Other Industrial Processes	0.19	0.20	0.33	0.33	0.32	0.32	0.31	0.31	0.30	0.30
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	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08
Highway Vehicles	8.10	7.95	8.11	7.63	7.87	7.98	7.70	7.82	7.72	7.48
Off-Highway	2.39	2.54	2.60	2.65	2.72	2.83	2.86	2.84	2.77	2.85
Natural Sources	0	0	0	0	0	0	0	0	0	0
Miscellaneous	0.25	0.21	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Total	22.01	22.63	22.42	22.28	22.81	23.63	23.48	23.56	23.41	23.15
NOTE: The sums of sub-categories may not equal total due to rounding.										

3.3.2 Recent NO_2 Trends: 1990-1992

Between 1991 and 1992, the composite annual mean NO_2 concentration at 235 sites, with complete data during the last three years, decreased 3 percent. This followed no change in the composite mean between 1990 and 1991. At the subset of 50 NAMS, the composite mean concentration decreased 4 percent between 1991 and 1992. Los Angeles, CA, the only urban area that has recorded violations of the annual average NO_2 standard during the past 10 years, had air quality levels meeting the NO_2 NAAQS for the first time in 1992. Nationwide emissions of nitrogen oxides are estimated to have decreased 2 percent between 1990 and 1992, due primarily to the 3 percent reduction in NO_x emissions from transportation sources.

Regional trends in the composite average NO_2 concentrations for the years 1990-92 are displayed in Figure 3-15 with bar graphs. Region X, which did not have any NO_2 sites meeting the 3-year data completeness and continuity criteria, is not shown.

Five of the nine Regions have 1992 composite average NO_2 annual mean concentrations that are lower than the 1990 and 1991 composite mean levels. The four remaining Regions recorded increases between 1991 and 1992, although Region IV 1992 levels are still less than the corresponding 1990 composite mean. These Regional graphs are primarily intended 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.

Los Angeles met the NO_2 NAAQS for the first time in 1992.

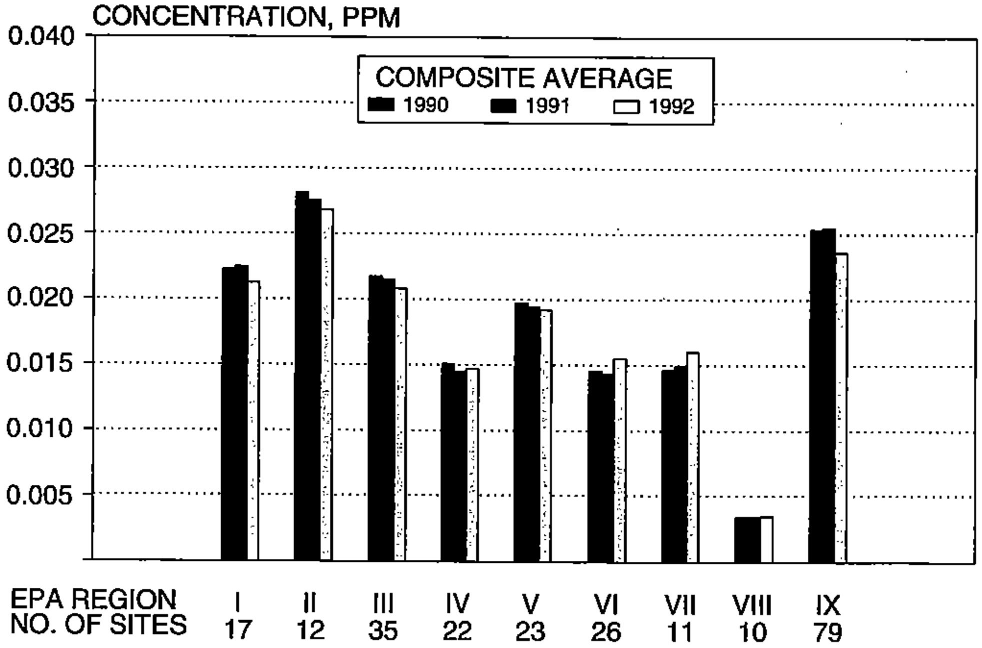


Figure 3-15. Regional comparisons of 1990, 1991, 1992 composite averages of the annual mean nitrogen dioxide concentrations.

3.4 Trends in Ozone

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

The reactivity of ozone 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 several hours at relatively low concentrations has been found to significantly reduce lung function 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 ozone season are considered in this analysis. The strong seasonality of ozone levels makes it possible for areas to limit their ozone monitoring to a certain portion of the year, termed the ozone season. The length of the ozone 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 ozone seasons such as May through September for North Dakota. This analysis uses these ozone seasons to ensure that the data completeness requirements apply to the relevant portions of the year.

The trends site selection process, discussed in Section 2.1 yielded 509 sites for the 1983-92 trends data base, and 672 sites for the 1990-92 data base. The NAMS compose 196 of the long-term trends sites and 222 of the sites in the 3-year data base.

3.4.1 Long-term O_3 Trends: 1983-92

Figure 3-16 displays the 10-year composite average trend for the second highest day during the ozone season for the 509 trends sites and the subset of 196 NAMS sites. The 1992 composite average for the 509 trend sites is 21 percent lower than the 1983 average and 20 percent lower for the subset of 196 NAMS. The 1992 value is the lowest composite average of the past ten years. The 1992 composite average is significantly less than all the previous nine years, 1983-91. As discussed in previous reports, the relatively high ozone concentrations in both 1983 and 1988 are likely attributed in part to hot, dry, stagnant conditions in some areas of the country that were more conducive to ozone formation than other years. Peak ozone concentrations typically occur during hot, dry, stagnant summertime conditions (high temperature and strong solar insolation).[14,15]

The interpretation of recent ozone trends is difficult due to the confounding factors of

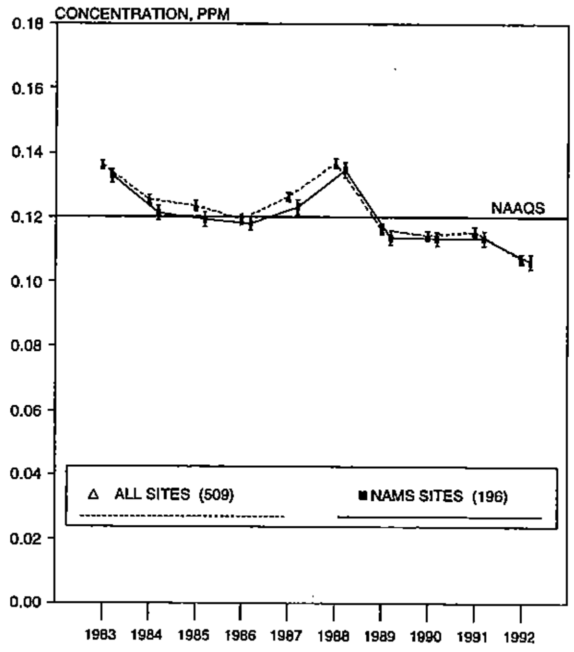


Figure 3-16. National trend in the composite average of the second highest maximum 1-hour ozone concentration at both NAMS and all sites with 95 percent confidence intervals, 1983-1992.

meteorology and emission changes. Just as the increase in 1988 is attributed in part to meteorological conditions, the 1992 decrease is likely due, in part, to meteorological conditions being less favorable for ozone formation in 1992 than in other recent years.[13,16] Previous reports have compared the regional variability in meteorological parameters such as maximum daily temperature with the variability in peak ozone concentrations.[13,16]

Nationally, summer 1992 was the third coolest summer on record.[17] Also, precursor emissions of nitrogen oxides and volatile organic compound emissions from highway vehicles have decreased in urban areas. The volatility of gasoline was 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 3 percent between 1989 and 1990.[21]

The inter-site variability of the annual second highest daily maximum concentrations for the 509 site data base is displayed in Figure 3-17. The years 1983 and 1988 values are similarly high, while the remaining years in the 1983-92 period are generally lower, with 1992 being the lowest, on average. The distribution of second daily maximum 1-hour concentrations in 1992 is lower than any previous year.

Figure 3-18 depicts the 1983-92 trend for the composite average number of ozone exceedances. This statistic is adjusted for missing data, and it reflects the number of days that the ozone standard is exceeded during the ozone season. Since 1983, the expected number of exceedances decreased 65 percent at the 509 long-term trend sites and 67 percent at the subset of 196 NAMS. Because ozone trends have not shown a consistent directional pattern, the percent change between the endpoints for the 10-year period, 1983-92, has to be recognized as a simplification, particularly because 1983 was a relatively high year. As with the second maximum, the 1983 and 1988 values are higher than the other years in the 1983-92 period. The composite averages of ozone estimated exceedances for the years 1989 through 1992 levels are significantly lower than all the previous years.

Historically, the long-term ozone trends in this annual report have emphasized air quality statistics that are closely related to the NAAQS. A recent report[2] by the National Academy of Sciences (NAS) stated that "the principal measure currently used to assess ozone trends (i.e., the second-highest daily maximum 1-hour concentration in a given year) is highly sensitive to meteorological fluctuations and is not a reliable measure of progress in reducing ozone over several years for a given area." The report recommended that "more statistically robust methods be

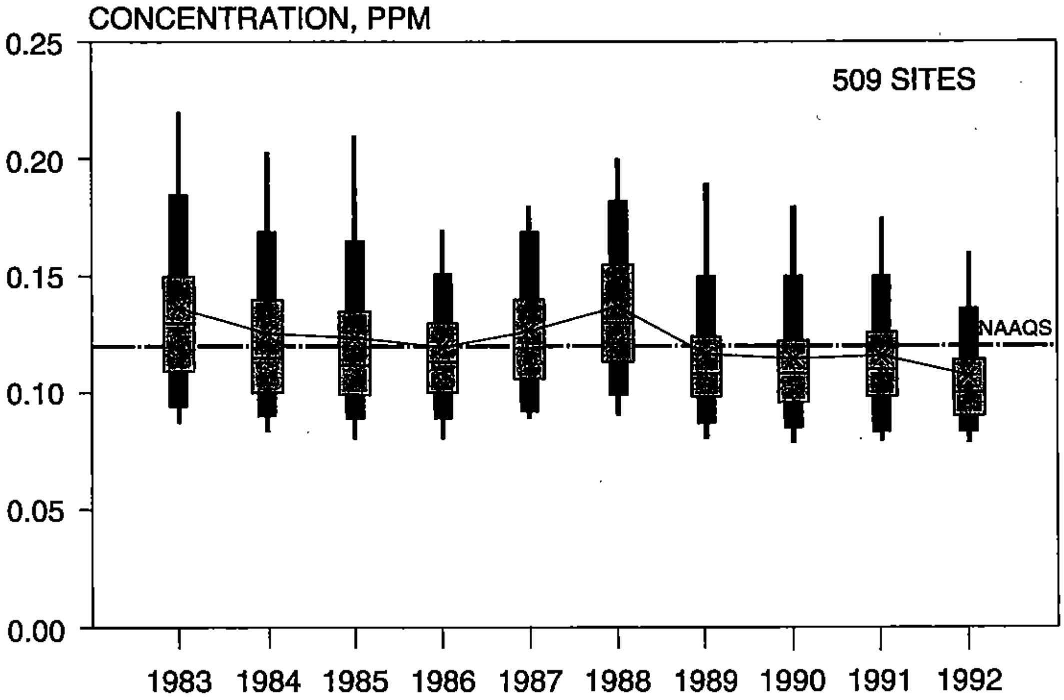


Figure 3-17. Boxplot comparisons of trends in annual second highest daily maximum 1-hour ozone concentration at 509 sites, 1983-1992.

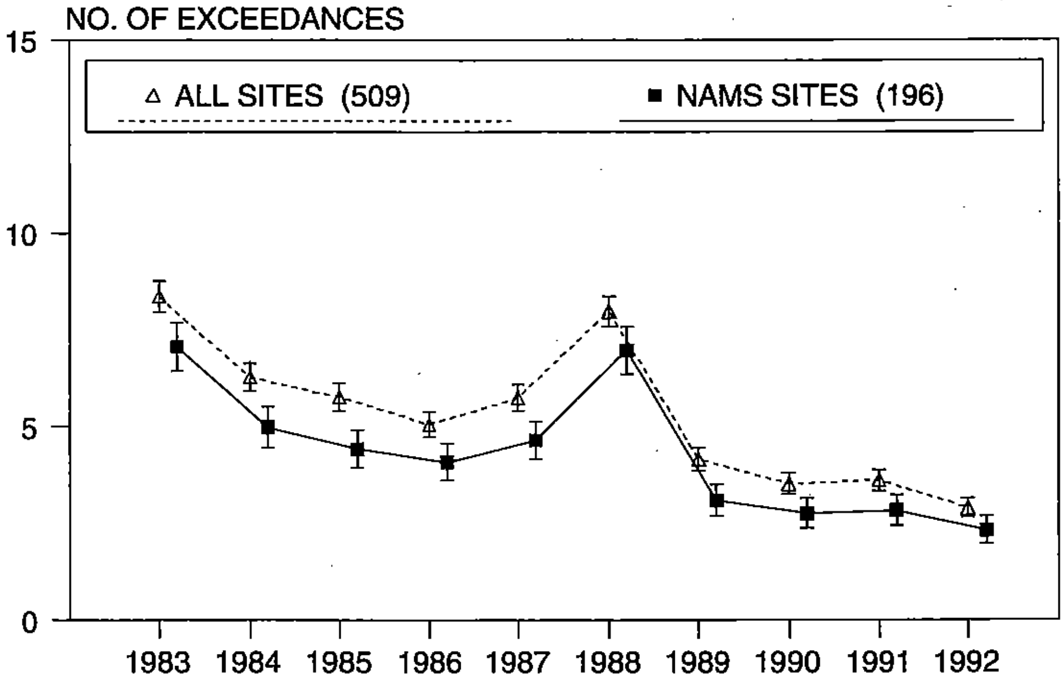


Figure 3-18. National trend in the estimated number of daily exceedances of the ozone NAAQS in the ozone season at both NAMS and all sites with 95 percent confidence intervals, 1983-1992.

developed to assist in tracking progress in reducing ozone." The report described "several other potentially robust indicators of ozone trends" and featured indicators described previously by Curran and Frank which used a comparison of different percentiles and maximum values[4]. Of course, the main focus of this 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 ozone air quality standard. Nevertheless, in last year's report we looked at trends in alternative summary statistics to see if there are sufficient differences among trends for different summary statistics to warrant concern. All of the trends patterns were somewhat similar among the various summary statistics, with a tendency to become flatter in the lower percentiles. That is, these more robust indicators, the percentiles, showed less improvement, i.e., smaller percentage changes, than the current trends indicator of the annual second maximum 1-hour concentration. However, the peak years of 1983 and 1988 were still evident in the trend lines for each robust indicator.[5]

The influence of meteorological conditions, particularly temperature, on ozone concentrations has been well established. Although the particular combination of meteorological variables most closely associated with high ozone events varies from location to location, high temperatures, clear skies, light winds and limited vertical mixing generally result in the highest ozone events.

EPA has initiated a study to investigate techniques for adjusting ozone trends for meteorological influences. One of the methods is a statistical model in which the frequency distribution of ozone concentrations is described as a function of meteorological parameters. Cox and Chu model the daily maximum ozone concentration using a Weibull distribution with a fixed shape parameter and a scale parameter the logarithm of which varies as a linear function of several meteorological variables and a year index.[22] Model parameters are fit via maximum likelihood. The fitted distribution can be used to estimate percentiles and threshold exceedance probabilities for the daily maximum ozone 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. The model can also be used to calculate "meteorologically adjusted" estimates of the upper percentiles of daily maximum concentrations in each year. These estimates are obtained by substituting a one-year sequence of adjusted daily meteorological variables into the Weibull scale parameter equation and finding the concentration value exceeded on 1 percent of days over the course of the year. The adjusted meteorological variables are obtained via a linear transformation of the actual daily values observed over the 10-year period being analyzed.

The results of application of the model to a number of urban areas are encouraging. Figure 3-19 displays ambient air quality trends, and meteorologically adjusted ozone trends for 43 metropolitan areas. The "adjusted" trend indicator shown in Figure 3-19 is the composite mean of the meteorologically adjusted 99th percentile daily maximum 1-hour concentrations across each of the 43 individual metropolitan areas. The smoothing introduced by the meteorological adjustment is especially evident in the ozone trends where the peak ozone years, such as 1983 and 1988, have been followed by years less conducive to ozone formation. The general pattern is clear, a steady downward trend. The composite average of the 99th percentile daily maximum 1-hour concentrations in 1992 is 10 percent lower than the 1983 level. This composite trend captures the spatial and temporal variability in meteorological conditions among these 43

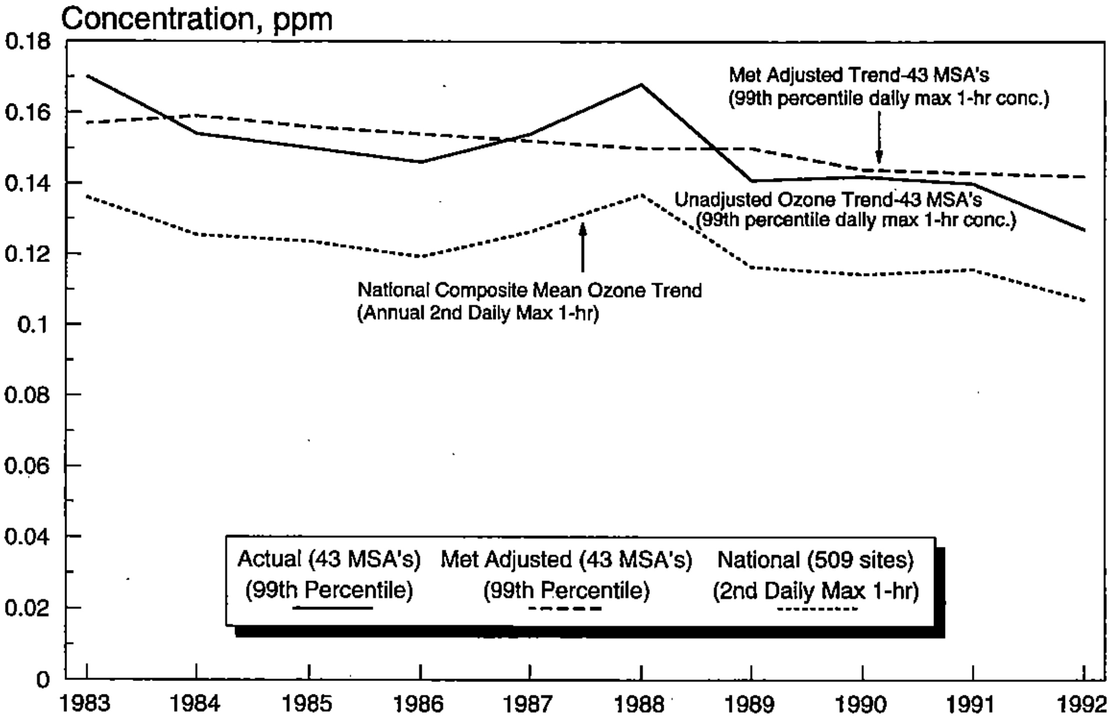


Figure 3-19. Comparison of meteorologically adjusted, and unadjusted, trends in the composite average of the second highest maximum 1-hour concentration for 43 MSAs, 1983-1992.

metropolitan areas. As illustrated by this figure, the composite trend in the unadjusted 99th percentile daily maximum 1-hour concentration for these 43 metropolitan areas tracks the national composite ozone trend in the second highest daily maximum 1-hour concentration. Thus, the meteorologically adjusted trend is likely to be a reasonable indicator of the composite national ozone trend. EPA is seeking to review and expand the technical basis for the methodology under a cooperative agreement with the National Institute of Statistical Sciences (NISS).

Table 3-4 lists the 1983-92 emission estimates for volatile organic compounds (VOC) which, together with nitrogen oxides shown earlier in Table 3-3, are involved in the atmospheric chemical and physical processes that result in the formation of O_3. Total VOC emissions are estimated to have decreased 11 percent between 1983 and 1992. During this same period, nitrogen oxides emissions, the other major precursor of ozone formation, increased 5 percent. Between 1983 and 1992, VOC emissions from highway vehicles decreased 39 percent, despite a 37 percent increase in vehicle miles of travel during this time period. These VOC estimates are annual totals based on statewide average monthly temperatures and statewide average RVP. However, ozone is predominately a warm weather problem and seasonal emission trends would be preferable. While only these national numbers were available as this report went to press, seasonal emissions estimates are being developed.

Table 3-4. National Volatile Organic Compound Emission Estimates, 1983-1992

(million short tons/year)

SOURCE CATEGORY	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Fuel Combustion -Electric Utilities	0.04	0.05	0.04	0.03	0.03	0.04	0.04	0.04	0.03	0.03
Fuel Combustion - Industrial	0.15	0.16	0.12	0.27	0.27	0.29	0.28	0.28	0.29	0.28
Fuel Combustion - Other	0.91	0.92	1.49	0.50	0.48	0.47	0.45	0.44	0.43	0.39
Chemical and Allied Product Manufacturing	1.55	1.62	0.88	1.64	1.63	1.75	1.75	1.77	1.78	1.76
Metals Processing	0.16	0.18	0.05	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Petroleum and Related Industries	1.27	1.25	1.03	0.76	0.75	0.73	0.73	0.74	0.75	0.72
Other Industrial Processes	0.25	0.23	0.26	0.45	0.46	0.48	0.48	0.48	0.48	0.48
Solvent Utilization	5.23	6.31	5.62	5.71	5.83	6.03	6.05	6.06	6.06	6.06
Storage and Transport	1.80	1.81	1.68	1.77	1.89	1.95	1.86	1.86	1.87	1.82
Waste Disposal and Recycling	0.69	0.69	1.55	2.29	2.26	2.31	2.29	2.26	2.22	2.31
Highway Vehicles	10.08	9.63	9.49	9.00	8.23	8.08	7.15	6.98	6.81	6.10
Off-Highway	2.13	2.35	2.25	2.30	2.25	2.23	2.18	2.12	2.06	2.13
Natural Sources	0	0	0	0	0	0	0	0	0	0
Miscellaneous	1.16	0.95	0.55	0.56	0.57	0.59	0.58	0.58	0.57	0.58
Total	25.41	26.14	25.01	25.35	24.73	25.02	23.91	23.67	23.40	22.73

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

3.4.2 Recent O_3 Trends: 1990-1992

This section discusses ambient O_3 changes during the 3-year time period 1990-92. Using this 3-year period permits the use of a larger data base of 672 sites, compared to 509 for the 10-year period.

Summer 1992 temperature averaged across the nation was below the long-term mean and ranks as the 3rd coolest summer on record since 1895.[17] The overall temperature pattern consisted of much below normal values in the eastern two-thirds of the country. In the East North Central, South, and Central regions, Summer 1992 was the second coolest summer on record, while the West North Central was the fourth coldest and the Northeast was the fifth coolest. This 3-year period follows the reduction in the volatility of gasoline, Reid Vapor Pressure (RVP), that has occurred since 1988.[20] 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]

Between 1991 and 1992, composite mean ozone concentrations decreased 7 percent at the 672 sites and 6 percent at the subset of 222 NAMS. Between 1991 and 1992, the composite average of the number of estimated exceedances of the ozone standard decreased by 23 percent at the 672 sites, and 19 percent at the 222 NAMS. Nationwide VOC emissions decreased 3 percent between 1991 and 1992.

The composite average of the second daily maximum concentrations decreased in eight of the ten Regions between 1991 and 1992, and remained unchanged in Region VII. Except for Region VII, the 1992 regional composite means are lower than the corresponding 1990 levels. As Figure 3-20 indicates, decreases were recorded in every region except Region VII and X.

1992 Ozone levels were the lowest of the past 10 years.

These Regional graphs are primarily intended 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.

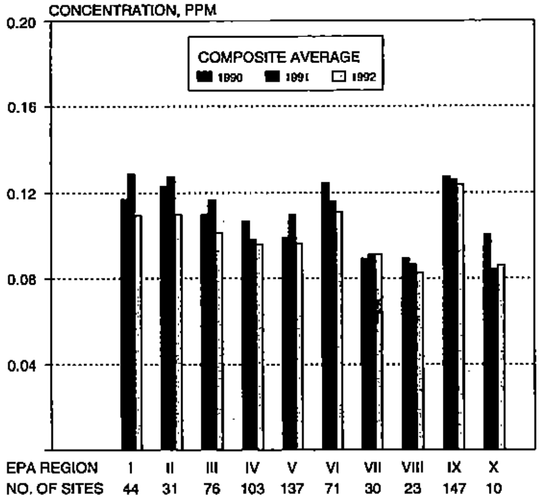


Figure 3-20. Regional comparisons of the 1990, 1991, 1992 composite averages of the second-highest daily 1-hour ozone concentrations.

PAMS: A New Program for Ozone Monitoring

Ozone is unique among the NAAQS pollutants in that it is not emitted directly into the air. This makes it a bit of a challenge to track and to control because we need to understand not only the ozone itself, but also the chemicals, reactions, and conditions that go into forming it.

To help put together the whole picture on ozone, Section 182(c)(1) of the 1990 Clean Air Act Amendments called for better monitoring of ozone and its precursors, VOC and NOx. This will be accomplished by a new EPA program which requires all serious, severe, and extreme ozone areas to set up monitoring networks that will gather a comprehensive set of data covering all aspects of ozone. The program is called PAMS, for Photochemical Assessment Monitoring Stations, and the requirements were announced on February 12, 1993. The 22 affected ozone areas, shown in Figure 3-21, cover 113 thousand square miles and have a total population of 79 million people.

The PAMS program will require as many as five monitoring stations in an area, depending on the area's population. Each monitoring station will be carefully located based on meteorology and other conditions at the site. Data will then be collected for ozone, oxides of nitrogen, a target list of VOCs including several carbonyls, and surface and upper air meteorology. All together, nearly 60 compounds may be reported at each monitoring station, including some compounds which are on the list of hazardous air pollutants (HAPs).

Data collected by the PAMS network will have many uses. It will enhance the ability of State and local air pollution agencies to evaluate ozone nonattainment conditions and identify cost-effective control strategies, help to verify ozone NOx and VOC emission inventories, serve as input to photochemical grid models, provide information to evaluate population exposure, and be used to develop and improve trends. Most importantly, it will give us a more complete understanding of the complex problem of ozone, so that we may move toward the best solution.

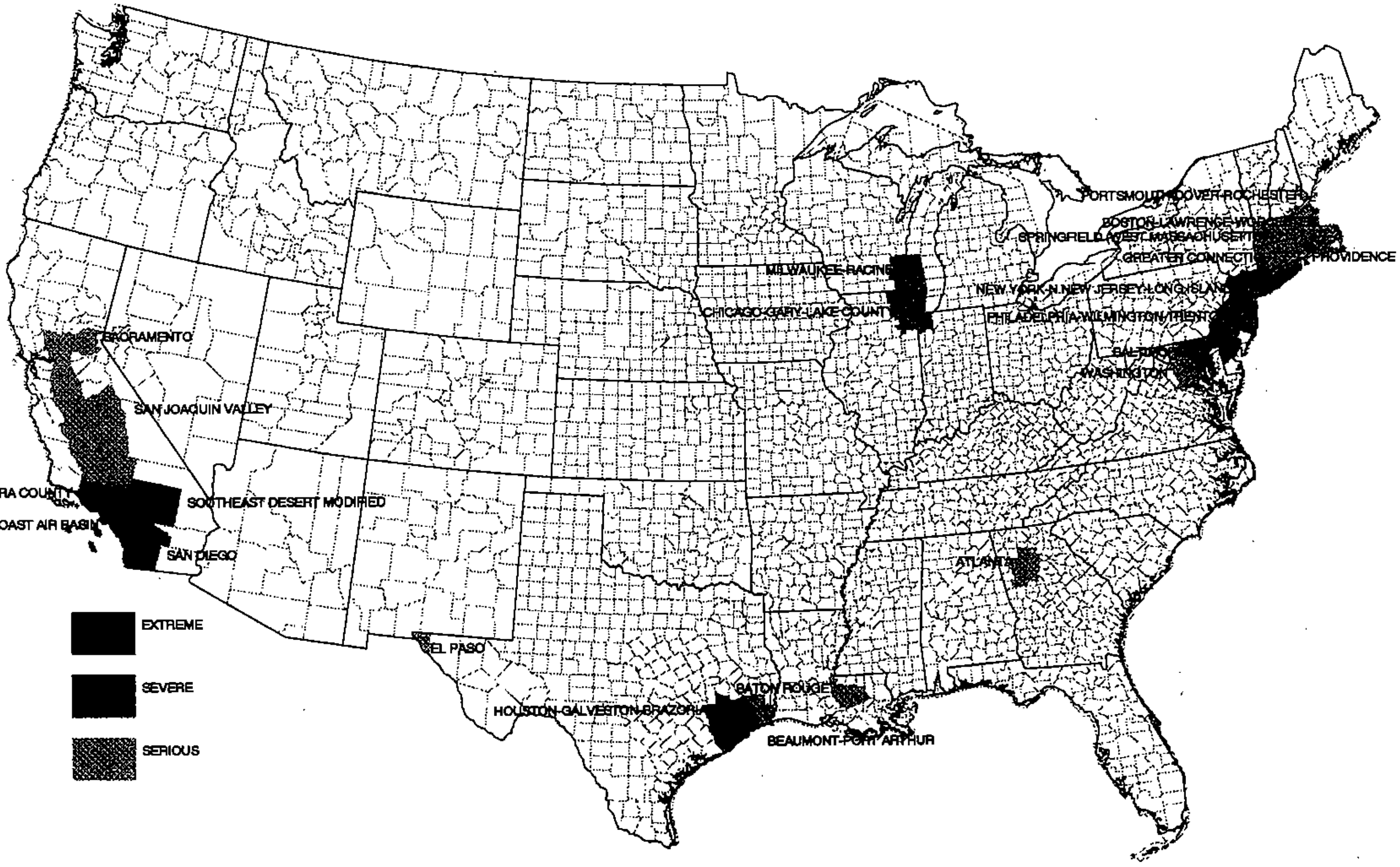


Figure 3-21. *Ozone nonattainment areas classified as extreme, severe and serious.*

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 sulfur dioxide and volatile organic compounds are also considered particulate matter.

Based on studies of human populations exposed to high concentrations of particles (often in the presence of sulfur dioxide), and laboratory studies of animals and humans, the major effects 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 most sensitive to the effects of particulate matter include individuals with chronic obstructive pulmonary or cardiovascular disease, individuals with influenza, asthmatics, the elderly and children. Particulate matter also soils and damages materials, and is a major cause of visibility impairment in the U.S.

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 annual arithmetic mean concentration is used to reflect average air quality, and a 90th percentile of 24-hour concentrations is used to represent the behavior of peak concentrations. The 90th percentile 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 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 5-year period from 1988 to 1992, with a sample of 652 trend sites.

Figures 3-22 and 3-23 display boxplots of the concentration distribution for annual arithmetic mean and 90th percentile of 24-hour concentrations, respectively. The trend is similar in each figure, with steady values between 1988 and 1989 followed by a more dramatic decrease over each of the next 3 years. Overall, annual mean concentrations decreased 17 percent over the 5-year period, while the 90th percentile concentrations decreased almost 20 percent.

Annual mean PM-10 concentrations over the last 3 years for each EPA region are shown in Figure 3-24. All regions experienced a drop in particulate matter over the last year, 1991 to 1992, and half of the regions exhibit a downward trend over the whole 3-year period.

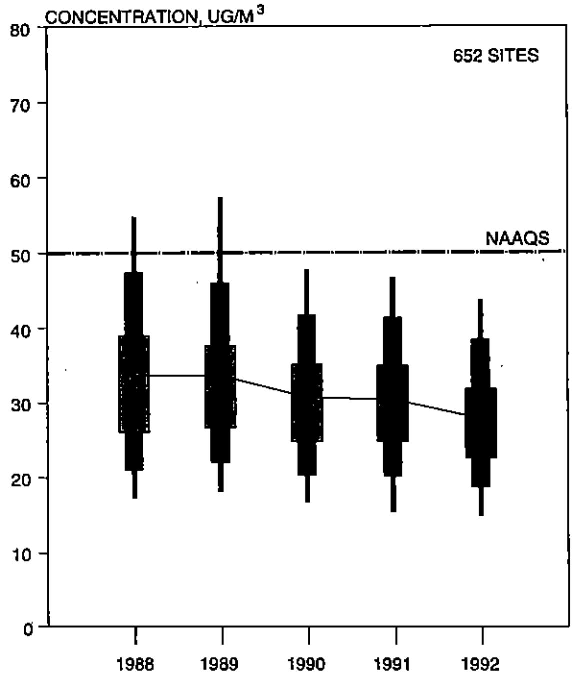


Figure 3-22. Boxplot comparisons of trends in annual mean PM-10 concentrations at 652 sites, 1988-1992.

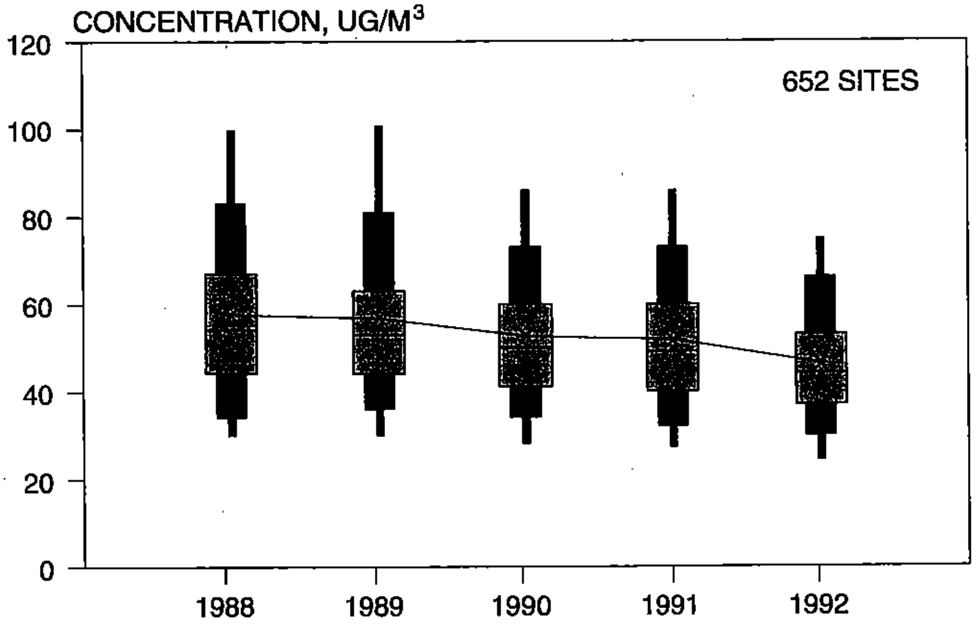


Figure 3-23. Boxplot comparisons of trends in the 90th percentile of 24-hour PM-10 concentrations at 652 sites, 1988-1992.

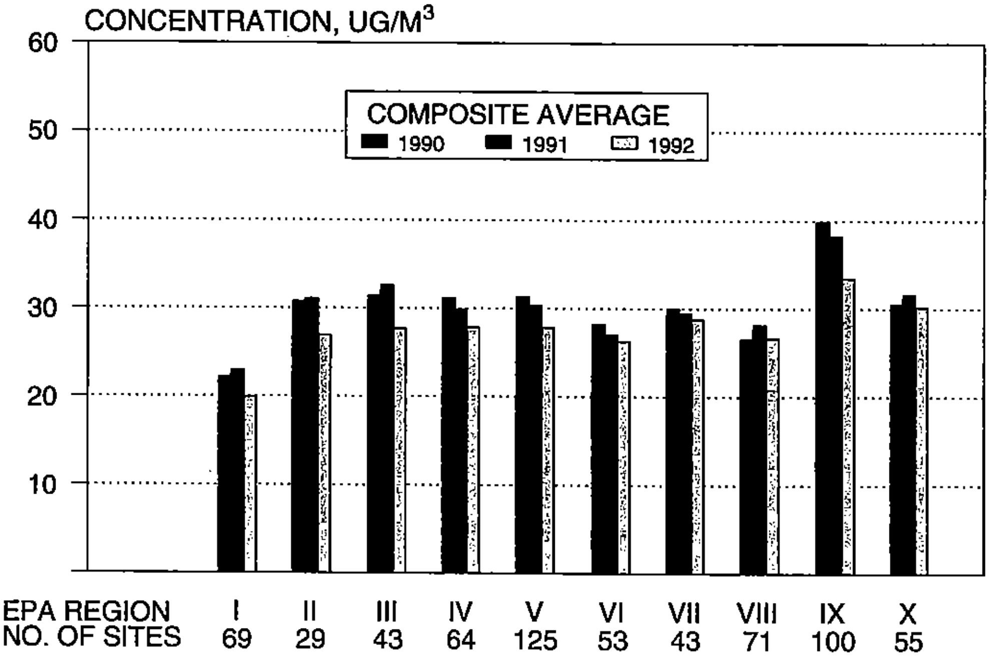


Figure 3-24. Regional comparisons of the 1990, 1991, 1992 composite averages of the annual average PM-10 concentrations.

3.5.2 PM-10 Emission Trends

Trends in PM-10 emissions (except fugitive dust emissions) are presented in Table 3-5 for a 10-year period from 1983 to 1992. In 1992, emissions in most categories were up slightly over 1991. Total PM-10 emissions for 1992 were 2 percent higher than total emissions in 1991.

Over the 10-year period, total PM-10 emissions decreased 3 percent. Emissions in most categories remained fairly steady, while other categories show a more definitive trend. PM-10 emissions of Highway Vehicles, for example, rose steadily, resulting in a 50 percent increase between 1983 and 1992. Offsetting this increase, the category for Fuel Combustion — Other, experienced a 52 percent decrease. Emissions in the Fuel Combustion — Other category are predominately due to residential wood combustion, or the in-home use of fireplaces and wood stoves. Several innovative approaches to controlling residential wood combustion are responsible for the large decrease in this emission category.

The four states in Region X, for example, have made significant progress during the past five years in reducing particulate matter with aggressive public education programs, restrictions on residential wood combustion, and positive incentives to reduce burning. In addition, the Region has further reduced PM-10 emissions by controlling fugitive dust from roads and placing new limitations on a few industrial sources.

Table 3-5. National PM-10 Emission Estimates, 1983-1992, No Fugitive Dust Emissions

(million short tons/year)

SOURCE CATEGORY	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**
Fuel Combustion - Electric Utilities	0.15	0.15	0.15	0.15	0.16	0.17	0.17	0.17	0.16	0.17
Fuel Combustion - Industrial	0.61	0.62	0.61	0.60	0.60	0.57	0.58	0.49	0.48	0.46
Fuel Combustion - Other	0.96	0.98	0.87	0.87	0.88	0.86	0.89	0.51	0.50	0.47
Chemical and Allied Product Manufacturing	0.12	0.14	0.13	0.10	0.10	0.08	0.11	0.12	0.11	0.12
Metals Processing	0.38	0.42	0.40	0.35	0.38	0.36	0.41	0.41	0.39	0.42
Petroleum and Related Industries	0.12	0.12	0.12	0.12	0.13	0.12	0.12	0.12	0.12	0.12
Other Industrial Processes	1.37	1.63	1.45	1.34	1.27	1.35	1.31	1.33	1.25	1.28
Solvent Utilization	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Storage and Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Disposal and Recycling	0.23	0.23	0.23	0.22	0.22	0.22	0.22	0.22	0.22	0.25
Highway Vehicles	1.04	1.09	1.18	1.18	1.30	1.38	1.40	1.48	1.53	1.56
Off-Highway	0.25	0.26	0.27	0.28	0.27	0.29	0.28	0.28	0.27	0.27
Miscellaneous	0.87	0.72	0.80	0.60	0.73	1.06	0.72	0.96	0.78	0.81
Total	6.09	6.35	6.18	5.81	6.04	6.44	6.21	6.08	5.81	5.93

NOTES: The sums of sub-categories may not equal total due to rounding.
1983 and 1984 PM-10 derived from TSP.

Some remaining PM-10 sources in the Region still present challenges. Agriculture is a significant source of particulate matter, especially during high winds, and upcoming prescribed burning activities for improving forest health are expected to have an impact in several areas. Table 3-6 shows 1985-92 fugitive dust PM-10 emissions. Fugitive dust actually contributes 6 to 8 times more PM-10 emissions than the sources listed in the previous table.

Construction activity and unpaved roads are consistently the major contributors of fugitive dust particulate matter emissions. Among road types, emissions from unpaved roads have remained fairly steady, while emissions from paved roads are estimated to have increased 20 percent since 1985, most likely due to increased vehicle traffic. Emissions due to construction have decreased an estimated 17 percent since 1985.

Agricultural activity is a smaller contributor to the national total, but estimated to be the major source in specific Regions. Tilling is estimated to be a big contributor in Regions V, VII, VIII and X, but has not shown much change over the 8-year period. 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, particularly for Regions VI and VII. Finally, among all fugitive categories surveyed, mining and quarrying is estimated to be a relatively small contributor to total fugitive particulate matter emissions at the national level, although is can be a major factor in specific local situations.

Table 3-6. National PM-10 Fugitive Dust Emission Estimates, 1985-1992

(million short tons/year)

SOURCE CATEGORY	1985	1986	1987	1988	1989	1990	1991	1992
Agricultural Tilling	6.83	6.90	7.01	7.09	6.94	7.00	6.97	6.85
Construction	12.67	11.83	12.12	11.66	11.27	10.04	9.67	10.54
Mining and Quarrying	0.34	0.31	0.38	0.34	0.39	0.35	0.37	0.38
Paved Roads	6.56	6.81	7.13	7.62	7.40	7.53	8.15	7.90
Unpaved Roads	14.71	14.66	13.95	15.62	15.34	15.65	14.25	15.17
Wind Erosion	3.57	9.39	1.46	17.51	11.83	4.19	10.13	4.66
TOTAL	44.68	49.90	42.04	59.84	53.16	44.77	49.54	45.50

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

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 3-hour level of 0.50 ppm (1300 $\mu g/m^3$). The first two standards are primary (health-related) standards, while the 3-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. The trend analyses which follow are 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, causing acidification of lakes and streams and damaging trees, crops, historic buildings, and statues. In addition, sulfur compounds in the air contribute to visibility degradation in large parts of the country, including 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 (summarized midnight to midnight).

3.6.1 Long-term SO_2 Trends: 1983-92

The long-term trend in ambient SO_2, 1983 through 1992, is graphically presented in Figures 3-25 and 3-26. In each figure, the trend at the NAMS is contrasted with the trend at all sites. For each of the statistics presented, a 10-year downward trend is evident, although the rate of decline has slowed over the last few years. Nationally, the annual mean SO_2, examined at 476 sites, decreased at a median rate of approximately 2 percent per year; this resulted in an overall change of 23 percent (Figure 3-25). The subset of 138 NAMS recorded higher average concentrations but declined at a median rate of 3 percent per year, with a net change of 30 percent for the 10-year period.

The annual second highest 24-hour values displayed a similar improvement between 1983 and 1992. Nationally, among 476 stations with adequate trend data, the median rate of change was almost 4 percent per year, with an overall decline of 31 percent (Figure 3-26). The 138 NAMS exhibited the same overall decrease of 31 percent.

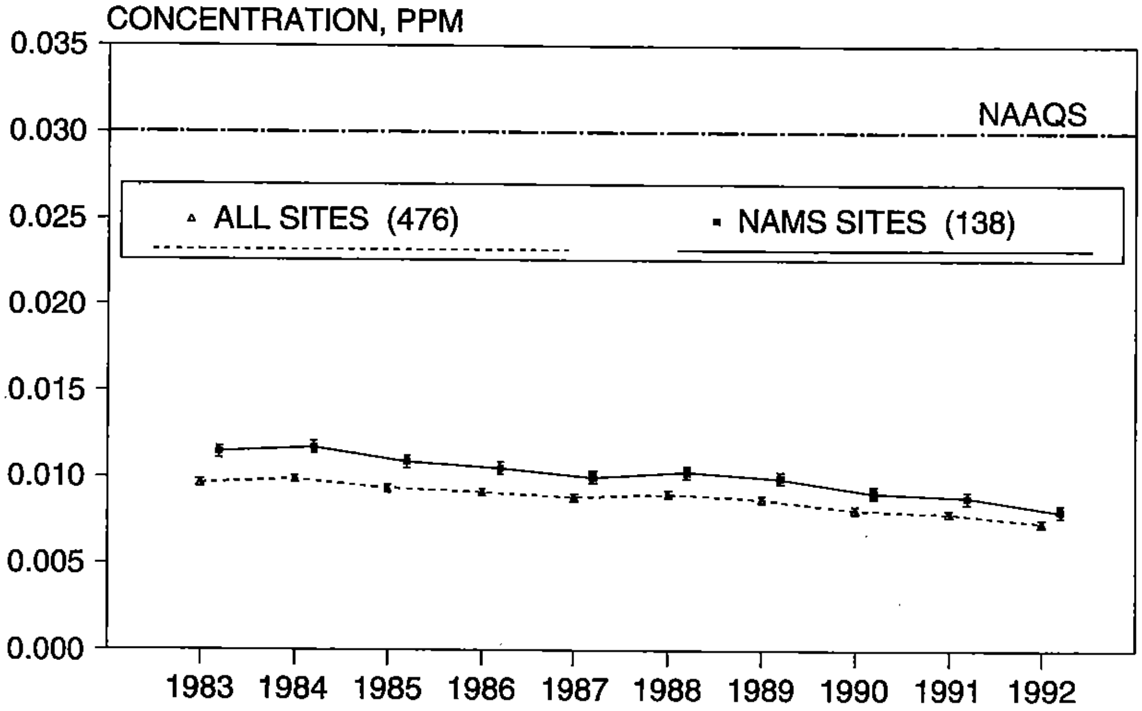


Figure 3-25. National trend in annual average sulfur dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1983-1992.

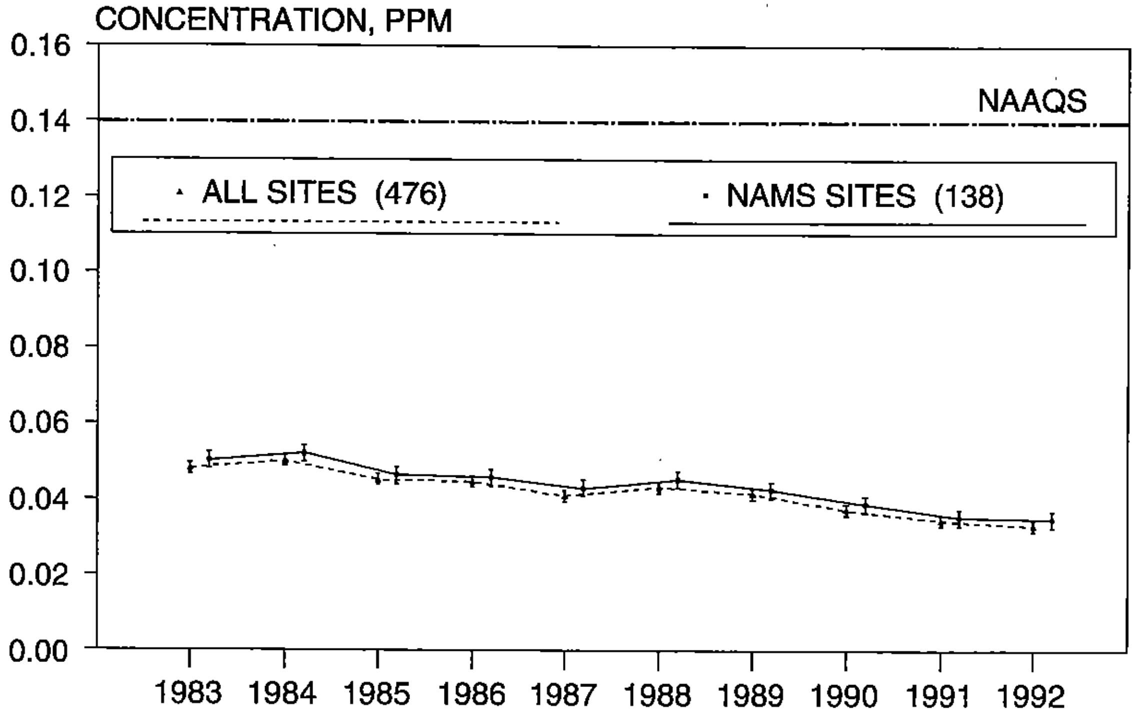


Figure 3-26. National trend in the second highest 24-hour sulfur dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1983-1992.

The statistical significance of these long-term trends is graphically illustrated in Figures 3-25 and 3-26 with the 95 percent confidence intervals. These figures show that the 1992 composite annual mean is statistically lower than all previous years, and the 1992 composite annual second maximum 24-hour level is statistically lower than all previous years except for 1991.

