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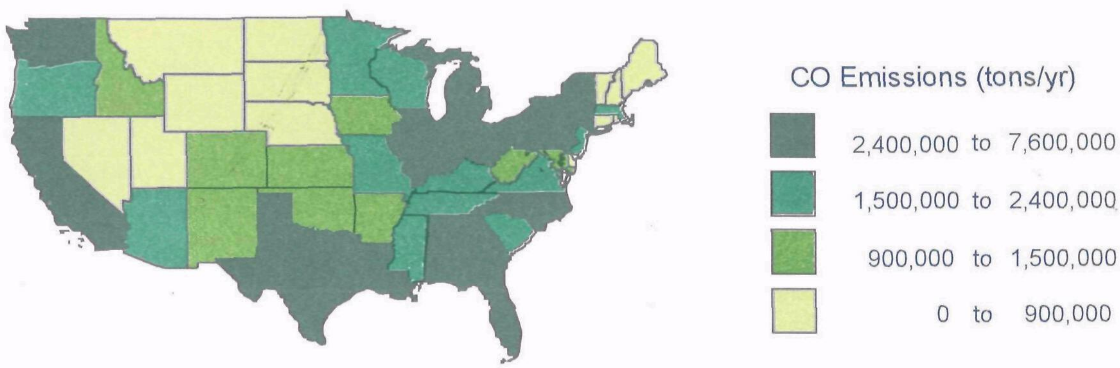
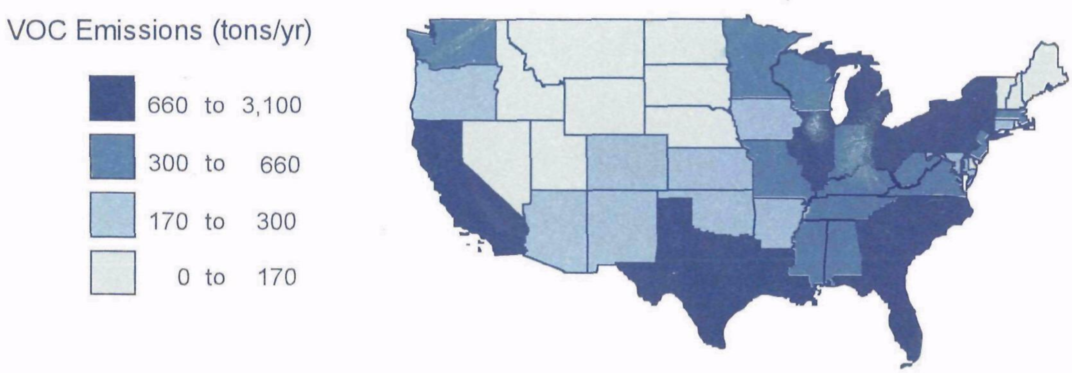
NATIONAL AIR POLLUTANT EMISSION TRENDS, 1900 - 1993

1993 CO STATE-LEVEL EMISSION DENSITIES



1993 VOC STATE-LEVEL EMISSION DENSITIES



National Air Pollutant Emission Trends 1900 — 1993

DISCLAIMER

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FOREWORD

This document presents the most recent estimates of national emissions of the criteria air pollutants. The emissions of each pollutant are estimated for many different source categories, which collectively account for all anthropogenic emissions. The report presents the total emissions from all 50 States and from each EPA region in the country. These estimates are updated annually.

This is the third of a series of reports that is tracking the changes in national emissions since passage of the Clean Air Act Amendments of 1990. Air emission trends are the net effect of many factors, including changes in the nation's economy and in industrial activity, technology, consumption of fuels, traffic, and other activities that cause air pollution. The trends also reflect changes in emissions as a result of air pollution regulations and emission controls. These reports will serve as a measure of our nation's progress in reducing air pollution emissions as a result of mandatory and voluntary controls and of continuous changes in national activity.

This report also reflects recent improvements in the way national and regional emissions are calculated. Improvement in estimation methods is an on-going effort, and it is expected that future reports will reflect this effort. Revisions to the *National Air Pollutant Emission Trends, 1900-1993,* (hereinafter referred to as *"Trends")* methodology include a change in the method used to estimate pre-1985 to the present emissions, recalculation of mobile source emissions for the years 1970 to 1993 using an updated emissions model, use of certain years' estimates for trends only, modification of the method used to calculate particulate matter emissions, and use of other years' estimates as both trend and absolute indicators. Further details of these methodological changes are described in section 6 of this report. Preliminary estimates are presented for the years 1990 through 1993. This year's report continues to provide limited coverage of biogenic, global warming gases, air toxics, and international emissions. Final estimates (including refinements to the data used to estimate emissions) will be presented in future reports.

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 Sharon V. Nizich, Project Officer, (MD-14) U.S. Environmental Protection Agency, Technical Support Division, Research Triangle Park, North Carolina 27711.

CONTENTS

SECTION 7.0

SECTION 8.0

SECTION 9.0

SECTION 10.0

TABLES

FIGURES

ACRONYMS AND ABBREVIATIONS

AAMA	American Automobile Manufacturers Association
AFS	AIRS Facility Subsystem
AIRS	Aerometric Information Retrieval System
AMS	AIRS Area/Mobile Source Subsystem
ARCINFO	name of commercial Graphical User Interface (GUI) product
BEA	Bureau of Economic Analysis
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAA	Clean Air Act
CAAA	1990 Clean Air Act Amendments
CCT	Clean Coal Technology
CE	control efficiency
CEC	European Commission
CEFIC	Conseil European de l'Industrie Chimique (European Chemical Industry Council)
CEUM	Coal and Electric Utility Model
CH_4	methane
CITEPA	Centre Interprofessionnel Technique d'Etudes de la Polution Atmopherique (currently, the main contractor for the CORINAIR program)
CO	carbon monoxide
CO_2	carbon dioxide
CORINAIR	CORINE AIR
CORINE	COoRdination d'INformation Environnementale
CTG	Control Techniques Guidelines
DDE	p,p'-dichlorodiphenyldichlorethylene
DGXI	Directorate General Environment, Nuclear Safety and Civil Protection
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
E-GAS	Economic Growth Analysis System
EEA	European Environment Agency
EFTA	European Free Trade Association
EIA	Energy Information Administration
EIB	Emission Inventory Branch
EMFAC7F	California on-road motor vehicle emission factor model
EOM	extractable organic matter
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act of 1986
ERCAM	Emission Reduction and Cost Analysis Model
EU-12	12 European Union countries
EUROTRAC	EUROpean experiment on TRAnsport and transformation of environmentally relevant trace Constituents in the troposphere over Europe (a scientific research program)
FCCC	Framework Convention on Climate Change
FHWA	Federal Highway Administration
FMVCP	Federal Motor Vehicle Control Program
FTP	Federal Test Procedure

GACT	generally available control technology
HAPs	hazardous air pollutants
HC	hydrocarbon
HCB	hexachlorobenzene
HDDV	heavy-duty diesel vehicle
HDGV	heavy-duty gasoline vehicle
HPMS	Highway Performance Monitoring System
I/M	inspection and maintenance
IIASA	International Institute for Applied Systems Analysis
IPCC	Intergovernmental Panel on Climate Change
L&E	Locating & Estimating (documents)
lbs	pounds
LDDT	light-duty diesel truck
LDDV	light-duty diesel vehicle
LDGT	light-duty gasoline truck
LDGV	light-duty gasoline vehicle
LEV	low emission vehicle
LRTAP	long range transboundary air pollution
MACT	maximum achievable control technology
MC	motorcycle
MEK	methyl ethyl ketone
MIBK	methyl isobutyl ketone
MOBILE5a	EPA's mobile source emission factor model
MSA	Metropolitan statistical area
MTBE	methyl tert-butyl ether
MVMA	Motor Vehicle Manufacturers Association
n.e.c.	not elsewhere classified
NAAQS	National Ambient Air Quality Standards
NADB	National Allowance Data Base
NACE	nomenclature generale des activites economiques de la Communaute europeenne
NAPAP	National Acid Precipitation Assessment Program
NCAR	National Center for Atmospheric Research
NEDS	National Emissions Data System
NESHAP	National Emission Standard for Hazardous Air Pollutants
NMHC	nonmethane hydrocarbons
NMOG	nonmethane organic gases
NMVOC	nonmethane VOC
NO	nitric oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NSPS	New Source Performance Standards
NSTU	Nomenclature of Statistical Territorial Units
O_3	ozone
OAQPS	Office of Air Quality Planning and Standards
OECD	Organization for Economic Cooperation and Development
OMS	Office of Mobile Sources
OPPE	Office of Policy Planning and Evaluation

Pb	lead
PCB	polychlorinated biphenyl
PHOXA	PHotochemical OXidants study (a scientific research program)
PM-10	particulate matter less than ten microns in aerodynamic diameter
POM	polycyclic organic matter
POTW	publicly owned treatment works
QA/QC	quality assurance/quality control
RACT	Reasonably Available Control Technology
RE	rule effectiveness
RIA	Regulatory Impact Analysis
ROM	Regional Oxidant Model
RVP	Reid vapor pressure
SCC	Source Classification Code
SEDS	State Energy Data System
SIC	Standard Industrial Classification
SIP	State Implementation Plan
SNAP90	source sector split
SO_2	sulfur dioxide
SOCMI	sysnthetic organic chemical manufacturing industry
SRAB	Source Receptor Analysis Branch
TCA	1,1,1-trichloroethane
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCDF	2,3,7,8-tetrachlorodibenzofuran
TEL	tetraethyl lead
TF	task force
TML	tetramethyl lead
TSP	total suspended particulate
tpy	tons per year
TRI	Toxic Release Inventory
TSDF	treatment storage and disposal facility
U.S.	United States
UAM	Urban Airshed Model
UNECE	United Nations Economic Commission for Europe
UNICE	UNion des Confederations de l'Industrie et des employeurs d'Europe (union of industrial and employers' confederations of Europe)
VMT	vehicle miles traveled
VOC	volatile organic compounds

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EXECUTIVE SUMMARY

This report presents the U.S. Environmental Protection Agency's (EPA) latest estimates of national and regional emissions for criteria air pollutants:[a] carbon monoxide (CO), lead (Pb), nitrogen oxides (NO_x), fine particulate matter less than 10 microns (PM-10), sulfur dioxide (SO_2), total suspended particulate matter [TSP (only in Appendix C)] and volatile organic compounds (VOC). Estimates are presented for the years 1900 to 1993, with greater detail in more recent years.

National emissions are estimated annually by the EPA based on statistical information about each source category, emission factor, and control efficiency. The estimates are made for over 450 individual source categories that include all major sources of anthropogenic emissions for the years 1900 through 1984.

> Methodologies to estimate pre-1985 and 1985 to the present emissions differ. Differences in methodologies for allocating emissions among source categories could result in significant changes in the emissions, particularly at the more detailed source category level. CAUTION SHOULD BE EXERCISED WHEN COMPARING TRENDS FOR TOTALS OF PRE-1985 AND 1985 TO THE PRESENT YEAR VALUES.

Starting with 1985, the estimates are based on a modified National Acid Precipitation Assessment Program (NAPAP)[1] inventory. This will allow for future inclusion of emissions data compiled and submitted by individual state pollution control agencies. As these detailed source emissions data progressively replace the broader, economic-activity based emissions, the accuracy of the national and regional estimates should improve, but comparisons with previously published estimates must take into account this changing complexion of the data base. This change in methodology is only a *first* step, however, so caution should be used when using this report for comparative purposes. More details on the changing methodology are described in section 6. The emissions for individual source categories are aggregated to show the emission trends at the national and regional levels and by major source category.

ES.1 EMISSION SUMMARY

Figures ES-1 and ES-2, in units of million short tons, and Table ES-1, in units of thousand short tons[b] per year, present national emissions of each pollutant. Table ES-1 shows estimates for every fifth year from 1900 to 1980, and for every year from 1983 to 1993. Table ES-2 shows the change in total national emissions of each pollutant since 1900, where available. The percentage change is shown for six time periods; 1900 to 1993, 1940 to 1993, 1970 to 1993, 1990 to 1993, the most recent decade, and the most recent year. The 1990 to 1993 interval has been added to help track progress following passage of the Clean Air Act Amendments of 1990 (CAAA).

Since 1900[c], total national NO_x emissions have increased by 796 percent (approximately a factor of 9), SO_2 emissions have increased approximately 120 percent, and VOC emissions have increased 200 percent. From 1970 to 1993, emissions of Pb show the greatest decrease (98 percent), followed by PM-10 [excluding fugitive dust (71 percent)], SO_2 (30 percent), CO (24 percent), and VOC (24 percent). NO_x emissions appear to have increased approximately 13 percent. Emissions of PM-10 and Pb show their greatest decrease in the 1970s; SO_2, CO, and VOC emissions show their largest decrease over the period 1970 to 1990. NO_x emissions have remained essentially constant since 1980.

Figure ES-3 shows the trend in population[2] and per capita emissions for NO_x, VOC, and SO_2 over the period 1900 to 1990. Although the emission trend for these pollutants shows variability over the entire time period, Figure ES-3 clearly shows that since the initial passage of the Clean Air Act in 1970 (CAA), per capita emissions have been steadily declining, with the exception of NO_x. NO_x emissions (on a per capita basis) have been declining since 1980.[d]

The following sections present a brief description of the changes in total emissions of each pollutant from 1940 to 1993. The data are presented in Table ES-1.

ES.2 EMISSIONS SUMMARY BY POLLUTANT

ES.2.1 Carbon Monoxide Emissions

Most anthropogenic CO is generated in some combustion process. Internal combustion engines, both in highway vehicles and in diverse off-highway uses, comprise the principle sources, contributing about 62 and 16 percent, respectively, of the estimated 97.2 million short tons of CO emissions in the United States in 1993. The majority of the carbon in gasoline and diesel fuel is oxidized to carbon dioxide (CO_2), a concern in its own right as a greenhouse gas (see section 8). A small fraction (up to 8 percent in an uncontrolled gasoline engine) is incompletely oxidized to CO, which is poisonous to humans.

The national trend in CO emissions since 1940 has been influenced primarily by changing emissions from highway vehicles. In 1940, highway vehicles contributed some 30 percent (27 million short tons) of the 91 million total short tons emitted; total CO emissions peaked in the early 1970s at around 130 million short tons, of which almost 70 percent (88 million short tons) derived from highway vehicles. By 1993, the national total had declined to 97 million short tons, 62 percent of which (60 million short tons) came from highway vehicles, despite increases in vehicle miles traveled (VMT) during the same period. In other notable categories, over the same 53 year period, off-highway engine emissions of CO increased by 90 percent and now stand at 16 percent of the total; CO from residential wood combustion deceased by 63 percent (from 11 million to 4 million short tons) and is now 4 percent of the total; the contribution from wildfires decreased 83 percent (from 25 million to 4 million short tons) and is currently 5 percent of the total.

Over the last 5 years, the overall trend in CO emissions has been slightly downward, from almost 101 million short tons in 1989 to 97 million short tons in 1993. This is primarily the result of decreasing CO emissions from the highway vehicle category as older vehicles are displaced by new models designed to operate more consistently at near-optimum air/fuel ratios and equipped with exhaust catalyzers that convert much of the remaining CO to additional CO_2.

ES.2.2 Nitrogen Oxides Emissions

Nitrogen oxides are formed during high temperature fuel combustion, principally in fossil fuel-fired electric utility and industrial boilers and in internal combustion engines. The principal components of NO_x, nitric oxide (NO) and nitrogen dioxide (NO_2), participate in the photochemical reactions producing tropospheric ozone, can be further oxidized to nitric acid (HNO_3), a component of acid rain, and can induce respiratory effects in humans.

From 1940 through 1970, NO_x emissions increased by over 200 percent (from 7.5 million to 20.5 million short tons). Since 1980, national NO_x emissions have leveled off at about 23 million short tons. In 1940, industrial fuel combustion was the largest of the four major contributors, adding 34 percent (2.5 million short tons) to the national total; fuel combustion by electric utilities added less than 9 percent (two thirds of a million short tons). Highway vehicles contributed 20 percent (1.5 million short tons); off-highway vehicles and machinery, principally coal-fueled railroad locomotives, added 13 percent (just under 1 million short tons). By 1993, NO_x emissions from electric utilities and highway vehicles had risen markedly, each now contributing about one third to the national total (approximately 7.5 million short tons each). Emissions from industrial combustion and off-highway sources have risen more slowly, in fact, industrial combustion emissions are now about 25 percent below their 1970 level; each now comprises about 13 percent (approximately 3 million short tons each) of the national total for NO_x.

ES.2.3 Volatile Organic Compound Emissions

Volatile organic compounds[e] are a principal component in the chemical and physical atmospheric reactions that form ozone and other photochemical oxidants. Emissions of VOC increased for the nation from 1900 to 1970, peaking in the early 1970s, but have decreased steadily since that time. Some categories have increased while others have decreased. Variability of emission levels is based on pollution controls, population, and economic factors. For instance, in 1900, emissions from all fuel combustion sources represented 68 percent of the total national VOC emissions, but by 1993 the contribution was 3 percent. These decreases, occurring despite large population growth, are due to increased controls on the burning of fossil fuels for utilities and industry. While emissions of petroleum product storage and marketing operations increased during the mid-1970s as a result of increased demand for petroleum products, especially motor gasoline, emissions from these sources began to decrease after 1978 as a result of more effective control measures. Another reason for the overall decrease in the emissions between 1970 and 1993 is the substitution of water-based emulsified asphalt for asphalt liquified with petroleum distillates.

With the advent of wider use of the automobile and aircraft, VOC emissions for transportation sources increased 161 percent from 1940 to 1970. After 1970, the Federal Motor Vehicle Control Program (FMVCP) initiative resulted in a drastic decline in vehicle emissions, even with the enormous increase in VMT. From 1970 to 1993, highway vehicle emissions dropped approximately 53 percent. Inspection/maintenance, oxygenated fuels programs, and other control programs are expected to contribute to a continuing decline in emission rates for highway vehicles, despite increasing VMT.

ES.2.4 Sulfur Dioxide Emissions

The majority of SO_2 emissions derive from the combustion of fossil-fuels containing trace amounts of sulfur. Various particulate sulfate compounds can be formed, as well. Once emitted into the atmosphere, SO_2 can be further oxidized to sulfuric acid, a component of acid rain.

In 1940, national SO_2 emissions were almost 20 million short tons. In the early 1970s, the total reached some 31 million short tons; by 1993 it had declined again to almost 22 million short tons. In 1940, the major contributor was the industrial fuel combustion category, producing 30 percent (6 million short tons) of the total. The next three ranking categories were "other combustion sources" (consisting primarily of residential and commercial coal furnaces), 18 percent (3.5 million short tons), metals refining and processing, and off-highway vehicles (largely coal-fueled locomotives), each adding about 16 percent (some 3 million short tons each). Fifth among the major categories was electric power generation; coal-fueled steam generators added about 12 percent (almost 2.5 million short tons) to the national total of SO_2 emissions.

By 1993, decreases were seen in the first four categories in varying degrees. Emissions of SO_2 from electric power generation, on the other hand, rose markedly with the demand for electric power; by the decade of the 1970s, SO_2 emissions from electric utilities had increased sevenfold and dominated the national total at 56 percent (17.5 million short tons). By 1993, the electric utility companies had installed emission controls and/or switched to low sulfur fuels, reducing their emissions to under 16 million short tons, but because of reductions in other categories as well, electric utilities now constitute some 72 percent of the national total of SO_2 emissions. The second ranking contributor is the industrial combustion category at 13 percent (less than 3 million short tons). The remaining three categories each now account for less than 3 percent of the national total (≤ 0.6 million short tons each).

ES.2.5 Particulate Matter (PM-10) Emissions

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 as well as particles formed in the atmosphere by condensation or transformation of emitted gases such as SO_2 and VOC. (Note: The particulate matter emissions in this report do not include emissions from gas phase particulate matter precursors.)

On July 1, 1987 EPA promulgated new annual and 24-hour standards for particulate matter using a new indicator, PM-10, that includes only those particles with an aerodynamic diameter smaller than 10 micrometers. These smaller particles are likely responsible for most adverse health effects of particulate because of their ability to reach the thoracic or lower regions of the respiratory tract. Because of the new standard, EPA now only reports total suspended particulate (TSP) in Appendix C of this report. Unless otherwise noted, all references in this report to particulate matter emissions are the 10 microns or less portion only. Trends in the PM-10 portion of historically inventoried (generally from sources referred to as "Point and Fugitive Processes") particulate matter emissions are presented for the years **1940 to 1993** in this report. National emissions are also provided for PM-10 fugitive dust emissions from **1985 to 1993**. In total, these fugitive emissions are 11 to 16 times more than the point and fugitive process categories.

In 1940, emissions from fuel combustion represented 25 percent of the total national PM-10 emissions. Despite continuing increases in coal consumption, PM-10 emissions from electric utilities decreased after 1970, as a result of installing air pollution control equipment required by new facilities constructed in the 1970s. Fuel combustion sources contributed 22 percent to the total national emissions in 1970, and 33 percent in 1993. In 1940, emissions from transportation emissions accounted for 17 percent of the total national PM-10 emissions. Railroad and light-duty gasoline vehicles (LDGV) represented 15 and 1 percent, respectively, of the total 1940 emissions. By 1970, the railroad emissions decreased by 99 percent and the LDGV emissions decreased by 61 percent. The railroad emissions increased from 1970 to 1993 by 91 percent. Over the same period, the LDGV emissions decreased by 49 percent. In 1993 emissions from the transportation source represented 16 percent of the total national PM-10 emissions.

The PM-10 emissions from industrial processes increased from 1940 through 1950, primarily as a result of increases in industrial production. From 1950 to 1970, industrial output continued to grow, but the emissions from industrial processes decreased due to the installation of pollution control equipment mandated by air pollution control programs. The reduction of emissions by these control devices more than offset the increase in emissions due to production increases. In 1970, industrial processes contributed 60 percent to the total national PM-10 emissions, while in 1993, they contributed 17 percent, thus indicating considerable progress in reducing emissions. In 1940, wildfires contributed 14 percent to the total national emissions, but in 1993 they contributed only 11 percent to the total.

The PM-10 emissions from fugitive dust sources decreased by 6 percent from 1985 to 1993. The decrease is mainly the result of wind erosion emissions. Particulate matter (PM-10) emissions due to wind erosion are very sensitive to regional soil conditions and year-to-year changes in total precipitation and wind speeds. For example, the total national emissions from wind erosion in 1993 are estimated to be 1 million short tons, compared to 18 million short tons in 1988. The lack of precipitation in 1988 prior to spring crop planting, especially in the central and western United States, contributed to greater wind erosion for that year. In 1993, unusually heavy spring rains in Kansas and Oklahoma, where wind erosion is normally very significant, resulted in a 97 percent decrease in the wind erosion emissions from the previous year.

ES.2.6 Lead Emissions

Lead gasoline additive, nonferrous smelters, and battery plants are the most significant contributors to atmospheric Pb emissions. Total Pb emissions from all sources dropped from 219 thousand short tons in 1985 to 5 thousand short tons in 1993. The decrease in lead emissions from highway vehicles accounts for essentially all of this drop. The reasons for this drop are noted in section 3.8.3 of this report.

Electric utility, industrial, and other fuel combustion emissions in 1940 represented 5 percent of the total national Pb emissions. The Pb emissions decreased by 95 percent from 1970 to 1993. By 1993, fuel combustion emissions accounted for 10 percent of the total emissions. Industrial processes in 1970 represented 12 percent of the total national Pb emissions. The emissions decreased by 91 percent from 1970 to 1993. By 1993, industrial process estimates accounted for 47 percent of the total emissions. Emissions from highway vehicles accounted for 78 percent of the total emissions in 1970. Total national Pb emissions decreased sharply from 1970 to 1986 as a result of the widespread use of catalytic converters on automobiles to reduce NO_x, VOC, and CO emissions and the use of unleaded gasoline for vehicles with these converters. From 1975 to 1993, the percent of unleaded gasoline sales increased from 13 to 99 percent, while the Pb emissions from highway vehicles decreased from 130 thousand short tons in 1975 to 1 thousand short tons in 1993, or about 99 percent. In 1993, highway vehicle emissions accounted for 28 percent of the total national Pb emissions.

ES.3 CURRENT NONATTAINMENT AREAS

The numbers of areas designated in nonattainment of air quality standards, as of mid-1994, are listed in Table ES-3. This list provides information on how the states are meeting their goals set forth in Title I of the 1990 Clean Air Act Amendments. As state data are federally approved for these nonattainment areas, they will be incorporated into the 1995 *Trends* Report.

ES.3 REFERENCES

1. *The 1985 NAPAP Emissions Inventory (Version 2): Development of the Annual Data and Modeler's Tapes.* EPA-600/7-89-012a. U.S. Environmental Protection Agency, Research Triangle Park, NC. November 1989.

2. *National Data Book and Guide to Sources, Statistical Abstract of the United States 1993.* U.S. Department of Commerce, Bureau of the Census, Washington, DC. 1989.

3. *Historic Emissions of Sulfur and Nitrogen Oxides in the United States from 1900 to 1980.* EPA-600/7-85-009a and b. U.S. Environmental Protection Agency, Cincinnati, OH. April 1985.

4. *Historic Emissions of Volatile Organic Compounds in the United States from 1900 to 1985.* EPA-600/7-88-008a. U.S. Environmental Protection Agency, Cincinnati, OH. May 1988.

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[a] The Clean Air Act (CAA) requires that the EPA Administrator publish a list of pollutants that have adverse effects on public health or welfare, and which are emitted from numerous and diverse stationary or mobile sources. For each pollutant, a "criteria" document must be compiled and published by the Administrator. The criteria are scientific compendia of the studies documenting adverse effects of specific pollutants at various concentrations in the ambient air. For each pollutant, NAAQS are set at levels which, based on the criteria, protect the public health and the public welfare from any known or anticipated adverse effects. These regulated pollutants are therefore referred to as "criteria pollutants."

[b] Unless otherwise noted, all references to tons in this report are short tons.

[c] It should be noted that the historic emissions may not be as reliable as the more recent estimates as a result of increased uncertainty in early statistics and assumptions.

[d] Please note that the apparently encouraging downward trend is probably due as much to the increase in population as to the decrease in emissions.

[e] It should be noted that EPA's definition of VOC (40CFR51.100) excludes methane, ethane, and certain other nonphotochemically reactive organic compounds.

Figure ES-1. Trend in National Emissions, NITROGEN OXIDES, VOLATILE ORGANIC COMPOUNDS, SULFUR DIOXIDE, (1900 to 1993) and PARTICULATE MATTER ([PM-10]: nonfugitive dust sources; 1940 to 1993)

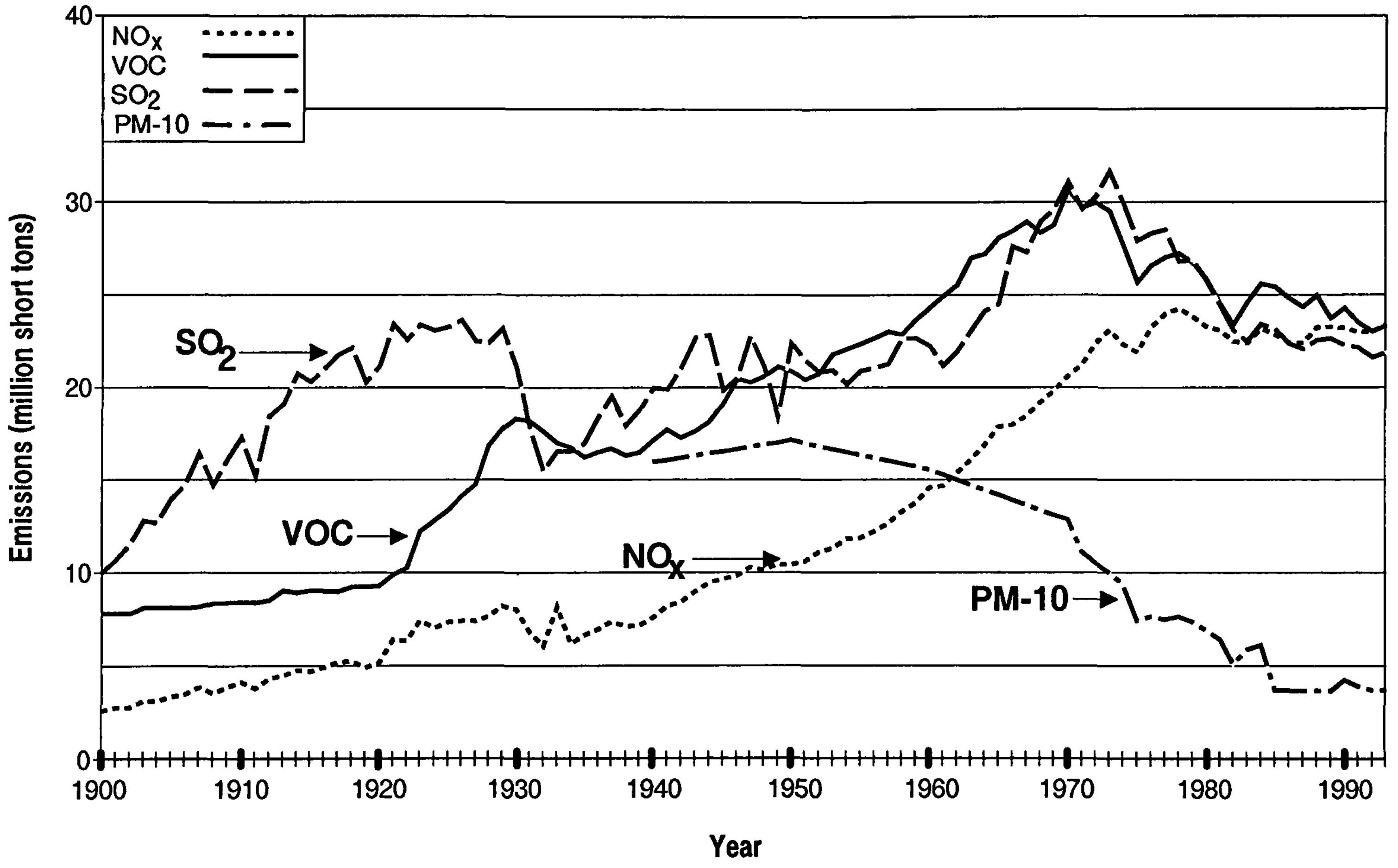
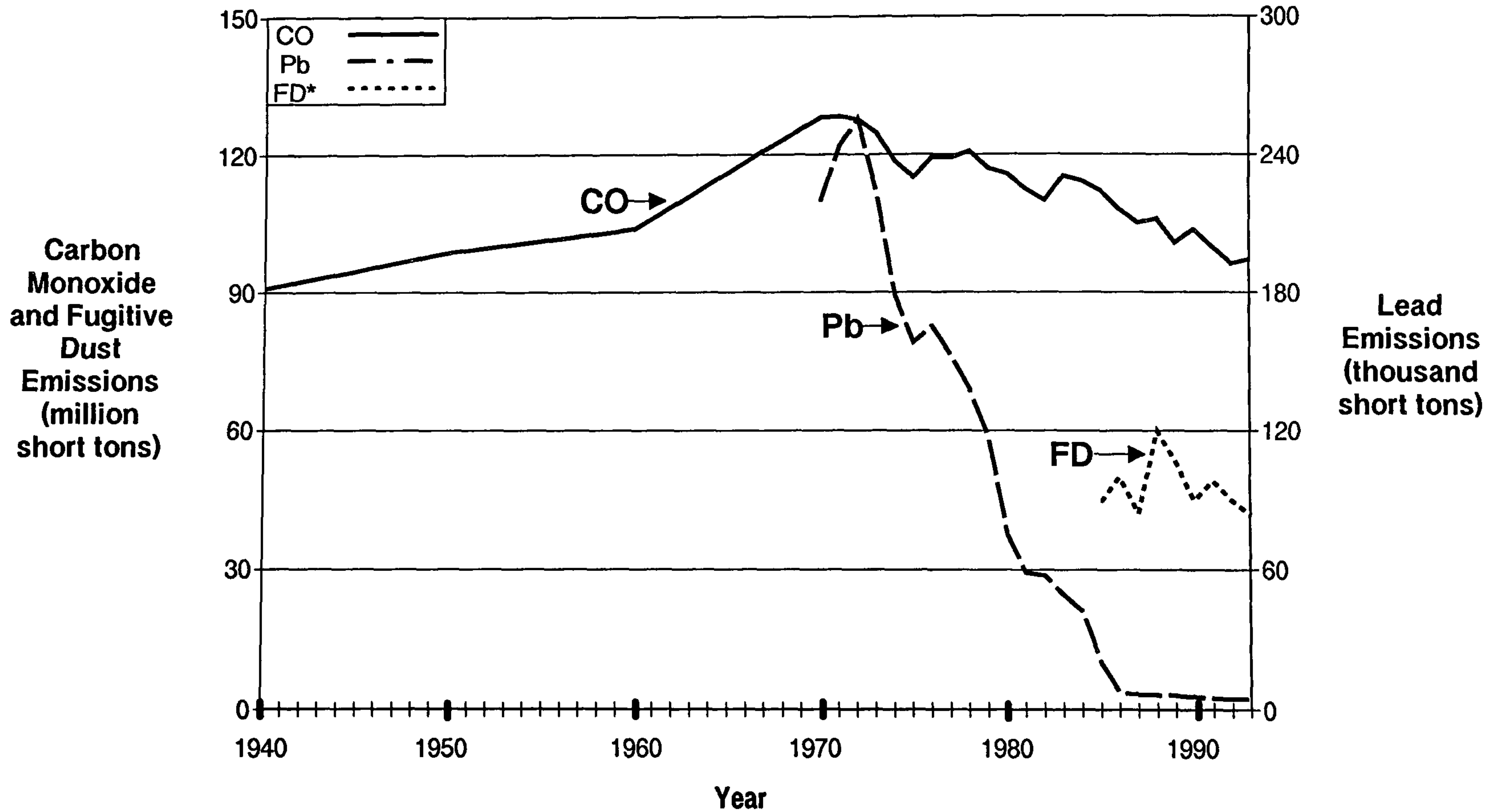


Figure ES-2. Trend in National Emissions, CARBON MONOXIDE (1940 to 1993), FUGITIVE DUST (1985 to 1993), and LEAD (1970 to 1993)



*FD=Fugitive dust

Table ES-1. Summary of National Emissions

(thousand short tons, 1.1 million short tons equals 1 million metric tons)

Year	Nitrogen Oxides	Volatile Organic Compounds	Sulfur Dioxide	Carbon Monoxide	Particulate Matter (PM-10) without fugitive dust	Fugitive Dust (PM-10)*	Lead (short tons)
1900***	2,611	7,765	9,988	NA**	NA	NA	NA
1905***	3,314	8,124	13,959	NA	NA	NA	NA
1910***	4,102	8,402	17,275	NA	NA	NA	NA
1915***	4,672	9,046	20,290	NA	NA	NA	NA
1920***	5,159	9,291	21,144	NA	NA	NA	NA
1925***	7,302	13,357	23,264	NA	NA	NA	NA
1930***	8,018	18,316	21,106	NA	NA	NA	NA
1935***	6,639	16,200	16,978	NA	NA	NA	NA
1940	7,568	17,118	19,954	90,865	15,956	NA	NA
1945****	9,643	19,128	19,850	94,825	16,545	NA	NA
1950	10,403	20,856	22,384	98,785	17,133	NA	NA
1955****	11,851	22,349	20,883	101,281	16,346	NA	NA
1960	14,581	24,322	22,245	103,777	15,558	NA	NA
1965****	17,836	28,072	24,500	115,928	14,198	NA	NA
1970*****	20,625	30,646	31,096	128,079	12,838	NA	219,471
1975	21,889	25,677	27,907	115,110	7,414	NA	158,541
1980	23,281	25,893	25,813	115,625	6,928	NA	74,956
1983	22,364	24,607	22,471	115,334	5,849	NA	49,232
1984	23,172	25,572	23,396	114,262	6,126	NA	42,217
1985******	22,853	25,417	23,148	112,072	3,676	44,701	20,124
1986	22,409	24,826	22,361	108,070	3,679	49,940	7,296
1987	22,386	24,338	22,085	105,117	3,630	42,131	6,840
1988	23,221	24,961	22,535	106,100	3,697	59,975	6,464
1989	23,250	23,731	22,653	100,806	3,661	53,323	6,099
1990*******	23,192	24,276	22,261	103,753	4,229	44,929	5,635
1991*******	22,977	23,508	22,149	99,898	3,902	49,127	5,020
1992*******	22,991	23,020	21,592	96,368	3,676	44,953	4,741
1993*******	23,402	23,312	21,888	97,208	3,688	41,801	4,885

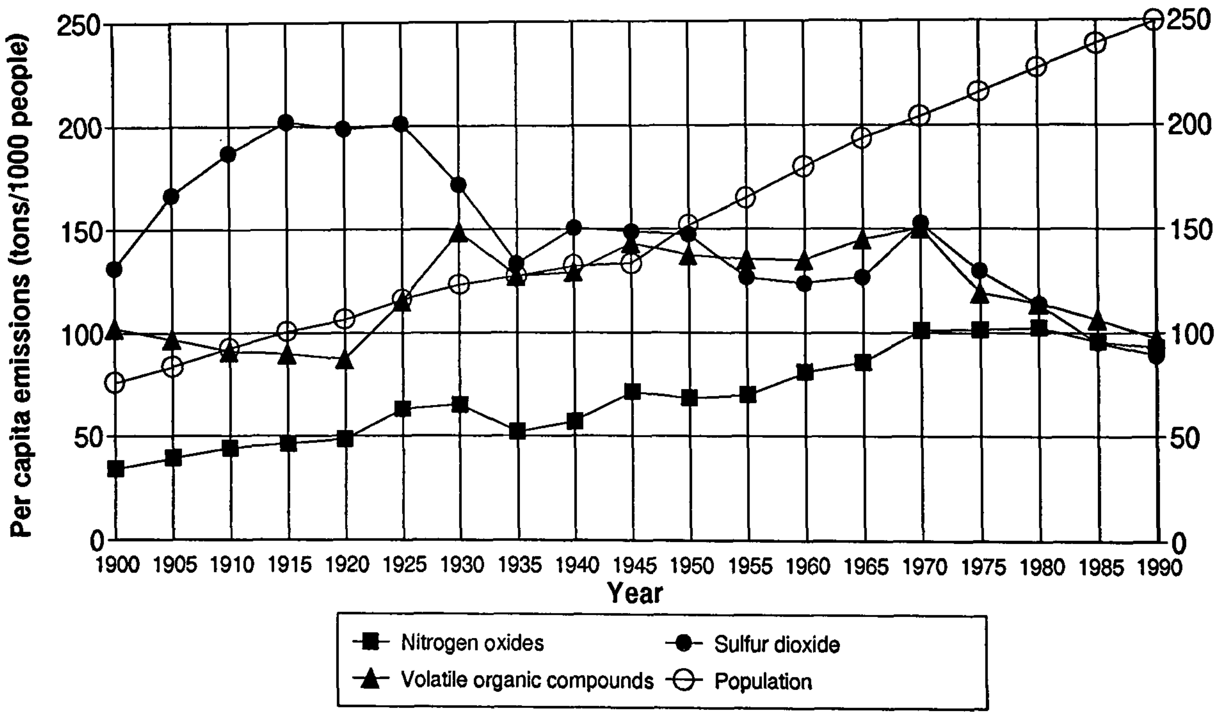
NOTE(S):
- * Fugitive dust emissions not estimated prior to 1985. They are defined in section ES.2.5.
- ** NA denotes not available.
- *** NAPAP historical emissions[3,4]
- **** Combination of revised transportation values and NAPAP historical emissions.
- ***** There is a change in methodology for determining highway vehicle and off-highway emissions (see section 6).
- ****** There is a change in methodology in all sources except highway vehicles and off-highway and all pollutants except lead, as reflected by the dotted line.
- ******* 1990, 1991, 1992, and 1993 estimates are preliminary.

Table ES-2. Percent Change in National Emissions

Year	Nitrogen Oxides	Volatile Organic Compounds	Sulfur Dioxide	Carbon Monoxide	Particulate Matter	Fugitive Dust	Lead
1900 to 1993	796	200	119	NA*	NA	NA	NA
1940 to 1993	209	36	10	7	-77	NA	NA
1970 to 1993	13	-24	-30	-24	-71	NA	-98
1983 to 1993	5	-5	-3	-16	-37	NA	-88
1990 to 1993	1	-4	-2	-6	-13	-7	-13
1992 to 1993	2	1	1	1	0	-7	3

NOTE(S): * NA denotes not available. 1990 to 1993 estimates are preliminary; negative percent change indicates a decrease.

Figure ES-3. Trend in National Per Capita Emissions of NITROGEN OXIDES, VOLATILE ORGANIC COMPOUNDS, and SULFUR DIOXIDE, 1900 to 1990



NOTE: The apparent encouraging downward trend in emissions is probably due as much to increase in population as to the decrease in emissions.
SOURCE: U.S. Department of Commerce's *Statistical Abstract of the United States, 1993*

TABLE ES-3. Current Nonattainment Areas

Category	As of 1990 CAAA*	Areas added or subtracted	Current	Redesignation Status**
OZONE	**98**		**93**	
Serious and above			22	1996-2010, area dependent
Moderate			31	1996
Marginal			40	Currently in process of redesignation to attainment
		5		In attainment
Unclassified			(59)***	
CO	**42**		**39**	
Serious			1	2000
Moderate			38	1996
		3		In attainment
Unclassified			(34)	
PM10	**70**		**83**	
Serious			5	10 years from nonattainment designation
Moderate			65	4 years from nonattainment designation
		13		6 years from nonattainment designation
SO_2	**51**	3	**49**	5 years from nonattainment designation
		5		In attainment
Pb	**12**	1	**13**	5 years from nonattainment designation
Unclassified			(9)	

NOTE(S): * Column presents original number in nonattainment as of passage of the Clean Air Act Amendments, 1990.
** Column presents expected dates that areas will be in attainment.
*** Denotes areas not in attainment, but not classified to date according to level of violation.

SECTION 1.0

INTRODUCTION

This report presents the U.S. Environmental Protection Agency's (EPA) latest estimates of national and regional emissions for criteria air pollutants: carbon monoxide (CO), lead (Pb), nitrogen oxides (NO_x), particulate matter less than ten microns (PM-10), sulfur dioxide (SO_2), total suspended particulate matter (TSP [only in Appendix C]), and volatile organic compounds (VOCs [excludes certain nonreactive organic compounds]). The Clean Air Act (CAA) requires that the EPA Administrator publish a list of pollutants that have adverse effects on public health or welfare, and which are emitted from numerous and diverse stationary or mobile sources. For each pollutant, a "criteria" document must be compiled and published by the Administrator. The criteria documents are scientific compendia of the studies documenting adverse effects of specific pollutants at various concentrations in the ambient air. For each pollutant, National Ambient Air Quality Standards (NAAQS) are set at levels that, based on the criteria, protect the public health and the public welfare from any known or anticipated adverse effects. Regulated pollutants are therefore referred to as "criteria pollutants." Some of the health effects are described in section 1.1.

Emissions are presented through this report since 1900 with increasing detail in the current year. This report also contains information on the improved methodology for estimating emissions from 1985 to the present, and for calculating emissions from highway vehicles. The tier category reporting initiated in last year's report has been continued. The methodology for estimating 1993 emissions allows emissions to be calculated by season as well as by state. International emissions from Europe and Canada are presented, as well as emissions from the Toxics Release Inventory (TRI).

1.1 HEALTH EFFECTS

1.1.1 Carbon Monoxide

Carbon monoxide enters the bloodstream and reduces the delivery of oxygen to the body's organs and tissues. The health threat from CO 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 CO levels is associated with impairment of visual perception, work capacity, manual dexterity, learning ability and performance of complex tasks.[1]

1.1.2 Nitrogen Dioxide

Nitrogen dioxide (NO_2) can irritate the lungs and lower resistance to respiratory infection (such as influenza). 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 concentrations.[2]

1.1.3 Volatile Organic Compounds

Volatile organic compounds are a principal component in the chemical and physical atmospheric reactions that form ozone and other photochemical oxidants. The reactivity of ozone (O_3) causes health problems because it damages biological tissues and cells. Ozone is also responsible each year for agricultural crop yield loss in the United States 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 O_3 levels.[3]

1.1.4 Sulfur Dioxide

The major health effects of concern associated with exposures to high concentrations of SO_2 include effects on breathing, respiratory illness and symptoms, alterations in the lung's defenses, aggravation of existing respiratory and cardiovascular disease, and mortality. Children and the elderly may also be sensitive. Also, SO_2 can produce foliar damage on trees and agricultural crops. Together SO_2 and NO_x are the 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.[4]

1.1.5 Particulate Matter (PM-10)

Based on studies of human populations exposed to ambient particle pollution (sometimes in the presence of SO_2), 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. Particulate matter causes damage to materials and soiling; it is a major cause of substantial visibility impairment in many parts of the United States.[4]

1.1.6 Lead

Exposure to Pb can occur through multiple pathways, including inhalation of air, diet and ingestion of Pb in food, water, soil, or dust. Lead accumulates in the body in blood, bone, and soft tissue. Because it is not readily excreted, Pb also affects the kidneys, liver, nervous system, and blood-forming organs. Excessive exposure to Pb may cause neurological impairments such as seizures, mental retardation and/or behavioral disorders. Even at low doses, Pb 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 does of Pb, often suffering central nervous system damage. Recent studies have also shown that Pb may be a factor in high blood pressure and subsequent heart disease in middle-aged caucasian males.[5]

1.2 POLLUTION TRENDS

Trends in emissions can result from a wide variety of individual, multiple, or synergistic influences. Tracking emission trends allows EPA, other government and private organizations, and individuals to assess the combined impacts of government regulatory programs, improvements in control technologies, changes in noncontrol related technologies, and the overall influence of the economy. Separating the effects of the parameters that can influence emissions can be straightforward; more often the combination of influences is less discernable. For instance, Figure ES-1 clearly shows a sharp decline in SO_2 estimates beginning in 1929 and a sharp increase in SO_2 estimates over the period 1940-1950. These affects can clearly be associated with the overall economic activity associated with the Great Depression and increased productivity during World War II, respectively. As another example, regulatory influences are clearly indicated in Figure ES-2 which shows a sharp reduction in lead emissions resulting from regulation of the lead content in gasoline in the early 1970s. Synergistic effects can be seen when looking at VOC emissions in Figure ES-1. The VOC emissions have steadily declined since 1970. This decline has occurred despite increases in vehicle miles traveled (VMT) by highway vehicles (a major source of VOC emissions). This decline is certainly the result of regulatory programs designed to reduce VOC emissions (i.e., cleaner cars and fuels), however the influence of economic factors on this trend is difficult to ascertain.

1.3 REPORT ENHANCEMENTS

To date, EPA has prepared annual national emissions in order to assess historic trends in criteria pollutant emissions since 1973. While these estimates were prepared using consistent methodologies and were useful for evaluating emission changes from year to year, they did not provide an absolute indication of emissions for any given year. Beginning with the 1900 to 1992 report (published in October 1993), EPA set the primary goal of preparing emission trends that would also represent the best available estimates of emissions.[f] Another goal is to show how emission levels have changed over time. To the extent possible, to allow fair comparison of these estimates, efforts have been made to develop the estimates using consistent methods. However, it is not possible to achieve both objectives in all cases. There must be a tradeoff between consistency of methodology and the completeness and accuracy of the data. A combination of methods is required to be able to present the best available emissions data. While the use of inconsistent methods has some effect on the integrity of the data for comparison purposes, technical judgments have been applied to attempt to balance the need for consistency with the need for accuracy. Data that are presented are judged to be the combination that best serves both purposes.

In this year's report, the reader will find four types of methodologies covering three distinct time periods: 1900 to 1939, 1940 to 1984, and 1985 forward (see description of methods on the following page and in section 6). Since the accuracy and availability of historical data is limited, revisions to earlier years' estimates will not generally be made (pre-1984 [some exceptions are discussed in section 6]). However, numerous changes in current year totals will be made as State Implementation Plan (SIP) and modeling data become available. Please note that methodologies within a given time period (especially more recent periods) will also vary, as more accurate data are loaded into the *Trends* data base.

States are currently finalizing a large emissions data base from calendar year 1990 to support Clean Air Act Amendments (CAAA) of 1990 requirements for ozone and carbon monoxide nonattainment areas. Actions in revising the *Trends* methodology to achieve consistency with state emission inventories will be described in more detail in section 6. This change in methodology has allowed the *Trends* report to present emissions for the state and ozone nonattainment areas. It also allows for the display of estimates by season. This report continues the change in scope from simply reporting national-level criteria pollutant emissions to providing additional information on international (Canada, Mexico, and Europe), air toxics, and greenhouse gas emissions.

1.3.1 Methodology Changes

Emission inventory data being submitted by the states in response to the CAAA will be used in numerous activities, one of which is ambient modeling. The modeling community will incorporate emissions data into Regional Oxidant Model (ROM) and Urban Airshed Model (UAM) runs. Results obtained with urban models may be sensitive to assumptions made about pollution transported into the urban modeling domain. Thus, the EPA will be using the ROM to provide base and future year boundary conditions. For the base year, this entails multiple ROM runs covering approximately 180 episode days over a 5-year period (1987 to 1991). For the future base year modeling, the attainment years 1996, 1999, 2005, or 2007 and 2010 will be modeled. To support the ROM runs, an emission inventory is needed for the regional modeling domain. Since the states are not required to develop or submit statewide emission inventories for all source categories, and since nonattainment area emission inventories are not required to be submitted and approved in a time frame to support the ROM runs, EPA developed *Regional Interim Emission Inventories*

(1987-1991), Volume I: Development Methodologies[6] (hereinafter referred to as "*Interim*") for the 1987 to 1991 base years.

Within the current Aerometric Information Retrieval System (AIRS), the majority of the emissions data reported are for sources within a nonattainment area or for sources emitting greater than 100 short tons per year, because this is the only information the states are required to report. However, for modeling analysis and trend evaluations, information on emissions from all sources (both within and outside of nonattainment areas) is required. Several projects are in progress or have been recently completed that attempt to reconcile the different data bases. For instance, in an effort to compare inventories, a new listing of source categories (Tier 1) and subcategories (Tier 2) applicable to all criteria pollutants was developed.[7] A third level of subcategories (Tier 3) that is pollutant specific was also developed, and Source Classification Codes (SCCs) were assigned to these subcategories.[8] The Tier 1 and Tier 2 categories are listed in Table 1-1.

The U.S. EPA's Emission Inventory Branch (EIB) is developing procedures/criteria for replacing *Interim* emissions data with ozone SIP-submitted data. Eventually, this will result in a 1990 Base Year Inventory that consists of state data for nonattainment areas and EPA-generated data for all other areas.[8]

The EIB is also developing a data management and reporting system to manipulate the output from the above tasks. When all these tasks are completed, the EIB will be able to extract the most current state inventories from AIRS and supplement the gaps with EPA-generated attainment inventories. The EIB has already made several changes to the *Trends* methodology to make the transition smoother.

By developing procedures/criteria for the replacement of *Interim* emissions data with state SIP data, and by developing management and reporting tools for these data, EIB is providing itself with the capability of tracking emission reductions related to passage of the CAAA. By the year 2005, the number of areas not meeting ambient air quality standards should be reduced from 190 to 15. This change will mean that the number of people living in areas that exceed ambient air quality standards will be reduced from 148 million people living in 190 nonattainment areas to 45 million living in nonattainment areas. The remaining 15 nonattainment areas are scheduled to meet NAAQS by 2010.

With regard to particular pollutants, ozone precursor emissions in nonattainment areas should be showing consistent annual reductions of 3 percent per year, beginning in 1990. The result of these emission reductions should be a decrease in the number of ozone nonattainment areas from 94 to 5 by the year 2005. By the year 2010, all of these areas should be in attainment.

Consistent annual reductions for the other pollutants are expected as well. The result should be that, by 2005, nonattainment areas for PM-10 should be reduced from 70 to zero, for CO from 41 to zero, for SO_2 from 46 to zero, for Pb from 13 to zero, and for NO_x from 1 to zero.

Efforts to revise the *Trends* methodology to achieve consistency with state emission inventories were initiated by integrating the *Interim* methodology into the current estimation procedures. The next step will be to integrate the state SIP emission inventories into *Trends*. In general, the *Trends* emissions will reflect the *Trends* methodology for 1900 through 1984 and the *Interim*-based methodology for 1985 through the present. Since the *Interim* methodology and emissions used the 1985 National Acid Precipitation Assessment Program Emissions Inventory (NAPAP)[9] as its base, 1985 emissions closely reflect the NAPAP estimates for many categories. As approved state SIP data become available, they will be incorporated into the *Trends* methodology (as defined in section 6) derived data to provide a composite set of emissions that represent the best available emissions data.

Although there have been many changes to the *Trends* methodology, some methods have remained constant. For example, the 1900 through 1939 VOC, NO_x, and SO_2 estimates were extracted from the NAPAP historical emissions report.[10,11] In addition, Pb estimates (1970 to present), PM-10 (1940 to 1984), and all SO_2, NO_x, CO, and VOC estimates from 1940 to 1984 reported in *Trends* are based upon the previous national "top-down" methodology. Section 6 describes exceptions to the above, and modifications made to the previous *Trends*, 1985 NAPAP, and *Interim* methodologies to produce this report. Thus, the *Trends* methodology is an amalgam of several different estimation methods. Starting with this report, *Trends* methodology reflects the information provided in section 6.

1.3.2 Highway Vehicle Emissions

The methodology for estimating highway vehicle emissions has been modified from that used to produce previous estimates. The main differences are use of MOBILE5a, and use of a California-specific version of MOBILE5a to estimate California emissions. More details are described in section 6.

1.3.3 Temporal and Spatial Allocation

Beginning with the 1900 to 1992 report (October 1993), emissions were allocated to various spatial and temporal apportionments for the current year for SO_2, CO, NO_x, and VOC. Starting with this report, PM-10 will also be presented for various spatial and temporal configurations. Because of greater uncertainty in historical estimates for small geographic areas, multiple year trends will continue to be portrayed only at the regional and national levels for all criteria pollutants.

1.3.4 Other Emission Inventories

In addition to presenting an update of the U.S. greenhouse gas emission inventory reported in the last *Trends* report, global greenhouse gases, and updated air toxic emissions are presented. The latest emissions from Canada, Mexico, Russia, and Europe are also presented in this report.

1.3.5 Particulate Matter (PM-10)Emissions

On July 1, 1987, EPA published a final rule embodying an ambient air quality standard for PM-10 designed to replace the existing standard for particulate matter, commonly referred to as TSP. Starting with last year's report, TSP is presented only in Appendix C. The PM-10 emissions for years prior to 1985 are based on TSP emissions and were developed by engineering judgment. The methodology is explained in section 6.

The PM-10 emissions for 1985 to the present are based upon a 1990 county-level emission inventory[12] developed for EPA's Office of Policy Planning and Evaluation (OPPE) using methods similar to those developed as part of the *Interim* inventory. For years prior to, and following 1990, PM-10 emissions were developed by backcasting and forecasting 1990 emissions using economic growth indicators for most source categories. Details of the methodology are explained in section 6.

1.4 REPORT STRUCTURE

Changes instituted in the format of last year's report, intended to make the report more comprehensible and informative, have been maintained for this report. The executive summary includes two parts: (1) a quick look at the emission trends and (2) an introduction, section 1, which informs the reader of changes to the report and how the report is structured. Section 2 gives a detailed account of the current year emissions by pollutant, source category, state, nonattainment area, county, and season and by a listing of top-emitting facilities. Section 3 discusses the national trend in emissions from 1900 (where available) to the current year. Section 4 presents the regional trends in emissions from 1985 through the current year. The total emission projections for the nation are presented in section 5. An explanation of the methodologies used to determine emissions for 1900 through 1939, 1940 through 1984, and 1985 through the current year is found in section 6. Sections 7, 8, and 10 display emissions from sources, noncriteria pollutants, or countries not traditionally part of the *Trends* report. These emissions were developed by EPA and other Government agencies. Section 9 presents biogenic emissions.

As in last year's report, all emissions reported in tables and figures in the body of the report are in multiples of thousand short tons, except Pb. Tables and figures now appear at the end of each section in the order in which they are discussed. Appendix A contains tables for each of the criteria pollutants by Tier 3 source categories. If a zero is reported, the emissions are less than 0.5 thousand tons (or 0.5 tons for Pb). A "NA" means that the apportionment of the historic emissions to these subcategories was not possible. If a tier category does not appear, then emissions are not currently estimated for that category (either EPA thinks the emissions are zero or does not currently know how to estimate them with limited resources). The regional total emissions for each criteria pollutant are located in Appendix B. The PM-10 fugitive dust emissions are also shown separately by region. Emissions of TSP by Tier 3 source categories are presented in Appendix C. Some duplicate tables of the major source categories and subcategories for each criteria pollutant in metric units are located in Appendix D of the report. Appendix E presents black and white copies of the county-level color maps presented in section 2.

Emissions of NO_x are expressed as weight-equivalent NO_2. Thus, the actual tons of NO emitted have been inflated to report them as if they were NO_2. The molecular weight of NO_x should therefore be assumed to be that of NO_2 when using numbers in this report. VOC emissions are reported as the actual weight of a multitude of different compounds. The relative amounts of the individual compounds emitted will determine the average molecular weight of a given source category's emissions. Therefore, no equivalent molecular weight standard exists for VOC. The VOC emissions referred to in this report exclude those organic compounds which are considered negligibly photochemically reactive, in accordance with the EPA definition of VOC at 40CFR51.100. Thus, methane, ethane, and certain other organic compounds are not included in the VOC totals.

1.5 REFERENCES

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2. Air Quality Criteria for Oxides of Nitrogen. EPA/600/8-91/049aF-cF.3v. Office of Health and Environment Assessment, Environmental Criteria and Assessment Office, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1993.

3. Air Quality Criteria for Ozone and Other Photochemical Oxidants. EPA/600/8-84/020aF-eF.5v (NTIS PB87-142949). Office of Health and Environment Assessment, Environmental Criteria and Assessment Office, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1991.

4. Air Quality Criteria for Particulate Matter and Sulfur Oxides. EPA/600/8-82/029aF-cF.3v (NTIS PB84-156777). Office of Health and Environment Assessment, Environmental Criteria and Assessment Office, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1991.

5. Air Quality Criteria for Lead. EPA/600/8-83/028aF-dF.4v (NTIS PB87-142378). Office of Health and Environment Assessment, Environmental Criteria and Assessment Office, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1991.

6. Regional Interim Emission Inventories (1987-1991), Volume I: Development Methodologies, EPA-454/R-93-021a. U.S. Environmental Protection Agency, Research Triangle Park, NC. May 1993.

7. Barnard, W., E. Laich, S. Bromberg, et al. "Development of Tier Categories for the Collection, Management, and Reporting of Emissions Inventory Data." In Proceedings of the 1993 U.S. EPA/A&WMA Emission Inventory Specialty Conference, Air and Waste Management Association, Pasadena, CA. 1993.

8. Laich, E., M. Mullen, D. Solomon, et al., "Incorporating Nonattainment Area Emissions Inventories into Regional Inventories." In Proceedings of the 1993 U.S. EPA/A&WMA's Emission Inventory Specialty Conference, Air and Waste Management Association, Pasadena, CA. October 1993.

9. *The 1985 NAPAP Emissions Inventory (Version 2): Development of the Annual Data and Modeler's Tapes.* EPA-600/7-89-012a. U.S. Environmental Protection Agency, Research Triangle Park, NC. November 1989.

10. Historic Emissions of Sulfur and Nitrogen Oxides in the United States from 1900 to 1980. EPA-600/7-85-009a and b. U.S. Environmental Protection Agency, Cincinnati, OH. April 1985.

11. Historic Emissions of Volatile Organic Compounds in the United States from 1900 to 1985. EPA-600/7-88-008a. U.S. Environmental Protection Agency, Cincinnati, OH. May 1988.

12. Emissions Inventory for the National Particulate Matter Study, Final Draft, Prepared for the Office of Policy, Planning and Evaluation/Office of Policy Analysis, U.S. EPA under EPA Contract No. 68-D3-0035, Work Assignment No. 0-10, Washington, DC. July 1994.

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[f] All data are estimates only, true values of emissions are not known.

[g] The SCC assignment to Tier category is available on the Technology Transfer Network's (919-541-5742) Emission Inventories/Emission Factors Information (CHIEF) Technical Information Area.

Table 1-1. Major Source Categories

TIER 1	TIER 2
FUEL COMBUSTION-ELECTRIC UTILITIES	
	Coal
	Oil
	Gas
	Other
	Internal Combustion
FUEL COMBUSTION-INDUSTRIAL	
	Coal
	Oil
	Gas
	Other
	Internal Combustion
FUEL COMBUSTION-OTHER	
	Commercial / Institutional Coal
	Commercial / Institutional Oil
	Commercial / Institutional Gas
	Misc. Fuel Combustion (except residential)
	Residential Wood
	Residential Other
CHEMICAL & ALLIED PRODUCT MFG.	
	Organic Chemical Mfg.
	Inorganic Chemical Mfg.
	Polymer & Resin Mfg.
	Agricultural Chemical Mfg.
	Paint, Varnish, Lacquer, Enamel Mfg.
	Pharmaceutical Mfg.
	Other Chemical Mfg.
METALS PROCESSING	
	Nonferrous
	Ferrous
	Not elsewhere classified (NEC)
PETROLEUM & RELATED INDUSTRIES	
	Oil & Gas Production
	Petroleum Refineries & Related Industries
	Asphalt Manufacturing
OTHER INDUSTRIAL PROCESSES	
	Agriculture, Food, & Kindred Products
	Textiles, Leather, & Apparel Products
	Wood, Pulp & Paper, & Publishing Products
	Rubber & Miscellaneous Plastic Products
	Mineral Products
	Machinery Products
	Electronic Equipment
	Transportation Equipment
	Construction
	Miscellaneous Industrial Processes
SOLVENT UTILIZATION	
	Degreasing
	Graphic Arts
	Dry Cleaning
	Surface Coating
	Other Industrial
	Nonindustrial
	Solvent Utilization (NEC)

(continued)

Table 1-1 (continued)

TIER 1	TIER 2
STORAGE & TRANSPORT	
	Bulk Terminals & Plants
	Petroleum & Petroleum Product Storage
	Petroleum & Petroleum Product Transport
	Service Stations: Stage I
	Service Stations: Stage II
	Service Stations: Breathing & Emptying
	Organic Chemical Storage
	Organic Chemical Transport
	Inorganic Chemical Storage
	Inorganic Chemical Transport
	Bulk Materials Storage
	Bulk Materials Transport
WASTE DISPOSAL & RECYCLING	
	Incineration
	Open Burning
	Publicly Owned Treatment Works
	Industrial Waste Water
	Treatment Storage and Disposal Facility
	Landfills
	Other
HIGHWAY VEHICLES	
	Light-Duty Gas Vehicles & Motorcycles
	Light-Duty Gas Trucks
	Heavy-Duty Gas Vehicles
	Diesels
OFF-HIGHWAY	
	Off-highway Gasoline
	Off-highway Diesel
	Aircraft
	Marine Vessels
	Railroads
NATURAL SOURCES	
	Biogenic
	Geogenic
	Miscellaneous (lightning, freshwater, saltwater)
MISCELLANEOUS	
	Agriculture & Forestry
	Other Combustion (forest fires)
	Catastrophic / Accidental Releases
	Repair Shops
	Health Services
	Cooling Towers
	Fugitive Dust

NOTE(S): Refer to section 6 for a description of source categories. For the purposes of this report, forest fires are considered anthropogenic sources although many fires are caused by nature.

SECTION 2.0

SUMMARY OF 1993 EMISSIONS

Although the EPA has produced an annual estimate of emission trends since 1973, this report is the second in a series which will present emissions at the state, ozone nonattainment area, and seasonal level for CO, NO_x, VOC, and SO_2 for the current year. Starting with this report, PM-10 will be presented at the same level of detail as CO, NO_x, VOC, and SO_2. The more detailed information (state, county, nonattainment area, and seasonal emissions) will be presented for the current year of emissions. The fourteen major source categories as listed in Table 1-1 are:

FUEL COMBUSTION - ELECTRIC UTILITIES,
FUEL COMBUSTION INDUSTRIAL,
FUEL COMBUSTION - OTHER,
CHEMICAL AND ALLIED PRODUCT MANUFACTURING,
METALS PROCESSING,
PETROLEUM AND RELATED INDUSTRIES,
OTHER INDUSTRIAL PROCESSES,
SOLVENT UTILIZATION,
STORAGE AND TRANSPORT,
WASTE DISPOSAL AND RECYCLING,
HIGHWAY VEHICLES,
OFF-HIGHWAY,
NATURAL SOURCES, AND
MISCELLANEOUS.

The 1993 emissions of Pb were estimated by the same methodology used to produce the 1992 emissions in the last report.[1] The 1993 estimates are based on extending the trend of the Pb activity data from previous years (details are provided in section 6) which are then multiplied by the current emission factors and control efficiencies. This methodology makes estimating state and seasonal emissions very resource intensive; therefore, only national emissions are presented here.

This report is the third in a series which will track the changes in the top-emitting sources of CO, NO_x, VOC, and SO_2 emissions and the second in a series which will track PM-10, Pb, and industrial SO_2. The AIRS Facility Subsystem (AFS) was used to determine the types of plants that emit large quantities of criteria pollutants. Emissions were extracted from AIRS/AFS using an ad hoc report[2] which excluded plants listed as permanently closed. In addition, some adjustments were made for data that were obviously in error after conferring with appropriate State and Region personnel.

2.1 EMISSIONS FOR 1993 BY SOURCE CATEGORY

The 1993 emissions of all criteria pollutants except lead were calculated using one of four major methodologies depending on the source category. These estimates were generated in a similar methodology as in the previous report. The exceptions are detailed in section 6. The methodology differs for highway vehicles, electric utilities, fugitive dust, and all other sources. The four methodologies are similar to the methodologies used to produce the 1992 emissions presented in this report. Modifications to the 1992 methodology were made due to inability to obtain information to generate the 1993 estimates. Changes in methodology are required in order to make the best estimate with available data. These emissions are preliminary and will be modified in the next *Trends* report.

2.1.1 Carbon Monoxide Emissions

Currently only 13 of the 14 Tier 1 source categories are estimated for CO. In Tier 1, the natural sources category contains minimal CO emissions and thus is not estimated for the *Trends* report. (Studies are currently underway, however, on isoprene oxidation, monoterpene, and other organic compound emissions which are likely to significantly change the current estimates.) Figure 2-1 presents a pie chart of the 13 Tier 1 categories, three of which (solvent utilization, storage and transport, and electric utility fuel combustion) constitute less than 0.5 percent of the total and are combined with petroleum and related industries, industrial fuel combustion, other industrial processes, waste disposal and recycling, and chemical and allied chemical manufacturing in the "Remaining Categories" grouping. As the figure shows, highway vehicles are the major contributor to CO emissions. In 1993, they represented 62 percent of the total CO emissions. Of the total highway emissions, 65 percent are from light-duty gasoline vehicles (LDGV). The second major contributor to CO emissions is off-highway vehicles, which constitute approximately 16 percent of total CO estimates. These emissions result primarily from the gasoline consumption by construction, industrial and farm equipment, and recreational marine vessels. Table A-1, in Appendix A presents a complete breakdown of CO emissions.

Table 2-1 presents the point and area split of the Tier 1 source categories. Area source emissions, including transportation sources, constituted 94 percent of total CO emissions in 1993.

2.1.2 Nitrogen Oxides Emissions

Currently only 13 of the 14 Tier 1 source categories are estimated for NO_x. Of these 14 categories, natural source emissions of NO_x are considered minimal, and therefore are not estimated for the *Trends* report. Studies underway to estimate fertilization NO_x emissions will likely change the natural source emissions. Figure 2-2 presents a pie chart of the remaining 13 categories, four of which (solvent utilization, storage and transport, waste disposal and recycling, and metals processing) constitute less than 1 percent of the total and are combined with chemical and allied product manufacturing, other industrial processes, miscellaneous, and petroleum and related industries in the "Remaining Categories" grouping. As shown, electric utility emissions represent 33 percent, of the total 1993 NO_x emissions. The estimates from electric utilities are made up of 90 percent coal, of which 61 percent are emissions from bituminous coal. As with CO emissions, LDGV (49 percent) are a major contributor to 1993 highway vehicle NO_x emissions. Table A-2, in Appendix A, present a complete breakdown of NO_x emissions.

Table 2-2 presents the point and area source split of the Tier 1 source categories. Area source emissions, including highway vehicles, contributed slightly more than half (54 percent) of the total NO_x emissions in 1993.

2.1.3 Volatile Organic Compound Emissions

Currently only 13 of the 14 Tier 1 source categories are estimated for VOC. Natural sources are not included, although biogenics, a subcategory of natural sources, are considered a major source of VOC emissions. Biogenic emissions for 1990 are included in section 9. More extensive studies are underway for this category, and results will be published in the 1995 *Trends* report. Figure 2-3 presents a pie chart of the remaining 13 categories. Two of the source categories (electric utility fuel combustion and metals processing) constituted less than 0.5 percent of the total emissions and are combined with chemical and allied products, petroleum and related industries, miscellaneous, other industrial processes, and fuel combustion (industrial, other) in the "Remaining Categories" grouping. The "Remaining Categories" grouping contributed 20 percent to the total VOC estimate in 1993. As shown, solvent utilization contributed 27 percent and highway vehicles contributed 26 percent to the total 1993 VOC emissions. Light-duty gasoline vehicles represent 63 percent of the highway vehicle 1993 VOC emissions. Surface coating represents 43 percent of the solvent utilization emissions. There are 26 subcategories of surface coating. Their contribution to surface coating emissions are presented in Figure 2-3. The emissions from all categories are presented in Table A-3, in Appendix A The contributions made to the "Remaining Categories" grouping by Tier 1 source categories are also presented in Figure 2-3.

Table 2-3 presents the point and area split of the Tier 1 source categories. Area source emissions, including highway vehicles, constituted 82 percent of total VOC emissions in 1993.

2.1.4 Sulfur Dioxide Emissions

Currently only 13 of the 14 Tier 1 source categories are estimated for SO_2. Only the natural sources category is not currently estimated for *Trends* (there are sulfur emissions from marine sources, but they are considered minor). Figure 2-4 presents a pie chart of the remaining 13 categories, five of which (solvent utilization, storage and transport, waste disposal and recycling, off-highway, and miscellaneous) constitute less than 2 percent of the total and are combined with chemical and allied product manufacturing, petroleum and related industries, and other industrial processes in the "Remaining Categories" grouping. As shown, electric utilities are the major contributor to SO_2 emissions. In 1993 they represented 72 percent of the total SO_2 emissions. The second largest contributor is industrial fuel combustion, which produced 13 percent of the 1993 SO_2 emissions. The combustion of coal is 96 percent of the electric utility emissions. Bituminous coal combustion is 87 percent of the electric utility coal combustion emissions.

Table 2-4 presents the point and area split of the Tier 1 source categories. Point source emissions constituted 92 percent of the total SO_2 emissions in 1993.

2.1.5 Particulate Matter (PM-10) Emissions

Currently all 14 Tier 1 source categories are estimated for PM-10. Figure 2-5 presents a pie chart in which all categories, with the exclusion of fugitive dust sources, have been combined in the "Remaining Categories" grouping. Fugitive dust sources constitute 92 percent of the 1993 total PM-10 emissions. Unpaved roads (32 percent) are the greatest contributor to 1993 PM-10 fugitive dust emissions. The remaining 5 categories are construction (24 percent), paved roads (18 percent), agricultural (16 percent), wind erosion (1 percent), and mining and quarrying (1 percent). The point source fugitive dust emissions are minimal and not presented in the column chart presented in Figure 2-5.

Table 2-5 presents the point and area source split of the Tier 1 source categories. Area source emissions, dominated by the fugitive dust category, contributed 97 percent to the total PM-10 emissions in 1993.

Wind erosion PM-10 emissions were significantly reduced during 1993. This reduction was the result of substantial spring and early summer precipitation in midwestern states that are normally significant contributors to wind erosion emissions (i.e., Kansas, Oklahoma, and to a lesser extent, Texas). The flooding that occurred along the Mississippi River during the summer of 1993 was a direct result of this precipitation, and subsequent runoff.

2.1.6 Lead Emissions

The 1993 emissions of Pb were estimated by the same methodology used to produce the 1992 emissions in the last report.[1] The 1993 estimates are based on extending the trend of the Pb activity data from previous years (details are provided in section 6) which are then multiplied by the current emission factors and control efficiencies. This methodology makes estimating point and area emissions very resource intensive; therefore, only national emissions are presented here.

Of the 14 Tier 1 source categories, the following five are not estimated for Pb, since they are though to be negligible: solvent utilization, storage and transport, petroleum and related industries, natural sources, and miscellaneous. The remaining nine categories are presented in a pie chart in Figure 2-6. The "Remaining Categories" grouping includes chemical and allied product manufacturing, other industrial processes, and fuel combustion (electric utility and industrial). Metal processing, the major contributor of Pb emissions in 1993, represents 43 percent of the total emissions. Nonferrous metal processing represents 64 percent of the 1993 metals processing Pb emissions. Primary and secondary Pb products are responsible for 49 and 42 percent, respectively, of the nonferrous metals processing Pb emissions in 1993.

2.2 SPATIAL EMISSIONS

The 1993 criteria pollutant emissions were estimated for all pollutants except lead at the county level and summed to the state level. These estimates are presented in Tables 2-6 to 2-15 and Figures 2-7 to 2-20.

2.2.1 State Level

Tables 2-6 through 2-14 present the point, area, and total emissions per pollutant for each state in alphabetical order and in descending order. The estimates for Alaska and Hawaii include only highway vehicle and fossil-fuel steam electric utility emissions. PM-10 estimates listed in Table 2-15 also include some fugitive dust estimates for Alaska and Hawaii. (A base year inventory similar to NAPAP was not available for these states.)

Figures 2-7 through 2-11 present the top 10 states with the largest emissions, by pollutant, for 1993. These top 10 states represent a range of 46 to 61 percent of the national emissions, depending on the particular pollutant.

2.2.2 County Level

For all criteria pollutants except Pb, the emissions are derived at the county level. The exceptions explained in detail in section 6 are fugitive dust sources and wildfires. Figures 2-12 to 2-16 presents the total 1993 emissions per square mile for each county. As Figure 2-12 shows, the eastern third and west coast emit more CO than the western two-thirds of the continental United States. In contrast, Figures 2-13 to 2-15 illustrate that the eastern half and the west coast emit more NO_x, VOC, and SO_2 than the western half of the continental United States. The emissions of PM-10 are dominated by the fugitive dust emissions that are predominant in the rural and agricultural areas.

2.2.3 Nonattainment Areas

In the 1993 *Trends* report,[1] charts of typical NO_x, VOC, and CO emissions in 'serious' and above ozone nonattainment areas were compiled using the 1992 *Trends* emissions. This year, sufficiently complete base year (1990) inventories for six such areas have been submitted to AIRS, as part of the SIP process, to warrant basing composite emission profiles on these actual inventory data. (As final action on these SIPs is still pending, the identity of the areas cannot be disclosed.) These six comprise a small portion of the set of nonattainment areas, thus their composite profiles must be considered provisional and they cannot be directly compared with last year's estimated profiles. Nevertheless, there are reassuring similarities with the profiles of estimated emissions from last year; there are two notable differences, discussed later. These six areas represent the populous northeast and the southwest. As additional base year inventories are completed in AIRS, composite profiles in future *Trends* reports will become increasingly comprehensive.

There are over 6,000 potential emission source categories (SCCs) that could be inventoried, covering detailed components of industrial, commercial, agricultural, residential, and recreational sources. Only sources emitting at least 10 tons per year (tpy) of VOC, 100 tpy of NO_x, or 100 tpy of CO need be inventoried as point sources, so in a given area the number of significant sources is smaller, and will vary in nature depending on the commercial and industrial complexion of each area. For summarization in Figure 2-17, these sources have been condensed into the following ten categories used previously, which differ in significance depending on the pollutant being considered:

- On-Road Mobile Sources: all cars, trucks, buses, motorcycles used on streets and highways (HWY VEH.);
- Off-highway Mobile Sources such as tractors, bulldozers, lawn mowers, power boats, planes, trains (OFF-HWY);
- Industrial fuel combustion emissions from factories, mills, etc. (FUEL:IND.);
- Fuel combustion emissions from electric power utilities (FUEL:ELEC.);
- Fuel combustion emissions from space heating for buildings, homes, etc. (FUEL:OTHER);
- Solvent evaporation during application of coatings, cleaners, adhesives, etc. (SOLV. UTIL.);
- Evaporative losses during the storage and transport of fuels, solvents, and products containing volatile components (STOR. & XPORT);
- Disposal activities such as open dump burning and incinerators (WASTE);
- Primary and secondary metals refining and processing (METALS); and
- All other emissions (MISC).

In Figure 2-17, composites of the relative emissions of NO_x, VOCs, and CO for the six inventoried nonattainment areas are graphed for these ten source categories. The small solid bars show the range from minimum to maximum percentage among the six areas, for each category.

Both highway vehicle and off-highway vehicles contribute significantly to emissions of all three pollutants, and are by far the predominant sources of CO. Stationary source fuel combustion is significant only for NO_x. One of the notable contrasts with the profiles presented last year is the large contribution to VOC emissions from solvent storage and transport. The second evident difference is that in last year's profiles, the metals industry made a small contribution to the CO profile; the six areas comprising the current profiles evidence no significant metals processing activity. These minor contrasts are interpreted as consequences of the different data sets employed, and the expectation that emissions for specialized source categories like chemicals and metals will vary from area to area more than emissions from the ubiquitous automobile. The spans from minimum to maximum in the data for these six areas demonstrate that profiles may vary significantly from area to area. (Pie charts based on the same percentage profiles are presented in Figures 2-18 to 2-20.)

2.3 SEASONAL EMISSIONS

The seasonal emissions were estimated using three methodologies for five pollutants. The methodology was specific to highway vehicles, electric utility point and all other area sources, and all other point sources. The five pollutants are CO, NO_x, VOC, SO_2, and PM-10. Highway vehicle emissions were estimated for each month, and then summed to the four seasons. Electric utilities and area source emissions were temporally apportioned using state point and area factors obtained from the NAPAP methodology.[3] The point emissions were distributed to the seasons based on the 1985 NAPAP seasonal throughput percentages for each point. The seasons are defined as winter (December, January, February), spring (March, April, May), summer (June, July, August), and autumn (September, October, November).

As shown in Figure 2-21, most Tier 1 source categories emitted CO in approximately equal amounts all year, with three exceptions. The first exception is fuel combustion-other, which contributes 56 percent during the winter and only 2 percent in the summer. This difference is a result of more residential wood burning during the winter months. The second exception is off-highway sources, which emit less in the winter and more in the summer. The third exception is highway vehicles that emit greater amounts in cold weather (i.e., the winter).

As shown in Figure 2-22, in 1993 most Tier 1 source categories emitted NO_x in approximately equal amounts all year, with two exceptions: fuel combustion-other and off-highway emissions. The estimates from fuel combustion-other are 47 percent in the winter and 8 percent in the summer. The off-highway emissions are 21 percent in the winter and 29 percent in the summer.

As shown in Figure 2-23, in 1993, most Tier 1 source categories emitted VOCs in approximately equal amounts with three exceptions. The first exception is the other fuel combustion sources (primarily residential wood) which accounts for 56 percent of VOC estimates during the winter and 3 percent during the summer. Secondly, off-highway sources emit 19 percent during the winter and 31 percent in the summer. Thirdly, even though the highway vehicle VOC emissions are distributed 27 percent in the winter and 24 percent in the summer, the evaporative VOC emissions (18 percent of total highway emissions) are greater during the summer (36 percent) than the winter (16 percent). The seasonal percentage distribution of highway vehicle evaporative and exhaust emissions are:

Season	Exhaust (%)	Evaporative (%)
Spring	25	25
Summer	23	36
Autumn	24	24
Winter	29	16

As shown in Figure 2-24, in 1993, most Tier 1 source categories emitted SO_2 in approximately equal amounts all year. An exception is fuel combustion-other, which emits 42 percent during the winter and only 12 percent in the summer. This difference is a result of more residential fuel combustion in the winter than any other time of the year. Highway vehicles and solvent utilization emit less during the winter.

As shown in Figure 2-25, in 1993 most Tier 1 source categories emitted PM-10 in approximately equal amounts all year. The only exception to this is other fuel combustion (primarily residential wood) which accounts for 56 percent of PM-10 emissions during the winter and 2 percent during the summer.

2.4 LARGEST POINT SOURCES IN AIRS/AFS

This report is the third in a series which will track the changes in the top-emitting sources of CO, NO_x, VOC, and SO_2 emissions and the second in a series which will track PM-10, Pb, and industrial SO_2. The AIRS/AFS[h] was also used to determine the types of plants that emit large quantities of criteria pollutants. Emissions were extracted on July 8, 1994 from AIRS/AFS using an ad hoc report which excluded plants listed as permanently closed. In addition, some adjustments were made for data that were obviously in error. Details on how the data was extracted from AIRS is provided in section 6.7.

NOTE: Depending on the day the data are extracted, the list of top emitters may change. Because these lists are based on several different extractions and some additional adjustments have been made, the data in tables in this report may not correspond precisely to the data currently in AIRS/AFS. However, this report has presented the top 30 sources based to the maximum extent possible, on AIRS/AFS.

The most common industries by pollutant contained in the list of top 30 emitting sources are defined in Table 2-16. Figures 2-26 to 2-32 and Tables 2-17 to 2-23 present the plant-level emissions of the top 30 largest point source emitters of these pollutants. Figures 2-31 and 2-32 also present states that currently have not reported any PM-10 or Pb point source emissions to AIRS.

2.5 REFERENCES

1. *National Air Pollutant Emission Trends, 1900-1992.* EPA-454/R-93-032, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1993.

2. *AIRS Facility Subsystem.* National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. June 1992.

3. Fratt, D.B., D.F. Mudgett, and R.A. Walters. *The 1985 NAPAP Emissions Inventory: Development of Temporal Allocation Factors.* EPA-600/7-89-010d. U.S. Environmental Protection Agency, Research Triangle Park, NC. April 1990.

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[h] The AIRS data is not the main basis for the data in this report.

Table 2-1. 1993 National Point and Area Carbon Monoxide Emissions by Source Category
(thousand short tons)

Source Category	Point	Area	Total	% Point	% Area	% Total
FUEL COMBUSTION - ELECTRIC UTILITY	322	0	322	5.17	0	0.33
FUEL COMBUSTION - INDUSTRIAL	465	202	667	7.47	0.22	0.69
FUEL COMBUSTION - OTHER	90	4,354	4,444	1.44	4.79	4.57
CHEMICAL AND ALLIED PROD. MFG	1,998	0	1,998	32.08	0	2.06
METALS PROCESSING	2,091	0	2,091	33.58	0	2.15
PETROLEUM & RELATED INDUSTRIES	398	0	398	6.40	0	0.41
OTHER INDUSTRIAL PROCESSES	730	2	732	11.72	0	0.75
SOLVENT UTILIZATION	2	0	2	0.03	0	0
STORAGE AND TRANSPORT	56	0	56	0.90	0	0.06
WASTE DISPOSAL & RECYCLING	76	1,657	1,732	1.21	1.82	1.78
HIGHWAY VEHICLES	0	59,989	59,989	0	65.94	61.71
OFF-HIGHWAY	0	15,272	15,272	0	16.79	15.71
MISCELLANEOUS	0	9,506	9,506	0	10.45	9.78
TOTAL	6,227	90,981	97,208	100	100	100

Table 2-2. 1993 National Point and Area Nitrogen Oxides Emissions by Source Category
(thousand short tons)

Source Category	Point	Area	Total	% Point	% Area	% Total
FUEL COMBUSTION - ELECTRIC UTILITY	7,782	0	7,782	72.98	0	33.26
FUEL COMBUSTION - INDUSTRIAL	1,856	1,319	3,176	17.41	10.36	13.57
FUEL COMBUSTION - OTHER	100	632	732	0.93	4.96	3.13
CHEMICAL AND ALLIED PROD. MFG	414	0	414	3.88	0	1.77
METALS PROCESSING	82	0	82	0.77	0	0.35
PETROLEUM & RELATED INDUSTRIES	95	0	95	0.89	0	0.40
OTHER INDUSTRIAL PROCESSES	310	5	314	2.90	0.04	1.34
SOLVENT UTILIZATION	3	0	3	0.02	0	0.01
STORAGE AND TRANSPORT	3	0	3	0.02	0	0.01
WASTE DISPOSAL & RECYCLING	20	64	84	0.19	0.51	0.36
HIGHWAY VEHICLES	0	7,437	7,437	0	58.38	31.78
OFF-HIGHWAY	0	2,986	2,986	0	23.44	12.76
MISCELLANEOUS	0	296	296	0	2.32	1.26
TOTAL	10,663	12,739	23,402	100	100	100

Table 2-3. 1993 National Point and Area Volatile Organic Compound Emissions by Source Category
(thousand short tons)

Source Category	Point	Area	Total	% Point	% Area	% Total
FUEL COMBUSTION - ELECTRIC UTILITY	36	0	36	0.85	0	0.16
FUEL COMBUSTION - INDUSTRIAL	254	17	271	5.92	0.09	1.16
FUEL COMBUSTION - OTHER	10	331	341	0.23	1.74	1.46
CHEMICAL AND ALLIED PROD. MFG	1,355	456	1,811	31.64	2.40	7.77
METALS PROCESSING	74	0	74	1.72	0	0.32
PETROLEUM & RELATED INDUSTRIES	305	415	720	7.12	2.18	3.09
OTHER INDUSTRIAL PROCESSES	407	79	486	9.50	0.41	2.08
SOLVENT UTILIZATION	1,225	5,024	6,249	28.60	26.40	26.80
STORAGE AND TRANSPORT	609	1,252	1,861	14.22	6.58	7.98
WASTE DISPOSAL & RECYCLING	8	2,263	2,271	0.19	11.89	9.74
HIGHWAY VEHICLES	0	6,094	6,094	0	32.03	26.14
OFF-HIGHWAY	0	2,207	2,207	0	11.60	9.47
MISCELLANEOUS	1	892	893	0.02	4.69	3.83
TOTAL	4,283	19,030	23,312	100	100	100

Table 2-4. 1993 National Point and Area Sulfur Dioxide Emissions by Source Category
(thousand short tons)

Source Category	Point	Area	Total	% Point	% Area	% Total
FUEL COMBUSTION - ELECTRIC UTILITY	15,836	0	15,836	78.52	0	72.35
FUEL COMBUSTION - INDUSTRIAL	2,254	577	2,830	11.18	33.51	12.93
FUEL COMBUSTION - OTHER	200	400	600	0.99	23.25	2.74
CHEMICAL AND ALLIED PROD. MFG	450	0	450	2.23	0	2.06
METALS PROCESSING	580	0	580	2.88	0	2.65
PETROLEUM & RELATED INDUSTRIES	409	0	409	2.03	0	1.87
OTHER INDUSTRIAL PROCESSES	412	2	413	2.04	0.10	1.89
SOLVENT UTILIZATION	1	0	1	0.00	0	0.00
STORAGE AND TRANSPORT	5	0	5	0.02	0	0.02
WASTE DISPOSAL & RECYCLING	21	16	37	0.11	0.92	0.17
HIGHWAY VEHICLES	0	438	438	0	25.46	2.00
OFF-HIGHWAY	0	278	278	0	16.13	1.27
MISCELLANEOUS	0	11	11	0	0.62	0.05
TOTAL	20,168	1,720	21,889	100	100	100

Table 2-5. 1993 National Point and Area Particulate Matter (PM-10) Emissions by Source Category
(thousand short tons)

Source Category	Point	Area	Total	% Point	% Area	% Total
FUEL COMBUSTION - ELECTRIC UTILITY	269	1	270	24.67	0.00	0.59
FUEL COMBUSTION - INDUSTRIAL	191	28	219	17.56	0.06	0.48
FUEL COMBUSTION - OTHER	14	709	723	1.27	1.60	1.59
CHEMICAL AND ALLIED PROD. MFG	75	0	75	6.91	0	0.17
METALS PROCESSING	141	0	141	12.91	0	0.31
PETROLEUM & RELATED INDUSTRIES	26	0	26	2.39	0	0.06
OTHER INDUSTRIAL PROCESSES	298	13	311	27.39	0.03	0.68
SOLVENT UTILIZATION	2	0	2	0.17	0	0.00
STORAGE AND TRANSPORT	55	0	55	5.02	0	0.12
WASTE DISPOSAL & RECYCLING	8	240	248	0.74	0.54	0.55
HIGHWAY VEHICLES	0	197	197	0	0.44	0.43
OFF-HIGHWAY	0	395	395	0	0.89	0.87
NATURAL SOURCES (wind erosion)	0	628	628	0	1.41	1.38
MISCELLANEOUS	10	42,189	42,200	0.96	95.02	92.77
fugitive all sources	10	41,790	41,801	0.96	94.12	91.89
nonfugitive dust	0	399	399	0	0.90	0.88
TOTAL	1,089	44,400	45,489	100	100	100

Table 2-6. 1993 State-level Point, Area, and Total Emissions of Carbon Monoxide

(thousand short tons)

State	Point	Area	Total	% Point	% Area	% Total
Alabama	251	2,142	2,393	4.03	2.35	2.46
Alaska	0	1,397	1,397	0.00	1.54	1.44
Arizona	11	1,702	1,712	0.17	1.87	1.76
Arkansas	108	947	1,054	1.73	1.04	1.08
California	104	7,487	7,591	1.67	8.23	7.81
Colorado	8	1,391	1,399	0.14	1.53	1.44
Connecticut	5	808	814	0.09	0.89	0.84
Delaware	42	216	258	0.67	0.24	0.27
District of Columbia	2	117	119	0.03	0.13	0.12
Florida	79	4,648	4,727	1.27	5.11	4.86
Georgia	197	3,675	3,873	3.17	4.04	3.98
Hawaii	1	248	249	0.01	0.27	0.26
Idaho	5	1,260	1,266	0.08	1.39	1.30
Illinois	157	3,287	3,444	2.53	3.61	3.54
Indiana	643	2,212	2,855	10.33	2.43	2.94
Iowa	10	963	973	0.17	1.06	1.00
Kansas	75	1,145	1,220	1.20	1.26	1.25
Kentucky	82	1,455	1,537	1.32	1.60	1.58
Louisiana	793	1,726	2,519	12.74	1.90	2.59
Maine	17	473	490	0.27	0.52	0.50
Maryland	25	1,314	1,339	0.40	1.44	1.38
Massachusetts	15	1,799	1,814	0.23	1.98	1.87
Michigan	273	3,209	3,482	4.39	3.53	3.58
Minnesota	77	1,712	1,789	1.24	1.88	1.84
Mississippi	94	1,397	1,492	1.52	1.54	1.53
Missouri	147	2,201	2,348	2.36	2.42	2.42
Montana	39	770	809	0.62	0.85	0.83
Nebraska	3	642	645	0.05	0.71	0.66
Nevada	59	636	695	0.95	0.70	0.72
New Hampshire	16	376	393	0.26	0.41	0.40
New Jersey	8	1,892	1,900	0.13	2.08	1.96
New Mexico	23	1,226	1,249	0.37	1.35	1.29
New York	37	3,852	3,889	0.60	4.23	4.00
North Carolina	130	2,708	2,838	2.09	2.98	2.92
North Dakota	8	277	286	0.14	0.30	0.29
Ohio	344	3,742	4,086	5.52	4.11	4.20
Oklahoma	81	1,280	1,360	1.30	1.41	1.40
Oregon	25	1,799	1,824	0.40	1.98	1.88
Pennsylvania	269	3,495	3,765	4.33	3.84	3.87
Rhode Island	0	299	299	0.00	0.33	0.31
South Carolina	51	1,518	1,569	0.82	1.67	1.61
South Dakota	5	364	370	0.09	0.40	0.38
Tennessee	155	2,083	2,238	2.49	2.29	2.30
Texas	764	6,721	7,485	12.28	7.39	7.70
Utah	48	848	896	0.77	0.93	0.92
Vermont	0	241	241	0.00	0.26	0.25
Virginia	51	2,303	2,354	0.83	2.53	2.42
Washington	433	2,065	2,499	6.96	2.27	2.57
West Virginia	329	644	973	5.28	0.71	1.00
Wisconsin	69	1,900	1,970	1.11	2.09	2.03
Wyoming	54	369	423	0.87	0.41	0.43
National	6,227	90,981	97,208	100	100	100

Table 2-7. 1993 State-level Point, Area, and Total Emissions of Carbon Monoxide Ranked by Total Emissions

(thousand short tons)

Rank	State	Point	Area	Total	% Point	% Area	% Total
1	California	104	7,487	7,591	1.67	8.23	7.81
2	Texas	764	6,721	7,485	12.28	7.39	7.70
3	Florida	79	4,648	4,727	1.27	5.11	4.86
4	Ohio	344	3,742	4,086	5.52	4.11	4.20
5	New York	37	3,852	3,889	0.60	4.23	4.00
6	Georgia	197	3,675	3,873	3.17	4.04	3.98
7	Pennsylvania	269	3,495	3,765	4.33	3.84	3.87
8	Michigan	273	3,209	3,482	4.39	3.53	3.58
9	Illinois	157	3,287	3,444	2.53	3.61	3.54
10	Indiana	643	2,212	2,855	10.33	2.43	2.94
11	North Carolina	130	2,708	2,838	2.09	2.98	2.92
12	Louisiana	793	1,726	2,519	12.74	1.90	2.59
13	Washington	433	2,065	2,499	6.96	2.27	2.57
14	Alabama	251	2,142	2,393	4.03	2.35	2.46
15	Virginia	51	2,303	2,354	0.83	2.53	2.42
16	Missouri	147	2,201	2,348	2.36	2.42	2.42
17	Tennessee	155	2,083	2,238	2.49	2.29	2.30
18	Wisconsin	69	1,900	1,970	1.11	2.09	2.03
19	New Jersey	8	1,892	1,900	0.13	2.08	1.96
20	Oregon	25	1,799	1,824	0.40	1.98	1.88
21	Massachusetts	15	1,799	1,814	0.23	1.98	1.87
22	Minnesota	77	1,712	1,789	1.24	1.88	1.84
23	Arizona	11	1,702	1,712	0.17	1.87	1.76
24	South Carolina	51	1,518	1,569	0.82	1.67	1.61
25	Kentucky	82	1,455	1,537	1.32	1.60	1.58
26	Mississippi	94	1,397	1,492	1.52	1.54	1.53
27	Colorado	8	1,391	1,399	0.14	1.53	1.44
28	Alaska	0	1,397	1,397	0.00	1.54	1.44
29	Oklahoma	81	1,280	1,360	1.30	1.41	1.40
30	Maryland	25	1,314	1,339	0.40	1.44	1.38
31	Idaho	5	1,260	1,266	0.08	1.39	1.30
32	New Mexico	23	1,226	1,249	0.37	1.35	1.29
33	Kansas	75	1,145	1,220	1.20	1.26	1.25
34	Arkansas	108	947	1,054	1.73	1.04	1.08
35	Iowa	10	963	973	0.17	1.06	1.00
36	West Virginia	329	644	973	5.28	0.71	1.00
37	Utah	48	848	896	0.77	0.93	0.92
38	Connecticut	5	808	814	0.09	0.89	0.84
39	Montana	39	770	809	0.62	0.85	0.83
40	Nevada	59	636	695	0.95	0.70	0.72
41	Nebraska	3	642	645	0.05	0.71	0.66
42	Maine	17	473	490	0.27	0.52	0.50
43	Wyoming	54	369	423	0.87	0.41	0.43
44	New Hampshire	16	376	393	0.26	0.41	0.40
45	South Dakota	5	364	370	0.09	0.40	0.38
46	Rhode Island	0	299	299	0.00	0.33	0.31
47	North Dakota	8	277	286	0.14	0.30	0.29
48	Delaware	42	216	258	0.67	0.24	0.27
49	Hawaii	1	248	249	0.01	0.27	0.26
50	Vermont	0	241	241	0.00	0.26	0.25
51	District of Columbia	2	117	119	0.03	0.13	0.12
	National	6,227	90,981	97,208	100	100	100

Table 2-8. 1993 State-level Point, Area, and Total Emissions of Nitrogen Oxides
(thousand short tons)

State	Point	Area	Total	% Point	% Area	% Total
Alabama	304	276	579	2.85	2.17	2.48
Alaska	3	51	54	0.03	0.40	0.23
Arizona	141	235	375	1.32	1.84	1.60
Arkansas	106	152	257	0.99	1.19	1.10
California	276	1,159	1,435	2.59	9.10	6.13
Colorado	145	187	332	1.36	1.46	1.42
Connecticut	18	124	142	0.17	0.97	0.61
Delaware	36	30	66	0.34	0.24	0.28
District of Columbia	2	18	20	0.02	0.14	0.08
Florida	398	514	912	3.73	4.03	3.90
Georgia	328	394	722	3.08	3.09	3.09
Hawaii	10	25	35	0.09	0.19	0.15
Idaho	7	90	97	0.07	0.71	0.42
Illinois	515	481	996	4.83	3.77	4.26
Indiana	628	350	978	5.89	2.75	4.18
Iowa	145	148	293	1.36	1.16	1.25
Kansas	218	211	428	2.04	1.65	1.83
Kentucky	410	270	680	3.84	2.12	2.91
Louisiana	363	407	769	3.40	3.19	3.29
Maine	16	58	74	0.15	0.46	0.32
Maryland	125	201	326	1.17	1.58	1.39
Massachusetts	78	231	309	0.73	1.81	1.32
Michigan	352	426	777	3.30	3.34	3.32
Minnesota	186	220	405	1.74	1.73	1.73
Mississippi	114	199	313	1.06	1.56	1.34
Missouri	300	273	573	2.81	2.14	2.45
Montana	68	84	152	0.64	0.66	0.65
Nebraska	80	111	190	0.75	0.87	0.81
Nevada	66	70	136	0.62	0.55	0.58
New Hampshire	27	48	75	0.26	0.38	0.32
New Jersey	99	285	384	0.93	2.23	1.64
New Mexico	162	124	286	1.52	0.97	1.22
New York	197	524	722	1.85	4.11	3.08
North Carolina	250	334	585	2.35	2.62	2.50
North Dakota	132	52	185	1.24	0.41	0.79
Ohio	631	497	1,128	5.92	3.90	4.82
Oklahoma	214	250	464	2.01	1.96	1.98
Oregon	23	197	220	0.21	1.55	0.94
Pennsylvania	446	486	932	4.18	3.82	3.98
Rhode Island	1	34	35	0.01	0.27	0.15
South Carolina	126	181	308	1.18	1.42	1.31
South Dakota	22	43	65	0.21	0.33	0.28
Tennessee	327	264	591	3.07	2.07	2.53
Texas	1,452	1,253	2,705	13.62	9.83	11.56
Utah	131	103	234	1.23	0.81	1.00
Vermont	0	28	28	0.00	0.22	0.12
Virginia	139	327	466	1.30	2.57	1.99
Washington	103	253	355	0.96	1.99	1.52
West Virginia	340	107	447	3.19	0.84	1.91
Wisconsin	209	253	462	1.96	1.99	1.97
Wyoming	194	104	299	1.82	0.82	1.28
National	10,663	12,739	23,402	100	100	100

Table 2-9. 1993 State-level Point, Area, and Total Emissions of Nitrogen Oxides Ranked by Total Emissions

(thousand short tons)

Rank	State	Point	Area	Total	% Point	% Area	% Total
1	Texas	1,452	1,253	2,705	13.62	9.83	11.56
2	California	276	1,159	1,435	2.59	9.10	6.13
3	Ohio	631	497	1,128	5.92	3.90	4.82
4	Illinois	515	481	996	4.83	3.77	4.26
5	Indiana	628	350	978	5.89	2.75	4.18
6	Pennsylvania	446	486	932	4.18	3.82	3.98
7	Florida	398	514	912	3.73	4.03	3.90
8	Michigan	352	426	777	3.30	3.34	3.32
9	Louisiana	363	407	769	3.40	3.19	3.29
10	Georgia	328	394	722	3.08	3.09	3.09
11	New York	197	524	722	1.85	4.11	3.08
12	Kentucky	410	270	680	3.84	2.12	2.91
13	Tennessee	327	264	591	3.07	2.07	2.53
14	North Carolina	250	334	585	2.35	2.62	2.50
15	Alabama	304	276	579	2.85	2.17	2.48
16	Missouri	300	273	573	2.81	2.14	2.45
17	Virginia	139	327	466	1.30	2.57	1.99
18	Oklahoma	214	250	464	2.01	1.96	1.98
19	Wisconsin	209	253	462	1.96	1.99	1.97
20	West Virginia	340	107	447	3.19	0.84	1.91
21	Kansas	218	211	428	2.04	1.65	1.83
22	Minnesota	186	220	405	1.74	1.73	1.73
23	New Jersey	99	285	384	0.93	2.23	1.64
24	Arizona	141	235	375	1.32	1.84	1.60
25	Washington	103	253	355	0.96	1.99	1.52
26	Colorado	145	187	332	1.36	1.46	1.42
27	Maryland	125	201	326	1.17	1.58	1.39
28	Mississippi	114	199	313	1.06	1.56	1.34
29	Massachusetts	78	231	309	0.73	1.81	1.32
30	South Carolina	126	181	308	1.18	1.42	1.31
31	Wyoming	194	104	299	1.82	0.82	1.28
32	Iowa	145	148	293	1.36	1.16	1.25
33	New Mexico	162	124	286	1.52	0.97	1.22
34	Arkansas	106	152	257	0.99	1.19	1.10
35	Utah	131	103	234	1.23	0.81	1.00
36	Oregon	23	197	220	0.21	1.55	0.94
37	Nebraska	80	111	190	0.75	0.87	0.81
38	North Dakota	132	52	185	1.24	0.41	0.79
39	Montana	68	84	152	0.64	0.66	0.65
40	Connecticut	18	124	142	0.17	0.97	0.61
41	Nevada	66	70	136	0.62	0.55	0.58
42	Idaho	7	90	97	0.07	0.71	0.42
43	New Hampshire	27	48	75	0.26	0.38	0.32
44	Maine	16	58	74	0.15	0.46	0.32
45	Delaware	36	30	66	0.34	0.24	0.28
46	South Dakota	22	43	65	0.21	0.33	0.28
47	Alaska	3	51	54	0.03	0.40	0.23
48	Rhode Island	1	34	35	0.01	0.27	0.15
49	Hawaii	10	25	35	0.09	0.19	0.15
50	Vermont	0	28	28	0.00	0.22	0.12
51	District of Columbia	2	18	20	0.02	0.14	0.08
	National	10,663	12,739	23,402	100	100	100

Table 2-10. 1993 State-level Point, Area, and Total Emissions of Volatile Organic Compounds
(thousand short tons)

State	Point	Area	Total	% Point	% Area	% Total
Alabama	207	392	599	4.82	2.06	2.57
Alaska	0	185	185	0.00	0.97	0.79
Arizona	2	275	277	0.05	1.44	1.19
Arkansas	39	197	237	0.92	1.04	1.02
California	98	1,672	1,770	2.29	8.79	7.59
Colorado	6	234	240	0.15	1.23	1.03
Connecticut	6	182	188	0.15	0.96	0.81
Delaware	14	101	115	0.32	0.53	0.49
District of Columbia	1	24	25	0.02	0.12	0.11
Florida	23	817	839	0.54	4.29	3.60
Georgia	50	613	663	1.17	3.22	2.84
Hawaii	0	31	31	0.01	0.16	0.13
Idaho	1	164	165	0.02	0.86	0.71
Illinois	308	681	989	7.20	3.58	4.24
Indiana	129	470	599	3.02	2.47	2.57
Iowa	12	218	230	0.27	1.15	0.99
Kansas	30	234	264	0.71	1.23	1.13
Kentucky	85	267	352	1.99	1.40	1.51
Louisiana	145	517	663	3.39	2.72	2.84
Maine	5	83	88	0.13	0.43	0.38
Maryland	24	247	271	0.55	1.30	1.16
Massachusetts	54	342	396	1.25	1.80	1.70
Michigan	105	646	751	2.45	3.39	3.22
Minnesota	60	346	405	1.40	1.82	1.74
Mississippi	62	266	327	1.44	1.40	1.40
Missouri	141	372	513	3.29	1.96	2.20
Montana	6	112	118	0.14	0.59	0.51
Nebraska	5	136	141	0.12	0.72	0.61
Nevada	1	111	112	0.02	0.58	0.48
New Hampshire	5	68	73	0.11	0.36	0.31
New Jersey	92	487	579	2.14	2.56	2.48
New Mexico	8	180	188	0.19	0.95	0.81
New York	157	812	969	3.67	4.26	4.16
North Carolina	190	578	768	4.45	3.04	3.30
North Dakota	2	79	80	0.04	0.41	0.34
Ohio	117	745	862	2.74	3.91	3.70
Oklahoma	25	263	288	0.58	1.38	1.24
Oregon	47	227	274	1.09	1.19	1.17
Pennsylvania	116	763	879	2.71	4.01	3.77
Rhode Island	10	60	70	0.23	0.32	0.30
South Carolina	30	662	692	0.70	3.48	2.97
South Dakota	8	74	83	0.20	0.39	0.35
Tennessee	170	402	572	3.98	2.11	2.45
Texas	1,234	1,848	3,082	28.81	9.71	13.22
Utah	9	132	142	0.22	0.70	0.61
Vermont	1	41	42	0.03	0.21	0.18
Virginia	145	454	599	3.39	2.39	2.57
Washington	45	348	392	1.05	1.83	1.68
West Virginia	106	455	561	2.47	2.39	2.41
Wisconsin	129	362	491	3.02	1.90	2.11
Wyoming	16	56	72	0.38	0.29	0.31
National	4,283	19,030	23,311	100	100	100

Table 2-11. 1993 State-level Point, Area, and Total Emissions of Volatile Organic Compounds Ranked by Total Emissions
(thousand short tons)

Rank	State	Point	Area	Total	% Point	% Area	% Total
1	Texas	1,234	1,848	3,082	28.81	9.71	13.22
2	California	98	1,672	1,770	2.29	8.79	7.59
3	Illinois	308	681	989	7.20	3.58	4.24
4	New York	157	812	969	3.67	4.26	4.16
5	Pennsylvania	116	763	879	2.71	4.01	3.77
6	Ohio	117	745	862	2.74	3.91	3.70
7	Florida	23	817	839	0.54	4.29	3.60
8	North Carolina	190	578	768	4.45	3.04	3.30
9	Michigan	105	646	751	2.45	3.39	3.22
10	South Carolina	30	662	692	0.70	3.48	2.97
11	Georgia	50	613	663	1.17	3.22	2.84
12	Louisiana	145	517	663	3.39	2.72	2.84
13	Indiana	129	470	599	3.02	2.47	2.57
14	Virginia	145	454	599	3.39	2.39	2.57
15	Alabama	207	392	599	4.82	2.06	2.57
16	New Jersey	92	487	579	2.14	2.56	2.48
17	Tennessee	170	402	572	3.98	2.11	2.45
18	West Virginia	106	455	561	2.47	2.39	2.41
19	Missouri	141	372	513	3.29	1.96	2.20
20	Wisconsin	129	362	491	3.02	1.90	2.11
21	Minnesota	60	346	405	1.40	1.82	1.74
22	Massachusetts	54	342	396	1.25	1.80	1.70
23	Washington	45	348	392	1.05	1.83	1.68
24	Kentucky	85	267	352	1.99	1.40	1.51
25	Mississippi	62	266	327	1.44	1.40	1.40
26	Oklahoma	25	263	288	0.58	1.38	1.24
27	Arizona	2	275	277	0.05	1.44	1.19
28	Oregon	47	227	274	1.09	1.19	1.17
29	Maryland	24	247	271	0.55	1.30	1.16
30	Kansas	30	234	264	0.71	1.23	1.13
31	Colorado	6	234	240	0.15	1.23	1.03
32	Arkansas	39	197	237	0.92	1.04	1.02
33	Iowa	12	218	230	0.27	1.15	0.99
34	Connecticut	6	182	188	0.15	0.96	0.81
35	New Mexico	8	180	188	0.19	0.95	0.81
36	Alaska	0	185	185	0.00	0.97	0.79
37	Idaho	1	164	165	0.02	0.86	0.71
38	Utah	9	132	142	0.22	0.70	0.61
39	Nebraska	5	136	141	0.12	0.72	0.61
40	Montana	6	112	118	0.14	0.59	0.51
41	Delaware	14	101	115	0.32	0.53	0.49
42	Nevada	1	111	112	0.02	0.58	0.48
43	Maine	5	83	88	0.13	0.43	0.38
44	South Dakota	8	74	83	0.20	0.39	0.35
45	North Dakota	2	79	80	0.04	0.41	0.34
46	New Hampshire	5	68	73	0.11	0.36	0.31
47	Wyoming	16	56	72	0.38	0.29	0.31
48	Rhode Island	10	60	70	0.23	0.32	0.30
49	Vermont	1	41	42	0.03	0.21	0.18
50	Hawaii	0	31	31	0.01	0.16	0.13
51	District of Columbia	1	24	25	0.02	0.12	0.11
	National	4,283	19,030	23,311	100	100	100

Table 2-12. 1993 State-level Point, Area, and Total Emissions of Sulfur Dioxide
(thousand short tons)

State	Point	Area	Total	% Point	% Area	% Total
Alabama	714	67	781	3.54	3.92	3.57
Alaska	1	2	3	0.00	0.13	0.01
Arizona	231	13	244	1.14	0.77	1.11
Arkansas	87	19	106	0.43	1.13	0.48
California	73	140	212	0.36	8.11	0.97
Colorado	94	11	105	0.47	0.63	0.48
Connecticut	41	18	59	0.20	1.07	0.27
Delaware	102	4	106	0.50	0.26	0.49
District of Columbia	5	2	6	0.02	0.10	0.03
Florida	853	43	896	4.23	2.47	4.09
Georgia	886	22	907	4.39	1.25	4.14
Hawaii	19	2	21	0.09	0.09	0.09
Idaho	25	11	36	0.12	0.65	0.17
Illinois	1,202	28	1,230	5.96	1.61	5.62
Indiana	1,545	144	1,689	7.66	8.39	7.72
Iowa	248	14	262	1.23	0.81	1.20
Kansas	117	10	127	0.58	0.59	0.58
Kentucky	1,050	41	1,091	5.21	2.38	4.99
Louisiana	295	125	420	1.46	7.24	1.92
Maine	62	14	76	0.31	0.84	0.35
Maryland	320	52	371	1.59	3.00	1.70
Massachusetts	213	39	252	1.06	2.27	1.15
Michigan	470	27	497	2.33	1.57	2.27
Minnesota	124	16	139	0.61	0.91	0.64
Mississippi	215	75	290	1.07	4.36	1.33
Missouri	758	39	797	3.76	2.28	3.64
Montana	73	5	78	0.36	0.31	0.36
Nebraska	67	9	77	0.33	0.54	0.35
Nevada	57	7	63	0.28	0.38	0.29
New Hampshire	66	7	73	0.33	0.40	0.33
New Jersey	117	47	164	0.58	2.75	0.75
New Mexico	244	12	256	1.21	0.69	1.17
New York	446	85	531	2.21	4.94	2.43
North Carolina	513	47	560	2.54	2.72	2.56
North Dakota	180	18	198	0.89	1.06	0.90
Ohio	2,451	83	2,533	12.15	4.81	11.57
Oklahoma	143	19	162	0.71	1.09	0.74
Oregon	24	30	55	0.12	1.76	0.25
Pennsylvania	1,325	63	1,388	6.57	3.68	6.34
Rhode Island	2	5	7	0.01	0.27	0.03
South Carolina	251	15	266	1.25	0.87	1.22
South Dakota	34	5	39	0.17	0.28	0.18
Tennessee	1,077	23	1,100	5.34	1.33	5.03
Texas	1,139	125	1,263	5.65	7.24	5.77
Utah	58	17	75	0.29	0.98	0.34
Vermont	1	5	6	0.01	0.27	0.03
Virginia	329	45	374	1.63	2.64	1.71
Washington	134	28	162	0.66	1.63	0.74
West Virginia	1,185	10	1,195	5.88	0.57	5.46
Wisconsin	384	19	403	1.90	1.10	1.84
Wyoming	118	15	133	0.59	0.86	0.61
National	20,168	1,720	21,888	100	100	100

Table 2-13. 1993 State-level Point, Area, and Total Emissions of Sulfur Dioxide Ranked by Total Emissions
(thousand short tons)

Rank	State	Point	Area	Total	% Point	% Area	% Total
1	Ohio	2,451	83	2,533	12.15	4.81	11.57
2	Indiana	1,545	144	1,689	7.66	8.39	7.72
3	Pennsylvania	1,325	63	1,388	6.57	3.68	6.34
4	Texas	1,139	125	1,263	5.65	7.24	5.77
5	Illinois	1,202	28	1,230	5.96	1.61	5.62
6	West Virginia	1,185	10	1,195	5.88	0.57	5.46
7	Tennessee	1,077	23	1,100	5.34	1.33	5.03
8	Kentucky	1,050	41	1,091	5.21	2.38	4.99
9	Georgia	886	22	907	4.39	1.25	4.14
10	Florida	853	43	896	4.23	2.47	4.09
11	Missouri	758	39	797	3.76	2.28	3.64
12	Alabama	714	67	781	3.54	3.92	3.57
13	North Carolina	513	47	560	2.54	2.72	2.56
14	New York	446	85	531	2.21	4.94	2.43
15	Michigan	470	27	497	2.33	1.57	2.27
16	Louisiana	295	125	420	1.46	7.24	1.92
17	Wisconsin	384	19	403	1.90	1.10	1.84
18	Virginia	329	45	374	1.63	2.64	1.71
19	Maryland	320	52	371	1.59	3.00	1.70
20	Mississippi	215	75	290	1.07	4.36	1.33
21	South Carolina	251	15	266	1.25	0.87	1.22
22	Iowa	248	14	262	1.23	0.81	1.20
23	New Mexico	244	12	256	1.21	0.69	1.17
24	Massachusetts	213	39	252	1.06	2.27	1.15
25	Arizona	231	13	244	1.14	0.77	1.11
26	California	73	140	212	0.36	8.11	0.97
27	North Dakota	180	18	198	0.89	1.06	0.90
28	New Jersey	117	47	164	0.58	2.75	0.75
29	Washington	134	28	162	0.66	1.63	0.74
30	Oklahoma	143	19	162	0.71	1.09	0.74
31	Minnesota	124	16	139	0.61	0.91	0.64
32	Wyoming	118	15	133	0.59	0.86	0.61
33	Kansas	117	10	127	0.58	0.59	0.58
34	Delaware	102	4	106	0.50	0.26	0.49
35	Arkansas	87	19	106	0.43	1.13	0.48
36	Colorado	94	11	105	0.47	0.63	0.48
37	Montana	73	5	78	0.36	0.31	0.36
38	Nebraska	67	9	77	0.33	0.54	0.35
39	Maine	62	14	76	0.31	0.84	0.35
40	Utah	58	17	75	0.29	0.98	0.34
41	New Hampshire	66	7	73	0.33	0.40	0.33
42	Nevada	57	7	63	0.28	0.38	0.29
43	Connecticut	41	18	59	0.20	1.07	0.27
44	Oregon	24	30	55	0.12	1.76	0.25
45	South Dakota	34	5	39	0.17	0.28	0.18
46	Idaho	25	11	36	0.12	0.65	0.17
47	Hawaii	19	2	21	0.09	0.09	0.09
48	Rhode Island	2	5	7	0.01	0.27	0.03
49	District of Columbia	5	2	6	0.02	0.10	0.03
50	Vermont	1	5	6	0.01	0.27	0.03
51	Alaska	1	2	3	0.00	0.13	0.01
	National	20,168	1,720	21,888	100	100	100

Table 2-14. 1993 State-level Fugitive Dust, Nonfugitive Dust, and Total Emissions of Particutlate Matter (PM-10)

(thousand short tons)

State	Fugitive Dust	Nonfugitive Dust	Total	% Fugitive Dust	% Nonfugitive Dust	% Total
Alabama	815	116	930	1.95	3.14	2.05
Alaska	214	120	335	0.51	3.26	0.74
Arizona	421	90	511	1.01	2.45	1.12
Arkansas	610	64	673	1.46	1.73	1.48
California	2,443	211	2,653	5.84	5.71	5.83
Colorado	737	32	770	1.76	0.88	1.69
Connecticut	227	22	249	0.54	0.58	0.55
Delaware	58	10	68	0.14	0.26	0.15
District of Columbia	16	1	18	0.04	0.04	0.04
Florida	1,234	147	1,380	2.95	3.97	3.03
Georgia	1,413	172	1,585	3.38	4.65	3.48
Hawaii	88	4	92	0.21	0.10	0.20
Idaho	782	100	882	1.87	2.71	1.94
Illinois	1,503	113	1,615	3.59	3.06	3.55
Indiana	840	87	926	2.01	2.35	2.04
Iowa	939	25	963	2.25	0.67	2.12
Kansas	1,116	52	1,168	2.67	1.41	2.57
Kentucky	528	75	603	1.26	2.02	1.32
Louisiana	639	109	747	1.53	2.94	1.64
Maine	112	24	137	0.27	0.66	0.30
Maryland	423	28	451	1.01	0.76	0.99
Massachusetts	534	37	572	1.28	1.00	1.26
Michigan	967	85	1,052	2.31	2.31	2.31
Minnesota	1,300	79	1,378	3.11	2.14	3.03
Mississippi	1,438	77	1,515	3.44	2.09	3.33
Missouri	1,609	121	1,729	3.85	3.27	3.80
Montana	838	60	898	2.00	1.63	1.97
Nebraska	930	18	948	2.23	0.48	2.08
Nevada	171	35	206	0.41	0.96	0.45
New Hampshire	83	13	96	0.20	0.36	0.21
New Jersey	523	45	569	1.25	1.23	1.25
New Mexico	1,454	78	1,532	3.48	2.12	3.37
New York	1,262	106	1,368	3.02	2.87	3.01
North Carolina	725	137	862	1.73	3.73	1.90
North Dakota	639	13	651	1.53	0.34	1.43
Ohio	1,166	108	1,274	2.79	2.93	2.80
Oklahoma	927	38	964	2.22	1.02	2.12
Oregon	729	125	853	1.74	3.38	1.88
Pennsylvania	1,098	142	1,240	2.63	3.84	2.73
Rhode Island	92	5	97	0.22	0.13	0.21
South Carolina	549	60	610	1.31	1.63	1.34
South Dakota	742	13	755	1.78	0.36	1.66
Tennessee	599	112	711	1.43	3.05	1.56
Texas	5,172	229	5,401	12.37	6.21	11.87
Utah	360	25	385	0.86	0.68	0.85
Vermont	110	8	118	0.26	0.23	0.26
Virginia	601	87	687	1.44	2.35	1.51
Washington	929	104	1,033	2.22	2.83	2.27
West Virginia	184	46	230	0.44	1.25	0.51
Wisconsin	665	56	721	1.59	1.52	1.59
Wyoming	252	25	277	0.60	0.69	0.61
National	41,801	3,688	45,489	100	100	100

Table 2-15. 1993 State-level Fugitive Dust, Nonfugitive Dust, and Total Emissions of Particutlate Matter (PM-10) Ranked by Total Emissions

(thousand short tons)

Rank	State	Fugitive Dust	Nonfugitive Dust	Total	% Fugitive Dust	% Nonfugitive Dust	% Total
1	Texas	5,172	229	5,401	12.37	6.21	11.87
2	California	2,443	211	2,653	5.84	5.71	5.83
3	Missouri	1,609	121	1,729	3.85	3.27	3.80
4	Illinois	1,503	113	1,615	3.59	3.06	3.55
5	Georgia	1,413	172	1,585	3.38	4.65	3.48
6	New Mexico	1,454	78	1,532	3.48	2.12	3.37
7	Mississippi	1,438	77	1,515	3.44	2.09	3.33
8	Florida	1,234	147	1,380	2.95	3.97	3.03
9	Minnesota	1,300	79	1,378	3.11	2.14	3.03
10	New York	1,262	106	1,368	3.02	2.87	3.01
11	Ohio	1,166	108	1,274	2.79	2.93	2.80
12	Pennsylvania	1,098	142	1,240	2.63	3.84	2.73
13	Kansas	1,116	52	1,168	2.67	1.41	2.57
14	Michigan	967	85	1,052	2.31	2.31	2.31
15	Washington	929	104	1,033	2.22	2.83	2.27
16	Oklahoma	927	38	964	2.22	1.02	2.12
17	Iowa	939	25	963	2.25	0.67	2.12
18	Nebraska	930	18	948	2.23	0.48	2.08
19	Alabama	815	116	930	1.95	3.14	2.05
20	Indiana	840	87	926	2.01	2.35	2.04
21	Montana	838	60	898	2.00	1.63	1.97
22	Idaho	782	100	882	1.87	2.71	1.94
23	North Carolina	725	137	862	1.73	3.73	1.90
24	Oregon	729	125	853	1.74	3.38	1.88
25	Colorado	737	32	770	1.76	0.88	1.69
26	South Dakota	742	13	755	1.78	0.36	1.66
27	Louisiana	639	109	747	1.53	2.94	1.64
28	Wisconsin	665	56	721	1.59	1.52	1.59
29	Tennessee	599	112	711	1.43	3.05	1.56
30	Virginia	601	87	687	1.44	2.35	1.51
31	Arkansas	610	64	673	1.46	1.73	1.48
32	North Dakota	639	13	651	1.53	0.34	1.43
33	South Carolina	549	60	610	1.31	1.63	1.34
34	Kentucky	528	75	603	1.26	2.02	1.32
35	Massachusetts	534	37	572	1.28	1.00	1.26
36	New Jersey	523	45	569	1.25	1.23	1.25
37	Arizona	421	90	511	1.01	2.45	1.12
38	Maryland	423	28	451	1.01	0.76	0.99
39	Utah	360	25	385	0.86	0.68	0.85
40	Alaska	214	120	335	0.51	3.26	0.74
41	Wyoming	252	25	277	0.60	0.69	0.61
42	Connecticut	227	22	249	0.54	0.58	0.55
43	West Virginia	184	46	230	0.44	1.25	0.51
44	Nevada	171	35	206	0.41	0.96	0.45
45	Maine	112	24	137	0.27	0.66	0.30
46	Vermont	110	8	118	0.26	0.23	0.26
47	Rhode Island	92	5	97	0.22	0.13	0.21
48	New Hampshire	83	13	96	0.20	0.36	0.21
49	Hawaii	88	4	92	0.21	0.10	0.20
50	Delaware	58	10	68	0.14	0.26	0.15
51	District of Columbia	16	1	18	0.04	0.04	0.04
	National	41,801	3,688	45,489	100	100	100

Table 2-16. Predominant Industries Listed Among the Top 30 Plants from AIRS/AFS

Pollutant	Industry	Number of Plants
CO	Steel mills	12
	Carbon black production	10
	Aluminum production	3
	Petroleum Refineries	3
NO_x	Electric utilities	30
VOC	Chemical & Allied Products	9
	Petroleum Refineries	6
	Steel mills	5
SO_2	Electric utility	29
Industrial SO_2	Petroleum refineries	8
	Primary smelting and refining of nonferrous metals	7
	Steel mills	5
	Paper mills	3
PM-10	Steel mills	6
	Mining	5
	Electric utilities	4
Pb	Primary smelting of nonferrous metals	6
	Secondary smelting nonferrous metals	5
	Electric utility	4

Table 2-17. Top 30 AIRS/AFS Plants Emitting Carbon Monoxide - 1993

Rank	Plant Name	EPA Region	State	County	NEDS ID	SIC	Year	Emissions (short tons)
1	USX Corporation - Edgar Thomson Works	3	PA	3	9	3312	91	288,469
2	Wheeling Pittsburgh Steel Steubenville	5	OH	81	5006	3312	90	185,571
3	U.S. Steel Co., Gary Works Part 2	5	IN	89	121	3312	92	175,432
4	Columbian Chemicals Co.	3	WV	51	19	2895	90	142,575
5	USX Corporation - Clairton Works	3	PA	3	11	3312	90	125,163
6	Bethlehem Steel	3	MD	5	147	3312	91	118,969
7	Shenango Iron & Coke Works	3	PA	3	50	3312	90	115,614
8	ACME Steel Company	5	IL	31	823	3312	93	100,507
9	Cabot Corp.	6	LA	101	4	2395	90	98,008
10	Gulf States Steel	4	AL	55	8	3312	92	97,000
11	Bethlehem Steel Corp.	3	PA	95	48	3312	90	91,305
12	Columbian Chemical	6	LA	101	5	2895	90	86,089
13	Cabot Corp.	6	LA	39	1	2895	90	66,615
14	Sid Richardson Carbon and Gasoline	6	TX	227	2	2895	92	65,207
15	Degussa Carbon Black	6	LA	101	18	2895	90	64,258
16	Cabot Corporation	6	TX	179	1	2895	92	63,232
17	ALCOA (Aluminum Co. of America)	5	IN	173	7	3334	92	61,582
18	Ashland Petroleum	5	MN	163	3	2911	90	59,264
19	WITCO Corp., Continental Carbon Division	6	OK	71	703	2895	92	54,955
20	Addis Plant Sid Richardson Rd.	6	LA	121	6	2895	90	54,322
21	WITCO Corp., Continental Carbon Division	6	OK	71	4	2895	85	53,430
22	ORMET Corporation	5	OH	111	5001	3334	90	52,947
23	LTV Steel Company	5	IN	89	318	3312	92	52,640
24	Noranda Aluminum, Incorporated	7	MO	143	8	3334	89	50,808
25	Degussa Corporation	5	OH	167	5015	2895	90	48,745
26	E.I. Du Pont De Nemours and Co.	4	TN	85	7	2816	90	46,928
27	Weirton Steel Corporation	3	WV	29	1	3312	90	46,153
28	Total Petroleum Inc	5	MI	57	9	2911	90	44,007
29	United Refining Co.	3	PA	123	3	2911	90	43,104
30	ARMCO Steel Company L.P.	5	OH	17	5002	3312	90	40,636

NOTE(S): These data were reported as found in AIRS/AFS. EPA recognizes that there may be inaccuracies and incompleteness in the data, and the data may not accurately reflect the current emissions of facilities. However, it is the most recent information available from States.
The values presented in the "County" column are FIPS county codes.
The AIRS data is not the main basis for the data in this report.

Table 2-18. Top 30 AIRS/AFS Plants Emitting Nitrogen Oxides - 1993

Rank	Plant Name	EPA Region	State	County	NEDS ID	SIC	Year	Emissions (short tons)
1	TVA Cumberland Steam Plant	4	TN	161	11	4911	90	106,928
2	TVA Paradise A & B	4	KY	177	6	4911	90	97,787
3	General James M. Gavin Plant	5	OH	53	5002	4911	90	86,748
4	Detroit Edison - Monroe	5	MI	115	20	4911	90	85,451
5	James M. Stuart Electric Generating Station	5	OH	1	5001	4911	90	76,905
6	Com Ed - Powerton Station	5	IL	179	53	4911	93	72,628
7	Indiana Kentucky Electric Corporation	5	IN	77	1	4911	90	70,705
8	Davis Gas Processing *	6	TX	235		1321	92	70,406
9	Appalachian Power Co., John E. Amos Plant	3	WV	79	6	4911	90	65,460
10	Com Ed - Kincaid Generating Station	5	IL	21	48	4911	93	64,984
11	Illinois Power Co. - Baldwin Power Plant	5	IL	157	33	4911	93	63,212
12	GA Power Co./Bowen Steam Elec. Gen. Station	4	GA	15	11	4911	90	63,131
13	Alabama Power Co. - E C Gaston	4	AL	117	5	4911	92	62,359
14	Penn Power-Mansfield	3	PA	7	5	4911	90	57,962
15	Central Illinois Public Service	5	IL	135	38	4911	93	57,687
16	Kyger Creek Station Ohio Valley Elec. Corp.	5	OH	53	5001	4911	90	57,462
17	PSI - Gibson	5	IN	51	13	4911	90	57,063
18	Ohio Edison Company W. H. Sammis Plant	5	OH	81	5010	4911	90	54,153
19	Associated Electric	7	MO	143	4	4911	90	54,027
20	FL Power-Crystal River	4	FL	17	4	4911	90	52,832
21	Alabama Power Co-Barry Steam Plant	4	AL	97	1001	4911	92	52,409
22	Assoc. Electric Co. - Thomas Hill	7	MO	175	1	4911	90	51,452
23	Monongahela Power - Harrison	3	WV	33	15	4911	90	50,726
24	Detroit Edison - Belle River	5	MI	147	36	4911	90	50,376
25	Pen Elec - Homer City	3	PA	63	3	4911	90	49,553
26	CP&L, Roxboro, Units 1 2 3 4	4	NC	145	29	4911	88	46,668
27	Pen Elec - Conemaugh	3	PA	63	1	4911	90	46,521
28	Pen Elec - Keystone	3	PA	5	12	4911	90	46,069
29	Muskingum River Plant	5	OH	167	5001	4911	90	45,409
30	Duke Power-Belews Cr	4	NC	169	4	4911	89	44,071

NOTE(S): * The Davis Gas Processing facility was extracted from the Texas Air Control Board's data base on its way to AIRS and did not have a NEDs ID yet.
These data were reported as found in AIRS/AFS. EPA recognizes that there may be inaccuracies and incompleteness in the data, and the data may not accurately reflect the current emissions of facilities. However, it is the most recent information available from States.
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Table 2-19. Top 30 AIRS/AFS Plants Emitting Volatile Organic Compounds - 1993

Rank	Plant Name	EPA Region	State	County	NEDS ID	SIC	Year	Emissions (short tons)
1	Air Products & Chemicals, Inc.	4	KY	157	9	2819	90	28,670
2	Courtaulds North America, Inc.	4	AL	97	5002	2823	92	22,349
3	Tenn Eastman Co.	4	TN	163	1007	2819	93	21,065
4	Chemi-trol Chemical Co.	5	OH	143	5017	3443	90	17,190
5	BP Oil Company	5	OH	95	5046	2911	90	15,337
6	3M Hutch Mag Media	5	MN	85	3	2641	90	13,316
7	BP Chemicals Inc.	5	OH	3	5006	2819	90	12,583
8	International Paper Company	6	TX	37	11	2421	88	12,198
9	Lenzing Fibers Corporation	4	TN	63	197	2823	92	11,850
10	Neches Butane Products	6	TX	245	19	2869	85	11,274
11	Wheeling-Pitt (Follansbee)	3	WV	9	2	3312	90	10,644
12	Ashland Oil Co.	4	KY	19	4	2042	90	10,134
13	LTV Steel Company - Pittsburgh Works	3	PA	3	22	3312	90	9,623
14	ARMCO Steel Company L.P.	5	OH	17	5002	3312	90	9,006
15	Farmland Industries, Inc. (Ref. Div.)	7	KS	125	3	2911	92	8,652
16	ACME Steel Company, Chicago Coke Plant	5	IL	31	1302	3312	93	8,386
17	EXXON Co USA Refinery	6	LA	33	15	2911	90	8,213
18	E.I. Dupont De Nemours & Company Inc.	4	NC	19	13	2824	87	7,944
19	E.I. Dupont De Nemours & Company Inc.	6	TX	245	3	2869	92	7,932
20	USX Corporation - Clairton Works	3	PA	3	11	3312	90	7,710
21	Roanoke Cement Co. (Formerly Tarmac)	3	VA	23	3	3241	92	7,516
22	CL Industries Inc.	5	IL	183	99	2992	93	7,504
23	Impression Coating, Inc.	5	OH	91	5008	3089	90	7,486
24	Tenn Eastman Co.	4	TN	163	1004	2824	93	7,374
25	Chevron U.S.A., Incorporated	6	TX	245	4	2911	92	7,355
26	Congoleum Corp.	3	PA	45	49	3996	90	7,242
27	Cook Inlet Pipe Line	10	AK	122	7	4463	79	7,148
28	Conoco Inc.	6	OK	71	502	2911	92	6,932
29	Modine Mfg. Co.	7	MO	79	4	3714	86	6,854
30	Shell Oil Company	6	TX	201	39	2911	92	6,785

NOTE(S): These data were reported as found in AIRS/AFS. EPA recognizes that there may be inaccuracies and incompleteness in the data, and the data may not accurately reflect the current emissions of facilities. However, it is the most recent information available from States.
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The AIRS data is not the main basis for the data in this report.