Figures 3-27 and 3-28 are boxplot comparisons of annual mean and second highest 24-hour SO_2 concentrations, respectively. The boxplots show the variability of concentration values at the 476 sulfur dioxide monitoring sites. In addition, they show that the range of concentrations has diminished over the 10-year period.

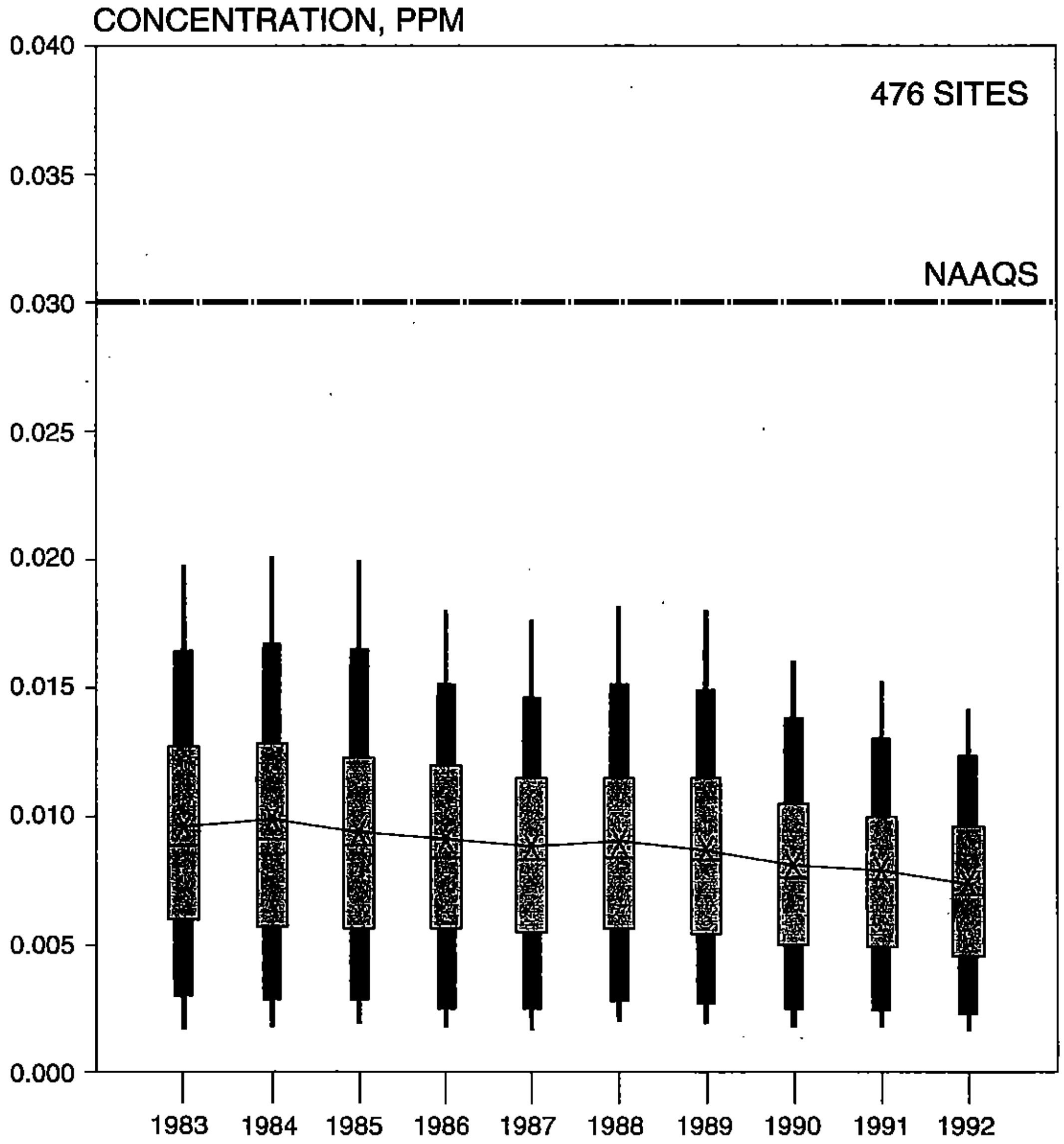


Figure 3-27. Boxplot comparisons of trends in annual mean sulfur dioxide concentrations at 476 sites, 1983-1992.

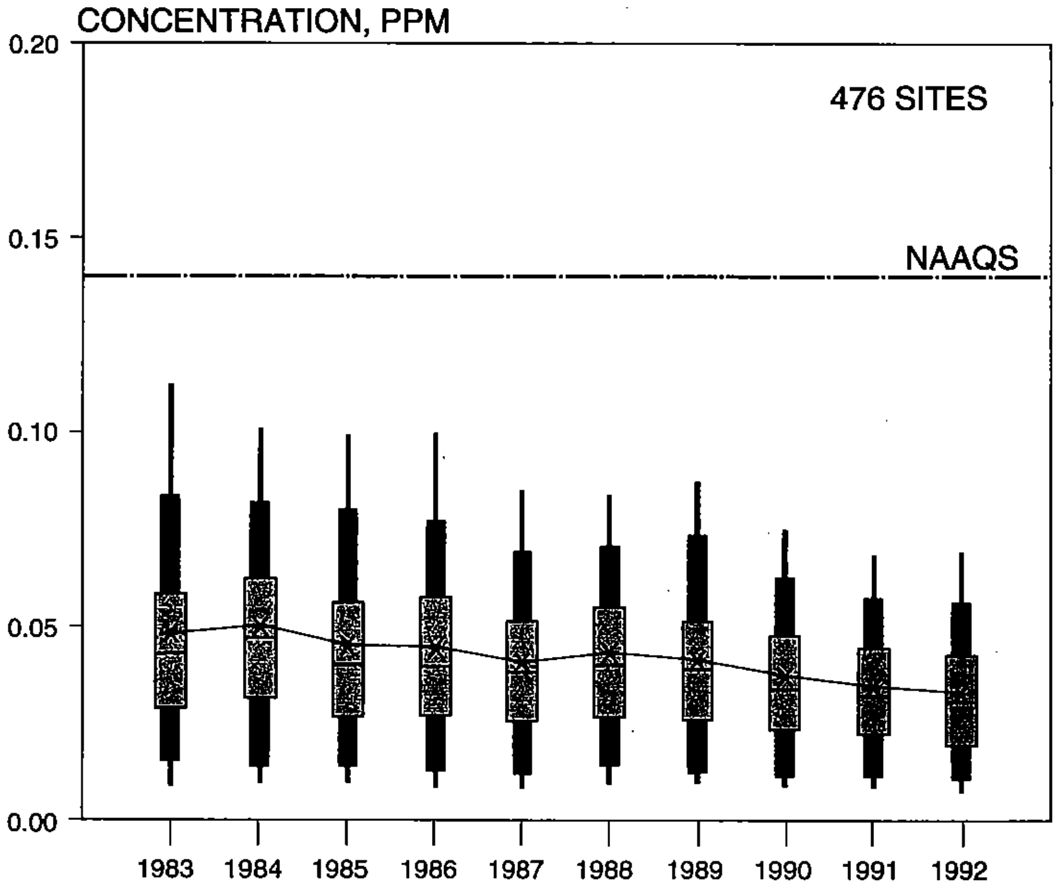


Figure 3-28. Boxplot comparisons of trends in second highest 24-hour average sulfur dioxide concentrations at 476 sites, 1983-1992.

The trend in nationwide emissions of sulfur oxides (SOx), broken down by source category, is shown in Table 3-7. After a 25 percent decrease in total emissions during the 70s and early 80's, SOx emissions have remained relatively unchanged in recent years. The largest contributor to SOx emissions has consistently been coal burning power plants.

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) 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.

Table 3-7. National Sulfur Oxides Emission Estimates, 1983-1992

(million short tons/year)

SOURCE CATEGORY	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**
Fuel Combustion - Electric Utilities	15.45	16.02	16.24	15.70	15.72	15.99	16.22	15.87	15.78	15.84
Fuel Combustion - Industrial	2.52	2.72	3.17	3.12	3.07	3.11	3.09	3.11	3.14	3.09
Fuel Combustion - Other	0.70	0.73	0.58	0.61	0.66	0.66	0.62	0.60	0.61	0.59
Chemical and Allied Product Manufacturing	0.22	0.23	0.44	0.42	0.41	0.43	0.42	0.42	0.43	0.42
Metals Processing	1.35	1.39	1.04	0.89	0.95	1.03	0.99	0.91	0.87	0.87
Petroleum and Related Industries	0.72	0.71	0.51	0.47	0.45	0.44	0.43	0.44	0.44	0.41
Other Industrial Processes	0.86	0.92	0.43	0.43	0.42	0.41	0.41	0.40	0.39	0.40
Solvent Utilization	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Storage and Transport	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Waste Disposal and Recycling	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Highway Vehicles	0.48	0.51	0.58	0.56	0.66	0.70	0.70	0.74	0.77	0.79
Off-Highway	0.39	0.40	0.35	0.23	0.24	0.25	0.26	0.27	0.27	0.27
Miscellaneous	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	22.73	23.66	23.39	22.48	22.62	23.09	23.20	22.82	22.77	22.73

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

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 may need them. Alternatively, 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.[24]

3.6.2 Recent SO_2 Trends: 1990-92

Nationally, SO_2 measured in the ambient air showed improvement over the last three years in both average and peak 24-hour concentrations. Composite annual mean concentrations decreased a total of 11 percent between 1990 and 1992. Over the last 2 years, the average annual mean SO_2 decrease was 7 percent. Composite 24-hour SO_2 concentrations declined 12 percent since 1990 and 4 percent since 1991.

Figure 3-29 presents the Regional changes in composite annual average SO_2 concentrations for the last 3 years, 1990-1992. Several Regions follow the national pattern of change in annual mean SO_2, with the largest drop in value occurring in Region III, where concentrations are highest. Only Regions VIII and X show a slight increase in 1992 over both 1990 and 1991, but these levels are still well below the SO_2 NAAQS.

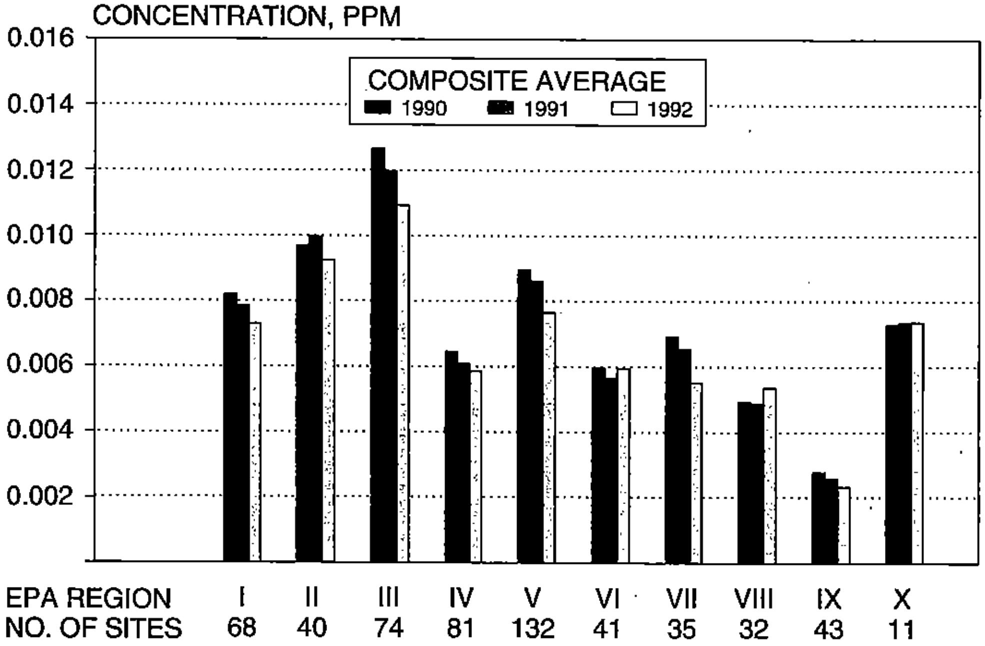


Figure 3-29. Regional Comparisons of the 1990, 1991, 1992 composite averages of the annual average sulfur dioxide concentrations.

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.

Many parts of the U.S. 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). All together, this collaborative visibility monitoring effort is called IMPROVE, for Interagency Monitoring of Protected Visual Environments. A recent report entitled "IMPROVE: Spatial and Temporal Patterns and the Chemical Composition of the Haze in the United States" discusses the IMPROVE program and is the basis for much of the following discussion.[25]

The objectives of IMPROVE are (1) to establish current background visibility levels in Class I areas, (2) to identify the chemical species and emission sources responsible for visibility impairment, and (3) to document long-term trends for assessing progress toward national visibility goals. Toward these objectives, IMPROVE has been collecting visibility data since 1987. The locations of current IMPROVE monitoring sites are shown in Figure 3-30. 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. From the data collected, some general points can be made.

Figure 3-31 presents IMPROVE data based upon mid-1970s data for average summertime visual range in miles. Areas of better visibility are shaded in dark green, while areas of poorest visibility appear in red. The best visibility, often exceeding 80 miles, is in the rural mountain desert area of the southwest,while east of the Mississippi River and south of the Great Lakes visibility is only about 12 miles. Note the large difference, in general, between the East and the West. Visibility in the West is 6 times better than visibility in the East during the winter, and up to 10 times better during the summer.

Figure 3-32 shows another way to present the data, this time in terms of units called deciviews, instead of miles. Deciview (dv) is a newly developed visibility index which is linear with respect to humanly-perceived changes in visual air quality over its entire range. This is analogous to the decibel scale for sound, which is how the deciview got its name. The dv scale is near zero for a clear atmosphere and increases as visibility degrades. Differences less than 1 dv are not thought to be perceptible.

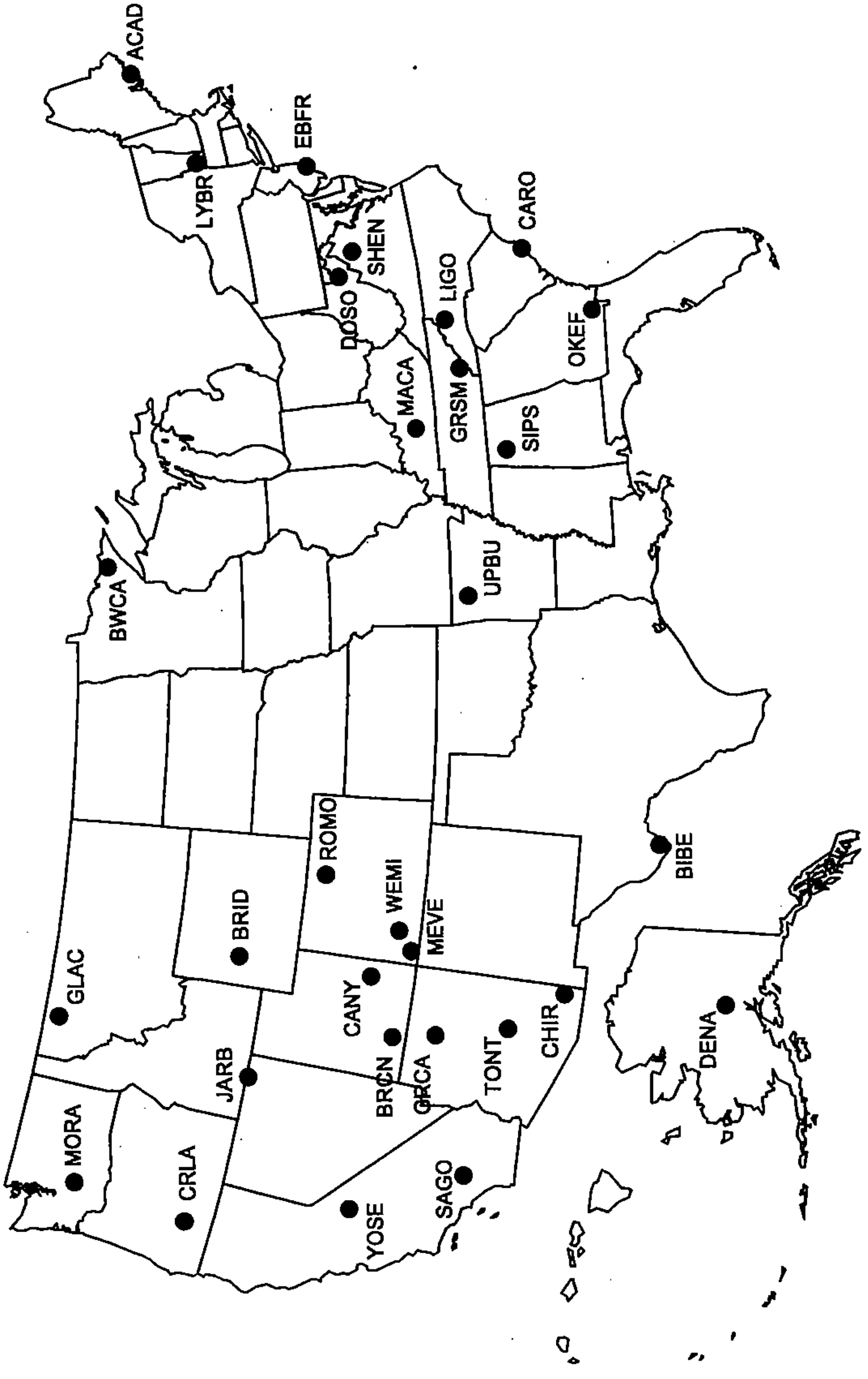


Figure 3-30. Current IMPROVE monitoring sites.

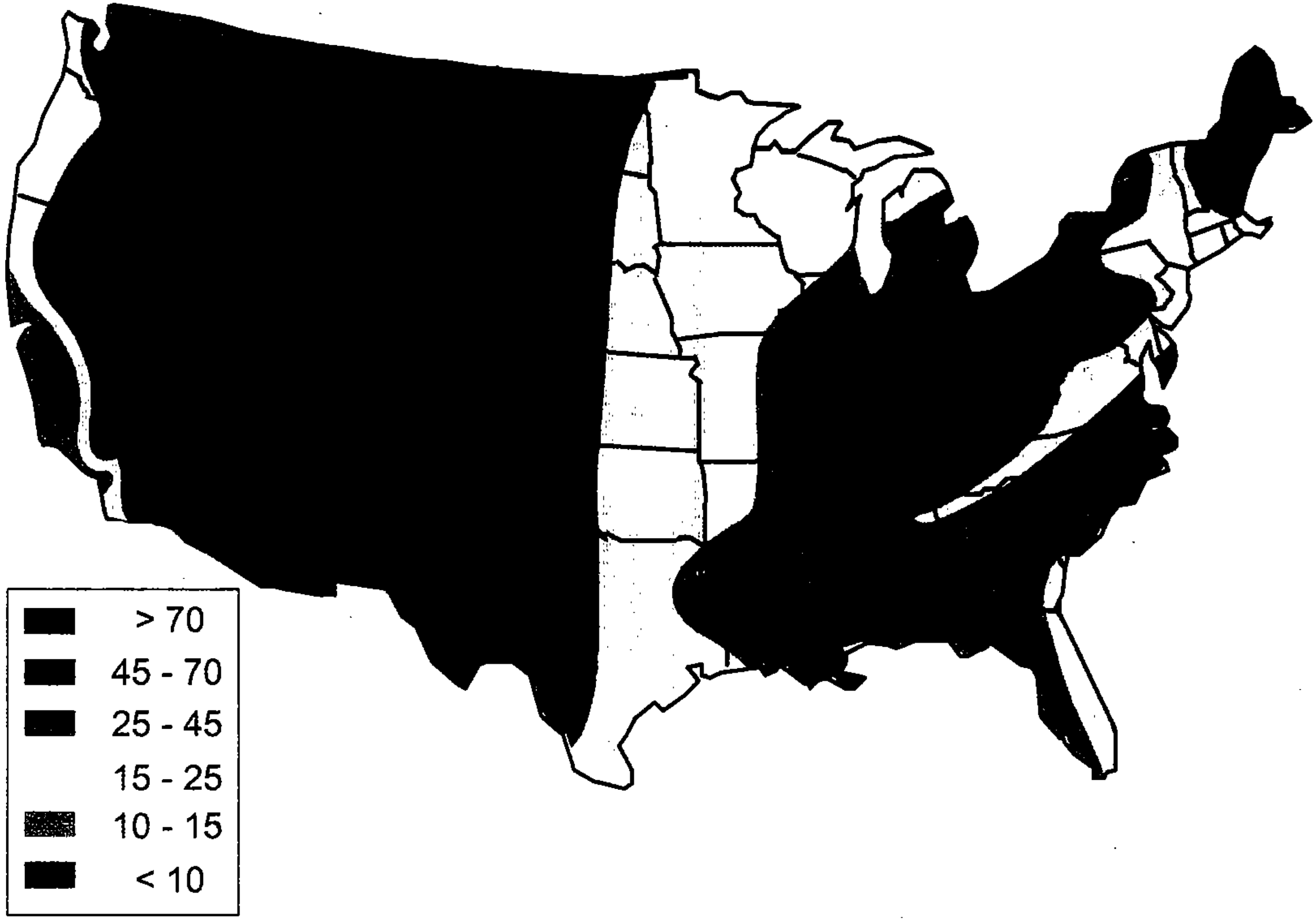


Figure 3-31. Average summer visibility in miles.

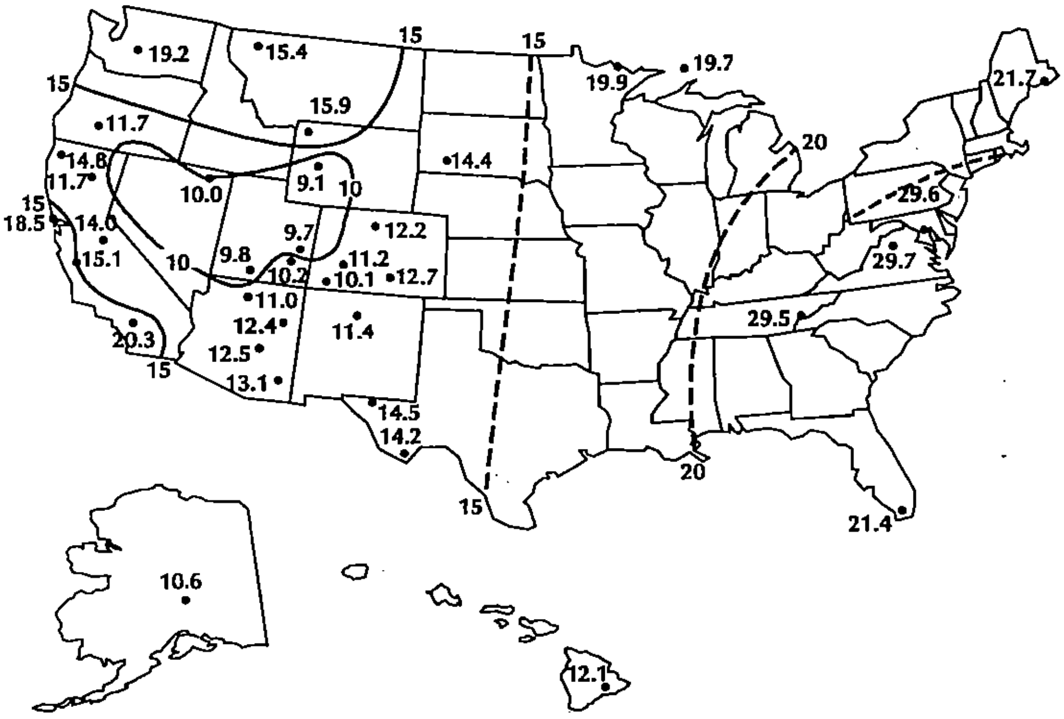


Figure 3-32. Average summer visibility in deciviews March 1988 to February 1991.

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

As Figure 3-33 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, nitrate, organic carbon, light-absorbing carbon (LAC), and soil dust.

Figure 3-34 illustrates the relationship between 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 organics are relatively equal in their contributions to light extinction. Nitrate is the single largest contributor to light extinction only in southern California, and light absorbing carbon, which appears in green, is generally the smallest contributor at all monitoring sites.

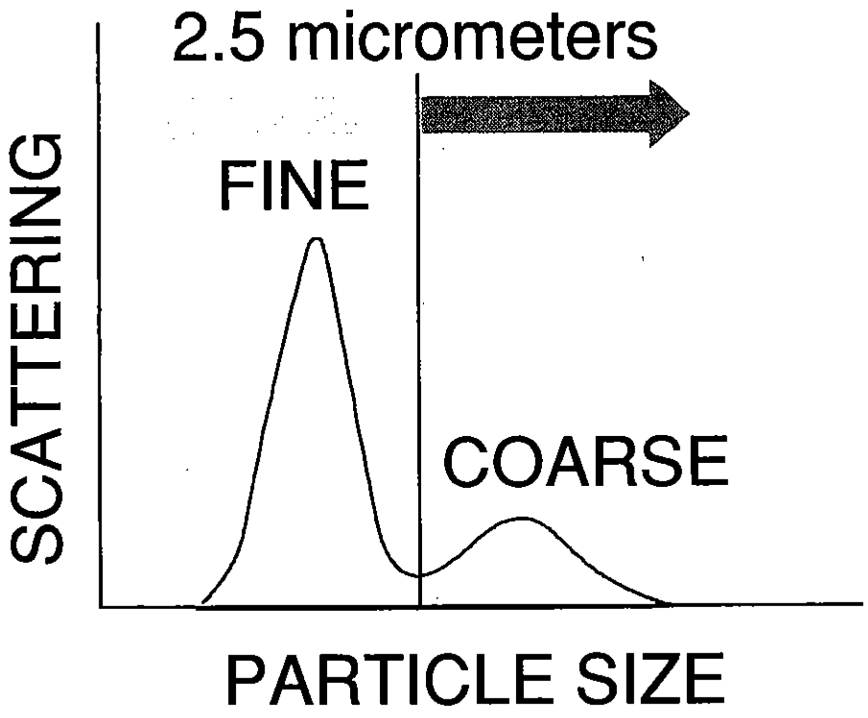


Figure 3-33. Aerosol size distribution.

The pie charts are scaled to show measured amounts of light extinction. The greater the light extinction, the poorer the visibility. The figure again illustrates the difference in visibility between the eastern and the western portions of the U.S. 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 is 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.

As noted earlier, there is a relationship between visibility impairment and the NAAQS pollutants. Controls for sources such as electric utilities, diesel vehicles, petroleum and chemical industries, and residential wood burning may be primarily designed for NAAQS pollutant problems but should also produce visibility improvements. The Acid Rain provisions resulting from the 1990 Clean Air Act Amendments will reduce sulfur oxides and nitrogen oxides, which should result in visibility improvements that can be tracked as these emission reductions take effect in the late 1990s.[26]

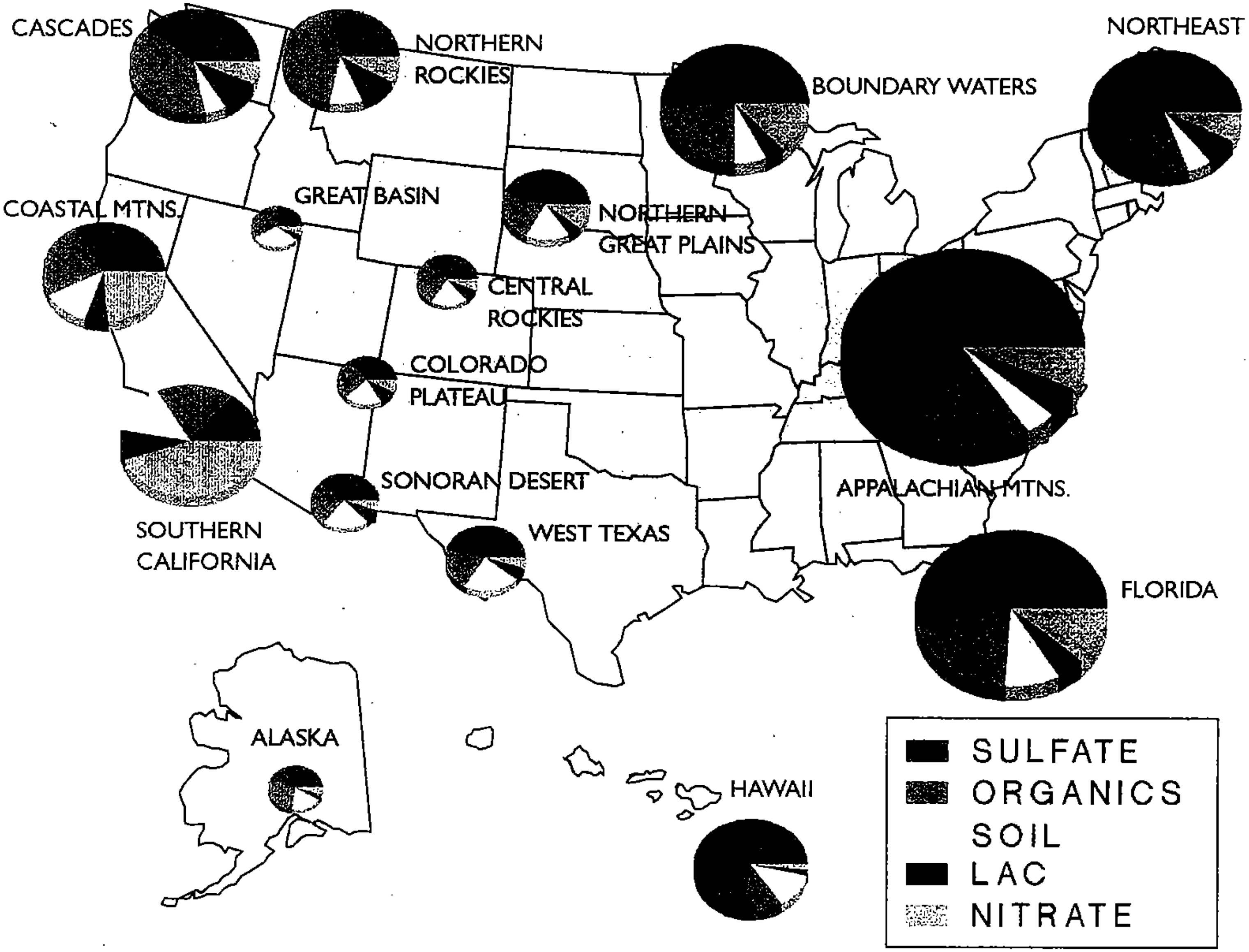


Figure 3-34. Annual average extinction.

3.8 References

1. *National Air Pollutant Emission Estimates, 1900-1992, EPA-454/R-93-032, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, October 1993.*

2. *Rethinking the Ozone Problem in Urban and Regional Air Pollution, National Research Council, National Academy Press, Washington, DC, December 1991.*

3. *Curran, T.C., "Trends in Ambient Ozone and Precursor Emissions in U.S. Urban Areas", Atmospheric Ozone Research and Its Policy Implications, Amsterdam, The Netherlands, 1989.*

4. *Curran, T.C. and N.H. Frank, "Ambient Ozone Trends Using Alternative Indicators", Tropospheric Ozone and the Environment, Los Angeles, CA, March 1990.*

5. *National Air Quality and Emissions Trends Report, 1991, EPA-450/R-92-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, October 1992.*

6. *National Primary and Secondary Ambient Air Quality Standards for Lead, 43 FR 46246, October 5, 1978.*

7. *Memorandum. Joseph S. Carra to Office Directors Lead Committee. Final Agency Lead Strategy. February 26, 1991.*

8. *R. B. Faoro and T. B. McMullen, National Trends in Trace Metals Ambient Air, 1965-1974, EPA-450/l-77-003, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1977.*

9. *W. Hunt, "Experimental Design in Air Quality Management," Andrews Memorial Technical Supplement, American Society for Quality Control, Milwaukee, WI, 1984.*

10. *Ambient Air Quality Surveillance, 46 FR 44159, September 3, 1981.*

11. *T. Furmanczyk, Environment Canada, personal communication to R. Faoro, U.S. Environmental Protection Agency, September 9, 1992.*

12. *Hazardous Air Pollutants Project Country Report of Japan, Organization For Economic Co-operation and Development, Paris, France, March, 1991.*

13. *National Air Quality and Emissions Trends Report, 1989, EPA-450/4-91-003, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1991.*

14. *D.J. Kolaz and R.L. Swinford, "How to Remove the Influence of Meteorology from the Chicago Areas Ozone Trend," presented at the 83rd Annual AWMA Meeting, Pittsburgh, PA, June 1990.*

15. *Use of Meteorological Data in Air Quality Trend Analysis, EPA-450/3-78-024, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, May 1978.*

16. *National Air Quality and Emissions Trends Report, 1988, EPA-450/4-90-002, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, March 1990.*

17. *W.O. Brown and R. R. Heim, Jr., "Climate Variations Bulletin", Volume 4, No. 8, National Climatic Data Center, NOAA, Asheville, NC, August 1992.*

18. *Volatility Regulations for Gasoline and Alcohol Blends Sold in Calendar Years 1989 and Beyond, 54 FR 11868, March 22, 1989.*

19. *National Fuel Survey: Motor Gasoline - Summer 1988, Motor Vehicle Manufacturers Association, Washington, D.C., 1988.*

20. *National Fuel Survey: Gasoline and Diesel Fuel - Summer 1989, Motor Vehicle Manufacturers Association, Washington, D.C., 1989.*

21. *National Fuel Survey: Motor Gasoline - Summer 1990, Motor Vehicle Manufacturers Association, Washington, D.C., 1990.*

22. *W.M. Cox and S.H. Chu, "Meteorologically Adjusted Ozone Trends in Urban Areas: A Probabilistic Approach", Tropospheric Ozone and the Environment II, Air and Waste Management Association, Pittsburgh, PA, 1992.*

23. *EHPA NEWSLETTER, Vol. 9, No. 3, E.H. Pechan & Associates, Inc., Springfield, VA, Summer 1992.*

24. *EPA Programs to Control Sulfur Dioxide in the Atmosphere, EPA 430/F-93-005, U.S. Environmental Protection Agency, Research Triangle Park, NC, March 1993.*

25. *IMPROVE, Spatial and Temporal Patterns and the Chemical Composition of the Haze in the United States: An Analysis of Data from the IMPROVE Network, 1988-1991, CIRA Cooperative Institute for Research in the Atmosphere, Colorado State University, CO, February 1993.*

26. *Effects of the Clean Air Act Amendments on Visibility in Class I Areas, EPA Report to Congress, Draft, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, August 1993.*

Chapter 4: Air Toxics

The Clean Air Act Amendments (CAAA) of 1990 mandated fundamental changes in air toxics regulation. Prior versions of the Act resulted in a cumbersome process for listing and regulating hazardous air pollutants (HAPs) with the potential for causing increases in mortality or serious illnesses. Between 1970 and 1990, only eight pollutants (arsenic, asbestos, benzene, beryllium, mercury, radionuclides, radon-222, and vinyl chloride) were regulated under this program. This program is known as the National Emission Standards for Hazardous Air Pollutants (NESHAPs). The CAAA of 1990 revises Clean Air Act Section 112 with new provisions that:

- explicitly list 189 substances requiring regulation;
- require technology-based standards for reducing emissions of these substances;
- require risk-based controls after evaluating residual risk remaining after implementing technology-based standards; and
- establish an accidental release program.

This issue of the trends report includes information on air toxics for the first time. Exposure to air toxics can result in a variety of severe health effects. These 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 additional human cancers each year.

Air toxics also can cause many serious noncancer effects. It is particularly difficult to assess risk for noncancer health effects as these may be manifested in many ways: simple poisoning, or immediate illness; or in less-measurable ways such as immunological, neurological, reproductive, developmental, mutagenic, or respiratory effects. These effects in turn may exhibit a wide range of severity and reversibility.

Inhalation is only one of several vehicles or modes of exposure to air toxics. For example, toxic particulate matter may be deposited onto soil or into water bodies. Soil deposition may result in exposure to children playing outdoors, or uptake by agricultural crops. Deposits in water may be taken up by fish which ultimately find their way to the marketplace. Toxic chemicals also can endanger the viability of species and ecosystems.

The inclusion of air toxics in the trends report will help assess progress in reducing emissions and concentrations of all air pollutants with known potential for causing health problems. Information on air toxics will address questions such as:

- How much improvement is there in the overall health of the Nation's air since the passage of the CAAA?
- What are the overlapping benefits of the ozone control program and the air toxics program? (Ozone control frequently focuses on reducing volatile organic compounds (VOCs) because of their importance to ozone formation; many VOCs are also air toxics).

In addition, the challenge of meeting the air toxics provisions in the CAAA encourages the development of numerous innovative control programs by some affected industries and states. Lessons from such programs can have important applications to criteria pollutant control programs.

While comprehensive long-term nationwide monitoring and emissions tracking programs exist for criteria pollutants, data on toxic air pollutants is more limited. Therefore, this chapter is structured differently from others in this report. Included are: (1) a brief description of the CAAA air toxics provisions; (2) a status report on air toxics regulations required by the CAAA; (3) other air toxics activities resulting in emission reductions; (4) a discussion of available data sources for emissions and concentrations of air toxics; and (5) a summary of current estimated emissions in the U.S. This summary includes profiles of several key sources of hazardous air pollutants. Additional information on air toxics for selected nonattainment areas is included in the chapter on selected metropolitan area trends.

4.1 Air Toxics Provisions in the CAAA

As noted above, the Act lists 189 hazardous pollutants that must 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 air toxics, or at least 25 tons a year of any combination of the 189) and are to be developed over a period of 10 years. Regulations must be developed according to the following timetable: for 25 percent of all source categories by 1994; for 50 percent of all source categories by 1997; and for 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 Act contains 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).

The Act also provides 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 for that category.

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 Act).

4.2 Status Report on Required Air Toxics Regulations

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

Major regulatory actions of the air toxics program are as follows:

- The proposed standard for the Synthetic Organic Chemical Manufacturing Industry requires reductions in emissions of 149 Hazardous Air Pollutants (HAPs) and affects nearly 370 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 about 3,700 industrial and large commercial dry cleaners were proposed in November 1991. This rule has been promulgated as of September, 1993 and is projected to decrease emissions of perchloroethylene by approximately 7,300 tons annually by 1996.

- Regulatory negotiations by EPA produced an agreement on regulations to reduce toxic emissions from steel industry coke ovens. These regulations should be finalized in late 1993.

- The EPA has initiated work on 35 additional emission standards. These include the emission standards due four years after enactment and several that are due seven years after enactment.

- The EPA announced the final rule for the Early Reductions Program in December 1992. By March 1993, EPA has received and initiated review on 87 enforceable commitments. If all of these commitments are carried out, the estimated reductions in HAPs would total 36 million pounds by January 1, 1994.

State and Local Assistance Programs: The EPA also is developing three programs to assist State and local air pollution control agencies in implementing the requirements of Section 112. The programs are being designed to provide these agencies with flexible requirements so as not to disrupt the progress individual States have already made in reducing air toxics emissions. The three programs include: (1) the Modifications program for new or modified sources, (2) a program to establish Equivalent Emission Limitation for air toxics standards, and (3) a program to take advantage of existing State regulations.

The Modifications rule requires control technology reviews for constructed, reconstructed, and modified major sources of pollutants. The rule governing Equivalent Emissions Limitations by Permit requires States to issue operating permits to major sources based on a case-by-case control technology assessment. Both rules apply in the event that EPA has not promulgated a standard for that industry. The State Programs delegation rule establishes EPA requirements for the approval of State or local air toxics rules or programs in lieu of otherwise applicable Federal rules.

Special Studies: The EPA also is conducting special studies assessing the emissions and effects of toxic air pollutants. Several of these studies have the potential to influence emission reductions in the future. These include:

- Atmospheric Deposition to Great Lakes and Coastal Waters (Great Waters Program);

- Urban Area Source Program;

- Electric Utilities Steam Generating Units;

- Mercury Study;

- National Academy of Sciences Study on Risk Assessment Methodology;
- Hydrogen Fluoride Study;
- Hydrogen Sulfide Study;
- Residual Risk Report;
- Coke Oven Production Technology Study; and
- Publicly-Owned Treatment Works Study.

4.3 Other Air Toxics Activities Resulting in Emission Reductions

The 33/50 Program: In addition to the Early Reductions Program, discussed above, the EPA initiated another voluntary program in February, 1991. Known as the 33/50 project, the program asks companies to voluntarily reduce releases of 17 pollutants to the air, water, and soil. As of September 1993, 1,172 companies had pledged their support for the 33/50 program by agreeing to reduce their releases of the 17 chemicals by 355 million pounds.

Nonattainment Provisions That Also Reduce Air Toxics: Adding to the efforts in Title III, Titles I and II of the CAA contain provisions that, when implemented, will reduce air toxics emissions. Title I, which deals with attainment and maintenance of the national ambient air quality standards, requires EPA to publish Control Techniques Guidelines (CTGs) for several source categories. The CTGs describe technologies effective in reducing emissions of volatile organic compounds that react to form ozone. Because most of the 189 listed HAPs are also volatile organic compounds, concomitant control of HAPs will result when the CTGs are implemented. Similarly, numerous provisions under Title II, such as reformulated gasoline, are expected to reduce emissions of air toxics from mobile sources by at least 15 percent by 1995, and 20 percent by the year 2000. Reductions in toxic emissions also will be realized from mobile sources due to inspection and maintenance programs, reductions in evaporative emissions and diesel particulate emissions, and clean-fuel vehicle programs. Achievements in these areas include:

- Significant progress on 11 CTG documents. Eight CTGs are being finalized, and three others are being coordinated with ongoing HAP work for the same source categories.
- Implementation of the "clean gasoline" initiatives to reduce motor vehicle pollution (including air toxics).
- Final rules announced in 1991 that affect the sulfur content of diesel fuel. These rules will cut diesel particulate pollution from urban buses substantially. The EPA also finalized rules in March 1993 for urban buses that is expected to reduce diesel particulate emissions 95 percent from uncontrolled levels.
- Inspection and maintenance programs, required in certain ozone nonattainment areas, were finalized in November 1992. These programs are projected to reduce emissions of volatile organic compounds (which include HAPs) by 5 to 30 percent.
- A draft report for public review on mobile source emissions of air toxics. This report was released by EPA in January 1993.

4.4. Available Data Sources for Air Toxic Emissions and Concentrations

An extensive and long-term monitoring and emissions tracking program similar to that for criteria pollutants is not available for air toxics. The development of such data is complicated by the number of chemical compounds involved, and the potential for secondary formation of one hazardous compound from other, often not hazardous, compounds. The limitations inherent in current data sources limit EPA's ability to identify trends in air toxic emissions and concentrations. Therefore, preliminary assessments of baseline emissions are somewhat tentative.

The primary sources of information on air toxics are the EPA's Toxic Release Inventory (TRI), which covers emissions, and the EPA's National Volatile Organic Compound Database and various field studies, which covers concentrations. The TRI is currently the only database available for assessing trends in emissions of air toxics. The TRI requires certain facilities emitting above specified threshold quantities of air toxics to submit annual reports to EPA on their releases. Statutory authority for this requirement is given in the Emergency Planning and Community Right to Know Act (EPCRA) of 1986. EPA has collected information in the TRI since 1987.

While TRI is the only database available for assessing air toxic emission trends, this database does have some limitations. The inventory of chemicals required to be reported in TRI includes all but 16 of the 189 HAPs covered in the CAAA. Some sources of air toxic emissions including non-manufacturing facilities such as mining, electric utilities, and mobile sources, are not required to report. As for the required data, TRI data are self-reported and does not require facilities to perform any actual monitoring to develop TRI estimates. The accuracy of the reported data may vary from facility to facility and year to year. Despite these limitations, TRI estimates are being used as rough indicators and EPA is working to enhance this database by eliminating these limitations.[1]

The National Volatile Organic Compound Database compiles information on 70 of the 189 compounds regulated under the air toxics provisions of the CAAA. Limited information on the other 119 compounds has been collected in field studies in various parts of the U.S. A recent study conducted by EPA collated all available information on air toxic concentrations available from the National Volatile Organic Compound Database and from an extensive literature search to locate additional data.[2] This study found widely varying concentrations of each HAP and underscored the difficulty and importance of developing a consistent and long-term monitoring network for air toxics.

As more information is collected on air toxic emissions, we will attempt to modify our baselines to accurately reflect how well the Title III regulations are decreasing the air toxic emissions. There are two types of air toxic emission numbers that are cited in this chapter: TRI air release emission summaries and engineering estimates of emissions by source category. The TRI summaries are used to gain an overall picture of the hot spots within the nation. The emission estimates were gathered during the rule-making process on specific source categories. These emission estimates were calculated using formal information-gathering letters and meetings with industry, plant visits, and existing state and local information on the sources. The source category estimates were derived 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 numbers may differ.

4.5 Summary of Emissions

Figures 4-1 and 4-2 show reported air toxic emissions (the sum of all 173 CAAA compounds covered by the TRI) in the U.S. in 1990 and 1991. Hawaii, Nevada, and Vermont emitted less than one million pounds of toxics per year. In 1990, reported emissions exceeded 100 million pounds for seven states, compared to three states in 1991. Figure 4-3 presents the same 1991 data base using a smaller grid scale to better illustrate the

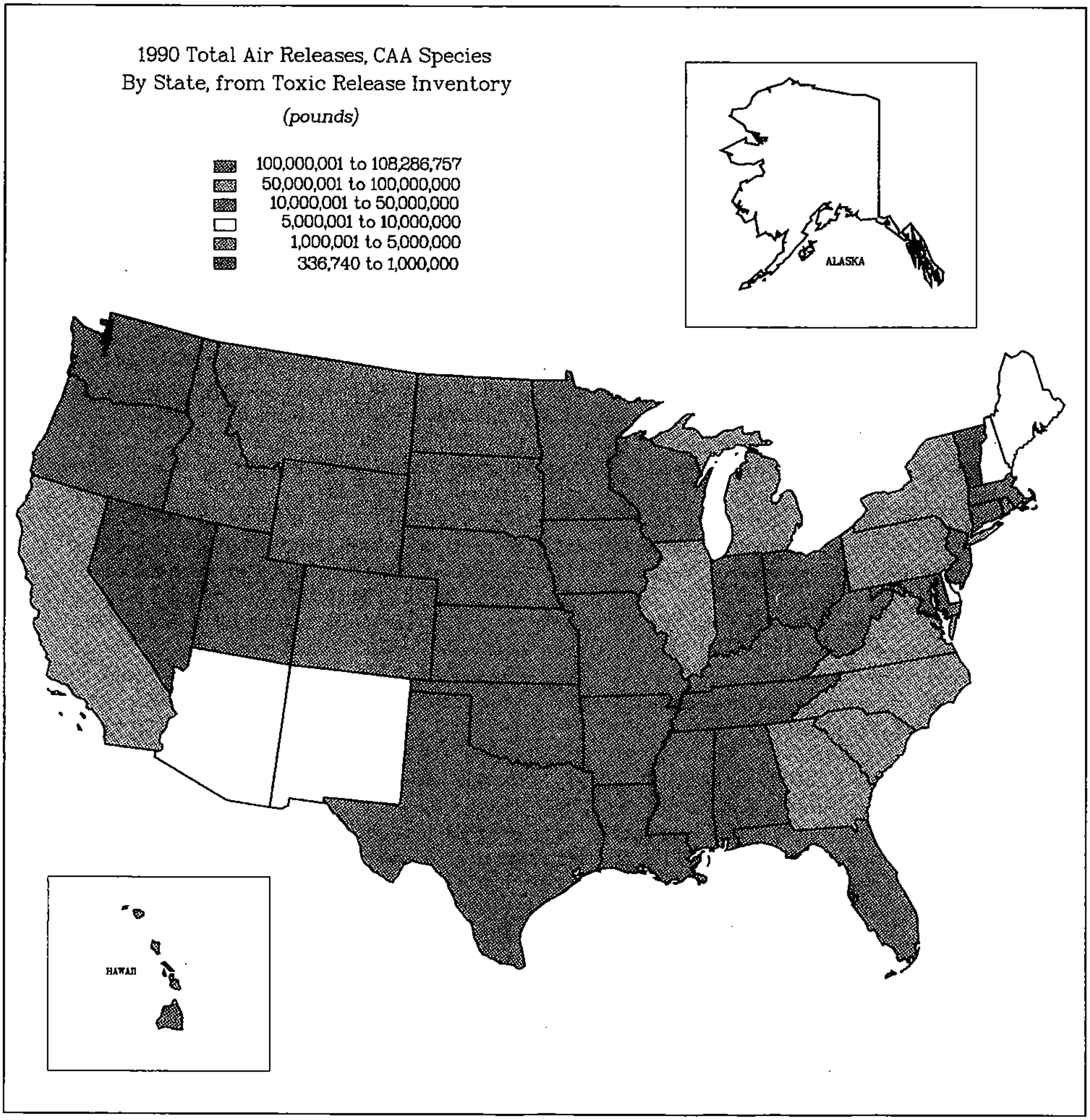


Figure 4-1. 1990 total air releases, all species by state, from Toxic Release Inventory.