Table 2-20. Top 30 AIRS/AFS Plants Emitting Sulfur Dioxide from All Sources - 1993

Rank	Plant Name	EPA Region	State	County	NEDS ID	SIC	Year	Emissions (short tons)
1	General James M. Gavin Plant	5	OH	53	5002	4911	90	373,413
2	TVA Cumberland Steam Plant	4	TN	161	11	4911	90	346,171
3	GA Power Co., Bowen Steam Elec. Gen. Station	4	GA	15	11	4911	90	305,302
4	Monongahela Power - Harrison	3	WV	33	15	4911	90	292,039
5	Indiana Kentucky Electric Corporation	5	IN	77	1	4911	90	281,423
6	PSI - Gibson	5	IN	51	13	4911	90	273,037
7	Union Electric Company - Labadie Plant	7	MO	71	3	4911	90	250,119
8	Kyger Creek Station Ohio Valley Elec. Corp.	5	OH	53	5001	4911	90	249,143
9	GA Power Co., Wansley	4	GA	149	1	4911	90	248,651
10	Muskingum River Plant	5	OH	167	5001	4911	90	245,099
11	Illinois Power Co - Baldwin Power Plant	5	IL	157	33	4911	93	233,768
12	Pen Electric - Conemaugh	3	PA	63	1	4911	90	179,167
13	Associated Electric	7	MO	143	4	4911	90	176,535
14	James M. Stuart Electric Generating Station	5	OH	1	5001	4911	90	173,828
15	Ohio Edison Company W.H. Sammis Plant	5	OH	81	5010	4911	90	169,131
16	Central Illinois Public Service	5	IL	135	38	4911	93	166,111
17	West Penn Power Co.	3	PA	59	6	4911	90	161,939
18	Alabama Power Co. E C Gaston	4	AL	117	5	4911	92	156,480
19	Tampa Elec, Big Bend	4	FL	57	39	4911	90	149,425
20	Cardinal Operating Company	5	OH	81	5002	4911	90	148,751
21	Virginia Power - Mount Storm	3	WV	23	3	4911	90	141,490
22	TVA- Paradise A & B	4	KY	177	6	4911	90	137,432
23	ALCOA Generating Corp.	5	IN	173	2	4911	90	135,281
24	Pen Elec - Keystone	3	PA	5	12	4911	90	134,880
25	PP & L - Montour	3	PA	93	3	4911	90	132,450
26	GA Power Co. Yates Steam Elec. Gen. Station	4	GA	77	1	4911	90	129,844
27	TVA-Gallatin	4	TN	165	25	4911	89	128,724
28	CEI - Eastlake	5	OH	85	5012	4911	90	128,547
29	Detroit Edison - Monroe	5	MI	115	20	4911	90	128,540
30	Columbus Southern Power - Conesville	5	OH	31	5001	4911	90	128,227

NOTE(S): These data were reported as found in AIRS/AFS. EPA recognizes that there may be inaccuracies and incompleteness in the data, and the data may not accurately reflect the current emissions of facilities. However, it is the most recent information available from States.
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The AIRS data is not the main basis for the data in this report.

Table 2-21. Top 30 AIRS/AFS Plants Emitting Sulfur Dioxide from Industrial Sources - 1993

Rank	Plant Name	EPA Region	State	County	NEDS ID	SIC	Year	Emissions (short tons)
1	Aluminum Company of America	6	TX	331	1	3334	92	67,988
2	Copper Range Company	5	MI	131	2	1021	90	65,156
3	Asarco Incorporated	6	TX	141	1	3331	90	47,341
4	Asarco Incorporated	7	MO	93	8	3332	90	44,136
5	Shell Oil Co., Wood River Mfg. Complex	5	IL	119	104	2911	93	40,063
6	Dakota Gasification Company	8	ND	57	13	1311	93	37,394
7	Phelps Dodge Mining/Hidalgo Smelter	6	NM	23	3	3331	91	34,592
8	USS/Kobe Steel Co. - Lorain Works	5	OH	93	5004	3312	90	34,467
9	Mead Corporation	5	OH	141	5001	2621	90	33,921
10	Star Enterprise, Delaware City Plant	3	DE	3	16	2911	92	33,574
11	Asarco Incorporated	9	AZ	7	4	3331	90	32,959
12	Kodak Park Div.	2	NY	55	258	3861	90	32,718
13	James River Corporation	5	MI	77	39	2621	90	32,714
14	Phillips 66 Company, Division of Phillips	6	TX	233	15	2911	92	30,661
15	Kennecott	8	UT	35	30	3331	90	30,047
16	ARMCO Steel Company L.P.	5	OH	17	5002	3312	90	29,132
17	Phelps Dodge/Chino Mines	6	NM	17	1	3331	91	28,058
18	Mobil Oil Corp.	2	NJ	15	6	2911	87	26,240
19	Bethlehem Steel Corporation	5	IN	127	1	3312	90	26,029
20	Exxon Co. USA	4	AL	53	7	1311	92	25,876
21	Mobil Joliet Refining Corp.	5	IL	197	89	2911	93	24,824
22	Wheeling Pittsburgh Steel, Steubenville	5	OH	81	5006	3312	90	22,714
23	Conoco Inc.	6	OK	71	10	2911	87	22,494
24	Inland Steel Flat Products, Part 2	5	IN	89	317	3312	90	21,242
25	Tenn Eastman Co.	4	TN	163	3	4961	93	19,236
26	Westvaco	3	MD	1	11	2621	91	18,901
27	Champion International Corp.	4	NC	87	159	2621	89	18,613
28	Fort Howard Corporation	5	WI	9	328	2621	90	18,071
29	Uno-Ven Company	5	IL	197	77	2911	93	18,021
30	Union Camp Corp., Fine Paper Div.	3	VA	93	6	2621	92	17,398

NOTE(S): These data were reported as found in AIRS/AFS. EPA recognizes that there may be inaccuracies and incompleteness in the data, and the data may not accurately reflect the current emissions of facilities. However, it is the most recent information available from States.
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Table 2-22. Top 30 AIRS/AFS Plants Emitting Particulate Matter (PM-10) - 1993

Rank	Plant Name	EPA Region	State	County	NEDS ID	SIC	Year	Emissions (short tons)
1	LTV Steel Mining Co.	5	MN	137	9	1011	90	15,992
2	US Steel	5	MN	137	5	1011	90	15,295
3	Jaeco Coal/Eel River Coal	5	IN	21	13	1211	88	14,705
4	Nemo Coal, Inc.	7	MO	175	15	1211	87	11,562
5	Inland Steel Flat Products Part 2	5	IN	89	317	3312	90	6,404
6	Asarco Incorporated	9	AZ	19	1	1021	92	5,920
7	Empire District Electric	7	MO	97	1	4911	90	5,661
8	Bethlehem Steel Corp.	5	IN	127	1	3312	90	4,161
9	Pacificorp - Jim Bridger	8	WY	37	1002	4911	92	3,999
10	Ash Grove Cement Co.	7	NE	25	2	3241	92	3,743
11	Kennecott	8	UT	35	30	3331	90	3,616
12	Inland Steel Flat Products	5	IN	89	316	3312	90	3,553
13	Peabody Coal Co. Midwest Division	5	IL	157	34	1222	93	3,371
14	Harbison-Walker Refractory	7	MO	27	1	3255	87	3,334
15	S. D. Warren Co., Scott Paper Co.	1	ME	25	27	2611	90	3,166
16	Aluminum Company of America	6	TX	57	2	2819	92	3,130
17	Central Soya Company Inc.	5	IN	1	5	2075	90	3,129
18	Medusa Cement Company	5	MI	29	7	3241	90	3,124
19	Pacificorp-Centralia Plant	10	WA	41	10	4911	93	2,944
20	Cal Portland Cement Co.	9	CA	29	9	3241	90	2,826
21	Bethlehem Steel Corp.	3	PA	95	48	3312	90	2,721
22	U.S. Army Engineer Center	7	MO	169	4	9711	87	2,648
23	U.S. Steel Corp.	3	PA	17	55	3312	90	2,613
24	PP & L - Montour	3	PA	93	3	4911	90	2,585
25	A. E. Staley Manufacturing Co.	5	IL	115	18	2046	93	2,568
26	Imperial Products Co.	7	MO	35	4	2861	90	2,461
27	GMC Powertrain Division	5	MI	145	30	3321	90	2,369
28	Mead Paper Company	5	MI	41	2	2621	90	2,354
29	A. P. Green Refracto	7	MO	7	1	3255	86	2,352
30	ACME Steel Company	5	IL	31	823	3312	93	2,326

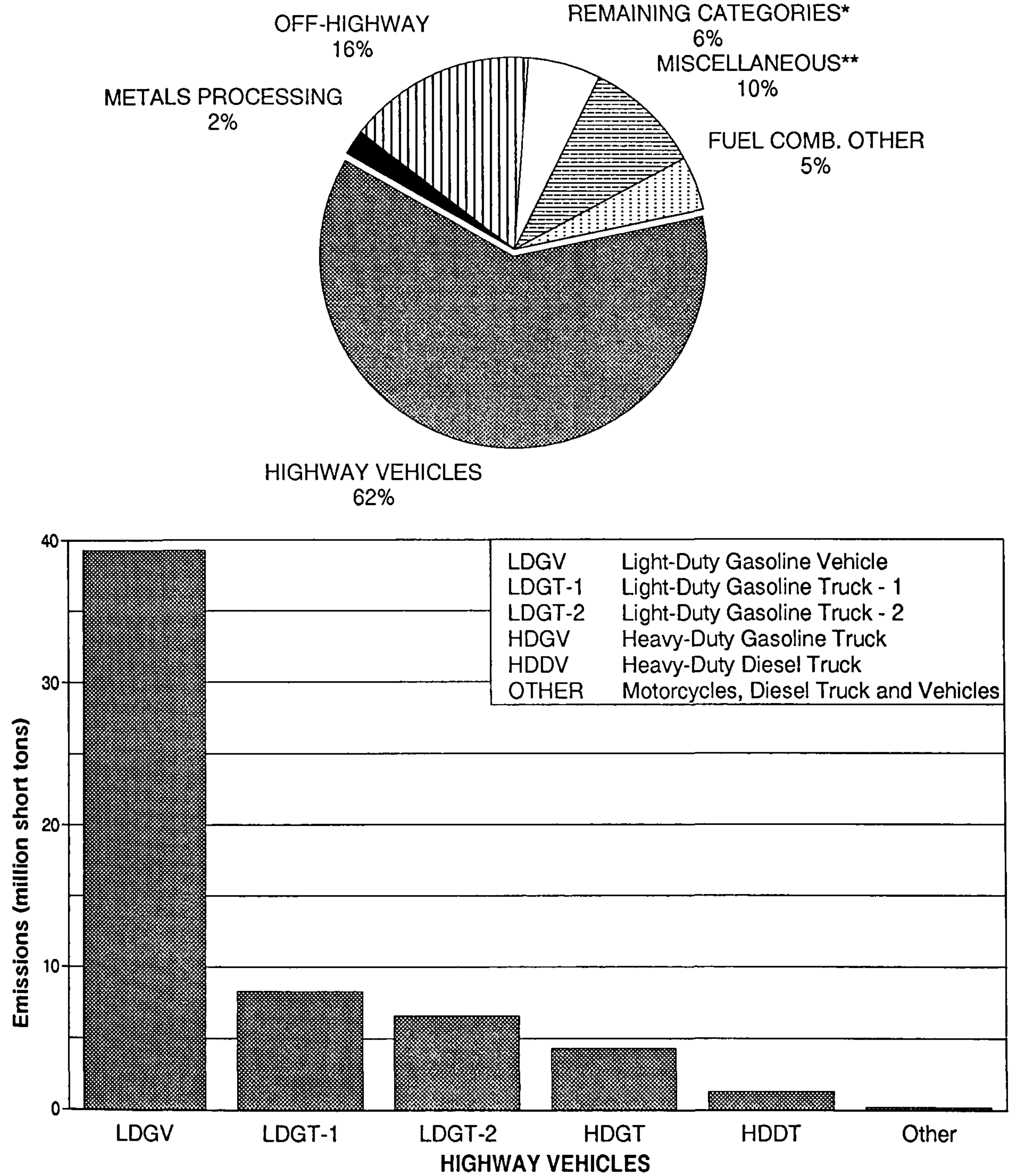
NOTE(S): These data were reported as found in AIRS/AFS. EPA recognizes that there may be inaccuracies and incompleteness in the data, and the data may not accurately reflect the current emissions of facilities. However, it is the most recent information available from States.
The values presented in the "County" column are FIPS county codes.
The AIRS data is not the main basis for the data in this report.

Table 2-23. Top 30 AIRS/AFS Plants Emitting Lead - 1993

Rank	Plant Name	EPA Region	State	County	NEDS ID	SIC	Year	Emissions (short tons)
1	Granite City Steel Company	5	IL	119	153	3312	93	689
2	Horsehead Resource Development Co., Inc.	5	IL	31	1199	3341	93	303
3	Northwestern Steel & Wire Co.	5	IL	195	70	3315	93	249
4	Doe Run Company	7	MO	99	3	3332	90	157
5	Chemetco	5	IL	119	128	3341	93	147
6	Medusa Cement Company	5	MI	29	7	3241	90	134
7	GMC Powertrain Division	5	MI	145	30	3321	90	126
8	ST. Joe Minerals Corp., Josephtown	3	PA	7	32	3339	85	72
9	Holnam Inc./Dundee Cement	5	MI	115	10	3241	90	55
10	Asarco Incorporated	7	MO	93	8	3332	90	54
11	Detroit Edison - Monroe	5	MI	115	20	4911	90	54
12	Doe Run Company	7	MO	93	9	3332	90	53
13	North Chicago Refiners and Smelters Inc.	5	IL	97	84	3341	93	49
14	National Cement Co.	9	CA	29	21	3241	90	47
15	Calaveras Cement Co.	9	CA	29	20	3241	90	40
16	Continental Cement	5	IL	31	35	5039	85	37
17	St. Joe Minerals Corp./Brushy Creek Div.	7	MO	179	5	1031	85	36
18	PPG Industries Inc., Works No. 14	5	IL	115	104	3211	93	35
19	Great Lakes Steel	5	MI	163	92	3312	85	35
20	Asarco Incorporated	6	TX	141	1	3331	92	34
21	East Jordan Iron Works Inc.	5	MI	29	4	3321	90	33
22	Detroit Edison - Belle River	5	MI	147	36	4911	90	32
23	Asarco Incorporated	7	NE	55	20	3341	93	27
24	C. R. Huntley Steam Station, Tonawanda	2	NY	29	1700	4911	85	24
25	Haeger Potteries, Inc.	5	IL	89	65	3269	93	22
26	CAL Portland Cement Co.	9	CA	29	9	3241	90	21
27	Southwestern Electric Power Company	6	TX	203	22	4911	92	21
28	Kurdziel Iron of Rothbury	5	MI	127	4	3321	90	20
29	Refined Metals Corp.	4	TN	157	212	3341	85	20
30	Northwest Waste to Energy	5	IL	31	1478	4953	93	19

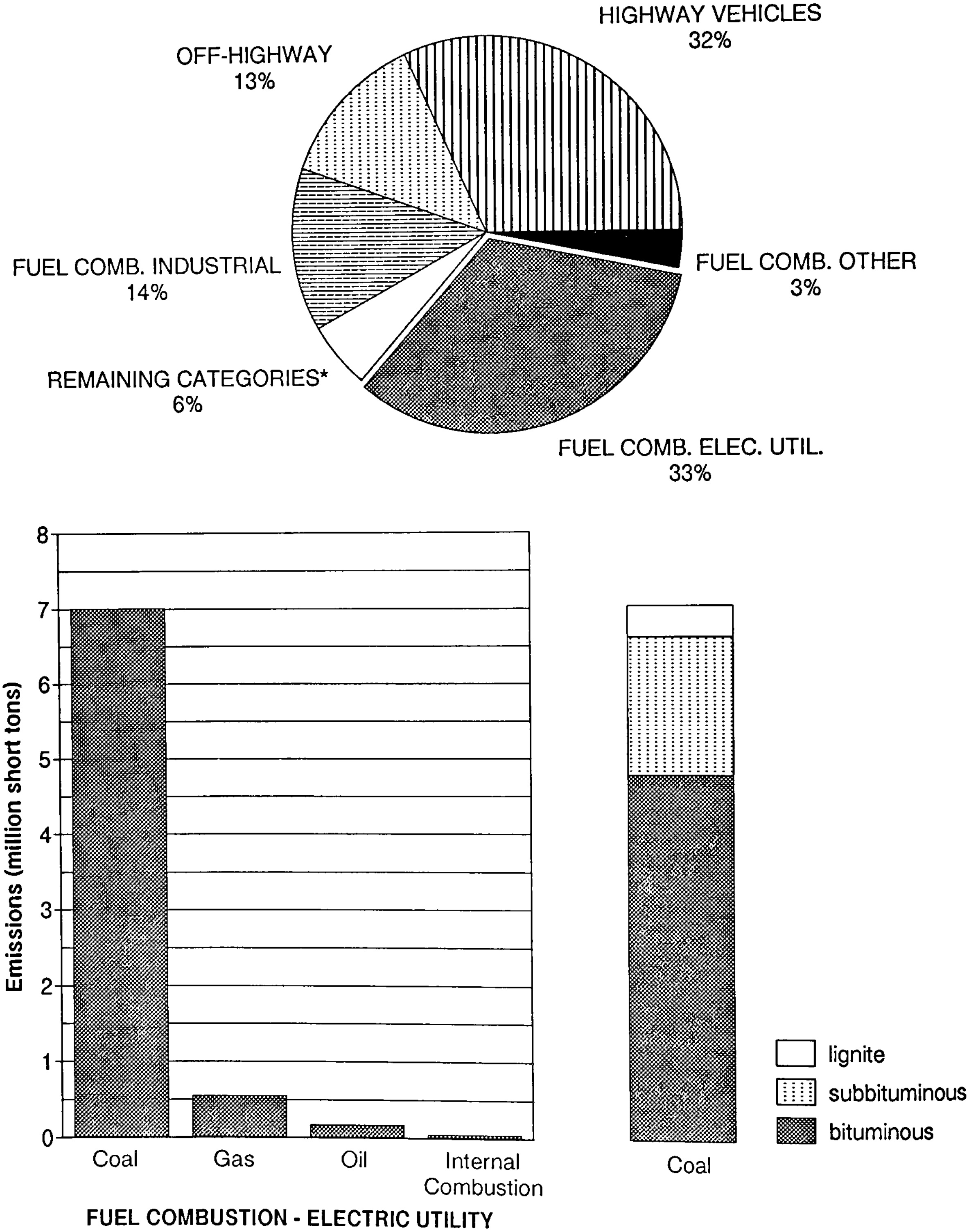
NOTE(S): These data were reported as found in AIRS/AFS. EPA recognizes that there may be inaccuracies and incompleteness in the data, and the data may not accurately reflect the current emissions of facilities. However, it is the most recent information available from States.
The values presented in the "County" column are FIPS county codes.
The AIRS data is not the main basis for the data in this report.

Figure 2-1. 1993 National CARBON MONOXIDE Emissions by 5 Principal Source Categories



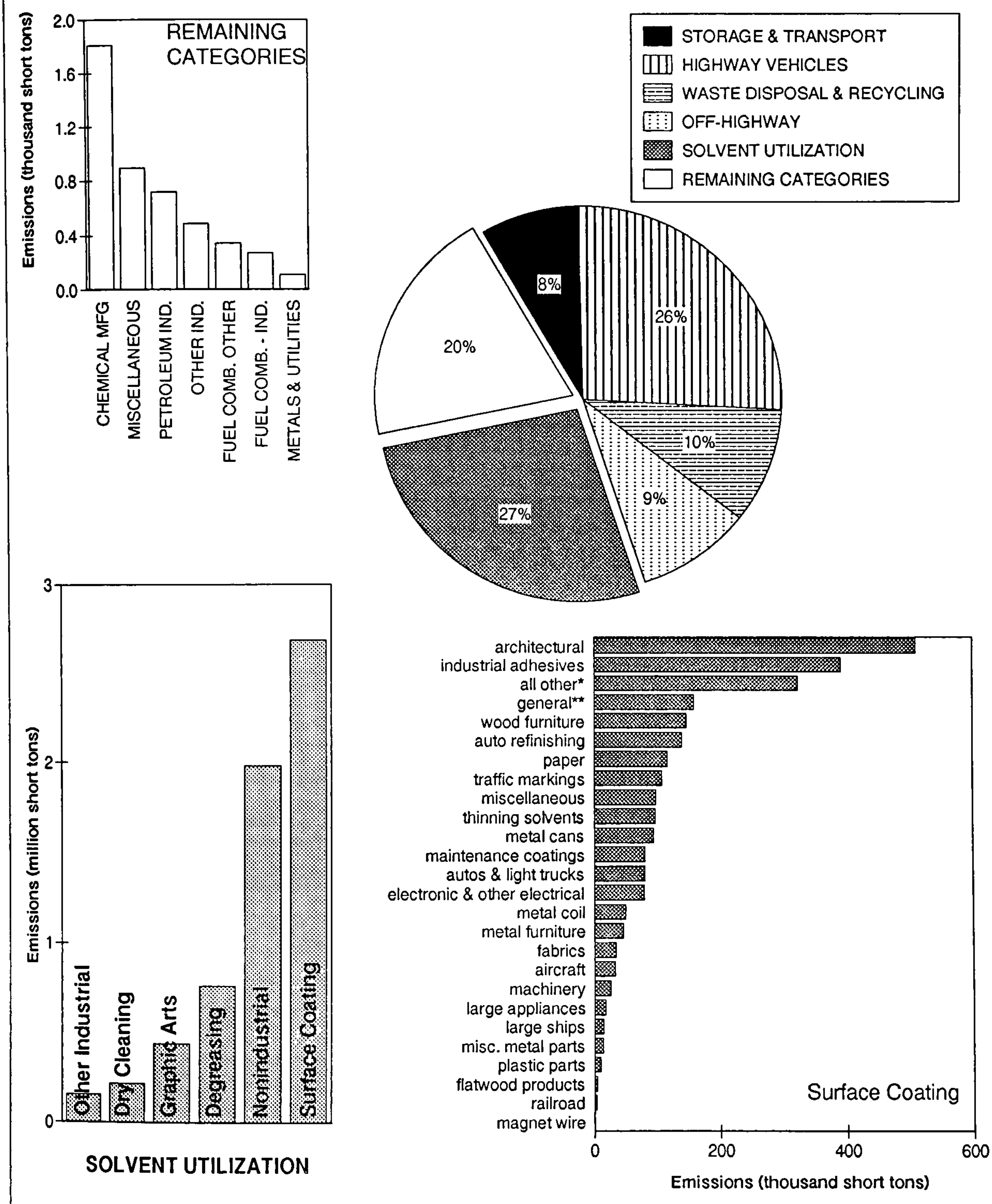
* REMAINING CATEGORIES are defined in section 2.1.1.
**MISCELLANEOUS is primarily wildfire emissions.

Figure 2-2. 1993 National NITROGEN OXIDES Emissions by 5 Principal Source Categories



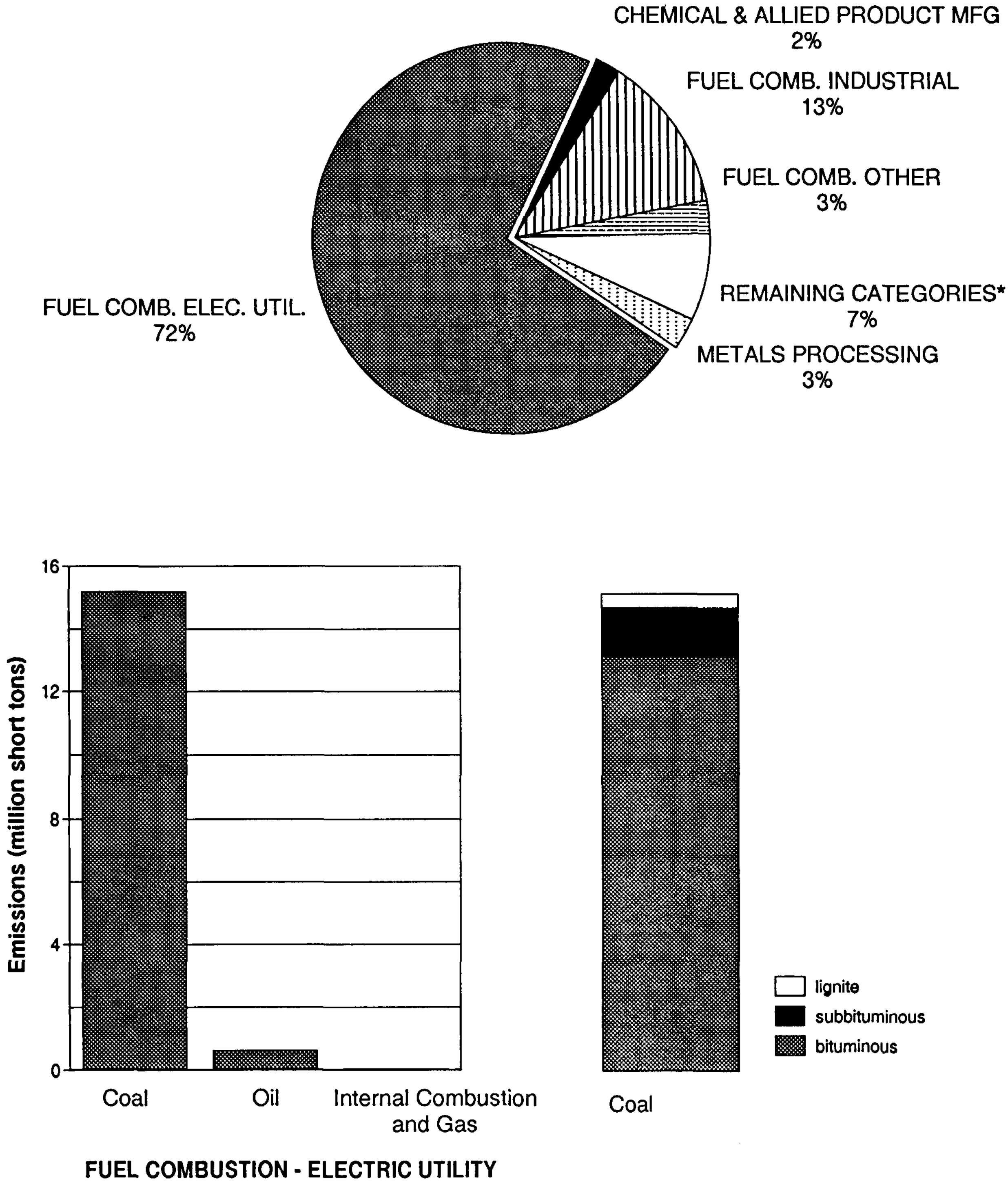
* REMAINING CATEGORIES are defined in section 2.1.2.

Figure 2-3. 1993 National VOLATILE ORGANIC COMPOUND Emissions by 5 Principal Source Categories



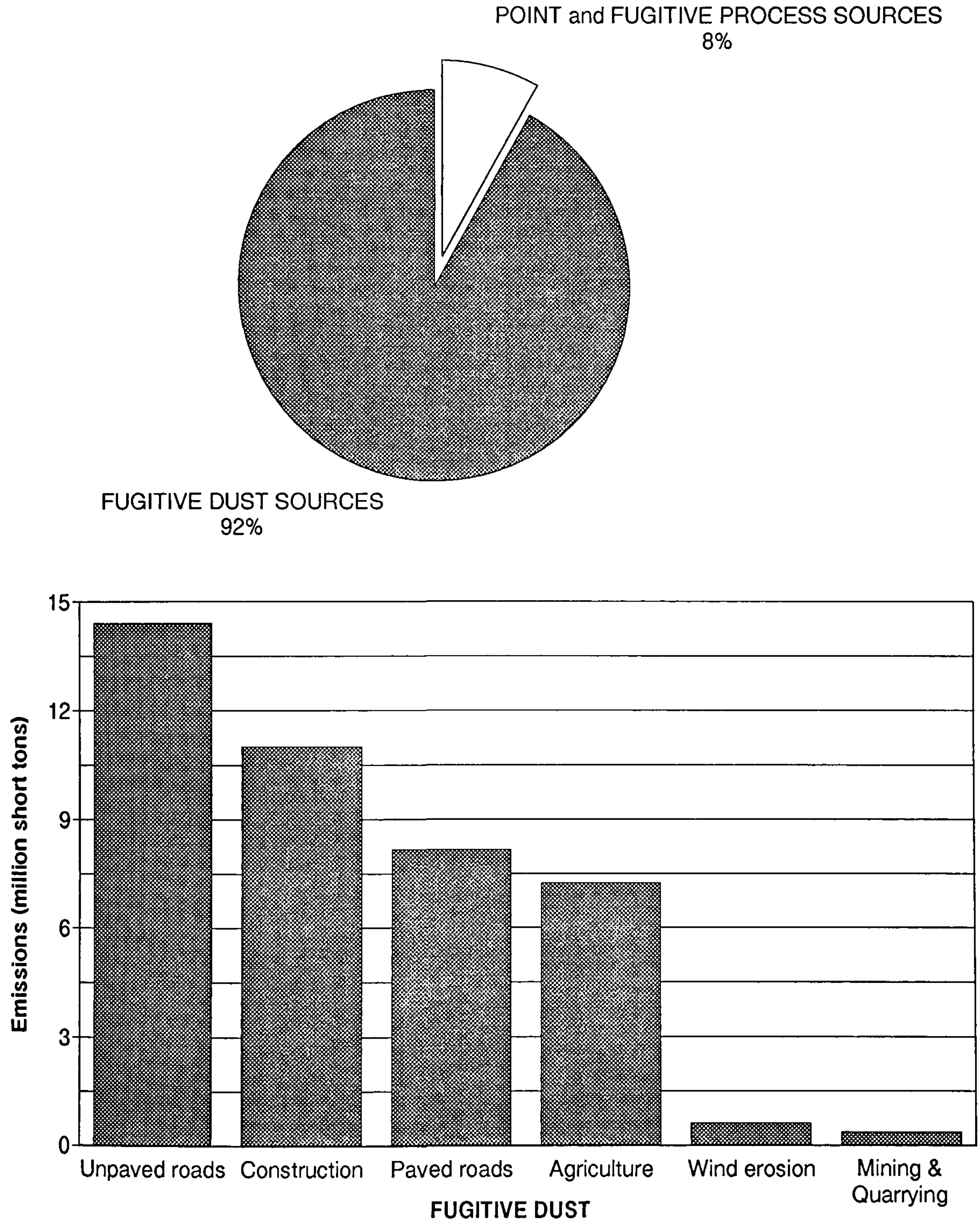
* general: sources that use nonspecific solvents on nonspecific surfaces
** all other: sources that use specific solvents on nonspecific surfaces

Figure 2-4. 1993 National SULFUR DIOXIDE Emissions by 5 Principal Source Categories



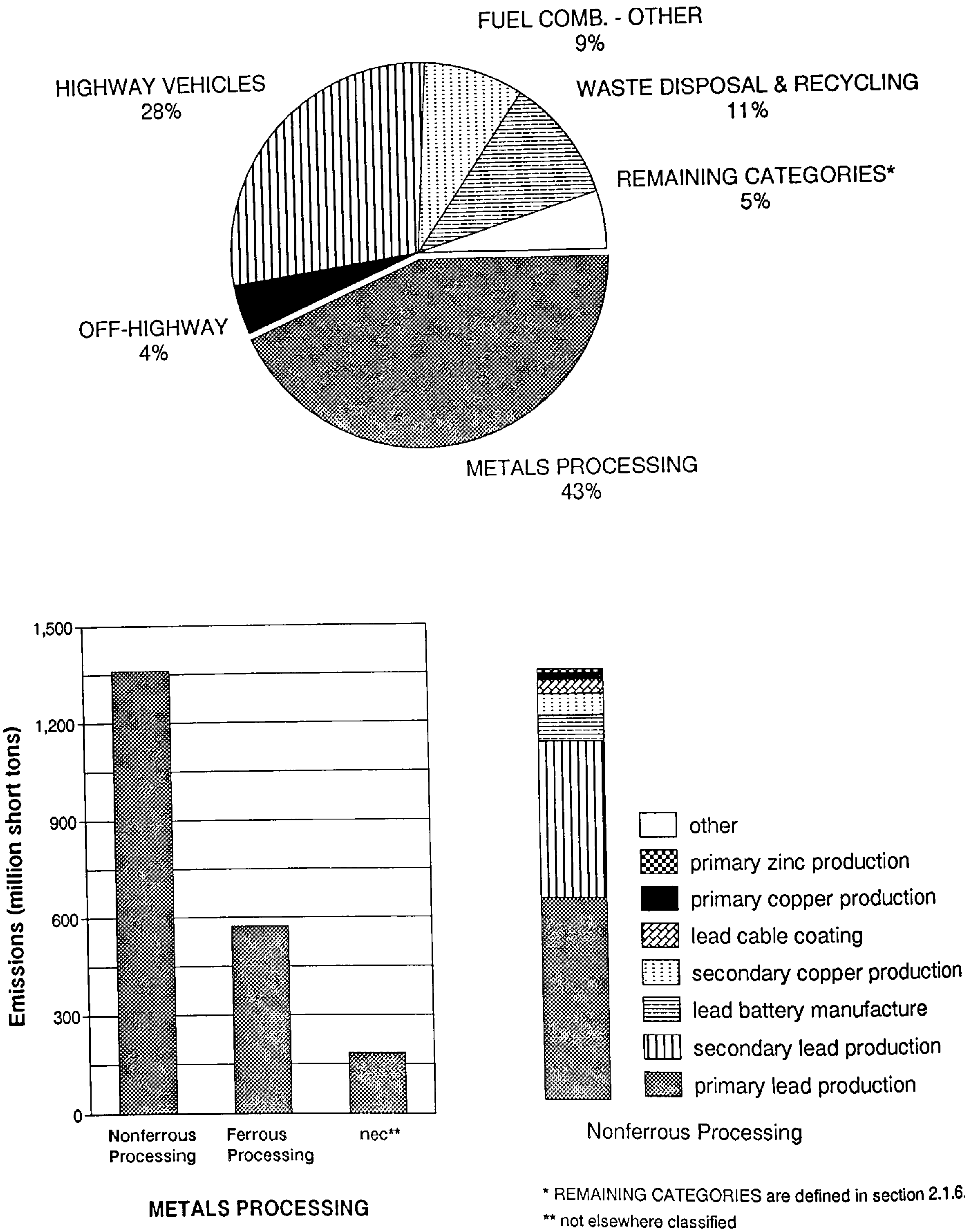
* REMAINING SOURCES are defined in section 2.1.4.

Figure 2-5. 1993 National PARTICULATE MATTER (PM-10) Emissions



* POINT and FUGITIVE PROCESS SOURCES are listed in Table A-5, in Appendix A.

Figure 2-6. 1993 National LEAD Emissions by 5 Principal Source Categories



* REMAINING CATEGORIES are defined in section 2.1.6.

** not elsewhere classified

Figure 2-7. Top 10 States Ranked by CARBON MONOXIDE Emissions in 1993

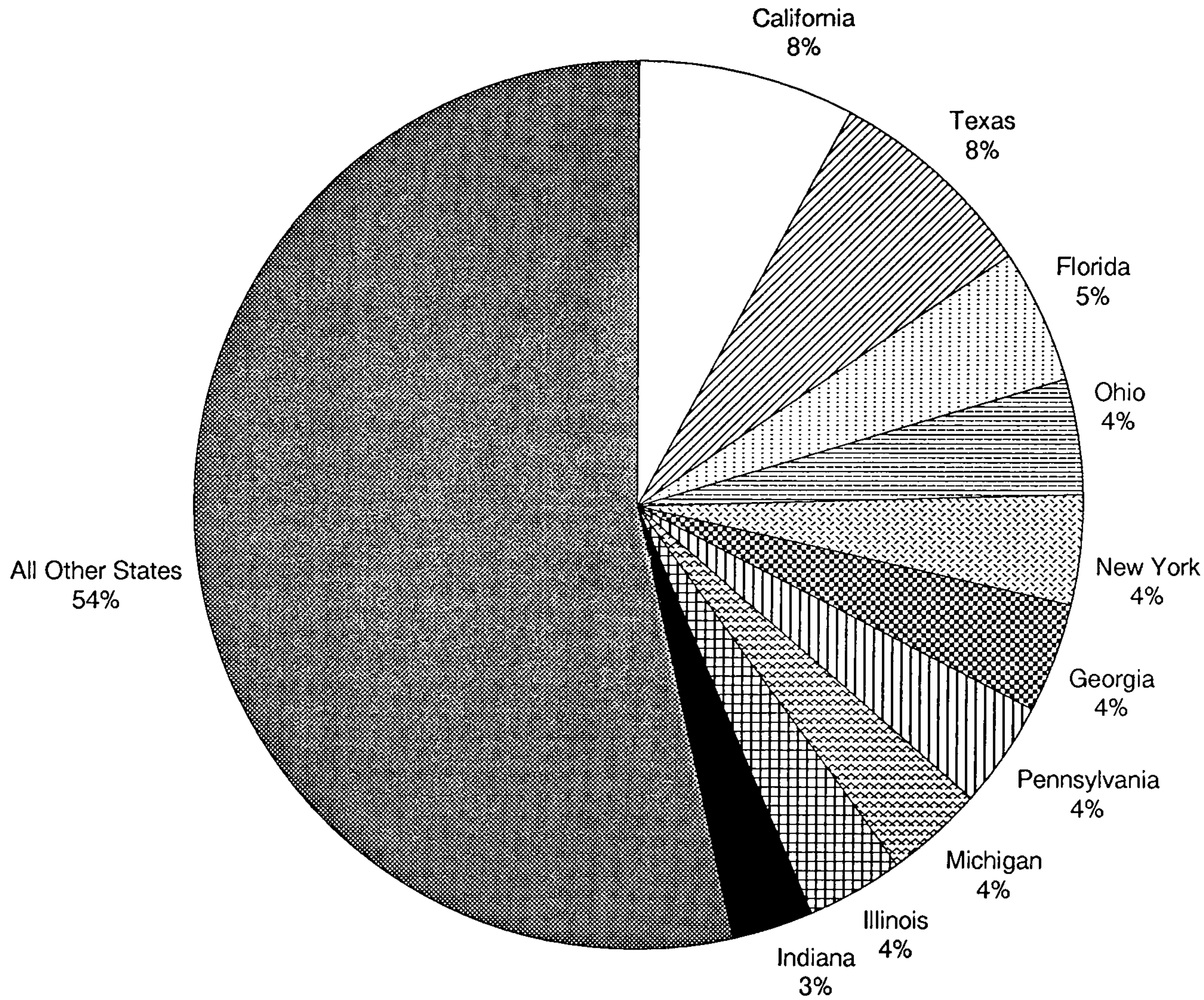


Figure 2-8. Top 10 States Ranked by NITROGEN OXIDES Emissions in 1993

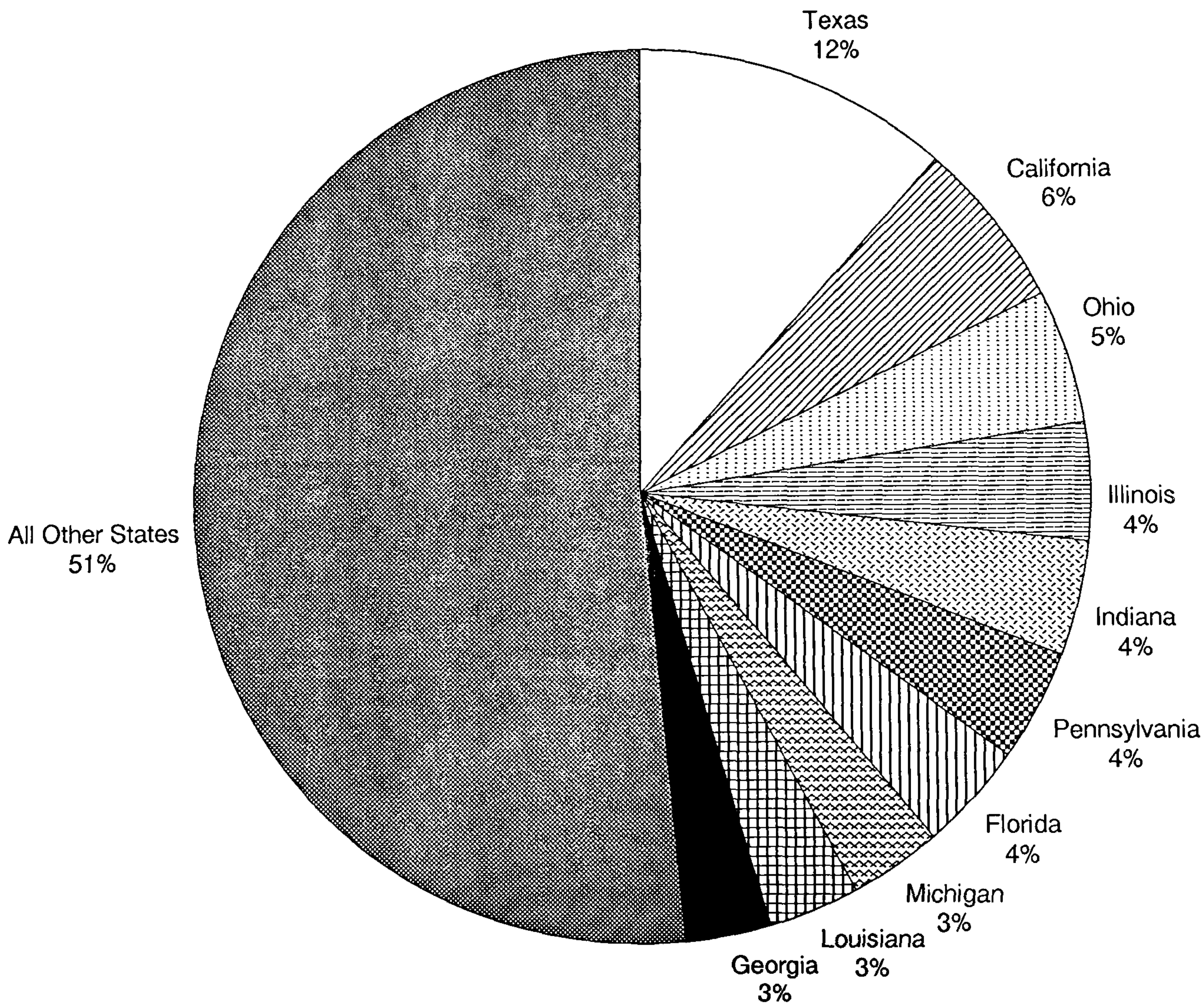


Figure 2-9. Top 10 States Ranked by VOLATILE ORGANIC COMPOUND Emissions in 1993

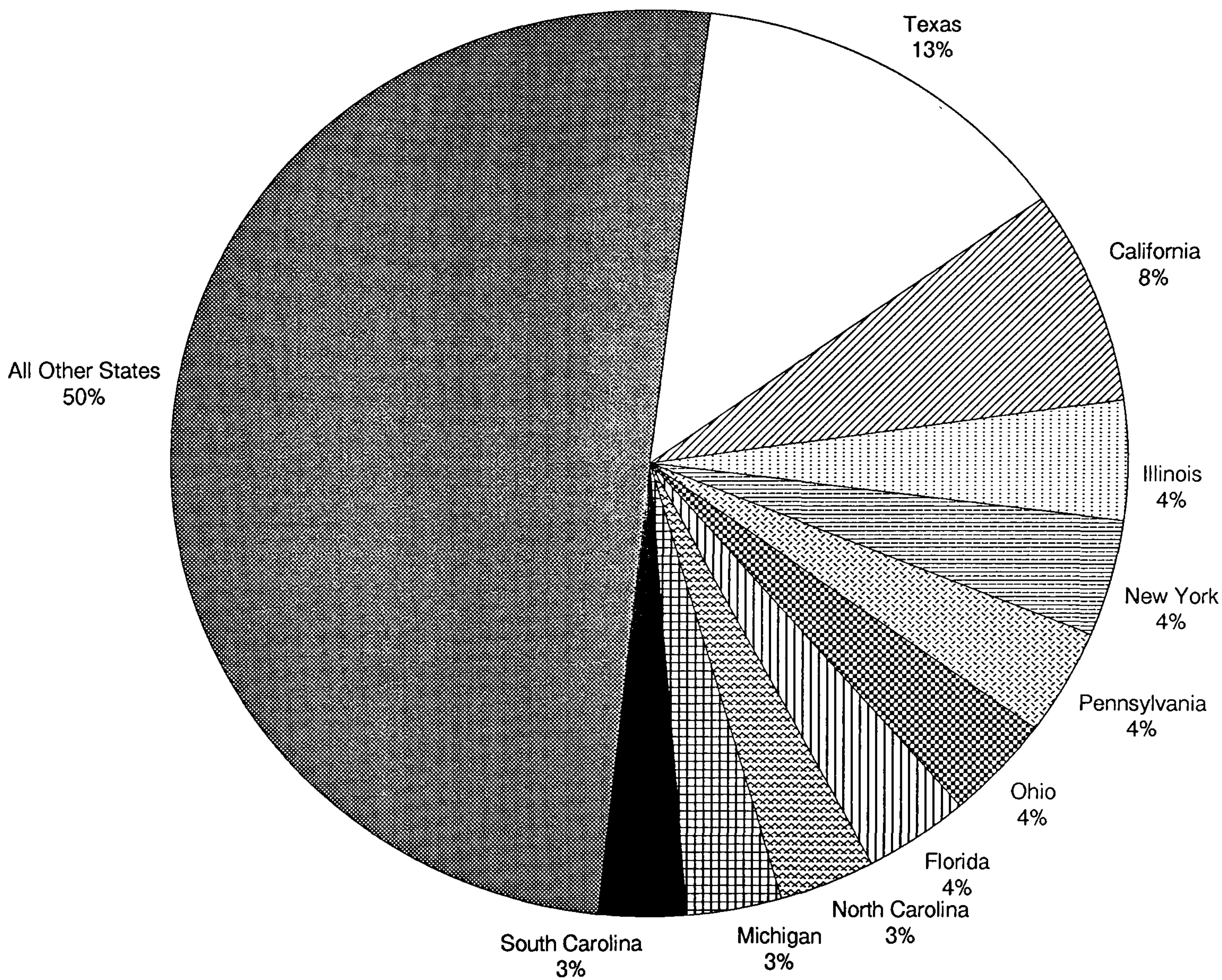


Figure 2-10. Top 10 States Ranked by SULFUR DIOXIDE Emissions in 1993

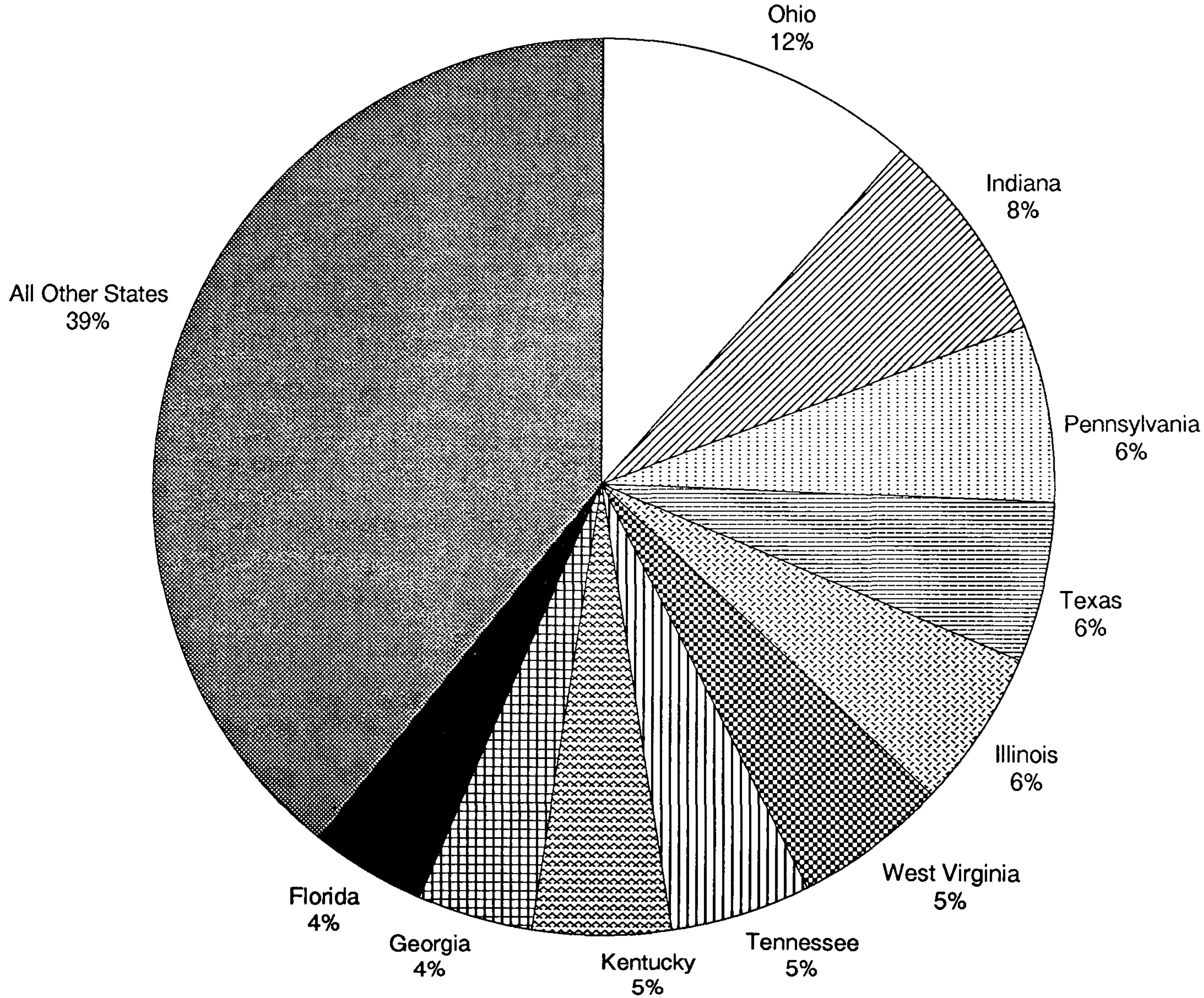
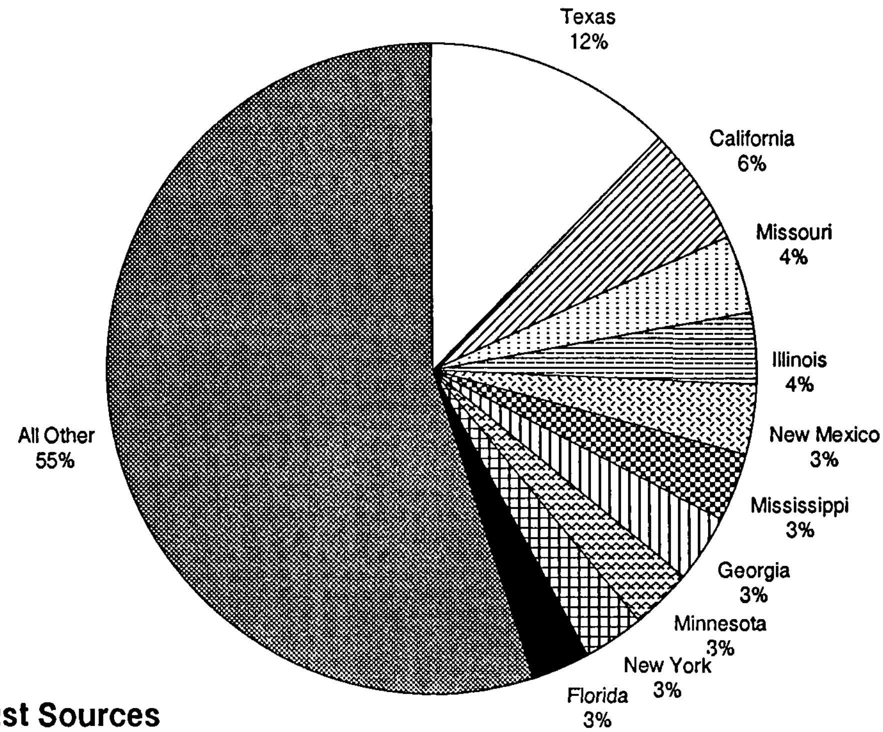
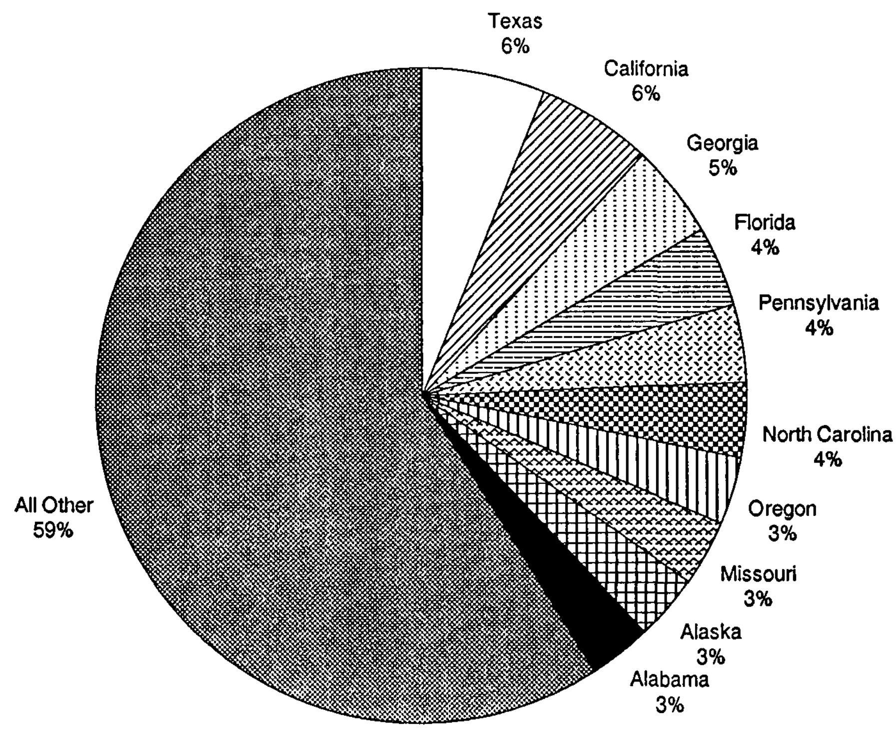


Figure 2-11. Top 10 States Ranked by PARTICULATE MATTER (PM-10) Emissions in 1993



Fugitive Dust Sources



Point and Fugitive Process Sources

Figure 2-12. Density Map of 1993 County-level CARBON MONOXIDE Emission Estimates

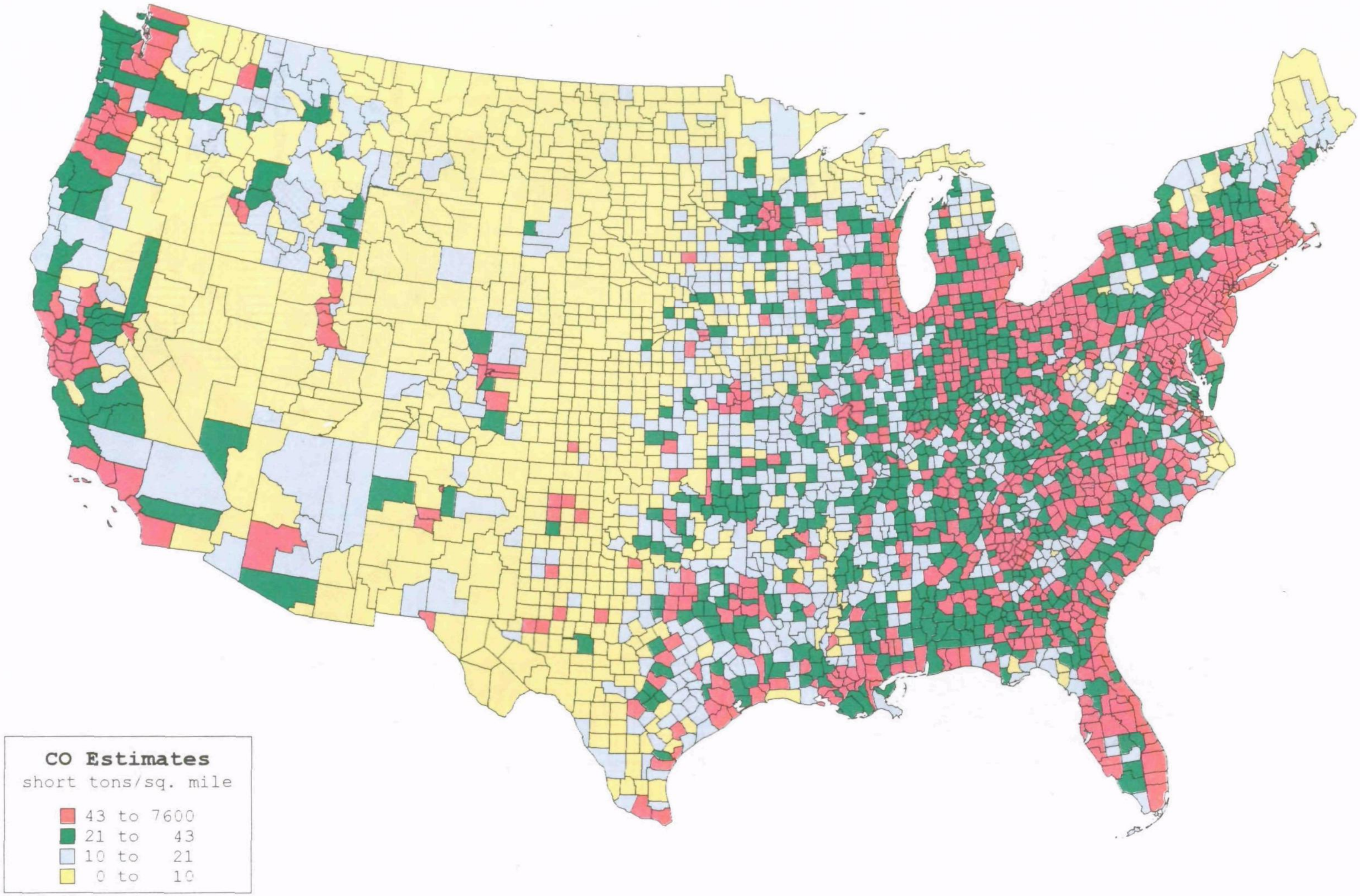


Figure 2-13. Density Map of 1993 County-level NITROGEN OXIDE Emission Estimates

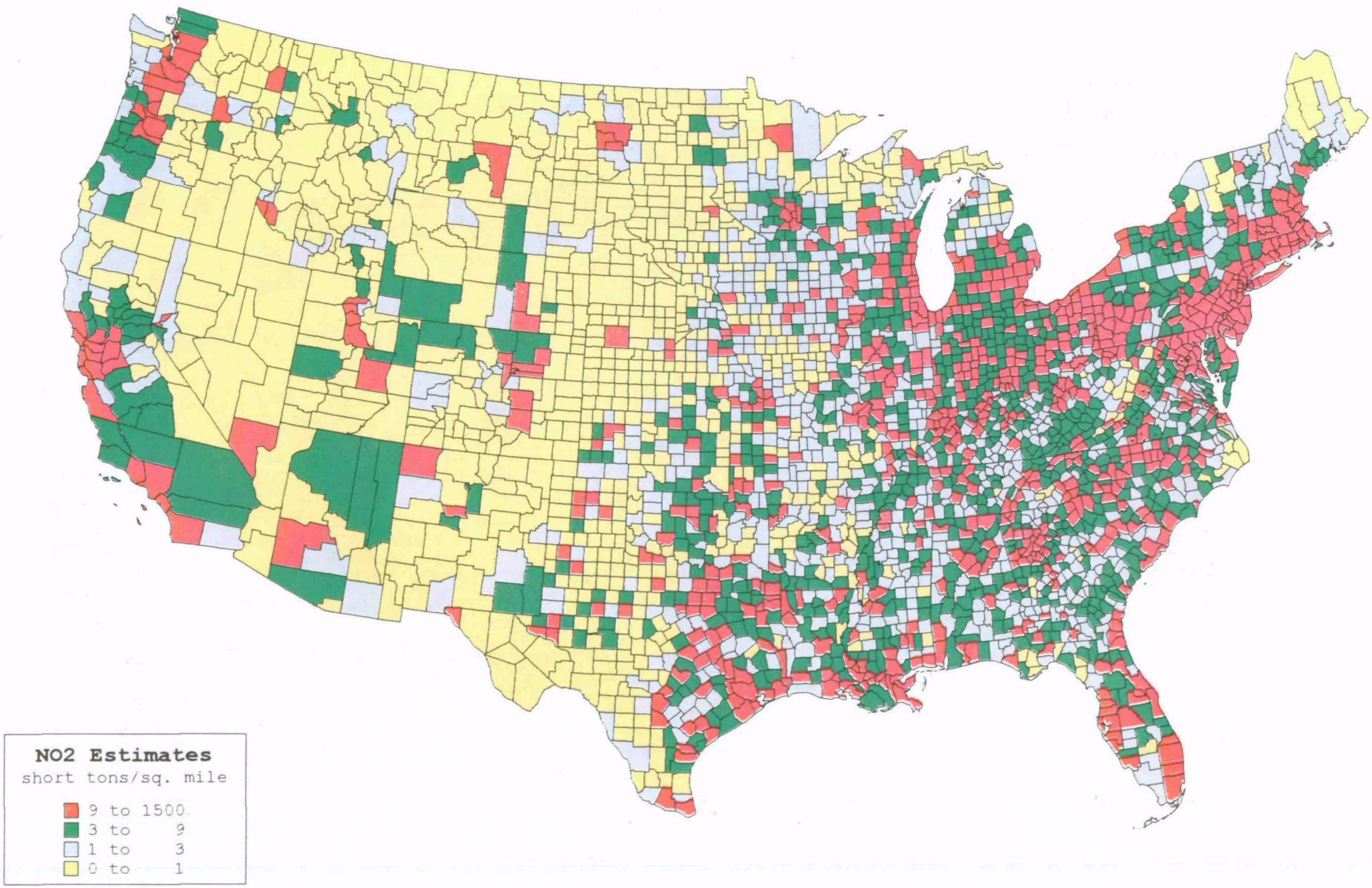


Figure 2-14. Density Map of 1993 County-level VOLATILE ORGANIC COMPOUND Emission Estimates