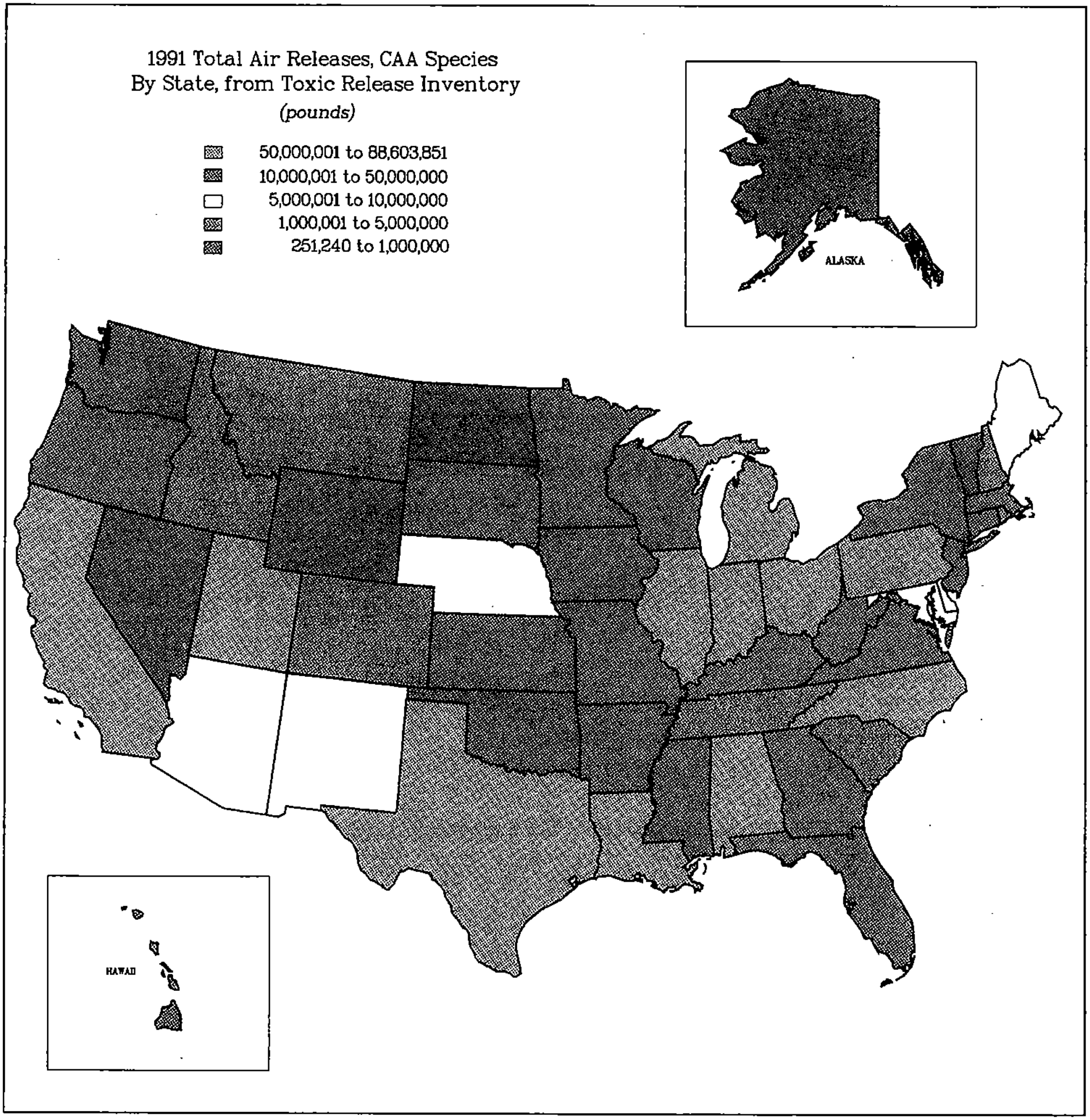


Figure 4-2. 1991 total air releases, all species, by state, from Toxic Release Inventory.

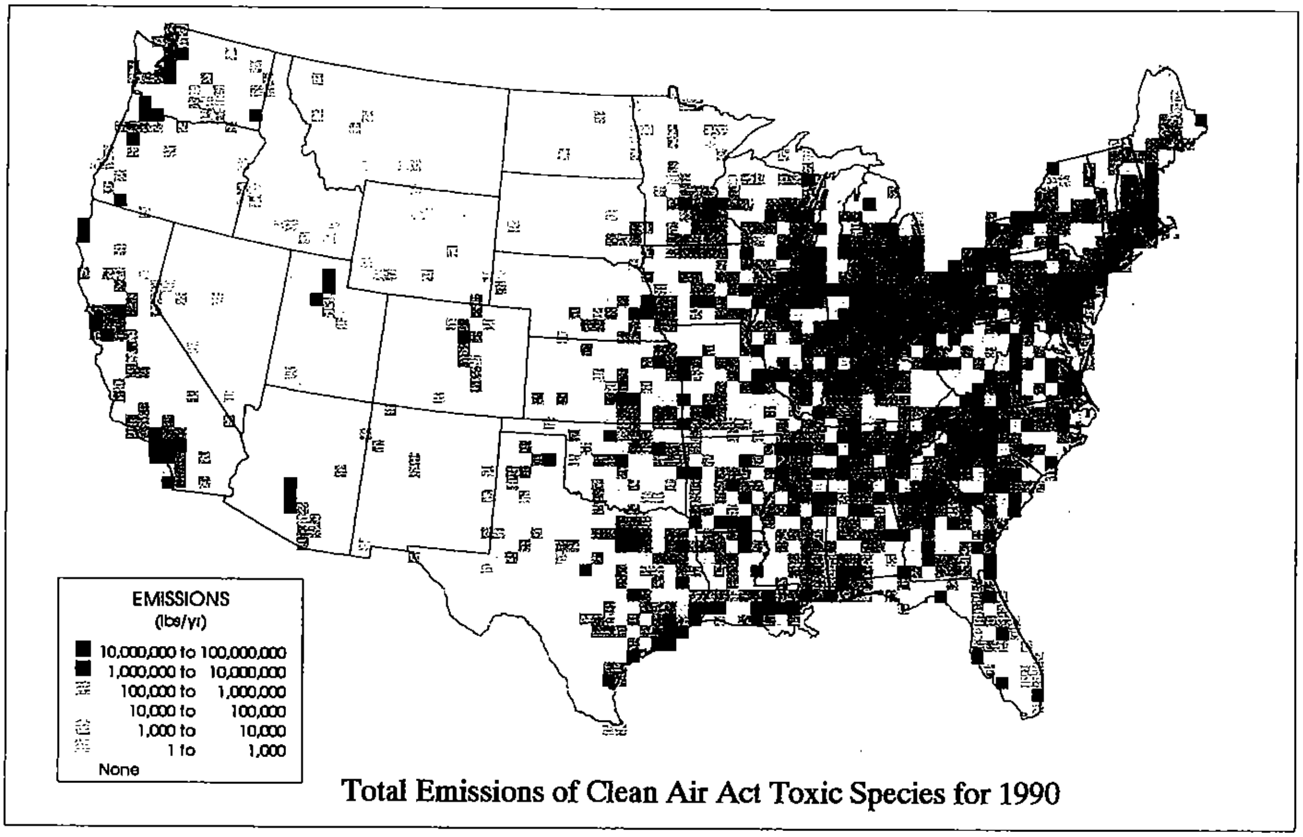
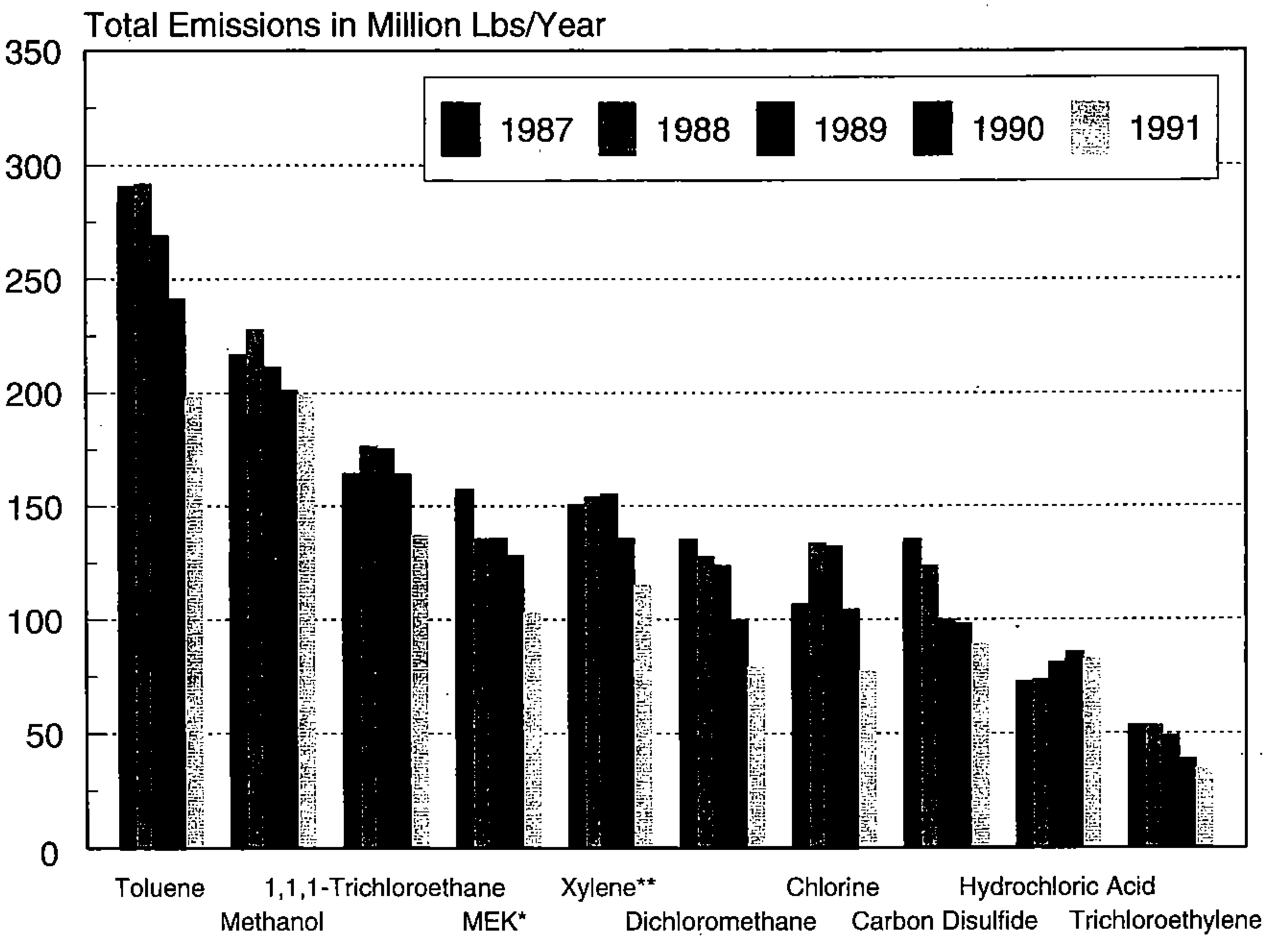


Figure 4-3. Gridded map of TRI total air releases from Clean Air Act toxic species, 1990.

geographic location of these emissions. Maps showing facility locations and sizes for selected nonattainment areas are presented in Chapter 6.

Figure 4-4 depicts emissions of the ten air toxics (in terms of emission quantities) from 1987 to 1991. Reported TRI emissions show a general downward trend for all but one of the pollutants listed. As implementation of the CAAA continues, this downward trend is likely to continue.

As described above, implementation of the CAAA toxics provisions focuses on source categories emitting large quantities of various air toxics, rather than on particular compounds. Brief profiles of key air toxic sources for which regulations have been developed or are in the final stages of development are presented below.



* Methyl Ethyl Ketone

** Mixed Isomers

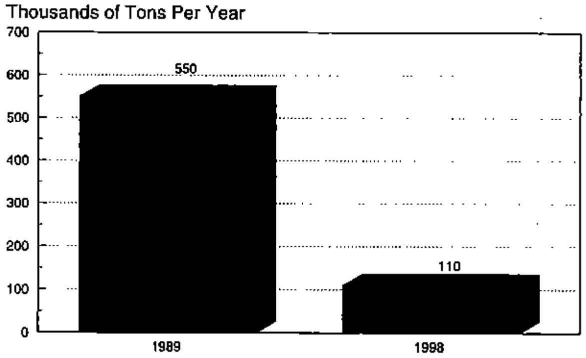
Figure 4-4. Top 10 hazardous air pollutants - 1987 BASIS.

4.6 Source Category Profiles

Synthetic Organic Chemical Manufacturing Industry (SOCMI). The various SOCMI processes are believed to emit as many as 150 of the 189 HAPs. Emission points at SOCMI facilities include process vents, storage vessels, transfer operations, waste water collection and treatment operations, and equipment leaks.

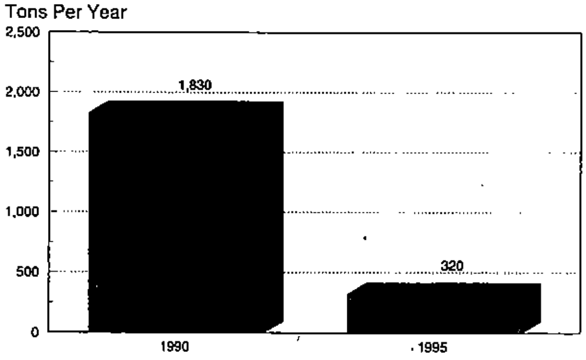
The EPA proposed the Hazardous Organic NESHAP (HON) rule in December 1992. It is estimated that approximately 370 facilities and 1,050 chemical manufacturing processes will be affected by the HON. Estimated 1989 HAP emissions were 550,000 tons; expected emission reductions resulting from the HON are projected to lower HAP emissions to 110,000 tons per year by 1998. Many of these HAPs are known or suspected carcinogens.

HAZARDOUS AIR EMISSIONS FROM SOCMI FACILITIES



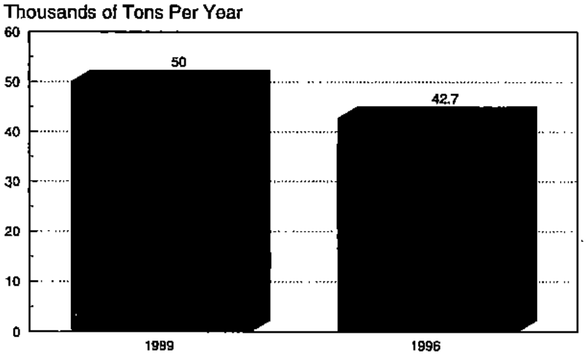
Coke Oven Batteries. Emissions from coke oven batteries include organic and inorganic particulate matter; volatile organic compounds; and gases such as hydrogen disulfide, sulfur dioxide, nitrogen oxides, ammonia, and carbon monoxide. The pollutants of primary interest with respect to long-term or chronic health effects are various carcinogenic polycyclic organic compounds (such as benzo(a)pyrene). Total HAP emissions are estimated to be 1,830 tons per year. The EPA rule proposed in December 1992 will require battery operators to limit the percentage of leaking doors, lids, and offtake systems; limit the time of visible emissions during charging; and install destructive flares on bypass/bleeder stacks. These requirements apply to 30 facilities located in 10 different states. The EPA rule is expected to reduce emissions from the current estimated level of 1,830 tons per year to no more than 320 tons per year by the end of 1995.

HAZARDOUS AIR EMISSIONS FROM COKE OVEN BATTERIES



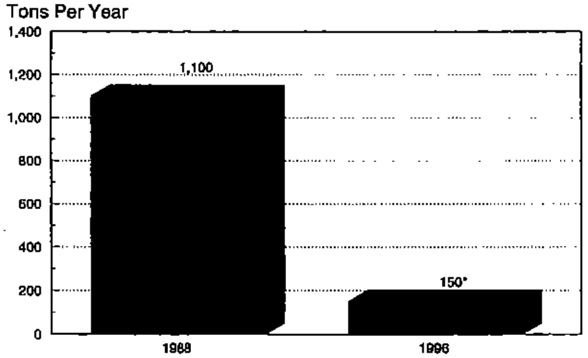
Perchloroethylene Dry Cleaning Facilities. There are about 25,000 perchloroethylene dry cleaning operations in the U.S., 3,700 of which are industrial and large commercial dry cleaners and are the focus of this standard. It is estimated that in 1988, 50,000 tons of perchloroethylene, a probable human carcinogen, were emitted from dry cleaning operations themselves, and an additional 44,000 tons were emitted from the off-gassing of materials that came in contact with the perchloroethylene during the dry cleaning process. The national emission standard for these dry cleaning operations was promulgated in September 1993. The regulation will require the use of a refrigerated condenser (or carbon adsorber if already installed) in order to reduce emissions from the dry cleaning operations themselves. Off-gassing would be minimized to the extent possible, with the remaining off-gassing left uncontrolled. It is estimated that by 1996, perchloroethylene emissions from dry cleaning operations will be reduced by 7,300 tons annually.

HAZARDOUS AIR EMISSIONS FROM DRY CLEANING FACILITIES



Ethylene Oxide Sterilization Facilities. Commercial ethylene oxide sterilization covers the use of ethylene oxide (EO), a probable human carcinogen, in the production of medical equipment supplies and in miscellaneous sterilization and fumigation operations. There are about 200 commercial ethylene oxide sterilization facilities in the U.S. It is estimated that in 1988, 1,100 tons of ethylene oxide were emitted from commercial sterilization facilities. The NESHAP for these sterilization/fumigation facilities currently is scheduled for promulgation in November 1994. The main sterilizer vent and aeration vent emissions are being considered for control. Regulatory alternatives under consideration are estimated to reduce emissions by approximately 950 to 1,050 tons annually.

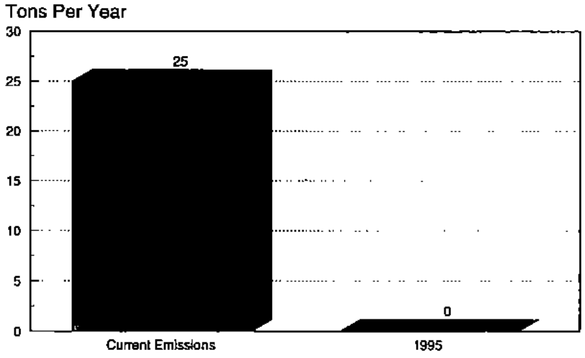
HAZARDOUS AIR EMISSIONS FROM ETHYLENE OXIDE STERILIZATION FACILITIES



* Reductions will result in emissions of 50-150 tons

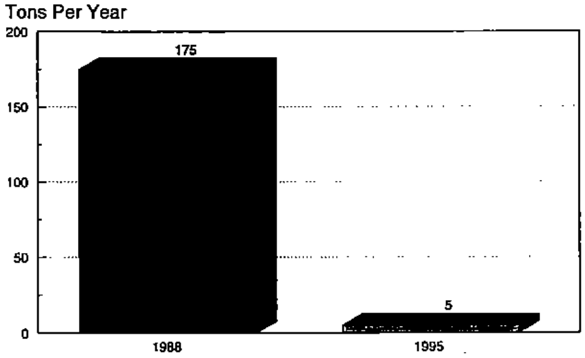
Industrial Process Cooling Towers. Hexavalent chromium compounds often are added to cooling towers used in the chemical manufacturing, petroleum refining, and primary metals industries to protect the towers from corrosion. Chromium-based water treatment chemicals are currently used at approximately 800 industrial process cooling towers (IPCTs) located at chemical and industrial facilities nationwide. Hexavalent chromium is discharged to the atmosphere from these towers. This results in increased ambient concentrations of chromium and resultant exposures. It is estimated that currently 25 tons per year of hexavalent chromium are emitted from IPCTs in the U.S. Hexavalent chromium is a known potent human carcinogen. EPA anticipates IPCT regulations for promulgation by November 1994. The rule-making will propose the substitution of nonchromium-based water treatment programs for chromium-based water treatment programs. This will result in a 100 percent reduction in chromium emissions from IPCTs within approximately six months after promulgation.

HAZARDOUS AIR EMISSIONS FROM INDUSTRIAL PROCESS COOLING TOWERS



Chromium Electroplating Operations. There are about 5,000 chromium electroplating operations in the U.S. It is estimated that in 1988 (baseline year) 175 tons of hexavalent chromium were emitted from these operations. Hexavalent chromium is a known potent human carcinogen. The NESHAP for these chromium electroplating operations currently is scheduled for promulgation at the end of 1994. The regulation would require the use of a scrubber in order to reduce emissions by 99 percent. It is estimated that one year after promulgation, hexavalent chromium emissions from chromium electroplating operations in the U.S. would be reduced to less than five tons per year.

HAZARDOUS AIR EMISSIONS FROM CHROMIUM ELECTROPLATING OPERATIONS



4.7 References

1. *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.*

2. *T. Kelly, M. Ramamurthi, A. Pollack, C. Spicer, and L. Cupitt, "Ambient Concentration Summaries for Clean Air Act Title III Hazardous Air Pollutants", presented at the Air and Waste Management Association, International Symposium on Measurement of Toxic and Related Air Pollutants, Durham, NC, May 1993.*

Chapter 5: Air Quality Status of Metropolitan Areas, 1992

This chapter provides general information on the current air quality status of metropolitan areas[1] within the United States. Four different summaries are presented in the following sections. First, a 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. Next, an estimate is provided of the number of people living in counties which did not meet the NAAQS based on only 1992 air quality data is provided. (Note that nonattainment designations typically involve multi-year periods.) Third, pollutant-specific maps are presented to provide the reader with a geographical view of how peak 1992 air quality levels varied throughout counties in the continental United States. Finally, the peak pollutant-specific statistics are listed for each Metropolitan Statistical Area (MSA) with 1992 air quality monitoring data.

5.1 Nonattainment Areas

The nonattainment designation, a formal rule-making process, may be viewed as simply indicating those areas which do not meet the air quality standard for a particular criteria pollutant. The Clean Air Act Amendments (CAAA) of 1990 further classify ozone and carbon monoxide nonattainment areas based upon the magnitude of the problem. Depending on its particular nonattainment classification, an area must adopt, at a minimum, certain air pollution reduction measures. The classification of an area also determines when the area must reach attainment. The technical details underlying these classifications are discussed elsewhere.[2]

Table 5-1 lists the number of nonattainment areas for each pollutant, as of September, 1993. 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 1990 Census figures. 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

Table 5-1. Nonattainment Areas for NAAQS Pollutants as of September 1993

Pollutant	Number of Nonattainment Areas*
Carbon Monoxide (CO)	41
Lead (Pb)	13
Nitrogen Dioxide (NO_2)	1
Ozone (O_3)	94
Particulate Matter (PM-10)	70
Sulfur Dioxide (SO_2)	46

* Unclassified areas are not included in the totals.

avoided by only 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 (Figures 5-1 and 5-2). Based on this preliminary estimate, there are 150 million people living in areas currently designated as nonattainment.

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

			POLLUTANT[c]						POPULATION[d]	
	STATE	AREA NAME[b]	O_3	CO	SO_2	PM-10	Pb	NO_2	(1000s)	
1	AK	Anchorage	.	1	.	1	.	.	222	
2	AK	Fairbanks	.	1	.	.	.	.	30	
3	AK	Juneau	.	.	.	1	.	.	27	
4	AL	Birmingham	1	.	.	.	1(e)	.	651	
5	AZ	Ajo	.	.	1	1	.	.	6	
6	AZ	Douglas	.	.	1	1	.	.	13	
7	AZ	Miami-Hayden	.	.	2	1	.	.	3	
8	AZ	Morenci	.	.	1	.	.	.	8	
9	AZ	Nogales	.	.	.	1	.	.	19	
10	AZ	Paul Spur	.	.	.	1	.	.	1	
11	AZ	Phoenix	1	1	.	1	.	.	2092	
12	AZ	Rillito	.	.	.	1	.	.	1	
13	AZ	San Manuel	.	.	1	.	.	.	5	
14	AZ	Yuma	.	.	.	1	.	.	55	
15	CA	Chico	.	1	.	.	.	.	72	
16	CA	Coachella Valley	.	.	.	1	.	.	183	
17	CA	Imperial Valley	.	.	.	1	.	.	92	
18	CA	Lake Tahoe South Shore	.	1	.	.	.	.	30	
19	CA	Los Angeles-South Coast Air Basin	1	1	.	1	.	1	13513	
20	CA	Mammoth Lakes	.	.	.	1	.	.	5	
21	CA	Monterey Bay	1	.	.	.	.	.	622	
22	CA	Owens Valley	.	.	.	1	.	.	18	
23	CA	Sacramento Metro	1	1	.	.	.	.	1639	
24	CA	San Diego	1	1	.	.	.	.	2498	
25	CA	San Francisco-Bay Area	1	1	.	.	.	.	5815	
26	CA	San Joaquin Valley	1	3	.	1	.	.	2742	
27	CA	Santa Barbara-Santa Maria-Lompoc	1	.	.	.	.	.	370	
28	CA	Searles Valley	.	.	.	1	.	.	31	
29	CA	Southeast Desert Modified AQMA	1	.	.	.	.	.	384	
30	CA	Ventura Co.	1	.	.	.	.	.	669	
31	CO	Aspen	.	.	.	1	.	.	5	
32	CO	Canon City	.	.	.	1	.	.	13	
33	CO	Colorado Springs	.	1	.	.	.	.	353	
34	CO	Denver-Boulder	.	1	.	1	.	.	1836	
35	CO	Fort Collins	.	1	.	.	.	.	106	
36	CO	Lamar	.	.	.	1	.	.	8	
37	CO	Longmont	.	1	.	.	.	.	52	
38	CO	Pagosa Springs	.	.	.	1	.	.	1	
39	CO	Telluride	.	.	.	1	.	.	1	
40	CT	Greater Connecticut	1	1	.	1	.	.	2470	
41	DC-MD-VA	Washington	1	1	.	.	.	.	3924	
42	DE	Sussex Co	1	.	.	.	.	.	113	
43	FL	Miami-Fort Lauderdale-W. Palm Beach	1	.	.	.	.	.	4056	
44	FL	Tampa-St. Petersburg-Clearwater	1	.	.	.	.	.	1686	
45	GA	Atlanta	1	.	.	.	.	.	2653	
46	GA	Muscogee Co.	.	.	.	.	1	.	179	
47	GU	Piti Power Plant	.	.	1	.	.	.	145	(Pop Guam)
48	GU	Tanguisson Power Plant	.	.	1	.	.	.	.	(See Guam above)
49	ID	Boise	.	.	.	1	.	.	126	
50	ID	Bonner Co.	.	.	.	1	.	.	27	
51	ID	Pinehurst	.	.	.	1	.	.	2	
52	ID	Pocatello	.	.	.	1	.	.	46	
53	IL-IN	Chicago-Gary-Lake County	1	.	1	3	.	.	7886	
54	IL	Groveland	.	.	1	.	.	.	124	
55	IL	Hollis Twp.	.	.	1	.	.	.	183	(Pop Peoria Co.)
56	IL	Jersey Co.	1	.	.	.	.	.	21	
57	IL	Oglesby	.	.	.	1	.	.	4	
58	IL	Peoria	.	.	1	.	.	.	.	(See Peoria above)
59	IN	Evansville	1	.	.	.	.	.	165	
60	IN	Indianapolis	1	.	1	.	1(f)	.	797	
61	IN	Laporte Co.	.	.	1	.	.	.	107	
62	IN	South Bend	1	.	.	.	.	.	403	
63	IN	Vermillion Co.	.	.	.	1	.	.	17	

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

					POLLUTANT[c]				POPULATION[d]
	STATE	AREA NAME[b]	O_3	CO	SO_2	PM-10	Pb	NO_2	(1000s)
64	IN	Vigo Co.	.	.	1	.	.	.	106
65	IN	Wayne Co.	.	.	1	.	.	.	72
66	KY	Edmonson Co.	1	.	.	.	.	.	10
67	KY	Lexington-Fayette	1	.	.	.	.	.	249
68	KY-IN	Louisville	1	.	.	.	.	.	834
69	KY	Muhlenberg Co.	.	.	1	.	.	.	31
70	KY	Owensboro	1	.	.	.	.	.	88
71	KY	Paducah	1	.	.	.	.	.	28
72	LA	Baton Rouge	1	.	.	.	.	.	582
73	LA	Lake Charles	1	.	.	.	.	.	168
74	MA-NH	Boston-Lawrence-Worcester	1	1	.	.	.	.	5500
75	MA	Springfield (W. Mass)	1	.	.	.	.	.	812
76	MD	Baltimore	1	1	.	.	.	.	2348
77	MD	Kent and Queen Anne Cos.	1	.	.	.	.	.	52
78	ME	Hancock and Waldo Cos.	1	.	.	.	.	.	80
79	ME	Knox and Lincoln Cos.	1	.	.	.	.	.	67
80	ME	Lewiston-Auburn	1	.	.	.	.	.	221
81	ME	Millinocket	.	.	1	.	.	.	8
82	ME	Portland	1	.	.	.	.	.	441
83	ME	Presque Isle	.	.	.	1	.	.	11
84	MI	Detroit-Ann Arbor	1	.	.	1	.	.	4591
85	MI	Grands Rapids	1	.	.	.	.	.	688
86	MI	Muskegon	1	.	.	.	.	.	159
87	MN	Duluth	.	1	.	.	.	.	85
88	MN	Minneapolis-St. Paul	.	1	1	1	1(g)	.	2310
89	MN	Olmsted Co.	.	.	1	1	.	.	71
90	MO	Dent	.	.	.	.	1	.	1
91	MO	Liberty-Arcadia	.	.	.	.	1	.	6
92	MO-IL	St. Louis	1	.	.	1(h)	1(i)	.	2390
93	MT	Butte	.	.	.	1	.	.	34
94	MT	Columbia Falls	.	.	.	1	.	.	3
95	MT	Kalispell	.	.	.	1	.	.	12
96	MT	Lame Deer	.	.	.	1	.	.	1
97	MT	Lewis & Clark	.	.	1	.	1(j)	.	2
98	MT	Libby	.	.	.	1	.	.	3
99	MT	Missoula	.	1	.	1	.	.	43
100	MT	Polson	.	.	.	1	.	.	3
101	MT	Ronan	.	.	.	1	.	.	2
102	MT	Yellowstone	.	.	1	.	.	.	5
103	NC	Charlotte-Gastonia	1	.	.	.	.	.	686
104	NC	Winston-Salem	.	1	.	.	.	.	266
105	NC	Raleigh-Durham	1	1	.	.	.	.	613
106	NE	Douglas	.	.	.	.	1	.	<1
107	NH	Manchester	1	.	.	.	.	.	222
108	NH	Portsmouth-Dover-Rochester	1	.	.	.	.	.	183
109	NJ	Atlantic City	1	.	.	.	.	.	319
110	NM	Albuquerque	.	1	.	.	.	.	481
111	NM	Anthony	.	.	.	1	.	.	2
112	NM	Grant Co.	.	.	1	.	.	.	28
113	NV	Central Steptoe Valley	.	.	1	.	.	.	9
114	NV	Las Vegas	.	1	.	1	.	.	741
115	NV	Reno	1	1	.	1	.	.	255
116	NY	Albany-Schenectady-Troy	1	.	.	.	.	.	874
117	NY	Buffalo-Niagara Falls	1	.	.	.	.	.	1189
118	NY	Essex Co. (White Mtn.)	1	.	.	.	.	.	<1
119	NY	Jefferson Co.	1	.	.	.	.	.	111
120	NY-NJ-CT	New York-N. New Jersey-Long Island	1	1	.	.	.	.	17947
121	NY	Poughkeepsie	1	.	.	.	.	.	259
122	OH	Canton	1	.	.	.	.	.	368
123	OH-KY	Cincinnati-Hamilton	1	.	.	.	.	.	1705
124	OH	Cleveland-Akron-Lorain	1	1	3	1	.	.	2859
125	OH	Columbus	1	.	.	.	.	.	1157
126	OH	Coshocton Co.	.	.	1	.	.	.	35
127	OH	Dayton-Springfield	1	.	.	.	.	.	951
128	OH	Gallia Co.	.	.	1	.	.	.	31
129	OH	Jefferson Co.	.	.	1	1	.	.	80
130	OH	Morgan Co.	.	.	1	.	.	.	14
131	OH	Toledo	1	.	1	.	.	.	575
132	OH	Washington Co.	.	.	1	.	.	.	62
133	OH-PA	Youngstown-Warren-Sharon	1	.	.	.	.	.	614
134	OR	Grants Pass	.	1	.	1	.	.	17
135	OR	Klamath Falls	.	1	.	1	.	.	18

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

					POLLUTANT[c]				POPULATION[d]
	STATE	AREA NAME[b]	O_3	CO	SO_2	PM-10	Pb	NO_2	(1000s)
136	OR	LaGrande	.	.	.	1	.	.	12
137	OR	Medford	.	1	.	1	.	.	63
138	OR-WA	Portland-Vancouver AQMA	1	1	.	.	.	.	1172
139	OR	Springfield-Eugene	.	.	.	1	.	.	157
140	PA-NJ	Allentown-Bethlehem-Easton	1	.	1	.	.	.	687
141	PA	Altoona	1	.	.	.	.	.	131
142	PA	Erie	1	.	.	.	.	.	276
143	PA	Harrisburg-Lebanon-Carlisle	1	.	.	.	.	.	588
144	PA	Johnstown	1	.	.	.	.	.	241
145	PA	Lancaster	1	.	.	.	.	.	423
146	PA-DE-NJ-MD	Philadelphia-Wilmington-Trenton	1	1	.	.	.	.	6010
147	PA	Pittsburgh-Beaver Valley	1	.	2	1	.	.	2468
148	PA	Reading	1	.	.	.	.	.	337
149	PA	Scranton-Wilkes-Barre	1	.	.	.	.	.	734
150	PA	Warren Co.	.	.	1	.	.	.	45
151	PA	York	1	.	.	.	.	.	418
152	PR	Guaynabo Co.	.	.	.	1	.	.	85
153	RI	Providence (all of RI)	1	.	.	.	.	.	1003
154	TN	Benton Co.	.	.	1	.	.	.	15
155	TN	Fayette Co.	.	.	.	.	1	.	26
156	TN	Humphreys Co.	.	.	1	.	.	.	16
157	TN	Memphis	1	1	.	.	1(k)	.	826
158	TN	Nashville	1	.	.	.	1(l)	.	881
159	TN	Polk Co.	.	.	1	.	.	.	14
160	TX	Beaumont-Port Arthur	1	.	.	.	.	.	361
161	TX	Dallas-Fort Worth	1	.	.	.	1(m)	.	3561
162	TX	El Paso	1	1	.	1	.	.	592
163	TX	Houston-Galveston-Brazoria	1	.	.	.	.	.	3731
164	UT	Ogden	.	1	.	.	.	.	63
165	UT	Salt Lake City	1	.	1	1	.	.	914
166	UT	Tooele Co.	.	.	1	.	.	.	27
167	UT	Utah Co.	.	1	.	1	.	.	264
168	VA	Norfolk-Virg. Beach-Newport News	1	.	.	.	.	.	1366
169	VA	Richmond-Petersburg	1	.	.	.	.	.	738
170	VA	Smyth Co. (White Top Mtn.)	1	.	.	.	.	.	<1
171	WA	Olympia-Tumwater-Lacey	.	.	.	1	.	.	63
172	WA	Seattle-Tacoma	1	1	.	3	.	.	2559
173	WA	Spokane	.	1	.	1	.	.	279
174	WA	Wallula	.	.	.	1	.	.	47
175	WA	Yakima	.	.	.	1	.	.	55
176	WI	Door Co.	1	.	.	.	.	.	26
177	WI	Kewaunee Co.	1	.	.	.	.	.	19
178	WI	Manitowoc Co.	1	.	.	.	.	.	80
179	WI	Marathon Co.	.	.	1	.	.	.	115
180	WI	Milwaukee-Racine	1	.	.	.	.	.	1735
181	WI	Oneida Co.	.	.	1	.	.	.	32
182	WI	Sheboygan	1	.	.	.	.	.	104
183	WI	Walworth Co.	1	.	.	.	.	.	75
184	WV	Charleston	1	.	.	.	.	.	250
185	WV	Follansbee	.	.	.	1	.	.	3
186	WV	Greenbrier Co.	1	.	.	.	.	.	35
187	WV	Hancock Co.	.	.	1	.	.	.	22
188	WV-KY	Huntington-Ashland	1	.	1	.	.	.	206
189	WV	Parkersburg	1	.	.	.	.	.	87
190	WY	Sheridan	.	.	.	1	.	.	14
			==	==	===	====	==	===	==========
			94	41	46	70	13	1	148,164

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

Notes: (a) This is a simplified listing of Classified Nonattainment areas. 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. 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 1 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, 1993.

(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.

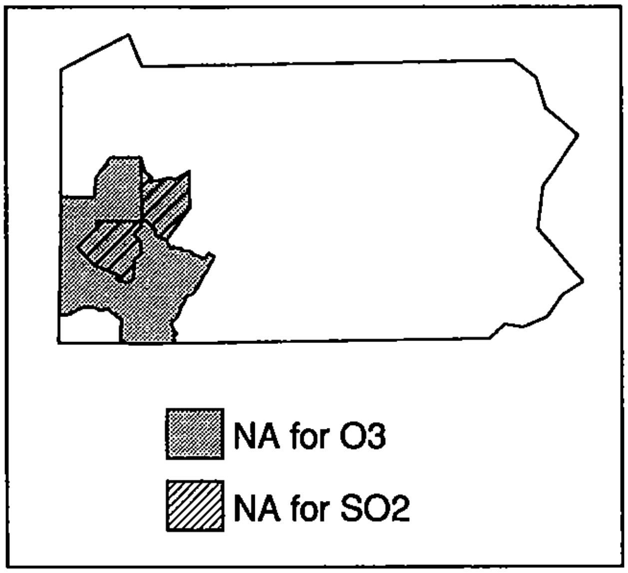


Figure 5-1. Example of multiple nonattainment (NA) areas within a larger NA area (two SO_2 NA areas inside the Pittsburgh-Beaver Valley ozone NA area, counted as one area).

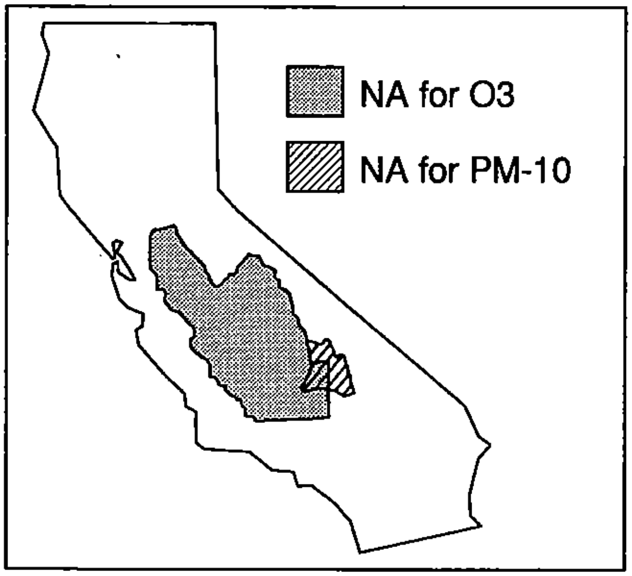


Figure 5-2. Example of overlapping NA areas (Searles Valley PM-10 NA area partially overlaps the San Joaquin Valley ozone NA area, counted as 2 areas).

5.2 Population Estimates for Counties not Meeting NAAQS, 1992

Figure 5-3 provides an estimate of the number of people living in counties in which the levels of the pollutant-specific primary health NAAQS were not met by measured air quality during 1992. 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 account more fully for variations in emissions and meteorological conditions. Selected air quality statistics and their associated NAAQS were listed in Table 2-1. Figure 5-3 clearly demonstrates that O_3 was the most pervasive air pollution problem in 1992 for the United States with an estimated 44.6 million people living in counties which did not meet the O_3 standard. This estimate is significantly lower than last year's estimate for 1991 of 69.7 million people. This is the lowest 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. This large decrease is likely due in part to meteorological conditions in 1988 being more conducive to ozone formation than recent years (recall the hot, dry summer in the eastern U.S.), and to new and ongoing emission control programs. Between 1988 and 1989, implementation of gasoline volatility regulations lowered the average Reid Vapor Pressure (RVP) of regular unleaded gasoline from 10.0 to 8.9 pounds per square inch (psi). RVP was reduced an additional 3 percent between 1989 and 1990.

PM-10 follows with 25.8 million people; CO with 14.3 million people; Pb with 4.7 million people. The year 1992 marks the first time since these population estimates have been made that no monitoring violations of either the NO_2 or the SO_2 NAAQS were recorded. Both CO and Pb recorded decreases, while PM-10 increased from 21.5 million people with the addition of areas such as Chicago, Philadelphia and Phoenix. A total of 54 million persons resided in counties not meeting at least one air quality standard during 1992 (out of a total 1990 population of 249 million). This estimate is down 37 percent from the 86 million people reported for 1991. Table 5-3 lists by state the total population living in counties not meeting the NAAQS in 1992. These population estimates are intended to provide a relative measure of the extent of

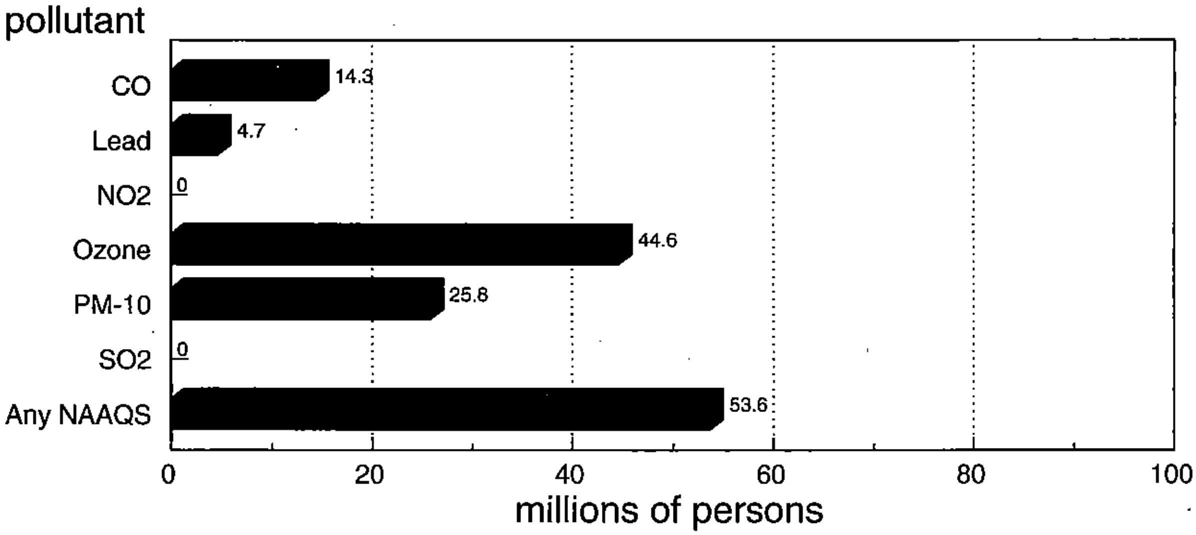


Figure 5-3. Number of persons living in counties with air quality levels not meeting the primary NAAQS in 1992. (Based on 1990 population data and 1992 air quality data.)

1992. These population estimates are intended to provide a relative measure of the extent of the problem for each pollutant. The limitations of this 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 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 45 million people living in counties that had 1992 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 45 million people only considers data from the single year, 1992, and only considers counties with ozone monitoring data. Presently, counties with ozone monitors contain 65 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 45 million people living in counties with air quality levels not meeting the ozone NAAQS only considers counties that had ozone monitoring data for 1992. There were only 852 ozone monitors reporting in 1992. These monitors were located in 513 counties, which clearly falls far short of the more than 3,100 counties in the U.S. 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 manmade 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.

The 1992 population count in counties with high levels of pollution is the lowest in ten years.

Table 5-3. Single Year Snapshot for 1992 of Number of People Living in Counties With Air Quality Levels Not Meeting at Least One of the National Ambient Air Quality Standards (NAAQS) - Population Totals by State. *(Based on 1992 data only. Additional years are required to demonstrate attainment to account for variations in emissions and meteorological conditions.)*

State	Total State Population, 1990	Number of People Living in Counties Not Meeting the NAAQS in 1992
Alabama	4,040,587	0*
Alaska	550,043	304,058
Arizona	3,665,228	2,249,401
Arkansas	2,350,725	0
California	29,760,021	19,896,154
Colorado	3,294,394	467,610
Connecticut	3,287,116	1,099,540
Delaware	666,168	441,946
District of Columbia	606,900	0*
Florida	12,937,926	0*
Georgia	6,478,216	599,928
Hawaii	1,108,229	0
Idaho	1,006,749	135,821
Illinois	11,430,602	5,671,776
Indiana	5,544,159	604,526
Iowa	2,776,755	150,979
Kansas	2,477,574	0
Kentucky	3,685,296	0*
Louisiana	4,219,973	744,050
Maine	1,227,928	164,587
Maryland	4,781,468	283,286
Massachusetts	6,016,425	995,625
Michigan	9,295,297	0*
Minnesota	4,375,099	0*
Mississippi	2,573,216	0
Missouri	5,117,073	1,175,635

* *Although the population figure is zero using only 1992 data, this state contains one or more officially classified nonattainment areas.*
Note: Based on data from AIRS as of July 15, 1993.

Table 5-3. Single Year Snapshot for 1992 of Number of People Living in Counties With Air Quality Levels Not Meeting at Least One of the National Ambient Air Quality Standards (NAAQS) - Population Totals by State. (Based on 1992 data only. Additional years are required to demonstrate attainment to account for variations in emissions and meteorological conditions.) (cont.)

State	**Total State Population, 1990**	**Number of People Living in Counties Not Meeting the NAAQS in 1992**
Montana	799,065	106,713
Nebraska	1,578,385	416,444
Nevada	1,201,833	741,459
New Hampshire	1,109,252	0*
New Jersey	7,730,188	3,260,931
New Mexico	1,515,069	135,510
New York	17,990,455	1,321,864
North Carolina	6,628,637	0*
North Dakota	638,800	0
Ohio	10,847,115	1,474,394
Oklahoma	3,145,585	0
Oregon	2,842,321	561,762
Pennsylvania	11,881,643	1,585,577
Rhode Island	1,003,464	0*
South Carolina	3,486,703	285,720
South Dakota	696,004	0
Tennessee	4,877,185	851,889
Texas	16,986,510	5,968,079
Utah	1,722,850	1,147,876
Vermont	562,758	0
Virginia	6,187,358	58,423
Washington	4,866,692	361,364
West Virginia	1,793,477	0*
Wisconsin	4,891,769	303,215
Wyoming	453,588	0*
Total	248,709,873	53,566,142

* *Although the population figure is zero using only 1992 data, this state contains one or more officially classified nonattainment areas.*
Note: Based on data from AIRS as of July 15, 1993.

5.3 Maps of Peak Air Quality Levels by County, 1992

This section presents air quality maps that show how air quality varied across the country during 1992. For each pollutant, the maps display the highest concentration recorded among all monitoring sites in each county. The bar chart accompanying each map displays the number of people living in counties within each pollutant concentration range. Table 5-4 lists the Pollutant Standards Index (PSI) ranges and pollutant concentration averaging times used for each of the pollutants, except for maximum quarterly Pb levels and annual arithmetic mean NO_2 levels. For these latter two pollutants, Table 5-5 lists the averaging times, pollutant ranges and colors used with the Pb and NO_2 air quality maps.

The PSI is a uniform air quality index used for the daily reporting of air pollution concentrations in most major U.S. cities. As indicated in Table 5-4, a standard color sequence is used when this information is reported to the public. The PSI colors are employed in the following maps to provide a readily identifiable and consistent color scheme throughout. 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.

Table 5-5. Plotting Points for Pb and NO_2.

Color	Pb Max Quarter µg/m^3	NO_2 Arith Mean ppm
Red	6.0^+	n/a
Orange	≤ 6.0	n/a
Yellow	≤ 3.0	≤ 0.106
Green	≤ 1.5	≤ 0.053
Blue	≤ 0.75	≤ 0.027

Table 5-4. Comparison of Pollutant Standard 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/m^3	SO_2 (24-hour) ug/m^3	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.