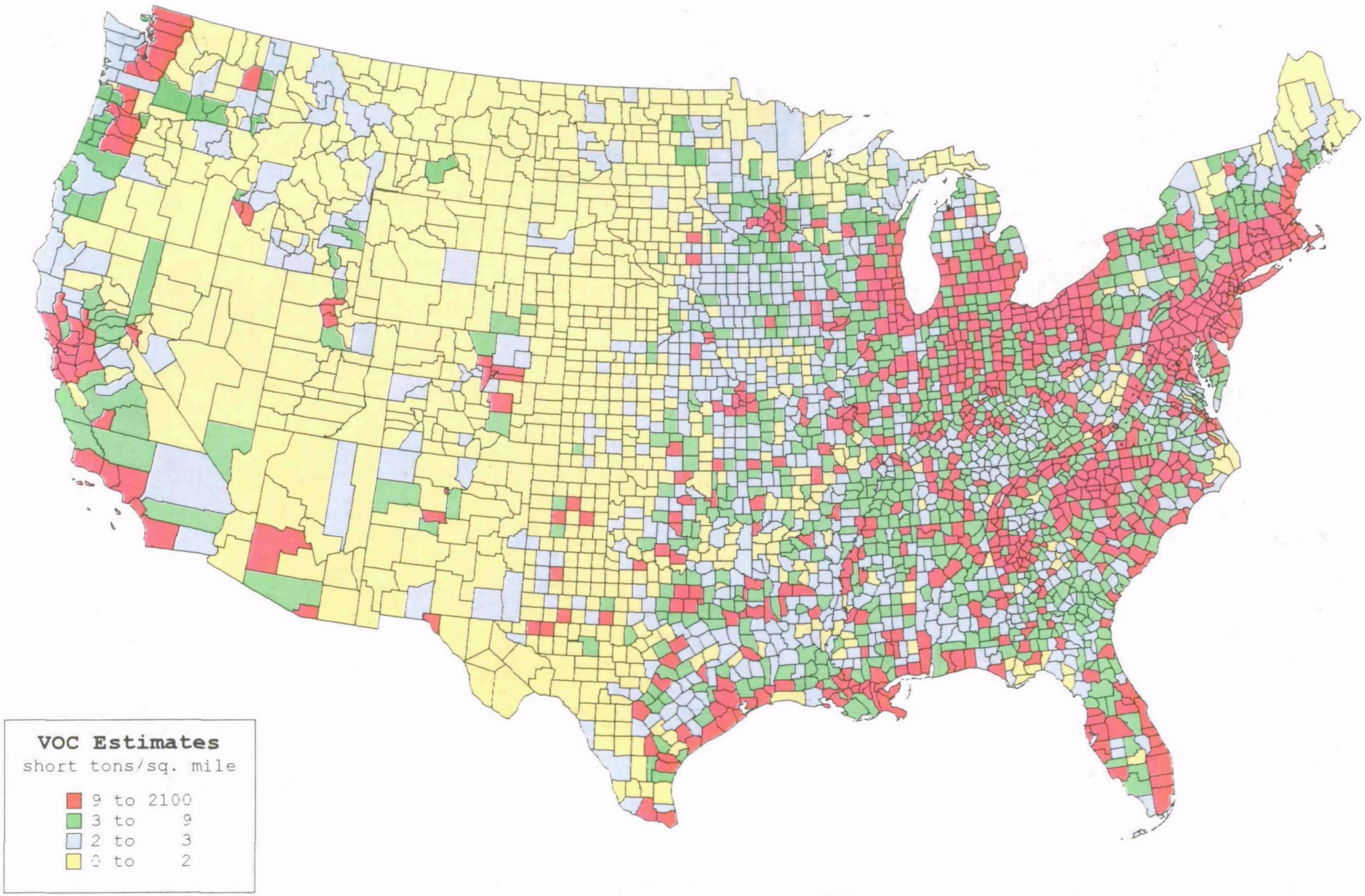


Figure 2-15. Density Map of 1993 County-level SULFUR DIOXIDE Emission Estimates

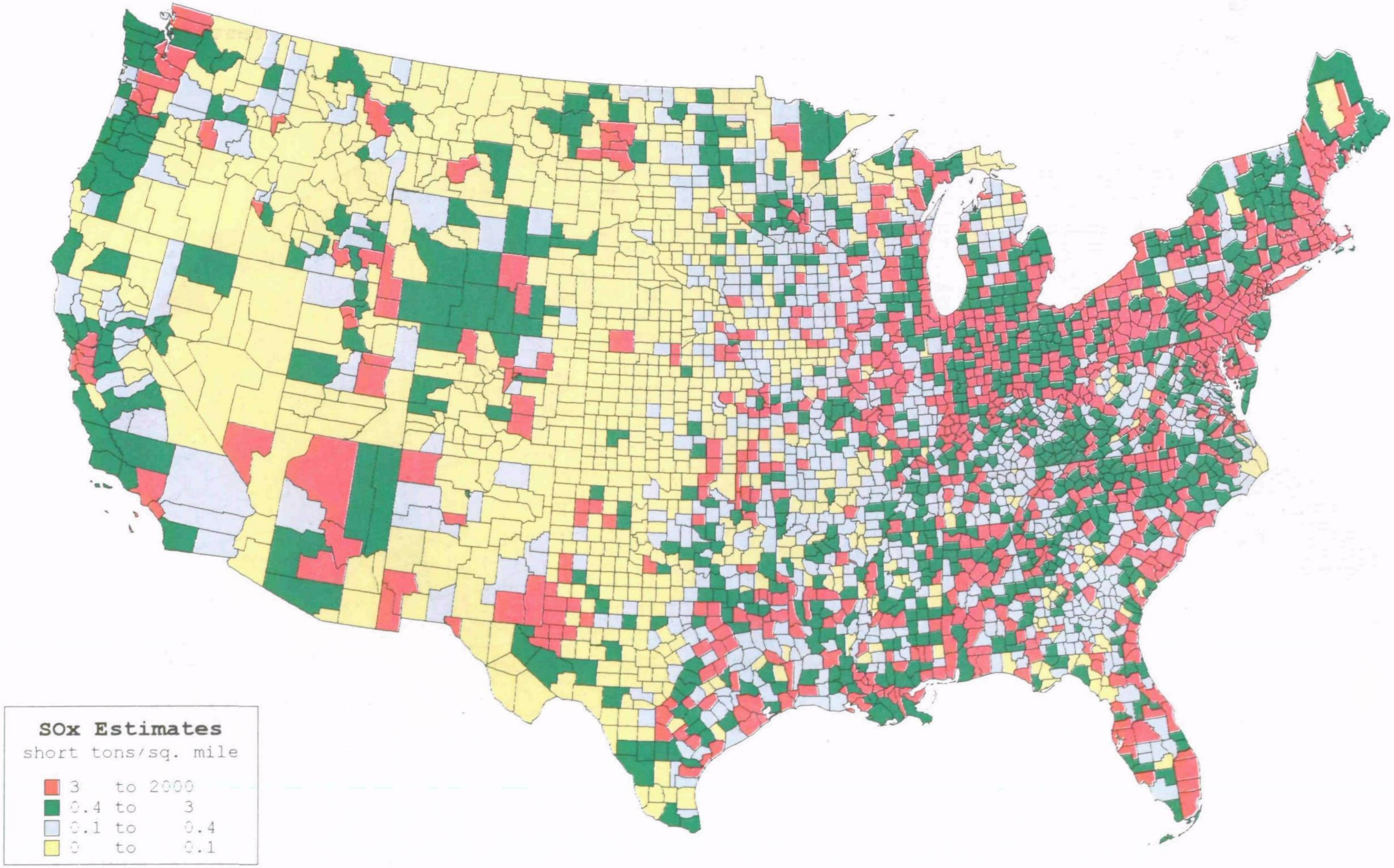


Figure 2-16. Density Map of 1993 County-level PARTICULATE MATTER Emission Estimates

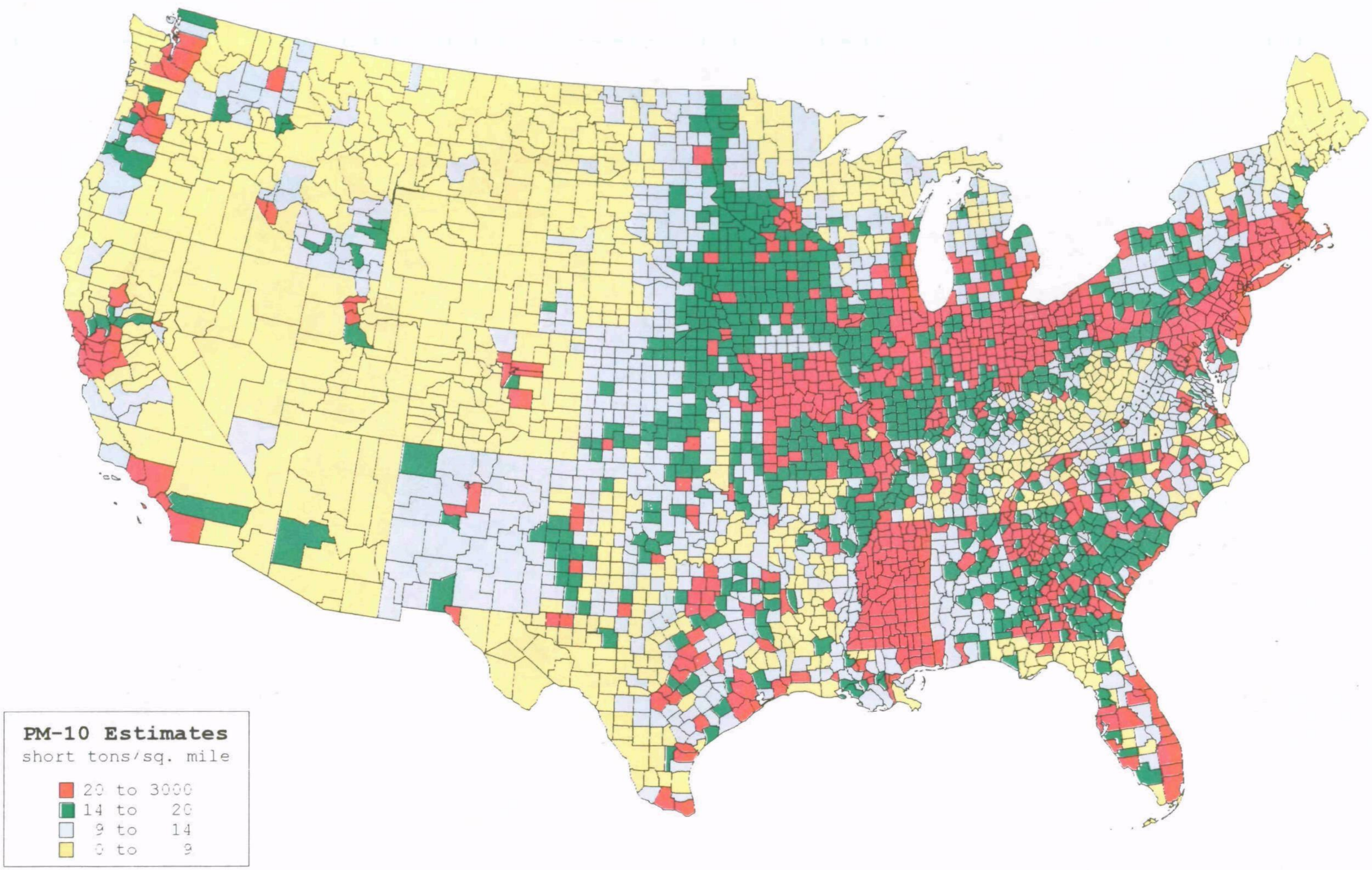


Figure 2-17. Relative Profiles of CARBON MONOXIDE, NITROGEN OXIDES, and VOLATILE ORGANIC COMPOUND Emissions in a Composite Ozone Nonattainment Area, by Principal Source Category - 1990

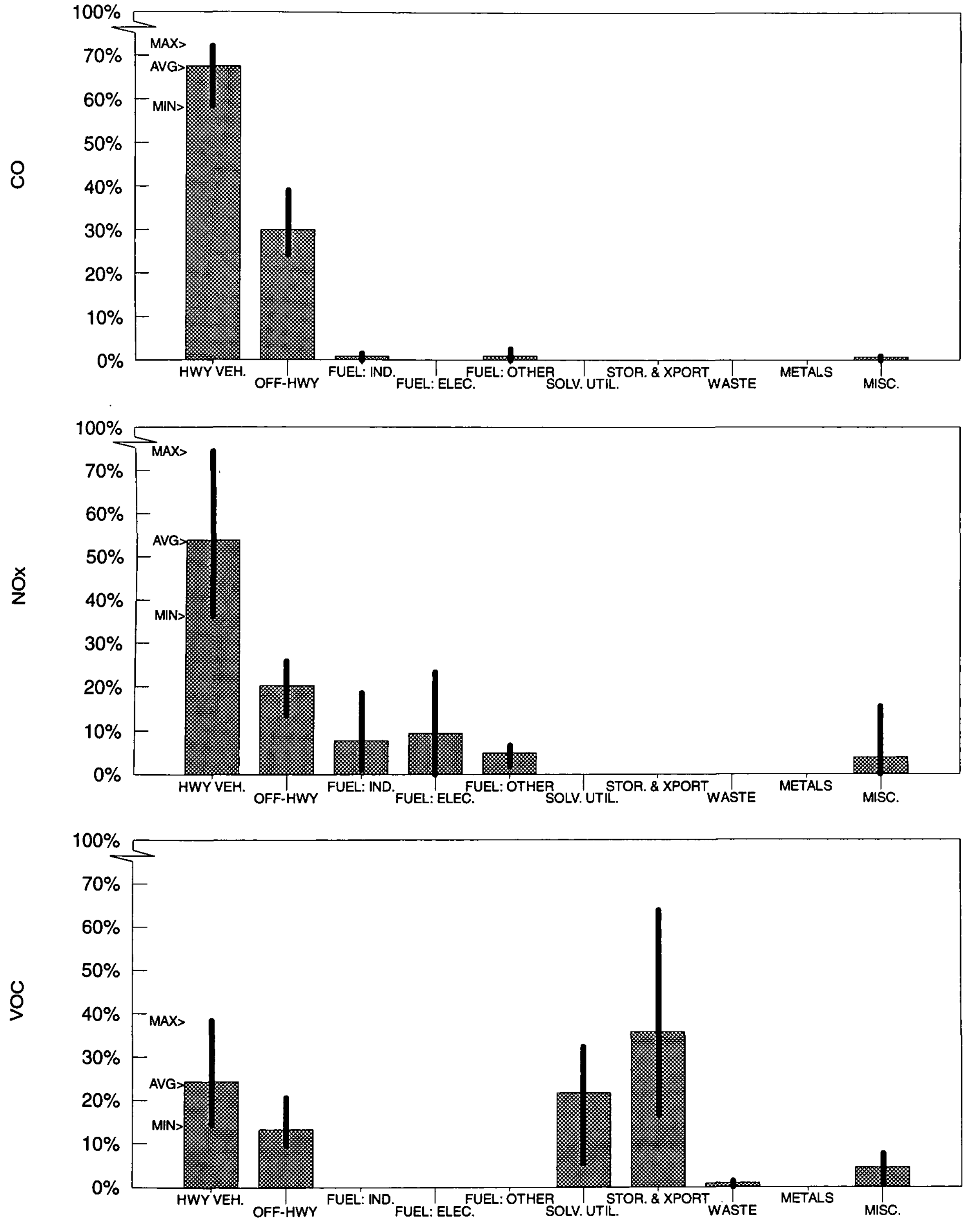


Figure 2-18. Principal CARBON MONOXIDE Emission Categories for a Composite Ozone Nonattainment Area - 1990

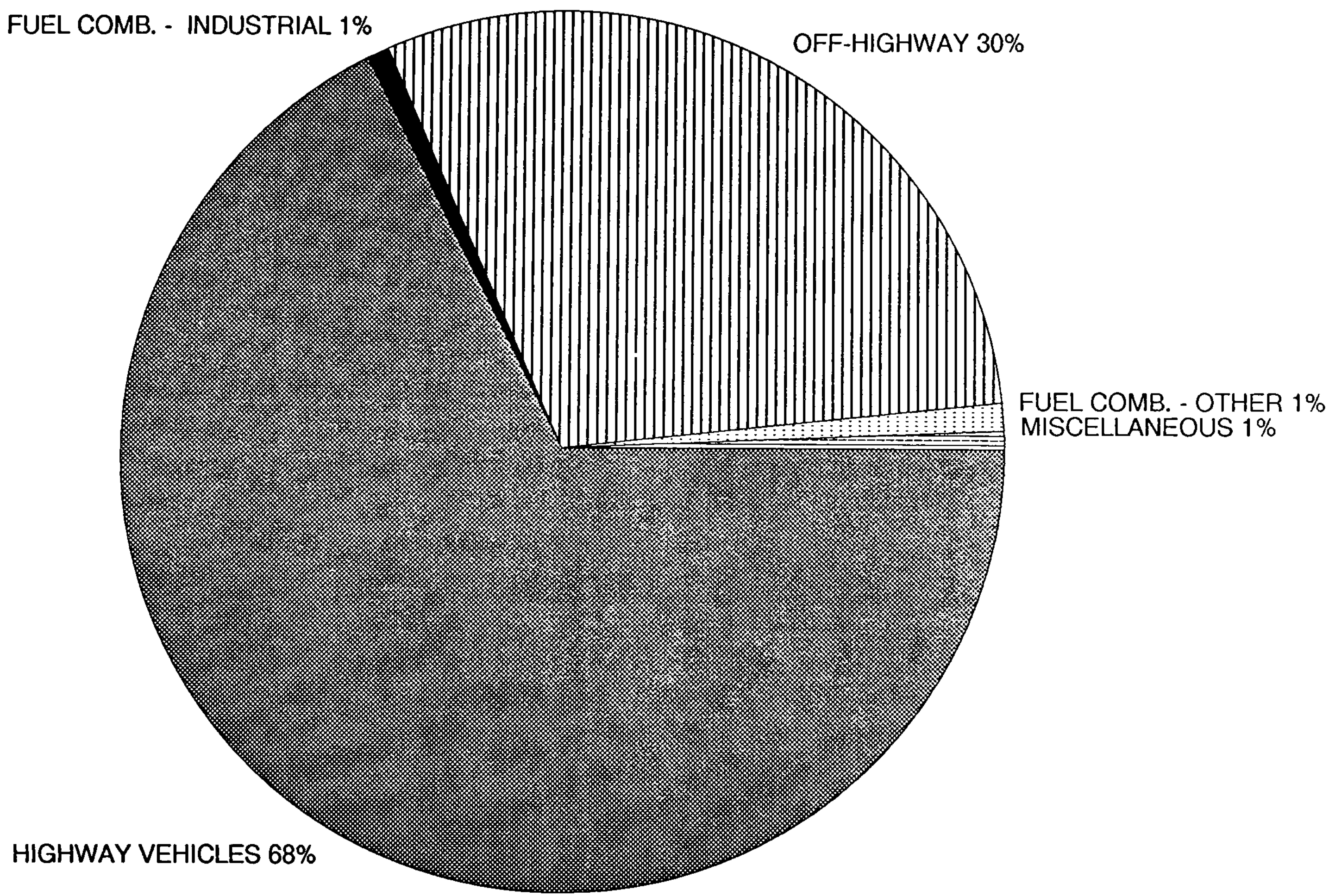


Figure 2-19. Principal NITROGEN OXIDES Emission Categories for a Composite Ozone Nonattainment Area - 1990

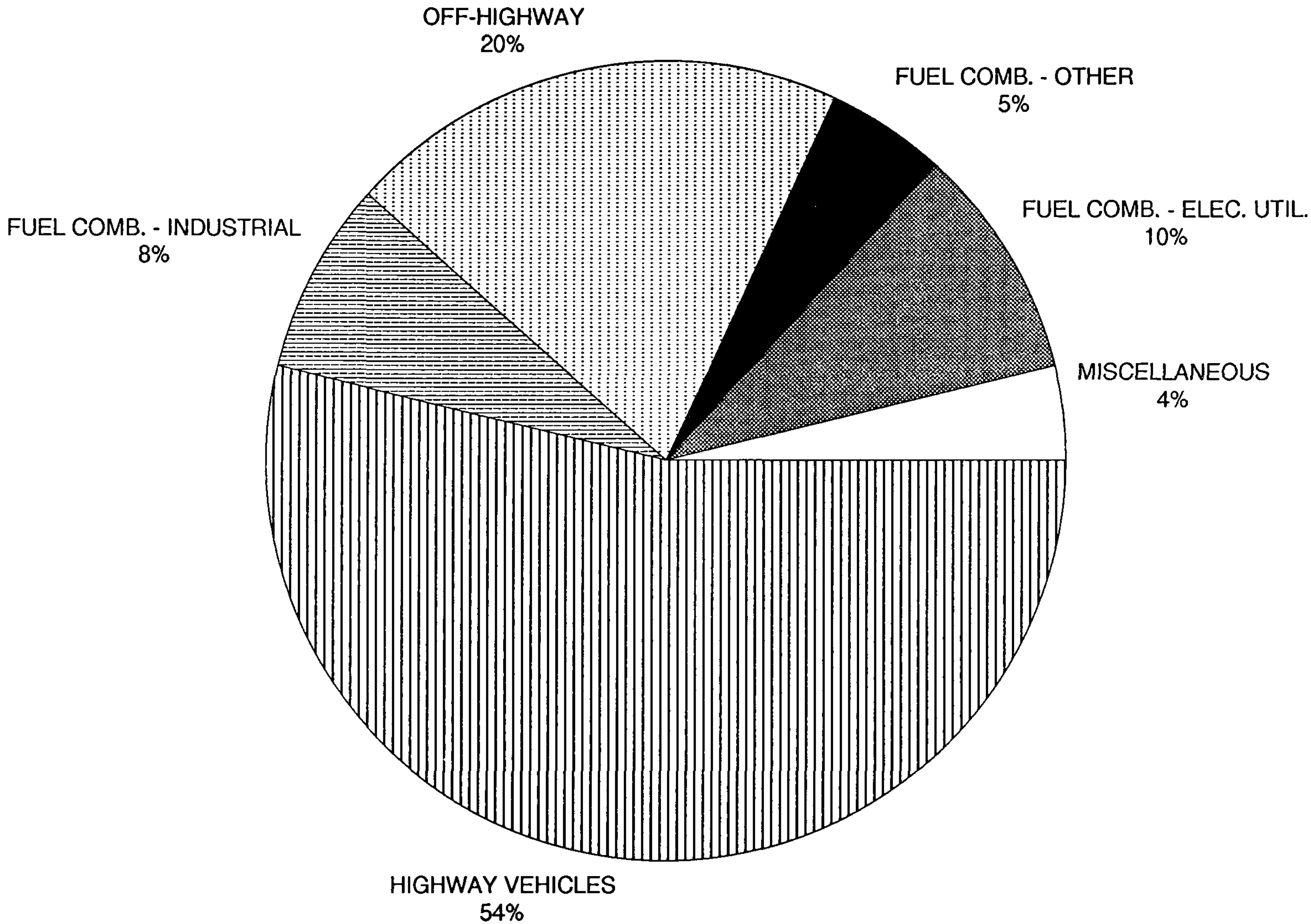


Figure 2-20. Principal VOLATILE ORGANIC COMPOUND Emission Categories for a Composite Ozone Nonattainment Area - 1990

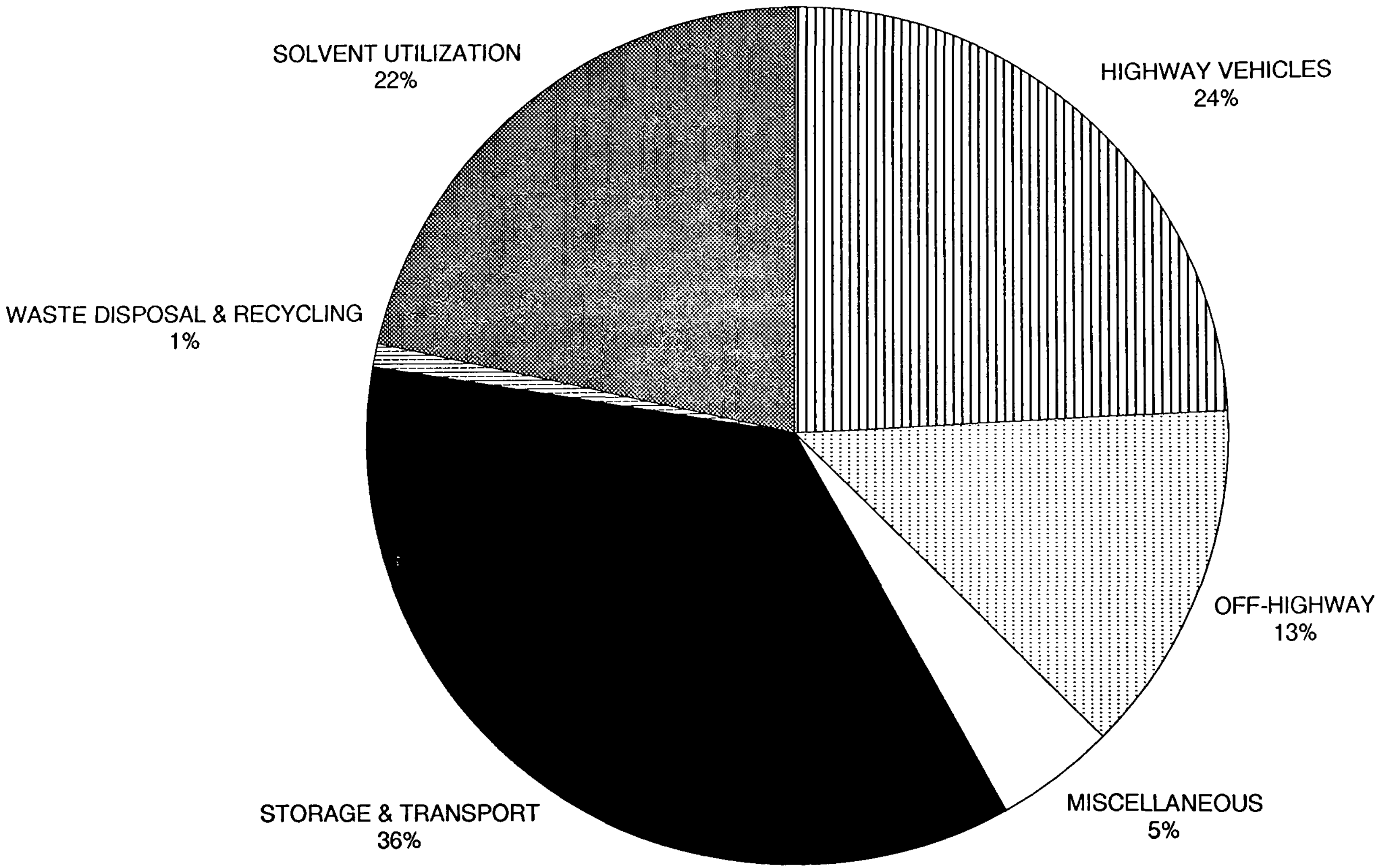


Figure 2-21. 1993 Seasonal CARBON MONOXIDE Emissions by Source Category

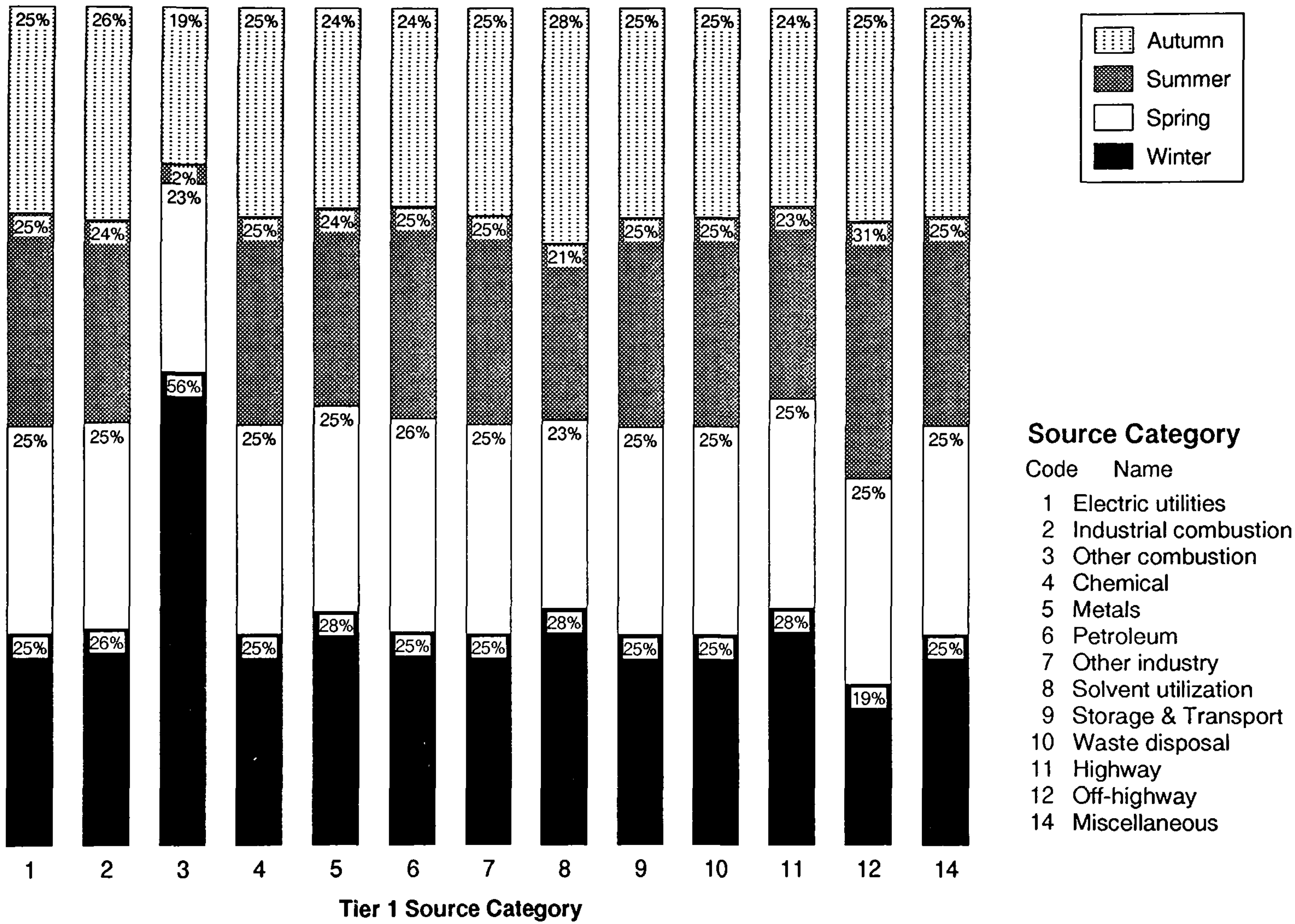


Figure 2-22. 1993 Seasonal NITROGEN OXIDES Emissions by Source Category

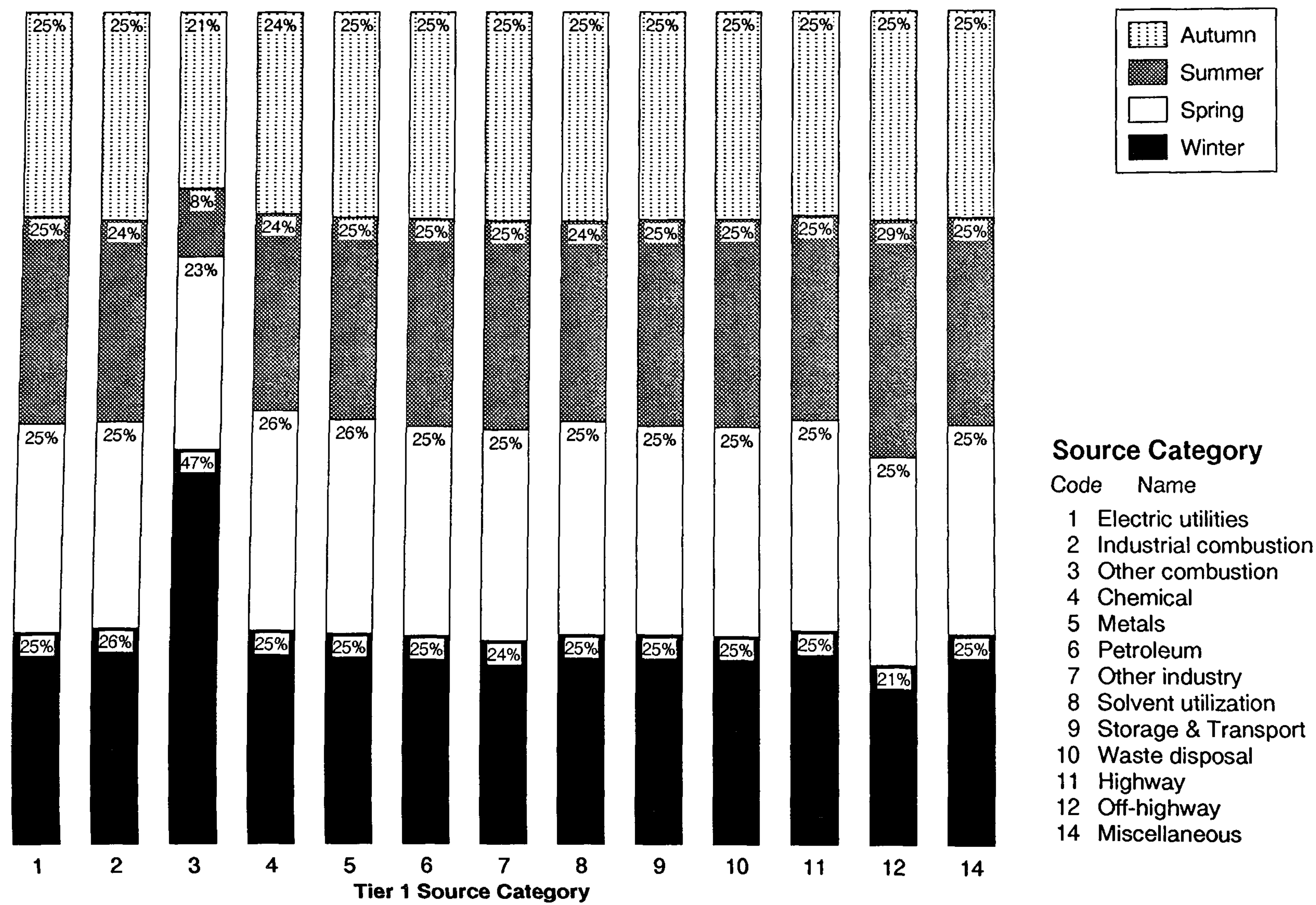


Figure 2-23. 1993 Seasonal VOLATILE ORGANIC COMPOUND Emissions by Source Category

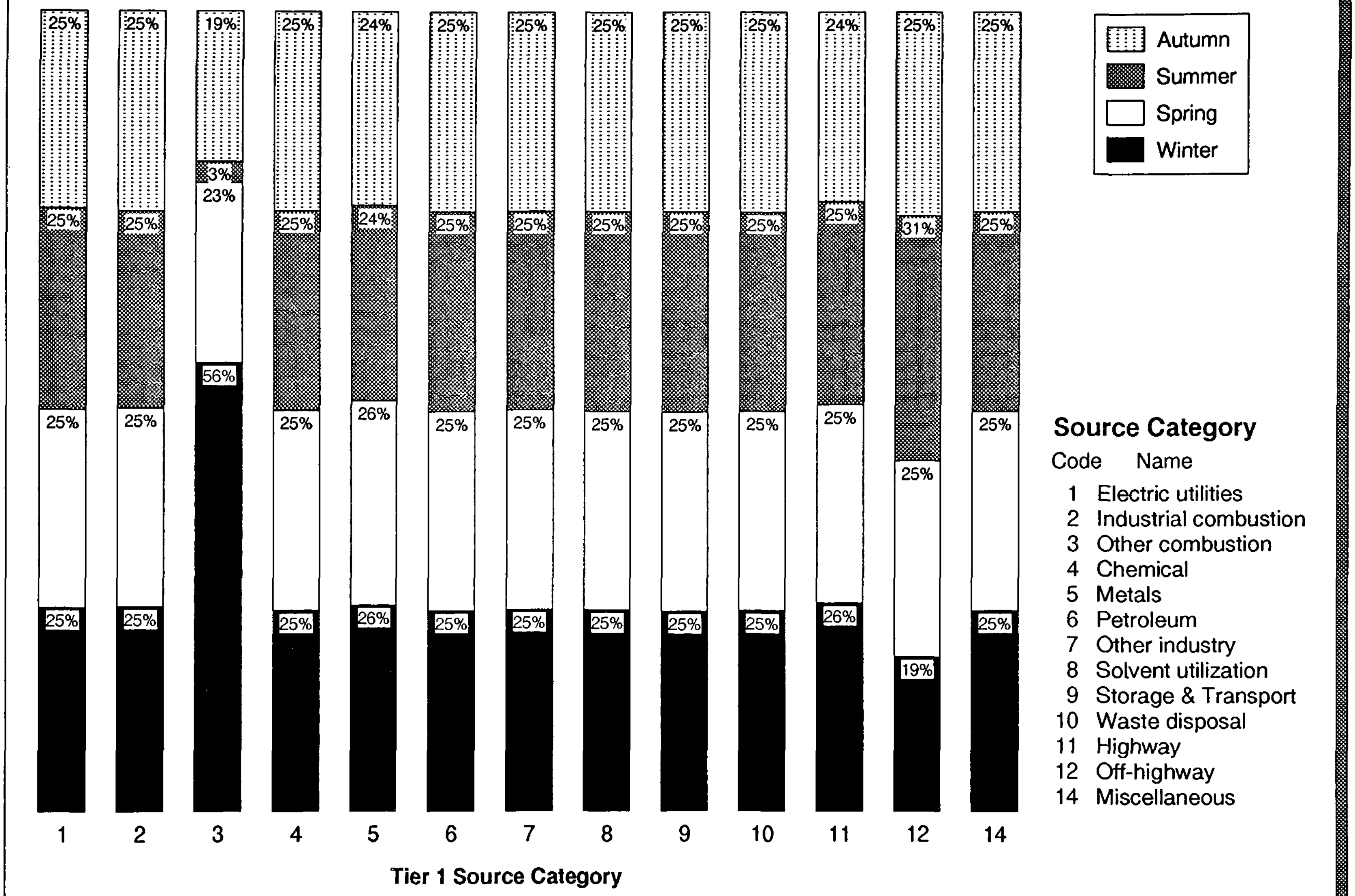


Figure 2-24. 1993 Seasonal SULFUR DIOXIDE Emissions by Source Category

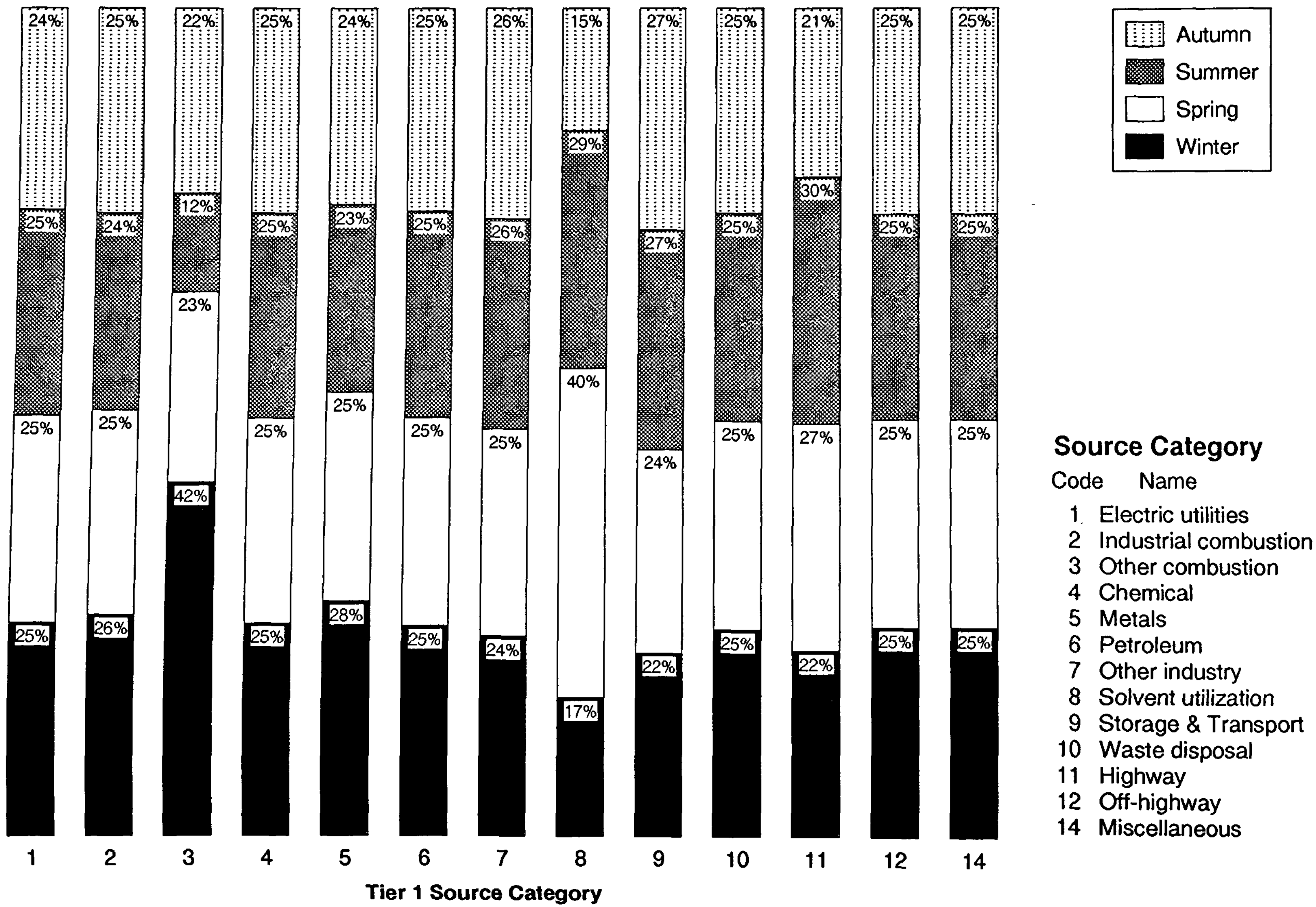
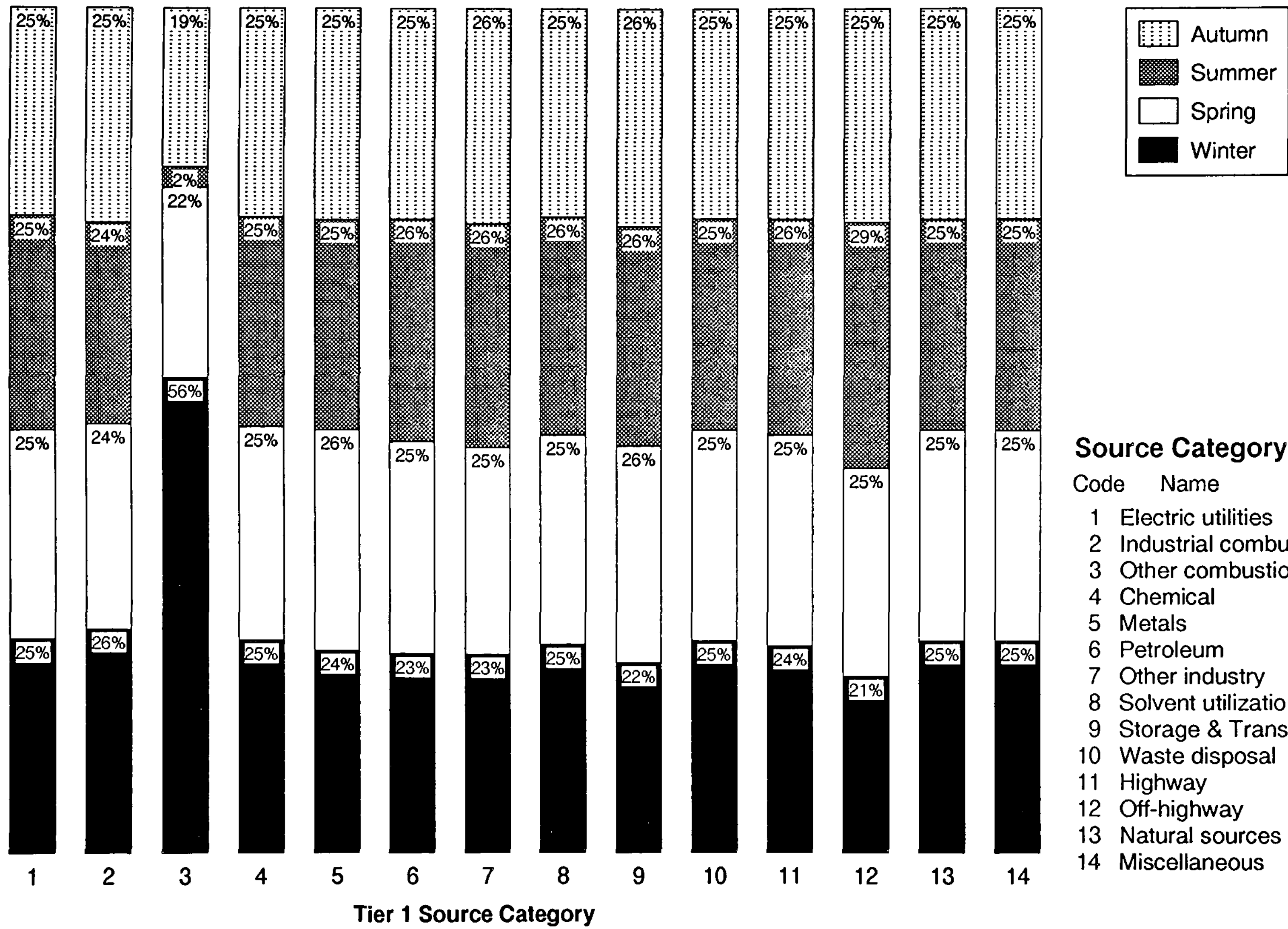


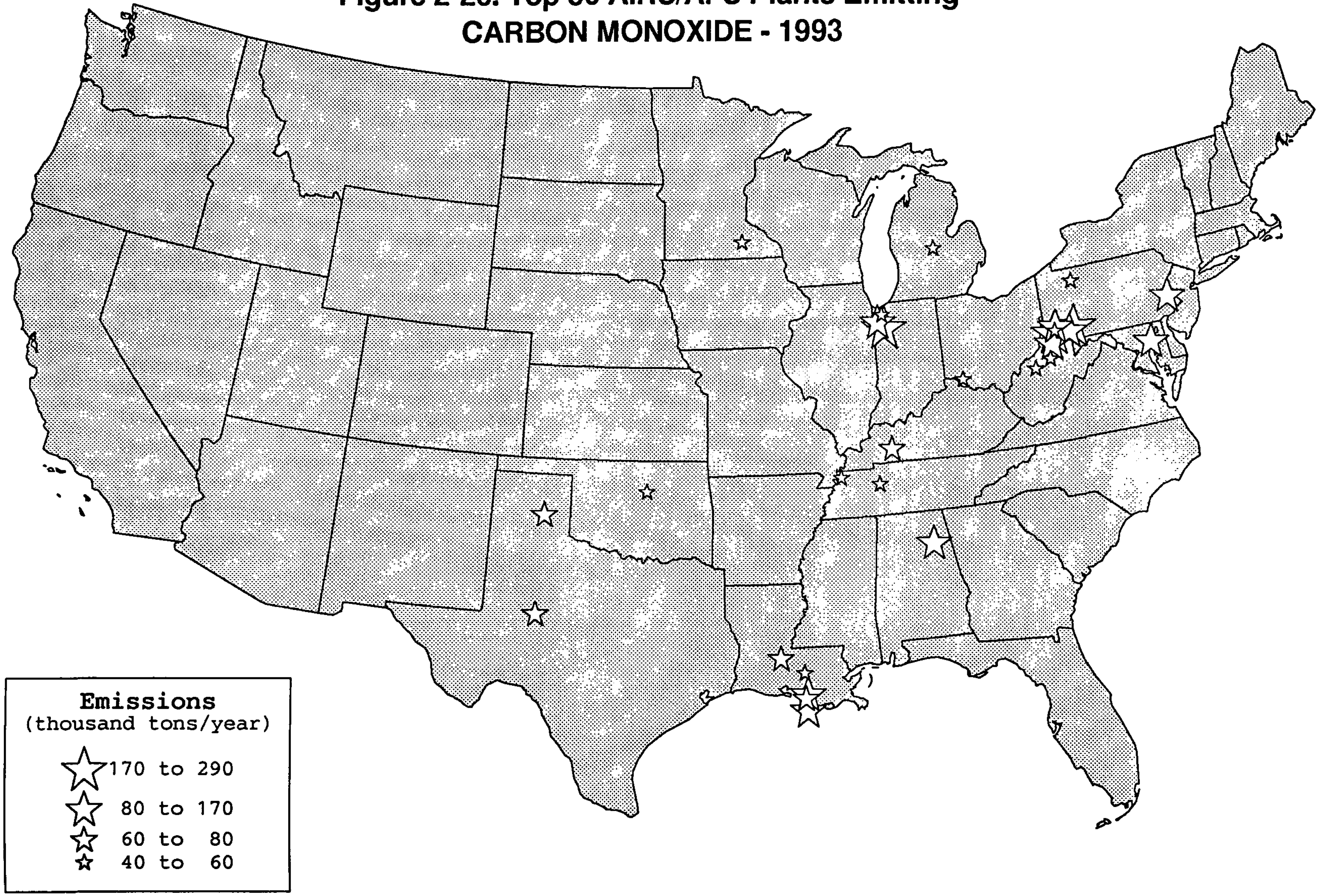
Figure 2-25. 1993 Seasonal PARTICULATE MATTER (PM-10) Emissions by Source Category



Source Category

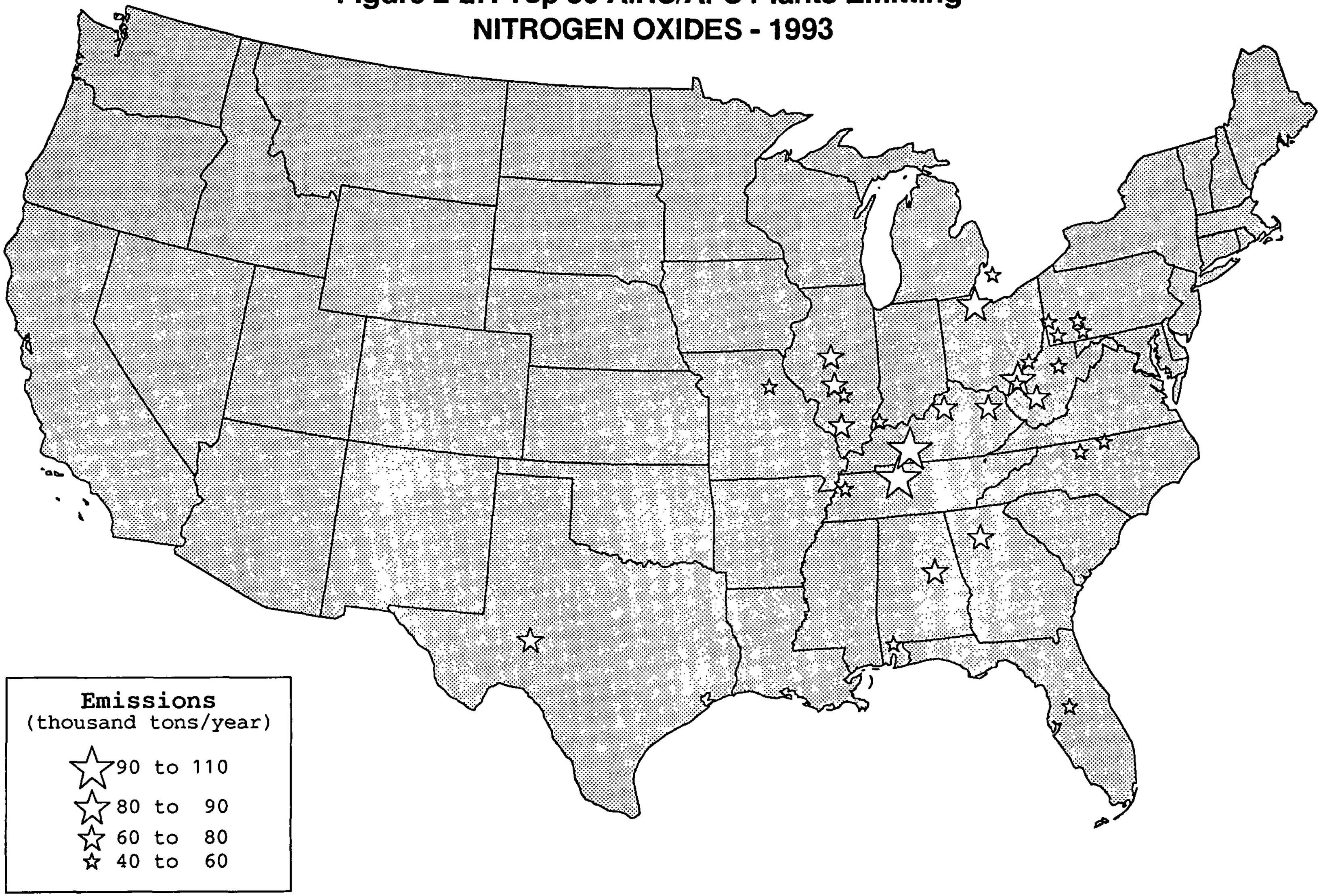
Code	Name
1	Electric utilities
2	Industrial combustion
3	Other combustion
4	Chemical
5	Metals
6	Petroleum
7	Other industry
8	Solvent utilization
9	Storage & Transport
10	Waste disposal
11	Highway
12	Off-highway
13	Natural sources
14	Miscellaneous

Figure 2-26. Top 30 AIRS/AFS Plants Emitting CARBON MONOXIDE - 1993



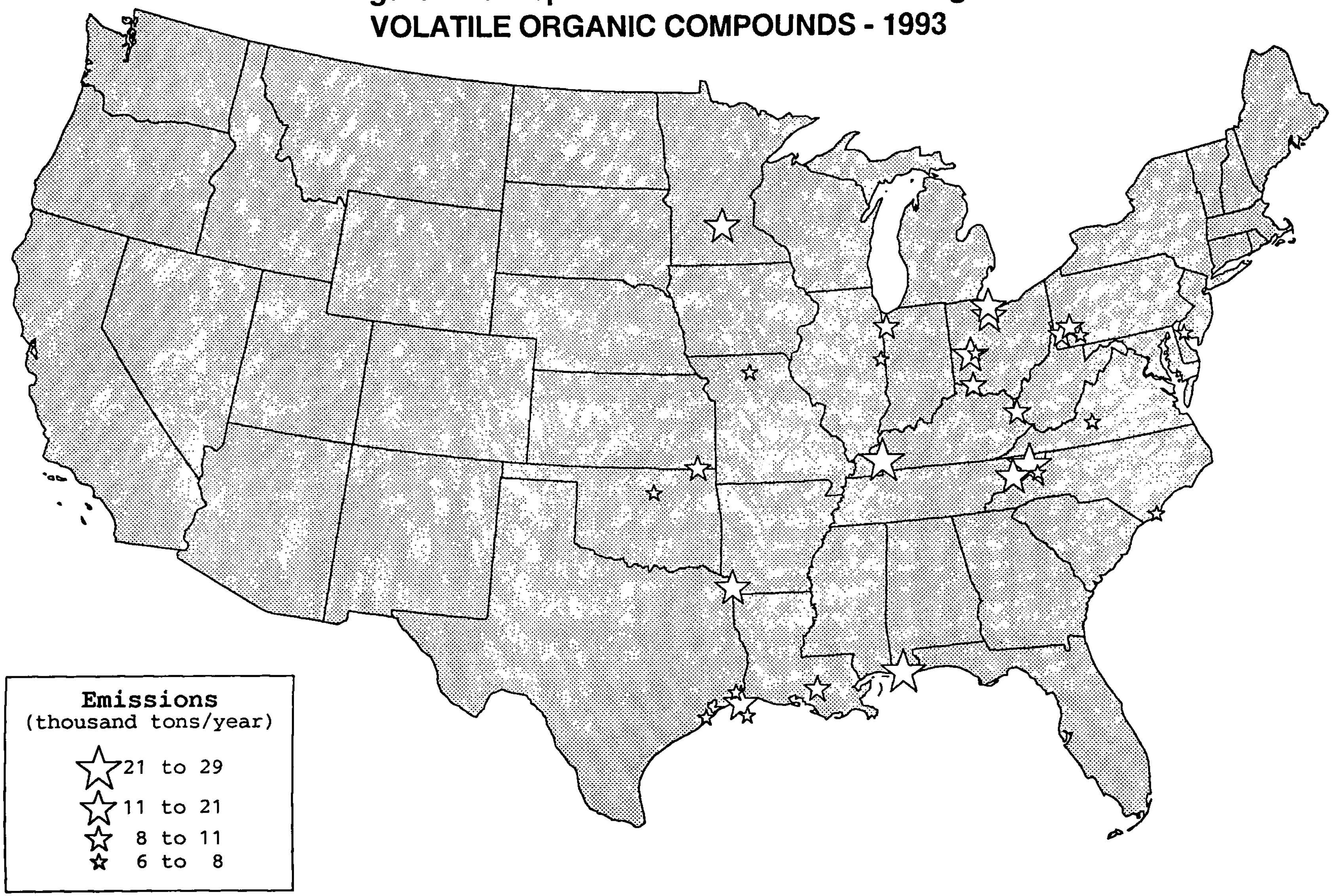
Note: These sources were extracted from AIRS/AFS on July, 8 1994

Figure 2-27. Top 30 AIRS/AFS Plants Emitting NITROGEN OXIDES - 1993



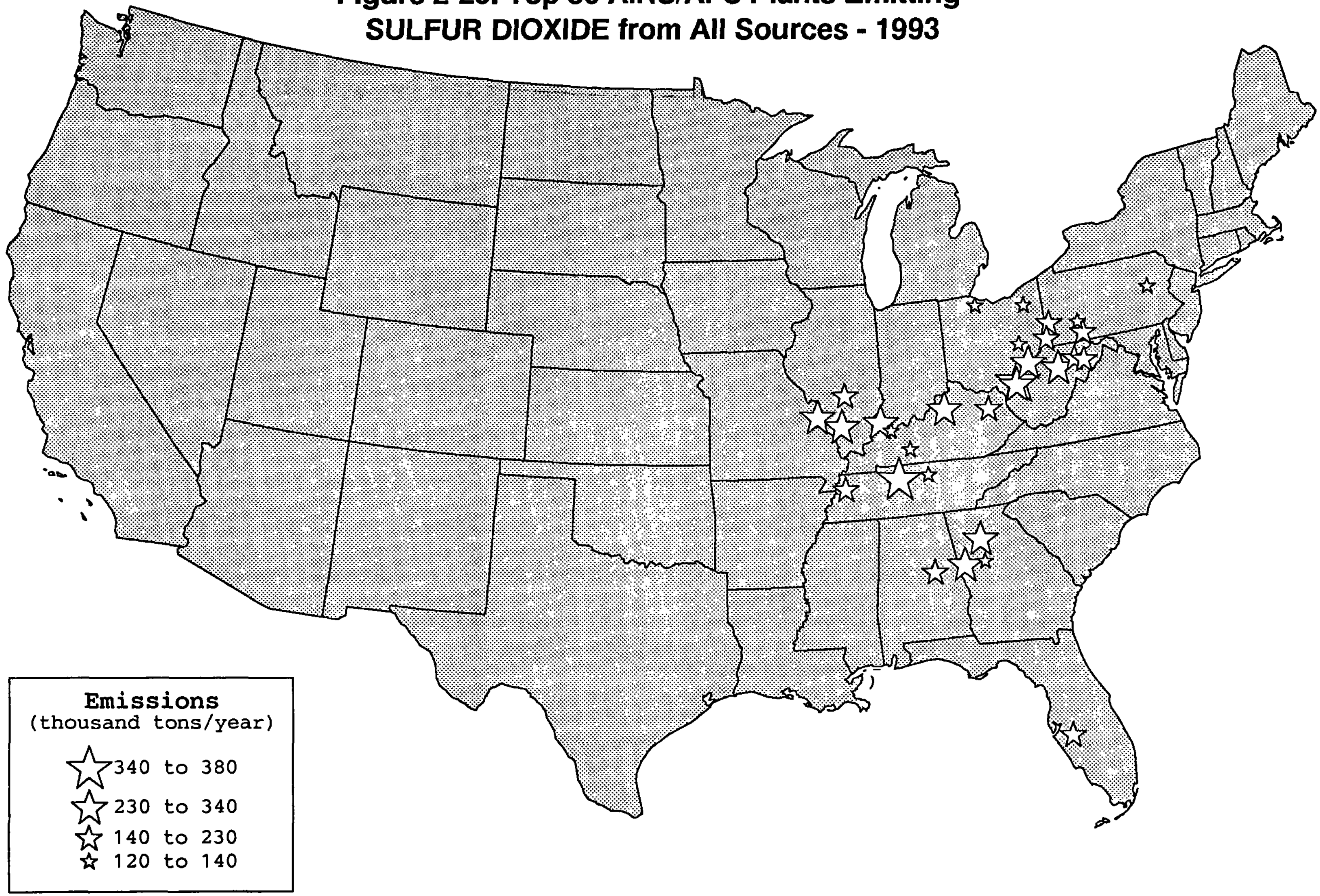
Note: These sources were extracted from AIRS/AFS on July, 8 1994

Figure 2-28. Top 30 AIRS/AFS Plants Emitting VOLATILE ORGANIC COMPOUNDS - 1993



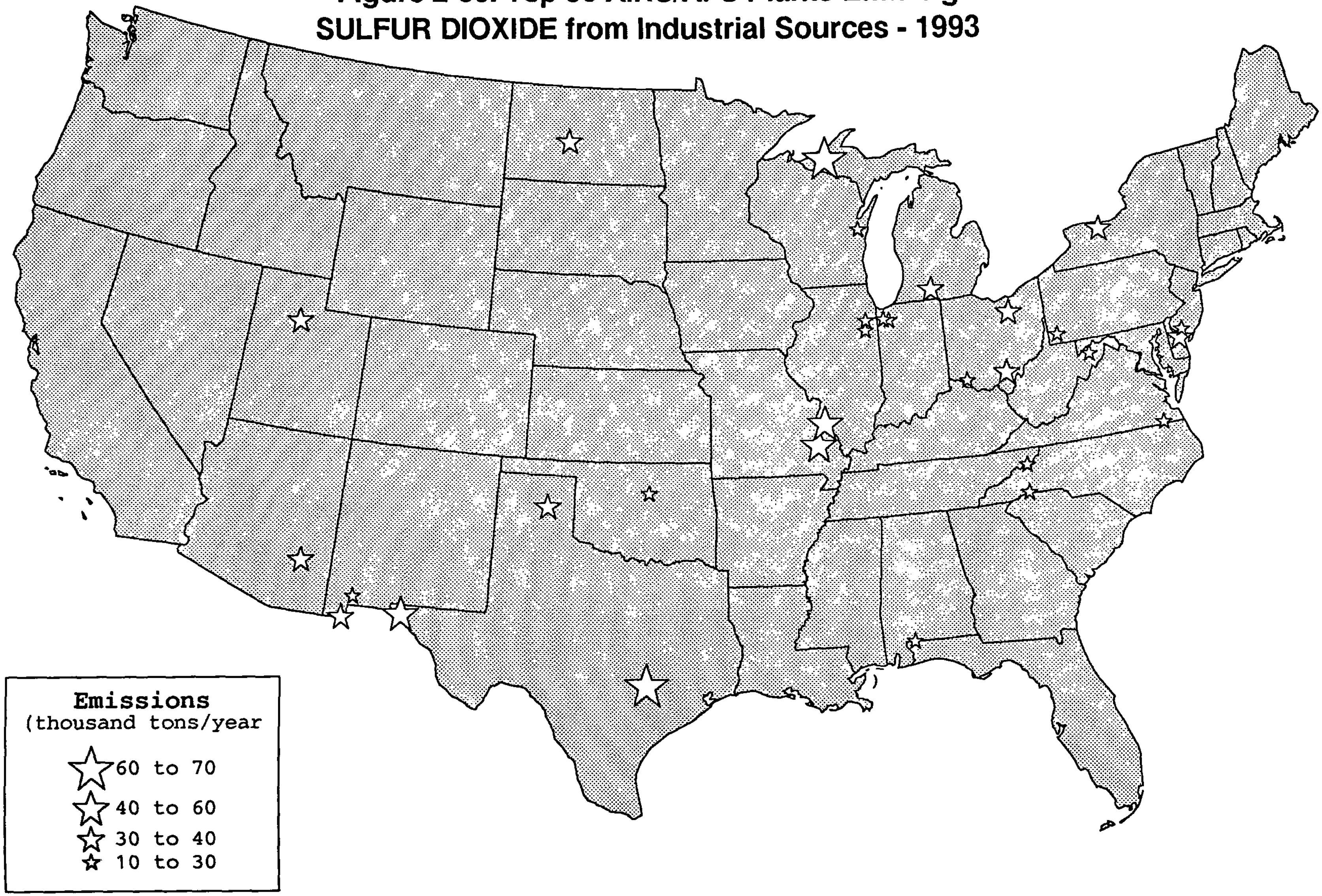
Note: These sources were extracted from AIRS/AFS on July, 8 1994

Figure 2-29. Top 30 AIRS/AFS Plants Emitting SULFUR DIOXIDE from All Sources - 1993



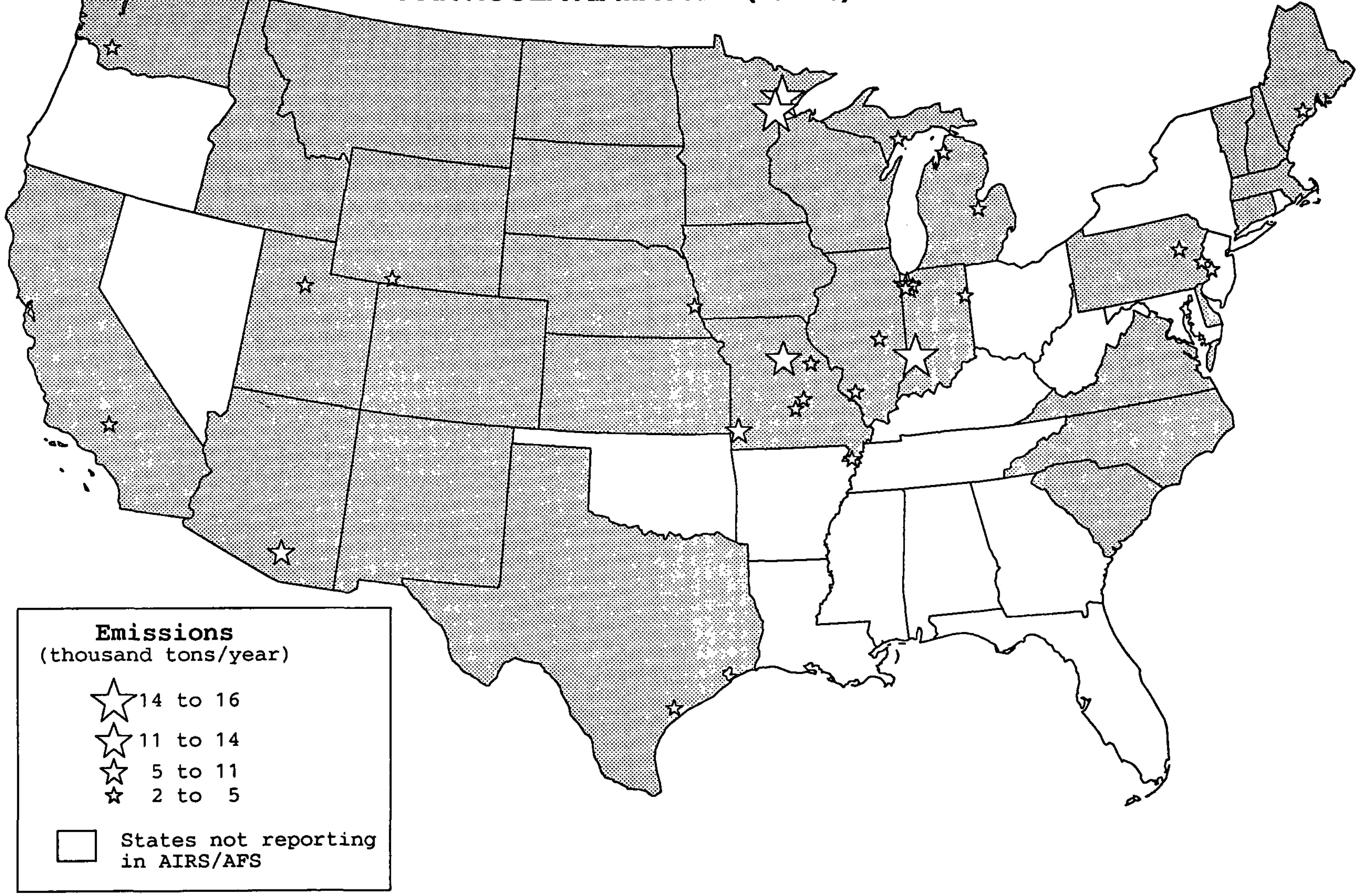
Note: These sources were extracted from AIRS/AFS on July, 8 1994

Figure 2-30. Top 30 AIRS/AFS Plants Emitting SULFUR DIOXIDE from Industrial Sources - 1993



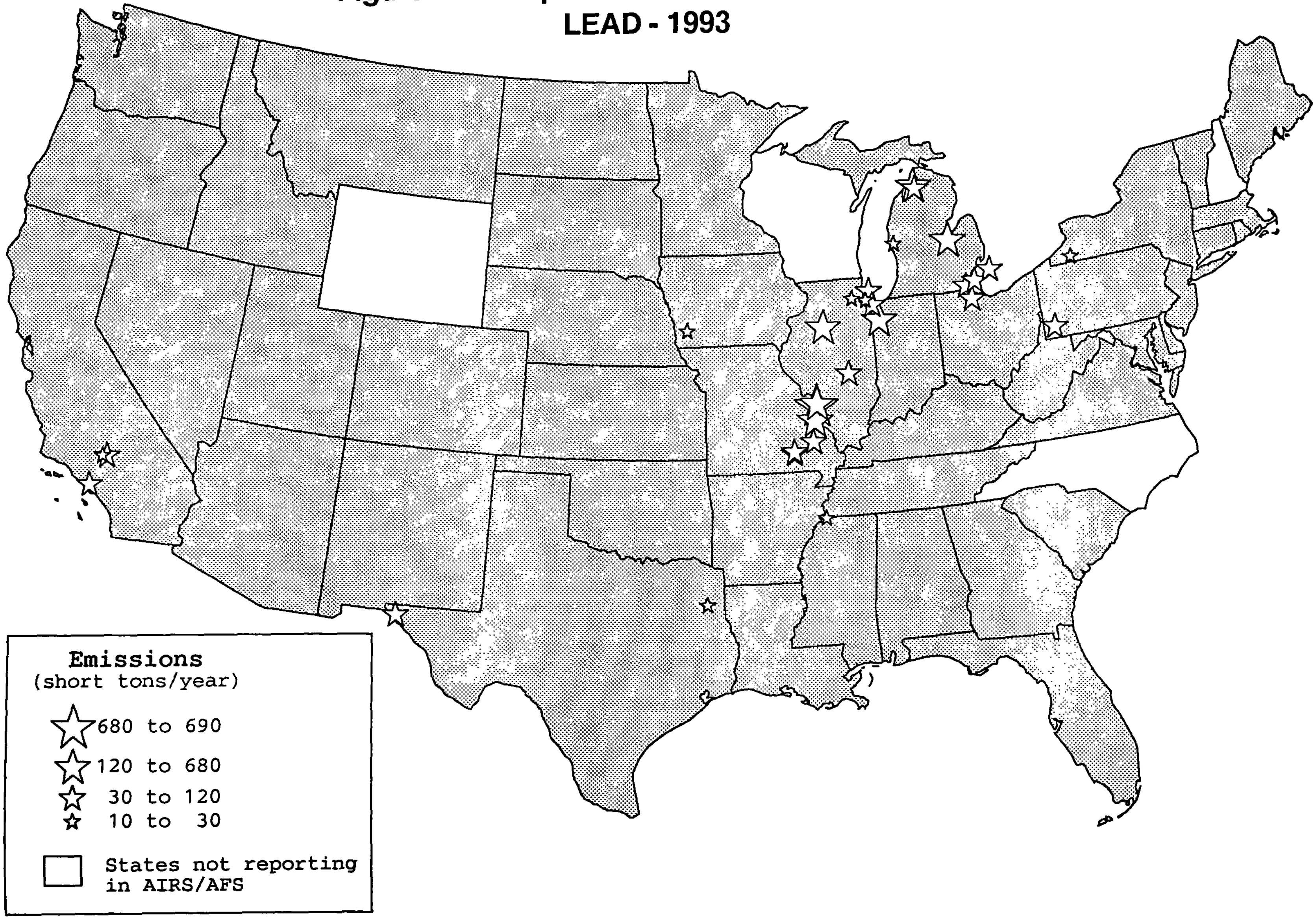
Note: These sources were extracted from AIRS/AFS on July, 8 1994

Figure 2-31. Top 30 AIRS/AFS Plants Emitting PARTICULATE MATTER (PM-10) - 1993



Note: These sources were extracted from AIRS/AFS on July, 8 1994

Figure 2-32. Top 30 AIRS/AFS Plants Emitting LEAD - 1993



Note: These sources were extracted from AIRS/AFS on July, 8 1994

SECTION 3.0

SUMMARY OF NATIONAL EMISSION TRENDS

This section presents the estimated national emission trends for the years 1900 through 1993. Emissions for CO, NO_x, PM-10, SO_2, and VOC for the years 1990 through 1993 are preliminary and will be replaced as ozone SIP inventory information becomes available. The 1993 emissions for Pb are preliminary and will be revised for the 1995 *Trends* report. The 1992 Pb emissions, reported as preliminary emissions in the previous report,[1] have been revised.

3.1 INTRODUCTION

The national emissions for the years 1940 through 1993 are presented in Tables 3-1 through 3-5 for each pollutant, except Pb. The emissions are given for every 10 years from the year 1940 to 1990 and for the years 1992 and 1993. The national Pb emissions are presented in Table 3-6 for every 5 years from the year 1970 to 1990 and for the years 1992 and 1993. Emissions prior to the year 1970 have not been developed for Pb. The emissions are provided by Tier 1 source categories as well as the Tier 2 and Tier 3 categories for which the emissions make a major contribution to the total. The Pb emissions are expressed in short tons per year and the emissions for all other pollutants are expressed in thousand short tons per year. Figures 3-1 through 3-5 present the emission trends for each pollutant, except Pb, for the years 1900 through 1993. The Pb emissions for the years 1940 through 1993 are presented in Figure 3-6. The emissions in these figures are grouped by major source categories.

Several different methodologies have been used to estimate the emissions presented in these tables and figures. In order to assess the trends in the emissions, it is important to know when these changes in methodology occur. The NO_x, SO_2, and VOC emissions for the years 1900 through 1969, with the exception of the years 1940, 1950, and 1960, have been estimated using the methodology described in section 6.4. The CO, NO_x, PM-10, SO_2, and VOC emissions for the years 1940, 1950, and 1960 and for the years 1970 through 1984 for all source categories, except the emissions for the transportation categories for the years 1970 through 1984, have been estimated by the methodology described in section 6.3. This methodology was also used to produce the Pb emissions for all source categories for the years 1940, 1950, 1960, and 1970 through 1993. The methodology described in section 6.2 was used to estimate the CO, NO_x, PM-10, SO_2, and VOC emissions for all source categories for the years 1985 through 1993 and for the transportation sources for the years 1970 through 1993. These changes in methodology are denoted in Tables 3-1 through 3-5 and may be a source of discontinuities in the emission trends presented in Figures 3-1 through 3-5.

3.2 NATIONAL EMISSION TRENDS, 1900 THROUGH 1993

From the year 1900 to 1993, total national NO_x emissions were estimated to have increased by a factor of 9. Over the same period, the emissions of SO_2 and VOC showed increases of 120 and 200 percent, respectively. From the year 1970 to 1993, emissions for Pb showed the greatest decrease (98 percent), followed by PM-10 (excluding fugitive dust [71 percent]), SO_2 (30 percent), CO (24 percent), and VOC (24 percent). Emissions of PM-10 and Pb showed their greatest decrease in the 1970s, while the emissions of the other pollutants showed their greatest decrease in the 1980s. Over the same period (1970 to 1993), NO_x emissions increased approximately 13 percent.

Changes in the emissions from 1992 to 1993 were caused primarily by (1) changes in fuels consumed by electric utilities, a major source of SO_2 emissions, (2) increased usage of highway vehicle emission controls, a major source of CO, NO_x, and VOC emissions, and (3) varied production levels in industrial activity. Based on the preliminary estimates for 1993, total PM-10 emissions decreased by 6 percent from 1992, while the emissions of all other pollutants increased.

The following sections discuss the most important factors influencing the emission trends of each pollutant. These analyses are divided by source category into three time periods: (1) the years 1900 to 1939, for which emissions are available only for NO_x, SO_2, and VOC, (2) the years 1940 to 1970, during which significant changes occur in technology, activity patterns, and fuel use, and (3) the years 1970 to 1993, when emissions controls are progressively applied.

Tables 3-1 to 3-5 present the CO, NO_x, VOC, SO_2, and PM-10 emissions for the Tier 1 source categories for every 10 years from 1940 to 1990 and for the years 1992 and 1993. The Pb emissions for every 5 years from 1970 to 1990 and for the years 1992 and 1993 are presented in Table 3-6. The emissions displayed for categories below are intended to show major contributors only. More detailed emissions for the years 1970, 1980, and 1984 through 1993 are presented in Tables A-1 through A-6, in Appendix A.

Figures 3-1 to 3-5 present the trends in CO, NO_x, VOC, SO_2, and PM-10 emissions by major source categories for the years 1900 through 1993. The Pb emissions are presented in Figure 3-6 for the years 1970 through 1993.

3.3 CARBON MONOXIDE EMISSION TRENDS, 1940 THROUGH 1993

The trend in CO emissions is presented in Table 3-1 and Figure 3-1. The "Remaining Categories" grouping includes the following Tier 1 categories:

FUEL COMBUSTION ELECTRIC UTILITY,
FUEL COMBUSTION INDUSTRIAL,
PETROLEUM AND RELATED INDUSTRIES,
OTHER INDUSTRIAL PROCESSES,
SOLVENT UTILIZATION, AND
STORAGE AND TRANSPORT.

The emissions for the miscellaneous category are primarily from forest fires.

3.3.1 Fuel Combustion: Electric Utility, Industrial, and Other

The CO emissions from fuel combustion sources occurred mainly in the residential sector. In 1940, residential wood combustion contributed 12 percent to the total CO national emissions. By 1970, this percentage decreased to only 2 percent of the total national emissions. Residential consumption of wood steadily declined until the late 1970s because fossil-fuels were abundant, cheap, and more convenient than fuel wood. The emissions doubled from the year 1970 to 1980 due to a disruption in crude oil supplies and the curtailment of natural gas deliveries, as well as rising crude oil and natural gas prices in the 1970s, which revived interest in wood as a fuel for residential space heating. The reduction in the estimated emissions from residential wood combustion by 30 percent from the year 1980 to 1993 was the result of a decline in conventional fuel prices after the mid-1980s. In 1993, residential wood combustion accounted for 4 percent of total national CO emissions.

The emissions from the combustion of fuels other than wood by the residential sector have also undergone substantial changes since 1940. The 82 percent reduction in the emissions from the year 1940 to 1970 resulted from a steady decline in the use of anthracite and bituminous coal for home heating. In 1993, emissions from the residential combustion of other fuels accounted for less than 1 percent of the total national CO emissions.

3.3.2 Industrial Processes

In 1940, industrial processes accounted for 8 percent of the total CO national emissions. Emissions for the chemical and allied product manufacturing category decreased 19 percent from 1940 to 1970. During the same period, the emissions for metals processing increased by 33 percent and those for petroleum and related industries increased by a factor of 10. The increase in the petroleum refining sector was a result of increased refinery throughput required to meet increased demand for gasoline and other distillate products. From 1970 to 1993, emissions decreased by 82 percent as a result of the obsolescence of certain high-polluting processes such as the manufacture of carbon black by the channel process and as a result of installing more emission control devices for processes such as fractional catalytic cracking units.

3.3.3 Transportation: Highway Vehicles and Off-highway

In 1940, highway vehicles contributed 30 percent of the total national CO emissions. From 1940 to 1970, emissions from all types of highway vehicles tripled. By 1970, highway vehicles accounted for 69 percent of the total national CO emissions.

Since 1940, highway vehicles have been the largest single contributing source of CO emissions. From 1970 to 1980, total VMT increased 36 percent, while the total CO emissions for highway vehicles decreased by 11 percent. This was due to the implementation of the Federal Motor Vehicle Control Program (FMVCP) on new vehicles and improvements in vehicle fuel efficiency. Figure 3-7 shows the relative trends in VMT, fuel usage, and CO emissions for the years 1970 through 1992. From 1980 to 1992, the VMT increased faster than the fuel usage as a result of increasing average fuel efficiency. The estimated CO emissions decreased 23 percent during this period due to the retirement of older, uncontrolled vehicles (i.e., fleet turnover). In the years since 1989, the trends in CO emissions and fuel usage became closely parallel, which implies that the retirement of uncontrolled vehicles has reached the limit of its effect on reduction in CO emissions. Improvements in fuel efficiency would still produce reductions in CO emissions. In 1993, highway vehicles produced 62 percent of the total national CO emissions. Without the implementation of vehicle emission controls, it is predicted that the CO emissions from highway vehicles would be three times higher in 1993 than the current estimated emissions.

In 1940, CO emissions for the off-highway category represented 9 percent of the national total. Of this amount, 51 percent was estimated to be the emissions from coal-fueled railroad locomotives. From 1940 to 1970, the emissions from railroads decreased 98 percent. The total off-highway emissions increased by 32 percent over the same period due primarily to the 151 percent increase in the emissions from off-highway gasoline vehicles and equipment. After 1970, the emissions for off-highway gasoline and diesel vehicles and equipment steadily increased while the emissions from highway vehicles decreased. These trends are presented in Figure 3-8 by the increasing ratio between the off-highway gasoline and diesel vehicles emissions and the highway vehicle emissions. In 1993, the total off-highway vehicles emissions were approximately one-fourth that of the emissions from highway vehicles or 16 percent of the national total. The emissions from the off-highway gasoline and diesel vehicles are essentially uncontrolled. Thus, their contribution to the total emissions is disproportionately large. Off-highway gasoline and diesel vehicles emit approximately 8 to 10 times the amount of pollutant as highway vehicles based on the average fuel consumption. Emission control measures for selected off-highway engine categories are scheduled to begin in 1996; although significant emission reductions are not expected until after the year 2000.

3.3.4 Remaining Sources

The CO emissions from other sources decreased from 1940 to 1993. In 1940, the emissions for the waste disposal and recycling and miscellaneous, other combustion, wildfires categories accounted for 4 and 28 percent, respectively, of the total emissions. By 1970, the emissions from wildfires decreased by 78 percent, while waste disposal emissions nearly doubled. From 1970 to 1993 forest wildfire emissions decreased from 5.6 million short tons to 4.4 million short tons, although there were wide variations in the emissions from year to year due to the uncontrolled nature of wildfires. Emissions from solid waste disposal decreased 75 percent from 1970 to 1993 as a result of regulating or prohibiting burning of solid waste in many areas of the country. By 1993, wildfires and waste disposal sources accounted for 5 and 2 percent, respectively, of the total CO emissions.

3.4 NITROGEN OXIDES EMISSION TRENDS, 1900 THROUGH 1993

The trend in NO_x emissions is presented in Table 3-2 and Figure 3-2. The "Remaining Categories" grouping includes the following Tier 1 categories:

PETROLEUM AND RELATED INDUSTRIES,
SOLVENT UTILIZATION,
METALS PROCESSING,
WASTE DISPOSAL AND RECYCLING,
MISCELLANEOUS, AND
STORAGE AND TRANSPORT.

3.4.1 Fuel Combustion: Electric Utility, Industrial, and Other

In 1900, electric utilities accounted for 4 percent of the total national NO_x emissions. By 1930, electric utility emissions increased by a factor of 6. The emissions continued to increase from 0.6 million short tons in 1930 to 4.9 million short tons in 1970. In 1993, the emissions from electric utilities were 7.8 million short tons, or 33 percent of the total emissions. New Source Performance Standards (NSPS) have helped to reduce the growth in NO_x emissions from electric utilities.

3.4.2 Transportation: Highway Vehicles and Off-highway

In 1900, highway vehicles made no contribution to the total national NO_x emissions. By 1920, the emissions from highway vehicles increased to 5 percent of the total emissions. The emissions continued to increase by a factor of 3 from 1920 to 1940 and, again, by a factor of 6 from 1940 to 1980. In 1993, highway vehicle emissions were 32 percent of the total emissions.

Highway vehicles emissions are now controlled as a result of the implementation of FMVCP during the 1970s and the replacement of older, less efficient automobiles with newer vehicles. Without these changes, NO_x emissions from highway vehicles in 1993 would be more than twice the current estimated emissions.

3.4.3 Remaining Sources

The NO_x emissions for the years 1900 through 1939 were generated for five source categories (electric utility, industrial, commercial-residential, highway vehicle, and other), making comparisons prior to 1940 on a source category basis difficult. In general, however, the emissions for the remaining sources of industrial processes, waste disposal, and miscellaneous sources increased from 1900 to 1920 and continued to increase from 1920 to 1940, but at a slower rate. Emissions from these sources accounted for 17 percent of the total 1940 NO_x emissions. The emissions for the miscellaneous, other combustion category steadily decreased by 67 percent from 1940 to 1970 and by 10 percent from 1970 to 1993. The emissions for the waste disposal and recycling category steadily increased by a factor of 4 from 1940 to 1970, but decreased by 81 percent from 1970 to 1993. Emissions from industrial processes steadily increased by a factor of 3 from 1940 to 1970. The emissions then decreased 28 percent from 1970 to 1980. The increase from 1980 to 1993 of

63 percent was due in part to change in the methodology used to estimate the emissions between the years 1984 and 1985. In 1993, the total emissions for the remaining sources were 6 percent of the total national NO_x emissions.

3.5 VOLATILE ORGANIC COMPOUND EMISSION TRENDS, 1900 THROUGH 1993

The trend in VOC emissions is presented in Table 3-3 and Figure 3-3. The "Remaining Categories" grouping includes the following Tier 1 categories:

FUEL COMBUSTION ELECTRIC UTILITY,
FUEL COMBUSTION INDUSTRIAL,
FUEL COMBUSTION OTHER,
PETROLEUM AND RELATED INDUSTRIES, AND
OTHER INDUSTRIAL PROCESSES.

The emissions for the miscellaneous category are primarily from wildfires.

Volatile organic compounds are a principal component in the chemical and physical atmospheric reactions that form ozone and other photochemical oxidants. The emissions of VOC species that primarily contribute to the formation of ozone were included in the total VOC emissions, while emissions of methane, a nonreactive compound, were not included. No adjustments are made to include chlorofluorocarbons or to exclude ethane and other VOCs with negligible photochemical reactivity. Highway vehicle emissions were estimated as nonmethane hydrocarbons. Emissions of organic compounds from biogenic sources, such as trees and other vegetation, are presented in section 9. VOC emissions from natural sources were almost equal to the emissions from anthropogenic sources, according to recent research, but the extent to which biogenic emissions contribute to oxidant formation has not been clearly established.

3.5.1 Fuel Combustion: Electric Utility, Industrial, and Other

In 1900, emissions from all fuel combustion sources represented 68 percent of the total national VOC emissions. The combustion of wood accounted for 90 percent of the emissions from these sources. By 1920, the emissions from fuel combustion sources decreased to 55 percent of the total emissions and, by 1940, to 12 percent of the total emissions. This decline in the emissions continued until 1993, with fuel combustion emissions contributing only 3 percent to the total emissions in 1993. The exception to this trend was the increase in the emissions from residential wood combustion in the 1970s as explained in section 3.3.1.

3.5.2 Industrial Processes

Based on the data and categories presented in Figure 3-3, the emissions from industrial processes in 1900 accounted for 17 percent of the total national VOC emissions. By 1920, the estimates for these emissions increased to 22 percent of the total emissions. From 1900 to 1920, the emissions from solvent utilization decreased from 11 to 8 percent of the industrial processes emissions. Over the same period, the emissions from the petroleum industry increased by a factor of 3. By 1940, the emissions for industrial processes were 26 percent of the total emissions.

Industrial processes emissions peaked in 1973 at 13 million short tons. Solvent utilization was responsible for 58 percent of the total industrial processes emissions in 1970. If uncontrolled, VOC emissions from industrial processes would have continued to increase through the 1970s, due to higher production levels, particularly in organic chemical production and industrial uses of organic solvents. Emission control devices and process changes helped limit the growth in these emissions. Emissions from petroleum product storage and marketing operations increased during the mid-1970s as a result of increased demand for petroleum products, especially motor gasoline.

After 1978, the emissions from these sources decreased as the result of more effective control measures. Another reason for the overall decrease in the emissions between 1970 and 1993 was the substitution of water-based emulsified asphalt for asphalt liquified with petroleum distillates. This reduction is reflected in the decreased emissions reported for solvent utilization. In 1993, industrial processes were 48 percent of the total emissions.

3.5.3 Transportation: Highway Vehicles and Off-highway

In 1900, transportation sources accounted for 4 percent of the total national VOC emissions; railroad coal emissions were 99 percent of the transportation emissions. Railroad emissions peaked in 1920, at which time, transportation emissions increased to 20 percent of the national total. The total VOC emissions from transportation sources increased 161 percent from 1940 to 1970. By 1970, railroads contributed only less than 1 percent to the total VOC emissions.

The highway vehicles emissions peaked in 1970 at 13 million short tons, or 42 percent of the national total. The VOC emissions from gasoline and diesel-powered highway vehicles decreased 53 percent from 1970 to 1993. The FMVCP initiatives were responsible for this decrease in emissions, despite increases in VMT. In 1993 highway vehicles accounted for 27 percent of the total emissions.

3.5.4 Remaining Sources

In 1900, emissions from the solid waste disposal and miscellaneous sources represented 10 and 24 percent, respectively, of the total national VOC emissions. By 1920, the emissions from solid waste disposal decreased to 9 percent and the emissions from miscellaneous sources decreased to 17 percent. The decrease in the emissions from the miscellaneous sources was due primarily to the success of fire prevention programs. The wildfire emissions peaked in 1930, representing 35 percent of the total national emissions. The forest wildfire emissions decreased after 1930. In 1993, wildfires accounted for 3 percent of the total national VOC emissions.

3.6 SULFUR DIOXIDE EMISSION TRENDS, 1900 THROUGH 1993

The trend in SO_2 emissions is presented in Table 3-4 and Figure 3-4. The "Remaining Categories" grouping includes the following Tier 1 categories:

PETROLEUM AND RELATED INDUSTRIES,
OTHER INDUSTRIAL PROCESSES,
SOLVENT UTILIZATION,
WASTE DISPOSAL AND RECYCLING,
CHEMICAL AND ALLIED PRODUCT MANUFACTURING, AND
STORAGE AND TRANSPORT.

3.6.1 Fuel Combustion: Electric Utility, Industrial, and Other

In 1900, electric utilities were responsible for 4 percent of the total national SO_2 emissions. The emissions from electric utilities steadily increased by an overall factor of 5 from 1900 to 1925. Emissions decreased during the 1930s due primarily to the Great Depression. The 1940 emissions were approximately the same as the 1920 emissions. From 1940 to 1970, emissions from electric utilities doubled every decade as the result of increased fossil-fuel consumption. In 1970, emissions from coal combustion accounted for 67 percent of total SO_2 emissions from all fuel combustion sources. From 1970 to 1993, coal consumption by electric utilities more than doubled, but electric utility emissions from coal combustion decreased by 4 percent as a result of coal cleaning and lower sulfur coal blending. The SO_2 emissions from other fuel combustion sectors generally decreased, primarily due to less coal burning by industrial, commercial, and residential consumers.

3.6.2 Industrial Processes

The SO_2 emissions for the years 1900 through 1939 were generated for 5 source categories (electric utility, industrial, commercial-residential, highway vehicle, and other), making comparisons prior to 1940 on a source category basis difficult. Industrial (both process and combustion) emissions steadily increased by an overall factor of 2 from 1900 to 1925. The emissions decreased during the 1930s due to the Great Depression. In 1940, industrial processes accounted for 20 percent of the total national emissions. The emissions increased by 74 percent from 1940 to 1970. From 1970 to 1993, industrial processes emissions decreased by 74 percent due to the increased use of emission control devices by industry. In particular, SO_2 emissions were greatly reduced at nonferrous smelters. By-product recovery of sulfuric acid at these smelters has increased since 1970, resulting in the recovered sulfuric acid not being emitted in the form of SO_2. In addition, sulfuric acid manufacturing plants built or modified after 1972 have been subject to the more stringent NSPS. In 1993, industrial processes accounted for 8 percent of the total national SO_2 emissions.

3.6.3 Remaining Sources

The SO_2 emissions for the years 1900 through 1939 were generated for five source categories (electric utility, industrial, commercial-residential, highway vehicle, and other), making comparisons prior to 1940 on a source category basis difficult. In 1940, the emissions from the remaining sources Tier 1 categories of waste disposal and recycling, highway vehicles, off-highway, and miscellaneous were 19 percent of the total national SO_2 emissions. Railroad emissions represented 15 percent of the total emissions in 1940. From 1940 to 1970, the railroad emissions decreased 99 percent as a result of the obsolescence of coal-fired locomotives. Over the same period, the emissions from the categories waste disposal and recycling and highway vehicles increased by factors of 3 and 115, respectively. Between 1970 and 1993, the emissions for these categories continued to increase: waste disposal and recycling emissions by a factor of 5 and highway vehicle emissions by 27 percent. The remaining sources accounted 3 percent of the total national SO_2 emissions in 1993.

3.7 PARTICULATE MATTER (PM-10) EMISSION TRENDS, 1940 THROUGH 1993

The trend in PM-10 emissions is presented in Table 3-5.

The emission trends for PM-10 sources are discussed separately for the point and fugitive process sources and for the fugitive dust sources. The PM-10 fugitive dust sources are categorized as follows:

- NATURAL SOURCES
  - Geogenic
    - wind erosion
- MISCELLANEOUS
  - Agriculture and Forestry
    - agricultural crops and livestock
  - Fugitive dust
    - construction
    - mining and quarrying
    - point source,
    - paved roads, and
    - unpaved roads.

The PM-10 point and fugitive process sources include all other PM-10 sources.

3.7.1 Point and Process Fugitive Sources

The PM-10 point and fugitive process sources are all PM-10 sources excluding the fugitive dust sources listed above. The totals for both categories are presented in Table ES-1. These emissions are also presented in Table 3-5 and Figure 3-5. Figure 3-5 presents the trends in PM-10 emissions from 1940 to 1993. The "Remaining Categories" grouping includes the following Tier 1 categories:

FUEL COMBUSTION INDUSTRIAL,
FUEL COMBUSTION OTHER,
PETROLEUM AND RELATED INDUSTRIES,
OTHER INDUSTRIAL PROCESSES,
CHEMICAL AND ALLIED PRODUCT MANUFACTURING,
WASTE DISPOSAL AND RECYCLING,

and, in the miscellaneous category, "other combustion," which consists primarily of wildfires and managed burning.

3.7.1.1 *Fuel Combustion: Electric Utility, Industrial, and Other*

In 1940, emissions from fuel combustion represented 25 percent of the total national PM-10 emissions. A large portion of the PM-10 emissions from electric utilities resulted from the combustion of coal. In 1940, coal was consumed mostly by the industrial and residential sectors. After 1940, residential coal use declined substantially, resulting in a corresponding reduction in emissions. Industrial coal use also declined, but not to the same extent as residential use. Emission controls used by industrial coal consumers increased over the years and, by 1970, industrial emissions decreased to about 15 percent of the 1940 level.

Despite continuing increases in coal consumption, PM-10 emissions from electric utilities decreased after 1970, as a result of installing air pollution control equipment required for new facilities constructed in the 1970s to meet the NSPS. Fuel combustion sources contributed 22 percent to the total nation emissions in 1970, and 33 percent in 1993. In 1993, 78 percent of PM-10 emissions from fuel combustion sources originated from wood burning as compared to 35 percent in 1970. Wood stoves, wood furnaces, and fireplaces in residential homes accounted for 91 percent of the PM-10 emissions from wood burning in 1993.

3.7.1.2 *Transportation: Highway Vehicles and Off-highway*

In 1940, emissions from transportation sources accounted for 17 percent of the total national PM-10 emissions. Railroads and LDGVs contributed 15 and 1 percent, respectively, of the total 1940 emissions. From 1940 to 1970, the railroad emissions decreased by 99 percent and the LDGV emissions decreased by 61 percent. The railroad emissions increased from 1970 to 1993 by 91 percent. Over the same period, the LDGV emissions decreased by 49 percent. Although the 1993 emissions from transportation sources still represent 16 percent of the total national PM-10 emissions, this represents only one-fourth of the 1940 PM-10 emissions.

3.7.1.3 *Remaining Sources*

Particulate matter (PM-10) emissions from industrial processes increased from 1940 to 1950, primarily as a result of increases in industrial production. From 1950 to 1970, industrial output continued to grow, but the emissions from industrial processes decreased due to the installation of pollution control equipment mandated by air pollution control programs. The reduction of emissions by these control devices was more than offset by the increase in emissions due to production increases. In 1970, industrial processes contributed 60 percent to the total national PM-10 emissions, while in 1993, they contributed 17 percent, thus indicating considerable progress in reducing emissions. In 1940, wildfires contributed 14 percent to the total national emissions; in 1993, they contributed 11 percent. Emissions from this category can be quite variable as they depend on weather conditions in forested areas. It should be noted, however, that the estimated emissions from prescribed burning and wildfires were held constant at the 1985 level for the years 1985 through 1989.

3.7.2 Fugitive Dust Sources

The inclusion of fugitive dust source emissions began with the 1991 *Trends* report.[3] The emissions are presented in Table 3-5 and Figure 3-5. Figure 3-5 presents the trend in PM-10 fugitive dust emissions for 1985 to 1993. The "Remaining Categories" grouping includes the Tier 3 categories: point source, construction, and mining and quarrying. More detailed emissions for the years 1985 through 1993 are presented in Table A-5, in Appendix A.

Unlike the methodology used to estimate the emissions from point and fugitive process sources, the methodology used to estimate fugitive dust emissions for several categories utilize meteorological data such as the number of days with greater than 0.01 inches of precipitation and the wind speed. These data can vary significantly from year-to-year, resulting in highly varying emissions.

The PM-10 emissions from fugitive dust sources decreased by 6 percent from 1985 to 1993. During this time period, the emissions ranged from 41.8 million short tons in 1993 to 60.0 million short tons in 1988. The emissions from wind erosion were highly variable. For example, the total national emissions from wind erosion in 1993 were estimated to be 0.63 million short tons, compared to 17.5 million short tons in 1988. The lack of precipitation in 1988 prior to spring crop planting, especially in the central and western United States, contributed to greater wind erosion for that year. In 1993, unusually heavy spring rains in Kansas and Oklahoma, where wind erosion was normally very significant, resulted in a 97 percent decrease in the wind erosion emissions for these two states from the 1992 values.

For 1993, total national fugitive dust PM-10 emissions were estimated to be about 11 times greater than the total emissions from point and fugitive process sources.

3.8 LEAD EMISSION TRENDS, 1970 THROUGH 1993

The trend in Pb emissions is presented in Table 3-6 and Figure 3-6. Table 3-6 presents the emissions for Tier 1 source categories for every 5 years for 1970 to 1990 and for the years 1992 and 1993. Figure 3-6 presents the trends in Pb emissions from 1970 to 1993. The "Remaining Categories" grouping includes the following Tier 1 categories:

FUEL COMBUSTION ELECTRIC UTILITY,
FUEL COMBUSTION INDUSTRIAL,
OTHER INDUSTRIAL PROCESSES, AND
CHEMICAL AND ALLIED PRODUCT MANUFACTURING.

More detailed emissions for the years 1970, 1980, and 1984 through 1993 are presented in Table A-6, in Appendix A.

3.8.1 Fuel Combustion: Electric Utility, Industrial, and Other

Fuel combustion emissions in 1940 contributed 5 percent of the total national Pb emissions. The emissions decreased by 95 percent from 1970 to 1993. By 1993, fuel combustion emissions accounted for 10 percent of the total Pb emissions.

3.8.2 Industrial Processes

Industrial process emissions in 1970 contributed 12 percent of the total national Pb emissions. The emissions decreased by 91 percent from 1970 to 1993. By 1993, emissions from industrial processes accounted for 47 percent of the total Pb emissions.

3.8.3 Transportation: Highway Vehicles and Non-highway

Lead emissions from highway vehicles accounted for 78 percent of the total emissions in 1970. Total national Pb emissions decreased sharply from 1970 to 1986 as a result of 2 air pollution control programs implemented by EPA. Regulations were issued in the early 1970s requiring the gradual reduction of the Pb content of all gasoline. Gasoline consumption increased 16 percent between 1970 and 1975, but, because of the decreased average Pb content of gasoline, Pb emissions from highway vehicles decreased by 24 percent. The most dramatic reductions of the Pb content in leaded gasoline occurred in 1985 and 1986. The average Pb content of leaded gasoline was reduced from an average of 1.0 grams/gallon to 0.5 grams/gallon on July 1, 1985. The average Pb content was reduced further on January 1, 1986 to 0.1 grams/gallon.

The other major contribution to the reduction of Pb emissions from transportation sources was the introduction of the FMVCP in 1975. This program resulted in the widespread use of catalytic converters to reduce NO_x, VOC, and CO emissions. Automobiles with these converters were required to use unleaded gasoline. From 1975 to 1993, the percent of unleaded gasoline sales increased from 13 to 99 percent.

With the implementation of these two control programs, the Pb emissions from highway vehicles decreased from 130 thousand short tons in 1975 to 1 thousand short tons in 1993. This is an overall reduction of 99 percent. For 1993, highway vehicle emissions accounted for 28 percent of the total national Pb emissions.

3.9 REFERENCES

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

2. *Highway Statistics*. Federal Highway Administration, U.S. Department of Transportation, Washington, DC. October 1993.

3. *National Air Pollutant Emission Trends, 1900-1991*. EPA-454/R-92-013. Office of Air Quality Planning and Standards, Research Triangle Park, NC. October 1992.

Table 3-1. Total National Emissions of Carbon Monoxide, 1940 through 1993
(thousand short tons)

Source Category	1940	1950	1960	1970	1980	1990	1992	1993
FUEL COMB. ELEC. UTIL.	**4**	**110**	**110**	**237**	**322**	**314**	**313**	**322**
FUEL COMB. INDUSTRIAL	**435**	**549**	**661**	**770**	**750**	**677**	**671**	**667**
FUEL COMB. OTHER	**14,890**	**10,656**	**6,250**	**3,625**	**6,230**	**5,726**	**5,033**	**4,444**
Residential Wood	11,279	7,716	4,743	2,932	5,992	5,435	4,750	4,161
fireplaces	2,639	1,805	1,110	686	1,402	NA	NA	NA
woodstoves	8,640	5,910	3,633	2,246	4,590	NA	NA	NA
Residential Other	3,501	2,833	1,507	630	178	158	150	149
CHEMICAL & ALLIED PRODUCT MFG	**4,190**	**5,844**	**3,982**	**3,397**	**2,151**	**1,940**	**1,964**	**1,998**
METALS PROCESSING	**2,750**	**2,910**	**2,866**	**3,644**	**2,246**	**2,080**	**2,044**	**2,091**
PETROLEUM & RELATED INDUSTRIES	**221**	**2,651**	**3,086**	**2,179**	**1,723**	**435**	**410**	**398**
OTHER INDUSTRIAL PROCESSES	**114**	**231**	**342**	**620**	**830**	**717**	**719**	**732**
SOLVENT UTILIZATION	**NA**	**NA**	**NA**	**NA**	**NA**	**2**	**2**	**2**
STORAGE & TRANSPORT	**NA**	**NA**	**NA**	**NA**	**NA**	**55**	**55**	**56**
WASTE DISPOSAL & RECYCLING	**3,630**	**4,717**	**5,597**	**7,059**	**2,300**	**1,686**	**1,717**	**1,732**
HIGHWAY VEHICLES	**27,370**	**41,372**	**58,297**	**88,034**	**78,049**	**62,858**	**59,859**	**59,989**
Light-Duty Gas Vehicles & Motorcycles	19,860	28,149	42,604	64,031	53,561	40,502	39,370	39,452
light-duty gas vehicles	19,849	28,098	42,547	63,846	53,342	40,316	39,190	39,265
Light-Duty Gas Trucks	2,596	4,229	5,390	16,570	16,137	15,084	14,567	14,879
light-duty gas trucks 1	1,992	3,251	4,135	10,102	10,395	8,511	8,161	8,286
light-duty gas trucks 2	603	978	1,255	6,468	5,742	6,573	6,407	6,593
Heavy-Duty Gas Vehicles	4,914	8,965	10,178	6,712	7,189	5,930	4,569	4,292
Diesels	NA	29	126	721	1,161	1,342	1,352	1,366
heavy-duty diesel vehicles	NA	29	126	721	1,139	1,307	1,315	1,327
OFF-HIGHWAY	**8,051**	**11,610**	**11,575**	**10,605**	**12,681**	**14,642**	**14,904**	**15,272**
Non-Road Gasoline	3,777	7,331	8,753	9,478	11,004	12,655	12,886	13,164
industrial	780	1,558	1,379	732	970	1,228	1,234	1,285
lawn & garden	NA	NA	NA	4,679	5,366	6,001	6,145	6,214
light commercial	NA	NA	NA	2,437	2,680	3,254	3,296	3,402
recreational marine vessels	60	120	518	976	1,102	1,207	1,233	1,245
Aircraft	4	934	1,764	506	743	966	980	1,019
Railroads	4,083	3,076	332	65	96	122	124	124
MISCELLANEOUS	**29,210**	**18,135**	**11,010**	**7,909**	**8,344**	**12,623**	**8,679**	**9,506**
Other Combustion								
forest wildfires	25,130	11,159	4,487	5,620	5,396	7,529	3,578	4,391
TOTAL	**90,865**	**98,785**	**103,777**	**128,079**	**115,625**	**103,753**	**96,368**	**97,208**

NOTE(S): Categories displayed below Tier 1 do not sum to Tier 1 totals because they are intended to show major contributors.
NA = not available
Change in methodology indicated by vertical lines. Transportation methodologies changed in 1970. All other methodologies changed in 1985.
1990 to 1993 emission estimates are preliminary and will be updated in the next report.
Tier 1 source categories and emissions are in bold type face.

Table 3-2. Total National Emissions of Nitrogen Oxides, 1940 through 1993
(thousand short tons)

Source Category	1940	1950	1960	1970	1980	1990	1992	1993
FUEL COMB. ELEC. UTIL.	**660**	**1,316**	**2,536**	**4,900**	**7,024**	**7,516**	**7,473**	**7,782**
Coal	467	1,118	2,038	3,888	6,123	6,698	6,694	7,005
bituminous	255	584	1,154	2,112	3,439	4,600	4,564	4,758
subbituminous	125	288	568	1,041	1,694	1,692	1,707	1,831
anthracite & lignite	58	123	204	344	542	406	423	416
FUEL COMB. INDUSTRIAL	**2,543**	**3,192**	**4,075**	**4,325**	**3,555**	**3,256**	**3,206**	**3,176**
Coal	2,012	1,076	782	771	444	613	557	520
bituminous	1,301	688	533	532	306	445	404	377
Gas	365	1,756	2,954	3,060	2,619	1,656	1,658	1,664
natural	337	1,692	2,846	3,053	2,469	1,436	1,444	1,453
FUEL COMB. OTHER	**529**	**647**	**760**	**836**	**741**	**732**	**735**	**732**
CHEMICAL & ALLIED PRODUCT MFG	**6**	**63**	**110**	**271**	**216**	**399**	**411**	**414**
METALS PROCESSING	**4**	**110**	**110**	**77**	**65**	**81**	**80**	**82**
PETROLEUM & RELATED INDUSTRIES	**105**	**110**	**220**	**240**	**72**	**100**	**96**	**95**
OTHER INDUSTRIAL PROCESSES	**107**	**93**	**131**	**187**	**205**	**306**	**305**	**314**
SOLVENT UTILIZATION	**NA**	**NA**	**NA**	**NA**	**NA**	**2**	**3**	**3**
STORAGE & TRANSPORT	**NA**	**NA**	**NA**	**NA**	**NA**	**2**	**3**	**3**
WASTE DISPOSAL & RECYCLING	**110**	**215**	**331**	**440**	**111**	**82**	**83**	**84**
HIGHWAY VEHICLES	**1,523**	**2,453**	**4,423**	**7,390**	**8,621**	**7,488**	**7,440**	**7,437**
Light-Duty Gas Vehicles & Motorcycles	1,105	1,611	2,967	4,158	4,421	3,437	3,614	3,685
light-duty gas vehicles	1,104	1,611	2,966	4,156	4,416	3,425	3,602	3,673
Light-Duty Gas Trucks	164	271	421	1,278	1,408	1,341	1,356	1,387
Heavy-Duty Gas Vehicles	255	487	597	278	300	335	308	304
Diesels	NA	83	438	1,676	2,493	2,375	2,163	2,061
heavy-duty diesel vehicles	NA	83	438	1,676	2,463	2,332	2,116	2,014
OFF-HIGHWAY	**991**	**1,538**	**1,443**	**1,628**	**2,423**	**2,843**	**2,885**	**2,986**
Non-Road Diesel	103	187	247	941	1,374	1,478	1,494	1,582
construction	70	158	157	599	854	944	940	1,007
Railroads	657	992	772	495	731	929	946	945
MISCELLANEOUS	**990**	**665**	**441**	**330**	**248**	**384**	**272**	**296**
TOTAL	**7,568**	**10,403**	**14,581**	**20,625**	**23,281**	**23,192**	**22,991**	**23,402**

NOTE(S): Categories displayed below Tier 1 do not sum to Tier 1 totals because they are intended to show major contributors.
NA = not available
Change in methodology indicated by vertical lines. Transportation methodologies changed in 1970. All other methodologies changed in 1985.
1990 to 1993 emission estimates are preliminary and will be updated in the next report.
Tier 1 source categories and emissions are in bold type face.

Table 3-3. Total National Emissions of Volatile Organic Compounds, 1940 through 1993
(thousand short tons)

Source Category	1940	1950	1960	1970	1980	1990	1992	1993
FUEL COMB. ELEC. UTIL.	**2**	**9**	**9**	**30**	**45**	**35**	**34**	**36**
FUEL COMB. INDUSTRIAL	**108**	**98**	**106**	**150**	**157**	**266**	**271**	**271**
FUEL COMB. OTHER	**1,867**	**1,336**	**768**	**541**	**848**	**437**	**385**	**341**
Residential Wood	1,410	970	563	460	809	405	354	310
fireplaces	340	231	131	107	189	NA	NA	NA
woodstoves	1,070	739	431	353	620	NA	NA	NA
CHEMICAL & ALLIED PRODUCT MFG	**884**	**1,324**	**991**	**1,341**	**1,595**	**1,771**	**1,799**	**1,811**
Organic Chemical Mfg	58	110	245	629	884	684	692	694
METALS PROCESSING	**325**	**442**	**342**	**394**	**273**	**72**	**72**	**74**
PETROLEUM & RELATED INDUSTRIES	**571**	**548**	**1,034**	**1,194**	**1,440**	**737**	**729**	**720**
OTHER INDUSTRIAL PROCESSES	**130**	**184**	**202**	**270**	**237**	**478**	**482**	**486**
SOLVENT UTILIZATION	**1,971**	**3,679**	**4,403**	**7,174**	**6,584**	**6,063**	**6,121**	**6,249**
Surface Coating	1,058	2,187	2,128	3,570	3,685	2,619	2,623	2,687
Nonindustrial	490	NA	1,189	1,674	1,002	1,900	1,953	1,982
consumer solvents	NA	NA	NA	NA	NA	1,083	1,106	1,116
STORAGE & TRANSPORT	**639**	**1,218**	**1,762**	**1,954**	**1,975**	**1,861**	**1,848**	**1,861**
Bulk Terminals & Plants	185	361	528	599	517	658	626	614
area source: gasoline	158	307	449	509	440	560	527	512
WASTE DISPOSAL & RECYCLING	**990**	**1,104**	**1,546**	**1,984**	**758**	**2,262**	**2,268**	**2,271**
HIGHWAY VEHICLES	**4,774**	**7,172**	**10,370**	**12,972**	**8,979**	**6,854**	**6,072**	**6,094**
Light-Duty Gas Vehicles & Motorcycles	3,720	5,331	8,224	9,193	5,907	4,285	3,832	3,854
light-duty gas vehicles	3,716	5,314	8,204	9,133	5,843	4,234	3,799	3,820
Light-Duty Gas Trucks	507	831	1,082	2,770	2,059	1,769	1,588	1,612
Heavy-Duty Gas Vehicles	547	998	1,018	743	611	470	334	314
Diesels	NA	11	46	266	402	330	318	315
heavy-duty diesel vehicles	NA	11	46	266	392	316	302	298
OFF-HIGHWAY	**778**	**1,213**	**1,215**	**1,542**	**1,869**	**2,120**	**2,160**	**2,207**
Non-Road Gasoline	208	423	526	1,284	1,474	1,646	1,678	1,704
lawn & garden	NA	NA	NA	574	655	728	745	754
MISCELLANEOUS	**4,079**	**2,530**	**1,573**	**1,101**	**1,134**	**1,320**	**780**	**893**
Other Combustion								
forest wildfires	3,420	1,510	768	770	739	1,032	490	602
TOTAL	**17,118**	**20,856**	**24,322**	**30,646**	**25,893**	**24,276**	**23,020**	**23,312**

NOTE(S): Categories displayed below Tier 1 do not sum to Tier 1 totals because they are intended to show major contributors.

NA = not available

Change in methodology indicated by vertical lines. Transportation methodologies changed in 1970. All other methodologies changed in 1985.

1990 to 1993 emission estimates are preliminary and will be updated in the next report.

Tier 1 source categories and emissions are in bold type face.

Table 3-4. Total National Emissions of Sulfur Dioxide, 1940 through 1993
(thousand short tons)

Source Category	1940	1950	1960	1970	1980	1990	1992	1993
FUEL COMB. ELEC. UTIL.	**2,427**	**4,515**	**9,264**	**17,398**	**17,469**	**15,898**	**15,417**	**15,836**
Coal	2,276	4,056	8,883	15,799	16,073	15,227	14,840	15,185
bituminous	1,359	2,427	5,367	9,574	NA	13,365	12,900	13,199
subbituminous	668	1,196	2,642	4,716	NA	1,425	1,456	1,509
anthracite & lignite	249	433	873	1,509	NA	438	484	477
Oil	151	459	380	1,598	1,395	639	546	620
residual	146	453	375	1,578	NA	629	537	614
FUEL COMB. INDUSTRIAL	**6,060**	**5,725**	**3,864**	**4,568**	**2,951**	**3,106**	**2,947**	**2,830**
Coal	5,188	4,423	2,703	3,129	1,527	1,843	1,681	1,575
bituminous	3,473	2,945	1,858	2,171	1,058	1,382	1,263	1,184
subbituminous	1,070	907	574	669	326	29	26	24
Oil	554	972	922	1,229	1,065	823	832	824
residual	397	721	663	956	851	633	645	641
Gas	145	180	189	140	299	352	348	346
Other	173	150	51	70	60	82	80	79
Internal Combustion	NA	NA	NA	NA	NA	6	6	6
FUEL COMB. OTHER	**3,642**	**3,964**	**2,319**	**1,490**	**971**	**597**	**600**	**600**
Residential Other	2,517	2,079	1,250	492	211	175	177	178
bituminous/subbituminous coal	2,267	1,758	868	260	43	30	26	25
CHEMICAL & ALLIED PRODUCT MFG	**215**	**427**	**447**	**591**	**280**	**440**	**447**	**450**
METALS PROCESSING	**3,309**	**3,747**	**3,986**	**4,775**	**1,842**	**578**	**557**	**580**
Nonferrous Metals Processing	2,760	3,092	3,322	4,060	1,279	401	383	401
copper	2,292	2,369	2,772	3,507	1,080	216	200	213
PETROLEUM & RELATED INDUSTRIES	**224**	**340**	**676**	**881**	**734**	**440**	**417**	**409**
OTHER INDUSTRIAL PROCESSES	**334**	**596**	**671**	**846**	**918**	**401**	**401**	**413**
SOLVENT UTILIZATION	**NA**	**NA**	**NA**	**NA**	**NA**	**1**	**1**	**1**
STORAGE & TRANSPORT	**NA**	**NA**	**NA**	**NA**	**NA**	**5**	**5**	**5**
WASTE DISPOSAL & RECYCLING	**3**	**3**	**10**	**8**	**33**	**36**	**37**	**37**
HIGHWAY VEHICLES	**3**	**103**	**114**	**345**	**429**	**480**	**483**	**438**
OFF-HIGHWAY	**3,190**	**2,392**	**321**	**83**	**175**	**265**	**273**	**278**
Railroads	2,975	2,174	215	36	53	68	69	69
MISCELLANEOUS	**545**	**545**	**554**	**110**	**11**	**14**	**10**	**11**
TOTAL	**19,953**	**22,358**	**22,227**	**31,096**	**25,813**	**22,261**	**21,592**	**21,888**

NOTE(S): Categories displayed below Tier 1 do not sum to Tier 1 totals because they are intended to show major contributors.
NA = not available
Change in methodology indicated by vertical lines. Transportation methodologies changed in 1970. All other methodologies changed in 1985.
1990 to 1993 emission estimates are preliminary and will be updated in the next report.
Tier 1 source categories and emissions are in bold type face.

Table 3-5. Total National Emissions of Particulate Matter (PM-10), 1940 through 1993
(thousand short tons)

Source Category	1940	1950	1960	1970	1980	1990	1992	1993
FUEL COMB. ELEC. UTIL.	**962**	**1,467**	**2,117**	**1,775**	**879**	**291**	**255**	**270**
Coal	954	1,439	2,092	1,680	796	278	243	257
bituminous	573	865	1,288	1,041	483	198	178	191
FUEL COMB. INDUSTRIAL	**708**	**604**	**331**	**641**	**679**	**228**	**223**	**219**
FUEL COMB. OTHER	**2,338**	**1,674**	**1,113**	**455**	**887**	**930**	**819**	**723**
Residential Wood	1,716	1,128	850	384	818	881	770	674
CHEMICAL & ALLIED PRODUCT MFG	**330**	**455**	**309**	**235**	**148**	**74**	**75**	**75**
METALS PROCESSING	**1,208**	**1,027**	**1,026**	**1,316**	**622**	**140**	**137**	**141**
Nonferrous Metals Processing	588	346	375	593	130	48	47	48
copper	217	105	122	343	32	4	4	4
Ferrous Metals Processing	246	427	214	198	322	88	86	88
Metals Processing NEC	374	254	437	525	170	4	4	5
PETROLEUM & RELATED INDUSTRIES	**366**	**412**	**689**	**286**	**138**	**28**	**27**	**26**
OTHER INDUSTRIAL PROCESSES	**3,996**	**6,954**	**7,211**	**5,832**	**1,846**	**306**	**303**	**311**
Agriculture, Food, & Kindred Products	784	696	691	485	402	24	25	25
Wood, Pulp & Paper, & Publishing	511	798	958	727	183	98	99	101
Mineral Products	2,701	5,460	5,563	4,620	1,261	156	152	157
cement mfg	1,363	1,998	2,014	1,731	417	35	35	36
surface mining	62	108	140	134	127	17	16	17
stone quarrying/processing	482	663	1,039	957	421	27	25	26
SOLVENT UTILIZATION	**NA**	**NA**	**NA**	**NA**	**NA**	**2**	**2**	**2**
STORAGE & TRANSPORT	**NA**	**NA**	**NA**	**NA**	**NA**	**54**	**53**	**55**
WASTE DISPOSAL & RECYCLING	**392**	**505**	**764**	**999**	**273**	**242**	**246**	**248**
HIGHWAY VEHICLES	**210**	**314**	**554**	**237**	**275**	**239**	**210**	**197**
OFF-HIGHWAY	**2,480**	**1,788**	**201**	**223**	**329**	**372**	**379**	**395**
NATURAL SOURCES	**NA**	**NA**	**NA**	**NA**	**NA**	**4,192**	**4,655**	**628**
* Geogenic - wind erosion	NA	NA	NA	NA	NA			
MISCELLANEOUS	**2,968**	**1,934**	**1,244**	**839**	**852**	**42,059**	**41,245**	**42,200**
Agriculture & Forestry	NA	NA	NA	NA	NA	7,380	7,238	7,236
* agricultural crops	NA	NA	NA	NA	NA	6,999	6,852	6,842
* agricultural livestock	NA	NA	NA	NA	NA	381	386	394
Other Combustion	2,968	1,934	1,244	839	852	1,322	947	1,027
wildfires	2,179	1,063	428	385	514	717	341	418
managed burning	591	662	606	390	315	546	547	549
Fugitive Dust	NA	NA	NA	NA	NA	33,356	33,060	33,937
* unpaved roads	NA	NA	NA	NA	NA	15,661	14,540	14,404
* paved roads	NA	NA	NA	NA	NA	7,299	7,621	8,164
* other	NA	NA	NA	NA	NA	10,396	10,899	11,368
TOTAL	**15,956**	**17,133**	**15,558**	**12,838**	**6,928**	**49,158**	**48,629**	**45,489**

NOTE(S): Categories displayed below Tier 1 do not sum to Tier 1 totals because they are intended to show major contributors.
NA = not available
Change in methodology indicated by vertical lines. Transportation methodologies changed in 1970. All other methodologies changed in 1985.
1990 to 1993 emission estimates are preliminary and will be updated in the next report.
Tier 1 source categories and emissions are in bold type face.
* Fugitive dust sources

Table 3-6. Total National Emissions of Lead, 1970 through 1993
(short tons)

Source Category	1970	1975	1980	1985	1990	1992	1993
FUEL COMB. ELEC. UTIL.	**327**	**230**	**129**	**64**	**64**	**59**	**62**
FUEL COMB. INDUSTRIAL	**237**	**75**	**60**	**30**	**18**	**18**	**18**
FUEL COMB. OTHER	**10,052**	**10,042**	**4,111**	**421**	**418**	**414**	**417**
Misc. Fuel Comb. (Except Residential)	10,000	10,000	4,080	400	400	400	400
Residential Other	47	16	9	11	10	7	9
CHEMICAL & ALLIED PRODUCT MFG	**103**	**120**	**104**	**118**	**136**	**93**	**109**
Inorganic Chemical Mfg - lead oxide and pigments							
METALS PROCESSING	**24,224**	**9,923**	**3,026**	**2,097**	**2,138**	**2,042**	**2,118**
Nonferrous Metals Processing	15,869	7,192	1,826	1,376	1,409	1,316	1,362
primary lead production	12,134	5,640	1,075	874	728	628	636
primary copper production	242	171	20	19	19	20	21
primary zinc production	1,019	224	24	16	9	11	12
secondary lead production	1,894	821	481	288	449	470	496
secondary copper production	374	200	116	70	75	66	71
lead battery manufacture	41	49	50	65	78	77	80
lead cable coating	127	55	37	43	50	44	45
Ferrous Metals Processing	7,395	2,196	911	577	576	560	572
ferroalloy production	219	104	13	7	18	16	17
iron production	266	93	38	21	18	18	18
steel production	3,125	1,082	481	209	138	145	147
gray iron production	3,773	910	373	336	397	378	387
OTHER INDUSTRIAL PROCESSES	**2,028**	**1,337**	**808**	**316**	**169**	**54**	**54**
Mineral Products	540	217	93	43	26	24	24
cement manufacturing							
Miscellaneous Industrial Processes	1,488	1,120	715	273	143	30	30
WASTE DISPOSAL & RECYCLING	**2,200**	**1,595**	**1,210**	**871**	**804**	**416**	**518**
Incineration							
municipal waste	581	396	161	79	67	11	45
other	1,619	1,199	1,049	792	738	405	472
HIGHWAY VEHICLES	**171,961**	**130,206**	**62,189**	**15,978**	**1,690**	**1,452**	**1,383**
Light-Duty Gas Vehicles & Motorcycles	142,918	106,868	48,501	12,070	1,263	1,084	1,033
OFF-HIGHWAY	**8,340**	**5,012**	**3,320**	**229**	**197**	**193**	**206**
Non-Road Gasoline							
TOTAL	**219,471**	**158,542**	**74,956**	**20,124**	**5,635**	**4,741**	**4,885**

NOTE(S): Categories displayed below Tier 1 do not sum to Tier 1 totals because they are intended to show major contributors.
1993 emission estimates are preliminary and will be updated in the next report.
Tier 1 source categories and emissions are in bold type face.