Carbon Monoxide Air Quality Concentrations, 1992

Highest Second Max 8 – Hour Average

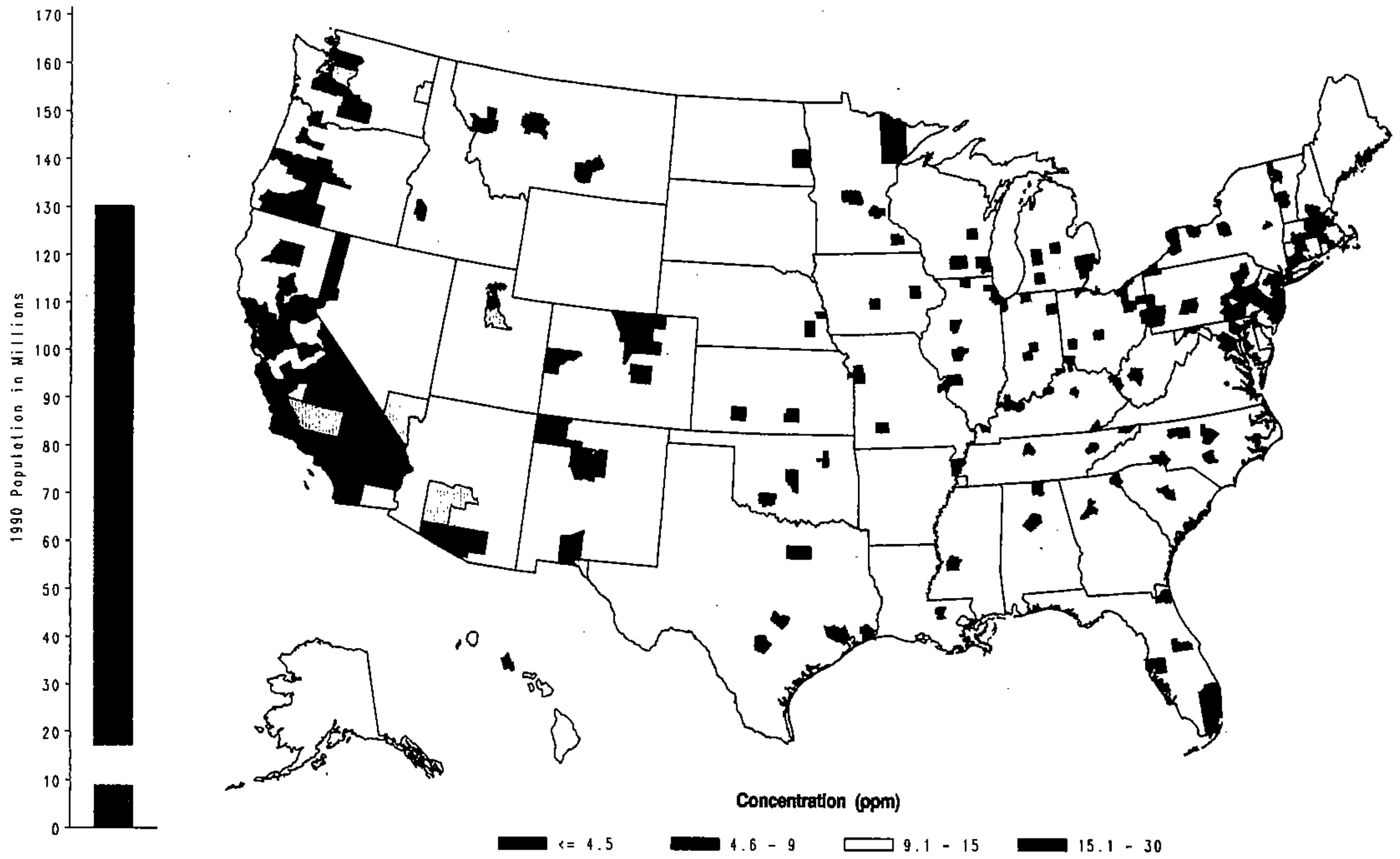


Figure 5-4. Carbon monoxide air quality concentrations, 1992.

Lead Air Quality Concentrations, 1992

Highest Quarterly Average

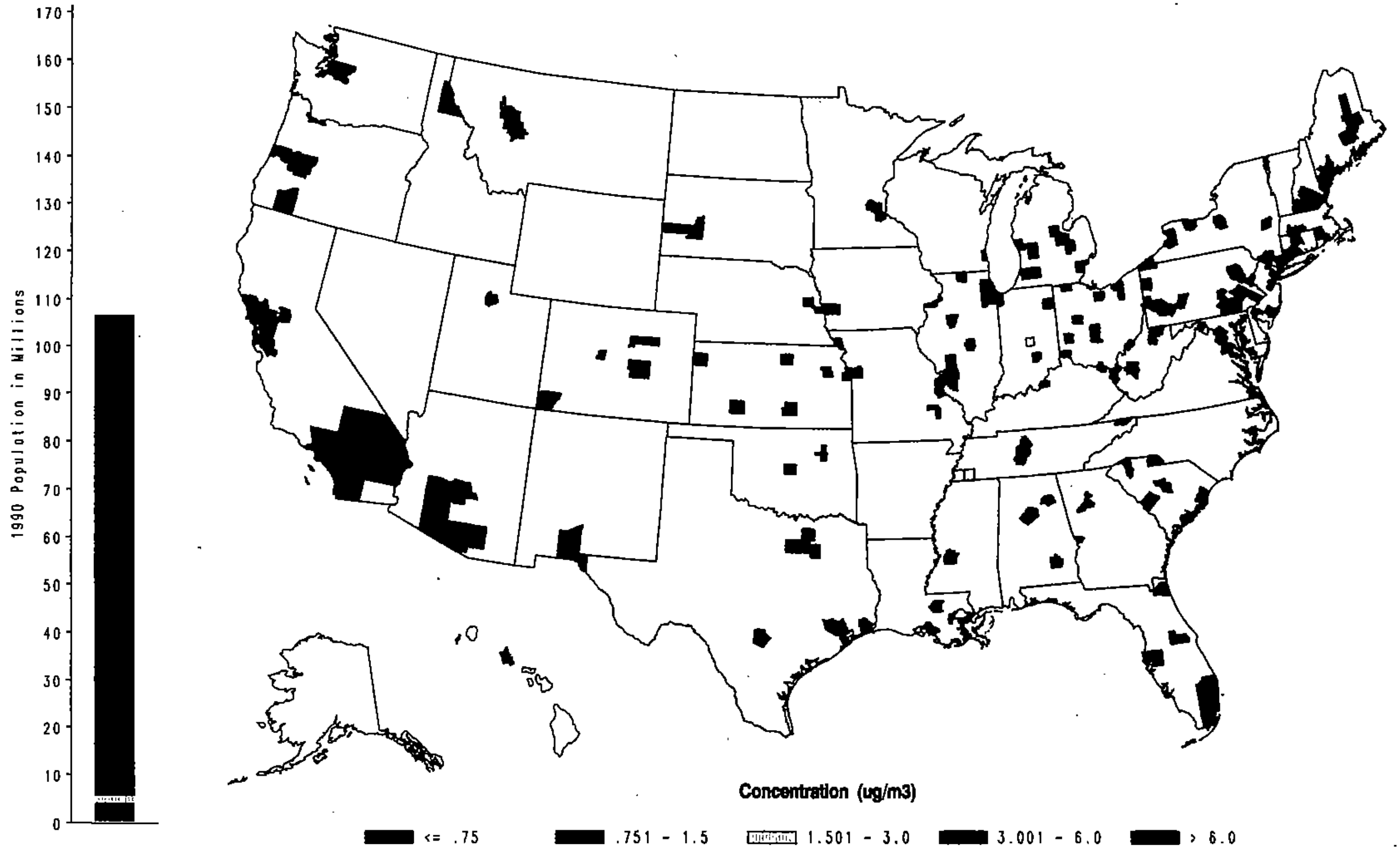


Figure 5-5. Lead air quality concentrations, 1992.

Nitrogen Dioxide Air Quality Concentrations, 1992

Highest Arithmetic Mean

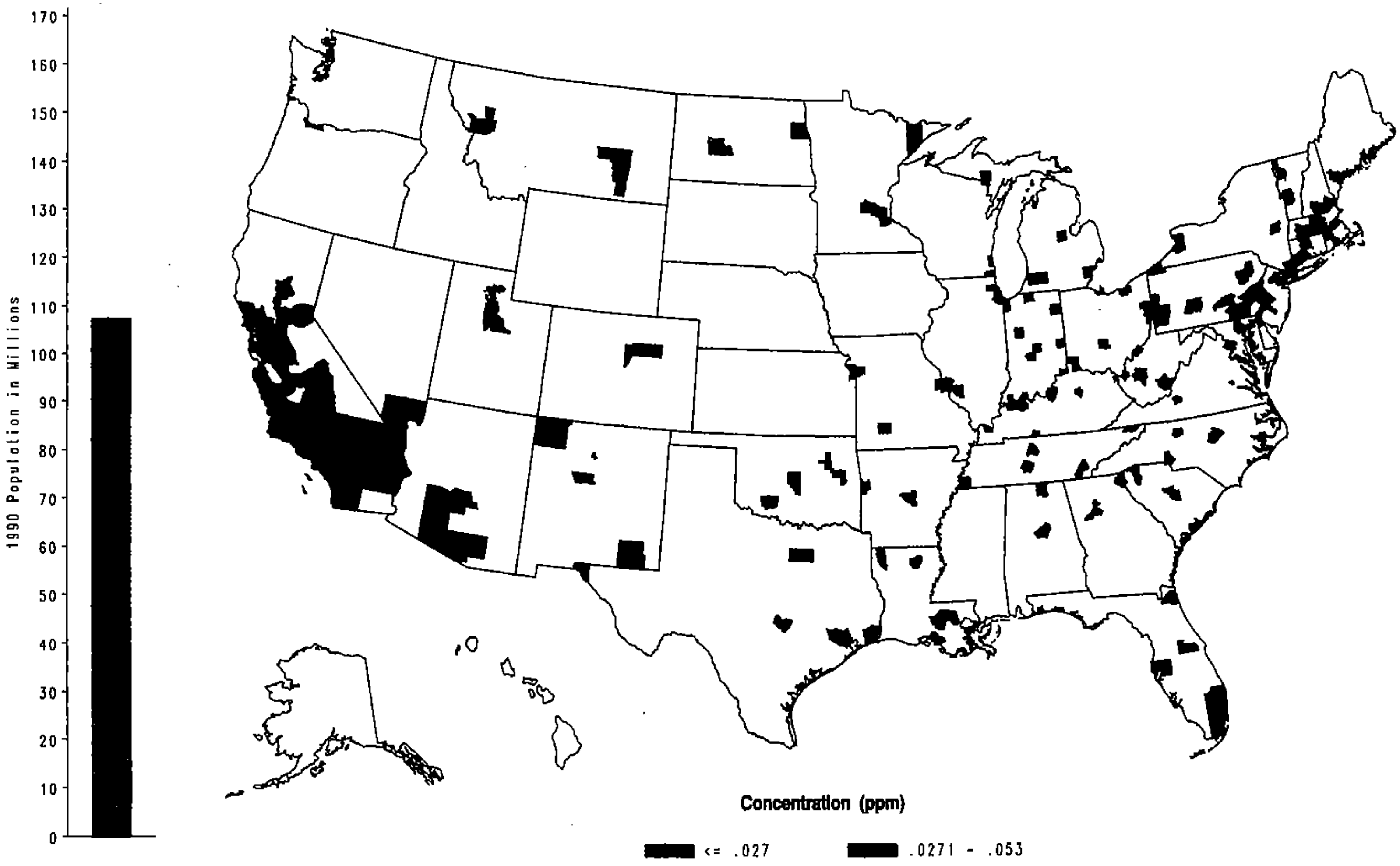


Figure 5-6. Nitrogen dioxide air quality concentrations, 1992.

Ozone Air Quality Concentrations, 1992

Highest Second Daily 1—Hour Max

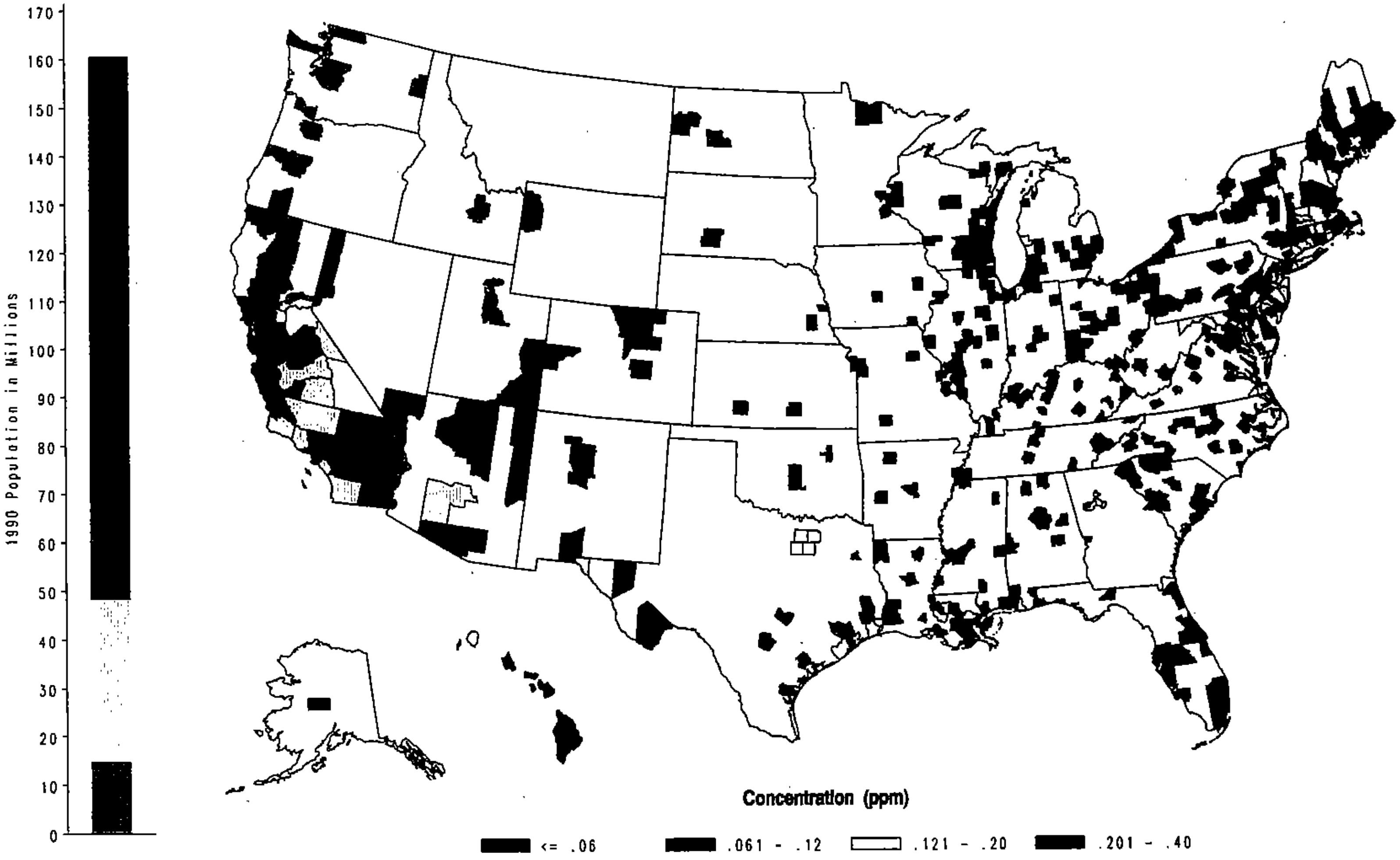


Figure 5-7. Ozone air quality concentrations, 1992.

PM – 10 Air Quality Concentrations, 1992

Highest Second Max 24 – Hour Average

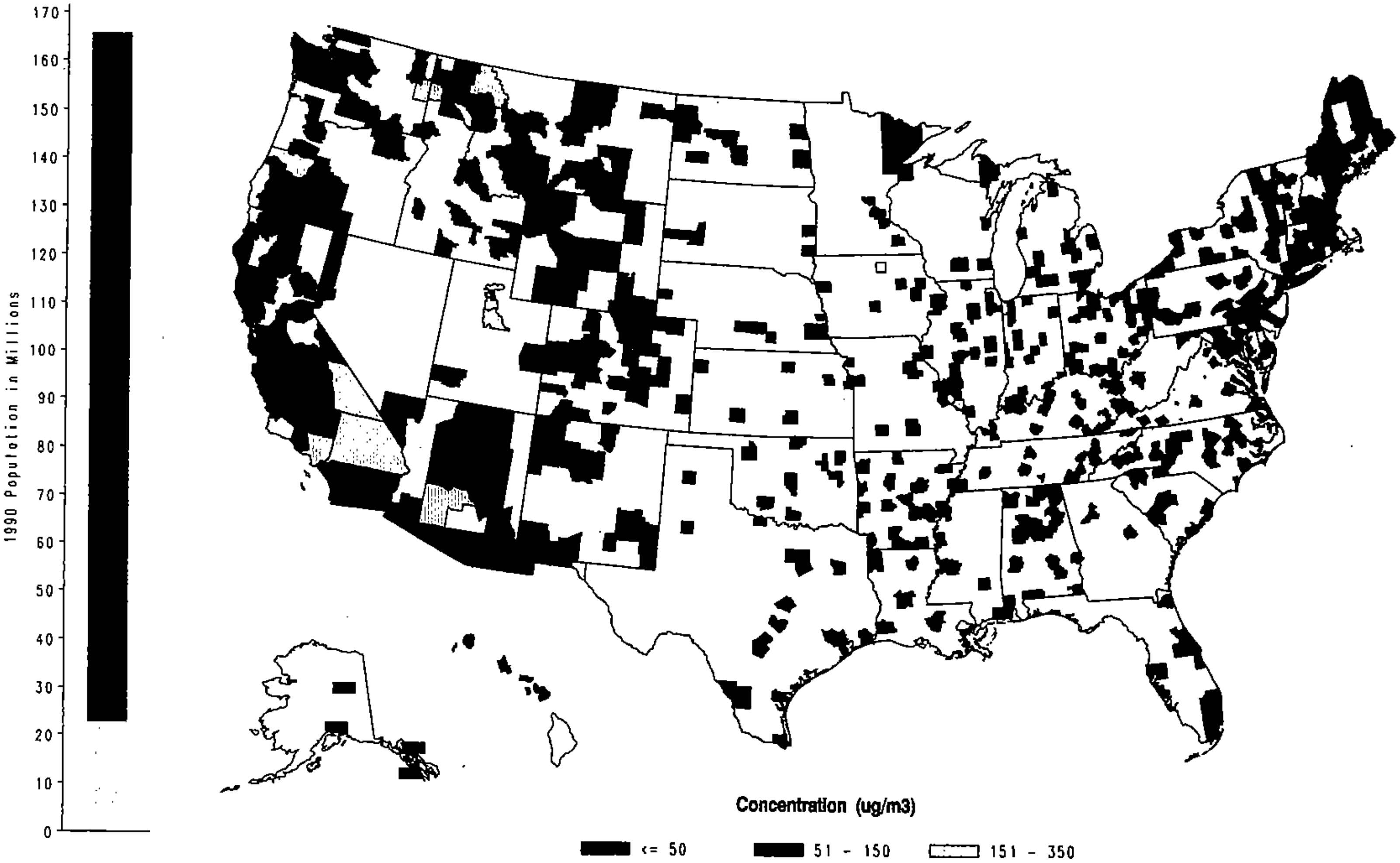


Figure 5-8. *PM-10 air quality concentrations, 1992.*

Sulfur Dioxide Air Quality Concentrations, 1992

Highest Second Max 24 – Hour Average

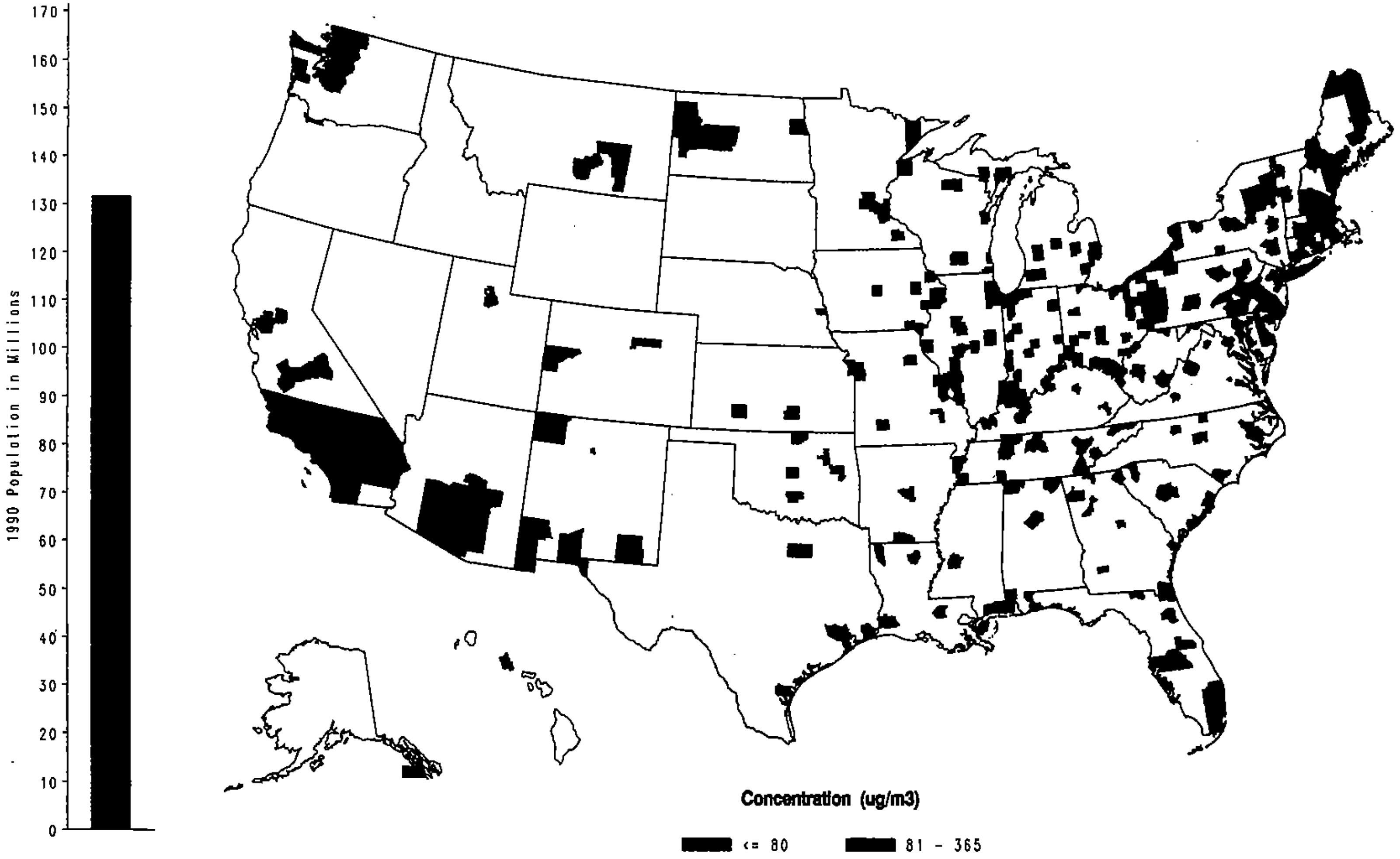


Figure 5-9. Sulfur dioxide air quality concentrations, 1992.

5.4 Environmental Justice Considerations

Recent years have brought an increased awareness that pollution risks are not necessarily equal for all members of society. There is growing concern that environmental risks may be greater for minority groups or other specific subgroups of society and that this inequity could be increasing.[3] This section focuses on environmental justice, or environmental equity, considered in terms of the NAAQS pollutants. More thorough discussions of environmental justice issues have been presented recently in a number of forums, including a wide ranging article in the *EPA Journal*, March/April 1992 issue.

An important component of studying environmental justice issues is to be able to associate population with a given air pollution problem. Several approaches are possible. Most simply, the population can be based on the number of people living in counties with at least one air quality monitor not meeting the standard. Or, population within a nonattainment area, which has boundaries specifically designed to encompass the pollution problem, may be used. This second method is usually more difficult due to the sometimes complicated nature of nonattainment boundaries. Finally, an even more involved method uses models which incorporate population, pollution, and mobility pattern information to focus on a specific area. The county and nonattainment area approaches are used here to provide an overview of air quality status.

Once the basic population numbers are established, it is important to understand both the nature of the area affected by the pollutants being studied and the characteristics of the population in the area. For example, a distinction may need to be made in a given situation between ozone, which affects a wide area, and a more localized problem caused by carbon monoxide, sulfur dioxide, lead, or particulate matter. These latter pollutants may be associated with specific sources where the effects may be limited to the immediate neighborhood. Figure 5-10 illustrates both the ozone and the carbon monoxide nonattainment areas associated with Baltimore and provides a striking example of the possible difference in the size of nonattainment areas for different pollutants. The carbon monoxide nonattainment area is less than 0.1 percent of the area of the ozone nonattainment area and contains only about 1 percent of the population.

To characterize the population in a given area, detailed demographics may be used. One step in this process is to develop computerized maps that show the boundaries of the specific nonattainment areas. Figure 5-11 illustrates this type of map for Chicago. Note that the Chicago ozone nonattainment area, shaded orange, covers a much broader area than the three PM-10 nonattainment areas, shaded red. The racial make-up of these areas, provided by census data, varies. For example, the population of the ozone nonattainment area is 71 percent white and 20 percent African-American (defined as Black by the U.S. Census Bureau), while the African-American proportion of the PM-10 areas within the ozone area ranges anywhere from 4 percent to 73 percent. This example provides a good illustration of how detailed population descriptions are useful for providing insight into who is being affected by the current nonattainment problems. Future EPA Trends Reports will make greater use of these detailed area characterizations.

Baltimore Non-Attainment Areas

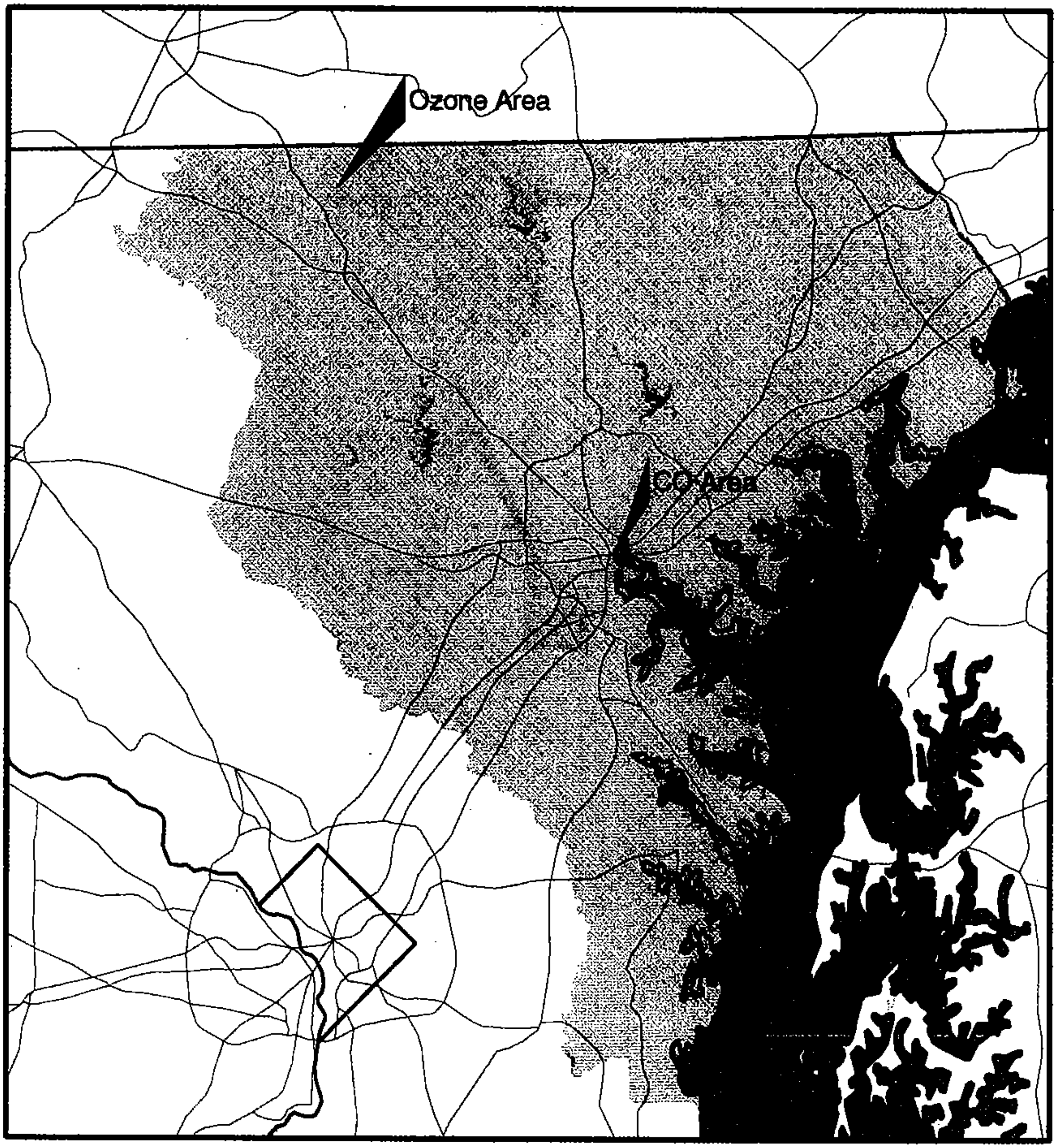


Figure 5-10. Ozone and carbon monoxide nonattainment areas within the Baltimore metropolitan area.

Chicago Non-Attainment Areas

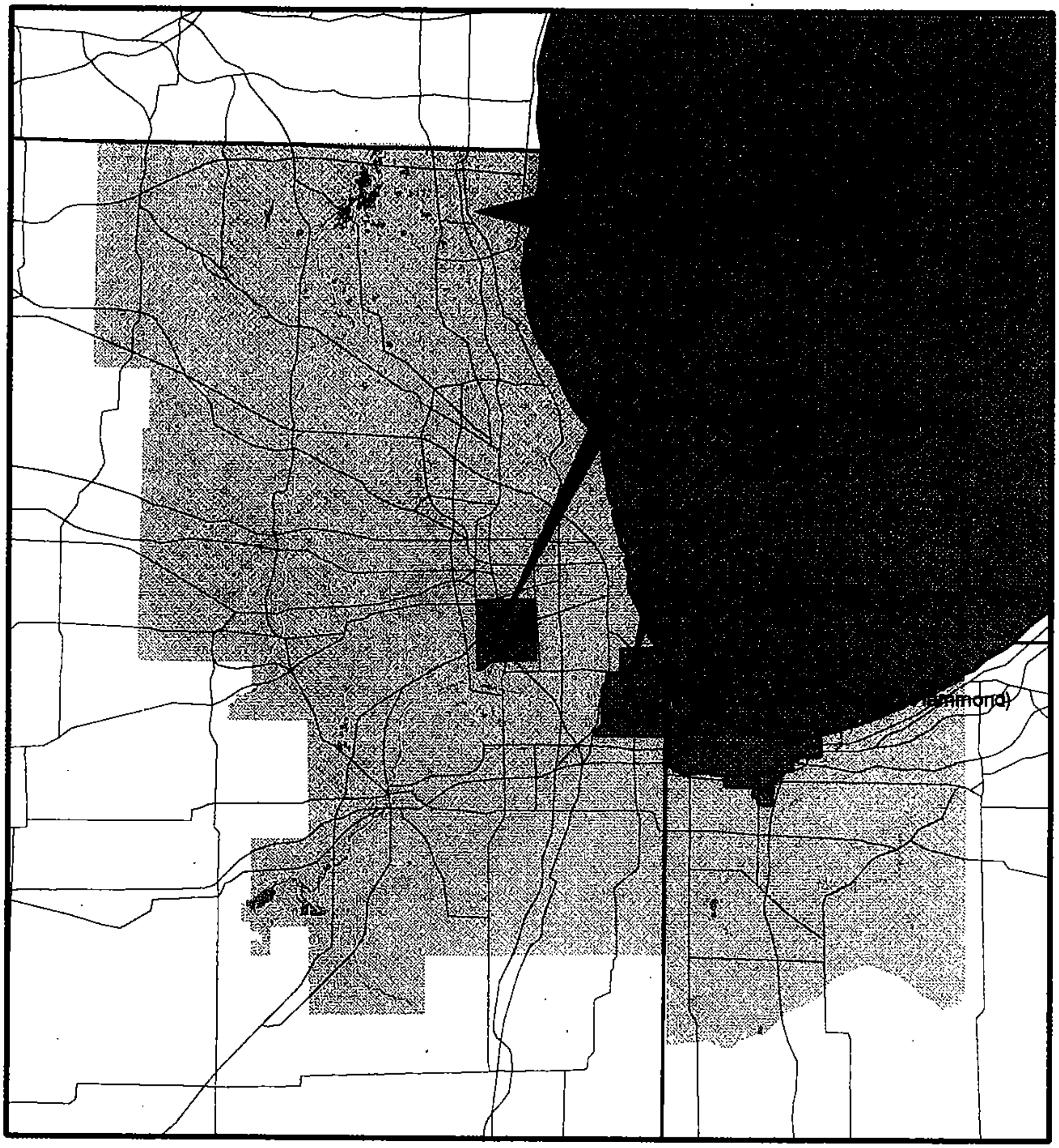


Figure 5-11. Ozone and PM-10 nonattainment areas within the Chicago metropolitan area.

5.5 Metropolitan Statistical Area (MSA) Air Quality Summary, 1992

This section provides information for general air pollution audiences on 1992 air quality levels in each Metropolitan Statistical Area (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. Metropolitan Statistical Areas 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 16 percent of the land area in the U.S., they account for 78 percent of the total population of 249 million.

Table 5-6 presents a summary of the highest air quality levels measured in each MSA during 1992. Individual MSAs are listed to provide more extensive spatial coverage for large metropolitan complexes. The 341 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. Pb monitors located near a point source are footnoted accordingly in Table 5-6.

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 1992 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 was 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 Section 3 which used a more relaxed indicator, only maximum quarterly average Pb concentrations meeting the AIRS validity criteria are displayed in Table 5-6.

5.6 References

1. *Statistical Abstract of the United States*, *1992, U. S. Department of Commerce, U.S. Bureau of the Census, Appendix II.*

2. *Code of Federal Regulations*, *40CFR Part 81.*

3. *P. Mohai and B. Bryant, "Race, Poverty, and Environment",* *EPA Journal*, *March/April, 1992.*

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 5-6. 1992 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK
PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1990 POPULATION	PM10 2ND MAX (UGM)	PM10 WTD AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8-HR (PPM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PB QMAX (UGM)
ABILENE, TX	120,000	ND	ND	ND	ND	ND	ND	ND	ND
AGUADILLA, PR	156,000	ND	ND	ND	ND	ND	ND	ND	ND
AKRON, OH	658,000	62	28	0.013	0.064	5	ND	0.11	0.05
ALBANY, GA	113,000	ND	ND	0.003	0.05	ND	ND	ND	ND
ALBANY-SCHENECTADY-TROY, NY	874,000	69	24	0.006	0.029	5	IN	0.1	0.03
ALBUQUERQUE, NM	481,000	67	31	ND	ND	8	0.021	0.09	ND
ALEXANDRIA, LA	132,000	ND	ND	ND	ND	ND	ND	ND	ND
ALLENTOWN-BETHLEHEM, PA-NJ	687,000	48	21	0.008	0.034	4	0.02	0.1	0.28
ALTOONA, PA	131,000	38	21	0.009	0.046	3	0.014	0.1	ND
AMARILLO, TX	188,000	30	IN	ND	ND	ND	ND	ND	ND
ANAHEIM-SANTA ANA, CA	2,411,000	85	40	0.002	0.008	9	0.039	***0.19***	0.03
ANCHORAGE, AK	226,000	149	42	ND	ND	***11***	ND	ND	ND
ANDERSON, IN	131,000	55	25	ND	ND	ND	ND	ND	ND
ANDERSON, SC	145,000	ND	ND	ND	ND	ND	ND	0.09	ND
ANN ARBOR, MI	283,000	115	IN	ND	ND	ND	ND	0.1	ND
ANNISTON, AL	116,000	45	25	ND	ND	ND	ND	ND	ND
APPLETON-OSHKOSH-NEENAH, WI	315,000	ND	ND	ND	ND	3	ND	0.09	ND
ARECIBO, PR	170,000	ND	ND	0.005	0.016	ND	ND	ND	ND
ASHEVILLE, NC	175,000	41	23	ND	ND	ND	ND	0.08	ND
ATHENS, GA	156,000	ND	ND	ND	ND	ND	ND	ND	ND
ATLANTA, GA	2,834,000	69	34	0.008	0.034	5	0.027	***0.13***	0.03
ATLANTIC CITY, NJ	319,000	51	31	0.003	0.016	5	ND	0.12	0.02
AUGUSTA, GA-SC	397,000	42	IN	ND	ND	ND	ND	0.1	0.01
AURORA-ELGIN, IL	357,000	ND	ND	ND	ND	ND	ND	0.1	ND
AUSTIN, TX	782,000	50	23	ND	ND	4	0.017	0.1	ND
BAKERSFIELD, CA	543,000	109	***63***	0.003	0.01	9	0.027	***0.15***	ND
BALTIMORE, MD	2,382,000	71	34	0.009	0.027	7	0.031	***0.13***	0.04
BANGOR, ME	89,000	78	22	ND	ND	ND	ND	ND	0.01
BATON ROUGE, LA	528,000	66	30	0.008	0.033	5	0.019	0.12	0.26
BATTLE CREEK, MI	136,000	57	27	ND	ND	ND	ND	ND	ND
BEAUMONT-PORT ARTHUR, TX	361,000	53	26	0.006	0.045	2	0.012	***0.14***	0.02
BEAVER COUNTY, PA	186,000	61	24	0.018	0.088	3	0.02	0.11	0.15
BELLINGHAM, WA	128,000	50	IN	0.007	0.022	ND	ND	0.07	ND
BENTON HARBOR, MI	161,000	ND	ND	ND	ND	ND	ND	0.08	ND
BERGEN-PASSAIC, NJ	1,278,000	71	39	0.011	0.047	5	0.03	0.1	0.02
BILLINGS, MT	113,000	49	27	0.025	0.103	5	ND	ND	ND
BILOXI-GULFPORT, MS	197,000	ND	ND	0.006	0.02	ND	ND	ND	ND
BINGHAMTON, NY	264,000	44	22	ND	ND	ND	ND	ND	ND
BIRMINGHAM, AL	908,000	122	39	0.007	0.027	8	IN	0.12	1.15 *
BISMARK, ND	84,000	45	21	ND	ND	ND	ND	ND	ND

BLOOMINGTON, IN	109,000	ND	ND	ND	ND	ND	ND	ND	ND
BLOOMINGTON-NORMAL, IL	129,000	ND	ND	ND	ND	ND	ND	ND	ND
BOISE CITY, ID	206,000	91	41	ND	ND	7	ND	ND	ND
BOSTON, MA	2,871,000	69	16	0.012	0.046	5	0.033	0.11	0.03
BOULDER-LONGMONT, CO	225,000	69	24	ND	ND	7	ND	0.09	ND
BRADENTON, FL	212,000	ND	ND	ND	ND	ND	ND	0.09	ND
BRAZORIA, TX	192,000	ND	ND	ND	ND	ND	ND	***0.13***	ND
BREMERTON, WA	190,000	ND	ND	ND	ND	ND	ND	ND	ND
BRIDGEPORT-MILFORD, CT	444,000	51	27	0.01	0.04	5	0.024	***0.13***	0.01
BRISTOL, CT	79,000	46	19	ND	ND	ND	ND	ND	ND
BROCKTON, MA	189,000	ND	ND	ND	ND	ND	ND	0.11	ND
BROWNSVILLE-HARLINGEN, TX	260,000	62	31	ND	ND	ND	ND	ND	ND
BRYAN-COLLEGE STATION, TX	122,000	ND	ND	ND	ND	ND	ND	ND	ND
BUFFALO, NY	969,000	63	25	0.011	0.07	6	0.021	0.1	0.03
BURLINGTON, NC	108,000	ND	ND	ND	ND	ND	ND	ND	ND
BURLINGTON, VT	131,000	50	23	0.003	0.013	4	0.016	ND	ND
CAGUAS, PR	275,000	ND	ND	ND	ND	ND	ND	ND	ND
CANTON, OH	397,000	72	30	0.01	0.04	3	ND	0.1	ND
CASPER, WY	61,000	41	21	ND	ND	ND	ND	ND	ND
CEDAR RAPIDS, IA	169,000	66	IN	0.005	0.046	5	ND	0.08	ND
CHAMPAIGN-URBANA-RANTOUL, IL	173,000	71	38	0.004	0.018	ND	ND	0.09	ND
CHARLESTON, SC	507,000	93	25	0.005	0.035	5	0.012	0.09	0.03
CHARLESTON, WV	250,000	50	28	0.009	0.035	3	0.017	0.07	0.04
CHARLOTTE-GASTONIA-ROCK HILL, NC-SC	1,162,000	57	31	ND	ND	7	0.016	0.1	0.08
CHARLOTTESVILLE, VA	131,000	37	22	ND	ND	ND	ND	ND	ND
CHATTANOOGA, TN-GA	433,000	76	35	ND	ND	ND	ND	0.1	ND
CHEYENNE, WY	73,000	51	17	ND	ND	ND	ND	ND	ND
CHICAGO, IL	6,070,000	***181***	42	0.009	0.056	6	0.03	***0.13***	0.99 #
CHICO, CA	182,000	ND	ND	ND	ND	6	0.016	0.09	ND
CINCINNATI, OH-KY-IN	1,453,000	82	36	0.015	0.05	5	0.026	0.1	0.05

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

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from an industrial source in Leeds, AL. Highest site in Birmingham, AL is 0.12 ug/m3.

- Impact from an industrial source in Chicago, IL. Highest population oriented site in Chicago, IL is 0.12 ug/m3.

TABLE 5-6. 1992 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1990 POPULATION	PM10 2ND MAX (UGM)	PM10 WTD AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8-HR (PPM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PB QMAX (UGM)
CLARKSVILLE-HOPKINSVILLE, TN-KY	169,000	ND	ND	0.009	0.035	ND	ND	ND	ND
CLEVELAND, OH	1,831,000	136	36	0.014	0.065	7	0.029	***0.14***	***37.4*** *
COLORADO SPRINGS, CO	397,000	120	26	ND	ND	7	ND	0.07	0.02
COLUMBIA, MO	112,000	ND	ND	ND	ND	ND	ND	ND	ND
COLUMBIA, SC	453,000	119	***53***	0.004	0.022	6	IN	0.1	0.05
COLUMBUS, GA-AL	243,000	51	26	ND	ND	ND	ND	0.1	1.46 #
COLUMBUS, OH	1,377,000	79	30	0.007	0.03	6	0.012	0.1	0.14
CORPUS CHRISTI, TX	350,000	60	IN	0.003	0.021	ND	ND	0.1	ND
CUMBERLAND, MD-WV	102,000	ND	ND	0.006	0.024	3	ND	ND	ND
DALLAS, TX	2,553,000	92	30	0.003	0.01	6	0.021	***0.14***	0.91 @
DANBURY, CT	188,000	57	IN	0.007	0.027	ND	ND	0.12	ND
DANVILLE, VA	109,000	ND	ND	ND	ND	ND	ND	ND	ND
DAVENPORT-ROCK ISLAND-MOLINE, IA-IL	351,000	126	31	0.006	0.031	ND	ND	0.11	0.02
DAYTON-SPRINGFIELD, OH	951,000	60	28	0.005	0.021	4	ND	0.1	0.04
DAYTONA BEACH, FL	371,000	35	19	ND	ND	ND	ND	0.08	ND
DECATUR, AL	132,000	48	25	ND	ND	ND	ND	ND	ND
DECATUR, IL	117,000	75	27	0.005	0.023	ND	ND	0.09	0.03
DENVER, CO	1,623,000	***181***	39	0.009	0.061	***13***	0.041	0.1	0.12
DES MOINES, IA	393,000	115	IN	ND	ND	4	ND	0.08	ND
DETROIT, MI	4,382,000	89	37	0.009	0.045	5	0.021	0.11	0.06
DOTHAN, AL	131,000	63	25	ND	ND	ND	ND	ND	ND
DUBUQUE, IA	86,000	ND	ND	0.003	0.017	ND	ND	ND	ND
DULUTH, MN-WI	240,000	61	23	0.002	0.016	4	ND	ND	ND
EAU CLAIRE, WI	138,000	ND	ND	ND	ND	ND	ND	ND	ND
EL PASO, TX	592,000	***158***	44	0.013	0.056	***10***	0.031	***0.14***	0.26
ELKHART-GOSHEN, IN	156,000	ND	ND	ND	ND	ND	ND	0.09	ND
ELMIRA, NY	95,000	41	21	0.005	0.021	ND	ND	0.09	ND
ENID, OK	57,000	ND	ND	ND	ND	ND	ND	ND	ND
ERIE, PA	276,000	56	22	0.011	0.056	4	0.014	0.1	0.05
EUGENE-SPRINGFIELD, OR	283,000	***161***	28	ND	ND	6	ND	0.1	0.02
EVANSVILLE, IN-KY	279,000	56	32	0.016	0.097	5	0.018	0.1	ND
FALL RIVER, MA-RI	157,000	38	17	0.008	0.058	ND	ND	ND	ND
FARGO-MOORHEAD, ND-MN	153,000	54	21	ND	ND	3	ND	ND	ND
FAYETTEVILLE, NC	275,000	44	26	ND	ND	7	ND	0.09	ND
FAYETTEVILLE-SPRINGDALE, AR	113,000	53	22	ND	ND	ND	ND	ND	ND
FITCHBURG-LEOMINSTER, MA	103,000	ND	ND	ND	ND	ND	ND	ND	ND
FLINT, MI	430,000	73	IN	IN	0.015	ND	ND	0.09	0.01
FLORENCE, AL	131,000	40	21	0.004	0.019	ND	ND	ND	ND
FLORENCE, SC	114,000	ND	ND	ND	ND	ND	ND	ND	ND
FORT COLLINS, CO	186,000	39	IN	ND	ND	7	ND	0.09	ND

FORT LAUDERDALE-HOLLYWOOD-POMPANO BEA	1,255,000	51	18	0.002	0.006	6	0.009	0.11	0.09
FORT MYERS-CAPE CORAL, FL	335,000	ND	ND	ND	ND	ND	ND	0.08	ND
FORT PIERCE, FL	251,000	ND	ND	ND	ND	ND	ND	ND	ND
FORT SMITH, AR-OK	176,000	51	24	ND	ND	ND	0.01	ND	ND
FORT WALTON BEACH, FL	144,000	ND	ND	ND	ND	ND	ND	ND	ND
FORT WAYNE, IN	364,000	61	23	0.003	0.012	4	0.011	0.1	0.03
FORT WORTH-ARLINGTON, TX	1,332,000	64	25	0.003	0.013	4	0.015	***0.13***	0.03
FRESNO, CA	667,000	111	***52***	0.003	0.01	7	0.023	***0.15***	ND
GADSDEN, AL	100,000	60	31	ND	ND	ND	ND	ND	0.21
GAINESVILLE, FL	204,000	ND	ND	ND	ND	ND	ND	ND	ND
GALVESTON-TEXAS CITY, TX	217,000	64	IN	0.005	0.039	ND	ND	0.1	0.02
GARY-HAMMOND, IN	605,000	***167***	39	0.01	0.052	5	0.019	0.12	0.16
GLENS FALLS, NY	119,000	45	22	0.004	0.017	ND	ND	ND	ND
GRAND FORKS, ND	71,000	78	18	IN	0.041	ND	IN	ND	ND
GRAND RAPIDS, MI	688,000	117	36	0.003	0.015	3	ND	0.1	0.02
GREAT FALLS, MT	78,000	53	21	ND	ND	6	ND	ND	ND
GREELEY, CO	132,000	74	IN	ND	ND	8	ND	0.08	ND
GREEN BAY, WI	195,000	47	18	0.005	0.029	ND	ND	0.08	ND
GREENSBORO-WINSTON SALEM-HIGH POINT, NC	942,000	55	30	0.006	0.019	6	0.015	0.1	ND
GREENVILLE-SPARTANBURG, SC	641,000	30	IN	0.003	0.013	ND	0.019	0.09	0.02
HAGERSTOWN, MD	121,000	41	IN	ND	ND	ND	ND	ND	ND
HAMILTON-MIDDLETOWN, OH	291,000	75	34	0.008	0.037	ND	ND	0.1	ND
HARRISBURG-LEBANON-CARLISLE, PA	588,000	42	18	0.007	0.03	5	0.018	0.1	0.04
HARTFORD, CT	768,000	62	25	0.007	0.031	8	0.017	***0.13***	0.02
HICKORY, NC	222,000	41	IN	ND	ND	ND	ND	ND	ND
HONOLULU, HI	836,000	51	15	0.002	0.009	3	ND	0.06	0.01
HOUMA-THIBODAUX, LA	183,000	ND	ND	ND	ND	ND	ND	0.09	ND
HOUSTON, TX	3,302,000	102	38	0.008	0.04	8	0.028	0.2	0.03
HUNTINGTON-ASHLAND, WV-KY-OH	313,000	74	32	0.013	0.079	3	0.02	0.11	0.04
HUNTSVILLE, AL	239,000	50	30	ND	ND	4	0.013	0.11	ND

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

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from an industrial source In Clevland, OH. Enforcement action has been initiated at this facility. Highest population oriented site in Cleveland, OH is 0.36 ug/m3.