Figure 3-1. Trend in CARBON MONOXIDE Emissions by 7 Principal Source Categories, 1940 to 1993

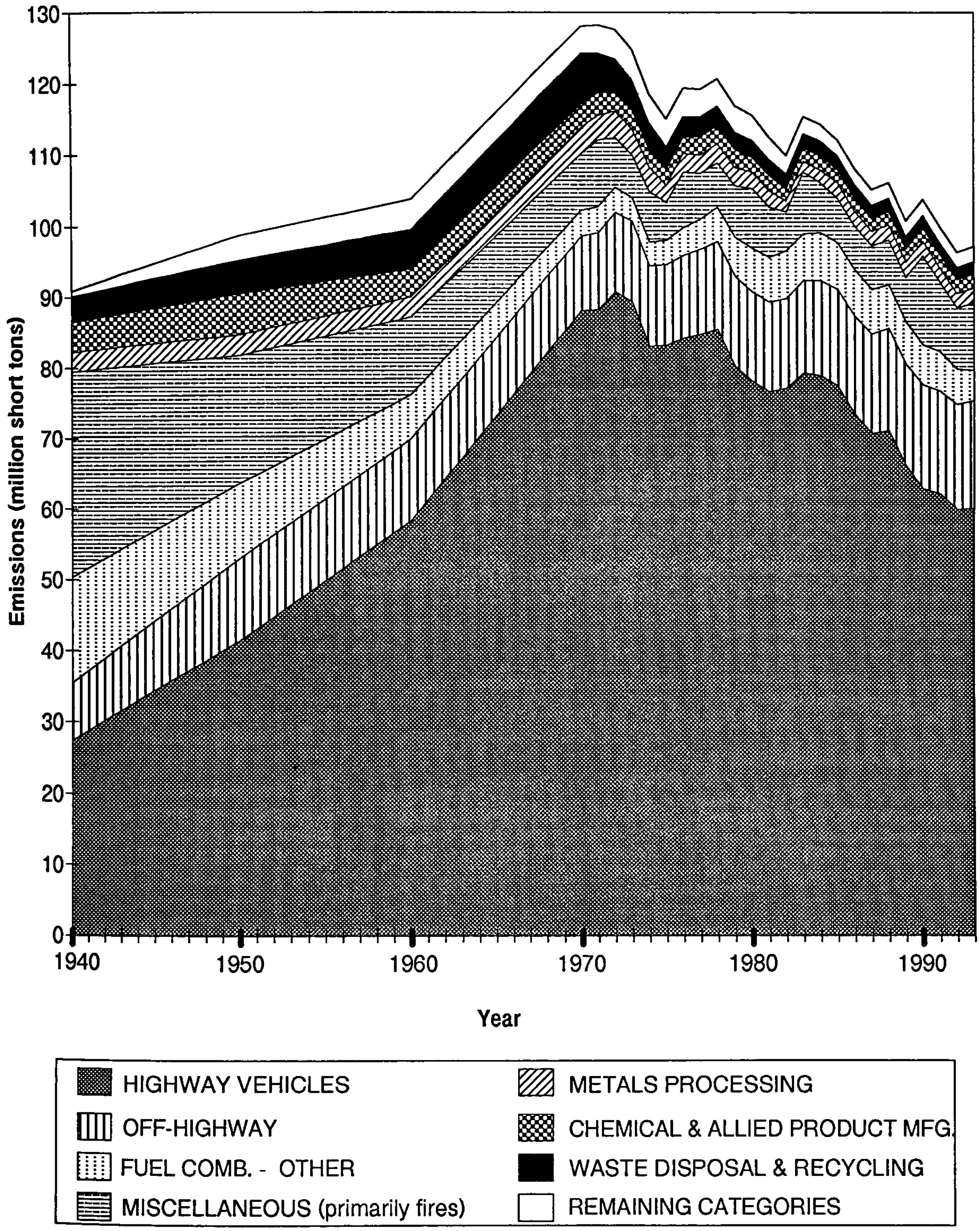


Figure 3-2. Trend in NITROGEN OXIDES Emissions by 7 Principal Source Categories, 1900 to 1993

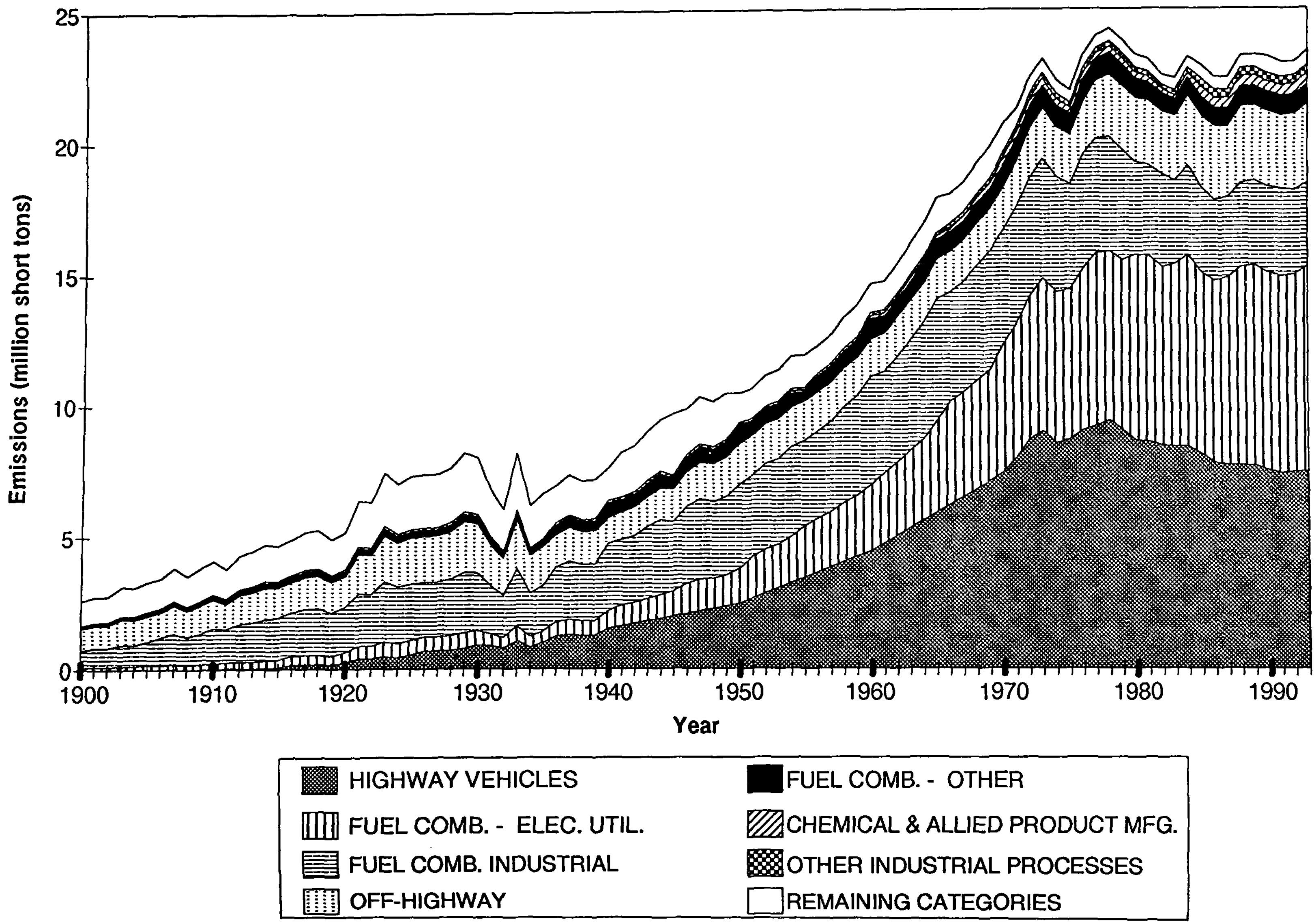


Figure 3-3. Trend in VOLATILE ORGANIC COMPOUND Emissions by 7 Principal Source Categories, 1900 to 1993

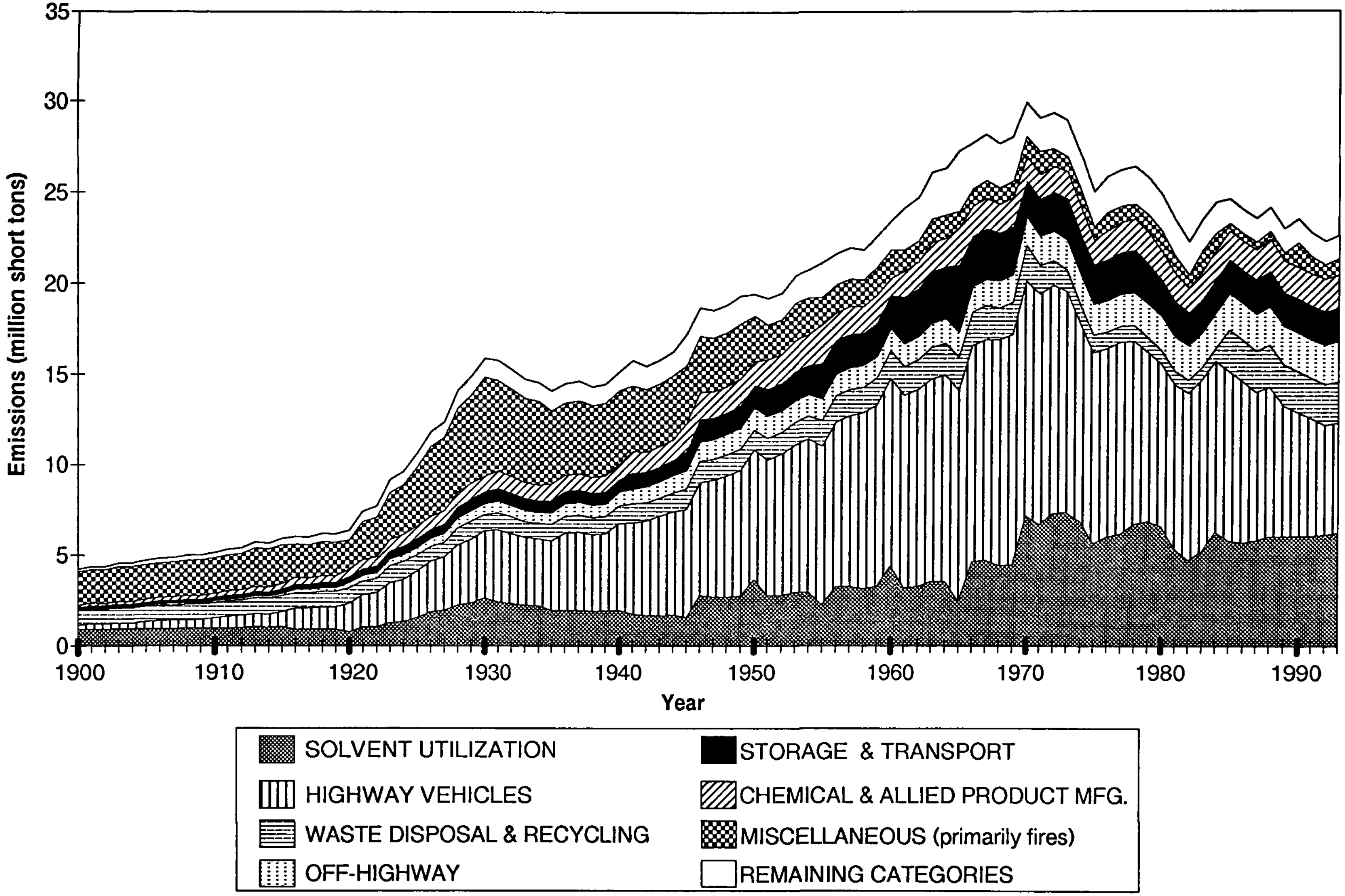


Figure 3-4. Trend in SULFUR DIOXIDE Emissions by 6 Principal Source Categories, 1900 to 1993

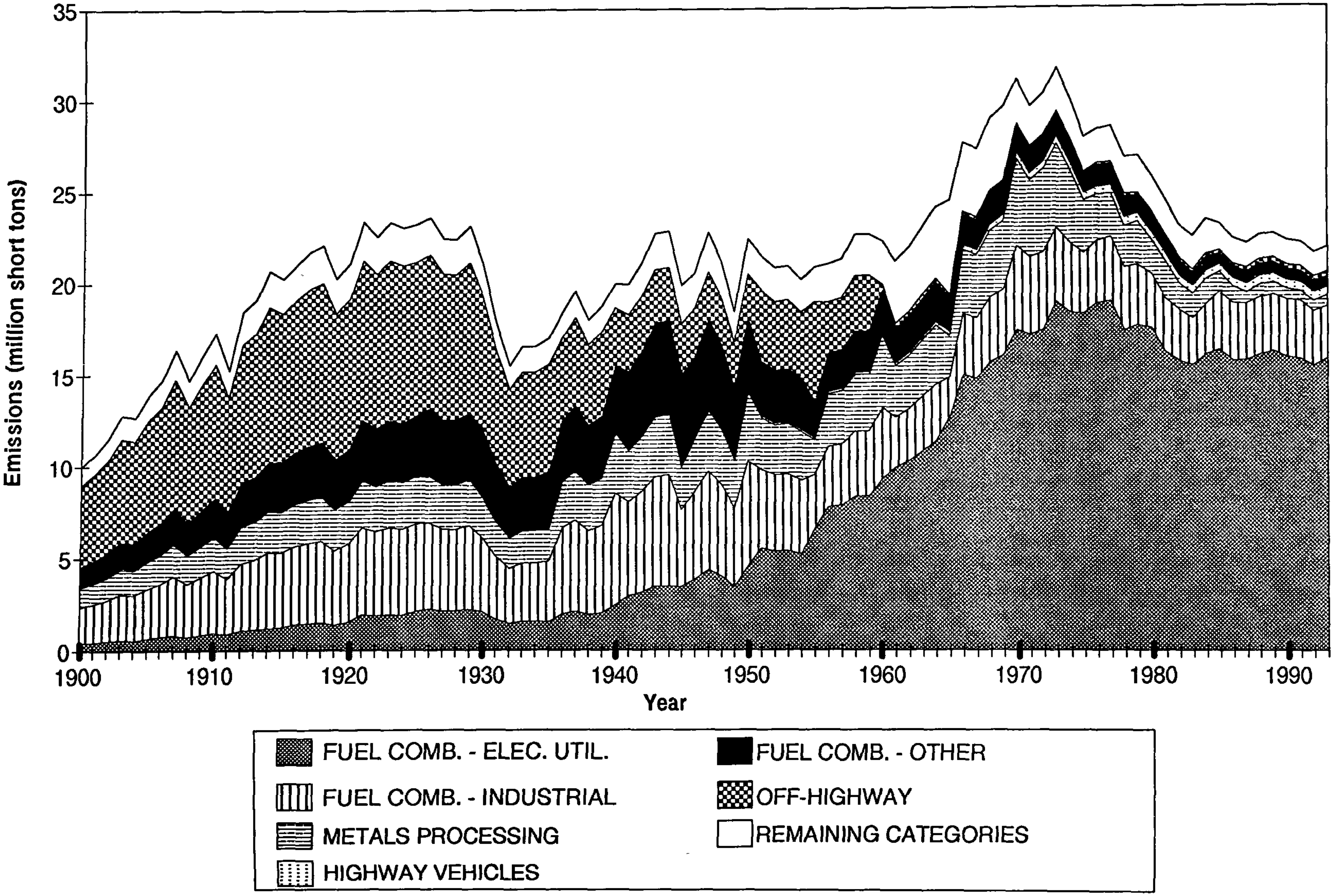
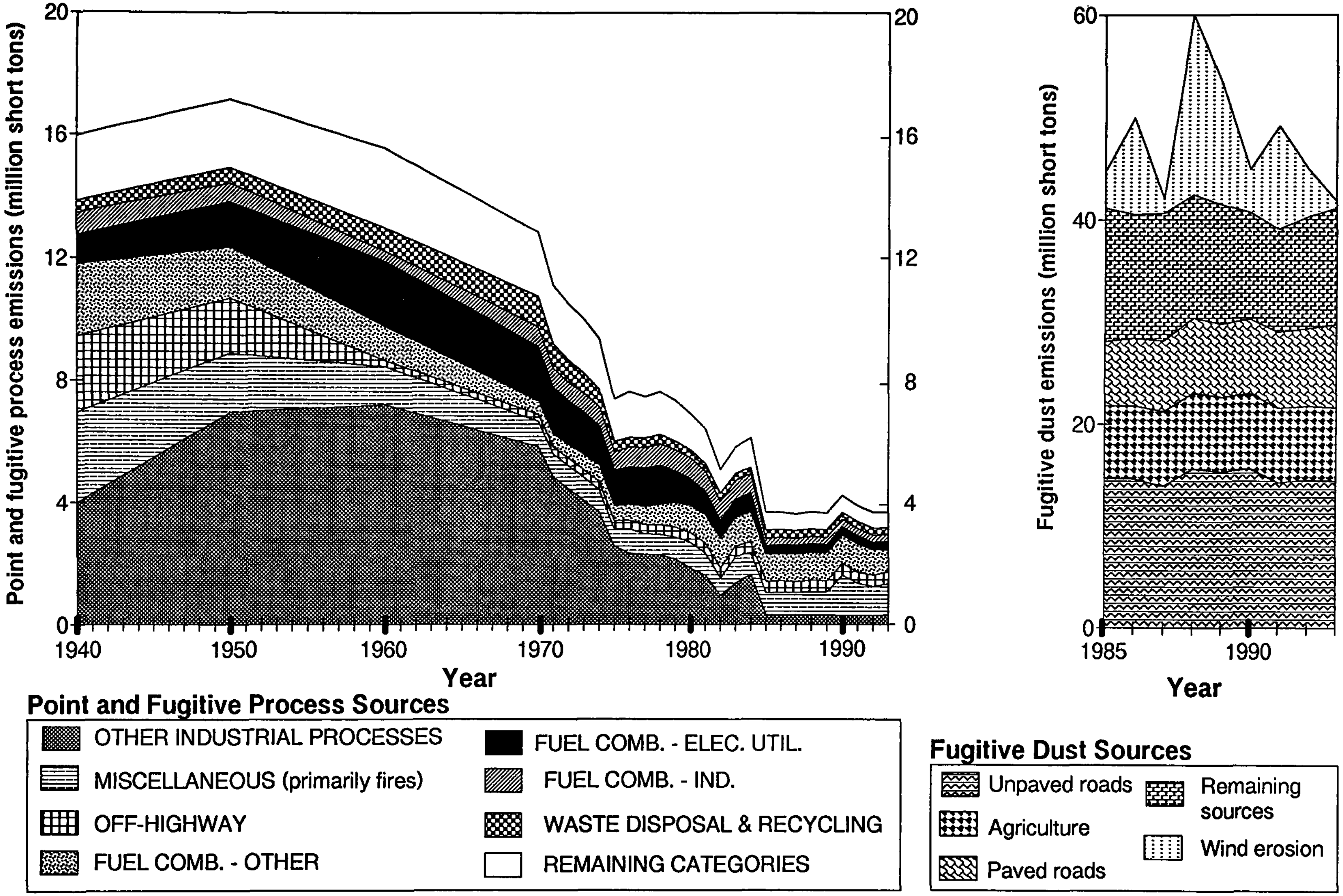


Figure 3-5. Trend in PARTICULATE MATTER (PM-10) Emissions by Point and Fugitive Process Sources (1940 to 1993) and by Fugitive Dust Sources (1985 to 1993)



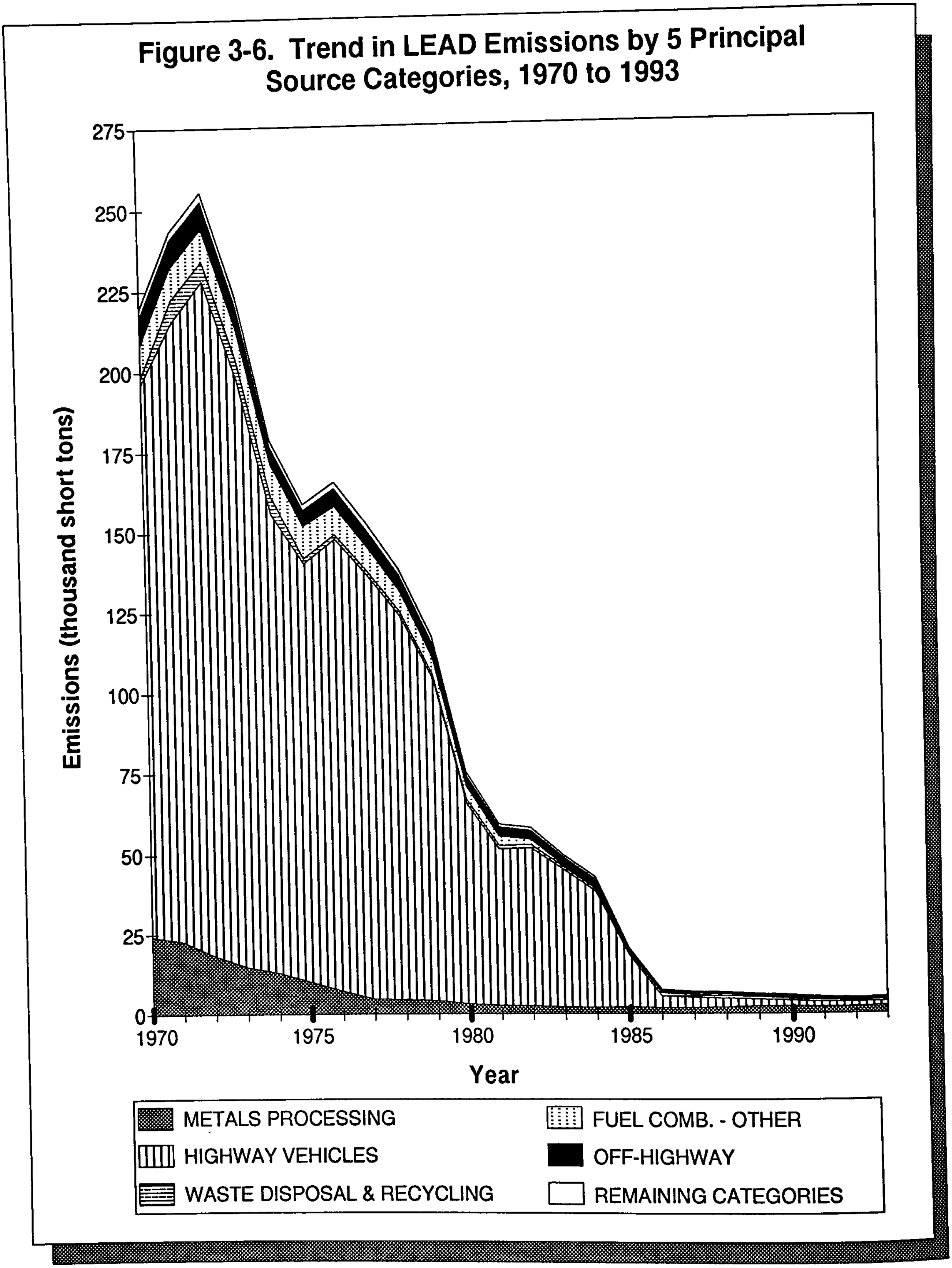
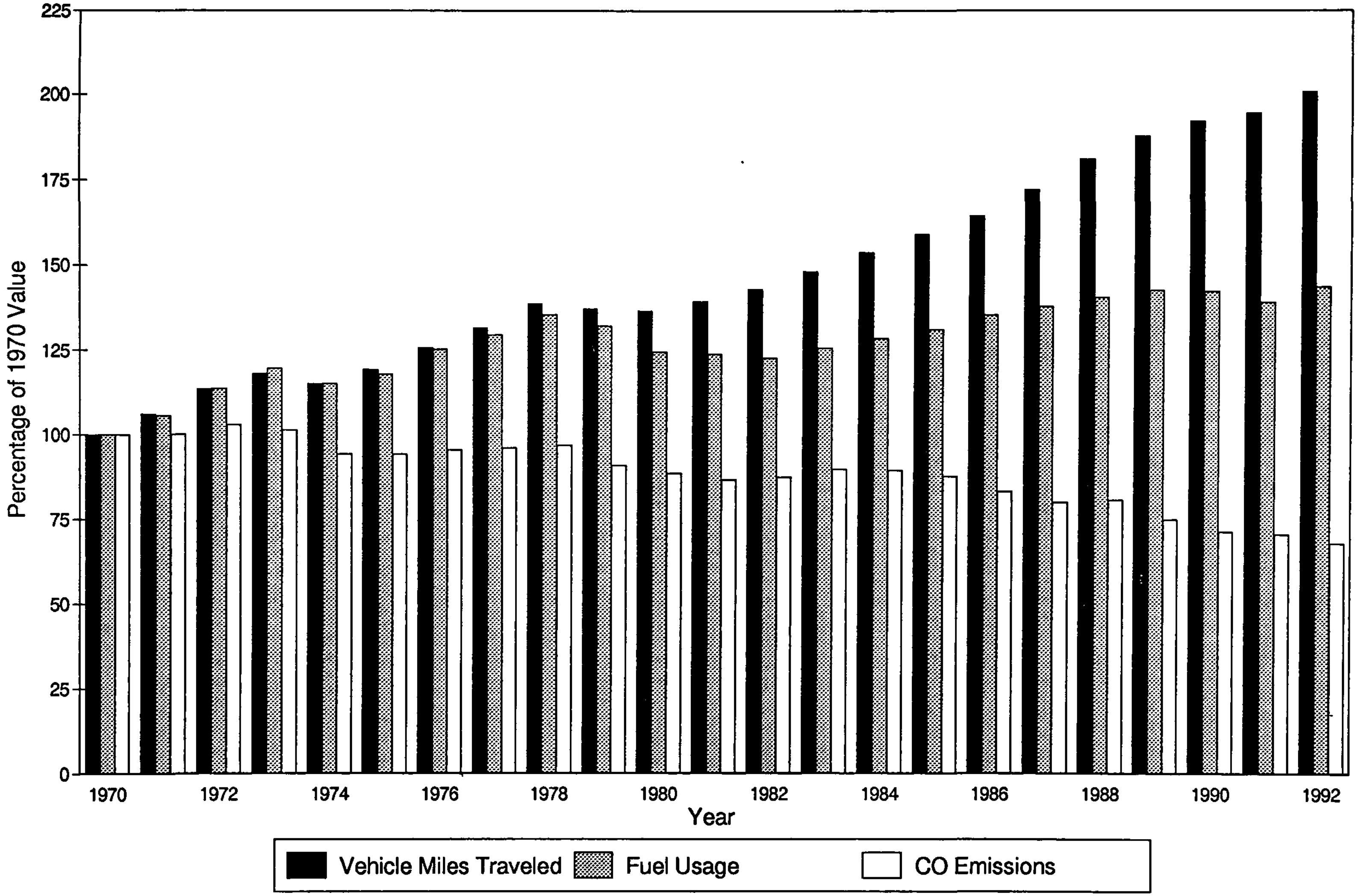


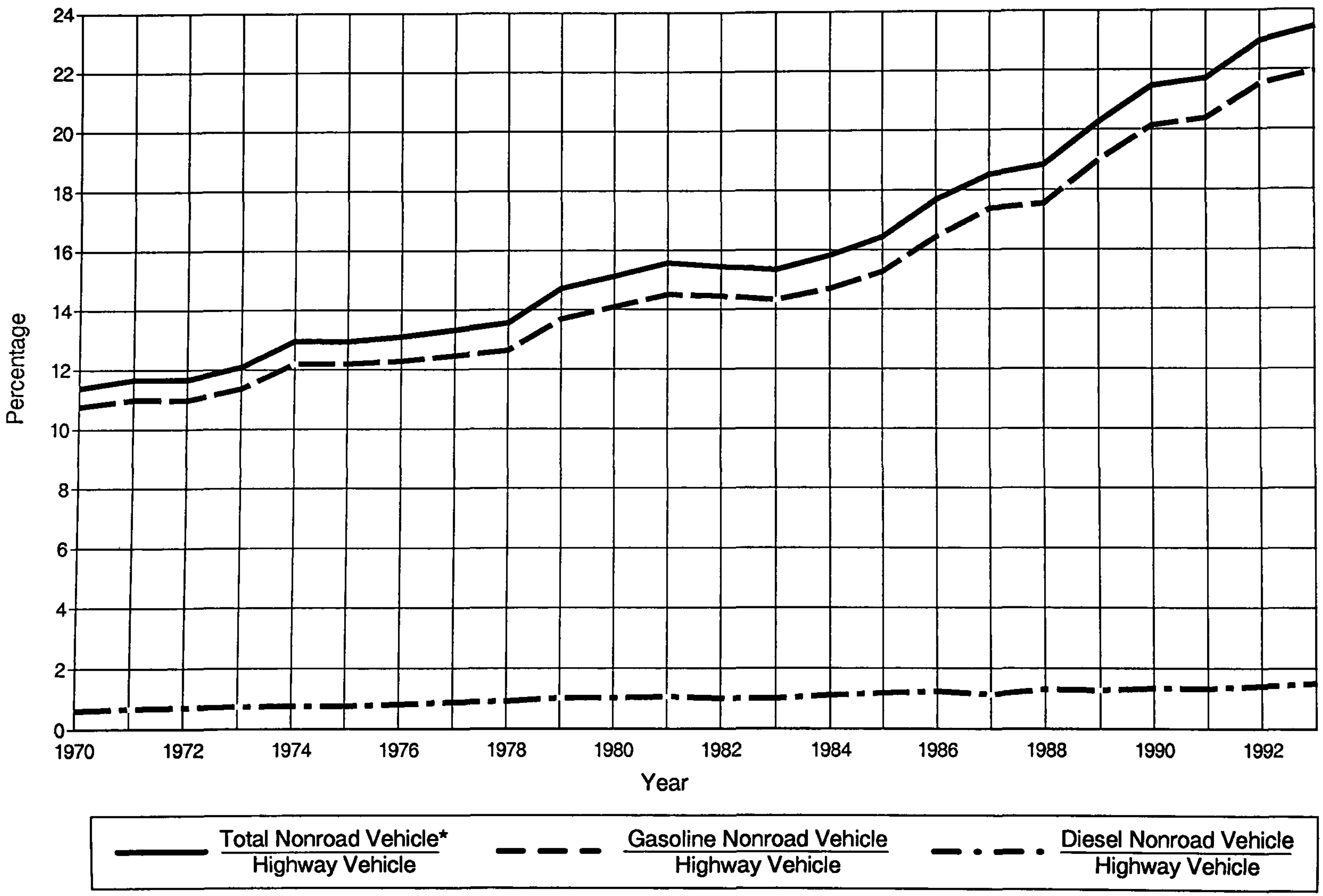
Figure 3-6. Trend in LEAD Emissions by 5 Principal Source Categories, 1970 to 1993
Emissions (thousand short tons)
275
250
225
200
175
150
125
100
75
50
25
0
1970
1975
1980
1985
1990
Year
METALS PROCESSING
HIGHWAY VEHICLES
WASTE DISPOSAL & RECYCLING
FUEL COMB. - OTHER
OFF-HIGHWAY
REMAINING CATEGORIES

Figure 3-7. Trends in CARBON MONOXIDE Emissions, Vehicle Miles Traveled, and Fuel Usage



Source: Fuel Consumption data from Highway Statistics, Tables MF-25 and MF-26, includes gasoline, diesel, and gasohol.

Figure 3-8. Ratio of Nonroad Gasoline and Diesel Vehicle to Highway Vehicle CARBON MONOXIDE Emissions



* Total Nonroad Vehicle emissions do not inlcude emissions from aircraft, railroads, or marine vessels.

SECTION 4.0

REGIONAL EMISSION TRENDS, 1985 THROUGH 1993

This section presents the results of estimating the total emissions in each of the 10 EPA regions. A map of the 10 EPA Administrative regions is presented in Figure 4-1. When comparing emissions from different regions, it is important to consider the size of the region, population, economic activity, predominant types of industry, soil type, and other factors that affect air pollution. Total regional emissions for 1985 through 1993 are presented by pollutant and year in Appendix B, Tables B-1 through B-6. Figures 4-2 through 4-7 show the total emissions of each pollutant by EPA region for 1985 through 1993.

It should be noted that the regional emissions shown in the previous report[1] have been replaced by new estimates. As described in section 6, regional emissions for lead are calculated as a fraction of the total national emissions of each source category.. Regional emissions of CO, NO_x, VOC, SO_2, and PM-10 are the sum of county emissions in each region.

The trends in regional emissions follow the trends in national emissions for most categories. This effect is largely due to the fact that each region has a diversity of source categories which reflect the national diversity. Some source categories, however, such as forest fires, prescribed burning, wind erosion, and certain industrial processes, produce significant regional effects and, therefore, do not necessarily follow national trends within the source category. These source categories will generally account for large changes at the regional level from one year to the next.

Of special note are the 1990 CO and VOC Region X emission changes presented in Figures 4-2 and 4-4. These changes are the result of a large number of wildfires in Alaska. Also of interest is the variation in the PM-10 emissions presented in Figure 4-6 for Regions VI and VII and to a lesser extent Region VIII. These changes are the result of wind erosion estimates being very sensitive to regional soil conditions and year-to-year changes in total precipitation and wind speeds.

4.1 REFERENCES

1. *National Air Pollutant Emission Trends, 1900 1992.* EPA-454/R-93-032, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1993.

Figure 4-1. U.S Environmental Protection Agency's Administrative Regions

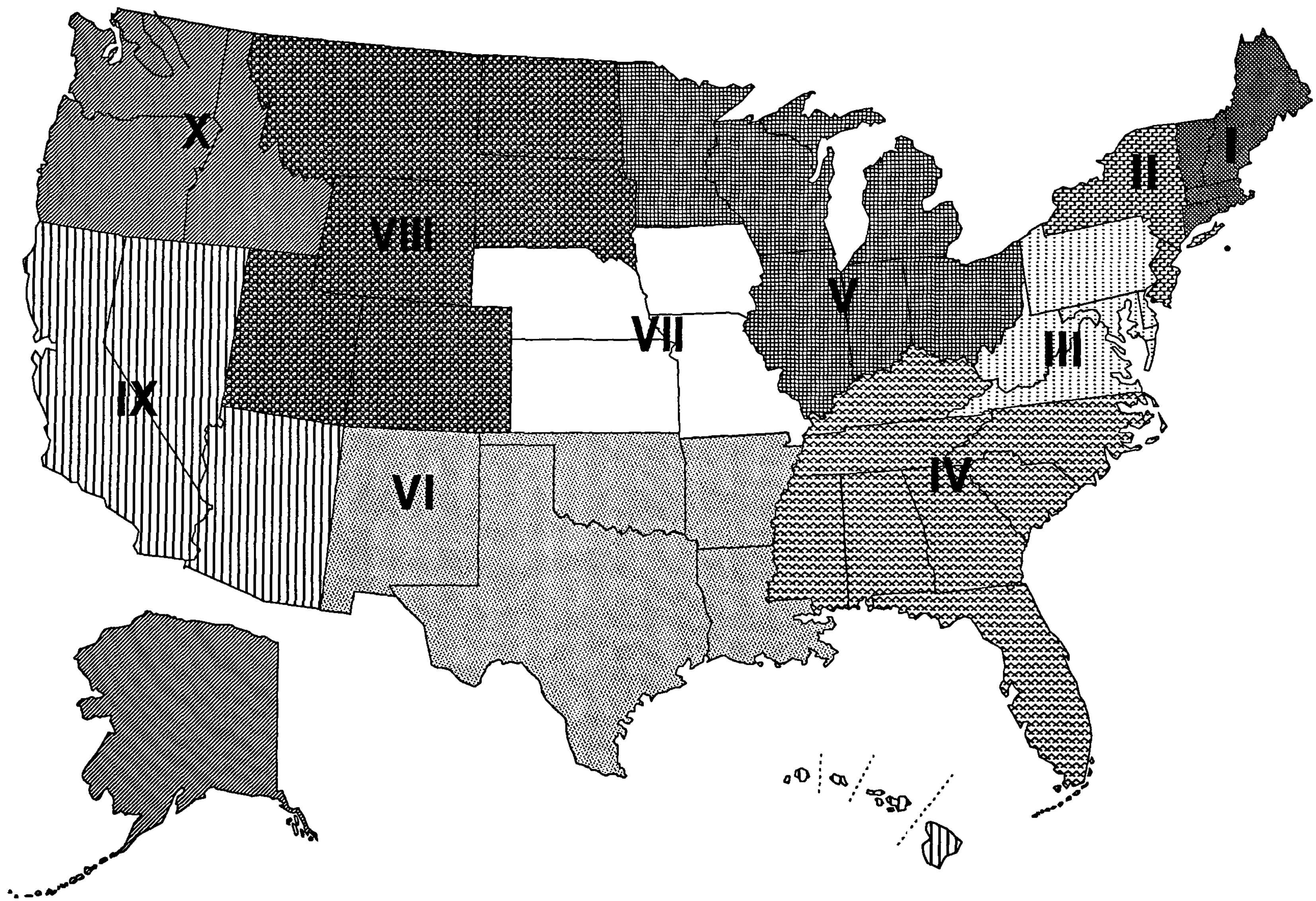


Figure 4-2. Trend in CARBON MONOXIDE Emissions by Region, 1985 TO 1993
(million short tons)

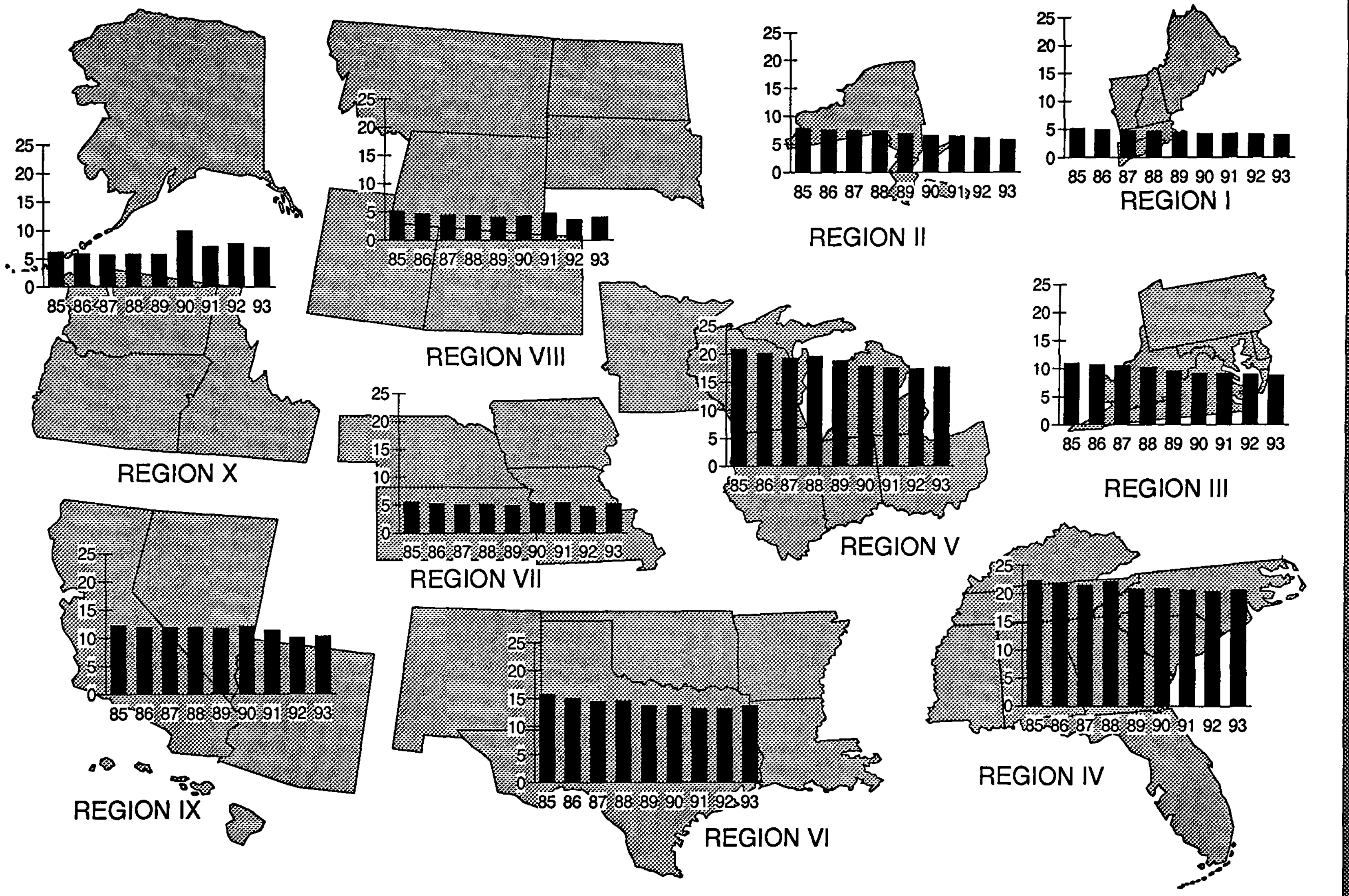


Figure 4-3. Trend in NITROGEN OXIDES Emissions by Region, 1985 TO 1993
(million short tons)

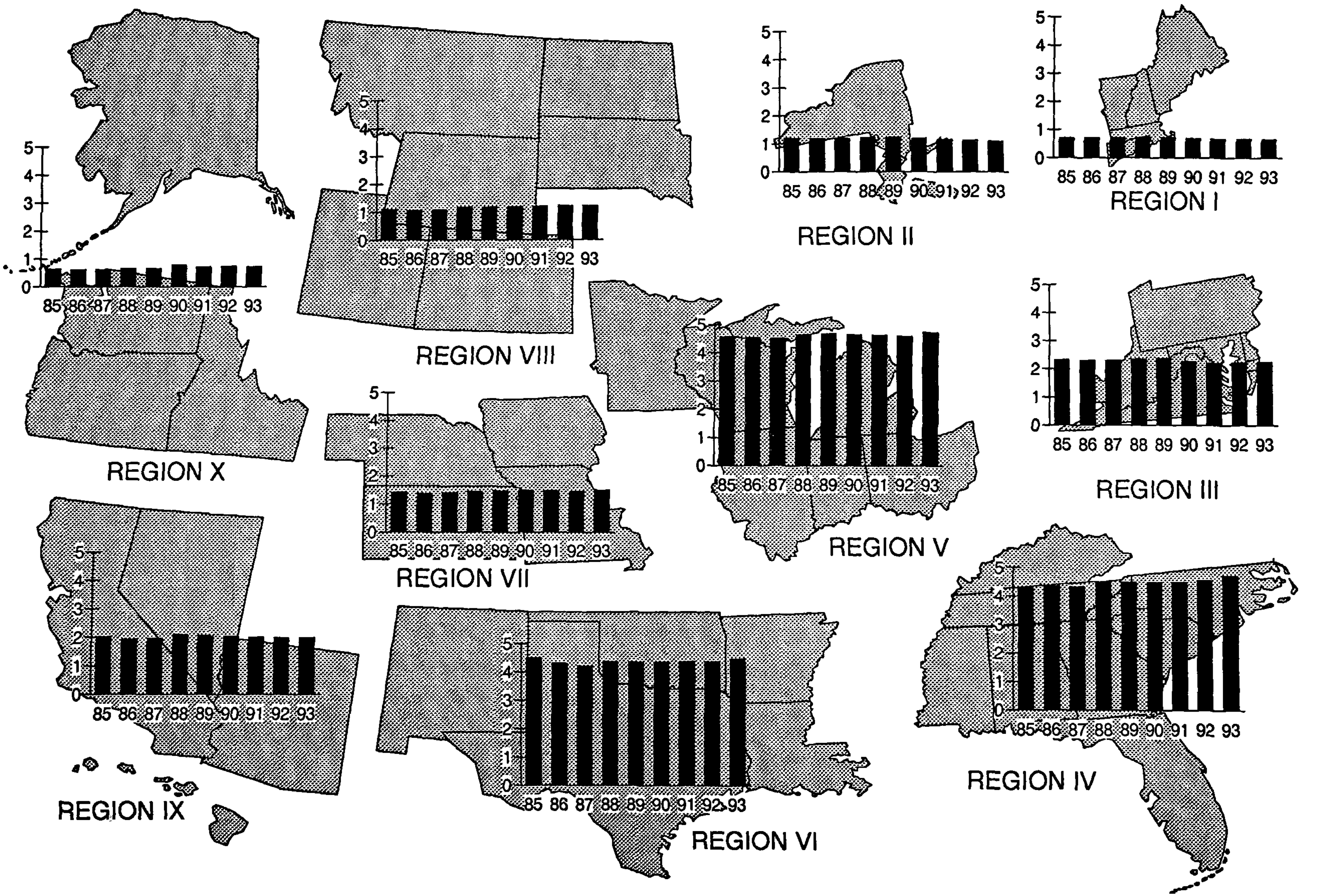


Figure 4-4. Trend in VOLATILE ORGANIC COMPOUND Emissions by Region, 1985 TO 1993
(million short tons)

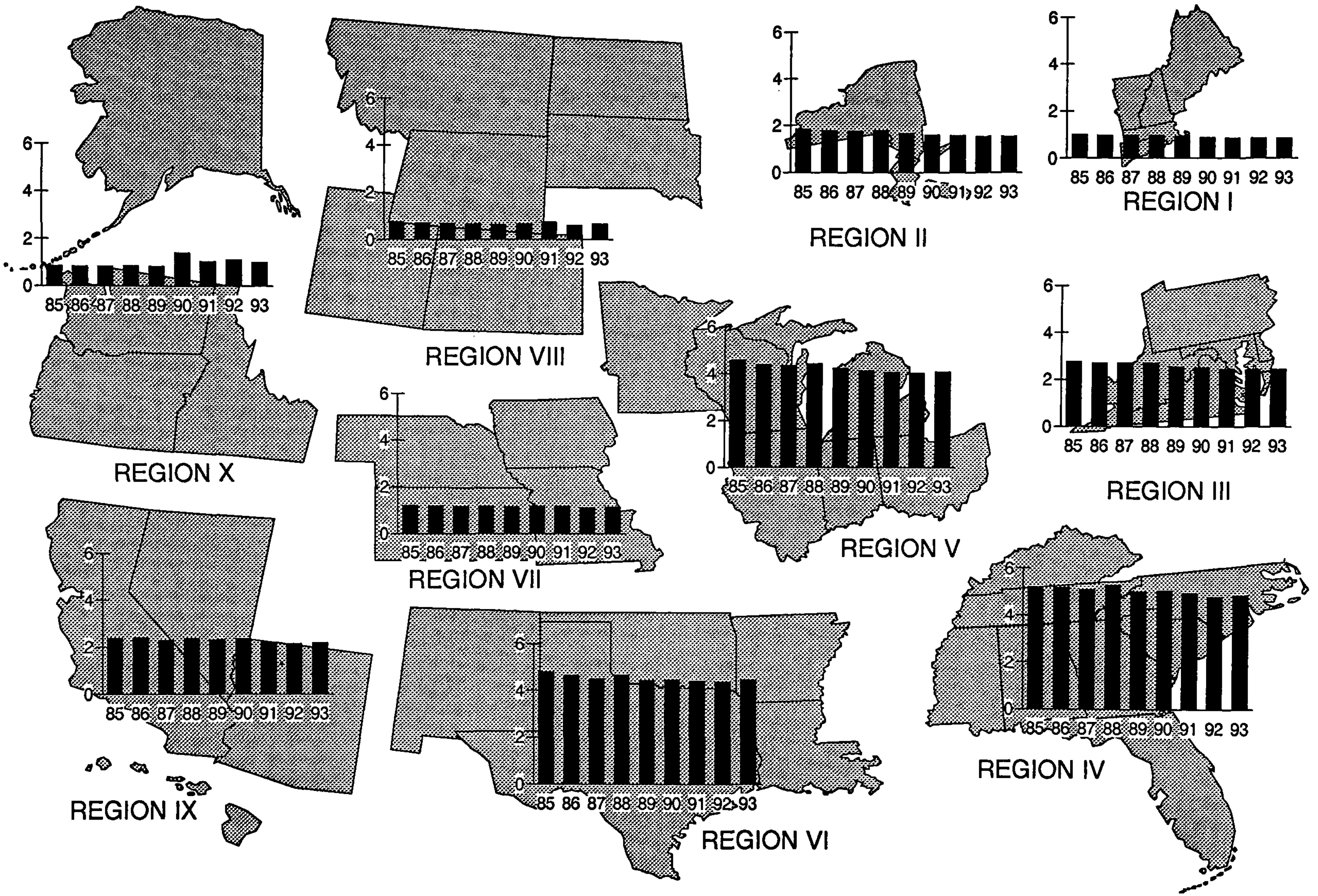


Figure 4-5. Trend in SULFUR DIOXIDE Emissions by Region, 1985 TO 1993
(million short tons)

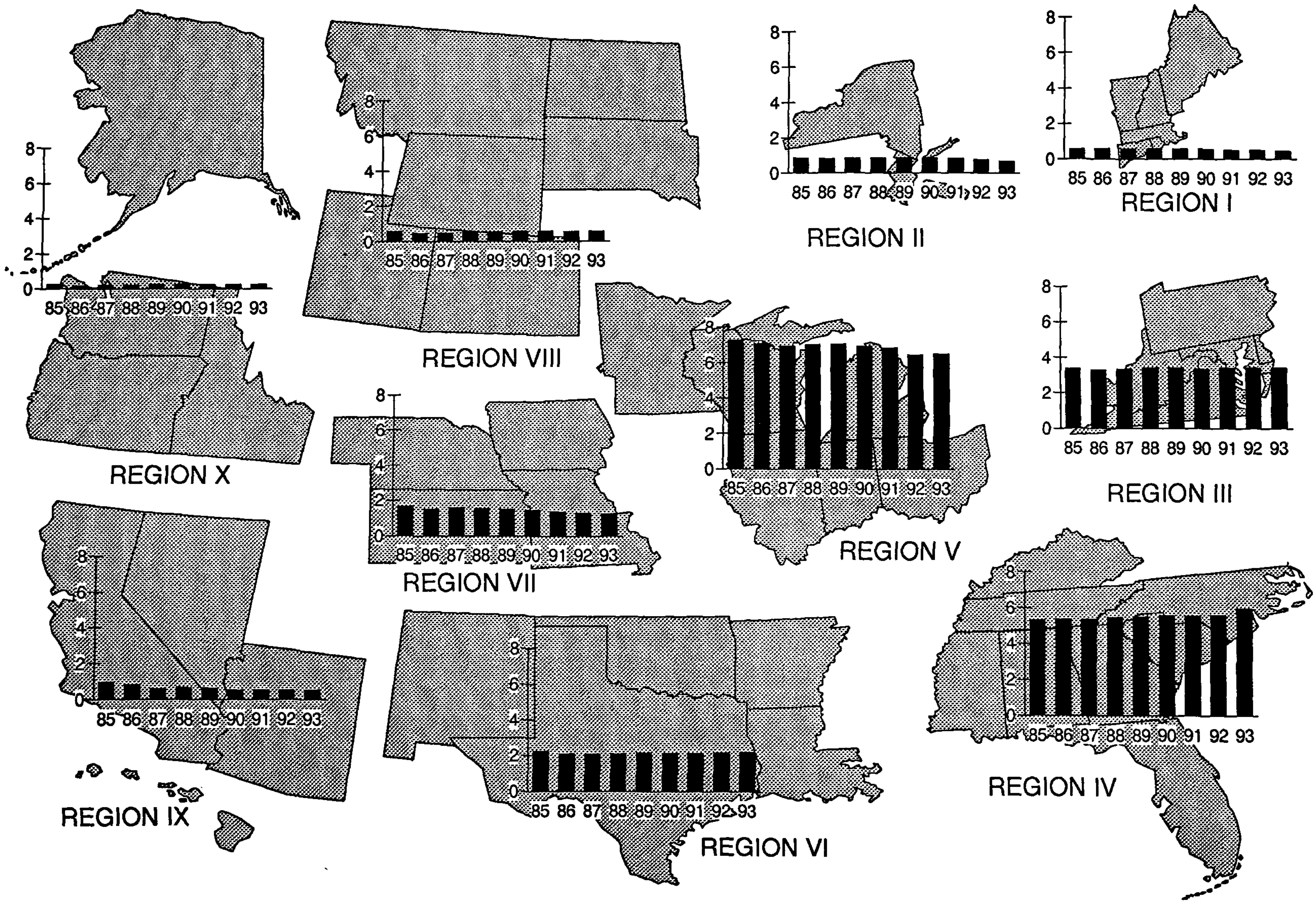


Figure 4-6. Trend in PARTICULATE MATTER (PM-10) Emissions by Region, 1985 TO 1993
(million short tons)

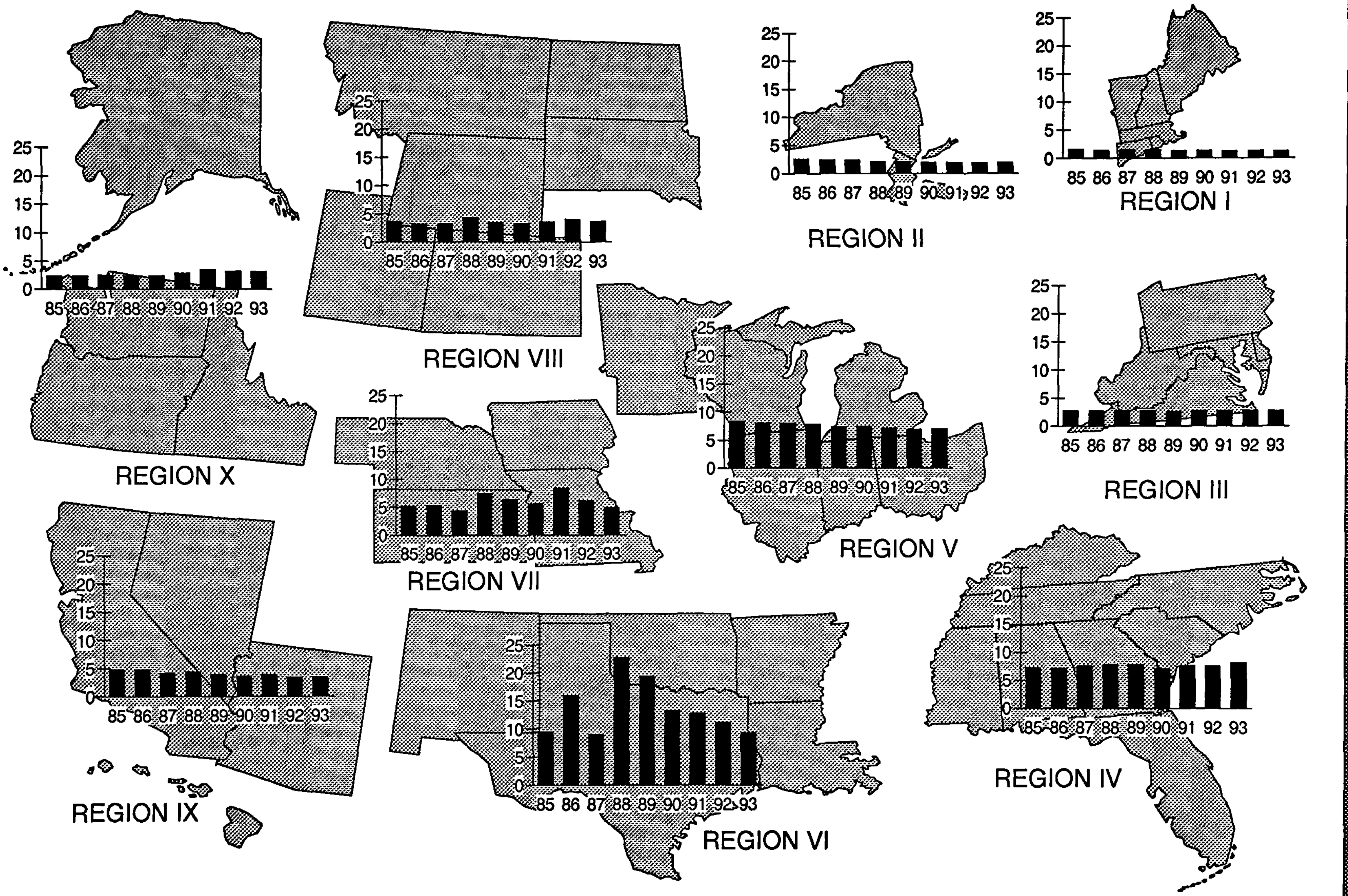
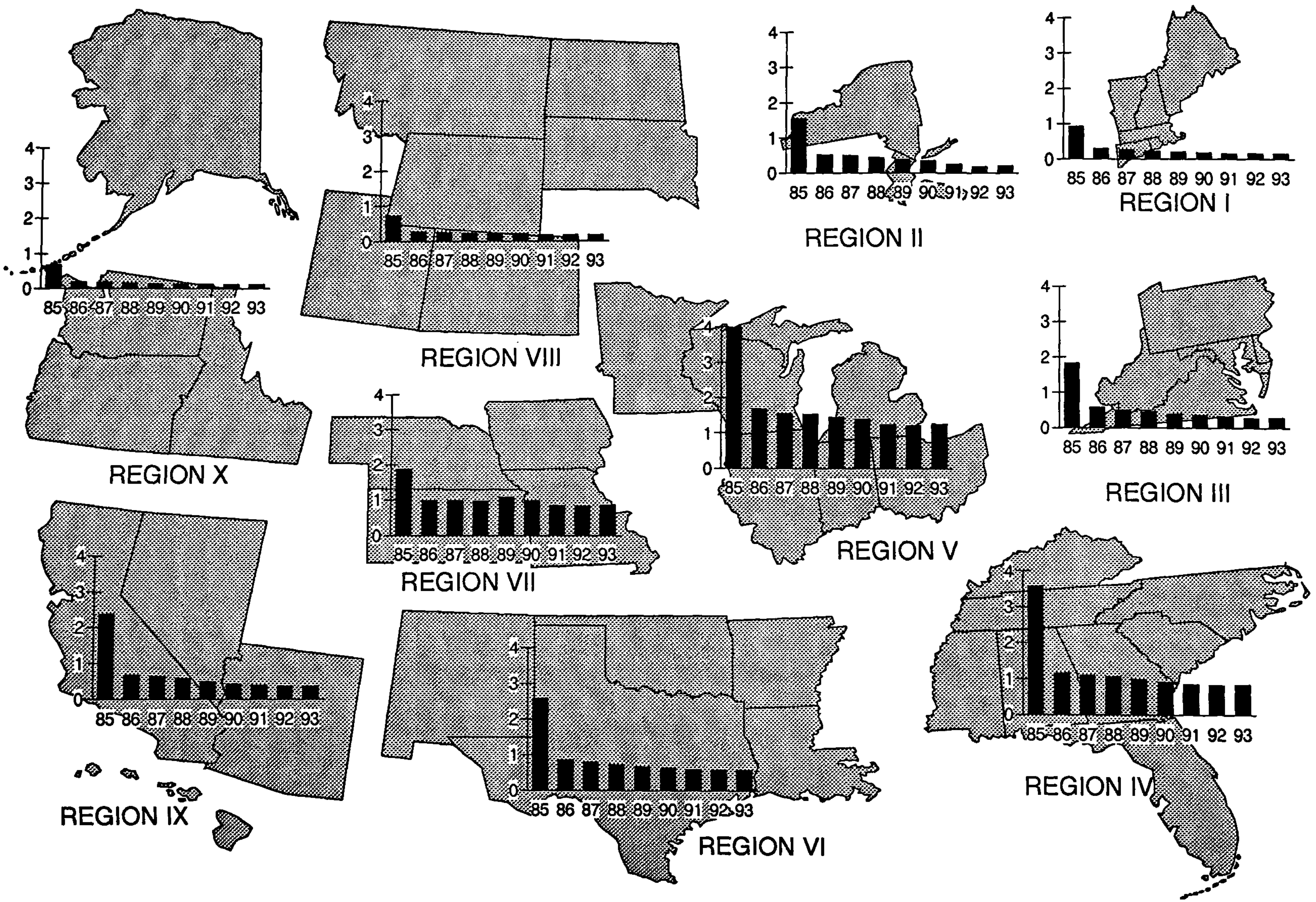


Figure 4-7. Trend in LEAD Emissions by Region, 1985 TO 1993
(thousand short tons)



SECTION 5.0

NATIONAL EMISSION PROJECTIONS, 1996 to 2010

Emission projections by pollutant through the year 2010 are shown in Tables 5-1 through 5-5 for CO, NO_x, SO_2, VOC, and PM-10, respectively. For most source categories, emission projections are based on growth factors from EPA's Economic Growth Analysis System (E-GAS).[1] (Department of Energy generation projections[2] are used for utilities and MOBILE4.1 Fuel Consumption Model[3] projections are used for motor vehicles.) Changes in emission controls are modeled to project the effects of the CAAA on future emission levels. The growth factors project growth in activity only and do not include changes due to new technology (i.e., improved efficiency). The control factors will capture changes in technology mandated by the CAAA but may not capture new technologies and increased efficiency of process which are not mandated by the CAAA.

Emission projections are a function of growth factors and future control level estimates, both of which have associated uncertainties. Growth factors, in general, are more uncertain the further into the future the growth is projected. In any given projection year, unexpected upturns or downturns in the economy may occur which are unaccounted for in projections of trends in activity. While the control factors applied may account for control initiatives resulting from CAAA requirements, increased production efficiency and technological changes (which may be a result of initiatives to decrease production costs) may not be taken into account.

National projections are shown in the following tables for each pollutant. These projections can be used to show which pollutants are expected to increase or decline, and to show which sectors have the greatest impact on total emissions and future emission levels. While the future levels may give an indication of whether air quality can be expected to improve, it should be noted that air quality indicators (e.g., ambient concentrations) vary significantly by area and that these national projections may not adequately indicate the emission changes expected in individual areas currently in nonattainment for PM-10, SO_2, CO, and ozone. Caveats associated with the controls modeled for each pollutant are discussed below.

5.1 FUTURE EXPECTED TRENDS IN CARBON MONOXIDE EMISSIONS

Trends in CO emissions through 2010 are shown in Table 5-1 and illustrated in Figure 5-1. Total emissions are expected to show a continued decline through 2000 with emissions showing a slight increase in 2002 continuing into the future. Emissions in 2010 likely will remain below 1990 levels. The decline through 2000 is due entirely to expected decreases in highway vehicle emissions as a result of more stringent tailpipe standards, enhanced inspection and maintenance (I/M) in ozone and CO nonattainment areas, and oxygenated fuels. These decreases in highway vehicle emissions outweigh small increases in other source categories. As VMT increases begin to dominate over any further decreases in highway vehicle emission factors, total emissions begin to increase.

5.2 FUTURE EXPECTED TRENDS IN NITROGEN OXIDES EMISSIONS

Projected levels of NO_x emissions through 2010 are shown in Table 5-2 and Figure 5-2. Total emissions show a slight increase from 1990 to 1993 followed by a decrease in 1996 as stationary source NO_x Reasonably Available Control Technology (RACT) is implemented and enhanced I/M programs begin in ozone nonattainment areas. Electric utility emissions show an expected decline in 1996 with RACT requirements and an additional decline between 1999 and 2000 as phase II Title IV standards become effective. While RACT control requirements for industrial fuel combustion emitters result in emission declines for this category, trends are dominated by decreases in predicted activity for coal and oil sectors. Highway vehicle emissions will likely continue to decline through 2005 as emission factor decreases due to tailpipe standards, phase II reformulated gasoline, and I/M requirements outweigh increases in VMT.

5.3 FUTURE EXPECTED TRENDS IN VOLATILE ORGANIC COMPOUND EMISSIONS

Trends in VOC emissions through 2010 are shown in Table 5-3 and Figure 5-3. Emission levels in 2010 are expected to remain lower than 1990 although total emissions show an upturn between 1999 and 2000. Emission projections for VOC include only the mandatory provisions of the CAAA including RACT, new Control Techniques Guidelines (CTGs), Federal measures for consumer solvents, Title I and II mobile source measures, and Title III Maximum Achievable Control Technology (MACT) standards. Provisions which are not accounted for and which may result in further declines (in ozone nonattainment areas) include new source offsets, progress requirements, and attainment and maintenance provisions. The largest expected decrease in emissions occurs between 1993 and 1996 as the majority of ozone nonattainment mandatory measures are implemented. Solvent utilization emissions show a continued decline through 1999 as more stringent control requirements become effective for consumer solvents. Highway vehicle emissions show a continued decline through 2005; VMT increases then begin to dominate over any additional reductions due to emission factor decreases. Effects of emission factor decreases become nil as tailpipe standards become increasingly pervasive in the course of fleet turnover.

5.4 FUTURE EXPECTED TRENDS IN SULFUR DIOXIDE EMISSIONS

Future year expected emission trends through 2010 for SO_2 are shown in Table 5-4 and Figure 5-4. Total emissions are predicted to continue to decline through 2010. Sulfur dioxide emissions are dominated by electric utility and industrial fuel combustion. Electric utility fuel combustion emissions show an expected continued decline through 2010 due to the lower emission cap in 2010. These projections assume that utilities bank a certain portion of their phase I allowances and use these banked allowances from 2000 to 2010. The projected 2010 utility emissions are approximately 6 million short tons greater than the 2010 electric utility SO_2 cap due to the use of the banked allowances.

Future year expected emission trends from industrial sources can be discerned from Table 5-4 by combining the emissions from Fuel Combustion-Industrial, Chemical and Allied Products Manufacturing, Metals Processing, Petroleum and Related Industries, Other Industrial Processes, Solvent Utilization, Storage and Transport, and Waste Disposal and Recycling. When future emissions from these sources are examined, they show a slight expected decrease from 1990 to 1993, and then show a slightly increasing trend to the year 2002. From 2002 to 2010 projected emissions are basically flat. In all cases, the emissions projections show that total national industrial SO_2 emissions remain below 5 million short tons, well below the 5.60 million short ton per year cap established by section 406 of the CAAA. As with historic emissions, industrial combustion emissions continue to be the largest contributor to future industrial SO_2 emissions, although Table 5-4 clearly shows that emissions from industrial combustion sources decrease in future years.

5.5 FUTURE EXPECTED TRENDS IN PARTICULATE MATTER (PM-10) EMISSIONS

Projections of future levels of PM-10 emissions are shown in Table 5-5 and Figure 5-5. Clean

Air Act Amendment controls reduce PM-10 emissions in nonattainment areas; however, because this is such a small subset of total national emissions, overall levels show an increase in emissions. The lower expected increase between 1990 and 1996 is generally due to the nonattainment area controls. Changes in emissions after 1996 are due solely to activity level changes with the exception of highway vehicles. Highway vehicle emission factors decrease due to diesel fuel standards and increased penetration of cleaner vehicles with fleet turnover. The further decrease between 2005 and 2008 is due to the CAAA standards for heavy duty diesel vehicles.

Wind erosion emissions can fluctuate substantially from year-to-year, depending on meteorological conditions which cannot be projected to the future. For this reason, all future year emissions are assumed to be equivalent to 1990 levels. The 1993 estimate is based on actual meteorological data. The large decrease seen in 1993 is due to substantial precipitation during the spring and summer months in the midwestern United States, which resulted in midwestern flooding and also acted to substantially reduce wind erosion emissions. The "dip" observed in Table 5.5 for wind erosion is a direct result of this 1993 anomaly.

5.6 REFERENCES

1. *Economic Growth Analysis System: User's Guide, Version 2.0.* EPA-600/R-94-139b. Joint Emissions Inventory Oversight Group, U.S. Environmental Protection Agency, Research Triangle Park, NC. August 1994.

2. *Recommendations to NAPAP Regarding SO_2 Emission Projections.* Report to the National Acid Precipitation Assessment Program (NAPAP). Prepared by Resources for the Future. Washington, DC. June 15, 1994.

3. *MOBILE4.1 Fuel Consumption Model.* Computer reports from EPA, Office of Mobile Sources, Ann Arbor, MI. August 1991.