- Impact from an industrial source.

@ - Impact from an industrial source in Collin County, TX. Highest site in Dallas, TX is 0.12 ug/m3.

TABLE 5-6. 1992 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1990 POPULATION	PM10 2ND MAX (UGM)	PM10 WTD AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8-HR (PPM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PB QMAX (UGM)
INDIANAPOLIS, IN	1,250,000	80	36	0.012	0.045	4	0.018	0.1	***1.53*** *
IOWA CITY, IA	96,000	ND	ND	ND	ND	ND	ND	ND	ND
JACKSON, MI	150,000	ND	ND	ND	ND	ND	ND	ND	ND
JACKSON, MS	395,000	55	27	0.005	0.013	4	ND	0.09	0.02
JACKSON, TN	78,000	56	27	ND	ND	ND	ND	ND	ND
JACKSONVILLE, FL	907,000	50	28	0.005	0.049	5	0.014	0.1	0.03
JACKSONVILLE, NC	150,000	40	23	ND	ND	ND	ND	ND	ND
JAMESTOWN-DUNKIRK, NY	142,000	49	20	0.011	0.05	ND	ND	0.1	ND
JANESVILLE-BELOIT, WI	140,000	ND	ND	ND	ND	ND	ND	0.1	ND
JERSEY CITY, NJ	553,000	78	30	0.012	0.048	***10***	0.028	0.11	0.05
JOHNSON CITY-KINGSPORT-BRISTOL, TN-VA	436,000	61	29	0.014	0.045	3	0.018	0.1	0.02
JOHNSTOWN, PA	241,000	56	28	0.013	0.052	4	0.018	0.09	0.14
JOLIET, IL	390,000	73	33	0.005	0.028	ND	ND	0.1	0.04
JOPLIN, MO	135,000	ND	ND	ND	ND	ND	ND	ND	ND
KALAMAZOO, MI	223,000	45	20	0.004	0.018	3	0.014	0.11	0.02
KANKAKEE, IL	96,000	ND	ND	ND	ND	ND	ND	ND	ND
KANSAS CITY, MO-KS	1,566,000	99	44	0.005	0.029	4	0.014	0.1	0.03
KENOSHA, WI	128,000	ND	ND	IN	0.01	ND	IN	***0.13***	ND
KILLEN-TEMPLE, TX	255,000	44	18	ND	ND	ND	ND	ND	ND
KNOXVILLE, TN	605,000	67	38	0.009	0.051	5	ND	0.1	ND
KOKOMO, IN	97,000	ND	ND	ND	ND	ND	ND	ND	ND
LA CROSSE, WI	98,000	ND	ND	ND	ND	ND	ND	ND	ND
LAFAYETTE, LA	209,000	ND	ND	ND	ND	ND	ND	0.09	ND
LAFAYETTE, IN	131,000	41	IN	0.008	0.045	ND	IN	ND	ND
LAKE CHARLES, LA	168,000	75	25	0.005	0.013	ND	ND	0.11	ND
LAKE COUNTY, IL	516,000	ND	ND	ND	ND	ND	ND	0.12	ND
LAKELAND-WINTER HAVEN, FL	405,000	ND	ND	0.004	0.018	ND	ND	0.11	ND
LANCASTER, PA	423,000	45	IN	0.006	0.023	3	0.015	0.11	0.04
LANSING-EAST LANSING, MI	433,000	ND	ND	ND	ND	ND	ND	0.1	ND
LAREDO, TX	133,000	58	IN	ND	ND	ND	ND	ND	ND
LAS CRUCES, NM	136,000	109	39	0.016	0.088	5	ND	0.12	0.13
LAS VEGAS, NV	741,000	95	IN	ND	ND	***10***	0.031	0.1	ND
LAWRENCE, KS	82,000	ND	ND	ND	ND	ND	ND	ND	ND
LAWRENCE-HAVERHILL, MA-NH	394,000	48	19	0.008	0.029	ND	ND	0.11	ND
LAWTON, OK	111,000	52	IN	ND	ND	3	IN	ND	ND
LEWISTON-AUBURN, ME	88,000	58	24	0.005	0.02	ND	ND	ND	0.02
LEXINGTON-FAYETTE, KY	348,000	53	26	0.007	0.03	4	0.016	0.08	ND
LIMA, OH	154,000	49	IN	0.004	0.02	ND	ND	0.1	ND
LINCOLN, NE	214,000	50	25	ND	ND	6	ND	0.07	ND
LITTLE ROCK-NORTH LITTLE ROCK, AR	513,000	79	32	0.005	0.012	ND	0.012	0.09	ND

LONGVIEW-MARSHALL, TX	162,000	ND	ND	ND	ND	ND	ND	0.1	ND	
LORAIN-ELYRIA, OH	271,000	74	27	0.007	0.032	ND	ND	0.1	ND	
LOS ANGELES-LONG BEACH, CA	8,863,000	***176***	49	0.006	0.027	***16***	0.051	***0.29***	0.48	
LOUISVILLE, KY-IN	953,000	58	33	0.012	0.042	8	0.012	0.11	0.05	
LOWELL, MA-NH	273,000	ND	ND	ND	ND	6	ND	ND	ND	
LUBBOCK, TX	223,000	58	22	ND	ND	ND	ND	ND	ND	
LYNCHBURG, VA	142,000	45	24	ND	ND	ND	ND	0.09	ND	
MACON-WARNER ROBINS, GA	281,000	ND	ND	ND	ND	ND	ND	ND	ND	
MADISON, WI	367,000	63	22	IN	0.016	4	ND	0.09	ND	
MANCHESTER, NH	148,000	52	18	0.008	0.067	6	0.015	0.1	0.02	
MANSFIELD, OH	126,000	68	26	ND	ND	ND	ND	ND	ND	
MAYAGUEZ, PR	210,000	ND	ND	ND	ND	ND	ND	ND	ND	
MCALLEN-EDINBURG-MISSION, TX	384,000	ND	ND	ND	ND	ND	ND	ND	ND	
MEDFORD, OR	146,000	117	42	ND	ND	7	ND	ND	0.02	
MELBOURNE-TITUSVILLE-PALM BAY, FL	399,000	43	18	ND	ND	ND	ND	0.09	ND	
MEMPHIS, TN-AR-MS	982,000	63	31	0.009	0.034	9	0.026	0.12	***1.84***	#
MERCED, CA	178,000	82	46	ND	ND	ND	0.015	0.12	ND	
MIAMI-HIALEAH, FL	1,937,000	62	29	0.001	0.005	7	0.016	0.11	0.01	
MIDDLESEX-SOMERSET-HUNTERDON, NJ	1,020,000	54	25	0.006	0.026	4	ND	***0.13***	1.22	@
MIDDLETOWN, CT	90,000	58	21	ND	ND	ND	ND	***0.13***	ND	
MIDLAND, TX	107,000	ND	ND	ND	ND	ND	ND	ND	ND	
MILWAUKEE, WI	1,432,000	66	28	0.006	0.029	4	0.024	0.11	0.06	
MINNEAPOLIS-ST. PAUL, MN-WI	2,464,000	73	26	0.011	0.08	8	0.021	0.09	0.89	
MOBILE, AL	477,000	86	42	0.01	0.055	ND	ND	0.11	ND	
MODESTO, CA	371,000	85	44	ND	ND	6	0.022	0.11	ND	

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

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from an industrial source in Indianapolis, IN. Highest population oriented site in Indianapolis, IN is 0.37 ug/m3.

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

@ - Impact from an industrial source in New Brunswick, NJ.

TABLE 5-6. 1992 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1990 POPULATION	PM10 2ND MAX (UGM)	PM10 WTD AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8-HR (PPM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PB QMAX (UGM)
MONMOUTH-OCEAN, NJ	986,000	ND	ND	ND	ND	5	ND	***0.14***	ND
MONROE, LA	142,000	79	28	0.002	0.01	ND	0.009	0.09	ND
MONTGOMERY, AL	293,000	48	24	ND	ND	ND	ND	0.1	ND
MUNCIE, IN	120,000	ND	ND	ND	ND	ND	ND	ND	ND
MUSKEGON, MI	159,000	ND	ND	ND	ND	ND	ND	0.12	0.02
NAPLES, FL	152,000	ND	ND	ND	ND	ND	ND	ND	ND
NASHUA, NH	181,000	54	19	0.005	0.02	7	ND	0.1	0.03
NASHVILLE, TN	985,000	74	34	0.01	0.052	6	0.014	0.12	0.83 *
NASSAU-SUFFOLK, NY	2,609,000	71	20	0.008	0.04	6	0.026	***0.13***	ND
NEW BEDFORD, MA	176,000	42	17	ND	ND	ND	ND	0.11	ND
NEW BRITAIN, CT	148,000	63	20	ND	ND	ND	ND	ND	ND
NEW HAVEN-MERIDEN, CT	530,000	112	33	0.012	0.052	5	0.025	0.12	0.13
NEW LONDON-NORWICH, CT-RI	267,000	57	20	0.006	0.025	ND	ND	0.12	ND
NEW ORLEANS, LA	1,239,000	99	29	0.005	0.019	6	0.023	0.11	0.05
NEW YORK, NY	8,547,000	96	28	0.019	0.071	9	0.036	0.12	0.11
NEWARK, NJ	1,824,000	60	30	0.012	0.048	7	0.038	***0.13***	0.44
NIAGARA FALLS, NY	221,000	58	24	0.012	0.074	4	ND	0.11	ND
NORFOLK-VIRGINIA BEACH-NEWPORT NEWS,	1,396,000	49	24	0.006	0.025	5	0.02	***0.14***	0.03
NORWALK, CT	127,000	64	29	ND	ND	ND	ND	ND	ND
OAKLAND, CA	2,083,000	73	29	0.003	0.012	5	0.022	0.11	0.03
OCALA, FL	195,000	ND	ND	ND	ND	ND	ND	ND	ND
ODESSA, TX	119,000	ND	ND	ND	ND	ND	ND	ND	ND
OKLAHOMA CITY, OK	959,000	59	23	0.002	0.009	6	0.013	0.1	0.03
OLYMPIA, WA	161,000	78	IN	ND	ND	5	ND	ND	ND
OMAHA, NE-IA	618,000	109	44	0.002	0.008	7	ND	0.09	***4.51*** #
ORANGE COUNTY, NY	308,000	ND	ND	ND	ND	ND	ND	ND	0.93 +
ORLANDO, FL	1,073,000	52	27	0.002	0.007	4	0.011	0.1	0
OWENSBORO, KY	87,000	53	28	0.009	0.053	5	0.012	0.09	ND
OXNARD-VENTURA, CA	669,000	77	32	0.001	0.008	3	0.022	***0.14***	ND
PANAMA CITY, FL	127,000	ND	ND	ND	ND	ND	ND	ND	ND
PARKERBURG-MARIETTA, WV-OH	149,000	58	IN	0.014	0.059	ND	IN	***0.22***	0.02
PASCAGOULA, MS	115,000	34	IN	IN	0.021	ND	ND	0.09	ND
PAWTUCKET-WOONSOCKET-ATTLEBORO, RI-MA	329,000	55	25	0.01	0.042	ND	ND	ND	ND
PENSACOLA, FL	344,000	ND	ND	0.008	0.069	ND	ND	0.11	ND
PEORIA, IL	339,000	57	31	0.007	0.05	7	ND	0.09	0.02
PHILADELPHIA, PA-NJ	4,857,000	***168***	38	0.013	0.042	***7***	0.035	***0.13***	***17.6*** @
PHOENIX, AZ	2,122,000	***158***	34	0.004	0.01	***10***	0.014	0.12	0.06
PINE BLUFF, AR	85,000	51	22	ND	ND	ND	ND	ND	ND
PITTSBURGH, PA	2,243,000	129	34	0.023	0.109	7	0.024	0.1	0.05
PITTSFIELD, MA	79,000	ND	ND	ND	ND	ND	ND	0.11	ND

PONCE, PR	235,000	79	30	ND	ND	ND	ND	ND	ND
PORTLAND, ME	215,000	63	23	0.008	0.029	ND	0.014	0.12	0.03
PORTLAND, OR-WA	1,240,000	74	30	0.006	0.017	8	IN	0.11	0.07
PORTSMOUTH-DOVER-ROCHESTER, NH-ME	224,000	63	20	0.006	0.027	ND	0.013	0.11	0.02
POUGHKEEPSIE, NY	259,000	ND	ND	ND	ND	ND	ND	0.11	ND
PROVIDENCE, RI	655,000	64	31	0.011	0.044	6	0.023	0.12	0.04
PROVO-OREM, UT	264,000	***224***	41	ND	ND	***10***	0.019	0.09	ND
PUEBLO, CO	123,000	54	26	ND	ND	ND	ND	ND	ND
RACINE, WI	175,000	ND	ND	ND	ND	5	ND	0.1	ND
RALEIGH-DURHAM, NC	735,000	47	24	ND	ND	7	0.015	0.1	ND
RAPID CITY, SD	81,000	144	43	ND	ND	ND	ND	ND	0.12
READING, PA	337,000	47	23	0.009	0.038	5	0.02	0.1	1.44 $
REDDING, CA	147,000	83	25	ND	ND	1	ND	0.08	ND
RENO, NV	255,000	137	35	ND	ND	8	ND	0.09	ND
RICHLAND-KENNEWICK-PASCO, WA	155,000	85	IN	ND	ND	ND	ND	ND	ND
RICHMOND-PETERSBURG, VA	866,000	50	23	0.005	0.024	3	0.023	0.12	ND
RIVERSIDE-SAN BERNARDINO, CA	2,589,000	***156***	***79***	0.002	0.011	6	0.04	***0.26***	0.04
ROANOKE, VA	224,000	72	35	0.004	0.016	ND	0.013	0.09	ND
ROCHESTER, MN	106,000	37	IN	0.002	0.015	5	ND	ND	ND
ROCHESTER, NY	1,002,000	56	26	0.013	0.045	4	ND	0.1	0.04
ROCKFORD, IL	284,000	49	21	ND	ND	5	ND	0.1	0.06
SACRAMENTO, CA	1,481,000	84	31	0.002	0.01	9	0.021	***0.16***	0.02
SAGINAW-BAY CITY-MIDLAND, MI	399,000	122	29	ND	ND	ND	0.008	ND	0.01
ST. CLOUD, MN	191,000	31	11	0.002	0.015	4	ND	ND	ND
ST. JOSEPH, MO	83,000	93	39	ND	ND	ND	ND	ND	ND

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

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from an industrial source in Williamson County, TN. Highest site in Nashville, TN is 0.11 ug/m3.

- Impact from an industrial source in Omaha, NE.

+ - Impact from an industrial source in Orange County, NY.

@ - Impact from an industrial source. Highest population oriented site in Philadelphia, PA is 0.39 ug/m3

$ - Impact from an industrial source in Reading, PA.

TABLE 5-6. 1992 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1990 POPULATION	PM10 2ND MAX (UGM)	PM10 WTD AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8-HR (PPM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PB QMAX (UGM)
ST. LOUIS, MO-IL	2,444,000	90	50	0.013	0.061	7	0.028	***0.13***	***11.8*** *
SALEM, OR	278,000	ND	ND	ND	ND	8	ND	ND	ND
SALEM-GLOUCESTER, MA	264,000	ND	ND	0.008	0.039	ND	ND	ND	ND
SALINAS-SEASIDE-MONTEREY, CA	356,000	38	22	ND	ND	2	0.012	0.08	ND
SALT LAKE CITY-OGDEN, UT	1,072,000	***179***	***51***	0.013	0.073	9	0.026	0.1	0.06
SAN ANGELO, TX	98,000	ND	ND	ND	ND	ND	ND	ND	ND
SAN ANTONIO, TX	1,302,000	53	29	ND	ND	5	ND	0.1	0.03
SAN DIEGO, CA	2,498,000	58	36	0.005	0.022	7	0.027	***0.16***	0.03
SAN FRANCISCO, CA	1,604,000	75	32	0.002	0.012	6	0.022	0.07	0.02
SAN JOSE, CA	1,498,000	100	34	ND	ND	7	0.028	0.12	0.03
SAN JUAN, PR	1,541,000	91	29	0.013	0.101	6	ND	0.07	ND
SANTA BARBARA-SANTA MARIA-LOMPOC, CA	370,000	ND	ND	0.001	0.004	2	0.013	0.12	ND
SANTA CRUZ, CA	230,000	35	22	ND	ND	ND	ND	0.07	ND
SANTA FE, NM	117,000	48	17	0.001	0.006	4	0.003	0.08	ND
SANTA ROSA-PETALUMA, CA	388,000	50	19	ND	ND	4	0.016	0.09	0.01
SARASOTA, FL	278,000	101	31	0.003	0.021	6	ND	0.1	ND
SAVANNAH, GA	243,000	ND	ND	0.002	0.008	ND	ND	ND	ND
SCRANTON-WILKES-BARRE, PA	734,000	50	29	0.009	0.034	4	0.017	0.1	0.05
SEATTLE, WA	1,973,000	114	38	0.01	0.024	9	ND	0.1	0.4
SHARON, PA	121,000	58	27	0.006	0.03	ND	ND	0.1	0.07
SHEBOYGAN, WI	104,000	ND	ND	ND	ND	ND	ND	0.1	ND
SHERMAN-DENISON, TX	95,000	ND	ND	ND	ND	ND	ND	ND	ND
SHREVEPORT, LA	334,000	52	24	0.003	0.013	ND	IN	0.1	ND
SIOUX CITY, IA-NE	115,000	87	IN	ND	ND	ND	ND	ND	ND
SIOUX FALLS, SD	124,000	48	26	ND	ND	ND	ND	ND	ND
SOUTH BEND-MISHAWAKA, IN	247,000	69	23	IN	0.013	3	IN	0.1	ND
SPOKANE, WA	361,000	***321***	39	ND	ND	***10***	ND	0.08	ND
SPRINGFIELD, IL	190,000	54	27	0.006	0.043	5	ND	0.09	ND
SPRINGFIELD, MO	241,000	44	19	0.006	0.056	8	0.01	0.09	ND
SPRINGFIELD, MA	530,000	75	27	0.011	0.045	7	0.024	0.12	0.05
STAMFORD, CT	203,000	48	24	0.009	0.041	6	ND	0.11	ND
STATE COLLEGE, PA	124,000	ND	ND	ND	ND	ND	ND	ND	ND
STEUBENVILLE-WEIRTON, OH-WV	143,000	128	40	0.024	0.098	7	0.02	0.09	0.14
STOCKTON, CA	481,000	88	45	ND	ND	7	0.023	0.1	ND
SYRACUSE, NY	660,000	69	33	0.004	0.013	8	ND	0.1	0.24
TACOMA, WA	586,000	105	36	0.01	0.035	9	ND	0.1	ND
TALLAHASSEE, FL	234,000	ND	ND	ND	ND	ND	ND	0.08	ND
TAMPA-ST. PETERSBURG-CLEARWATER, FL	2,068,000	64	30	0.007	0.062	4	0.013	0.11	1.35 #
TERRE HAUTE, IN	131,000	65	29	0.007	0.035	ND	ND	0.08	ND
TEXARKANA, TX-AR	120,000	50	23	ND	ND	ND	ND	ND	ND

TOLEDO, OH	614,000	53	28	0.006	0.029	4	ND	0.09	0.57
TOPEKA, KS	161,000	58	28	ND	ND	ND	ND	ND	0.01
TRENTON, NJ	326,000	49	26	ND	ND	ND	ND	***0.15***	ND
TUCSON, AZ	667,000	95	32	0.002	0.007	6	0.025	0.1	0.06
TULSA, OK	709,000	59	26	0.011	0.053	6	0.018	0.1	0.1
TUSCALOOSA, AL	151,000	45	26	ND	ND	ND	ND	ND	ND
TYLER, TX	151,000	41	19	ND	ND	ND	ND	ND	ND
UTICA-ROME, NY	317,000	45	24	ND	ND	ND	ND	0.09	ND
VALLEJO-FAIRFIELD-NAPA, CA	451,000	73	27	0.002	0.013	6	0.017	0.1	0.02
VANCOUVER, WA	238,000	67	23	ND	ND	8	ND	0.1	ND
VICTORIA, TX	74,000	ND	ND	ND	ND	ND	ND	0.1	ND
VINELAND-MILLVILE-BRIDGETON, NJ	138,000	ND	ND	0.006	0.021	ND	ND	0.1	ND
VISALIA-TULARE-PORTERVILLE, CA	312,000	114	IN	ND	ND	4	0.02	***0.13***	ND
WACO, TX	189,000	ND	ND	ND	ND	ND	ND	ND	ND
WASHINGTON, DC-MD-VA	3,924,000	60	28	0.01	0.042	7	0.028	0.12	0.03
WATERBURY, CT	222,000	53	24	0.007	0.029	ND	ND	ND	0.19
WATERLOO-CEDAR FALLS, IA	147,000	74	IN	ND	ND	ND	ND	ND	ND
WAUSAU, WI	115,000	ND	ND	ND	ND	ND	ND	0.09	ND
WEST PALM BEACH-BOCA RATON-DELRAY BEAC	864,000	48	21	0.003	0.01	4	0.011	0.07	0
WHEELING, WV-OH	159,000	67	31	0.02	0.09	6	ND	0.1	ND
WICHITA, KS	485,000	86	37	0.006	0.034	6	ND	0.09	0.02
WICHITA FALLS, TX	122,000	52	IN	ND	ND	ND	ND	ND	ND
WILLIAMSPORT, PA	119,000	42	24	0.007	0.029	ND	ND	0.09	ND
WILMINGTON, DE-NJ-MD	579,000	57	28	0.016	0.072	4	0.017	0.12	0.05
WILMINGTON, NC	120,000	46	23	ND	ND	ND	ND	0.1	ND
WORCESTER, MA	437,000	49	IN	0.007	0.033	8	0.024	***0.13***	ND
YAKIMA, WA	189,000	120	IN	ND	ND	9	ND	ND	ND
YORK, PA	418,000	47	27	0.007	0.034	4	0.02	0.1	0.05
YOUNGSTOWN-WARREN, OH	493,000	74	28	0.011	0.039	2	ND	0.11	ND
YUBA CITY, CA	123,000	ND	ND	ND	ND	6	0.017	0.11	ND
YUMA, AZ	107,000	50	IN	ND	ND	ND	ND	ND	ND

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

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from an industrial source in Madison County, IL. Highest site in St. Louis, MO is 0.07 ug/m3.

\# - Impact from an industrial source in Tampa, FL. Highest population oriented site in Tampa, FL is 0.01 ug/m3.

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 discusses 1983-92 air quality trends in 23 major urban areas: the ten EPA Regional Offices (Boston, New York, Philadelphia, Atlanta, Chicago, Dallas, Kansas City, Denver, San Francisco and Seattle) and thirteen additional cities (Baltimore, Cleveland, Detroit, El Paso, Houston, Los Angeles, Miami, Minneapolis-St. Paul, Phoenix, Pittsburgh, San Diego, St. Louis and Washington, DC.) The areas are defined as either the Primary Metropolitan Statistical Area (PMSA) or Consolidated Metropolitan Statistical Area (CMSA).

The presentation of urban area trends includes tables of the Pollutant Standards Index (PSI) for the areas, maps of the urban area showing the toxic release inventory sites (TRI), and a graphical display of the PSI trends for each individual area. To complement the map and show the major factors affecting air pollution in each specific area, toxic emissions and transportation statistics (VMT, vehicle counts, etc.) are included. The PSI trend is shown in the number of days in 5 PSI categories.

The air quality data used for the trend statistics were obtained from the EPA Aerometric Information Retrieval System (AIRS). This is the third year that the report presents trends in the PSI, used locally in many areas to characterize and publicly report air quality. The PSI analyses are based on daily maximum statistics from selected monitoring sites. It should be noted that no interpolation is used in this chapter; this corresponds with typical PSI reporting.

6.1 The Pollutant Standards Index

The PSI is used in this section as an air quality indicator for describing urban area trends. The PSI has found widespread use in the air pollution field to report daily air quality to the general public. The index integrates information from many pollutants across an entire monitoring network into a single number that represents the worst daily air quality experienced in the urban area. 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 criteria pollutant not included in the index because it does not have a short-term NAAQS, a Federal Episode Criteria or a Significant Harm Level.

The PSI converts daily monitoring information into a single measure of air quality 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. 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 and one O_3 trend site. 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 1992, 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 0 to 500. The PSI uses data from all selected sites in the PMSA or 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 5 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.

Table 6-1. PSI Categories and Health Effect Descriptor Words

Index Range	Descriptor Words
0 to 50	Good
51 to 100	Moderate
101 to 199	Unhealthful
200 to 299	Very Unhealthful
300 and Above	Hazardous

Throughout this section, emphasis is placed on CO and O_3 which cause most of the NAAQS violations in urban areas.

6.2 Summary of PSI Analyses

Table 6-2 shows the trend in the number of PSI days greater than 100 (unhealthful or worse days). The impact of the very hot and dry summers in 1983 and 1988 in the eastern United States on O_3 concentrations can clearly be seen. Pittsburgh is the only city where a significant number of 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. The two right most columns show the number of corresponding total number of PSI days greater than 100, using all active monitoring sites. Note that for all urban areas except El Paso, there is close agreement between the two totals for 1992 of the number of days when the PSI is greater than 100. The differences are attributed to currently active sites without sufficient historical data to be used for trends. For all practical purposes CO, O_3, PM-10 and SO_2 are the only pollutants that contribute to the PSI in these analyses. 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. 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.

Table 6-3 shows the trend in the number of PSI days greater than 100 (unhealthful or worse) due to only O_3. The 9 areas where O_3 did not account for all of the PSI greater than 100 days in 1992 were: Boston, Chicago, Cleveland, Denver, El Paso, Los Angeles, New York City, Phoenix, and Pittsburgh. In Denver, Los Angeles and New York City, CO accounted for the additional PSI greater than 100 days. In Chicago, Cleveland and Pittsburgh PM-10 accounted for the extra PSI greater than 100 days. In the other areas a combination of PM-10 and CO accounted for the extra days. Because of the overall improvement in CO levels (see Section 3.1 in this report), CO accounts for far less of these days in the latter half of the 10-year period. Overall, 66 percent of the PSI greater than 100 days were due to O_3.

There are several assumptions that are implicit in the 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. Finally, the PSI assumes that synergism does not exist between pollutants. Each pollutant is examined independently. Combining pollutant concentrations is not possible at this time because the synergistic effects upon health are not understood.

Note: Urban lead concentrations have dropped dramatically over the past 15 or so years (See Chapter 3). As a result, lead violations now occur typically in the vicinity of lead point sources. Of the 23 urban areas featured in this chapter, only Cleveland, Philadelphia, St. Louis have a 1992 lead violation. In Cleveland, an enforcement action has been initiated at the facility. In Philadelphia, the problem occurred near a lead smelter and a materials handling operation. In St. Louis, the problem occurred near an industrial source.

Table 6-2. Number of PSI Days Greater Than 100 at Trend Sites, 1983-92, and All Sites in 1992

	NUMBER OF PSI DAYS GREATER THAN 100 AT TREND SITES YEAR											All Active Monitoring Sites in MSA 1992	
MSA	# trend sites	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Total # sites	PSI > 100
ATLANTA	6	23	8	9	17	19	15	3	16	5	4	12	5
BALTIMORE	16	60	46	21	24	28	41	7	12	20	4	31	6
BOSTON	30	37	28	9	9	10	17	5	3	7	4	51	4
CHICAGO	58	23	18	16	15	21	30	6	7	15	8	95	8
CLEVELAND	29	17	4	1	2	10	18	8	1	5	3	48	5
DALLAS	16	20	18	19	10	10	6	4	7	7	4	35	5
DENVER	19	69	62	39	47	37	19	12	7	7	7	35	7
DETROIT	28	18	7	2	5	9	18	10	3	7	0	45	1
EL PASO	16	16	20	24	34	27	13	29	20	8	11	25	25
HOUSTON	29	70	49	48	45	54	48	32	48	40	29	44	33
KANSAS CITY	19	4	12	3	4	3	3	2	2	1	1	29	1
LOS ANGELES	85	194	225	205	218	199	240	231	180	177	183	142	187
MIAMI	13	3	2	5	4	4	4	4	1	2	0	37	0
MINNEAPOLIS-ST. PAUL	15	36	21	21	13	7	1	6	1	0	0	41	0
NEW YORK	70	89	140	88	72	64	58	27	24	30	10	119	13
PHILADELPHIA	52	58	39	29	24	37	43	22	17	32	8	77	11
PHOENIX	22	72	107	82	85	40	22	30	8	4	8	31	14
PITTSBURGH	31	27	15	9	8	13	23	9	11	3	1	61	2
SAN DIEGO	21	60	51	54	45	41	49	61	39	25	19	34	19
SAN FRANCISCO	52	26	33	31	16	15	11	17	7	12	2	82	2
SEATTLE	15	11	4	27	11	13	6	4	3	0	0	25	3
ST. LOUIS	45	33	22	10	14	16	17	12	8	6	2	68	3
WASHINGTON	29	53	30	15	12	25	35	7	5	16	2	59	2
TOTAL	716	1019	961	767	734	702	737	548	430	429	310	1226	356

Table 6-3. (Ozone Only) Number of PSI Days Greater Than 100 at Trend Sites, 1983-92, and All Sites in 1992.

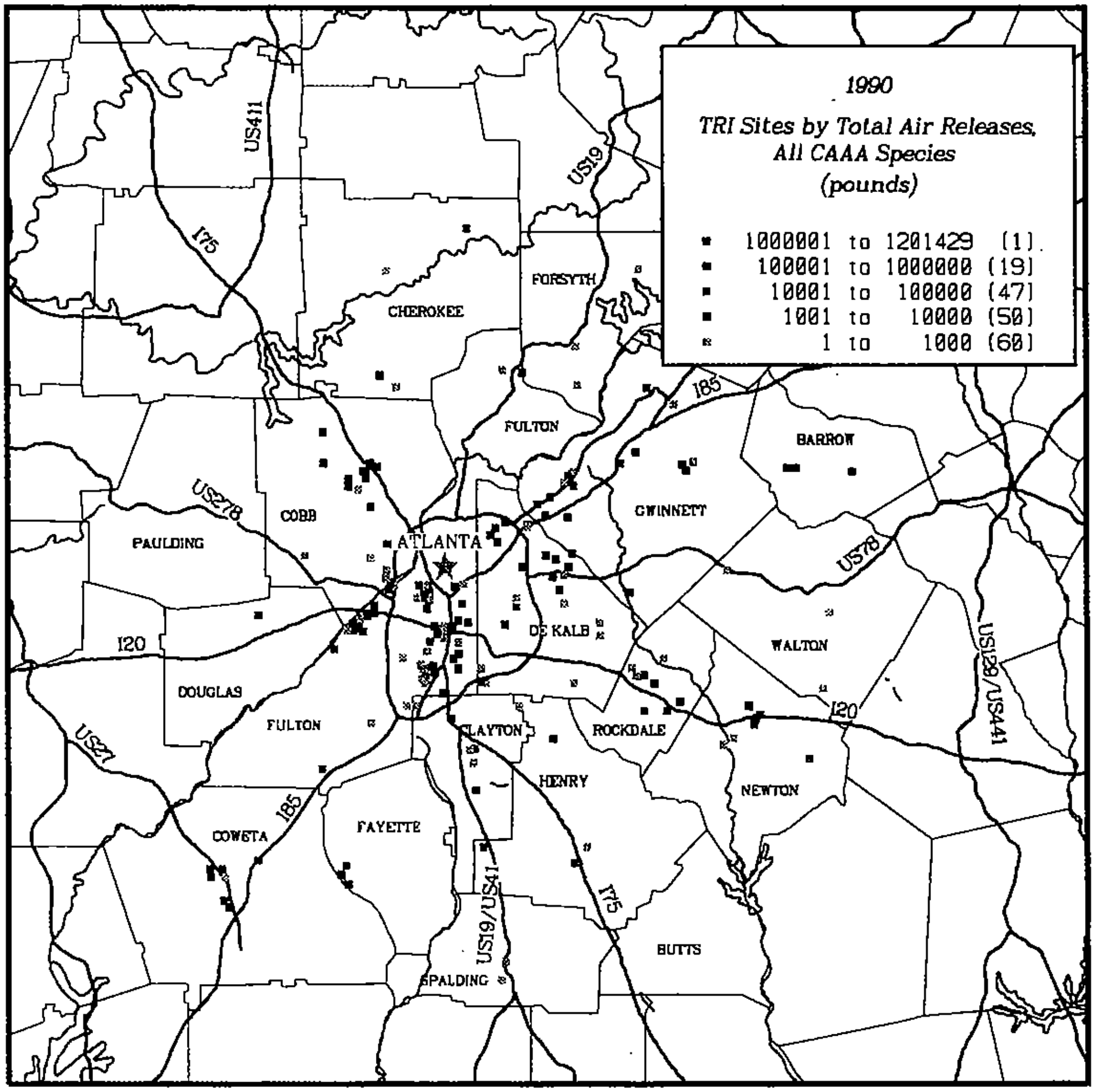
		Number of PSI Days Greater Than 100 at Ozone Trend Sites YEAR										All Active O3 monitoring sites in MSA 1992	
MSA	O3 trend sites	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	total O3 sites	PSI > 100
ATLANTA	2	23	8	9	17	19	15	3	16	5	4	4	5
BALTIMORE	7	38	19	13	19	26	38	7	11	20	4	8	6
BOSTON	6	13	10	5	3	7	16	4	1	7	2	9	2
CHICAGO	19	21	14	8	9	16	26	4	2	12	3	26	3
CLEVELAND	8	17	3	1	2	10	18	6	1	5	1	10	3
DALLAS	5	20	18	18	10	10	6	4	7	7	4	8	5
DENVER	3	14	2	0	3	5	4	1	0	0	0	8	0
DETROIT	9	16	4	1	3	6	17	10	3	7	0	12	0
EL PASO	3	3	9	10	11	12	3	10	4	5	6	4	6
HOUSTON	10	68	49	48	43	51	48	32	48	40	29	13	33
KANSAS CITY	5	4	11	3	3	2	3	1	2	1	1	6	1
LOS ANGELES	35	154	172	158	165	158	181	156	131	130	142	46	145
MIAMI	4	0	0	3	4	4	4	3	1	2	0	7	0
MINNEAPOLIS-ST. PAUL	4	2	2	0	1	1	1	1	0	0	0	5	0
NEW YORK	14	60	36	37	25	34	44	21	19	26	9	22	9
PHILADELPHIA	15	54	29	29	22	33	43	20	17	32	8	16	8
PHOENIX	7	13	11	6	0	2	2	0	2	0	4	9	5
PITTSBURGH	6	9	0	2	1	5	14	2	0	1	0	9	0
SAN DIEGO	7	59	51	50	42	40	45	54	39	25	19	9	19
SAN FRANCISCO	20	21	22	8	5	14	5	4	2	2	2	24	2
SEATTLE	1	0	0	0	1	0	1	0	2	0	0	3	0
ST. LOUIS	15	33	20	10	12	14	17	7	8	6	2	17	2
WASHINGTON	12	39	12	12	10	20	34	4	5	16	2	15	2
TOTAL	217	681	502	431	411	489	585	354	321	349	242	290	256

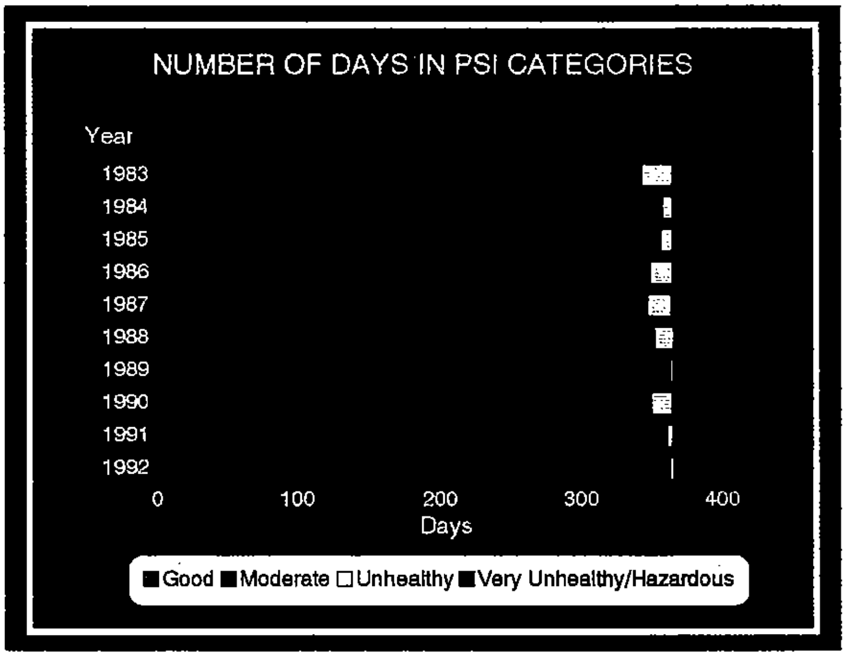
6.3 Description of Graphics

The highlights of the principal analyses for each of the 23 cities are expressed on a single page in bullets of salient information and supporting graphics. The bullets refer to facts about the MSAs focusing principally on TRI sources and emissions totals; and transportation statistics such as VMT, percent carpooling, and mass transit usage.

The accompanying graphs are based on the PSI methodology described earlier. The PSI graphs feature a bar chart which shows the number of PSI days in four PSI categories: 0-50 (good), 51-100 (moderate), 101-199 (unhealthful) and $\geq$200 (very unhealthful and hazardous). Table 6-1 shows the PSI descriptor words associated with these categories. The last 2 PSI categories (very unhealthful and hazardous) were combined because there were so few hazardous days reported. The total number of unhealthful, very unhealthful and hazardous days is used to indicate trends. These days are sometimes referred to as the days when the PSI is greater than 100. It is important to note that a PSI of 100 means that the pollutant with the highest sub-index value is at the level of its NAAQS. Because of numerical rounding, the number of days with PSI greater than 100 does not necessarily correspond exactly to the number of NAAQS exceedances.

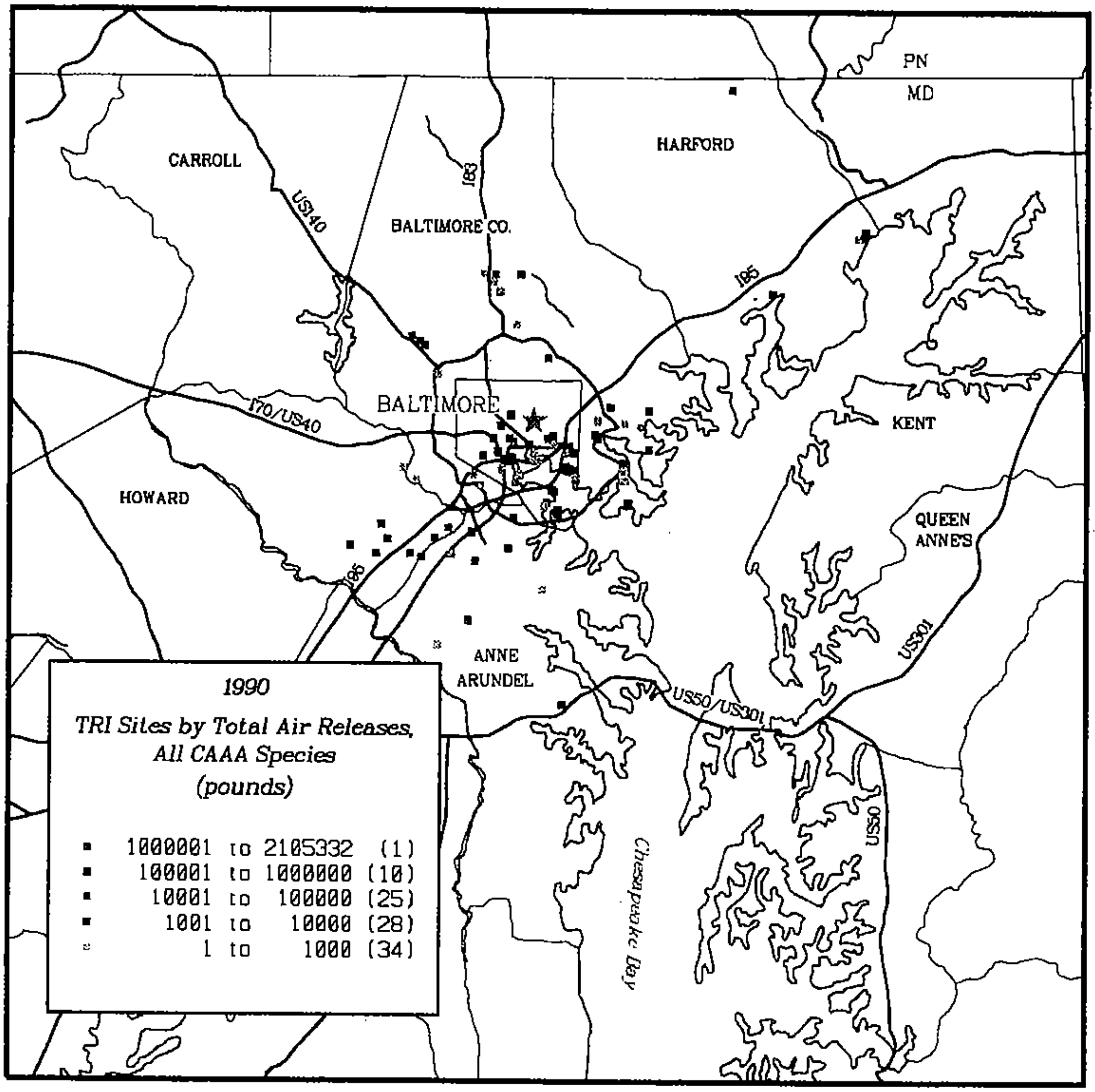
ATLANTA

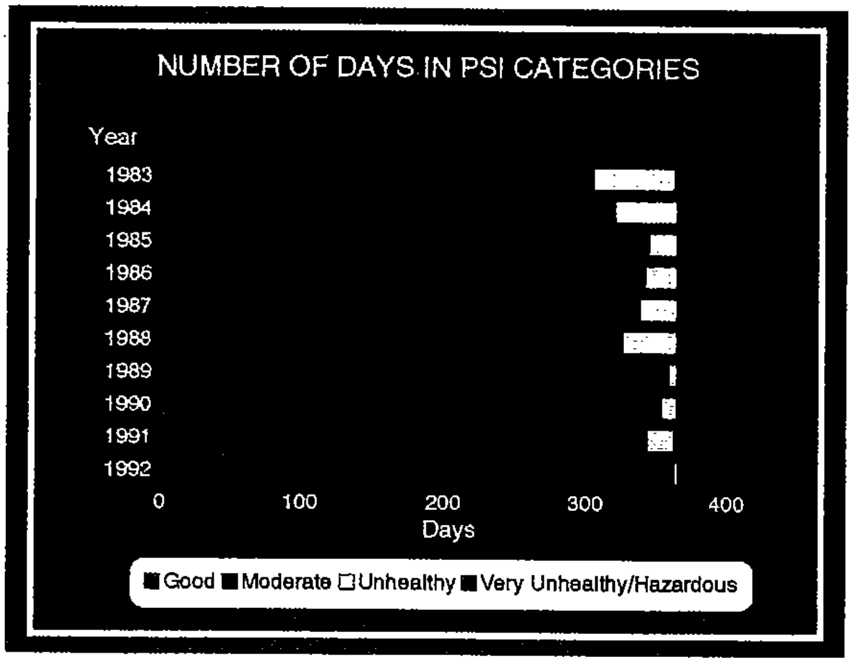




- Increase of 3.1% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 15% to 12,747 between 1983 and 1990.
- State vehicle registrations per capita increased 11% to 1.064 between 1983 and 1990.
- 1992 daily VMT equalled 72,104,133 miles.
- Percent of the population using single occupant vehicles for work trips increased from 68.1% in 1980 to 78.2% in 1990. Transit use decreased from 7.1% to 5.1%; carpooling decreased from 20% to 12% during the same period.

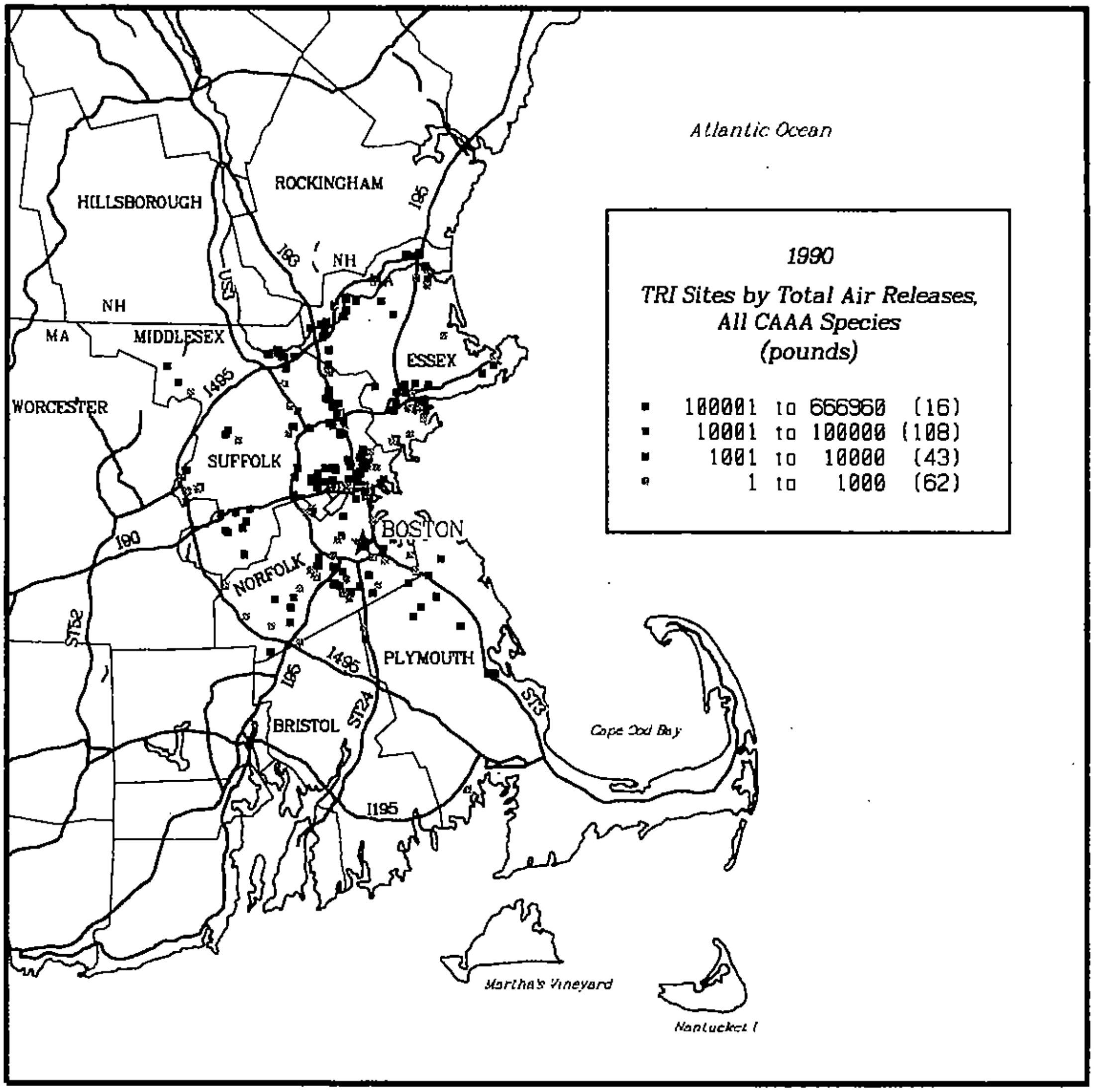
BALTIMORE

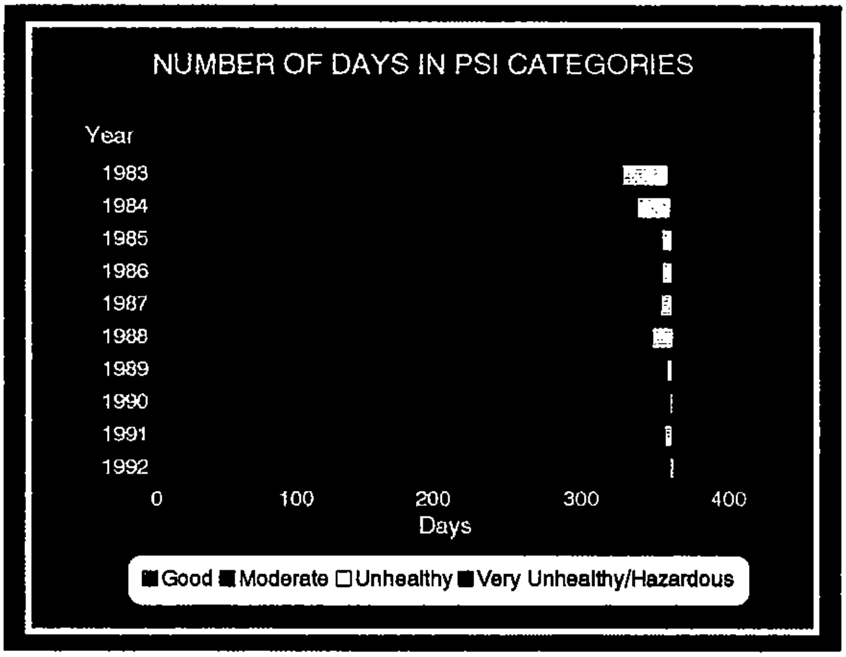




- Decrease of 16% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 12% to 10,030 between 1983 and 1990.
- State vehicle registrations per capita increased 5% to 0.93 between 1983 and 1990.
- Average vehicle occupancy for work trips decreased from 1.37 in 1980 to 1.20 in 1990.
- Daily VMT increased 40% between 1980 and 1990.
- Percent of the population using single occupant vehicles for work trips increased from 61% in 1980 to 73% in 1990. Transit use decreased from 10% to 7.8%; carpooling decreased from 23% to 15% during the same period.