Table 5-1. National Carbon Monoxide Emissions by Source Category for 1990 to 2010

(thousand short tons)

Source Category	1990	1993	1996	1999	2000	2002	2005	2008	2010
Fuel Combustion - Electric Utility	314	322	364	395	402	416	435	462	482
Fuel Combustion - Industrial	677	667	662	652	650	646	641	636	634
Fuel Combustion - Other	5,726	4,444	4,051	3,697	3,796	3,850	4,012	4,337	4,554
Chemical and Allied Prod. Mfg	1,940	1,998	2,086	2,192	2,230	2,309	2,436	2,502	2,540
Metals Processing	2,080	2,091	2,192	2,288	2,322	2,395	2,514	2,624	2,690
Petroleum & Related Industries	435	398	362	331	322	304	279	266	257
Other Industrial Processes	717	732	768	814	831	866	921	950	966
Solvent Utilization	2	2	2	2	2	2	2	2	2
Storage and Transport	55	56	60	65	66	70	75	77	79
Waste Disposal & Recycling	1,686	1,732	1,771	1,804	1,815	1,836	1,866	1,892	1,910
Highway Vehicles	62,858	59,989	48,874	46,003	45,309	44,525	44,533	45,835	46,749
Off-Highway	14,642	15,272	16,173	17,033	17,329	17,945	18,919	19,460	19,800
Miscellaneous	12,623	9,506	6,331	6,372	6,387	6,418	6,468	6,493	6,507
Total	103,753	97,208	83,697	81,649	81,461	81,580	83,100	85,535	87,169

Table 5-2. National Nitrogen Oxides Emissions by Source Category for 1990 to 2010

(thousand short tons)

Source Category	1990	1993	1996	1999	2000	2002	2005	2008	2010
Fuel Combustion - Electric Utility	7,516	7,782	6,761	6,978	5,921	6,102	6,379	6,781	7,072
Fuel Combustion - Industrial	3,256	3,176	2,985	2,908	2,892	2,866	2,827	2,793	2,772
Fuel Combustion - Other	732	732	718	706	702	692	678	655	639
Chemical and Allied Prod. Mfg	399	414	421	432	436	445	458	470	478
Metals Processing	81	82	86	90	91	94	99	103	106
Petroleum & Related Industries	100	95	91	88	87	86	84	83	83
Other Industrial Processes	306	314	339	366	375	395	427	445	455
Solvent Utilization	2	3	3	3	3	3	3	3	3
Storage and Transport	2	3	3	3	3	3	3	3	3
Waste Disposal & Recycling	82	84	86	88	89	90	92	93	94
Highway Vehicles	7,488	7,437	7,041	6,700	6,531	6,349	6,281	6,387	6,495
Off-Highway	2,843	2,986	3,184	3,344	3,400	3,519	3,711	3,824	3,893
Miscellaneous	384	296	206	207	207	207	209	209	209
Total	23,192	23,402	21,924	21,912	20,737	20,851	21,250	21,849	22,301

Table 5-3. National Volatile Organic Compound Emissions by Source Category for 1990 to 2010

(thousand short tons)

Source Category	1990	1993	1996	1999	2000	2002	2005	2008	2010
Fuel Combustion - Electric Utility	36	36	40	42	43	44	45	48	50
Fuel Combustion - Industrial	266	271	269	267	267	267	267	270	272
Fuel Combustion - Other	437	341	311	284	292	295	306	330	346
Chemical and Allied Prod. Mfg	1,771	1,811	1,682	1,594	1,605	1,632	1,675	1,713	1,735
Metals Processing	72	74	64	68	69	72	76	79	81
Petroleum & Related Industries	737	720	633	555	550	540	526	533	537
Other Industrial Processes	478	486	465	457	447	455	469	478	483
Solvent Utilization	6,063	6,249	6,247	5,867	5,947	6,170	6,532	6,730	6,853
Storage and Transport	1,861	1,861	1,761	1,519	1,530	1,556	1,603	1,635	1,654
Waste Disposal & Recycling	2,262	2,271	2,277	1,269	1,271	1,275	1,280	1,284	1,288
Highway Vehicles	6,854	6,094	5,147	4,846	4,742	4,632	4,578	4,657	4,726
Off-Highway	2,120	2,207	2,321	2,401	2,437	2,511	2,628	2,692	2,732
Miscellaneous	1,320	893	458	464	466	471	478	481	483
Total	24,276	23,312	21,678	19,634	19,666	19,919	20,462	20,931	21,240

Table 5-4. National Sulfur Dioxide Emissions by Source Category for 1990 to 2010

(thousand short tons)

Source Category	1990	1993	1996	1999	2000	2002	2005	2008	2010
Fuel Combustion - Electric Utility	15,898	15,836	12,100	11,500	11,300	10,980	10,500	9,900	9,500
Fuel Combustion - Industrial	3,106	2,830	2,866	2,887	2,908	2,958	2,962	2,912	2,882
Fuel Combustion - Other	597	600	592	566	554	530	494	455	430
Chemical and Allied Prod. Mfg	440	450	467	479	483	491	501	516	524
Metals Processing	578	580	579	579	580	580	581	582	583
Petroleum & Related Industries	440	409	390	371	364	352	335	328	323
Other Industrial Processes	401	413	445	477	488	510	545	566	578
Solvent Utilization	1	1	1	1	1	1	1	1	1
Storage and Transport	5	5	5	5	5	5	5	5	5
Waste Disposal & Recycling	36	37	38	39	39	39	40	41	41
Highway Vehicles	480	438	315	336	344	360	385	411	429
Off-Highway	265	278	291	305	309	319	335	348	355
Miscellaneous	14	11	7	7	7	7	7	7	7
Total	22,261	21,888	18,095	17,552	17,382	17,133	16,693	16,071	15,659

Table 5-5. National Particulate Matter (PM-10) Emissions by Source Category for 1990 to 2010

(thousand short tons)

Source Category	1990	1993	1996	1999	2000	2002	2005	2008	2010
Fuel Combustion - Electric Utility	291	270	309	334	338	353	375	404	425
Fuel Combustion - Industrial	228	219	214	201	198	193	186	179	176
Fuel Combustion - Other	930	723	660	594	609	618	643	694	729
Chemical and Allied Prod. Mfg	74	75	76	78	79	80	82	84	86
Metals Processing	140	141	148	155	157	162	171	178	182
Petroleum & Related Industries	28	26	24	23	22	21	20	19	19
Other Industrial Processes	306	311	331	353	360	376	402	416	424
Solvent Utilization	2	2	2	2	2	2	2	2	2
Storage and Transport	54	55	58	61	62	65	69	71	72
Waste Disposal & Recycling	242	248	254	259	260	263	268	271	274
Highway Vehicles	239	197	153	131	122	126	132	127	122
Off-Highway	372	395	427	455	464	485	517	531	540
Natural sources (wind erosion)	4,192	628	4,192	4,192	4,192	4,192	4,192	4,192	4,192
Miscellaneous	42,059	42,200	43,598	48,850	49,834	51,835	54,937	57,383	59,012
Total	49,158	45,489	50,447	55,686	56,701	58,772	61,996	64,553	66,255

Figure 5-1. Projected Trend in CARBON MONOXIDE Emissions by 5 Principal Source Categories, 1990 to 2010

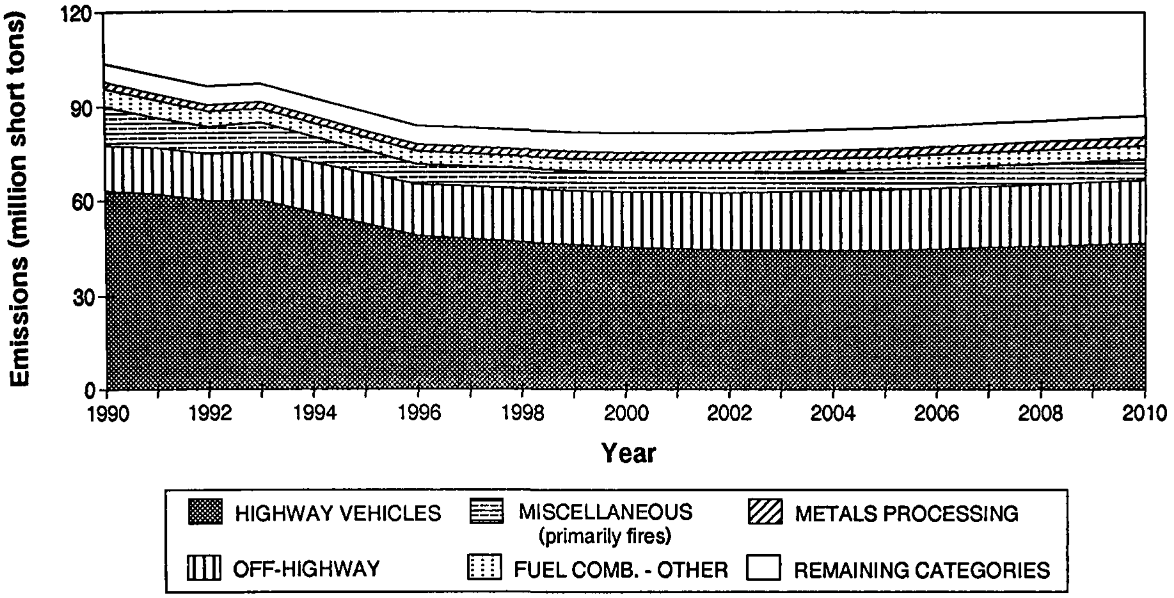


Figure 5-2. Projected Trend in NITROGEN OXIDES Emissions by 5 Principal Source Categories, 1990 to 2010

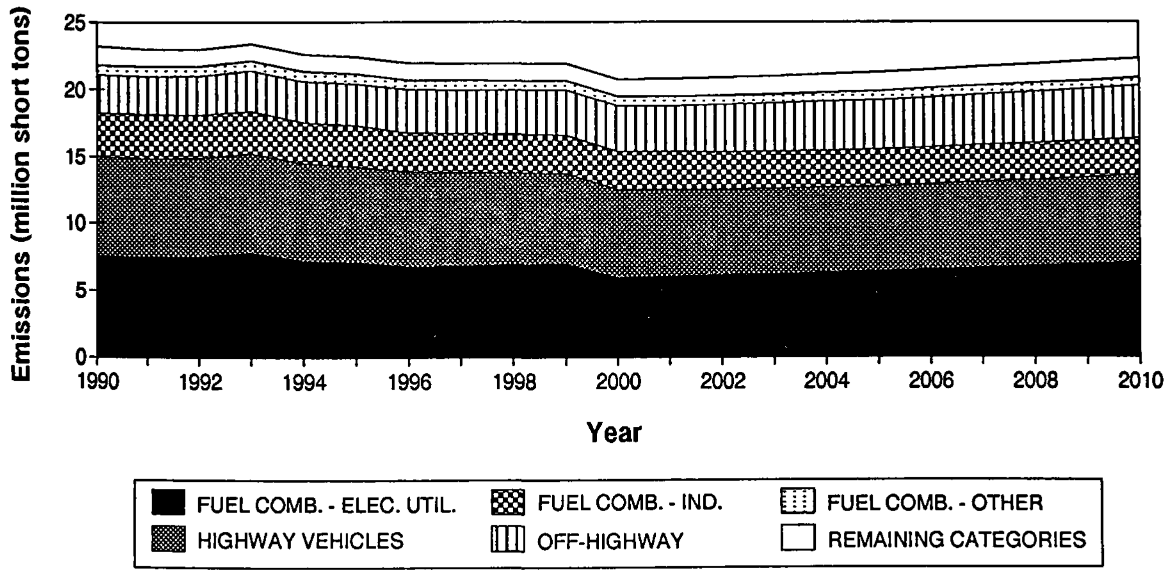


Figure 5-3. Projected Trend in VOLATILE ORGANIC COMPOUND Emissions by 5 Principal Source Categories, 1990 to 2010

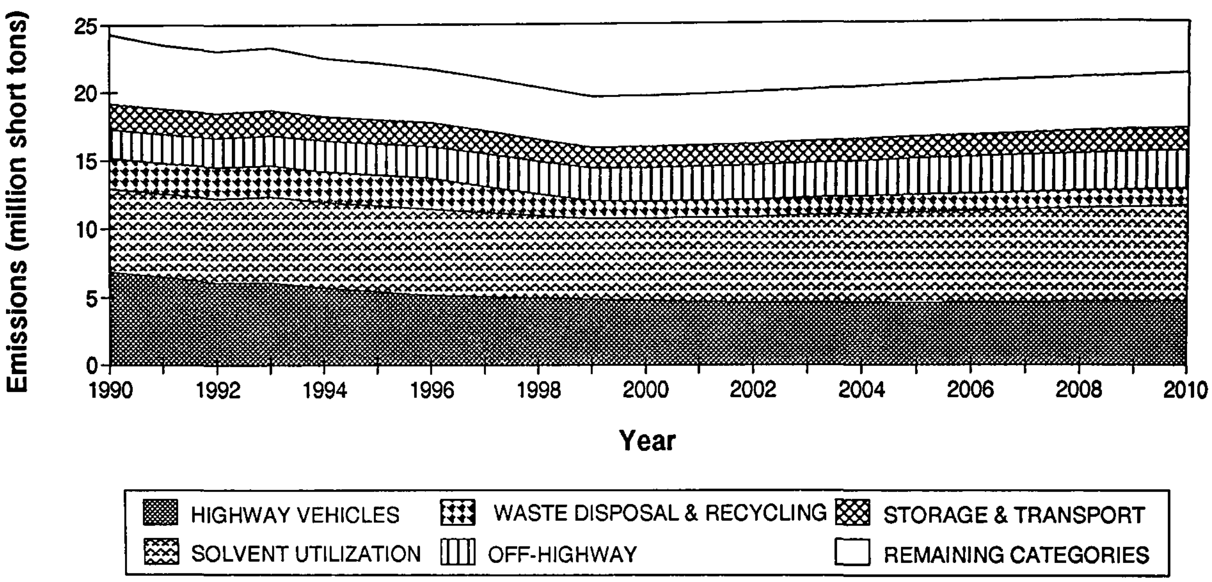


Figure 5-4. Projected Trend in SULFUR DIOXIDE Emissions by 5 Principal Source Categories, 1990 to 2010

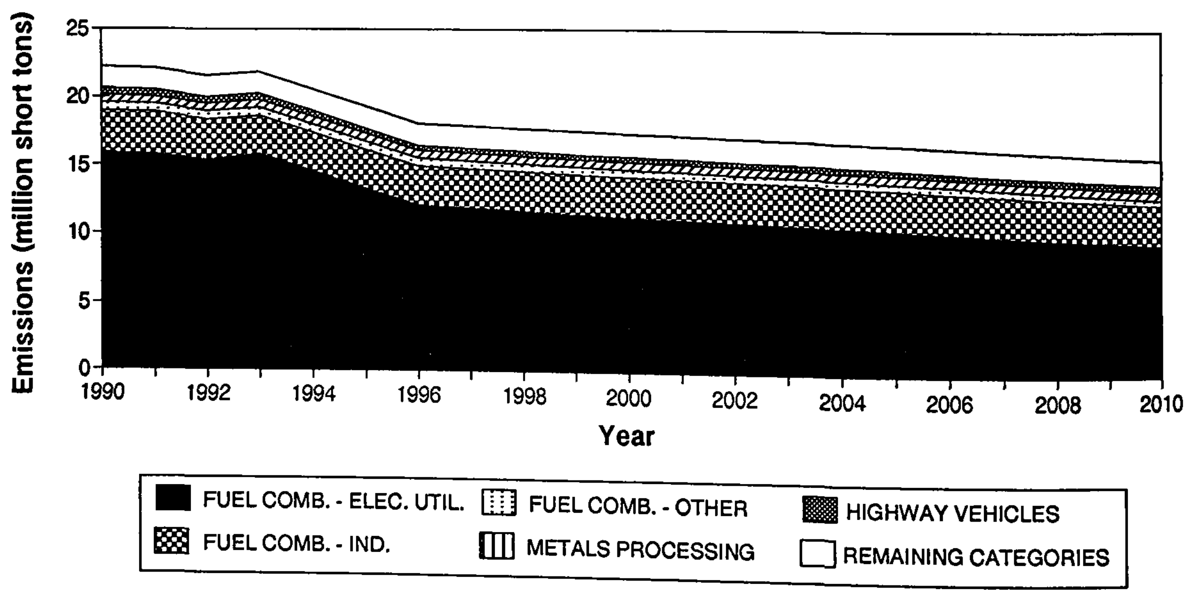
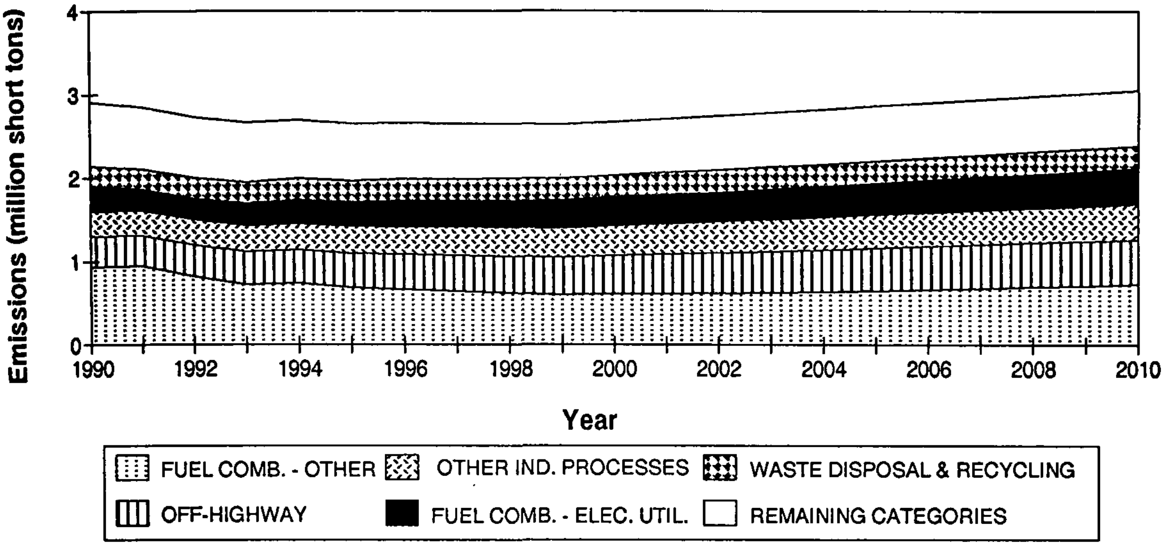


Figure 5-5. Projected Trend in PARTICULATE MATTER (PM-10) Emissions by 5 Principal Source Categories, 1990 to 2010



NOTE(s): Wind erosion, miscellaneous fires, and fugitive dust emissions are not included.

SECTION 6.0

NATIONAL CRITERIA POLLUTANT ESTIMATION METHODOLOGY

Each year the EPA prepares national emissions for assessing trends in criteria pollutant emissions. In the past, the emissions were estimated using consistent methodologies employing national statistics on economic activity, material flows, etc., for the years 1940 to the current year of the report. Although emissions prepared in this way were useful for evaluating changes from year to year, they did not provide an absolute or geographically detailed measure of emissions for any given year. Absolute emissions are extremely useful in many applications, such as inputs into atmospheric models. During the past several years, changes have been made to the methodologies in order to produce emissions for the *Trends* report, starting at the county level, which both represent an absolute measure of the emissions and allow for an evaluation of changes in emissions from year to year. For future *Trends* reports, these methodological changes will allow the incorporation of even more detailed SIP data for ozone nonattainment areas.

> Because of these changes in methodologies, COMPARISON OF VALUES WITH PREVIOUS *TRENDS* REPORTS IS NOT A VALID EXERCISE. The reader should use caution when comparing estimates for the years 1940 to 1993 from this report with values in any report previously published.

6.1 INTRODUCTION

Three major methodologies are used to estimate the emissions for successive intervals from 1900 through 1993 presented in this report. The applicable methodology is used according to the year for which emissions are being estimated. For the years 1985 to the current year, the emissions are based on the emissions inventories created for use in the modeling efforts made in response to the CAAA. Emission inventories known as the *Interim* inventories[1] were created for the years 1987 through 1991 for use as inputs into the Regional Ozone Model (ROM) and the Urban Airshed Model (UAM); the use of this methodology has been expanded in this report to the emissions for the years 1985 through 1993. In addition, the 1990 base year *Interim* inventory was designed to allow the replacement of emissions by the SIP data for nonattainment areas.

The emissions presented for the years 1940 through 1984 are based on the methodology used to estimate the emissions for these years found in all prior *Trends* reports, with several exceptions and modifications over the emissions previously presented. The emissions presented for the years 1900 through 1939 are taken from two reports on historic emissions.[2,3] The emissions presented for these years in the *Trends* report are unchanged from the emissions presented in past *Trends* reports.

This chapter presents a general description of the methodologies used to estimate the emissions presented in this report, as identified by the period of years for which each methodology is most often applied. More detailed descriptions of these methodologies are presented in the *Trends* Procedure Manual.[4]

Apart from applying the major methodologies, the emissions presented in this report have undergone additional revisions. These revisions include incorporation of current information, refinements in the methodology, and changes in priorities.

These revisions, as well as revisions anticipated in future *Trends* reports, are presented in this section.

The 1993 emissions are presented in this report at the region, state, county, nonattainment, and seasonal level for various tier level categories. Brief descriptions of the methodologies used to create these spatial and temporal emissions are also presented in this chapter.

In addition to presenting emissions for the current year and prior years, the *Trends* report presents national emission projections for the years 1996 through 2010. The methodologies used to produce these projected emissions are applied according to the following source categories: highway vehicles, electric utilities, and all other sources. This chapter includes a description of these three projection methodologies.

6.2 NATIONAL EMISSIONS, 1985 THROUGH 1993

The CO, NO_x, SO_2, and VOC emissions presented in this report for the years 1985 through 1993 have been estimated using a methodology based on the methodology developed for the *Interim* Inventories, with several exceptions. The *Interim* methodology was developed to produce the inventories for the years 1987 through 1991 and is presented in the *Regional Interim Emission Inventories (1987-1991).*[1] A similar methodology was developed for the preparation of a national 1990 PM-10 inventory as documented in the *Emissions Inventory for the National Particulate Matter Study.*[5] In order to generate the necessary emissions for the *Trends* report, the *Interim* methodology has been expanded to generate CO, NO_x, SO_2, and VOC emissions for the years 1985 and 1986, as well as PM-10 emissions for the years 1985 through 1989 and 1991. The 1992 and 1993 emissions for all pollutants, except Pb, and all source categories, except for steam generated fossil-fuel electric utility units, highway vehicles, wildfire, and most fugitive dust sources, have been projected from the 1990 emissions using growth factors created by the EPA's prereleased E-GAS, version 2.0.[6]

The lead emissions for the years 1985 through 1992 have been estimated using the methodologies presented in section 6.3 of this report. The weighted emission factors and control efficiencies were assumed to be constant from 1990 to 1993. The 1993 preliminary estimates were made by growing the 1992 activity data by one of two methods applied to the appropriate source category. The first of these two methods used a quadratic regression with weighted 20-year specific source category activity data. The other method used a linear regression with weighted 7-year activity data. This second method was applied to source categories where the trend in the activity data has changed significantly over the past 10 years.

A summary description of the methodology used to generate the emissions for the years 1985 through 1993 is presented in this section. This methodology is described in detail in the 1993 *Trends* Procedures Manual.[4]

6.2.1 Fuel Combustion

The emissions included in the fuel combustion category fall under three Tier 1 source categories:

FUEL COMBUSTION ELECTRIC UTILITY,
FUEL COMBUSTION INDUSTRIAL, AND
FUEL COMBUSTION OTHER.

The methodologies used to generate the CO, NO_x, PM-10, SO_2, and VOC emissions are described for the electric utilities category (section 6.2.1.1) and for the industrial and other categories, combined (section 6.2.1.2). Lead emissions were determined for the years 1985 through 1992 by using the methodology described in section 6.3 and for 1993 by using the methodology described in the introduction to section 6.2.

6.2.1.1 *Electric Utility Units*

The emissions from the combustion of fuel by electric utilities have been divided into two classifications: (1) steam generated fossil-fuel units (an electric utility unit is a boiler) and (2) nonsteam generated fossil-fuel units such as gas turbines (GT) and internal combustion (IC) engines. Two very different methodologies have been used to estimate the emissions for these two classes; each is described separately in this section. More detailed descriptions of the methodologies are presented in the *Trends* Procedures Manual.[4]

6.2.1.1.1 Fossil-Fuel Steam Electric Utility Units — The emissions from fossil-fuel steam electric utility units for the years 1985 through 1992 have been based on four basic factors: (1) fuel consumption, (2) emission factor, which relates the quantity of fuel consumed to the quantity of pollutant emitted, (3) fuel characteristics, such as sulfur content, ash content, and heating value of fuels, and (4) control efficiency, which indicates the amount of pollutant not removed by the use of control devices. The fuel consumption characteristics and control efficiencies were obtained at the boiler-level, while the emission factors were specified at the SCC-level. The 1993 emissions were extrapolated from the 1992 boiler-level emissions based on plant-level 1993 fuel consumption. These two methodologies are explained below.

It should be noted that these estimates do not include emissions from the combustion of anthracite coal which accounts for a very small percentage (< 1%) of the overall emissions from fuel combustion by fossil-fuel steam electric utility units.

6.2.1.1.1.1 1985 through 1992. The boiler-level fuel consumption and other data were obtained from the *Steam-Electric Plant Operation and Design Report* (Form EIA-767),[7] collected and published annually by the Energy Information Agency (EIA) of the U.S. Department of Energy (DOE). This form provided sulfur content and SO_2 control efficiency data necessary to estimate the SO_2 emissions, as well as ash content necessary to estimate the PM-10 emissions. In cases where more than one fuel type was consumed by an individual boiler, the EIA-767 data were specific to the fuel type.

In order to associate the boiler-level data with the appropriate emission factor, an SCC was assigned to each boiler and fuel type. These assignments were made based on the fuel type, boiler firing configuration, and boiler bottom type. Emission factors were obtained from the EPA's *Compilation of Air Pollutant Emission Factors* (AP-42),[8] and were both SCC- and pollutant-specific.

Although the NO_x control efficiency was not included in the EIA-767 data, this value was calculated for each boiler based on the assumption that the boiler was controlled such that the emission rate was equal to its regulatory limit.

The SO_2 emissions were computed as controlled emissions assuming 100 percent rule effectiveness and using the sulfur content of the fuel as specified in the EIA-767 data. The PM-10 emissions were computed as controlled emissions assuming 100 percent rule effectiveness. The PM-10 control efficiencies were determined by using the PM-10 calculator[14] and the TSP control devices from the EIA-767 data; the ash content of the fuel was also specified in the EIA-767 data. The NO_x emissions were computed as controlled emissions assuming 80 percent rule effectiveness. The CO and VOC emissions were calculated as uncontrolled emissions. These algorithms are presented in Table 6-1.

6.2.1.1.1.2 1993. Because the EIA-767 data were not available for the year 1993, 1992 and 1993 plant-level data from the *Monthly Power Plant Report* (Form EIA-759)[9] were used to grow the 1992 emissions to the year 1993. For the years 1992 and 1993, the annual fossil-fuel steam fuel consumption plant data were obtained from the EIA-759 data. The plant-level ratio of the

1993 fuel consumption to the 1992 fuel consumption was applied as a growth factor to the 1992 fuel consumption, heat input, and emissions for all pollutants for each boiler within a given plant.

6.2.1.1.2 Gas Turbines and Internal Combustion Engines — The 1990 emissions for GT and IC engines have been estimated from the point source portion of the 1985 NAPAP Emissions Inventory[10] for the appropriate sources. These 1990 emissions served as the base year from which the emissions for the years 1985 through 1989 and the years 1991 though 1993 were estimated. The emissions for the years 1985 through 1991 were estimated using historical earnings data complied by the Bureau of Economic Analysis (BEA), while the 1992 and 1993 emissions were estimated using growth factors produced by the prereleased E-GAS, version 2.0.

The methodology used to develop the emissions for the 1990 base year and the two methodologies used to estimate the emissions from the base year emissions are discussed in section 6.2.1.2. More detailed descriptions of the methodologies are presented in the *Trends* Procedure Manual.[4]

6.2.1.2 Industrial and Other Combustion

The source categories falling under industrial and other combustion include the combustion of fuels for use by industry, commercial establishments, institutions, and residences. The 1990 emissions for these source categories were generated from both the nonutility point source and nonsolvent area source portions of the 1985 NAPAP Emissions Inventory. These 1990 emissions served as the base year from which the emissions for the years 1985 through 1989 and the years 1991 through 1993 were estimated. The emissions for the years 1985 through 1991 were estimated using historical data compiled by the BEA or historic estimates of fuel consumption based on the DOE's State Energy Data System (SEDS).[11] The 1992 and 1993 emissions were estimated using growth factors produced by the prereleased E-GAS, version 2.0.

The methodologies used to generate the emissions for the 1990 base year and the two methodologies used to generate the emissions from the base year are discussed in this section. More detailed descriptions of these methodologies are presented in the *Trends* Procedures Manual.[4]

6.2.1.2.1 1990 Base Year Inventory — The 1985 NAPAP Emission Inventory estimates for the nonutility point sources have been projected to the year 1990 based on the growth in BEA historic earnings for the appropriate state and industry, as identified by the 2-digit Standard Industrial Classification (SIC) code.[12] In order to remove the effects of inflation, the earnings data were converted to 1982 constant dollars using the implicit price deflator for personal consumption expenditures (PCE).[13] State and SIC-level growth factors were calculated as the ratio of the 1990 earnings data to the 1985 earning data.

The area source emissions from the 1985 NAPAP Emissions Inventory that fall within this category have been projected to the year 1990 based on BEA historic earnings data, BEA historic population data, DOE SEDS data, or other growth indicators. The specific growth indicator was assigned based on the source category. The BEA earnings data were converted to 1982 dollars as described above. The 1990 SEDS data were extrapolated from data for the years 1985 through 1989. All growth factors were calculated as the ratio of the 1990 data to the 1985 data for the appropriate growth indicator.

When creating the 1990 emissions inventory, changes were made to emission factors, control efficiencies, and emissions from the 1985 inventory for both the nonutility and area sources. The PM-10 control efficiencies were obtained from the PM-10 Calculator.[14] Details of these changes are presented in the *Trends* Procedures Manual,[4] as well as the reports documenting the *Interim* Inventories and 1990 PM-10 inventory.[1,5]

In addition, rule effectiveness which was not applied in the 1985 NAPAP Emission Inventory, was applied to the 1990 emissions estimated for the nonutility point sources. The CO, NO_x, and VOC point source controls were assumed to be 80 percent effective; PM-10 and SO_2 controls were assumed to be 100 percent effective.

The 1990 emissions for CO, NO_x, SO_2, and VOC were calculated using the following steps: (1) projected 1985 controlled emissions to 1990 using the appropriate growth factors, (2) calculated the uncontrolled emissions using control efficiencies from the 1985 NAPAP Emission Inventory, and (3) calculated the final 1990 controlled emissions using revised control efficiencies and the appropriate rule effectiveness. The 1990 PM-10 emissions were calculated using the TSP emissions from the 1985 NAPAP Emission Inventory. The 1990 uncontrolled TSP emissions were estimated in the same manner as the other pollutants. From these TSP emissions, the 1990 uncontrolled PM-10 estimates were calculated by applying SCC-specific uncontrolled particle size distribution factors.[8] The controlled PM-10 emissions were estimated in the same manner as the other pollutants. Because the majority of area source emissions for all pollutants represented uncontrolled emissions, the second and third steps were not required to estimate the 1990 area source emissions.

6.2.1.2.2 1985 through 1989 and 1991 — The 1990 emissions served as the base year emissions; these emissions were used to generate the emissions for the years 1985 through 1989 and for the year 1991. The methodologies developed to produce the CO, NO_x, SO_2, and VOC emissions for the *Interim* inventory were applied to the PM-10 emissions.

The changes in the nonutility point source emissions were equated with the changes in historic earnings by state and industry. Emissions from each point source in the 1985 NAPAP Emissions Inventory (excluding steam electric utilities) were projected to the years 1987 through 1991 based on the growth in earnings by industry (2-digit SIC code). Historical earnings data from BEA's Table SA-5[12] were used to represent growth in earnings from 1985 through 1990. (Earnings data from a different BEA source, Table SQ-5 discussed below, were used to estimate 1991 emissions.) Table SA-5 historical annual earnings data are by state and industry.

The 1985 through 1990 earnings data in Table SA-5 are in nominal dollars. In order to be used to estimate growth, these values were converted to constant dollars to remove the effects of inflation. Earnings data for each year were converted to 1982 constant dollars using the implicit price deflator for personal consumption expenditures (PCE).[13] The PCE deflators used to convert each year's earnings data to 1982 dollars are:

Year	1982 PCE Deflator
1985	111.6
1987	114.3
1988	124.2
1989	129.6
1990	136.4

Several BEA categories did not contain a complete time series of data for the years 1985 through 1990. Because the SA-5 data must contain 1985 earnings and earnings for each inventory year (1987 through 1990) to be useful for estimating growth, a log linear regression equation was used to fill in missing data elements where possible. This regression procedure was performed on all categories that were missing at least one data point and which contained at least three data points in the time series.

Each record in the point source inventory was matched to the BEA earnings data based on the state and the 2-digit SIC. Table 6-2 shows the BEA earnings category used to project growth for each of the 2-digit SICs found in the 1985 NAPAP Emission Inventory. No growth in emissions was assumed for all point sources for which the matching BEA earnings data were not complete. Table 6-2 shows the national average growth and earnings by industry from Table SA-5.

At the time the *Interim* Inventory was compiled, 1991 BEA earnings data were not available in Table SA-5. Earnings data from BEA Table SQ-5[15] were used to estimate emissions for 1991. Table SQ-5 contains historical quarterly earnings data by state and 1-digit SIC. These data were converted to an annual constant dollars basis.

The 1991 quarterly earnings data were first summed to compute annual totals. Because the PCE deflator used to convert to constant 1982 dollars was not available for 1991, a 1987 PCE deflator[13] was used to convert the 1990 and 1991 earnings data from Table SQ-5 to a 1987 constant dollar basis. The PCE deflators are as follows:

Year	1987 PCE Deflator
1990	114.7
1991	119.3

The 1991 inventory was then developed by growing the 1990 inventory based on the changes in State industry earnings (by 1-digit SIC) from 1990 to 1991. National average growth in earnings by industry is shown below in Table 6-3.

The changes in the area source emissions were equated with the changes in the same growth indicators used to generate the 1990 emissions. The growth indicators based on BEA earnings data were applied in the same manner as described above for the point source emissions. All growth factors were calculated as the ratio of the data for the specific year to the 1990 data for the appropriate growth indicator.

The emissions for all pollutants for a given year between 1985 and 1991 were calculated by applying the appropriate growth factors to the 1990 base year emissions. The 1985 emissions estimated by this method do not match exactly the 1985 NAPAP Emissions Inventory due to the changes made when creating the 1990 emissions (e.g., the application of rule effectiveness or the application of updated emission factors).

6.2.1.2.3 1992 and 1993 — The 1992 and 1993 emissions for all pollutants were estimated by applying growth factors to the 1990 emissions. The growth factors were obtained from the prereleased E-GAS, version 2.0. The E-GAS generates growth factors at the SCC-level for counties representative of all counties within each ozone nonattainment area classified as serious and above and for counties representative of all counties within both the attainment portions and the marginal and moderate nonattainment areas within each state. The appropriate growth factors were applied by county and SCC to the 1990 emissions.

There are approximately 150 representative counties in E-GAS and 2000 SCCs present in the base year inventory. This yields a matrix of 300,000 growth factors generated to determine a single year's inventory. To list all combinations would be inappropriate. A subset of growth factors was extracted from the E-GAS output files based on those SCCs with growth factors greater than 1.1 (i.e., 10 percent or greater increase) or less than 0.8 (i.e., 20 percent or greater decrease). From this list Table 6-4 was generated by grouping the SCCs into Tier 1 and Tier 2 subcategories. The reader is cautioned that the growth factors for these source categories could have been applied to small emissions for one SCC in one county or to large emissions for several SCCs in several counties. The overall growth factors are best illustrated by the changes in emissions presented at the Tier 3 subcategory in Appendix A, Tables A-1 to A-5.

6.2.2 Transportation

The emissions included in the general heading of transportation fall under two Tier 1 source categories: highway vehicles and off-highway. The off-highway category includes the emissions from off-highway vehicles and equipment as well as aircraft, commercial marine vessels, and railroads. The methodologies used to estimate the emissions for the two tier categories are described separately. Lead emissions were determined for the years 1985 through 1992 by the methodology described in section 6.3 and for 1993 by the methodology described in the introduction to section 6.2.

6.2.2.1 Highway Vehicles

Highway vehicles emissions have been estimated for every year from 1970 through 1993. These annual emissions were based on county-level VMT and emission factors. Emissions were estimated for the following eight vehicle categories:

- light-duty gasoline vehicles (LDGV),
- light-duty diesel vehicles (LDDV),
- light-duty gasoline trucks-1 (LDGT-1 [trucks less than 6,000 pounds in weight]),
- light-duty gasoline trucks-2 (LDGT-2 [6,000 to 8,500 pounds in weight]),
- light-duty diesel trucks (LDDT),
- heavy-duty diesel trucks (HDDT),
- heavy-duty gasoline trucks (HDGT), and
- motorcycles (MC).

6.2.2.1.1 VMT Data — Annual VMT data for the years 1980 through 1993 were obtained from the Federal Highway Administration's (FHWA) highway performance monitoring system (HPMS) data base.[17] The data are specifed by state, vehicle type, and roadway type. Using population data from the 1980 census,[18] the data were distributed among the counties. For the years 1970 through 1979, the state-level VMT data were obtained from FHWA's Highway Statistics[19] and apportioned to the counties based on the distribution of the 1980 county-level VMT data. The data for all years were then apportioned from the HPMS vehicle categories to the eight vehicle classes listed above using allocations provided by the EPA's Office of Mobile Sources (OMS).

The resulting annual county-level vehicle and roadway type specific VMT data were temporally allocated to months. Seasonal NAPAP temporal allocation factors[20] were used to apportion the VMT to the four seasons. Monthly VMT data were obtained using a ratio between the number of days in a month and the number of days in the corresponding season.

6.2.2.1.2 CO, NO_x, VOC Emission Factors — County-level emission factors for CO, NO_x, and VOC were calculated using the MOBILE5a model,[21] which is designed to estimate exhaust and evaporative emission factors for highway vehicles. To calculate the emission factors for each year from 1970 through 1993, the model utilized information on state-level monthly maximum and minimum temperatures, nine vehicle speeds, national vehicle registration distributions, gasoline volatility given in terms of in-use Reid vapor pressure (RVP), and county-level I/M and oxygenated fuels programs. The Federal Test Procedure (FTP) operating mode was modeled at all speeds. The states of Colorado, New Mexico, and Utah were modeled as high altitude, while all other states were modeled as low altitude.

The state-level temperature data were based on data from the National Climatic Data Center.[22] Monthly temperature data from a selected city for each year were used to represent a state's average temperature. The national vehicle registration distributions for each year were based on the number of cars in operation by model year[23], sales data[24], and automobile survival rates.[25] The in-use RVP data for each year were obtained from OMS based on January and July fuel survey data from the American Automobile Manufacturers Association (AAMA).[26] Using guidance from OMS, these data were allocated and weighted to obtain state-level January and July RVP data. These data were then allocated to a monthly basis using American Society for Testing and Materials (ASTM) fuel volatility guidelines by state and month.[27] Information concerning the characteristics and implementation of I/M programs was obtained from the most recent I/M program summaries.[28] Information on the months and areas for which the oxygenated fuel program was modeled was provided by OMS.

The emission standards and fuel requirements in California are different from those for the remainder of the United States. Therefore, the California emission factors were generated separately using an OMS-modified version of MOBILE5a adapted to simulate the California fleet. In order to more accurately represent the temperature conditions for California, the state was divided into two regions and emission factors were produced independently for each region.

6.2.2.1.3 ***PM-10 and SO_2 Emission Factors —*** National 1990 PM-10 exhaust emission factors were developed independently for gasoline vehicles and for diesel vehicles. The PM-10 emission factors for gasoline vehicles were based on TSP emission factor data by vehicle type and model year.[29] The emission factors for diesel vehicles by vehicle type and model year were also based on TSP emission factor data and on diesel fraction of VMT.[30] A single TSP emission factor was developed for each of the five gasoline vehicle classes and the three diesel vehicle classes using travel fractions from MOBILE5[31] to weigh the TSP emission factors by model year and technology type. From these TSP emission factors, the PM-10 emission factors were developed using the PM-10 particle size multipliers[8].

The 1984 PM-10 exhaust emission factors were generated by the same methodology used for the 1990 emission factors. The differences between emission factors for 1984 and 1990 are due to changes in the mix of the vehicle technologies.

The final PM-10 emission factors include AP-42 emission factors accounting for tire wear and brake wear. The emission factors for all other years between the 1970 and 1993 were interpolated from the 1984 and 1990 emission factors.

National SO_2 emission factors were generated for every year between 1970 and 1993 using the parameters used to calculate the motor vehicle SO_2 emission factors in AP-42. The SO_2 emission factors are based on the fuel sulfur content, fuel density, and fuel economy. Of these parameters, the fuel economy varied from year to year. In addition, the sulfur content of diesel fuel changed in 1993.

6.2.2.2 Off-highway

This category includes the estimated emissions from aircraft, commercial marine vessels, railroads, and all other off-highway vehicles and equipment. The methodology used to generate the emissions for these sources is described in this section.

6.2.2.2.1 ***1990 Base Year Inventory —*** The 1990 emissions from aircraft, commercial marine vessels, and railroads have been estimated from the area source portion of the 1985 NAPAP Emission Inventory by the process described in section 6.2.1.2. The basis for the 1990 off-highway emissions was emission inventories prepared by OMS for 27 nonattainment areas (NAAs). These inventories were combined and used to create national county-level emissions. These emissions were classified by equipment and engine type in the OMS inventories and were distributed to the appropriate off-highway vehicle SCCs. The OMS inventories did not contain emissions for SO_2 and, therefore, none were included for the off-highway SCCs. It was assumed, based on the emissions from the 1985 NAPAP Emissions Inventory, that the SO_2 emissions for these SCCs were very small (< 92,000 short tons/year).

6.2.2.2.2 ***1970 to 1989 and 1991 —*** The off-highway emissions for the years 1970 through 1989 have been based on the 1990 estimates. Historic E-GAS growth factors were obtained by Bureau of Labor Statistics (BLS) codes and correlated to the off-highway SCCs.[32] These factors were applied to the 1990 emissions according to the methodology described in section 6.2.1.2.3.

6.2.2.2.3 ***1992 and 1993*** — The off-highway emissions for the years 1992 and 1993 were grown from the 1990 estimates using E-GAS growth factors according to the methodology described in section 6.2.1.2.3.

6.2.3 ***Industrial Processes***

The industrial processes category includes the estimated emissions for the following Tier I source categories:

CHEMICAL AND ALLIED PRODUCT MANUFACTURING,
METALS PROCESSING,
PETROLEUM AND RELATED INDUSTRIES,
OTHER INDUSTRIAL PROCESSES,
SOLVENT UTILIZATION (INDUSTRIAL AND NONINDUSTRIAL), AND
STORAGE AND TRANSPORT.

The CO, NO_x, PM-10, SO_2, and VOC emissions for these source categories, excluding the area source solvent utilization sources, have been produced by the methodology described in section 6.2.1.2. This includes all emissions based on the nonutility point source and nonsolvent area source emissions from the 1985 NAPAP Emission Inventory. Lead emissions were determined for the years 1985 through 1992 by the methodology described in section 6.3 and for 1993 by the methodology described in the introduction to section 6.2. The methodology used to estimate the emissions for area source solvent utilization is presented in this section.

The emissions from solvent utilization were based on a national material balance of the total point and area source solvent consumption. The 1989 national solvent consumption data were obtained from three sources.[33,34,35] The national solvent emissions were calculated by subtracting the quantity of solvent transferred to waste management operations[36] and the quantity of solvent destroyed by air pollution controls[10,37] from the total solvent consumption.

The 1989 national solvent emissions were apportioned to states and counties using data from the 1988 census data base.[38,39,40] Specific census measures such as population or employment were used for each solvent end-use category. State and local regulations covering solvent emissions, along with control efficiencies, rule effectiveness, and rule penetration were then applied to the county-level emissions.[41,42]

The 1989 county-level solvent emissions were projected to 1990 using BEA earnings data as previously described in section 6.2.1.2. The resulting 1990 solvent emission inventory included emissions from both area and point sources. The 1990 county-level point source solvent emissions estimated as described in section 6.2.1.2 were subtracted from the total solvent inventory to yield the 1990 area source solvent emissions. These estimates were projected to the years 1985 through 1989 and the years 1991 through 1993 by the method described in section 6.2.1.2.

6.2.4 ***Remaining Categories***

The "Remaining Categories" grouping includes the estimated emissions for three Tier I source categories:

WASTE DISPOSAL AND RECYCLING,
NATURAL SOURCES, AND
MISCELLANEOUS.

The emissions for the natural sources category included here are from geogenic sources producing PM-10 from wind erosion. The miscellaneous category is divided into four subcategories: agriculture and forestry, other combustion, fugitive dust, and health services.

The CO, NO_x, PM-10, SO_2, and VOC emissions for the years 1984 through 1993 from all source categories, except for those listed below, were produced using the methodology described in section 6.2.1.2. Lead emissions for the waste disposal and recycling sources were determined for the years 1985 through 1992 by the methodology described in section 6.3 and for 1993 by the methodology described in the introduction to section 6.2. This section presents a description of the methodology used to estimate the emissions for the following tier categories:

NATURAL SOURCES
- Geogenic
  - wind erosion

MISCELLANEOUS
- Agriculture and Forestry
  - agricultural crops and agricultural livestock
- Other Combustion
  - forest fires/wildfires
  - prescribed/slash and managed burning
  - fugitive dust.

More detailed descriptions of the methodologies used to produce these emissions are presented in the *Trends* Procedure Manual.[4]

6.2.4.1 Natural Sources, Geogenic, Wind Erosion

The PM-10 emissions for the years 1985 through 1993 from the wind erosion of agricultural lands were made using a modified version of the NAPAP methodology.[43] Monthly emissions were estimated from the acres of crops planted, the number of seconds, and the dust flux. The expected dust flux was based on the probability distribution of wind energy, the mean wind speed and the coefficient of drag.

The probability distribution of wind energy was determined from the mean wind speed and the threshold velocity which was, in turn, determined from the threshold friction velocity. The threshold friction velocity was a function of soil type and precipitation. Monthly meteorological data for average wind speed, total precipitation, and anemometer height (used in the calculation of the coefficient of drag) were obtained for each state.[22] Assignments of soil type were made for each state based on information from U.S. Department of Agriculture (USDA) surface soil map.[44] Based on this information and the assumption that wind erosion is zero from the time of plant emergence until harvest, fugitive dust emission fluxes were calculated.

The monthly precipitation value is critical in determining the dust flux from agricultural soils. Once the total monthly precipitation value exceeds 5.08 cm, an "after precipitation" threshold friction velocity is used to calculate the dust flux for that month. For most soil types, the "after precipitation" threshold friction velocity is substantially higher than the "before precipitation" value, because precipitation acts to "cement" soil grains together, thus increasing the wind velocity required to initiate erosion. The wind velocity required to initiate wind erosion must equal or exceed the threshold friction velocity. The average wind speed is related to the threshold friction velocity by the probability distribution for wind energy. Thus, by raising the threshold friction velocity required to initiate wind erosion, the probability that wind erosion will occur is reduced, since it requires a higher wind energy. In terms of probability theory, a higher wind energy is further out on the probability distribution curve. The overall effect of the "before" and "after" precipitation change in the threshold friction velocity is to provide an "on/off" function (i.e., a step function) to the calculation of wind erosion at equivalent average monthly wind speeds.

6.2.4.2 Miscellaneous, Agriculture and Forestry

The methodology used to estimate the emissions from agricultural crops and livestock are described in this section.

6.2.4.2.1 Agricultural Crops — The PM-10 emissions for the years 1985 through 1993 were estimated using the AP-42 emission factor equation for agricultural tilling.[8] The activity data for this calculation were the acres of land planted. The emission factor, expressed in terms of the mass of TSP produced per acre-tilled was corrected by the following constant parameters: the silt of the surface soil, the particle size multiplier, and the number of tillings per year.

6.2.4.2.2 Agricultural Livestock — The 1990 emissions from agricultural livestock were determined from activity data, expressed in terms of the number of heads of cattle[38] and a national PM-10 emission factor.[45] The emissions for the years 1985 through 1991 were produced using the methodology described for area source emissions in section 6.2.1.2.2. The emissions for the years 1992 and 1993 were produced using E-GAS growth factors as described in section 6.2.1.2.3.

6.2.4.3 Miscellaneous, Other Combustion

The emissions for the miscellaneous, other combustion category include agricultural burning, forest fires/wildfires, prescribed/slash and managed burning, and structural fires. The emissions from agricultural burning and structural fires were produced using the methodology described in section 6.2.1.2. The methodologies used to estimate the emissions for forest fires/wildfires and prescribed/slash and managed burning are described below.

6.2.4.3.1 Forest Fires/Wildfires — The emissions for the wildfire category were generated for the years 1990 through 1993 using the methodology described in section 6.3.4.2. For the years 1990 through 1992, the number of acres burned was obtained according to this methodology. For the 1993 emissions, the number of acres burned were determined by summing the 1993 Department of Interior (DOI) acreage data[46] and the USDA Forest Service acreage data[47,48] averaged over the years 1990 through 1992.

The emissions for the years 1985 through 1989 were estimated by the methodology described in section 6.2.1.2.

6.2.4.3.2 Prescribed/Slash and Managed Burning — The emissions for all pollutants were based on the 1989 USDA Forest Service inventory of particulate matter from prescribed burning.[49] This inventory contains state-level emissions for CO, PM-10, and VOC. The NO_x and SO_2 emissions were calculated by assuming the ratio between the CO emissions to either the NO_x or SO_2 emissions in the Forest Service inventory was equal to the corresponding ratio using the 1985 NAPAP Emission Inventory. The resulting 1989 emissions for CO, NO_X, PM-10, SO_2, and VOC have been used for all years between 1985 and 1993.

6.2.4.4 Miscellaneous, Fugitive Dust

The PM-10 fugitive dust emissions arise from construction activities, mining and quarrying, paved road resuspension, and unpaved roads. The general methodology used for these categories estimated the emissions by using an activity indicator, an emission factor, and one or more correction factors. The activity indicator for a given category varied from year to year as may the overall correction factor.

6.2.4.4.1 Construction Activities — The PM-10 emissions for the years 1985 through 1992 were calculated from an emission factor, an estimate of the acres of land under construction, and the average duration of construction activity.[50] The acres of land under construction were estimated from the dollars spent on construction.[51] The PM-10 emission factor was calculated from the TSP emission factor for construction obtained from AP-42 and the PM-10/TSP ratio.[45]

The 1993 emissions were extrapolated from the 1992 emissions using the ratio between the numbers of residential and nonresidential construction permits issued in 1993 and the numbers issued in 1992.

6.2.4.4.2 Mining and Quarrying — The PM-10 emissions for the years 1985 through 1992 were the sum of the emissions from metallic ore, nonmetallic ore, and coal mining operations. These PM-10 emissions arise from the following activities: (1) overburden removal, (2) drilling and blasting, (3) loading and unloading, and (4) overburden replacement. Emissions from transfer and conveyance operations, crushing and screening operations, and storage and travel on haul roads were not included.

To calculate the emissions from metallic ore mining, the PM-10 emission factors for copper ore processing operations[8,52] were applied to all metallic ores. The PM-10 emission factors for western surface coal mining[53] were used to estimate the emissions from both nonmetallic ore and coal mining.

The activity data for the metallic and nonmetallic mining was obtained from the Bureau of Mines, U.S. DOI.[54] The coal mining activity data was obtained from the U.S. DOE.[55]

The 1993 PM-10 emissions were produced through a linear projection of the emissions for the years 1985 through 1992.

*6.2.4.4.3 **Paved Road Resuspension*** — The calculation of total PM-10 emissions for the years 1985 through 1993 were based on the paved road VMT, a AP-42 base emission factor, and two correction factors: road surface silt loading and the number of dry days.[22] A dry day is defined as any day with less than 0.1 inches of precipitation. This term attempts to account for the effect of precipitation. Surface silt loading values by paved road functional classes and EPA region were determined using an empirical model based on traffic volume.[56]

Total VMT data for the years 1985 through 1992 were obtained by EPA region and road functional class.[19] The total preliminary 1993 VMT data were obtained by EPA region and two road types (urban and rural). The rural and urban VMT data were apportioned to the road functional classes using the distribution of the 1992 VMT data. The VMT from paved roads for each year was calculated by subtracting the unpaved road VMT (see section 6.2.4.3.6) from the total VMT for each year.

The base emission factor used in the calculation of total PM-10 emissions from paved roads accounts for the emissions from the vehicle (tailpipe, brake wear, and tire wear) as well as from the interaction between the vehicle and the road surface. The fugitive dust category includes only those emissions from the road surface and not the vehicle. For this reason, the PM-10 emissions for highway vehicles calculated as described in section 6.2.2.1 and distributed to paved roads using VMT data were subtracted from the total PM-10 emissions for paved roads. The results were the PM-10 fugitive dust emissions for paved roads.

*6.2.4.4.4 **Unpaved Roads*** — The total PM-10 emissions for the years 1985 through 1992 were based on the unpaved roads VMT data, a AP-42 base TSP emission factor, and the following correction factors: particle size multiplier, silt content of road surface material,[58] mean vehicle speed, mean vehicle weight, mean number of wheels,[57] and the number of dry days.[22] Mean vehicle speeds were assigned to each unpaved road functional class. The number of dry days is defined in the same manner as for estimating the paved road estimates. The VMT data for unpaved roads were obtained for rural and urban road functional classes excluding local types and for local road types.[19,59]

As with the PM-10 emissions from paved roads, the emissions from highway vehicles must be subtracted from the total emissions determined by the method described above in order to yield the PM-10 fugitive dust emissions from unpaved roads and to prevent the double-counting of vehicle emissions. The highway vehicle emissions were calculated as described in section 6.2.2.1 and were distributed to unpaved road using VMT data.

The 1993 PM-10 emissions were produced by multiplying the 1992 VMT by the AP-42 emission factor and 1993 correction factors.

6.3 NATIONAL EMISSIONS, 1940 THROUGH 1984

A top-down estimating procedure has been used to produce the criteria pollutant emissions for the years 1940, 1950, 1960, and 1970 through 1984, with several major exceptions. For all transportation sources, both highway vehicles and all off-highway transportation, the emissions for only the years 1940, 1950, and 1960 have been produced using this methodology. The lead emissions have been produced using this methodology for the years 1970 through 1992. In addition, the TSP emissions presented in Appendix C have been produced by this methodology. The SO_2 emissions for copper smelters for the years 1975 to 1984 were obtained from the plants as documented by the Argonne National Laboratories.[60]

The emissions were estimated either for individual sources or groups of sources using three basic factors: (1) activity indicator which represents the activity of a source producing emissions, (2) emission factor which relates the quantity of emissions produced to the activity of the source, and (3) control efficiency which quantifies the amount of pollutant not emitted due to the presence of control devices. Depending on the source category, the activity indicator was represented by the quantity of fuel consumed (or delivered), VMT, refuse burned, raw material processed, or some other measure of production activity. The emission factors are quantitative estimates of the average rate of emissions from many sources combined and are most valid when applied to a large number of sources. The basic calculation procedure for most source categories, excluding highway vehicles and copper smelters, is represented by the following equation:

$$E_{p,s} = A_s * EF_{p,s} * \left(1 - \frac{C_{s,p}}{100}\right)$$

where:
- E = estimated emission
- A = activity indicator
- EF = emission factor
- C = percent control efficiency
- p = pollutant
- s = source category

National activity data for individual source categories were obtained from many different publications. Emission factors were generally obtained from the AP-42[8], and from MOBILE5.[31] Control efficiencies were derived from several sources, depending on the year for which the emissions were being produced. For the years 1940 through 1984, the primary source was the National Emissions Data System (NEDS) archives.[37]

The following sections describe the methodology used for estimating the annual emissions of all criteria pollutants for each major source category for the years 1940 through 1984.

6.3.1 Fuel Combustion

The fuel combustion category includes emissions from the combustion of bituminous, lignite, and anthracite coal, fuel oil, natural gas, wood, and other fuels by electric utilities, industries, and other consumers. The methodologies for estimating emissions from this category are discussed by fuel type. The only exceptions to these methodologies are for the 1980 SO_2 emissions from electric utilities, which have been taken directly from the 1980 NAPAP Emissions Inventory.[61]

6.3.1.1 Coal

The emissions from coal combustion were based on the consumption of bituminous, lignite, and anthracite coal by various end users.[62,63] Most coal was consumed by electric utilities. The reported consumption by source category was multiplied by an average emission factor representative of each category. To produce the SO_2 emissions, the emission factor included an average sulfur content value for each type of coal consumed.[64] In addition, the SO_2 emission factor for electric utilities was adjusted to account for the amount of sulfur controlled by flue gas desulfurization systems.[64] In the case of TSP, an overall control efficiency was obtained from the NEDS archives for all power plants combined.

6.3.1.2 Fuel Oil

Residual, distillate, and kerosene oil are burned by electric utilities, industrial boilers, commercial and institutional boilers and furnaces, and residential heaters. Average emission factors and sulfur content values were calculated and applied to the consumption data reported for each fuel type by end user.[65]

6.3.1.3 Natural Gas

The estimated emissions associated with natural gas combustion were calculated from consumption data reported for various end-user groups[66] and AP-42 emission factors.

6.3.1.4 Wood and Other Fuels

The emissions estimated for this category were based on the consumption of wood for wood stoves and residential fireplaces,[67,68,69] the consumption of bagasse,[37] the sales of liquified petroleum gas,[70] and the consumption of coke and coke-oven gas.[71] These consumption values were multiplied by appropriate emission factors obtained from AP-42.

Lead emissions from the combustion of waste oil were based on information obtained from the EPA's Office of Solid Waste. While the amount of waste oil burned was assumed to remain constant, the Pb content of waste oil was assumed to be decreasing as a result of the general reduction in leaded oil and petroleum products.

6.3.2 Transportation

The methodology used to estimate the emissions produced by highway vehicle and all off-highway sources is described in this section. This source category includes gasoline and diesel-powered motor vehicles, aircraft, railroad, commercial marine vessels, and off-highway use of motor fuels. The methodology described here has been used to estimate the emissions for the years 1940, 1950, and 1960.

6.3.2.1 Highway Vehicles

The emissions from gasoline and diesel-powered motor vehicles were based upon VMT[19] and emission factors. Eight vehicle categories were considered:

- light-duty gasoline vehicles (LDGV),
- light-duty diesel vehicles (LDDV),
- light-duty gasoline trucks-1 (LDGT-1 [trucks less than 6,000 pounds in weight]),
- light-duty gasoline trucks-2 (LDGT-2 [6,000 to 8,500 pounds in weight]),
- light-duty diesel trucks (LDDT),
- heavy-duty diesel trucks (HDDT),
- heavy-duty gasoline trucks (HDGT), and
- motorcycles (MC).

Emission factors for VOC, NO_x, and CO were obtained from the MOBILE5 model, which is designed to be used as a tool for estimating exhaust and evaporative emission factors for highway vehicles. The model determines national emission factors using a national average maximum and minimum annual temperature, a single gasoline volatility, three vehicle speeds, and eight vehicle types. Emission factors for PM-10 and SO_2 were obtained from AP-42. The PM-10 emission factors account for tire wear, brake wear, and tailpipe exhaust emissions. The VMT data were distributed by three vehicle speeds, eight vehicle types, and low and high altitude areas.

Lead emissions were based on gasoline consumption, gasoline Pb content,[8,72] percent unleaded gasoline,[70] and emission factors.

6.3.2.2 Aircraft

The emissions from aircraft were based on the number of landings and take-offs[73] and the AP-42 emission factors for various types of aircraft. Emissions occurring when aircraft are above 3,000 feet are not included in the estimates. Average emission factors were calculated, taking into account the national mix of different types of aircraft used for general aviation, military, and commercial purposes.

6.3.2.3 Railroads

The emissions from railroads were based on diesel and residual fuel oil consumption by railroads.[65] Coal consumption by steam locomotives has been negligible since 1955. Average emission factors were applied to each type of fuel. To estimate the SO_2 emissions, the average sulfur content of each fuel was included in the emission factor.

6.3.2.4 Vessels

The emissions from commercial marine vessels were based on the consumption of diesel fuel, residual oil, and coal by vessels operating inside the U.S. boundaries.[62,65,70] Gasoline consumption was based on national boat and motor registrations together with usage factors (gallons/motor/year),[70] and marine gasoline sales.[19] The estimates of fuel consumption were multiplied by AP-42 emission factors. In the case of coal-fired vessels, an average emission factor for coal combustion in boilers was used.

6.3.2.5 Off-highway

The off-highway source category includes the estimated emissions from farm tractors, other farm machinery, construction equipment, industrial machinery, recreational marine vessels, motorcycles, and small general utility engines such as lawn mowers and snowmobiles. Fuel use was estimated for each subcategory from equipment population data and an annual fuel use factor[74] together with fuel deliveries of diesel fuel[65] and gasoline sales for off-highway use.[19]

6.3.3 Industrial Processes

The industrial processes source category includes the estimated emissions for the following Tier I source categories:

CHEMICAL AND ALLIED PRODUCT MANUFACTURING,
METALS PROCESSING,
PETROLEUM AND RELATED INDUSTRIES,
OTHER INDUSTRIAL PROCESSES,
SOLVENT UTILIZATION (BOTH INDUSTRIAL AND NONINDUSTRIAL), AND
STORAGE AND TRANSPORT.

Production data for industries that produce the majority of emissions were obtained from available annual publications; generally, the Minerals Yearbook[72] and Current Industrial Reports[75] provided most of the necessary data. Average emission factors were applied to the various production data. Average nationwide control efficiency values for various processes were obtained from published reports.[76]

Petroleum product storage and petroleum marketing operations, including gasoline, crude oil and distillate fuel oil storage and transfer, gasoline bulk terminals and bulk plants, and retail gasoline service stations, are included as industrial processes. Other processes included in this category are industrial surface coating and degreasing operations, graphic arts (printing and publishing), and dry cleaners. All of these processes involve the use of organic solvents. Emissions from the consumption of organic solvents were estimated from information reported by the EPA.[77] It was assumed that all solvents consumed eventually evaporated and were uncontrolled, except in surface coating operations where some of the organic solvent vapors were controlled. The control efficiencies of surface coating operations were derived from the NEDS archives.

Sources of emissions from nonindustrial organic solvent use include the solvent evaporation from consumer products such as aerosols, deodorants, polishes, and toiletries, the nonindustrial use of surface coatings for architectural coating, and the use of organic compounds in products such as general cleaning solvents, paint removers, and liquefaction of asphalt paving compounds. Total national organic solvent use was estimated from chemical production reports, along with estimates of the percentages of total production represented by each chemical used as a solvent.[77,78] It was assumed that the total quantity of each solvent produced included an offset for the quantity of solvent lost during production through evaporation.

Lead emissions from miscellaneous industrial processes include lead alkyl production (a major source of Pb)[79] and other minor sources such as type metal production, can soldering, and cable covering.[72] As of the year 1992, lead alkyl is no longer produced in the United States.

6.3.4 Remaining Categories

The "Remaining Categories" grouping includes the emissions for the Tier I categories waste disposal and recycling and miscellaneous sources. The miscellaneous sources subcategories included are: agricultural burning, coal refuse burning, forest fires, prescribed burning, and structural fires.

6.3.4.1 Solid Waste Disposal

The emissions for the waste disposal and recycling category were based on an assumed per capita solid waste generation rate of 5.5 pounds per day. This value was based on a study of solid waste collection and disposal practices.[80] Average AP-42 emission factors were applied to the estimated quantities of solid waste disposal. The emissions were adjusted each year based on information contained in the NEDS archives.

6.3.4.2 Miscellaneous Sources

This section describes the procedure for estimating the emissions for the following source categories falling under the miscellaneous tier category: (1) agricultural burning, (2) coal refuse burning, (3) forest fires, (4) prescribed burning, and (5) structural fires.

The emissions from agricultural burning were based on a study conducted by the EPA to obtain local agricultural and air pollution control agency estimates of the number of acres burned and quantity of material burned per acre in agricultural burning operations.[81] These data were updated and used to estimate emissions based on average emission factors.

The emissions from coal refuse burning were estimated from the number of burning coal-refuse piles in the United States.[82] Detailed information is available concerning the nature, origin, and extent of this source of pollution. Rough estimates of the quantity of emissions were made by applying average emission factors for coal combustion. It should be noted that the number of coal-refuse piles decreased to a negligible level by 1975.

Forest fire emissions were estimated from information on the number of forest fires, their location, and the acreage burned each year.[46,47,48] The amount of biomass used to determine the quantity of vegetation burned was estimated by the EPA.[81] Average emission factors were applied to the estimated quantities of vegetation burned.

The emissions from prescribed burning were based on information on the acres burned and the biomass per acre.[83] Emission factors from AP-42 were applied to the estimated quantities of vegetation burned.