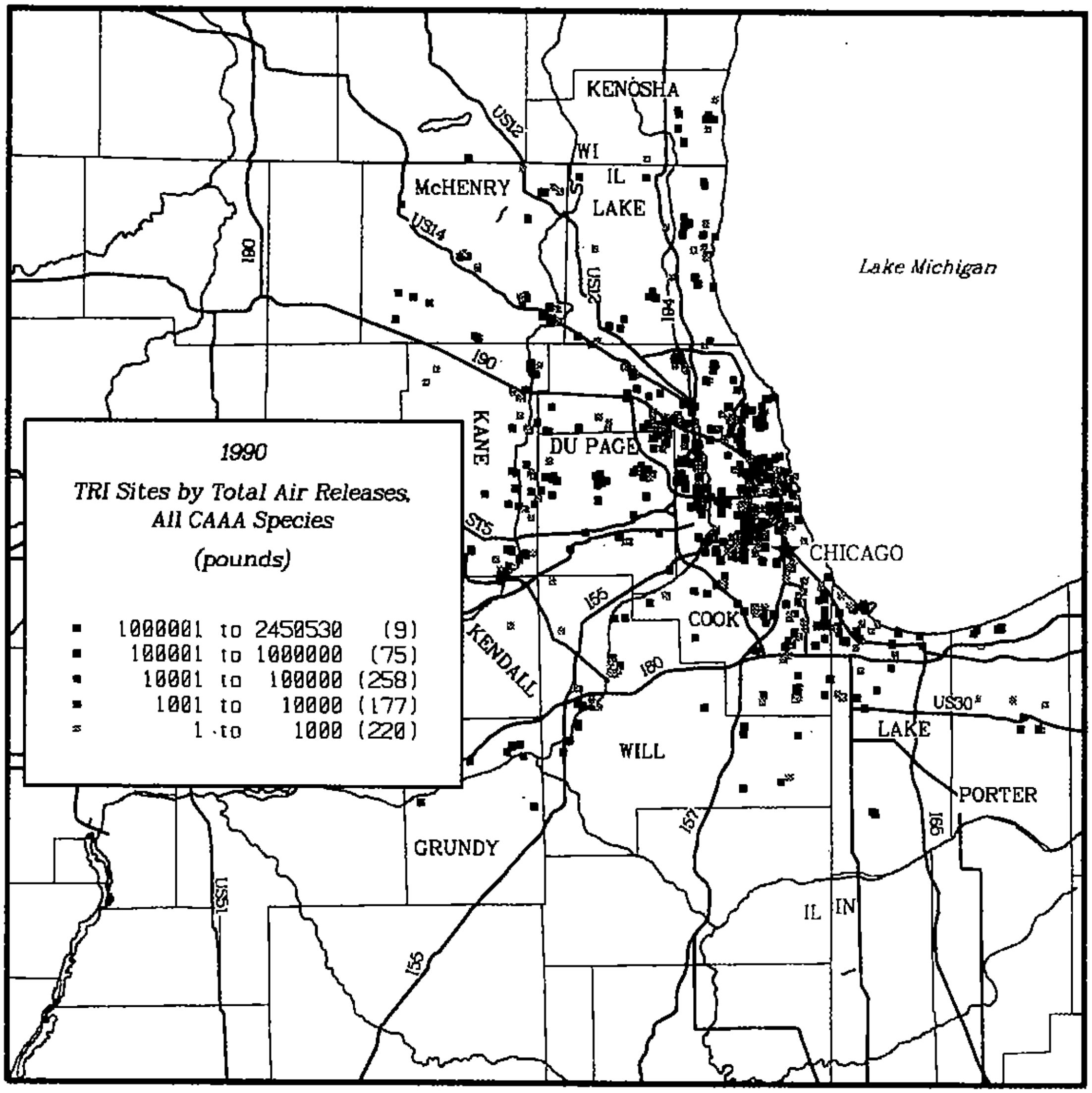
BOSTON

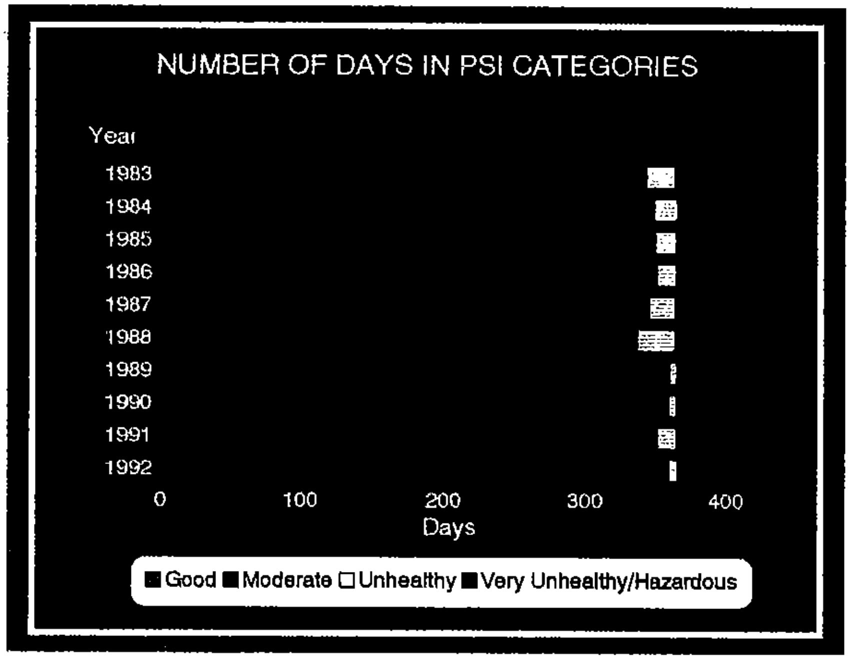




- Decrease of 11.8% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 11% to 8,667 between 1983 and 1990.
- State vehicle registrations per capita decreased 5% to 0.79 between 1983 and 1990.

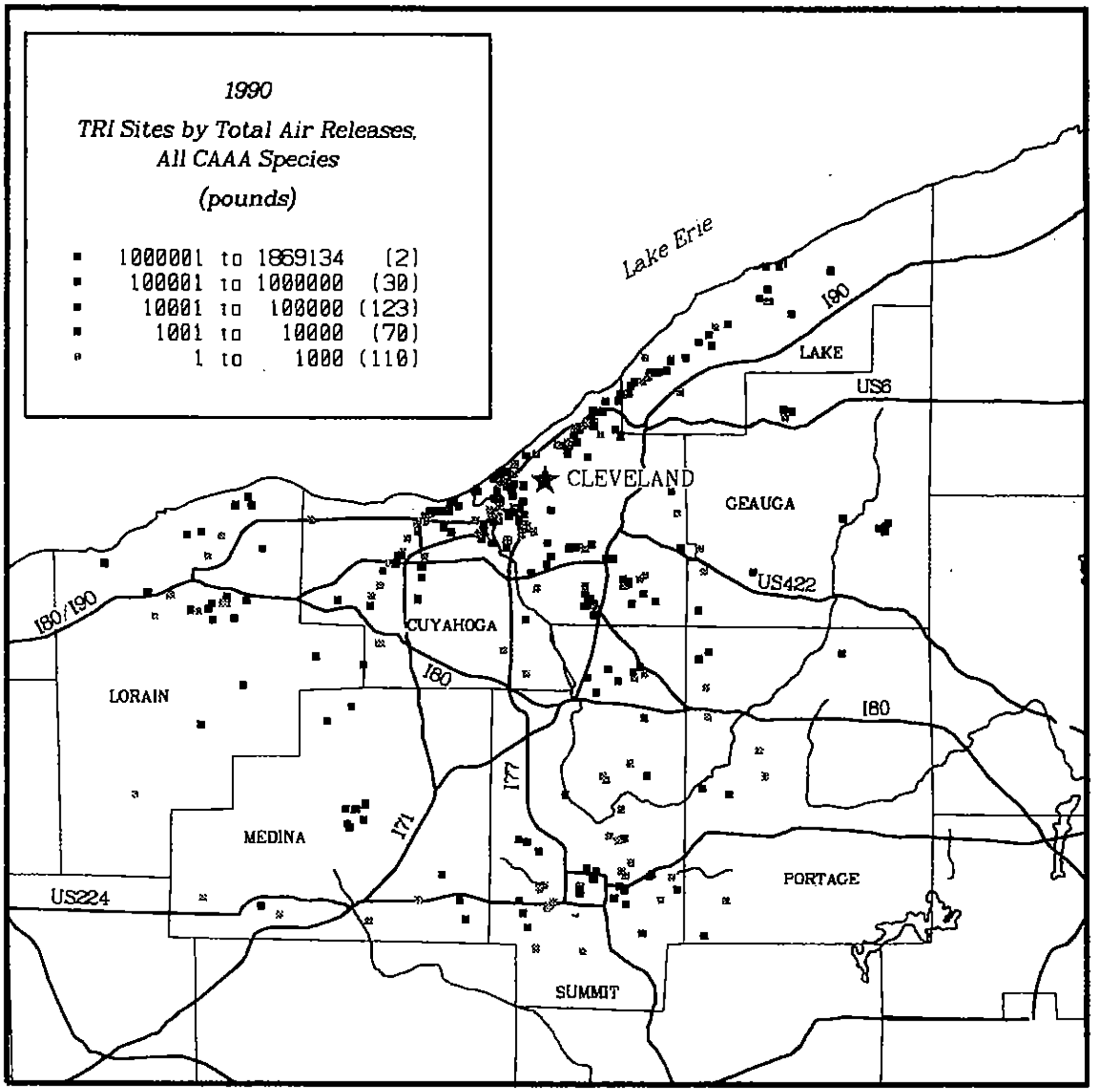
CHICAGO

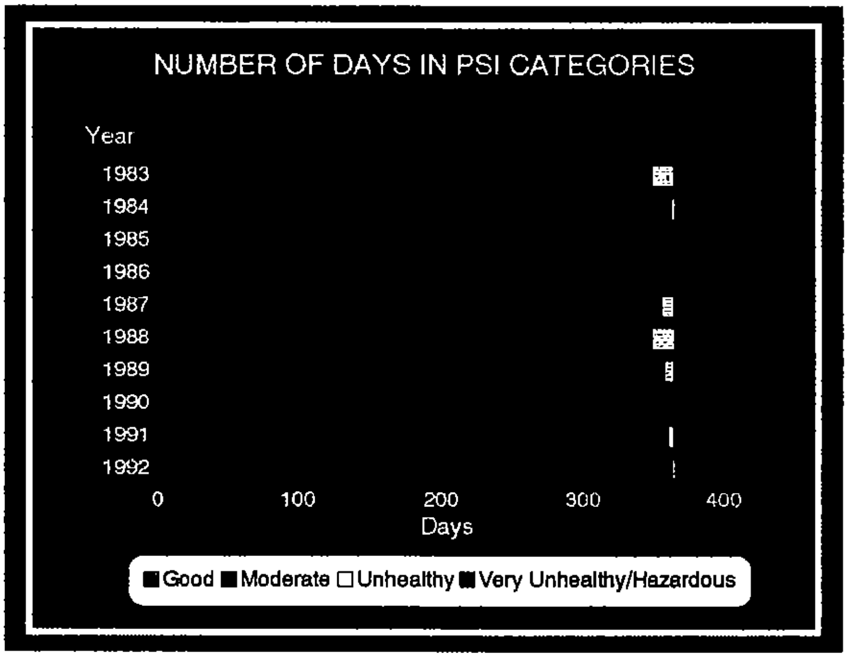




- Decrease of 16.1% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 9% to 8,869 between 1983 and 1990.
- State vehicle registrations per capita increased 3% to 0.89 between 1983 and 1990.

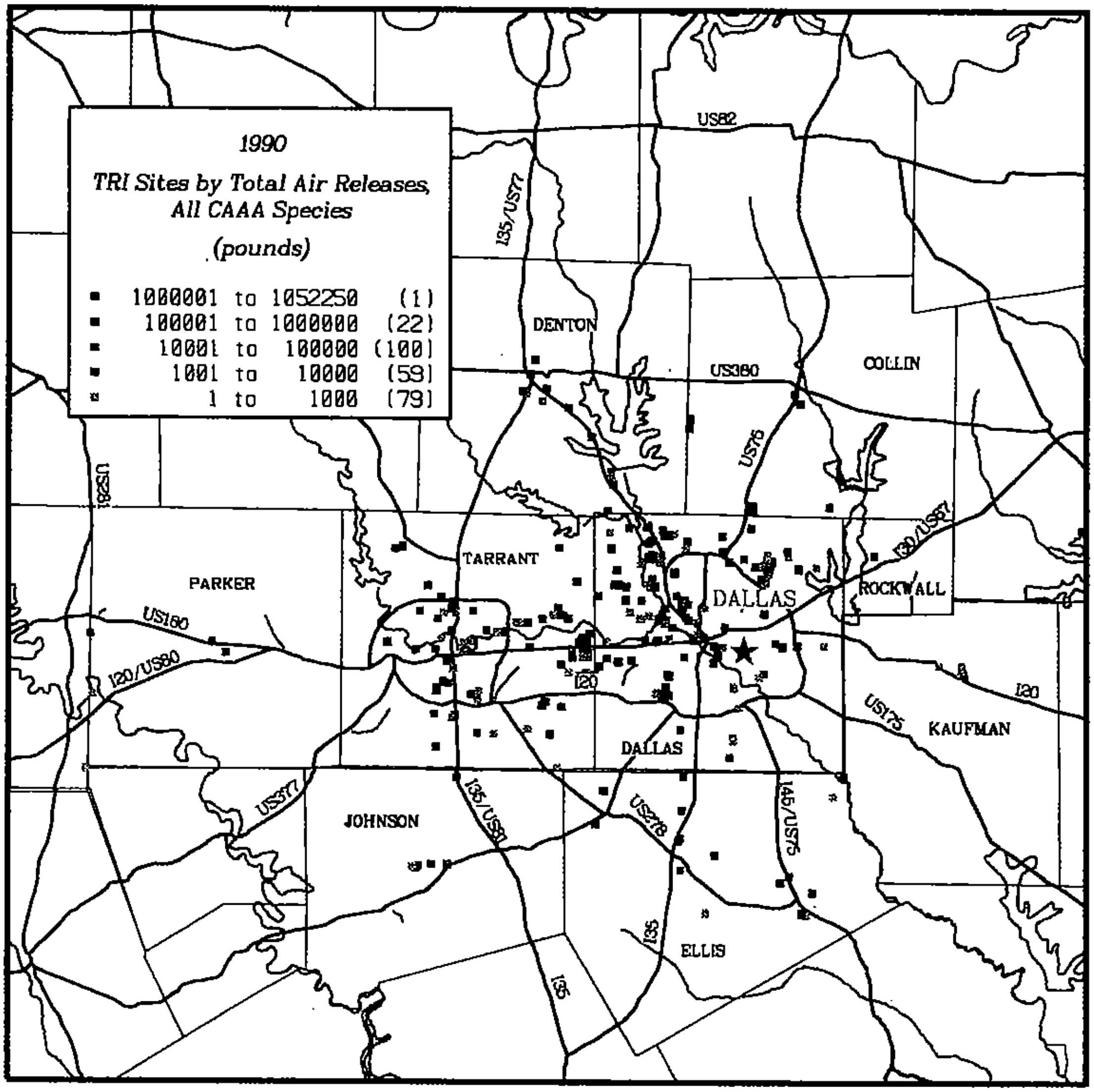
CLEVELAND

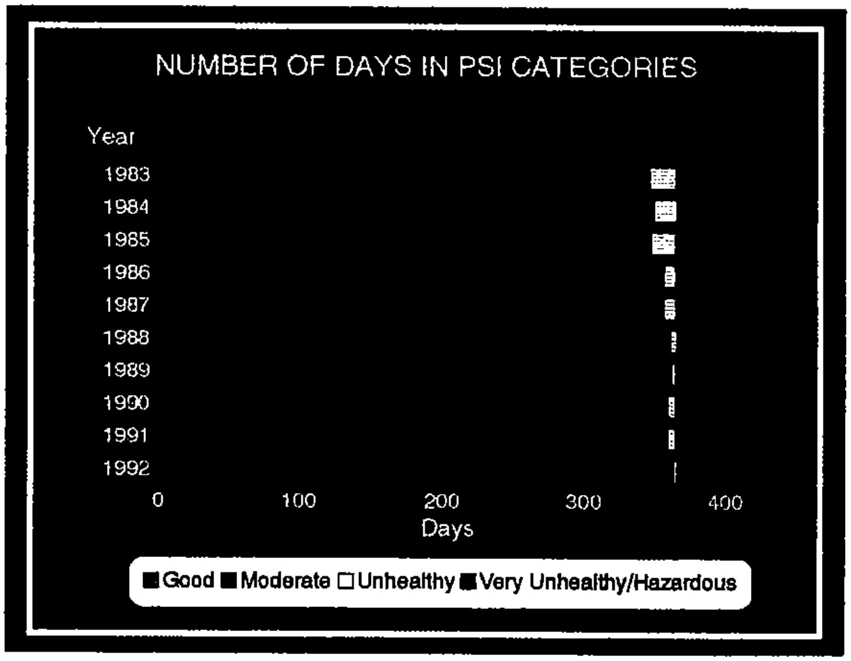




- Decrease of 13.5% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 10% to 9,786 between 1983 and 1990.
- State vehicle registrations per capita increased 8% to 1.03 between 1983 and 1990.

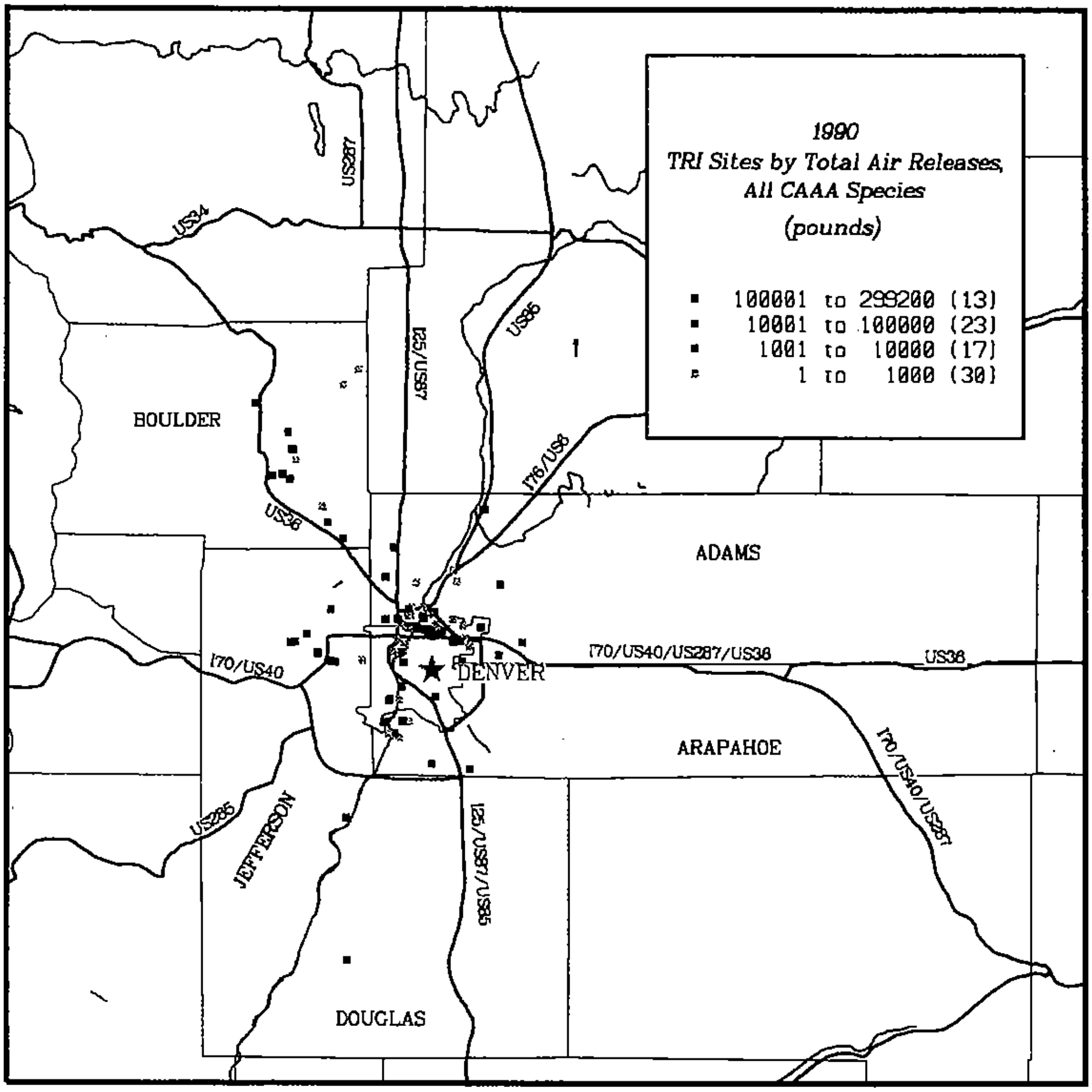
DALLAS

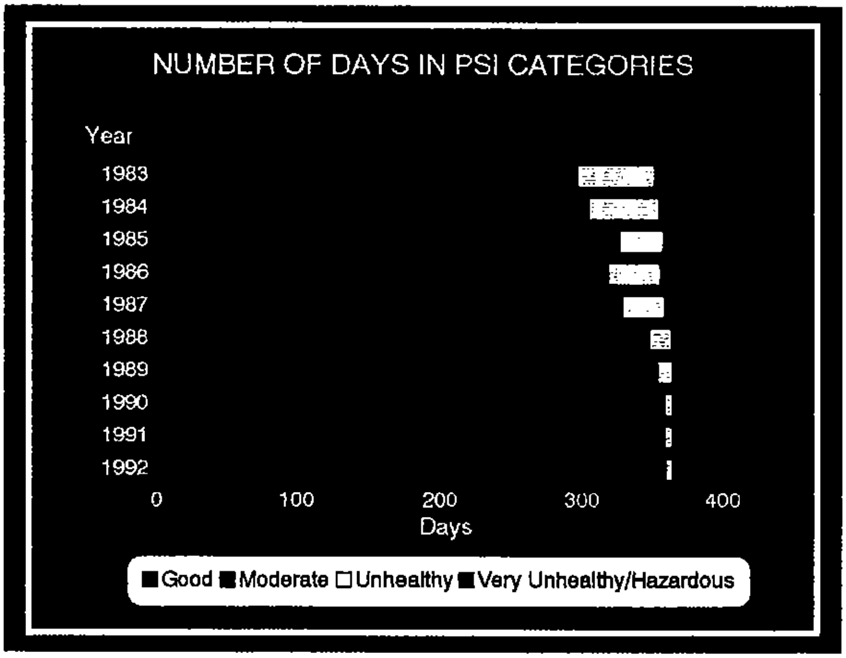




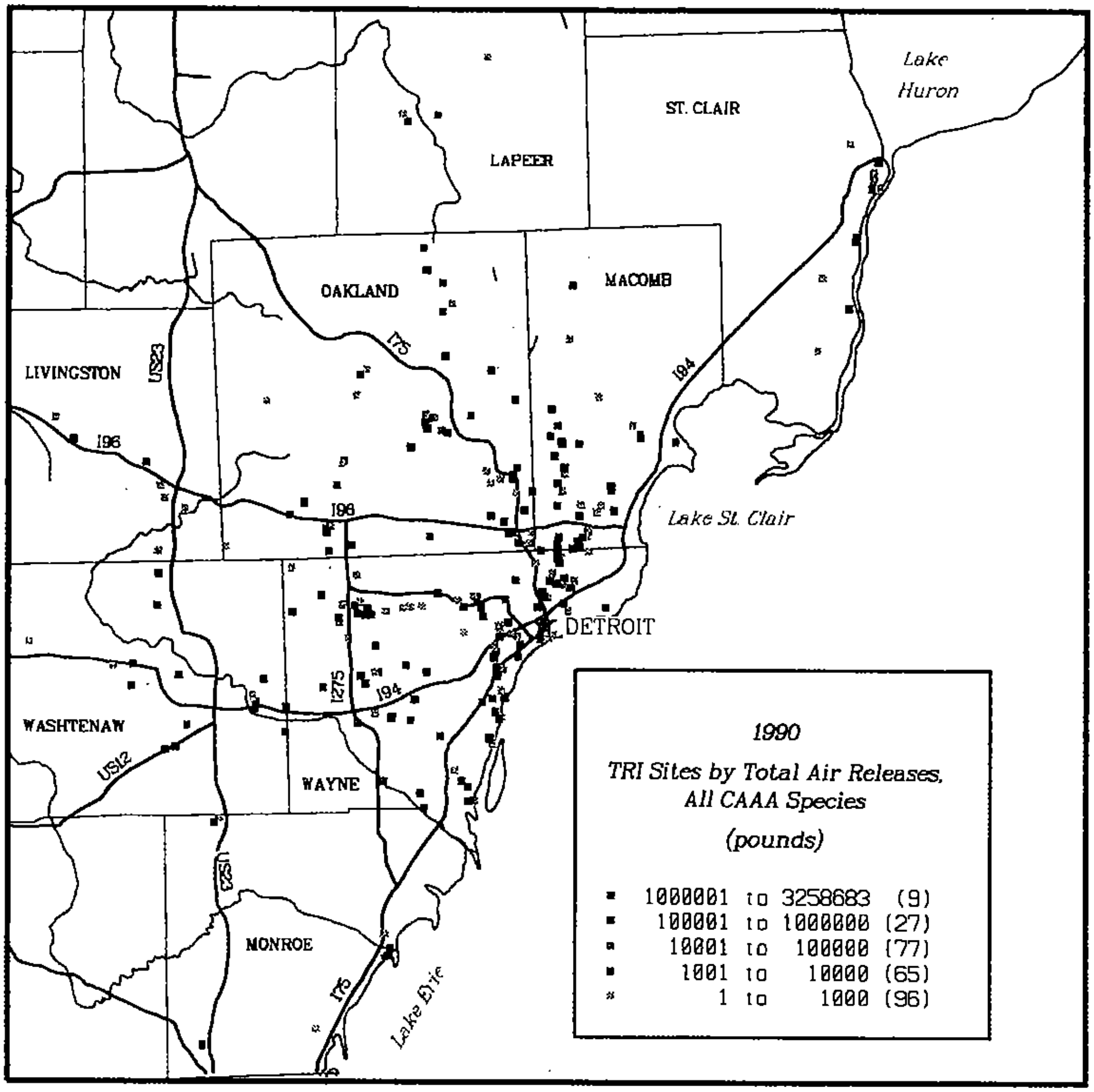
- Increase of 5.2% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 6% to 11,912 between 1983 and 1990.
- State vehicle registrations per capita decreased 5% to 0.95 between 1983 and 1990.
- Average vehicle occupancy for work trips decreased from 1.13 in 1984 to 1.09 in 1990.
- Daily VMT increased 25% between 1984 and 1990.

DENVER

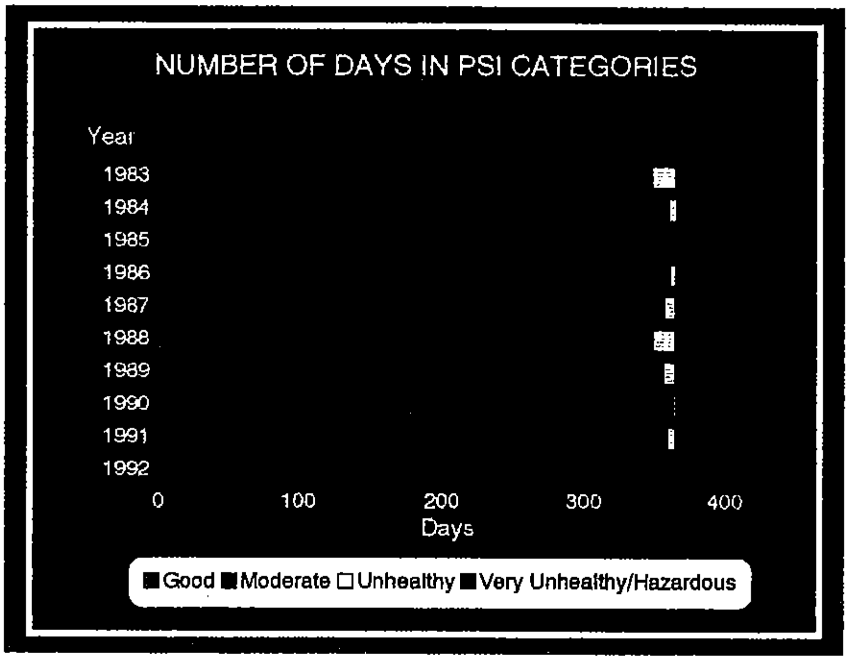




- Decrease of 14.8% in toxic air emissions between 1990 and 1991.
- State VMT per capita decreased 16% to 8,399 between 1983 and 1990.
- State vehicle registrations per capita decreased 33% to 0.80 between 1983 and 1990.
- Percent of the population using single occupant vehicles for work trips increased from 65.4% in 1980 to 73% in 1990. Carpooling increased from 20.4% in 1980 to 23.7% in 1990. Transit use decreased from 6.2% to 3.3% during the same period

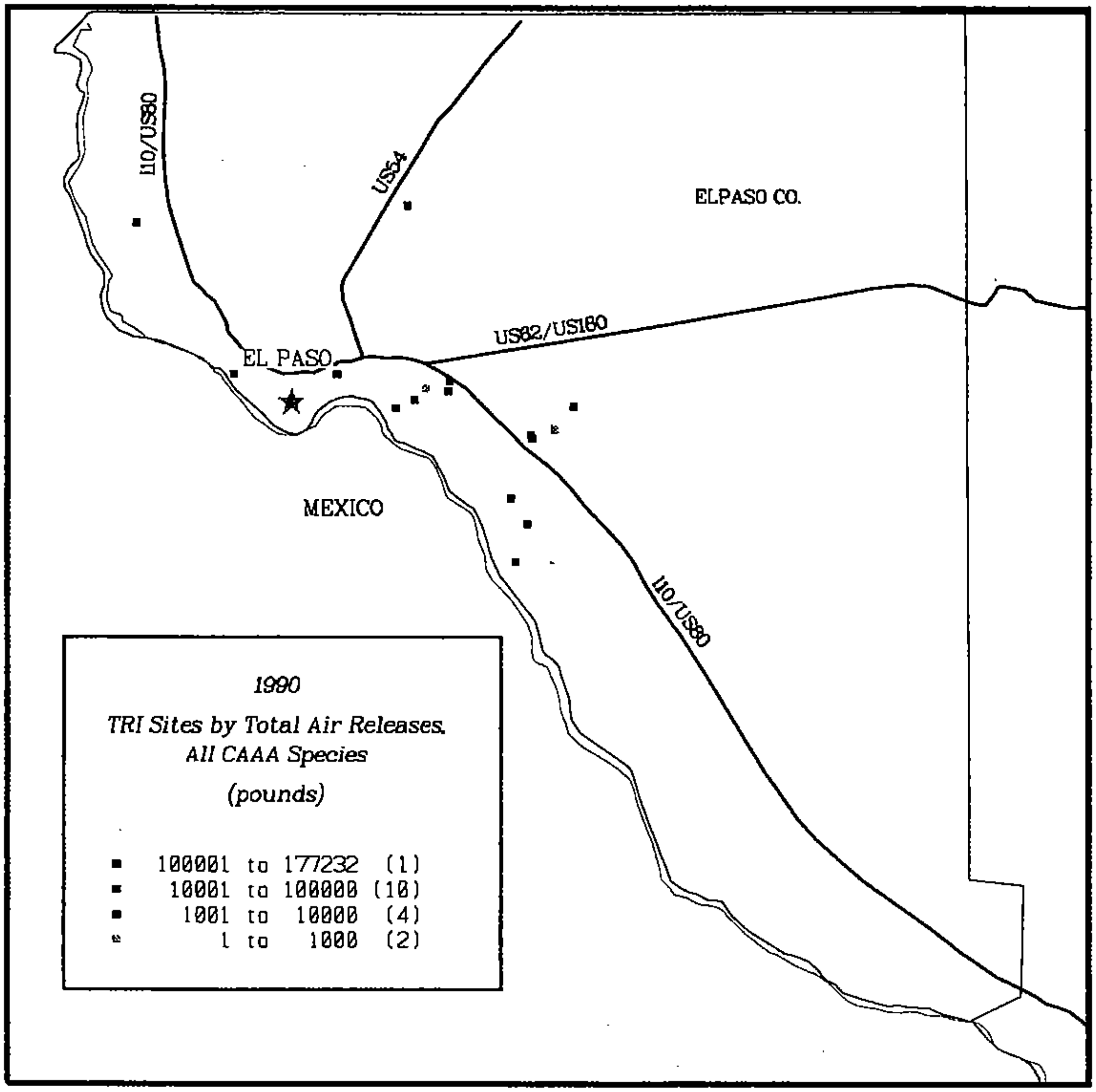


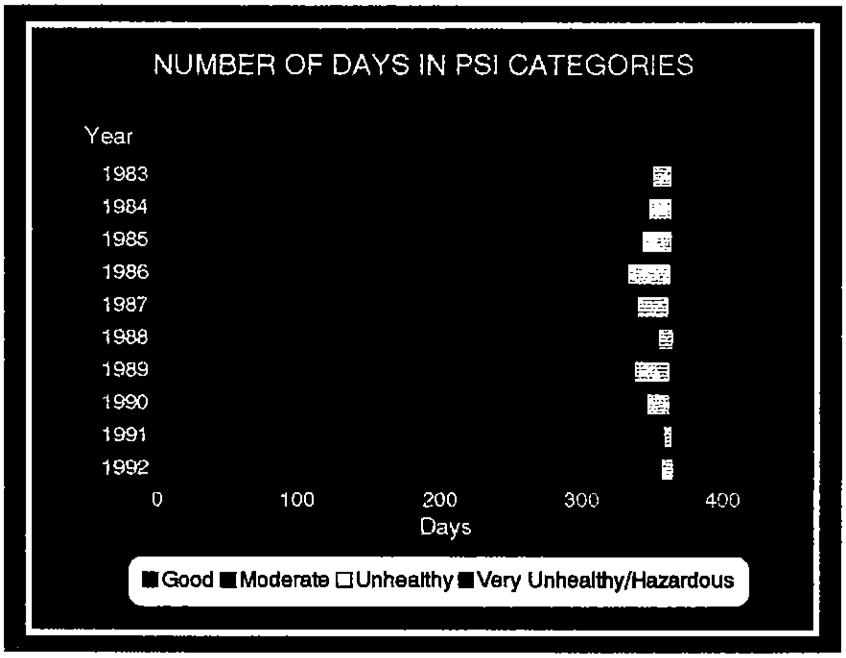
DETROIT



- Decrease of 22.4% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 29% to 11,387 between 1983 and 1990.
- State vehicle registrations per capita increased 14% to 1.04 between 1983 and 1990.

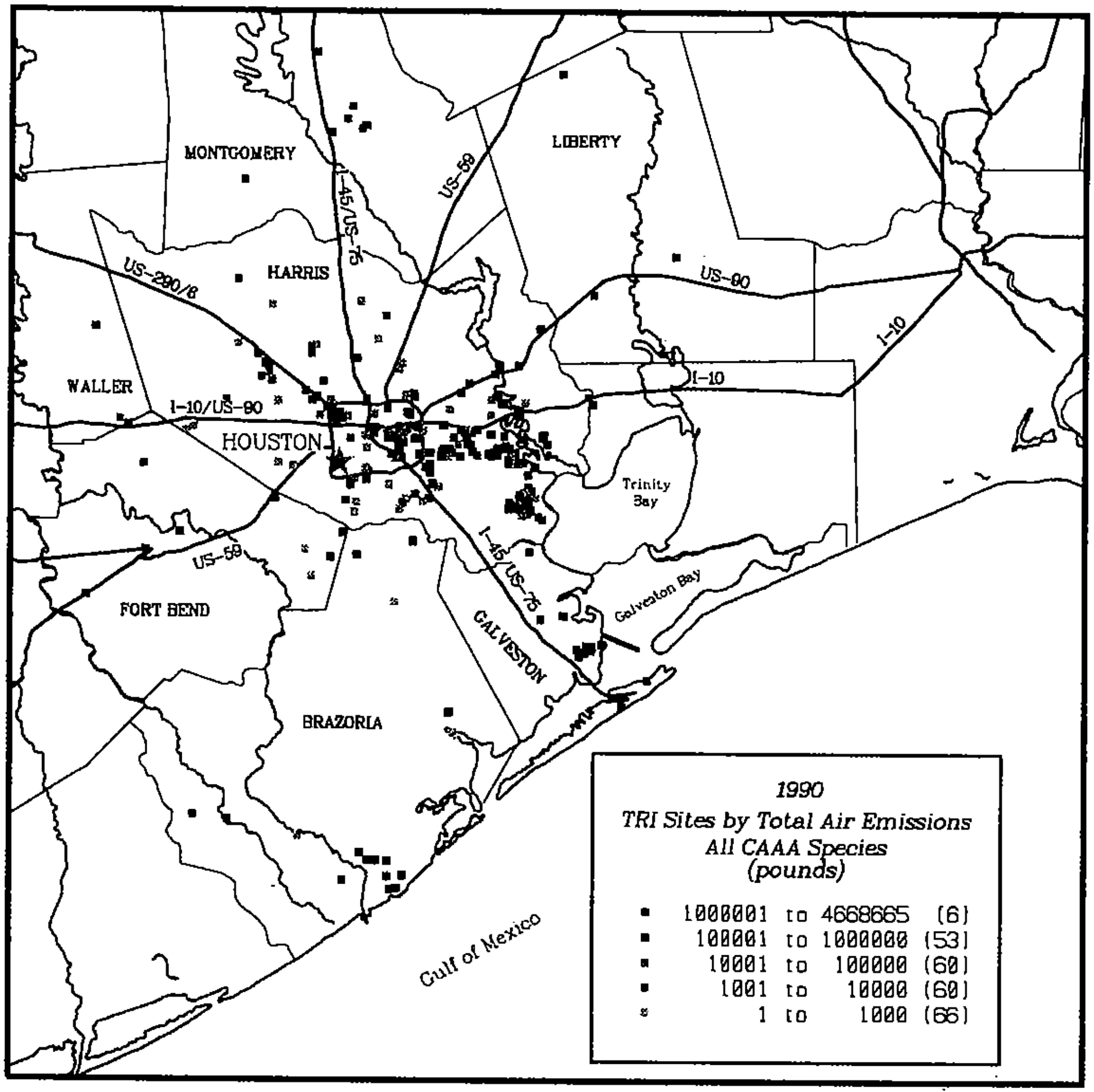
EL PASO

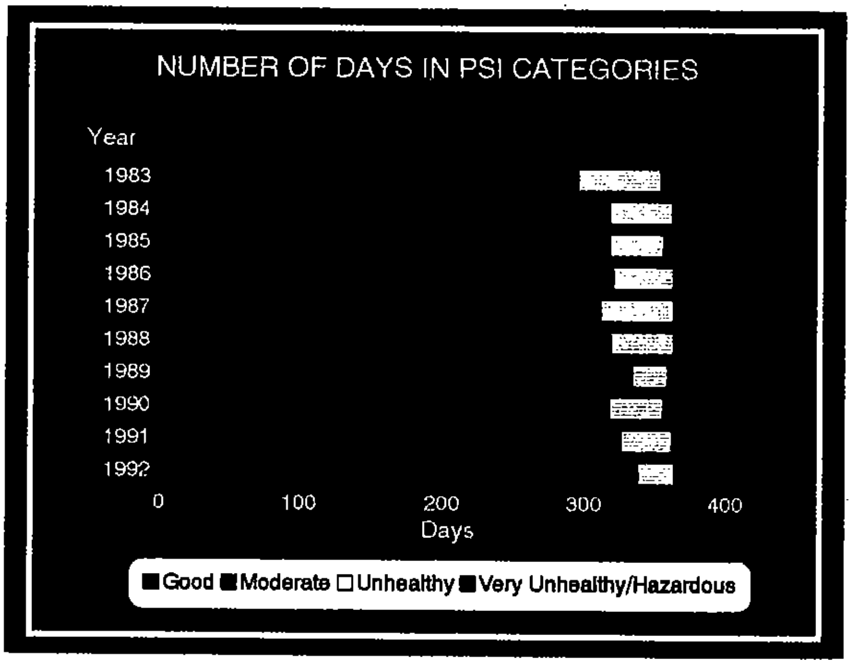




- Decrease of 14.2% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 6% to 11,912 between 1983 and 1990.

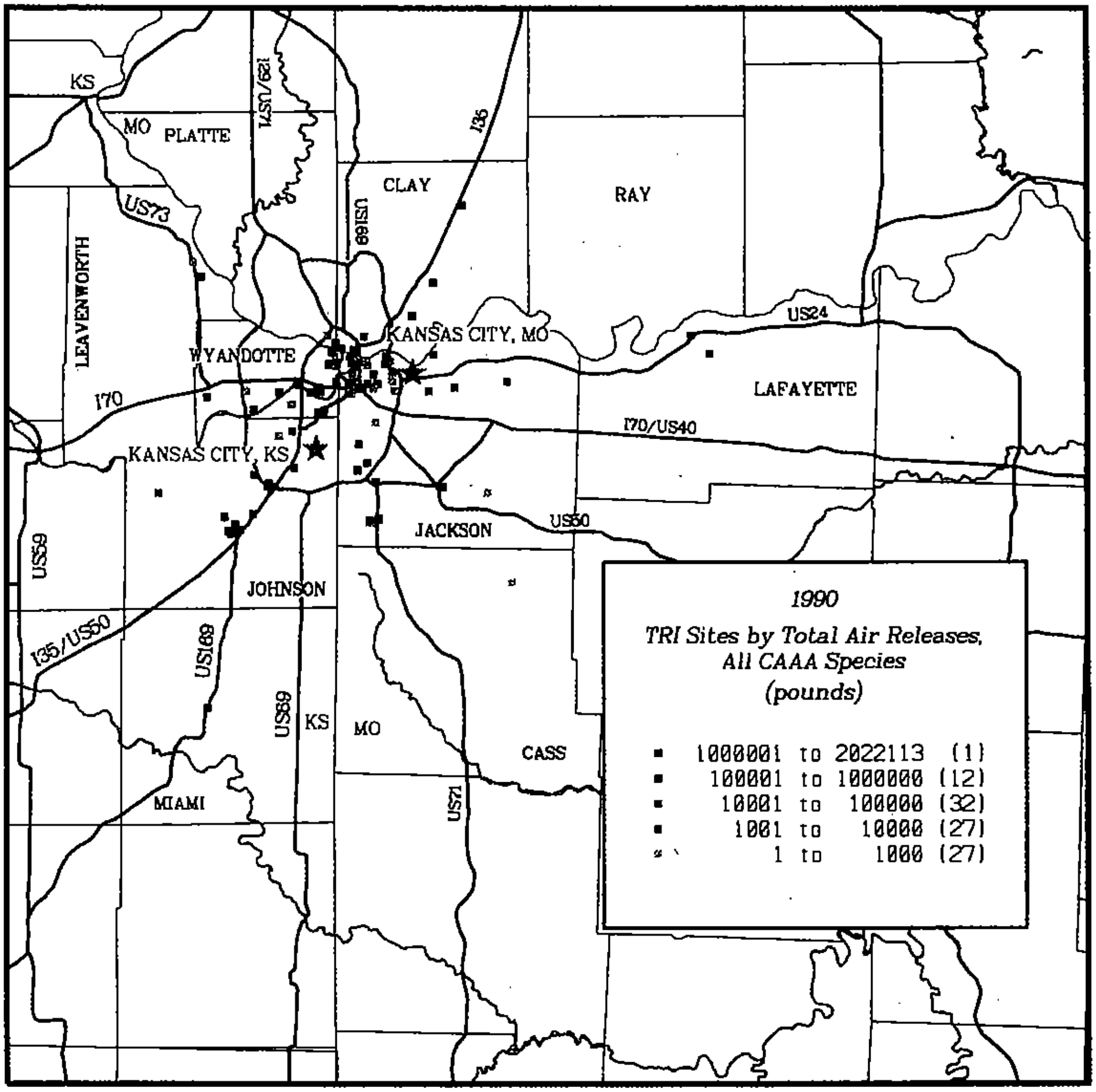
HOUSTON

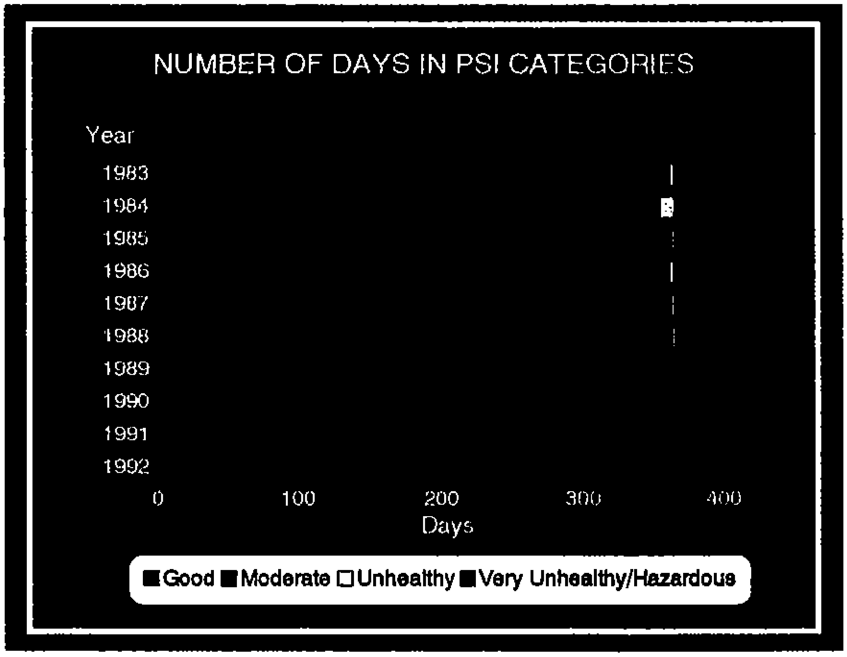




- Increase of 2.2% in toxic air emissions between 1990 and 1991.
- State vehicle registrations per capita decreased 5% to 0.95 between 1983 and 1990.

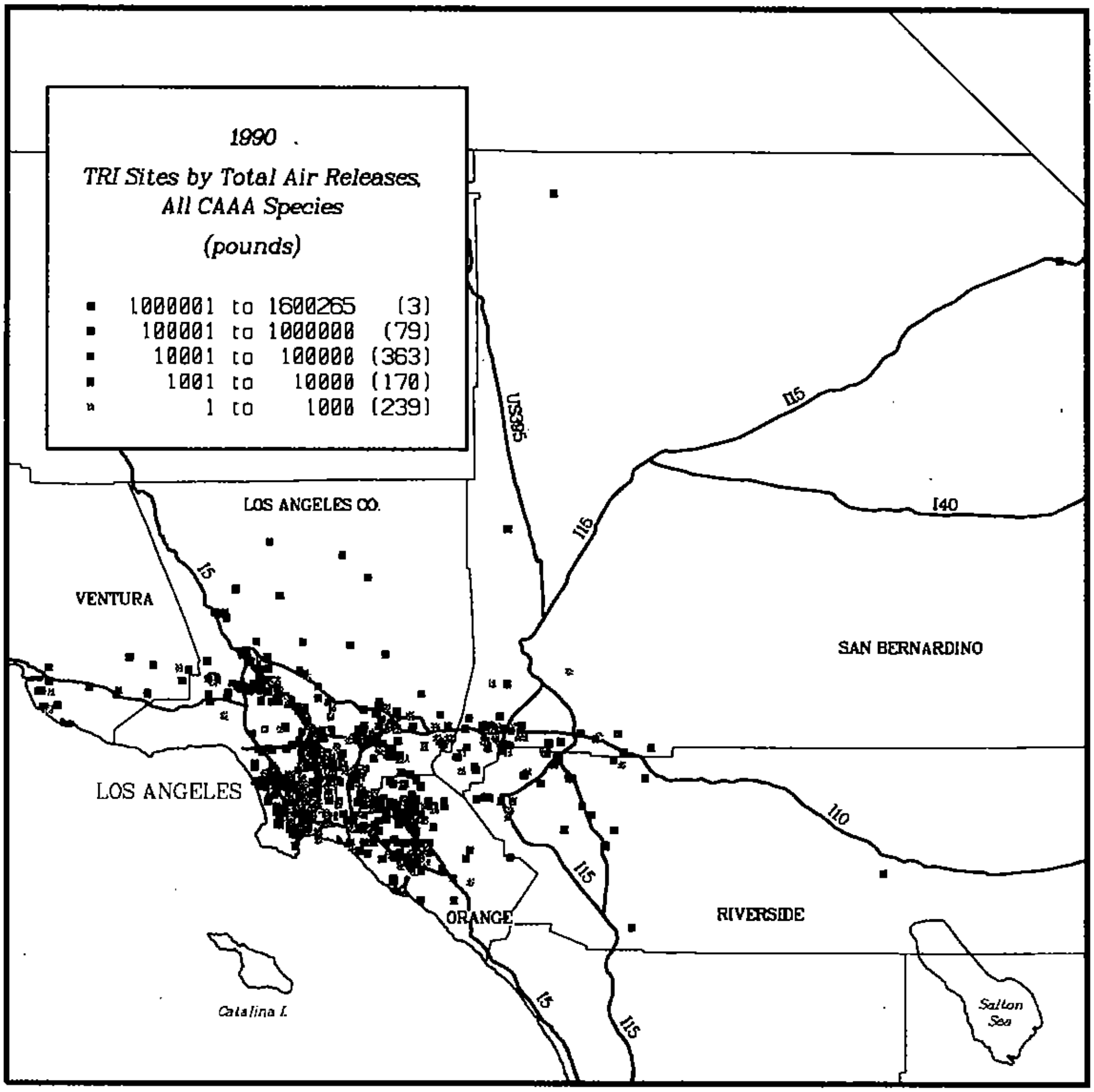
KANSAS CITY

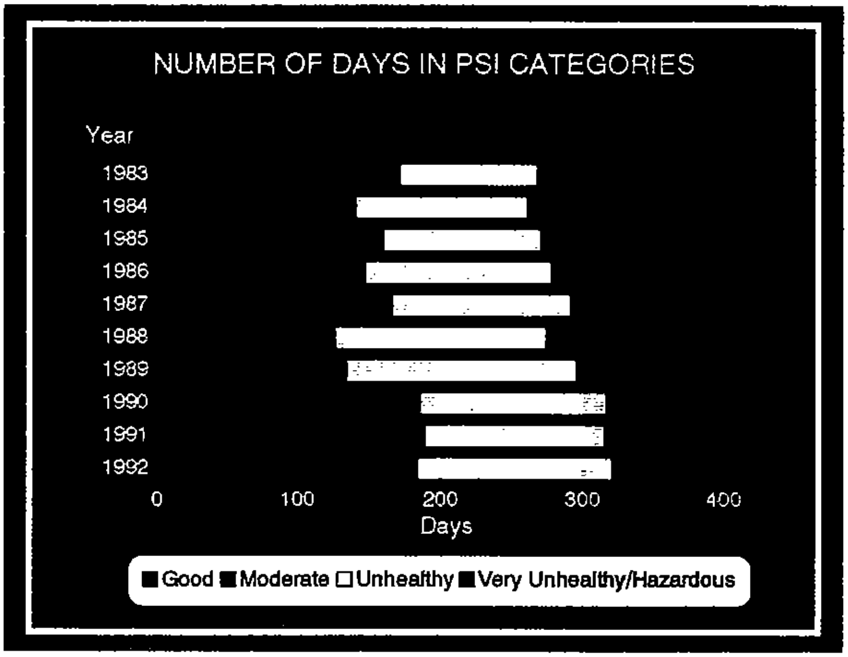




- Decrease of 3.5% in toxic air emissions between 1990 and 1991.
- Single occupant vehicle work trips increased 18% between 1983 and 1990.
- Average vehicle occupancy for the PM peak period decreased 4% between 1990 and 1993.
- State VMT per capita increased 20% to 11,413 between 1983 and 1990.
- State vehicle registrations per capita increased 7% to 0.95 between 1983 and 1990.

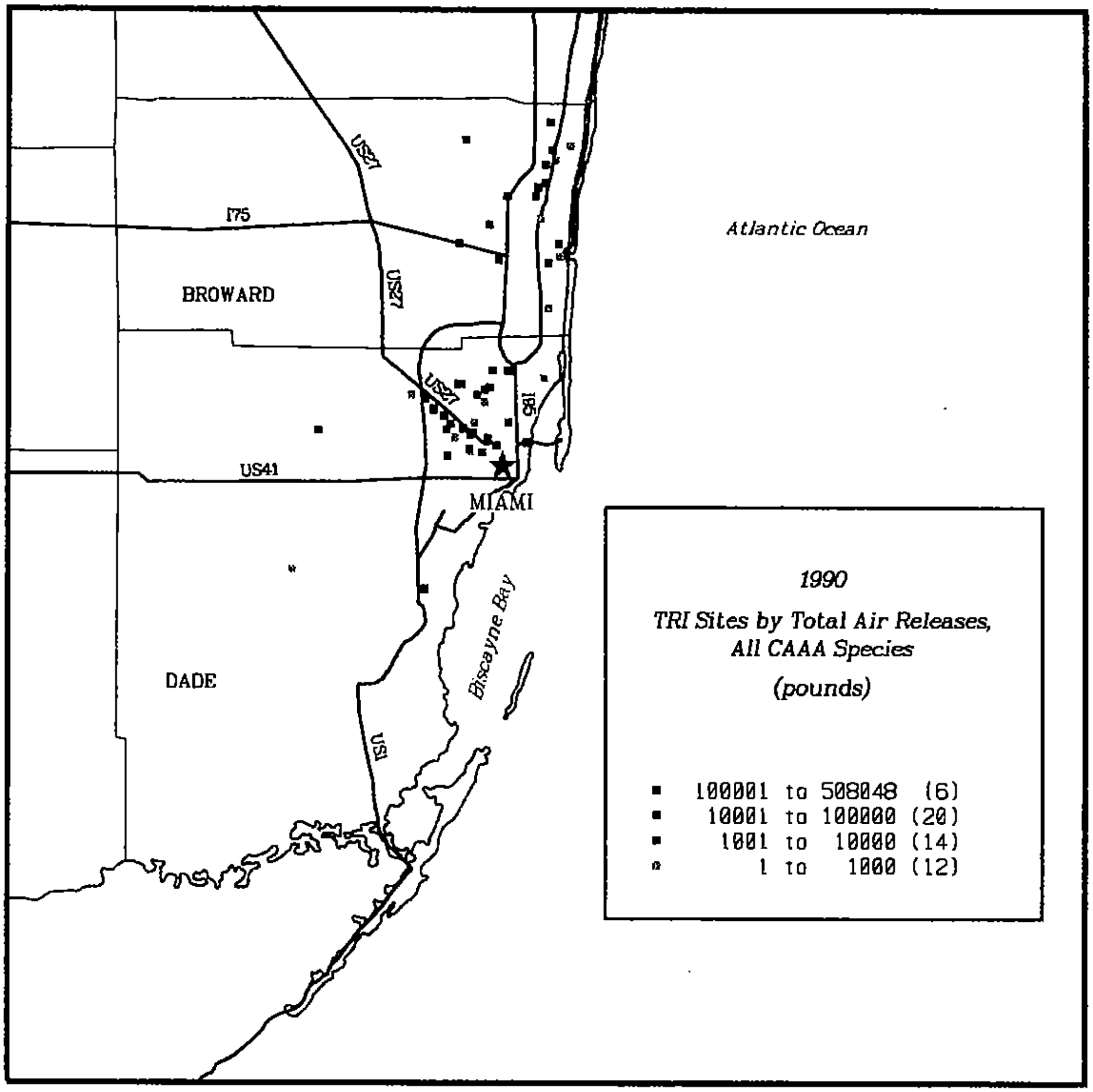
LOS ANGELES

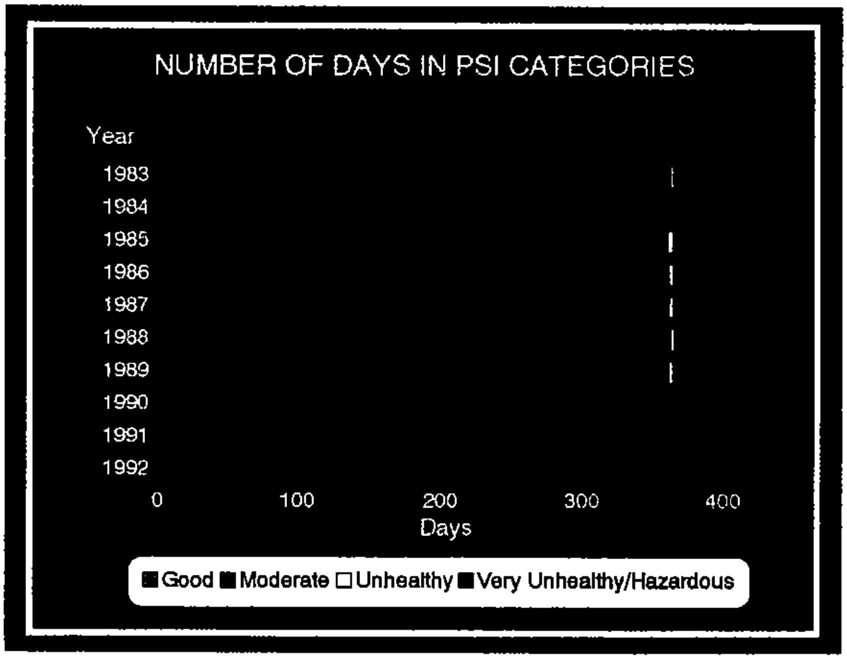




- Decrease of 12.5% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 16% to 10,594 between 1983 and 1990.
- State vehicle registrations per capita increased 4% to 0.94 between 1983 and 1990.
- VMT in the South Coast Air Basin is projected to increase 18.7% between 1987 and 1994.

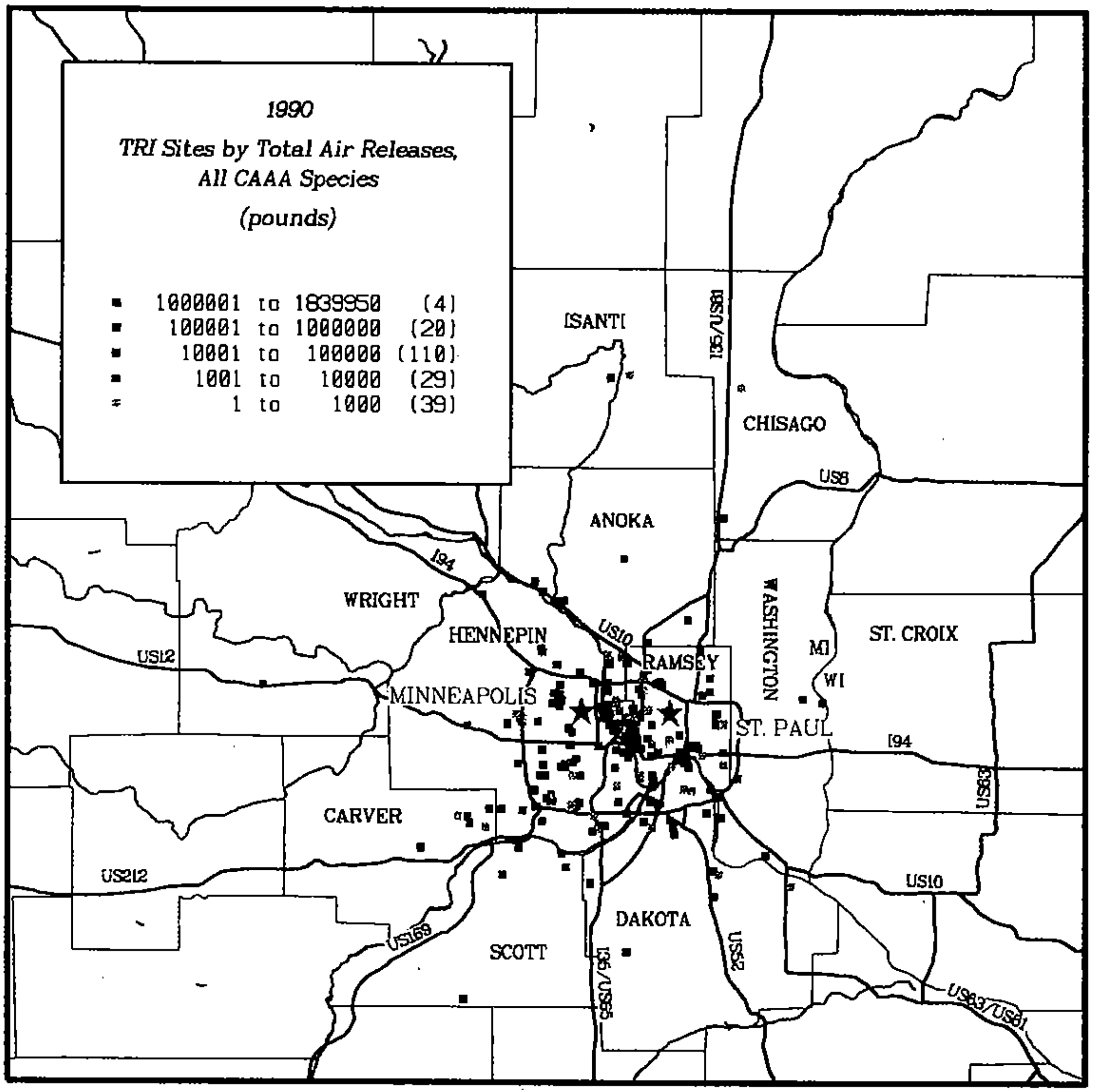
MIAMI

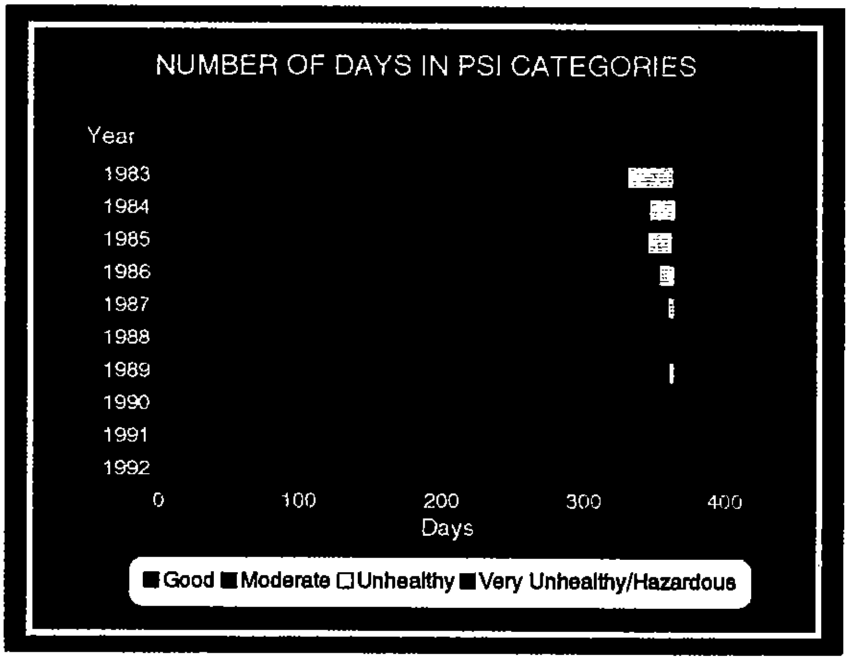




- Decrease of 18.4% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 9% to 10,179 between 1983 and 1990.
- State vehicle registrations per capita increased 5% to 1.06 between 1983 and 1990.

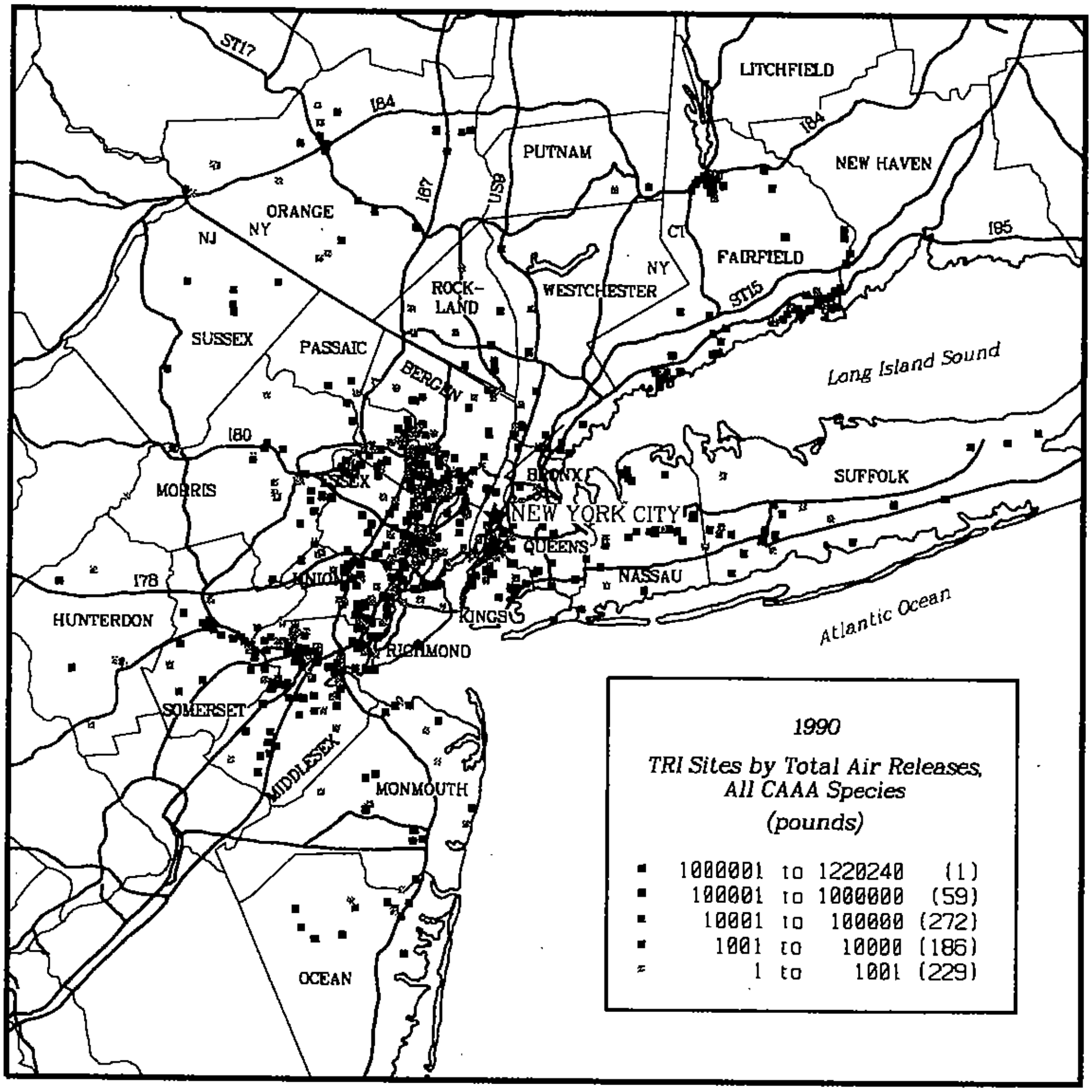
MINNEAPOLIS ST PAUL

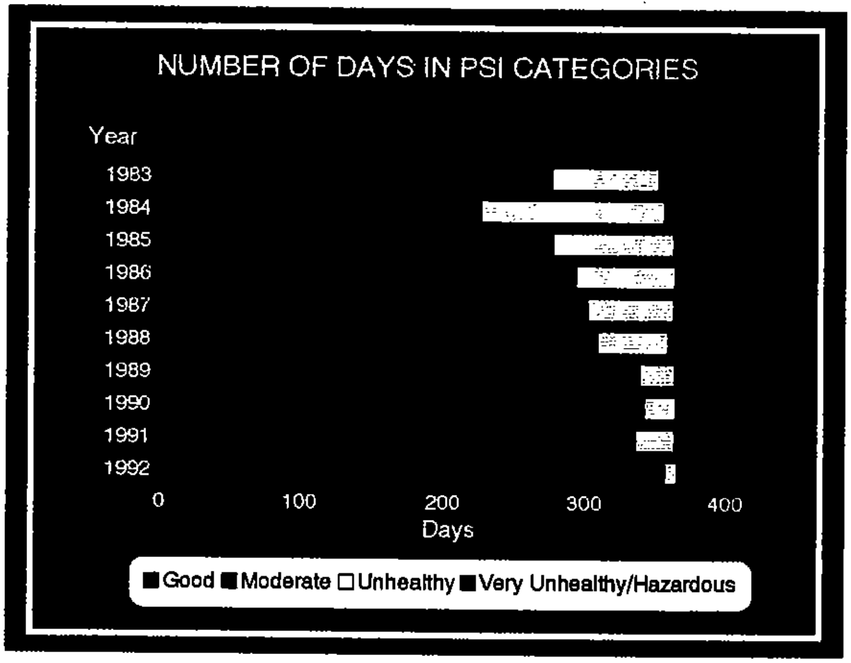




- Decrease of 17.3% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 10% to 10,798 between 1983 and 1990.
- State vehicle registrations per capita decreased 8% to 0.95 between 1983 and 1990.

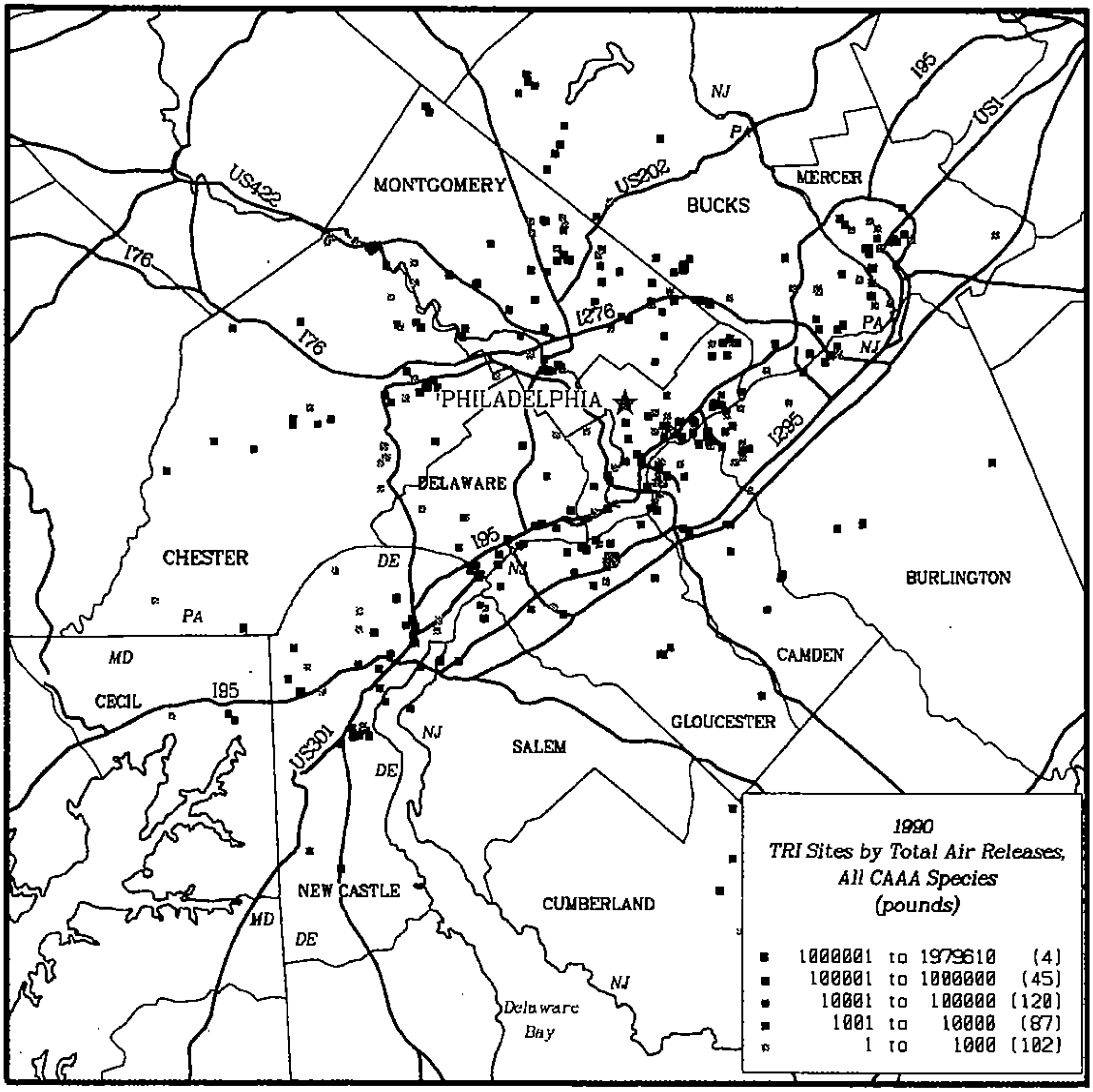
NEW YORK

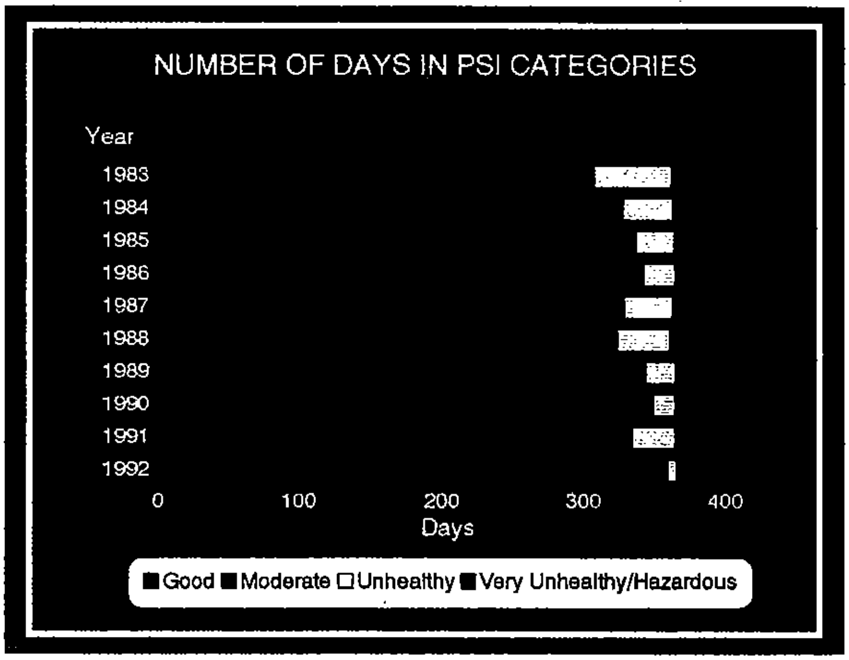




- Decrease of 12.8% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 22% to 7,329 between 1983 and 1990.
- State vehicle registrations per capita increased 13% to 0.69 between 1983 and 1990.

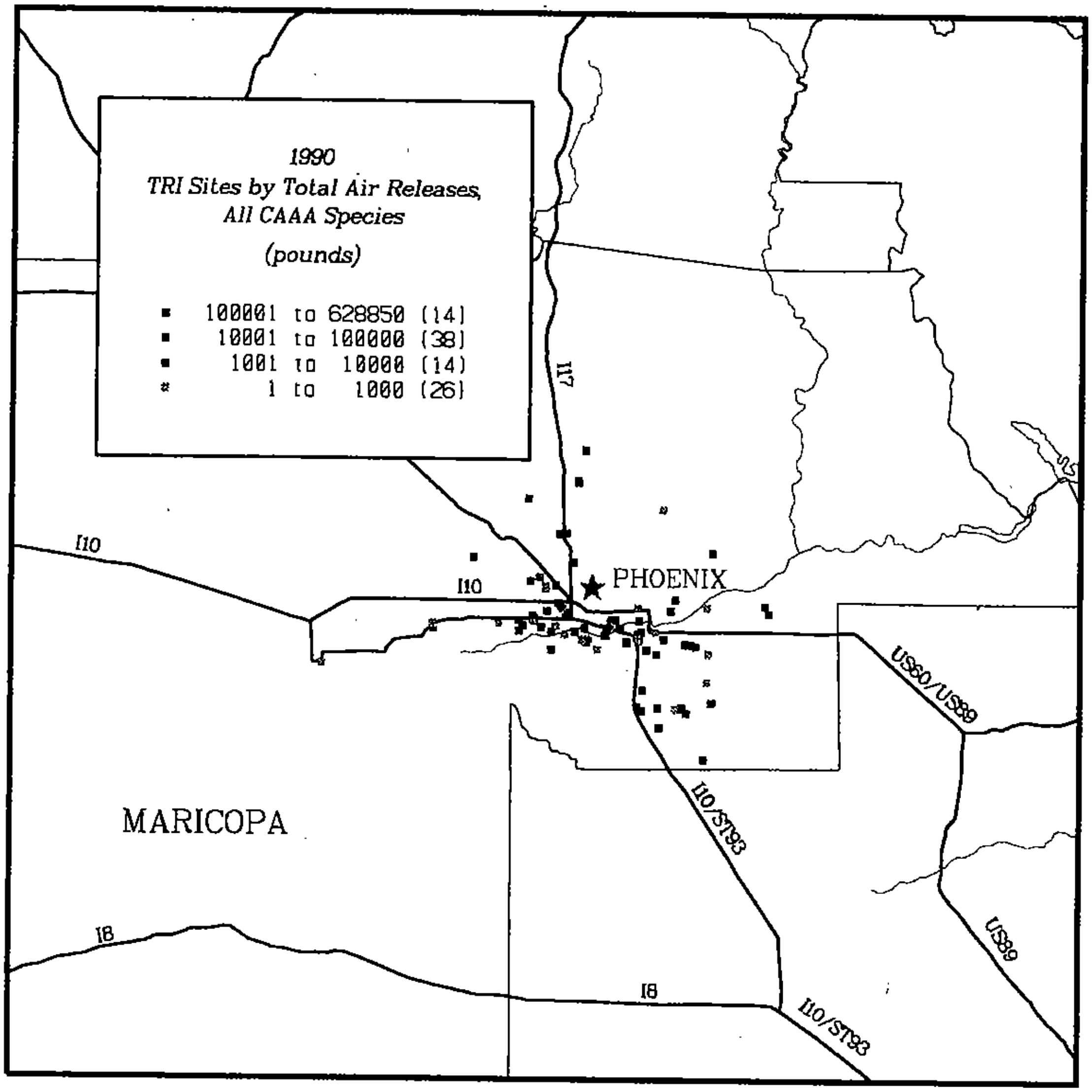
PHILADELPHIA

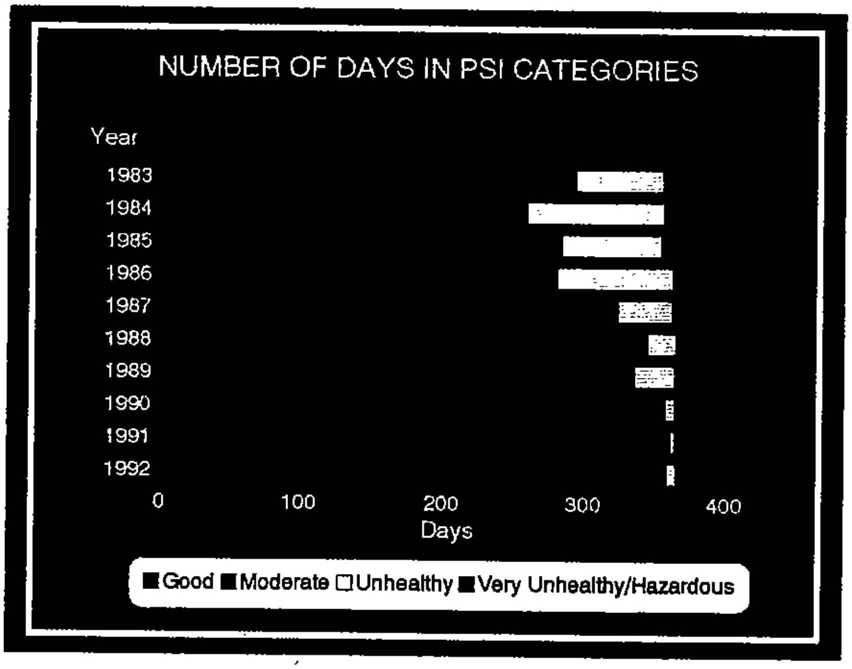




- Decrease of 12.9% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 12% to 8,635 between 1983 and 1990.
- One complete Early Emission Reduction Commitment, reducing toxic emissions by 855,000 pounds per year.

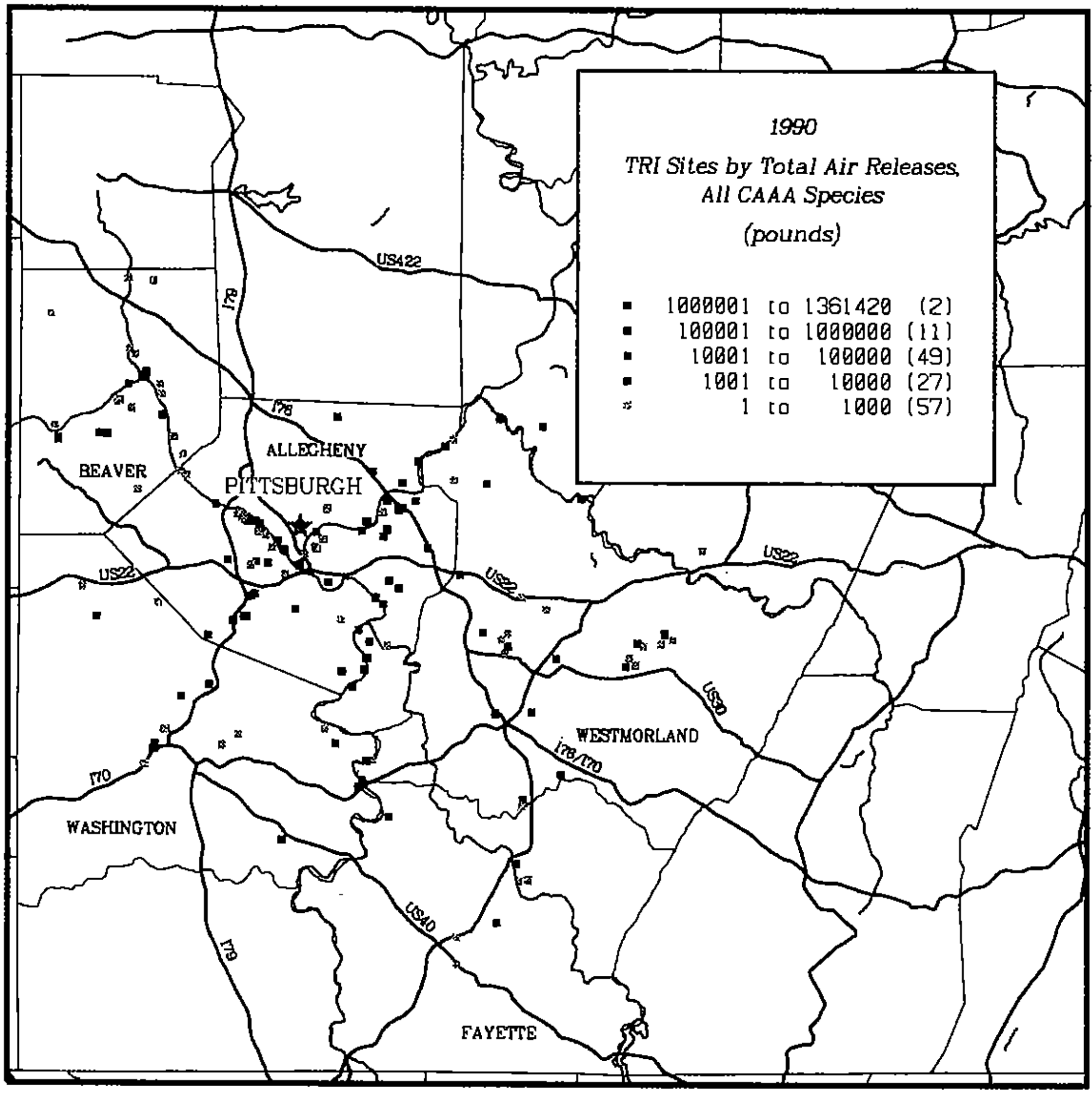
PHOENIX

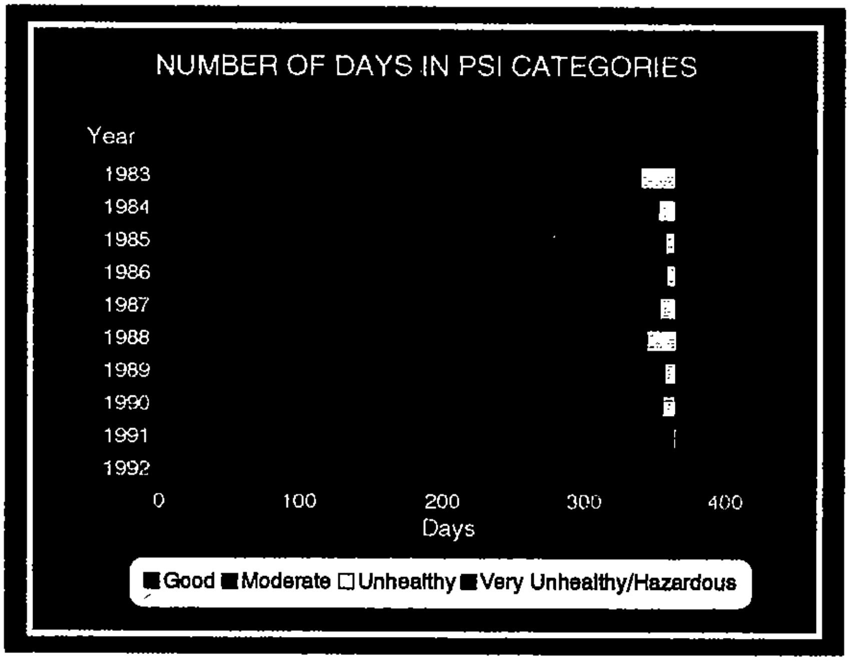




- Decrease of 28.2% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 47% to 12,553 between 1983 and 1990.
- State VMT increased 9% to 48,560,0000 between 1988 and 1991.
- Percent of VMT occurring under congested conditions decreased 29% to 30.7% between 1988 and 1991.
- Transit ridership increased 13% between 1989 and 1991.

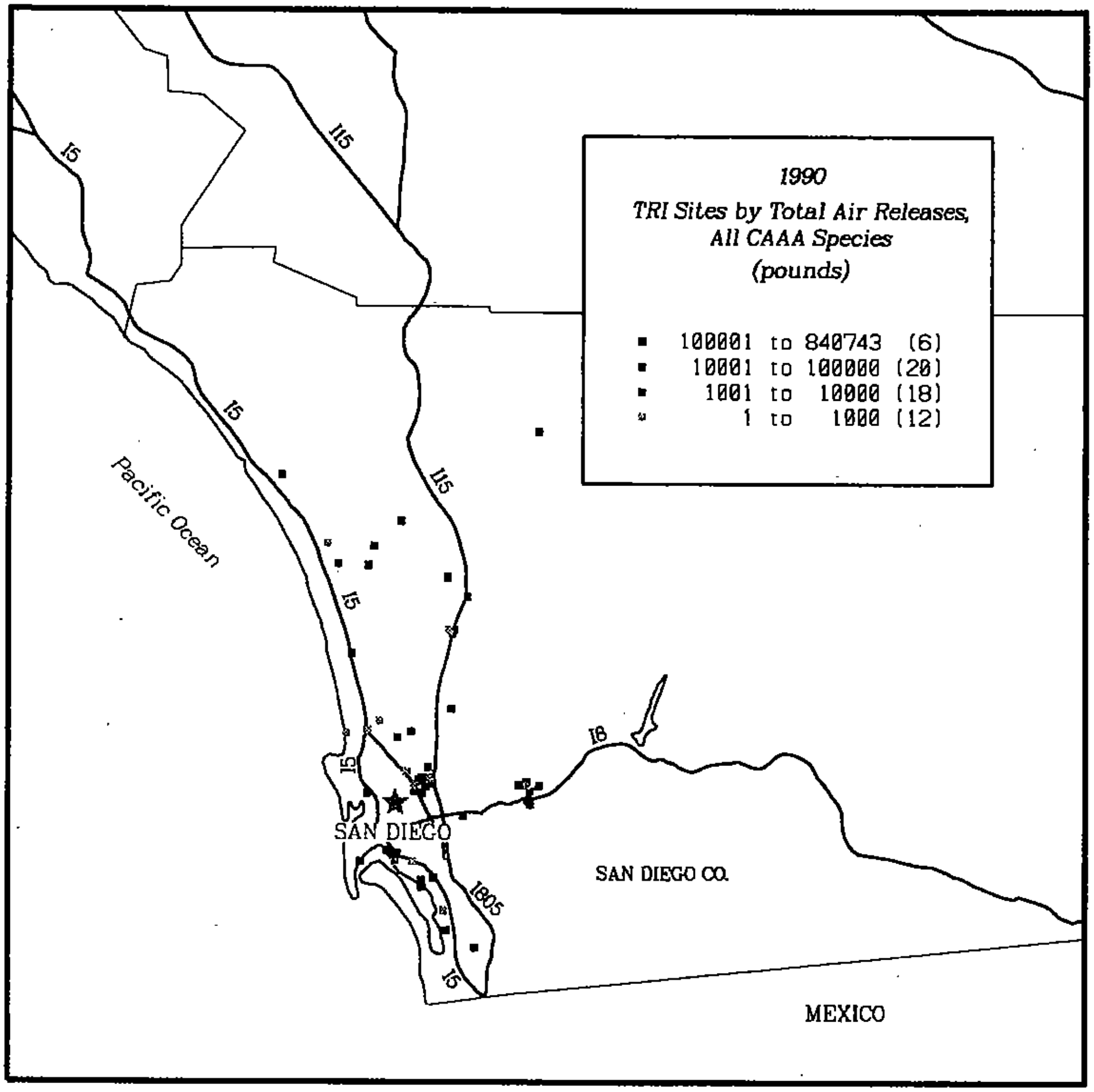
PITTSBURGH

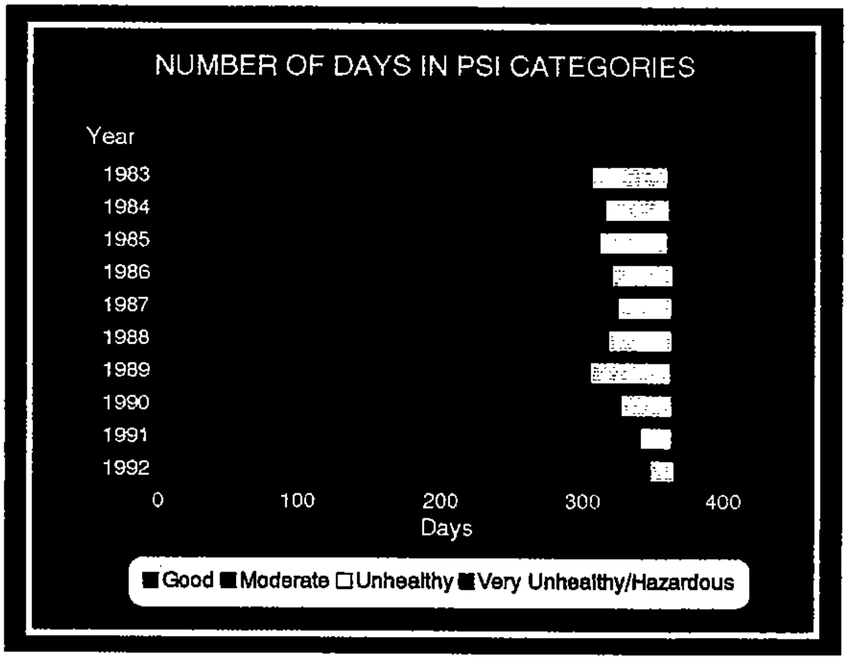




- Decrease of 26.5% in toxic air emissions between 1990 and 1991.
- State vehicle registrations per capita increased 14% to 0.83 between 1983 and 1990.
- Percent of people using single occupant vehicles to travel to work increased from 60.9% in 1980 to 73% in 1990. Carpooling decreased from 19.7% to 13.1% and transit usage decreased from 11% to 8.2% during the same period.
- Average vehicle occupancy for work trips was 1.09 in 1990.

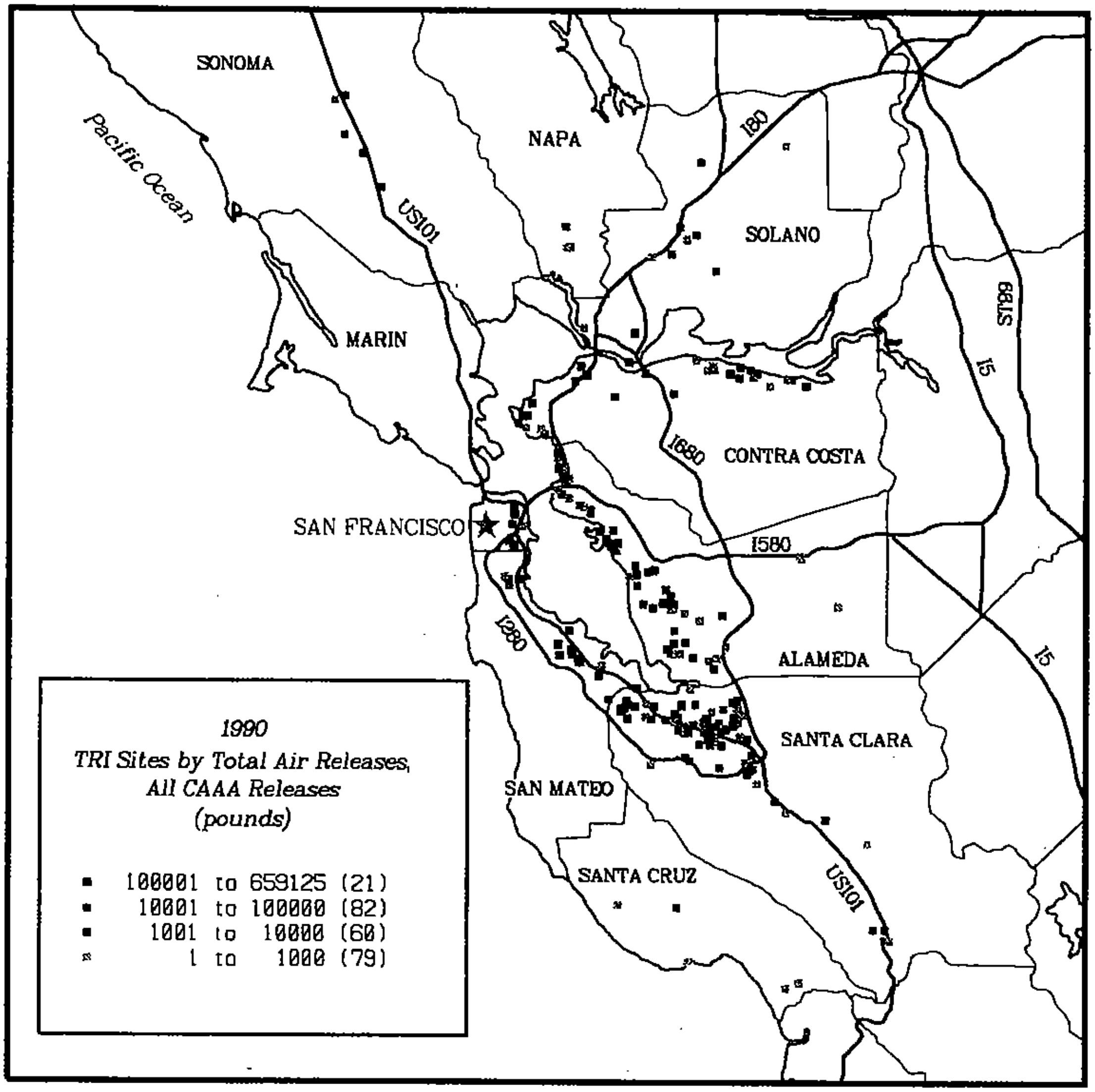
SAN DIEGO

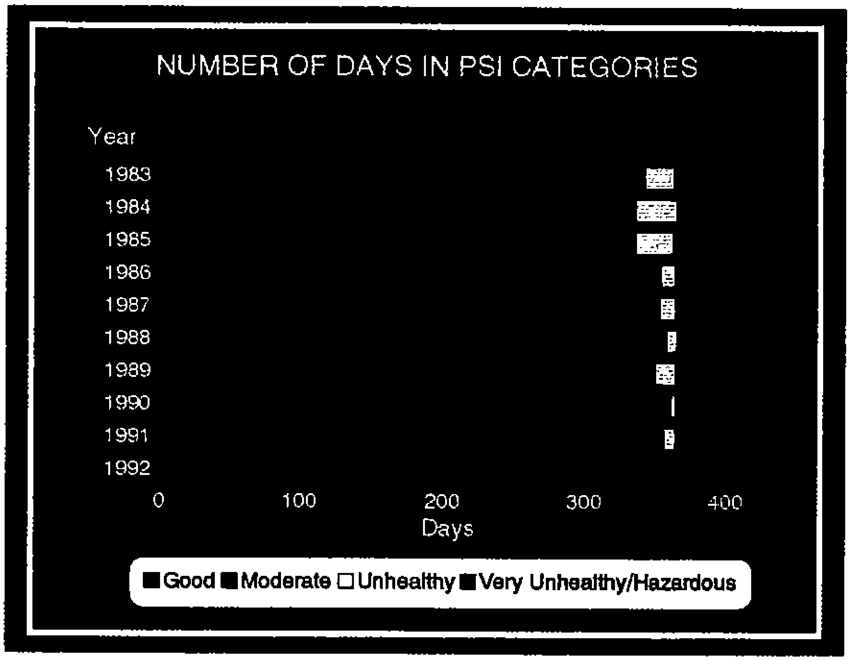




- **Decrease of 17.3% in toxic air emissions between 1990 and 1991.**
- **State vehicle registrations per capita increased 4% to 0.94 between 1983 and 1990.**

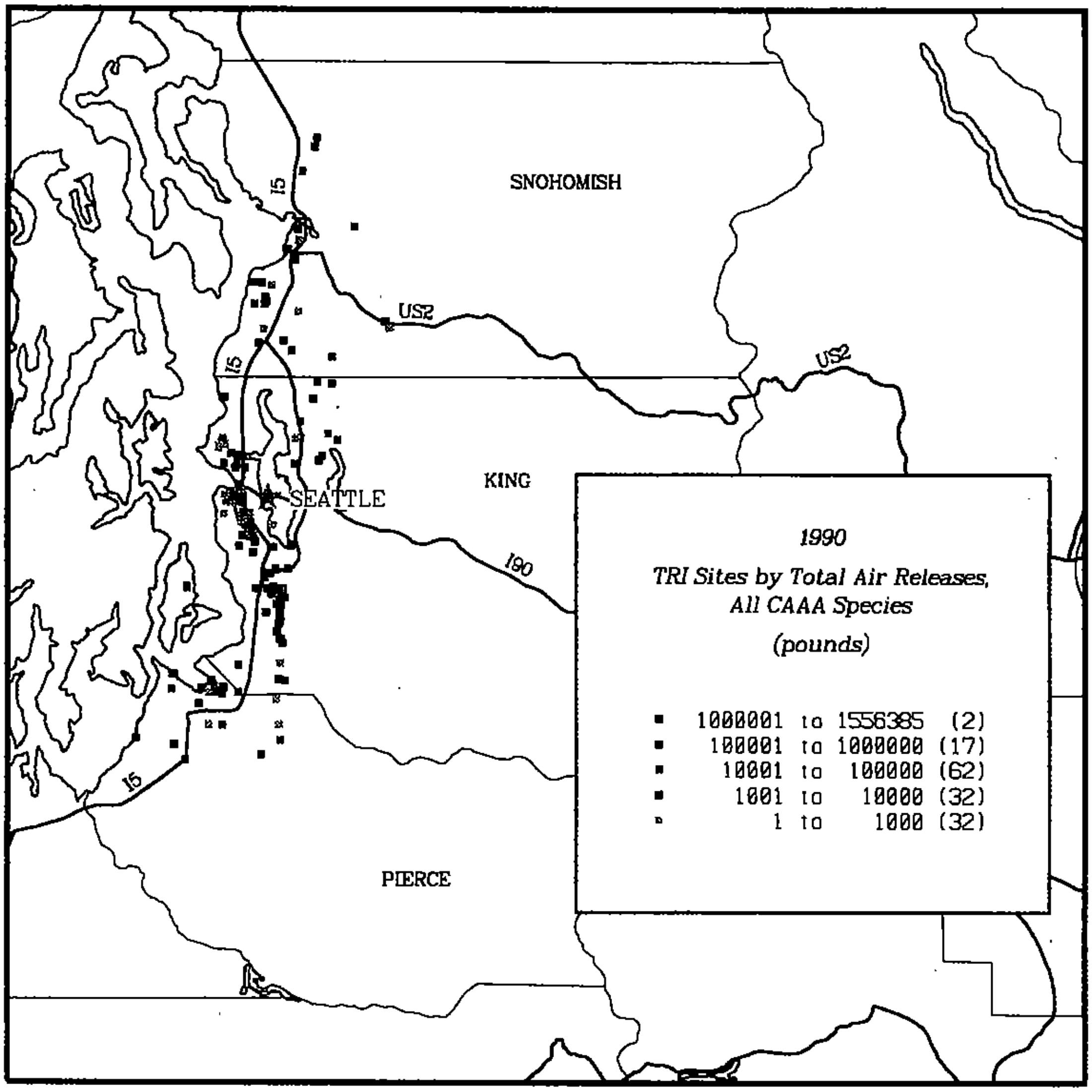
SAN FRANCISCO

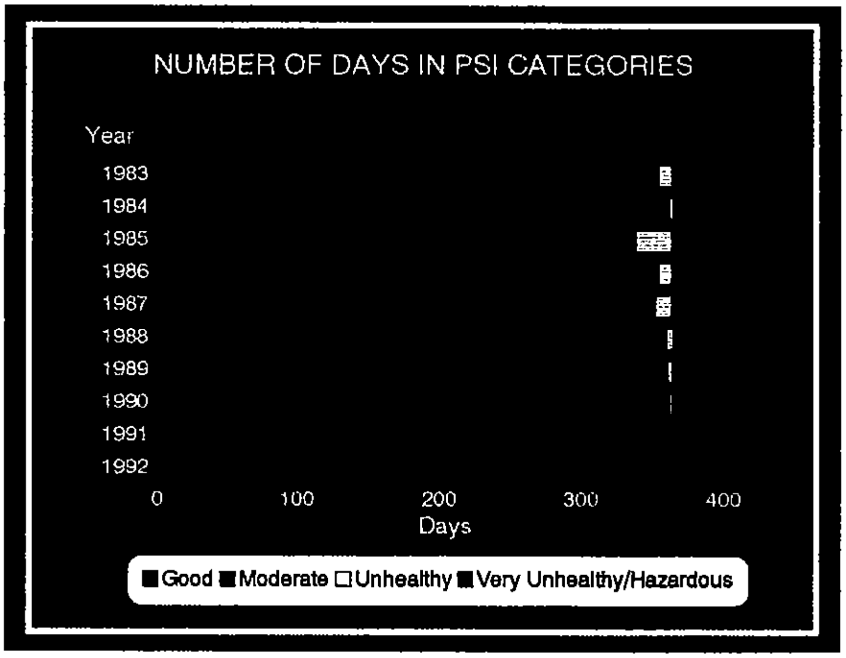




- Decrease of 5% in toxic air emissions between 1990 and 1991.
- Average vehicle occupancy for work trips decreased from 1.29 to 1.26 between 1987 and 1993.
- Single occupant vehicle work trips increased 2% between 1987 and 1990.
- Work trips made via carpools decreased 12% between 1987 and 1990.

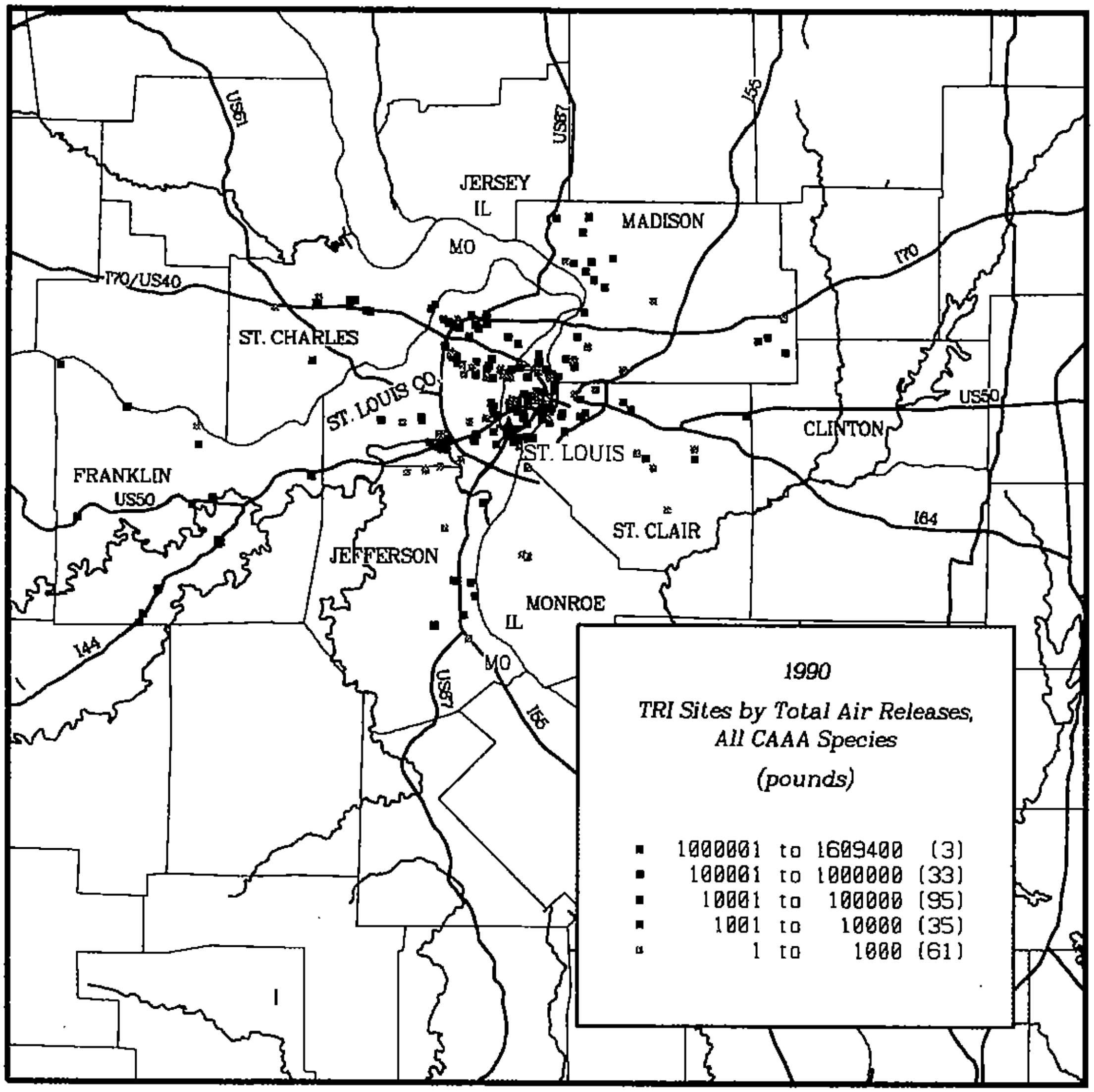
SEATTLE

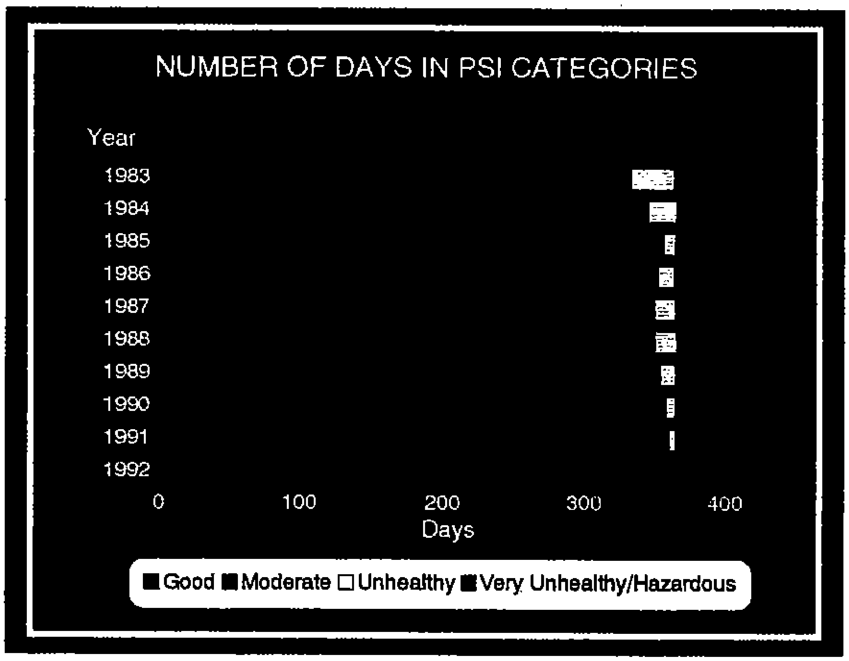




- Decrease of 17.3% in toxic air emissions between 1990 and 1991.
- State VMT per capita increased 2% to 11,087 between 1983 and 1990.
- State vehicle registrations per capita increased 2% to 1.03 between 1983 and 1990.

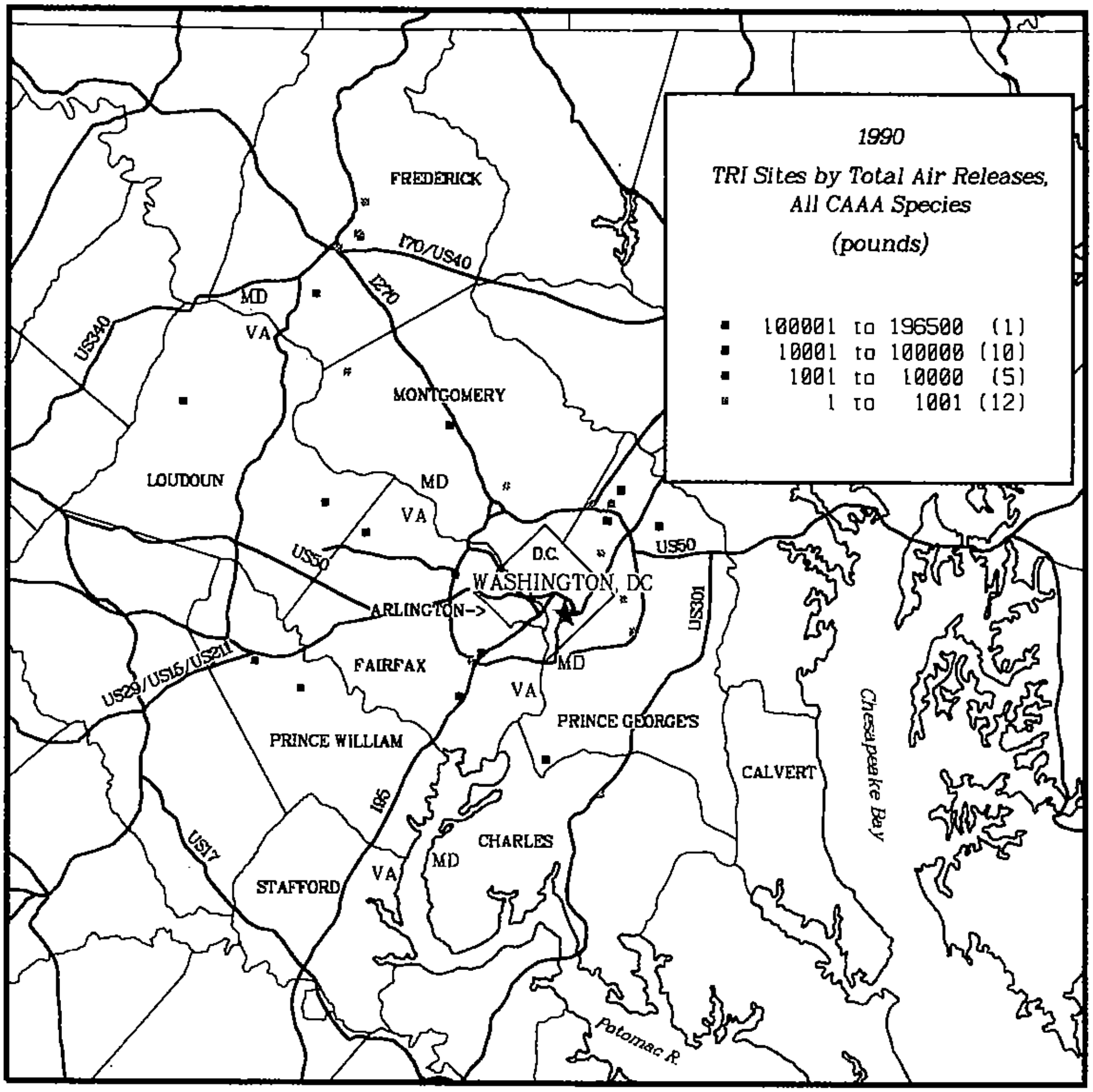
ST LOUIS

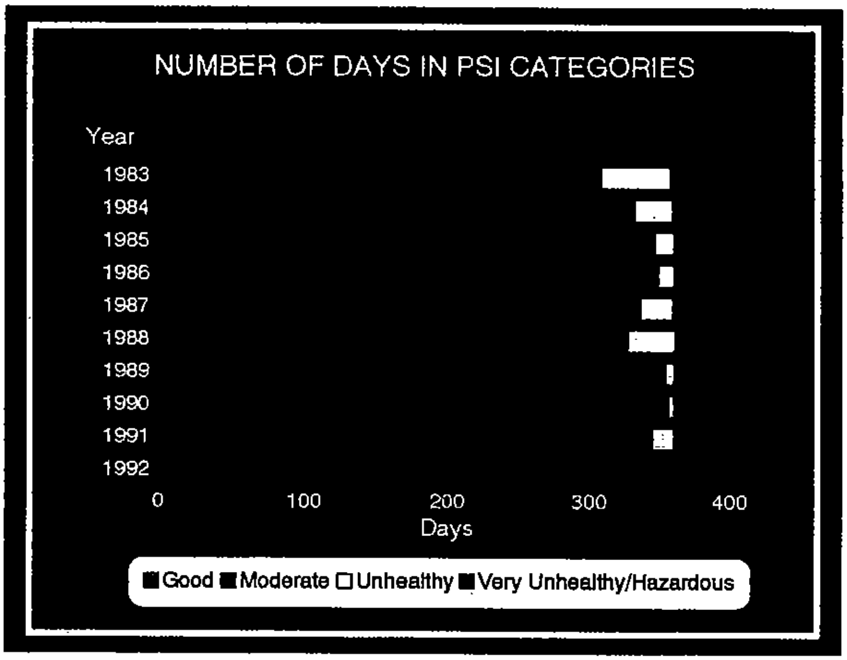




- Decrease of 14% in toxic air emissions between 1990 and 1991.
- One complete Early Emission Reduction Commitment, reducing toxic emissions by 855,000 pounds per year.
- Transit usage for work trips declined 39% to 3.5% between 1980 and 1993.

WASHINGTON DC





- Increase of 7.4% in toxic air emissions between 1990 and 1991.
- District VMT per capita increased 15% to 7,045 between 1983 and 1990.
- District vehicle registrations per capita increased 19% to 0.55 between 1983 and 1990.

Chapter 7: International Air Pollution Perspective

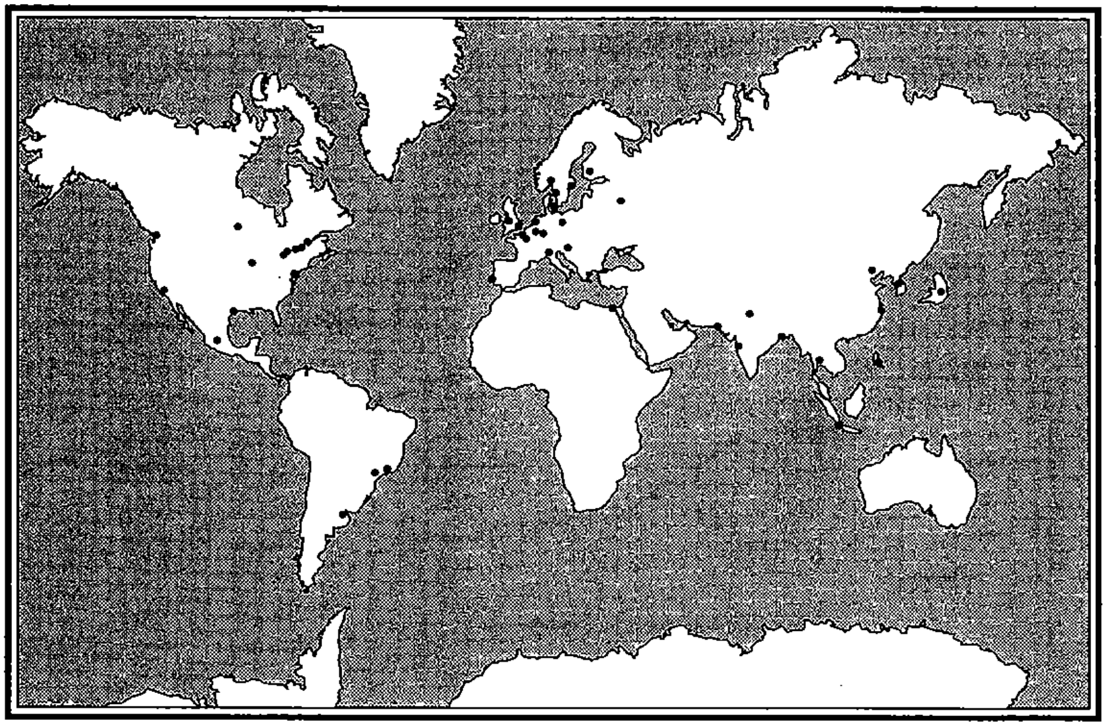


Figure 7-1. Cities selected for discussion in Chapter 7.

This chapter discusses air pollution levels, trend patterns, and emissions for selected cities around the world (Figure 7-1). Because the form of air quality standards and goals may differ among countries, common air quality statistics have been selected for comparison. 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 sulfur oxides (SO_x) 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 4 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 7-2). Table 7-1 provides additional comparative information on SO_x emissions. About 90 percent of the human-induced emissions originate in the Northern Hemisphere. The United States and countries within the former Soviet Union are

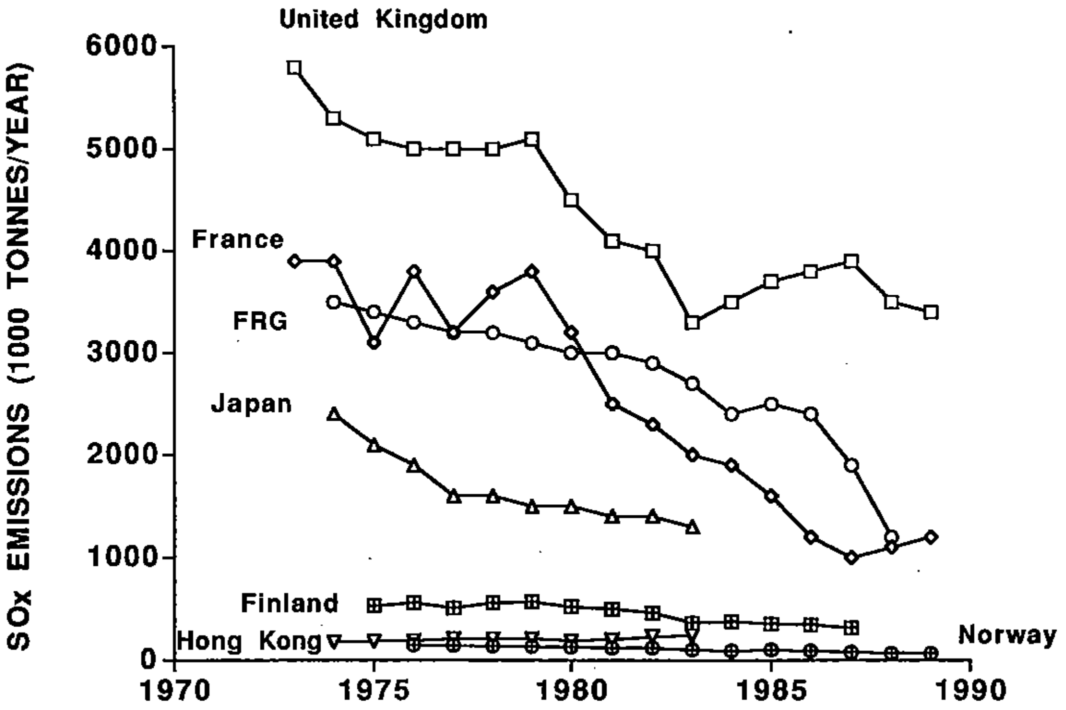


Figure 7-2. SO_x emissions in 1,000 metric tons/year for selected countries. Source: UNEP, 1991a.

the two biggest sources.[3] For example, in 1975, the United States emitted approximately 26 million metric tons of SO_x, which had been reduced to approximately 21 million metric tons by 1991.[4] Countries within the former Soviet Union emitted approximately 20 million metric tons in 1981 compared to approximately 18 million metric tons in 1988.[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, Mexico, and India.[2,3,5]

In 1990, global emissions of total suspended particulate matter were estimated to be approximately 57 million metric tons per year.[6] However, estimates vary widely. The United Nations Environment Program 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 7-1 provides additional information on particulate emissions to allow for comparisons among countries. Although information is limited for Eastern Europe and other developing countries, particulate emissions appear to be increasing.[3]

Table 7-1. Human-induced Emissions of Sulfur Oxides and Particulates

Country	Sulfur Oxides (1000 metric tons/year)	Sulfur Oxides (kg/capita)	Particulates (1000 metric tons/year)
Canada	3,800	146.4	1,709
USA	20,700	84.0	6,900
Japan	835	6.8	101
France	1,335	22.8	298
Germany (FRG)	1,306	21.3	532
Italy	2,070	36.0	413
Netherlands	256	17.3	95
Norway	65	15.4	25
Sweden	199	23.6	170
UK	3,664	63.1	533
N. America	24,500	—	9,000
OECD Europe	13,200	—	4,000
World	99,000	—	57,000

7.2 Ambient Concentrations

On a global scale, in general, declining annual average sulfur dioxide (SO_2) levels over time correspond with declining emission trends (Figure 7-2). Trends in SO_2 annual average concentration levels for developed countries within the Organization for Economic Cooperation and Development (OECD) are displayed in Table 7-2. 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 7-3 presents a comparison of annual average SO_2 levels for several sites. Figure 7-4 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 three sites in Canada, a site in Montreal (Quebec), one in Toronto (Ontario), and one in Winnipeg (Manitoba), Canada.[7]

Table 7-2. Urban Trends in Annual Average Sulfur Dioxide Concentrations ($\mu g/m^3$)

Country	City	1970	1975	1980	1985	Late 1980s
Canada	Montreal (Queb)	—	40.3	40.7	20.2	16.1
USA	New York (NY)	—	43.1	37.5	36.6	32.3
Japan	Tokyo	109.2	60.0	48.0	25.2	19.8
Belgium	Brussels	160.4	99.0	62.4	33.7	31.7
Denmark	Copenhagen	—	45.0	31.0	26.1	21.2
Finland	Tampere	—	103.0	58.7	41.2	7.2
France	Paris	121.9	115.0	88.6	54.0	43.7
	Rouen	—	63.0	69.9	37.2	35.3
Germany	Berlin (West)	—	95.0	90.2	67.4	60.8
Italy	Milan	258.6	244.0	200.0	87.8	56.1
Luxembourg	Nat'l Network	—	61.0	37.2	18.9	17.1
Netherlands	Amsterdam	76.2	34.0	25.2	16.0	13.9
Norway	Oslo	—	48.0	36.0	14.9	13.0
Portugal	Lisbon	—	36.2	44.2	31.1	43.1
Sweden	Götenborg	—	41.0	24.2	21.2	13.1
	Stockholm	—	59.0	41.9	41.8	14.2
UK	London	—	116.0	69.6	41.8	39.4
	Newcastle	143.4	112.0	69.4	40.3	35.8

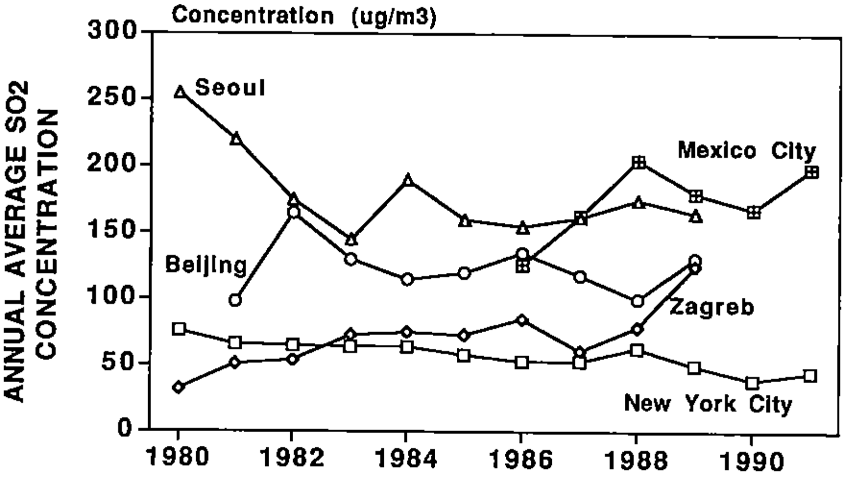


Figure 7-3. Trend in annual average sulfur dioxide concentrations in selected cities in the world. Source: UNEP, 1992; UNEP/WHO, 1992a; UNEP/WHO, 1992b.

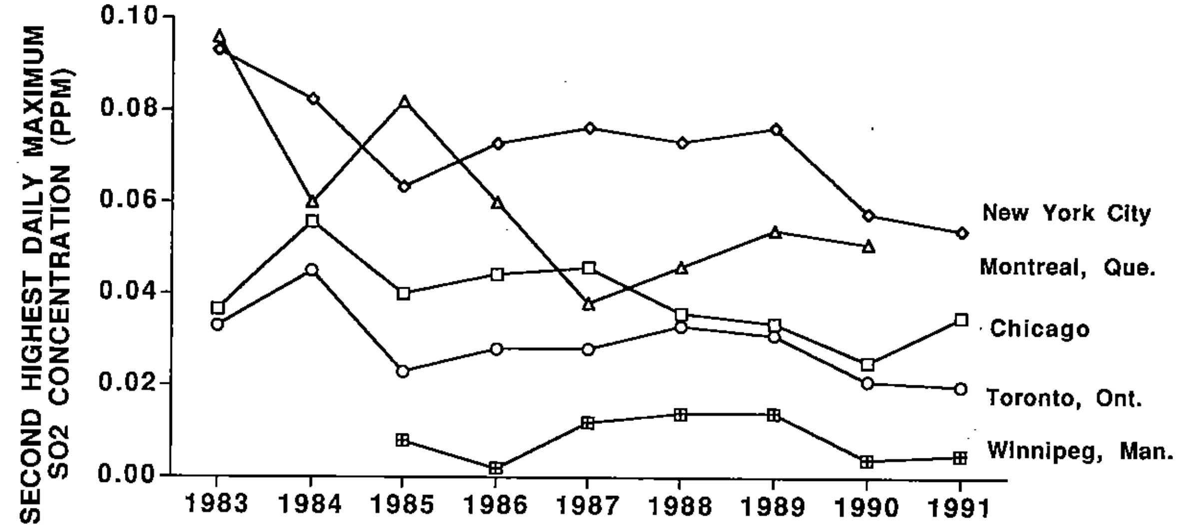


Figure 7-4. Trend in annual second highest 24-hour sulfur dioxide concentrations in selected U.S. and Canadian cities, 1983-1991. Source: T. Dann, Environment Canada; AIRS database.

Similar to the SO_2 trend, annual average total suspended particulate matter (TSP) concentrations in cities are declining in many of the world's industrialized cities. Urban particulate matter concentrations have declined in OECD countries from annual average concentrations of between 50 and 100 $\mu g/m^3$ in the early 1970s, to levels between 20 and 60 $\mu g/m^3$ on a current annual basis.[1] However, TSP concentrations in many of the developing countries are high when compared to some of the more industrialized cities (Figure 7-5). In North America, a comparison of the TSP annual geometric mean 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 7-6.

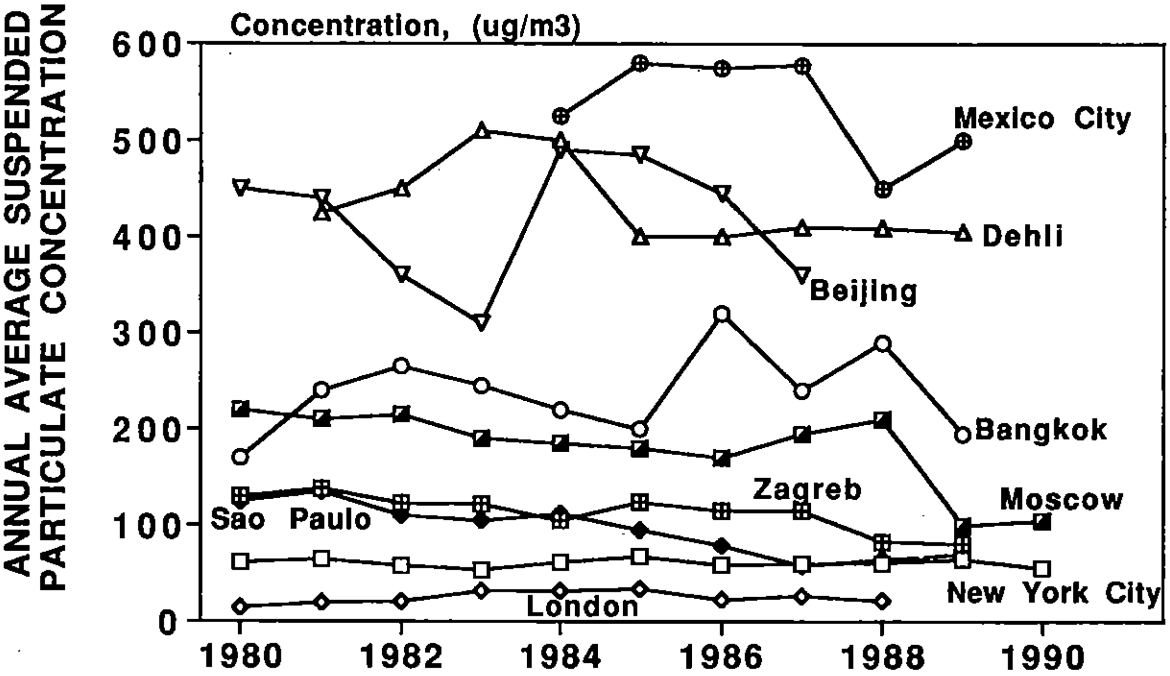


Figure 7-5. Trend in annual average total suspended particulate concentrations in selected cities in the world. Source: UNEP/WHO, 1992a; UNEP/WHO, 1992b.

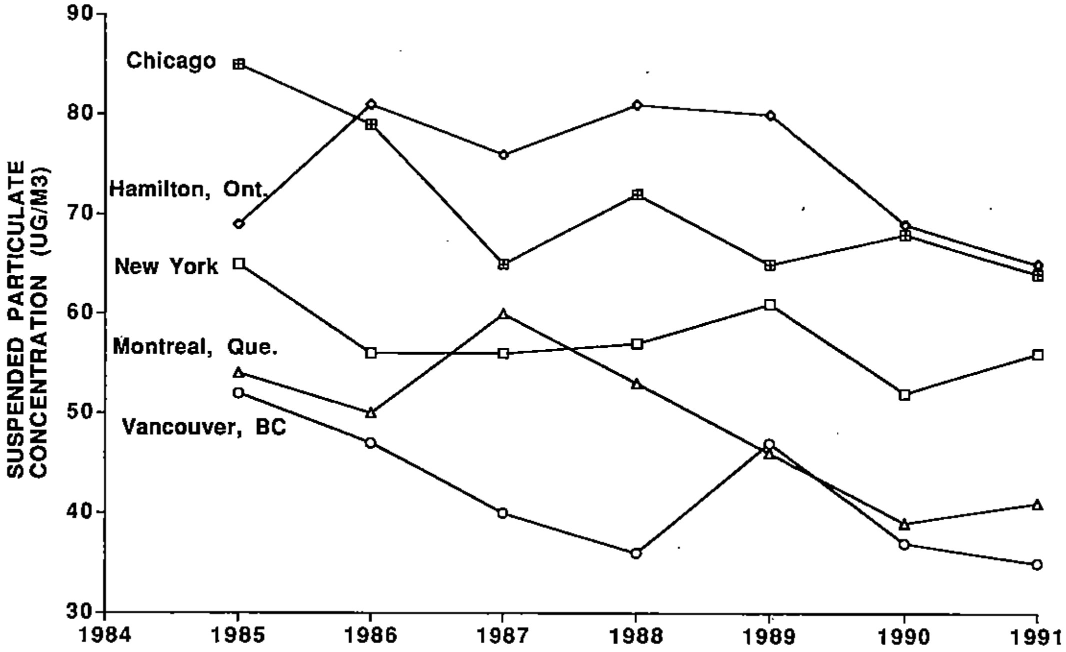


Figure 7-6. Trend in annual geometric mean total suspended particulate concentrations in selected U.S. and Canadian cities, 1985-1991. Source: T. Dann, Environment Canada; AIRS database.

Hourly average values of ozone (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.

Figure 7-7 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.

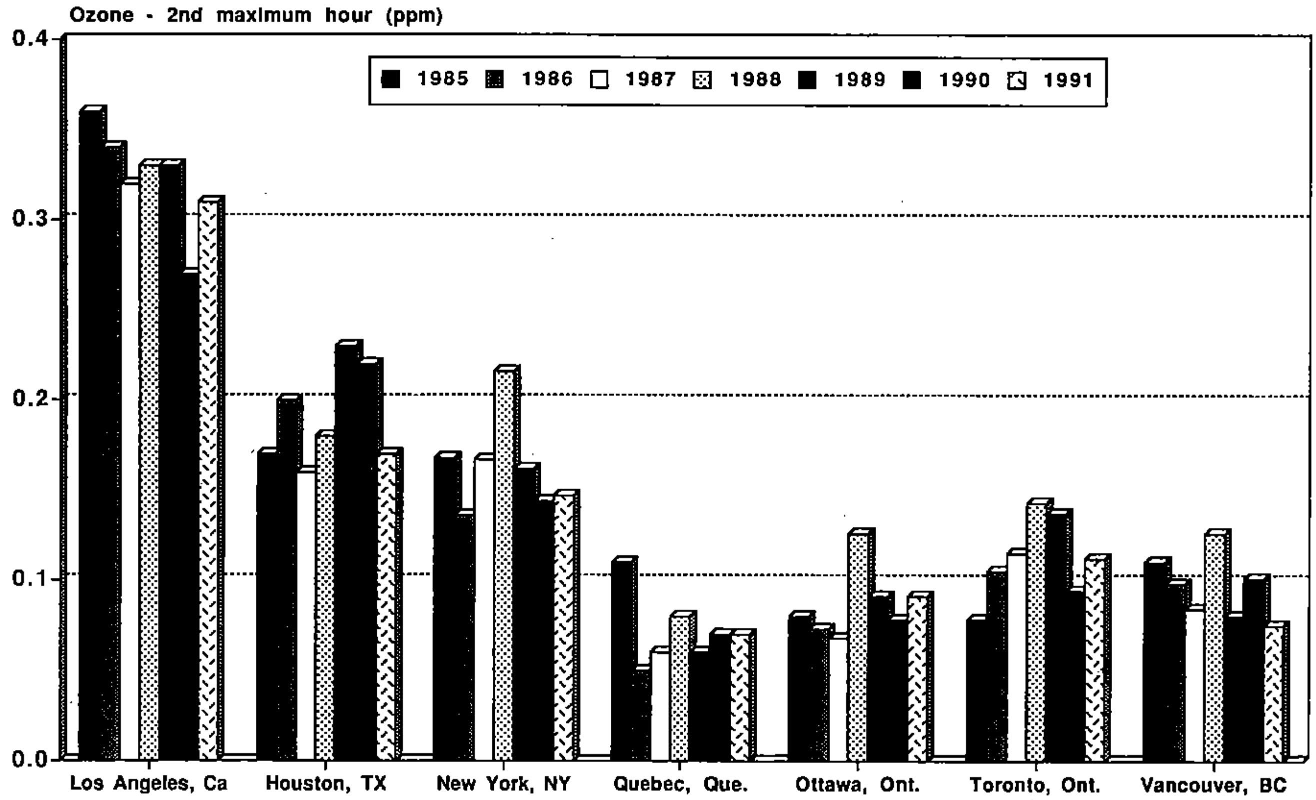


Figure 7-7. Trend in annual second highest daily maximum 1-hour ozone concentrations in selected U.S. and Canadian cities, 1985-1991. Source: T. Dann, Environment Canada; AIRS database.

A comparison of TSP, SO_2 and O_3 concentrations experienced in some cities around the world is presented in Figure 7-8. Concentrations, in micrograms per cubic meter, for TSP, SO_2, and O_3 vary substantially among cities in the world. The pollutant concentrations presented in this figure, for all cities except Los Angeles and New York, were adapted from a joint United Nations and World Health Organization report.[8] This report studied the air pollution problems in the 20 largest cities (megacities) in the world. The data for the U.S. cities were obtained from the Aerometric Information Retrieval System[9] (AIRS). The TSP and SO_2 values presented represent the maximum annual average measured in the city; while, the O_3 values represent the maximum hourly concentration recorded. This information represents measurements taken over the time period 1988-92. The highest TSP annual concentrations occurred in Cairo(1,100), Calcutta(600), and Mexico City(500). These were the only cities which experienced TSP levels of 500 µg/m³ or above. SO_2 was highest in Mexico City(200) followed by Rio de Janeiro(170), Seoul(160), Beijing(130), and Shanghai(120). These were the only cities with SO_2 levels above 100 µg/m³. There were only 8 out of the 20 cities where recent O_3 levels were reported. Mexico City experienced the highest hourly O_3 concentration of 792 µg/m³ followed by Los Angeles(660), New York City(545) and Sao Paulo(350).

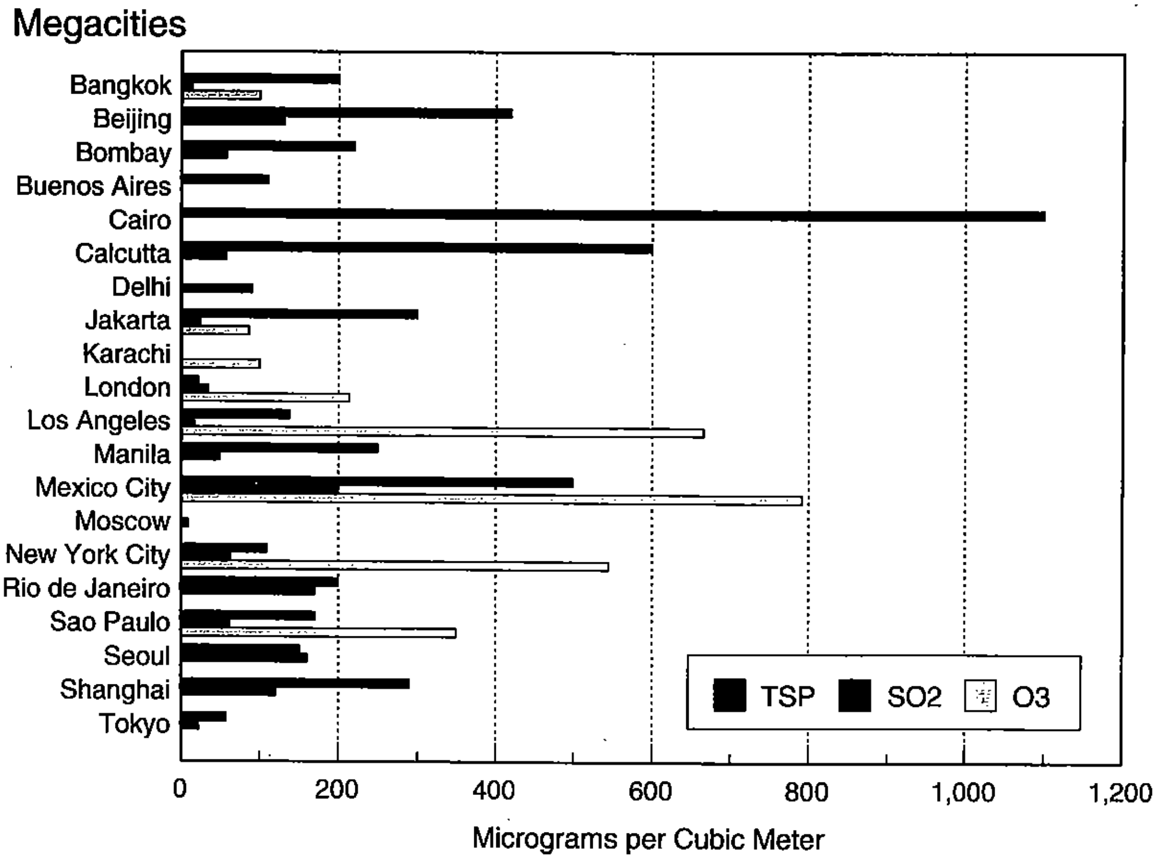


Figure 7-8. Comparison of ambient levels of annual second daily maximum 1-hour ozone, annual average total suspended particulate matter, and sulfur dioxide among selected cities. Source: UNEP/WHO, 1992a; UNEP/WHO 1992b; Varshney and Aggarwal, 1992; AIRS database.

7.3 References

1. The State of the Environment, *Published by the Organization for Economic Co-operation and Development, Paris, France, 1991.*
2. Assessment of Urban Air Quality, *Published by the United Nations Environment Program and the World Health Organization, Global Environment Monitoring System, Nairobi, Kenya, 1988.*
3. Urban Air Pollution, *UNEP/GEMS Environment Library, No 4, Published by the United Nations Environment Program, Nairobi, Kenya, 1991.*
4. National Air Quality and Emissions Trends Report, 1991, *EPA-450/R-92-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, October 1992.*
5. Environmental Data Report 1991/92, *UNEP/GEMS Monitoring and Assessment Research Centre, London, United Kingdom, Basil Blackwell, Oxford, United Kingdom, 1991.*
6. The State of the Environment (1972-1992), *UNEP/GCSS, III/2, Published by the United Nations Environment Program, Nairobi, Kenya, 1992.*
7. *Written communication from T. Dann, Environment Canada to A.S. Lefohn, A.S.L. & Associates, Helena, MT, March 17, 1992, and March 17, 1993.*
8. Urban Air Pollution in Megacities of the World, *Published by the World Health Organization and United Nations Environment Program, Blackwell Publishers, Oxford, United Kingdom, 1992.*
9. *Aerometric Information Retrieval System (AIRS), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July, 1993.*

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16. ABSTRACT

This report presents national and regional trends in air quality from 1983 through 1992 for particulate matter, sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone and lead. Air quality trends are also presented for 23 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 also contained in this report. Overview information on visibility and air toxics is introduced for the first time.

This report also includes a section, 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, 1992. Air quality statistics are presented for each of the pollutants for all MSAs with data in 1992.

17. KEY WORDS AND DOCUMENT ANALYSIS

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

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