The emissions from structural fires were based on the number and type of structures damaged by fires each year.[84] The emissions were estimated by applying average emission factors for wood combustion to these statistics.

6.4 NATIONAL EMISSIONS, 1900 THROUGH 1939

The national SO_2, NO_x, and VOC emissions presented for the years 1900 through 1939 have been taken from two reports on historic emissions. The first report contains SO_2 and NO_x emissions for the years between 1900 and 1980.[2] The VOC emissions for the years between 1900 and 1985 are contained in the second.[3] For the emissions presented in these reports, the term "national" refers to the contiguous United States.

These reports have also served as the sources of the emissions for the years 1941 through 1949, 1951 through 1959, and 1961 through 1969. The methodologies for estimating the emissions for these years requires the emissions for the years 1940, 1950, 1960, and 1970. Therefore, the methodologies described in this section apply to emissions for the years 1900 through 1970. It must be emphasized that the methodology used to estimate the emissions presented in this report for the years 1940, 1950, 1960, and 1970 are described in section 6.3.

A summary of the methodologies used to produce the emissions is presented here, along with the basic assumptions and categorizations used to estimate these emissions. Detailed descriptions, including explanations of the calculations required to estimate these emissions, are found in the *Trends* Procedures Manual.[4]

6.4.1 Emission Estimation Methodologies for Sulfur Dioxide and Nitrogen Oxides

The emissions of SO_2 and NO_x have been estimated every 5 years from 1900 through 1970 for specific sources of emissions. The emissions for all intervening years between 1900 and 1970 have been extrapolated from these previously calculated emissions based on changes in the national activity for each source category.

6.4.1.1 Emissions for Every 5 Years

The SO_2 and NO_x emissions have been produced for every fifth year beginning in 1900 and ending in 1970. The methodologies used to estimate the emissions fall into three general groups: (1) emissions from the combustion of fuels for heat and power, (2) emissions from the combustion of fuel for transportation, and (3) emissions from miscellaneous processes. The source categories included in each of these general groups are presented in Table 6-5.

6.4.1.1.1 Fuel Combustion — The emissions in this group were categorized by the source category and by the fuel type. The emissions were determined using a fuel use indicator, a fuel sulfur content (necessary to estimate SO_2 emissions only), and an emission factor. The fuel use indicator was the fuel consumption for a specific source and fuel type. There are combinations of fuel types and source categories for which no fuel use indicators were available over specific time periods. For those cases, emissions were not estimated.

The emission factors were derived from those contained in AP-42, up to and including Supplement 14 to the third edition.[85] Emission factors representing a given source category, fuel type, and pollutant were weighted averages of the AP-42 emission factors representing specific processes. The weighting factors were the quantities of the specific fuel type consumed by each of the processes.

In order to estimate SO_2 emissions, the sulfur content of the fuel burned was required. Because sulfur content data are unavailable prior to 1955, the emissions for all years prior to 1955 were made using the 1955 sulfur content data for all fuels. The 1955 coal sulfur contents are estimated for each state based on coal quality, quantity, and distribution.

6.4.1.1.2 Transportation — The emissions produced by highway vehicles were divided into two subcategories based on fuel type: gasoline and diesel. Emissions were estimated based on the gasoline or diesel fuel consumption, fuel efficiency (for gasoline only), and emission factor. The fuel efficiency factor correlated the amount of gasoline consumed to the average number of miles traveled. A national average miles per gallon was estimated for the year 1935 and all years following, but was held constant for all years prior to 1935.

Emission factors were obtained from the MOBILE2 emission factor model[86] for the years 1950 through 1970. The 1950 emission factors were used for the years preceding 1950. The factors for NO_x emissions were derived to represent two distinct road types: urban and rural. The emission factors for gasoline-powered vehicles were expressed as the amount of pollutant emitted for every mile traveled. The emission factors for diesel-powered vehicles were expressed as the amount of pollutant emitted for every gallon of diesel fuel consumed. Therefore, no fuel efficiency was required to estimate the emissions from diesel-powered vehicle.

6.4.1.1.3 Industrial Processes and Other Sources — The source subcategories composing the miscellaneous processes group are presented in Table 6-5. With the exception of the two miscellaneous categories, the emissions were based on an activity indicator and an emission factor. The activity indicator specified the industrial output of the process or, in the case of the wildfire category, the area burned. The emission factors were derived from AP-42.[85] Because of the diverse nature of this group, specific details of the methodologies used to calculate the emissions are discussed for each category individually.

6.4.1.1.3.1 Coke Plants. The methodology used to estimate the uncontrolled emissions produced from the combustion stacks of coke plants is similar to that used for coal combustion. In place of the amount of coal burned, these estimates were based on the amount of coal charged into the coke ovens. This methodology accounted for only about 67 percent of the total SO_2 emitted by coke plants. The remaining 33 percent of the emissions were passed to the coke oven gas and were emitted latter in the steel manufacturing process. These emissions were categorized with miscellaneous industrial processes.

6.4.1.1.3.2 Smelters. The primary smelters category consists of copper, lead, and zinc smelters. The methodology used to estimate the emissions was based on the quantities of ore smelted and the emission factors. For the years prior to 1940, the quantity of ore smelted was estimated using the amount of recoverable metal produced by the mines in a given state. It was assumed that any ore mined in a given state was smelted in the same state. If the given state was known to have no smelters, then it was assumed that the ore was smelted in the nearest state having a smelter.

The controlled SO_2 emissions were determined by subtracting the amount of SO_2 recovered by the production of by-product sulfuric acid. Because only national by-product sulfuric acid production data were available, it was assumed that the amount of SO_2 recovered for each state was proportional to the smelter output for that state.

6.4.1.1.3.3 Cement Plants. SO_2 and NO_x emissions from cement plants were produced by both the minerals processed in the kiln and the combustion of fuels to heat the kiln. The activity indicator used to estimate the emissions was the total annual production of Portland cement by state. The emission factors were the sum of the emission factors for the mineral sources, the combustion of coal, and the combustion of oil. The emission factors calculated for the year 1955 were used to estimate the emissions for all preceding years.

6.4.1.1.3.4 Wildfires. Wildfire emissions are defined as emissions from the combustion of vegetation in any uncontrolled fire. The activity indicator for this category was the total area burned annually in each state. This information was available for most states by 1925 and for all states by 1940. Prior to 1925, the acreage burned was assumed to be equal to the acreage burned in 1925. The emission factors reflected variations in vegetation (e.g., woodlands as compared to grasslands).

6.4.1.1.3.5 Miscellaneous Processes. The SO_2 and NO_x emissions for the two miscellaneous source categories, industrial processes and other processes, were estimated by backcasting 1980 emissions obtained from the 1984 National Emissions Report[87] using national growth factors. The growth factors were based on the changes in the national population.

6.4.1.2 Emissions for Intervening Years

The SO_2 and NO_x emissions have been estimated every fifth year from 1900 to 1970 as described in the preceding section. For all source categories representing the combustion of fuels and for coke plants, the emissions for each intervening year have been estimated by equating the changes in the national consumption of the corresponding fuel to the changes in the emissions.

For the following fuel types and years, the national fuel consumption changed radically and, therefore, was not used to estimate the annual emissions: bituminous coal for the years 1912 and 1913 and natural gas for the years 1931, 1932, and 1933. In these cases, the annual SO_2 and NO_x emissions were determined using a linear interpolation.

For the source categories grouped as miscellaneous processes (excluding coke plants), the annual emissions were also calculated by a linear interpolation.

6.4.2 Emission Estimation Methodologies for Volatile Organic Compounds

The national VOC emissions have been estimated using activity indicators and emission factors. The VOC emissions were divided into five broad source categories, each of which was subdivided into more refined subcategories. These categories and corresponding subcategories are presented in Table 6-6.

6.4.2.1 Emissions for Every 5 Years

The VOC emissions have been calculated for every fifth year between 1900 and 1970. The emissions for the years 1940 through 1970 were obtained from the 1985 *Trends* report.[80] The emissions for the years 1900 through 1935, 1945, 1955, and 1965 were based on the national annual activity and the national annual emission factor for each source category. In cases where the activity indicators contained data from Alaska, Hawaii, or the U.S. territories, the activity indicators for areas outside the contiguous United States were subtracted from the total activity indicators.

The emission factors for the years 1900 through 1935, 1945, 1955, and 1965 were extrapolated from the emission factors for the years 1940, 1950, 1960, 1965, 1970, 1975, 1980, and 1985. The emission factors for these years between 1940 and 1985 were calculated from the estimated emissions and the activity indicators obtained from the 1985 *Trends* report. These emissions and activity indicators were disaggregated into the source subcategories given in Table 6-6.

For some source subcategories, the emission factors were unchanged over the period from 1940 to 1985. Therefore, these emission factors were used to calculate the corresponding emissions for the years prior to 1940 and for the years 1945, 1955, and 1965. For source categories where the emission factors changed between the years 1940 through 1985, the emission factors for the years before 1940 and for the years 1945, 1955, and 1965 were extrapolated from these calculated emission factors.

6.4.2.2 *Emissions for Intervening Years*

The emissions for the intervening years were estimated from the emissions for every fifth year between 1900 and 1970 and the change in the corresponding activity indicator for each source category as presented in Table 6-5. The activity data for each year were obtained from the report of historic SO_2 and NO_x emissions.[2] For source categories where population was used as the activity indicators, the annual emissions were calculated using a linear interpolation.

6.4.2.3 *Changes in Estimated Emissions*

The emission factors for the source category external fuel combustion, subcategory wood have been changed since the time the original report[3] was published. An adjustment of the erroneously high emission factor was based on more current information. No changes have been made to the activity indicators for this subcategory. Therefore, the values published in this report supersede those presented in the orginal report.[3]

6.5 EMISSIONS REVISIONS

The estimated emissions presented in this report have in some instances been modified from the emissions presented in previous *Trends* reports. These modifications have come about due to the use of different methodologies to estimate the emissions, the refinement of the methodologies used for the 1993 *Trends* report, the availability of updated information used to estimate the emissions, and the recategorization of some emission source categories. These modifications to the emissions are documented in this section.

6.5.1 *Methodological Changes*

The emissions presented in this report reflect several major changes in the methodologies used to estimate the emissions. These changes are included in the methodologies described in the preceding section of this chapter. The changes in the methodologies from those used to estimate the emissions presented in the 1993 *Trends* report[91] are summarized below.

- The *Interim* Inventory methodology was expanded to include the CO, NO_x, and VOC emissions for the year 1985. The previously reported emissions were taken directly from the 1985 NAPAP Emission Inventory, with the exception of the emissions for highway vehicles, off-highway, and solvent use, and the SO_2 emissions from steam generated fossil-fuel electric utility units.

- Prior to this report, the PM-10 emissions for the years 1985 through 1992 were estimated using the methodology currently used to estimate the emissions for the years 1940 through 1984. For this report, the PM-10 emissions for all source categories, excluding fugitive dust sources and forest fires, for the years 1985 to the current year were estimated using the methodology reported in the *Emissions Inventory for the National Particulate Matter Study.*[5] In addition, the methodology developed for that study was used to estimate the fugitive dust emissions from cattle feedlots.

- The methodology for estimating fugitive dust PM-10 emissions from paved and unpaved roads was changed to eliminate the inclusion of tailpipe, brake, and tire wear emissions produced by vehicles. Previously, these emissions had been included in both the PM-10 fugitive dust categories and the PM-10 highway vehicle categories.

- Emissions from highway vehicles for the years 1970 through 1993 were estimated using a modified method based on the methodology used to produce the 1992 emissions presented in the 1993 *Trends* report.[91]

6.5.2 *Other Changes*

In addition to the changes in methodology affecting most, if not all, source categories and pollutants, other changes were made to the emissions for specific pollutants, source categories, and/or individual sources. Such changes are discussed below.

- The SO_2 emissions from metals processing at copper smelters were modified for the years 1987 through 1993 by removing the emissions from a facility demolished on January 15, 1987.

- The PM-10 emissions from electric utilities for the years 1940 through 1984 were revised as a result of correcting the emission factor for bituminous coal.

- The off-highway emissions for the years 1970 through 1989 and 1991 for CO, NO_x, PM-10, and VOC were revised by adjusting 1990 off-highway nonattainment area emissions obtained from OMS using E-GAS historical growth factors.[32]

- Several of the changes to the fugitive dust emissions were the result of a recategorization. The wind erosion emissions have been moved to Tier 1 natural sources, while the remaining fugitive dust sources remained in Tier 1 miscellaneous sources. This included wind erosion fugitive dust from surface mining operation, exposed areas (SCC = 3-05-010-49). In 1990 these emissions were 157 short tons. The fugitive dust emissions from agricultural tilling were recategorized under Tier 2 agricultural and forestry for agricultural crops. The emissions for cattle feedlots were categorized under the same Tier 2 category for agricultural livestock.

- The emissions from two SCCs were reassigned to different Tier 1 categories. The emissions from logging operations, SCC 23-07-010-000, were moved from the tier category other industrial processes wood, pulp & paper, & publishing products to the category miscellaneous - agriculture & forestry. The emissions from carbon black production pellet dryer, SCC 3-01-005-07 were moved from the tier category storage and transport organic chemical storage to the category chemical and allied product manufacturing - other chemical manufacturing (carbon black manufacturing).

- As described in section 6.2.4.3.1, the forest fire emissions for the years 1990 through 1993 were made using year specific acreage of land burned. Previously, the emissions for the years 1990 through 1992 had been held constant at the 1985 level as taken from the 1985 NAPAP Emissions Inventory. The emissions presented in this report for the years 1985 through 1989 continued to be held constant at the 1985 level.

- The highway vehicle emission factors for PM-10 and SO_2 were revised based on updated correction factors.

- The 1985 and 1990 emissions from steam generated fossil-fuel electric utility units were estimated based on the updated version of the Form EIA-767. The 1992 emissions were based on the first release version of the Form EIA-767 as compared with the preliminary emissions presented in last year's report based on the 1992 Form EIA-759.

- The prerelease E-GAS, version 2.0 model was used in place of the E-GAS, version 1.0 model. The 1992 emissions estimated for last year's report using version 1.0 of the model were revised using the growth factors from the prereleased version 2.0 of the model. The sources and pollutants for which E-GAS was used to estimate the 1992 and 1993 emissions are specified in section 6.2.

6.5.3 Future Changes

One of the future goals in generating the emission inventories reported in the *Trends* report is the incorporation of ozone SIP data reported by the states in AIRS. At the time these emissions were being estimated for this report, no SIP data had been approved. When SIP data are approved and become available in AIRS, the SIP data will replace the data currently used in this report.

6.6 SPATIAL AND TEMPORAL EMISSIONS, 1993

Although the EPA has produced an annual national estimate of emission trends since 1973, this report is the second in a series which presents emissions at the county, state, ozone nonattainment area, and seasonal levels for CO, NO_x, SO_2, and VOC. Starting with this year's report, PM-10 emissions are presented by various geographical areas. The spatial and temporal emissions are presented for the current year of emissions in section 2.2 and 2.3. The regional emissions are presented for the years 1985 through 1993 in section 4.0 of this report. Lead emissions are presented only at the regional level in this report.

6.6.1 Spatial Emissions, 1993

The 1993 emissions for CO, NO_x, PM-10, SO_2, and VOC have been derived at the county level by the method described in section 6.2, except for the categories of forest fires/wildfires and fugitive dust. For the purposes of this section, the term fugitive dust includes natural sources and agricultural crops and excludes point source wind erosion. The procedures used to estimate the county-level emissions for the forest fires/wildfires and fugitive dust categories are summarized in this section.

The 1993 forest fire/wildfire emissions were produced at the state level as described in section 6.2 These state emissions were distributed to the counties using the same pollutant specific county-level distributions used in the 1985 NAPAP Emissions Inventory. For states not reporting wildfire emissions in the 1985 NAPAP Emissions Inventory, *Trends* wildfire emissions were distributed equally among counties within the state. The fugitive dust emissions were derived at either the region or state level as described in section 6.2. These estimates were distributed to the county level by various methods depending on the specific source category. State-level PM-10 emissions from agricultural crops were distributed to the county level using 1987 county estimates of cropland harvested.[38] Regional PM-10 emissions from construction activities were distributed to the county level using county estimates of payroll for construction (SICs 15, 16, 17).[89] The state-level rural and urban PM-10 paved and unpaved road emissions were distributed to the county level using estimates of county rural and urban land area.[102] The natural source wind erosion emissions were distributed from the state level to the county level using the rural land area.[102] The mining and quarrying emissions were distributed equally among counties within the EPA region.

For all source categories, the point and area county emissions were summed to the state level and presented in section 2.2. The state emissions were summed to the EPA regions as defined in Figure 1-1 and presented in section 4.0.

In the 1993 *Trends* report, charts of typical CO, NO_x, and VOC emissions in "serious" and above ozone nonattainment areas were compiled using 1992 emissions. This year, sufficiently complete 1990 base year inventories for six such areas have been submitted (but not approved) to the AIRS to warrant basing composite emission profiles on these actual inventory data. These six areas represent the populous northeast and the southwest. As additional base year inventories are completed in AIRS, composite profiles in future *Trends* reports will become increasingly comprehensive. These emissions are presented in section 2.2.3 of this report.

6.6.2 Temporal Emissions, 1993

The 1993 emissions presented in section 2.3 were allocated to the four seasons by three methodologies depending on source category. The highway emissions for CO, NO_x, and VOC were calculated for each month as described in section 6.2 and summed to the seasonal total. Electric utility, PM-10 and SO_2 highway vehicle, and all area source emissions were temporally apportioned using state-level point and area factors obtained from the 1985 NAPAP methodology.[92] Point source emissions were distributed to the seasons based on the 1985 NAPAP Emissions Inventory seasonal throughput percentages for each point. The seasons are defined as winter (December, January, February), spring (March, April, May), summer (June, July, August), and autumn (September, October, November). The fugitive dust emissions, as defined in section 6.6.1, were distributed equally to all seasons.

6.7 LARGEST POINT SOURCES IN AIRS/AFS

This report is the third in a series to track the top-emitting sources of CO, NO_x, SO_2, and VOC and the second to track the top-emitting sources of PM-10, industrial SO_2, and Pb. The plant level emissions were extracted for AIRS/AFS excluding only those facilities having an operating status defined as permanently closed. The lists for each pollutant of the 30 top-emitting sources in 1993 are presented in section 2.4 of this report. The process by which these lists were compiled is described below.

The top-emitting facilities were extracted February 9, 1994 based on the following criteria set: (1) region greater than zero, (2) default emissions greater than zero, (3) default emission units equal to short tons per year, and (4) pollutant equal to one of the six criteria pollutants. One file for each pollutant was generated. Each file contained information on the EPA region, state, county, plant identification by NED's code, plant name, primary SIC, year of inventory, default emissions, default emission units, plant location by latitude and longitude, and plant operating status.

After excluding all closed plants, the remaining plants were ranked according to emissions. The preliminary lists for each pollutant included only the top 100 facilities. To obtain a list of the 200 top SO_2-emitting industrial facilities, all electric utility plants or any plant reporting a primary SIC equal to 4911, 4931, or 4939 were removed from the list of top SO_2-emitting sources.

These lists were sent to the EPA regions and they were informed that such lists of top-emitting facilities would appear in the 1994 *Trends* report. If any errors were found in the information on the plants in their region, they were instructed to make corrections to the AIRS/AFS data files. In addition, they were informed that a second extraction from AIRS/AFS was to be made in July for inclusion in the 1994 *Trends* report.

After reviewing these lists, it was noted that several plants included on the lists published in the 1993 *Trends* report were no longer present. After investigating AIRS/AFS interactively, it was determined that in order to include all plants emitting a specific pollutant, data for all inventory years must be downloaded from the AIRS/AFS data base. The criteria set for the data extraction was modified in order to include all records where the year of inventory was not blank. Data extractions for each pollutant were performed on April 13 using the modified criteria set. The six output files were processed using the following steps: (1) retain the record for a given facility with the latest year of inventory and data in all other fields, (2) delete all closed plants (i.e., operating status = "x"), (3) rank plants by emissions, and (4) retain the 50 top-emitting facilities. The processing of the industrial sources emitting SO_2 included the additional step of removing all electric utilities after ranking the plants by emissions. In addition, the list of industrial sources emitting SO_2 included the top 200 facilities.

The same extraction procedure was performed the second week of July. Comments received on the lists produced in February were used to assure the quality of the lists produced in July. These revised lists were once again sent to the EPA regions for review. The final lists of top-emitting sources are presented in both tables and maps in section 2.4.

6.8 NATIONAL EMISSIONS, 1996 to 2010

Projections of future year emissions have been estimated using the following general procedure:

- Grow 1990 emissions or activity levels.
- Apply future year control efficiencies or emission factors reflecting CAAA requirements.

The application of the above procedure differs slightly by major emitting sector — highway vehicle, utility, nonutility point, and area/off-highway sources.

6.8.1 Highway Vehicles

Highway vehicle emissions were projected using the Emission Reduction and Cost Analysis Model (ERCAM). Growth factors were first applied to 1990 VMT estimates. VMT was then allocated to the monthly level and MOBILE5a emission factors were applied. The monthly emissions were then summed to calculate annual emissions.

6.8.1.1 VMT Growth

The 1990 VMT estimates were projected to the future years using metropolitan statistical area (MSA) level growth factors by vehicle class. These factors were developed from national growth by vehicle class from the MOBILE4.1 Fuel Consumption Model.[93] The national growth was scaled to the MSA-level based on population projections.[94] Thus, if an area shows population growth higher than the national average, VMT growth will also be higher than the national average.

The resulting annual county-level vehicle and roadway type projected VMT data were temporally allocated to months using NAPAP temporal allocation factors[20] and the number of days in each month.

6.8.1.2 Emission Factor Modeling

6.8.1.2.1 Carbon Monoxide, Nitrogen Oxides, and Volatile Organic Compound Emission Factor Modeling — The MOBILE5a emission factor model[21] was used to calculate all CO, NO_x, and VOC highway vehicle emission factors for all states except California. California emission factors for these pollutants were calculated using an OMS-modified version of MOBILE5a that simulates the California fleet. As with the 1970 through 1993 emission highway vehicle emission factors, the projection year emission factors were calculated at the county level.

Temperature inputs for the projection years were 30-year average monthly maximum and minimum daily temperatures, with a single set of temperature inputs for each state.[84] California was broken into two regions to capture the climatic variation within the state, so a separate set of temperature inputs was used for each of these regions.

Reid vapor pressure inputs were provided at the monthly level for each state, and did not vary by year. For the period from May 1 through September 15, the Phase II RVP limits are in effect in nonattainment areas. During this period, nonattainment areas in the ASTM Class B are subject to an RVP limit of 7.8 psi, while all other areas were subject to an RVP limit of 8.7 psi (9.0 psi with an assumed 0.3 psi margin of safety). Reid vapor pressure values for the other months were based on monthly values calculated by OMS for the AAMA survey cities, and applied to the state level using the same allocation procedure used in the projection of the historical emissions.[96]

Enhanced and basic I/M programs were applied in the areas required by the CAAA (or that have otherwise indicated that they would enact such a program). The MOBILE5a inputs for these areas were based on EPA's enhanced and basic I/M program performance standards.[96] Oxygenated fuels were modeled in the MSAs listed as having such a program by OMS in the months specified for that area.[97] Federal reformulated gasoline was modeled in the areas included in the latest list of areas that have opted in to the program[98]. In California, the California reformulated gasoline program was modeled statewide, using the modified version of MOBILE5a. A reduction was applied to the NO_x emission factors obtained from MOBILE5a to account for the NO_x benefits specified in the final reformulated gasoline rulemaking which are not included in MOBILE5a. This benefit was approximately 6 percent for LDGVs and LDGTs starting in 2000 (the first year of the Phase II reformulated gasoline program). The California low emission vehicle (LEV) program was modeled throughout the state of California, with maximum LEV credits applied in counties with enhanced I/M programs and minimum LEV credits elsewhere.[99]

6.8.1.2.2 Particulate Matter (PM-10) Emission Factor Modeling — Particulate matter (PM-10) emission factors were calculated at the national level by vehicle type, using the same procedure as discussed for the historical PM-10 emission factors. These emission factors were then applied to the national VMT totals by vehicle type.

6.8.1.2.3 Sulfur Dioxide Emission Factor Modeling — Sulfur dioxide emission factors were calculated at the national level by vehicle type, following the same procedure as described for the calculation of the 1970 to 1993 SO_2 highway vehicle emission factors. Fuel economy projections were obtained from the MOBILE4.1 Fuel Consumption Model.[93]

6.8.2 Utilities

6.8.2.1 Electric Utility Growth

Utility growth was projected using the ERCAM-NO_x model[100], and the 1990 Interim Inventory[1] as the base for the projections. In ERCAM-NO_x, changes in the capacity utilization of existing electric utility units are based on historical capacity utilization at the unit level. Additional growth is projected based on planned and projected electric utility units. Data on planned units and projected electric utility demand was obtained from DOE.[101,102] Generation projections from the existing and planned units have been subtracted from the projected generation demand demand at the regional and fuel type level. The remaining generation is assumed to be filled by projected units. Existing units were assumed to retire after 65 years of service.

6.8.2.2 Electric Utility Controls

Nitrogen oxides controls were applied using the ERCAM-NO_x model.[100] This model applies Title I and Title IV RACT level controls to the required units, applying the expected percentage reductions from RACT that are specific to the boiler type and fuel type. Planned and projected units coming on line in 1996 or later in nonattainment areas and the ozone transport regions were assumed to be subject to new source review and were assumed to apply selective catalytic reduction. No new controls were applied to VOC, CO, or PM-10 emissions.

Sulfur dioxide projections are based on the SO_2 electric utility allowance caps of Title IV. The emission caps per year change from 1995 to 2000 to 2010. The projections presented here are based on ICF Resources, Incorporated's projections of how utilities will use these allowances.[103] Their analysis assumes that a certain portion of the Phase I allowances from 1995 to 1999 will be banked and then used from 2000 to 2010.

6.8.3 Nonutility Point Sources

Nonutility point source emissions were projected using the Multiple Projections System[104] (MPS). MPS combines growth factors and future year control levels to calculate projection year emissions. The E-GAS growth factors were used in nonutility point source emission projections with the exception of industrial source fuel combustion emissions from coal, residual oil, and distillate oil. Growth factors for these industrial source fuel combustion categories were generated using a Btu Efficiency Neural Network (BENNET). This neural network provides growth factors that reflect changes in fuel prices, general economic growth in the industrial sector, and that account for fuel switching in future years. These BENNET growth factors were used in place of E-GAS growth factors by MPS to develop industrial combustion point source projected emissions. Additional details concerning BENNET and how industrial source emission projections were developed are available elsewhere.[105]

6.8.3.1 Carbon Monoxide Controls

Carbon monoxide nonattainment area requirements generally focus on mobile source controls — enhanced I/M and oxygenated fuels. While there may be isolated cases of point source controls, these are not incorporated into the projections.

6.8.3.2 Nitrogen Oxides Controls

Nitrogen oxides control information was also taken from the ROM control strategy files[106] again simulating the mandatory control requirements of the 1990 Act, namely, RACT requirements. Possible substitution of NO_x for VOC to meet rate-of-progress (ROP) requirements, new source offsets, and controls needed for attainment demonstrations are not incorporated into the projections.

6.8.3.3 Volatile Organic Compound Controls

Volatile organic compound control information is based on the ROM point source control input.[106] This file simulates the mandatory control requirements of the CAAA. Controls are specified by source category and ozone nonattainment classification. Additional CAAA requirements which are not incorporated into these projections include: ROP requirements, new source offsets, and attainment demonstrations.

6.8.3.4 Sulfur Dioxide Controls

The CAAA does not specify any mandatory SO_2 controls. Regulations applicable to sources of SO_2 emissions are determined on a State or nonattainment area basis. A national emission cap of 5.6 million short tons of SO_2 per year was set by the CAAA for industrial sources. If the cap is exceeded, EPA may promulgate new regulations. Projections of growth to 2005 utility E-GAS did not show emissions exceeding this cap. Point source SO_2 emitters were therefore assumed to remain at current control levels.

6.8.3.5 Particulate Matter (PM-10) Controls

Review of PM-10 SIPs indicate that control efforts are focusing primarily on area source emitters; therefore, point sources were assumed to remain at current control levels.

6.8.4 Area/Off-highway Projections

Area and nonroad pollutant sources were also projected using MPS.[104] E-GAS growth factors were used in combination with estimates of future year control efficiencies.

6.8.4.1 Carbon Monoxide Area/Off-Highway Controls

Carbon monoxide controls efforts mandated by the CAAA focus on highway vehicle controls; therefore, no new area source control initiatives were modeled. However, CO standards will be proposed for certain off-highway engines, with varying effective dates beginning as early as 1996. Timing of the benefits of these CO standards will depend upon phase-in schedules and fleet turnover. Standards will be set for lawn and garden, utility, small farm and construction, light industrial applications, gasoline and marine engines. The off-highway emission projections will reflect the effect of these standards in future *Trends* reports.

6.8.4.2 *Nitrogen Oxides Area/Off-highway Controls*

Nitrogen oxides control information is also taken from the ROM control strategy file. Reasonably available control technology requirements are incorporated for industrial fuel combustion emissions as a result of the Title I/RACT requirements. Reasonably available control technology controls are applied to major stationary sources. The definition of major stationary source differs according to the ozone nonattainment classification (e.g., marginal, moderate, serious, severe, extreme, ozone transport region) of the area. Controls for compression ignition (diesel) engines were added. Increases in NO_x emissions due to the spark ignition standards (aimed at reducing VOC) were also incorporated.

6.8.4.3 *Volatile Organic Compound Area/Off-highway Controls*

Volatile organic compound control information is based on the ROM area source control strategy file.[106] Area source control requirements include RACT and new CTG requirements in ozone nonattainment areas, stage II vapor recovery, Title III control for HAPs, and Federal measures for consumer solvents and architectural and industrial maintenance coatings. Off-highway controls for spark ignition engines (phase 1) and recreational marine vessels were added to the ROM controls. The VOC controls modeled reflect the mandatory control requirements under the CAAA.

6.8.4.4 *Sulfur Dioxide Area/Off-highway Controls*

Sulfur dioxide area source emitters were projected assuming no change in current control levels. Unlike nonutilty point sources, sulfur dioxide emissions from the area source component of industrial fuel combustion sources were projected using E-GAS growth factors, rather than BENNET growth factors. The E-GAS growth factors were utilized because industrial fuel combustion area sources are unlikely to switch fuels like point sources.

6.8.4.5 *Particulate Matter (PM-10) Area/Off-highway Controls*

Area source PM-10 controls were modeled in all PM-10 nonattainment areas. Particulate matter areas are classified as moderate or serious depending on the severity of the nonattainment problem. Controls applied include watering of cattle feedlots, recycled asphalt paving and chemical suppressants on unpaved roads, vacuum sweeping of paved roads, limiting tilling on windy days, dust control plans at construction sites, and replacement of non-EPA certified woodstoves with pellet stoves or EPA Phase II stoves. The controls applied to each area depend on the magnitude of emissions from the potentially controlled source categories and the severity of nonattainment.

6.9 REFERENCES

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Table 6-1. Equations Used to Estimate Emissions from Electric Utility Boilers

$$E_{NO_x,b} = FC_b * EF_{NO_x,SCC} * (1 - (RE_{NO_x} * CE_{NO_x,b})) * UCF$$

$$E_{PM\text{-}10,b} = FC_b * EF_{PM\text{-}10,SCC} * A_f * (1 - CE_{PM\text{-}10,b}) * UCF$$

$$E_{SO_2,b} = FC_b * EF_{SO_2,\,SCC} * S_f \times (1 - CE_{SO_2,b}) * UCF$$

$$E_{VOC\ or\ CO,b} = FC_b * EF_{VOC\ or\ CO,SCC} * UCF$$

where:	*E*	=	estimated emission (expressed in short tons)
	FC	=	fuel consumption (expressed in $unit_f$)
	EF	=	emission factor (expressed in lbs $SO_2/unit_f$)
	S	=	sulfur content (expressed as a decimal)
	A	=	ash content (expressed as a decimal)
	RE	=	rule effectiveness (expressed as a decimal)
	CE	=	control efficiency (expressed as a decimal)
	b	=	boiler
	f	=	fuel type (coal, oil, gas)
	UCF	=	units conversion factor (1 ton/2000 lbs)
	$unit_{coal}$	=	tons burned
	$unit_{oil}$	=	1000 gallons burned
	$unit_{gas}$	=	million cubic feet burned

Table 6-2. Bureau of Economic Analysis's SA-5 National Changes in Earnings by Industry

Industry	SIC	Percent Growth from: 1985 to 1987	1987 to 1988	1988 to 1989	1989 to 1990
Farm	01, 02	14.67	-2.73	14.58	-3.11
Agricultural services, forestry, fisheries, and other	07, 08, 09	23.58	5.43	1.01	2.48
Coal mining	11	-17.46	-6.37	-4.16	4.73
Oil and gas extraction	13	-39.23	4.94	-3.88	5.16
Metal mining	10	-3.03	18.01	8.94	4.56
Nonmetallic minerals, except fuels	14	2.33	3.74	-2.79	-0.45
Construction	15	7.27	4.81	-1.36	-3.80
Food and kindred products	20	1.67	1.34	-1.20	-0.24
Textile mill products	22	8.50	-0.64	-1.39	-4.97
Apparel and other textile products	23	-1.72	1.25	-1.62	-4.22
Paper and allied products	26	2.62	0.94	-0.14	-0.39
Printing and publishing	27	7.44	5.67	-0.81	0.43
Chemicals and allied products	28	1.75	6.94	0.32	1.61
Petroleum and coal products	29	-10.82	-3.22	-3.02	1.06
Tobacco manufactures	21	-1.97	2.43	-2.43	-5.01
Rubber and miscellaneous plastic products	30	5.27	5.51	0.68	-0.14
Leather and leather products	31	-9.39	-1.64	-3.58	-2.55
Lumber and wood products	24	10.03	5.15	-3.54	-3.71
Furniture and fixtures	25	6.82	2.35	-1.46	-2.98
Primary metal industries	33	-9.09	5.32	-0.34	-3.03
Fabricated metal products	34	-4.72	2.55	-0.86	-1.91
Machinery, except electrical	35	-5.72	6.02	-0.32	-1.92
Electric and electronic equipment	36	-3.17	-18.01	-1.91	-3.22
Transportation equipment, excluding motor vehicles	37	8.44	-1.57	0.55	-1.07
Motor vehicles and equipment	371	-6.45	2.20	-2.96	-5.43
Stone, clay, and glass products	32	-0.23	-1.61	-1.96	-3.19
Instruments and related products	38	-0.04	60.65	-0.82	-2.91
Miscellaneous manufacturing industries	39	1.84	6.92	-2.21	-2.54
Railroad transportation	40	-14.13	-2.53	-3.83	-6.03
Trucking and warehousing	42	5.63	3.26	-0.20	0.99
Water transportation	44	-8.92	0.07	-1.02	2.83
Local and interurban passenger transit	41	13.45	0.51	2.14	1.44
Transportation by air	45	12.01	4.63	4.94	4.36

(continued)

Table 6-2. Bureau of Economic Analysis's SA-5 National Changes in Earnings by Industry (continued)

Industry	SIC	Percent Growth from:			
		1985 to 1987	1987 to 1988	1988 to 1989	1989 to 1990
Pipelines, except natural gas	46	-5.21	3.67	-4.93	3.53
Transportation services	47	15.92	8.52	4.60	4.97
Communication	48	1.94	0.68	-2.81	2.07
Electric, gas, and sanitary services	49	0.07	3.05	0.63	0.39
Wholesale trade	50, 51	5.01	5.87	2.44	-1.02
Retail trade	52 to 59	5.19	4.39	0.65	-0.94
Banking and credit agencies	60, 61	12.44	2.45	-0.33	-0.49
Insurance	63, 64	14.09	4.20	1.52	2.71
Real estate	65, 66	92.14	-6.98	-7.87	-0.48
Holding companies and investment services	67	39.05	-34.86	-12.18	16.91
Hotels and other lodging places	70	12.65	5.59	1.71	2.29
Personal services	72	7.17	2.35	7.44	5.41
Private households	88	-5.68	2.41	0.83	-3.69
Business and miscellaneous repair services	76	17.05	-17.34	5.79	4.34
Auto repair, services, and garages	75	6.65	2.46	3.00	3.93
Amusement and recreation services and motion pictures	78, 79	17.93	16.43	4.06	7.59
Health services	80	15.15	7.08	5.11	6.28
Legal services	81	20.14	9.92	4.09	4.80
Educational services	82	9.35	7.17	3.88	2.60
Social services and membership organizations	83	17.39	8.45	7.95	7.37
Miscellaneous professional services	84	11.28	5.04	7.08	4.12
Federal, civilian	91	-0.54	3.79	1.21	1.96
Federal, military	97	1.96	-1.07	-1.58	-3.19
State and local government	92 to 96	7.88	3.63	3.19	3.04

Table 6-3. Bureau of Economic Analysis's SQ-5 National Growth in Earnings by Industry

Industry	Percent Growth from 1990 to 1991
Farm	-18.38
Agricultural services, forestry, fisheries, and other	-5.06
Coal mining	-0.75
Construction	-10.37
Manufacturing	-3.01
Nondurable goods	-0.89
Durable goods	-4.30
Wholesale trade	-2.55
Retail trade	-2.84
Services	1.91
Government and government enterprises	1.16
Federal, civilian	-0.49
Federal, military	-1.94
State and local	2.00

Table 6-4. Sample E-GAS Growth Factors Arranged by Tier 1 and Tier 2 Source Category

Tier 1	Modified Tier 2	1992 Growth Factor	1993 Growth Factor
INDUSTRIAL FUEL COMBUSTION	Pulp & Paper Process Heaters: Residual Oil	0.8456	0.7685
MISCELLANEOUS	Agricultural Burning and Livestock	1.1854	1.2082
OFF-HIGHWAY	Diesel and Gasoline Construction Equipment	1.1071 to 1.3805	1.2079 to 1.4703
	Diesel and Gasoline Industrial Equipment	1.1682	1.2184
OTHER FUEL COMBUSTION	Commercial/Institutional Distillate and Residual Oil	1.1591 to 1.1705	1.2335 to 1.2530
	Residential Oil	0.6508	0.4520
	Residential Wood	0.7361 to 0.8897	0.5245 to 0.7994
OTHER INDUSTRIAL PROCESSES	Agriculture and Food	1.1854	1.2082
	Mineral Products	1.1751	1.2125
STORAGE & TRANSPORT	Bulk Material Storage	1.1751 to 1.1854	1.2125 to 1.2082
	Bulk Material Transport	1.1751	1.2125
WASTE DISPOSAL	Incineration and Open Burning	1.1682	1.2184

Table 6-5. Historic Nitrogen Oxides and Sulfur Dioxide Emission Source Categories and Subcategories

Methodological Groups	Source Category	Subcategories (or Fuel Types)
Combustion of Fuels for Heat and Power	Electric Utilities	Bituminous Coal, Residual and Distillate Oil, and Natural Gas
	Industrial Boilers	Bituminous Coal, Residual and Distillate Oil, and Natural Gas
	Commercial and Residential	Bituminous Coal, Residual and Distillate Oil, and Natural Gas
	Anthracite Coal	All uses
	Wood	All uses
	Railroads	Bituminous Coal and Distillate Oil
	Vessels	Residual and Distillate Oil
	Off-Highway Diesel	Diesel Fuel
Combustion of Fuels for Transportation	Highway Vehicles	Gasoline and Diesel fuel
Miscellaneous Processes	Coke Plants	
	Smelters	
	Cement Plants	
	Wildfire	
	Miscellaneous Industrial Processes	Pulp and paper, Petroleum Refineries, Iron and Steel Manufacture, Primary Aluminum, Secondary Lead, Glass Manufacture and Chemical Manufacture (sulfuric acid, carbon black, petrochemicals, ammonia, nitric acid, and TNT)
	Miscellaneous Other Processes	Aircraft, Vessels (gasoline-powered, coal-powered), Miscellaneous off-highway gasoline-powered vehicles, Fuel combustion (LPG, coke-oven gas, and bagasse), Solid Waste Disposal, Agricultural Burning, Coal Refuse Burning, Prescribed Burning

Table 6-6. Historic Volatile Organic Compound Emission Source Categories and Subcategories

Source Category	Source Subcategory	Activity Indicators for Interpolating Emissions for Intervening Years
Transportation	Highway Vehicles	Gasoline and Diesel Consumption
	Aircraft	Population
	Railroads (oil and coal fired)	
	Vessels (oil and coal fired)	
	Other Off-highway Use	
External Fuel Combustion	Anthracite Coal	Anthracite Coal Consumption
	Bituminous Coal	Bituminous Coal Consumption
	Residual Oil	Fuel Oil Consumption
	Distillate Oil	
	Natural Gas	Natural Gas Consumption
	Wood	Wood Consumption
	Coke and Other Fuels	Population
Industrial Processes	Petrochemical Manufacture	Population
	Petroleum Marketing (gasoline and other)	Gasoline and Diesel Consumption
	Surface Coating Operations	Population
	Petroleum Refinery Process Operations	Crude Oil Consumption
	Petroleum Production (crude oil and natural gas liquids)	
	Miscellaneous Industrial Processes (carbon black manufacturing)	
Solid Waste Disposal	Incineration	Population
	Open Burning	
Miscellaneous Other Sources	Wildfire	Population
	Prescribed Fires	
	Other Burning	
	Other Solvent Evaporation	

SECTION 7.0

INTERNATIONAL CRITERIA POLLUTANT EMISSIONS

This is the second report in the *Trends* series to present international emissions. This section presents the 1985 criteria pollutant emissions that are available for Canada, Mexico, and 12 European Union (EU-12) countries:

- Belgium,
- Denmark,
- France,
- Former West Germany,
- Greece,
- Ireland,
- Italy,
- Luxembourg,
- Netherlands,
- Portugal,
- Spain, and
- United Kingdom.

For these countries, 1990 estimates are also presented if emissions data were available. The 1990 emissions are presented for 9 additional European countries that now have emissions data available:

- Austria,
- Bulgaria,
- Czech Republic,
- Finland,
- Former East Germany,
- Norway,
- Poland,
- Slovakia, and
- Sweden.

It should be noted that 1990 estimates for several countries are still preliminary. Additionally, 1991 emissions for Russia are presented for comparative purposes. It is important to note that to the extent that emission estimation methodologies differ between countries, intercountry comparisons may be misleading.

7.1 PER CAPITA EMISSIONS

Data are available to make 1985 per capita emission comparisons for NO_x, VOC, and SO_2 between 15 countries, including the United States. Table 7-1 presents the per capita emission figures, which are calculated from the international emissions data provided in this chapter as well as the U.S. data presented in section 2. These data indicate that of the 15 countries analyzed, the United States generated either the largest or second largest amount of 1985 emissions per capita. For NO_x emissions in 1985, the United States emitted 192 pounds per person, while the second largest per capita emitter, Canada, emitted 175 pounds per person. At 328 pounds per person, Canada generated the largest per capita emissions of SO_2 in 1985, nearly double the level of the second largest emitter (the United States at 191 pounds). The United States emitted the greatest amount of VOC per person in 1985, at 214 pounds per person; the former West Germany was second at 212 pounds emitted per person.

It is difficult to analyze the trends in per capita emissions for most of these countries because consistent time-series data are not available. However, 1990 United States data indicate a decrease in per capita emissions of NO_x, VOC, and SO_2 of 3, 9, and 6 percent, respectively, from the 1985 per capita levels.

7.2 CANADA

Canadian emissions data for 1985 and 1990 were provided by Libby Greenwood of Environment Canada.[1] The 1990 estimates are preliminary and do not correspond with those reported in the

Interim[2] report. The 1990 NO_x and VOC estimates are from Canada's Residual Discharge Information System; the 1990 SO_2 emissions are taken from a report developed for Eastern Canada's Acid Rain Program.[3] National Canada estimates are presented in this report, as well as estimates for three provinces — Ontario, Quebec, New Brunswick. Tables 7-2 and 7-3 display the 1985 emissions by major source category for NO_x and VOC, respectively. Tables 7-4 and 7-5 present the 1990 NO_x and VOC emissions by major source category. Table 7-6 shows the SO_2 emissions by major source category for both 1985 and 1990. National estimates for Canada were not available by major source category for 1990.

7.3 EUROPE

There has been a considerable on-going effort in Europe to develop consistent emissions for countries in the European community. This section provides the 1985 and 1990 estimates of NO_x, VOC, and SO_2 emissions developed under this effort.

7.3.1 CORINAIR: The Atmospheric Emission Inventory for Europe[i]

On June 27, 1985, the European Council of Ministers adopted Decision 85/338/EEC on a Commission world program for gathering, coordinating, and ensuring the consistency of information on the state of the environment and natural resources in the European Community. This program was called CORINE (COoRdination d'INformation Environnementale) and one of its component projects was the CORINe AIR emission inventory (CORINAIR).[4]

When the Council Decision on CORINE was adopted, there were several air emissions data collection campaigns in progress at the international level (OECD, UNECE, and PHOXA). The methodology for the prototype 1985 CORINAIR (CORINAIR85) inventory was based on the methodology of OECD and was developed in collaboration with experts from each of the member states, as well as from the European Commissions (CEC), OECD, UNICE, CEFIC, EUROTRAC, and IIASA.

On May 7, 1990, the Council adopted Regulation 1210/90 which established the European Environment Agency (EEA) and the European environment information and observation network. The regulation gives the EEA responsibility for the collection, processing, and analysis of environmental data and for the continuation of work started under the CORINE decision. It also lists several areas of work to be given priority. Air quality and atmospheric emissions are included in this list.

Pending a decision on the location of the EEA, the CORINE program is being continued by the EEA Task Force (EEA-TF) formed within the Directorate General Environment, Nuclear Safety and Civil Protection (DGXI) of the CEC. The CORINAIR project is being continued through an update for 1990 (CORINAIR90).

7.3.2 CORINAIR85

The prototype emission inventory for 1985 — CORINAIR85 — was based on the following:

(1) a new nomenclature (which was technology-based, since the NACE was considered inappropriate for environmental needs);

(2) a *Default Emission Factor Handbook* (based broadly on OECD and PHOXA results but also introducing new developments);

(3) addressing major localized emission sources as point sources (large point sources) and other minor or diffuse sources as area sources, with areas based on the Community's Nomenclature of Statistical Territorial Units (NSTU); and

(4) software for data input and the calculation of emissions.

These features of the CORINAIR system were developed by the contractor (CITEPA, in Paris) in conjunction with the following:

(1) the CORINAIR Technical Unit (which included other contractors and representatives of DGXI, the customer);

(2) working groups covering specific sources/pollutants (stationary NO_x, mobile sources, stationary VOC, natural VOC, and ammonia); and

(3) the CORINAIR Expert Group, with experts from each of the member states and from related international activities.

The CORINAIR85 inventory was based on 120 activities divided into eight categories:

- combustion (other than industry),
- oil refining,
- industrial combustion,
- industrial processes,
- solvent evaporation,
- road transport,
- nature, and
- miscellaneous activities.

It also quantified three pollutants: NO_x, VOC (including CH_4), and SO_2. Tables 7-7, 7-8, and 7-9 present the summary of the results obtained.

With certain restrictions on the use of the limited subset of data held in confidence within the CORINAIR data base, CORINAIR85 data are available on request from the CITEPA in Paris or the EEA-TF in Brussels. The complete CORINAIR85 inventory (activity statistics, emission factors, emissions, etc.) is held in personal computer files in Paris and Brussels. Emissions by territorial unit are held for mapping and analysis in ARCINFO files on the CORINE data base in Brussels.

7.3.3 CORINAIR90

Atmospheric emission inventory requirements and methodologies were developed rapidly at the national and international level during the course of the CORINAIR85 project. Estimates were extended to newly quantified sources of emissions and to additional pollutants. Each international project became informed of the work being carried out elsewhere. The need to harmonize these activities became clear when overlaps were discovered in the work that was being performed.

In preparing for the CORINAIR90 project, the CORINAIR Technical Unit and Expert Group were able to collaborate closely with UNECE and OECD. The UNECE requires emission inventory data as part of the obligations under the various Protocols for the Long Range Transboundary Air Pollution (LRTAP) convention. The OECD is developing the methodology for inventorying greenhouse gas emissions on behalf of the IPCC. This collaboration has achieved these results:

(1) produced a more developed nomenclature (source sector split [SNAP90]) involving over 260 activities grouped into a three-level hierarchy of subsectors and 11 main sectors;

(2) extended the list of pollutants to be covered to eight (SO_2, NO_x, NMVOC, ammonia, CO, CH_4, NO, and CO_2);

(3) extended the number of sources to be considered as point sources (there were over 1400 large point sources in the CORINAIR85 inventory);

(4) extended the availability of the CORINAIR system to 30 countries; and

(5) increased the awareness of CORINAIR and the need to produce an inventory within a reasonable time frame to serve

the requirements of the user community.

Following agreements reached with the UNECE on a common source sector split for reporting atmospheric emissions, the CORINAIR90 system has been made available to 30 European countries on a voluntary basis or with financial support from the CEC.

The CORINAIR90 system is currently available to the following:

(1) The EU-12 countries;

(2) 5 EFTA countries: Austria, Finland, Norway, Sweden, and Switzerland;

(3) 3 Baltic States: Estonia, Latvia, and Lithuania;

(4) 9 Central and Eastern European countries: Albania, Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia, and Slovenia; and

(5) Russia.

7.3.4 CORINAIR90 Summary Tables

The summary tables for the 11 main source sectors and 8 pollutants covered by the CORINAIR 1990 Programme (Tables 7-10 through 7-22) were prepared from data supplied to date to the European Environment Agency Task Force (EEA-TF).[5] The following countries and regions are included in this first set of summary tables to be released:

12 European Union countries (excluding the Former East Germany) —
- Belgium (Flemish region),
- Belgium (Wallonie region),
- Denmark,
- France,
- Former West Germany,
- Greece,
- Ireland,
- Italy,
- Luxembourg,
- Netherlands,
- Portugal,
- Spain,
- United Kingdom

12 European Union countries (plus 9 additional European countries) —
- Austria,
- Bulgaria,
- Czech Republic,
- Finland,
- Former East Germany,
- Norway,
- Poland,
- Slovakia, and
- Sweden.

Due to nomenclature and emission factor changes between the 1985 and 1990 inventories, the 1990 data are not comparable to the CORINAIR85 data.

7.4 RUSSIA

Table 7-23 presents 1991 and 1992 emissions for Russia, which were obtained from the V.B. Miliaev, Director, Scientific Research Institute of Atmospheric Air Protection, Ministry for Environmental Protection and Natural Resources, Russian Federation, St. Petersburg, Russia, 1994.[6]

7.5 MEXICO

Estimates of 1985 NO_x, SO_2, HC (VOC), CO, and TSP emissions for Mexico are contained in a draft report prepared as part of joint project between the World Bank, United Nations Statistical Office, and the Mexican Instituto Nacional de Estadistica, Geografia e Informatica (INEGI). ("Chapter 6, Integrated Environmental and Economic Accounting: A Case Study for Mexico," *Part 2: Applied Work and Case Studies in Developing and Industrial Countries*, World Bank, 1992.) The World Bank report includes emissions for five sectors: motor vehicles, manufacturing, electricity, oil refining, and services (services refers to miscellaneous industries that use combustion processes such as bakeries, hotels, and hospitals). Table 7-24 presents the emissions for Mexico in 1985 for the aforementioned source categories.

7.6 REFERENCES

1. Telefax entitled "Canadian Data for U.S. National Air Pollutant Emission Trends Report" from Libby Greenwood, Pollution Data Branch, Environment Canada, Hull, Quebec to Sharon Nizich, Emissions Inventory Branch, Technical Support Division, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. September 28, 1994.

2. *Regional Interim Emission Inventories (1987-1991), Volume I: Development Methodologies.* EPA-454/R-93-021a. U.S. Environmental Protection Agency, Research Triangle Park, NC. May 1993.

3. *Annual Report on the Federal Provincial Agreement for the Eastern Canada Acid Rain Program.* Environment Canada, Hull, Quebec. 1992.

4. *CORINAIR Newsletter.* G. McInnes, European Environment Agency Task Force, DGXI, Commission of the European Communities, Brussels, Belgium. March 1993.

5. Computer files from Gordon McInnes, European Environment Agency, Copenhagen, Denmark to Sharon Nizich, Emissions Inventory Branch, Technical Support Division, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. August 1994.

6. Letter from V.B. Miliaev of Scientific Research Institute of Atmospheric Air Protection, Ministry for Environmental Protection and Natural Resources, Russian Federation, St. Petersberg, Russia to D. Misenheimer, Emissions Inventory Branch, Technical Support Division, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1994.

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[i] The acronyms found in section 7.3.2 are defined in the list of Acronyms and Abbreviations found on page xvii.

Table 7-1. 1985 Per Capita Emissions for 15 Selected Countries
(pounds per capita)

COUNTRY	NO_X	VOC	SO_2
Belgium	71	97	88
Denmark	118	89	144
France	64	111	59
Former West Germany	98	212	84
Greece	69	137	111
Ireland	52	67	86
Italy	61	114	81
Luxembourg	137	82	98
Netherlands	72	66	30
Portugal	21	44	43
Spain	48	122	124
United Kingdom	83	153	147
Average of European Union	**71**	**135**	**93**
Canada	175	155	328
Mexico	45	60	167
United States	192	214	191
Average of 15 Selected Countries	**115**	**155**	**146**

NOTE(S): European Union excludes the Former East Germany.
1990 data for the United States are as follows:
United States — 186 pounds of NO_X, 195 pounds of VOC, and 179 pounds of SO_2 per person

Table 7-2. 1985 Canada Nitrogen Oxides Emissions by Province
(thousand short tons)

SECTOR	Ontario	Quebec	New Brunswick	CANADA
Transportation				
Cars	139	80	10	383
Light-Duty Trucks				
Gas	26	9	3	92
Diesel	0	0	0	0
Heavy-Duty Trucks				
Gas	10	4	1	33
Diesel	90	29	9	273
Off-Road Diesel				
Construction	10	4	1	35
Agriculture	8	5	1	59
Railroads	31	17	3	135
Other	30	23	4	160
Other	22	18	1	86
Fuel Combustion				
Residential	17	8	1	45
Commercial	14	4	1	33
Industrial				
Natural Gas	0	0	0	153
Other	108	46	5	267
Power Generation	172	2	8	330
Industrial Processes	33	12	3	112
Incineration/Miscellaneous	5	6	1	28
TOTAL	715	267	51	2,222

NOTE(S): The sums may not equal total due to rounding.

SOURCE: Libby Greenwood of Environment Canada, Pollution Data Branch, Hull, Quebec.

Table 7-3. 1985 Canada Volatile Organic Compound Emissions by Province
(thousand short tons [as total nonmethane hydrocarbons])

SECTOR	Ontario	Quebec	New Brunswick	CANADA
Transportation				
Cars	175	99	12	507
Light-Duty Trucks				
Gas	44	12	5	126
Diesel	0	0	0	1
Heavy-Duty Trucks				
Gas	14	6	1	47
Diesel	11	4	1	34
Off-Road Gasoline	7	3	1	72
Other	32	14	2	74
Fuel Combustion				
Fuelwood	37	44	6	119
Residential/Commercial	1	0	0	4
Industrial	6	0	0	53
Industrial Processes				
Petrochemicals	13	6	0	33
Petroleum Refining	67	40	7	179
Plastics	9	4	0	15
Other	30	11	1	68
Incineration/Miscellaneous				
Surface Coatings	60	35	3	134
Fuel Marketing	10	4	1	31
Dry Cleaning	6	4	0	16
Solvent Use	143	76	8	325
Slash Burning	18	22	5	106
Other	5	10	1	21
Power Generation	1	0	0	3
TOTAL	688	394	55	1,968

NOTE(S): The sums may not equal total due to rounding.

SOURCE: Libby Greenwood of Environment Canada, Pollution Data Branch, Hull, Quebec.

Table 7-4. 1990 Canada Nitrogen Oxides Emissions by Province
(thousand short tons)

SECTOR	Ontario	Quebec	New Brunswick	CANADA
Transportation				
Automobiles	121	80	10	
Heavy-Duty Diesel Vehicles	129	80	11	
Light-Duty Gasoline Trucks	36	17	4	
Other	147	91	14	
Fuel Combustion				
Electric Power Generation	86	7	28	
Residential Fuel Combustion	15	6	0	
Other	14	10	1	
Industrial Processes				
Pulp and Paper Industry	5	19	27	
Copper and Nickel Industry	58	1	0	
Iron and Steel Industry	24	5	0	
Petroleum Refining	16	5	2	
Other	110	39	1	
Incineration/Miscellaneous	15	2	0	
TOTAL	776	362	98	2,370

NOTE(S): The sums may not equal total due to rounding.

SOURCE: These are preliminary numbers provided by Libby Greenwood of Environment Canada, Pollution Data Branch, Hull, Quebec.

Table 7-5. 1990 Canada Volatile Organic Compound Emissions by Province
(thousand short tons [as total nonmethane hydrocarbons)

SECTOR	Ontario	Quebec	New Brunswick	CANADA
Transportation				
Automobiles	177	117	13	
Light-Duty Gasoline Trucks	50	23	6	
Off-Road Use of Gasoline	34	17	2	
Other	46	24	4	
Fuel Combustion				
Residential Fuelwood	126	131	1	
Other	3	1	0	
Industrial Processes				
Petroleum Refining	67	31	7	
Petrochemical Industry	17	7	0	
Other	108	14	3	
Incineration				
Wood Waste	4	7	3	
Other	1	1	1	
Miscellaneous				
Surface Coatings	140	47	1	
General Solvent Use	180	80	8	
Other	32	6	1	
TOTAL	985	505	50	2,972

NOTE(S): The sums may not equal total due to rounding.

SOURCE: These are preliminary numbers provided by Libby Greenwood of Environment Canada, Pollution Data Branch, Hull, Quebec.

Table 7-6. Canada Sulfur Dioxide Emissions by Province
(thousand short tons)

PROVINCE	SECTOR: Primary Metals	SECTOR: Power Generation	SECTOR: Other *	TOTAL
Ontario				
1985	860	370	408	1,637
1990	805	215	266	1,285
Quebec				
1985	553	1	250	803
1990	271	15	233	519
New Brunswick				
1985	19	103	29	151
1990	7	155	37	200
CANADA				
1985	1,968	811	1,389	4,168
1990	N/A	N/A	N/A	3,684

NOTE(S): The sums may not equal total due to rounding.
* "Other" includes remaining Industrial Process sectors, Fuel Combustion, Transportation, and Incineration/Miscellaneous.

SOURCE: These are preliminary numbers provided by Libby Greenwood of Environment Canada, Pollution Data Branch, Hull, Quebec.

Table 7-7. CORINAIR 1985: Nitrogen Oxides Emissions
(thousand short tons)

	Combustion excluding industry	Oil refineries	Industrial combustion	Processes	Solvent evaporation	Road transport	Nature	Misc	Total	Percent of Total
Belgium	72	7	41	30	0	201	0	0	349	3
Denmark	164	2	14	6	0	114	0	0	300	3
Germany	919	31	250	157	0	1,637	0	0	2,994	26
Greece	163	4	9	31	0	132	0	0	340	3
Spain	293	14	44	75	0	500	0	0	927	8
France	284	20	137	121	0	1,207	0	0	1,769	15
Ireland	40	0	9	6	0	39	0	0	93	1
Italy	487	30	128	139	0	951	0	0	1,735	15
Luxembourg	2	0	3	10	0	10	0	0	25	0
Netherlands	149	22	31	19	0	299	0	0	519	5
Portugal	15	2	12	13	0	63	0	0	106	1
United Kingdom	942	45	331	14	0	1,010	0	0	2,342	20
Total Europe-12	3,532	177	1,009	619	0	6,162	0	0	11,499	
Percent of Total	31	0	9	5	0	54	0	0		

NOTE(S): The sums may not equal total due to rounding.

SOURCE: Commission of the European Communities, European Environment Agency Task Force.

Table 7-8. CORINAIR 1985: Volatile Organic Compound Emissions
(thousand short tons)

	Combustion excluding industry	Oil refineries	Industrial combustion	Processes	Solvent evaporation	Road transport	Nature	Misc.	Total	Percent of Total
Belgium	20	12	3	32	90	213	31	78	479	2
Denmark	15	3	2	2	64	106	8	28	228	1
Germany	110	32	23	100	1,235	1,286	280	3,383	6,450	30
Greece	2	7	1	4	31	127	216	290	678	3
Spain	40	24	2	23	360	539	966	406	2,360	11
France	208	34	8	73	483	1,311	467	476	3,060	14
Ireland	19	1	1	1	23	26	23	26	121	1
Italy	52	42	6	50	438	1,090	244	1,326	3,246	15
Luxembourg	0	0	0	0	3	7	3	2	15	0
Netherlands	8	13	11	12	181	239	15	0	479	2
Portugal	1	4	1	19	57	58	72	8	220	1
United Kingdom	99	34	62	267	736	872	88	2,165	4,323	20
Total Europe-12	574	207	120	583	3,701	5,874	2,413	8,188	21,661	
Percent of Total	3	1	1	3	17	27	11	38		

NOTE(S): The sums may not equal total due to rounding.

SOURCE: Commission of the European Communities, European Environment Agency Task Force.

Table 7-9. CORINAIR 1985: Sulfur Dioxide Emissions
(thousand short tons)

	Combustion excluding industry	Oil refineries	Industrial combustion	Processes	Solvent evaporation	Road transport	Nature	Misc.	Total	Percent of Total
Belgium	208	39	109	60	0	18	0	0	433	3
Denmark	266	4	67	18	0	12	0	0	367	2
Germany	1,705	160	459	164	0	65	0	0	2,553	17
Greece	411	31	89	20	0	0	0	0	551	4
Spain	1,873	107	290	69	0	74	0	0	2,413	16
France	672	247	489	116	0	109	0	0	1,634	11
Ireland	87	1	61	2	0	4	0	0	155	1
Italy	1,307	163	606	143	0	84	0	0	2,304	15
Luxembourg	3	0	6	9	0	0	0	0	18	0
Netherlands	78	90	17	23	0	12	0	0	220	1
Portugal	95	14	76	25	0	8	0	0	218	1
United Kingdom	3,250	133	615	106	0	47	0	0	4,151	28
Total Europe-12	9,956	990	2,884	755	0	433	0	0	15,018	
Percent of Total	66	7	19	5	0	3	0	0		

NOTE(S): The sums may not equal total due to rounding.

SOURCE: Commission of the European Communities, European Environment Agency Task Force.

Table 7-10. CORINAIR90 Emissions for Belgium
(thousand short tons)

BELGIUM (FLEMISH REGION)	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	79	51	0	0	2	18,490	2	0
2 Commercial, institutional and residential combustion	26	7	4	1	52	14,025	2	0
3 Industrial combustion	79	20	2	0	18	12,198	1	0
4 Production processes	41	4	46	3	11	74	2	0
5 Extraction and distribution of fossil fuels	0	0	11	25	0	0	0	0
6 Solvent use	0	0	59	0	0	0	0	0
7 Road transport	9	116	116	9	781	12,225	1	0
8 Other mobile sources and machinery	0	0	0	0	0	0	0	0
9 Waste treatment and disposal	1	1	0	1	1	1,026	0	0
10 Agriculture	0	0	0	139	0	0	4	53
11 Nature	0	0	12	17	0	0	2	0
TOTAL	**235**	**200**	**251**	**193**	**865**	**58,038**	**14**	**54**

BELGIUM (WALLONIE REGION)	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	25	14	0	0	1	5,987	0	0
2 Commercial, institutional and residential combustion	12	7	4	4	19	9,401	1	0
3 Industrial combustion	63	57	3	3	103	19,215	2	0
4 Production processes	1	2	13	13	154	6,377	3	3
5 Extraction and distribution of fossil fuels	0	0	0	22	0	0	0	0
6 Solvent use	0	0	34	0	0	0	0	0
7 Road transport	6	104	94	1	227	7,250	0	0
8 Other mobile sources and machinery	0	4	4	0	2	195	0	0
9 Waste treatment and disposal	1	1	0	5	7	266	0	0
10 Agriculture	0	0	1	150	0	0	6	30
11 Nature	0	0	21	0	0	0	3	0
TOTAL	**109**	**188**	**174**	**197**	**513**	**48,690**	**15**	**33**

NOTE(S): The sums may not equal total due to rounding.
Emission estimates for the Wallonie Region are preliminary.

SOURCE: These final and preliminary tables are provided by Gordon McInnes of the European Environment Agency, Copenhagen, Denmark.

Table 7-11. CORINAIR90 Emissions for Denmark and France
(thousand short tons)

DENMARK	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	148	99	1	1	41	29,288	1	0
2 Commercial, institutional and residential combustion	10	6	9	7	154	8,687	0	0
3 Industrial combustion	30	15	1	1	5	8,411	0	0
4 Production processes	0	1	4	0	0	1,283	0	0
5 Extraction and distribution of fossil fuels	0	4	7	13	38	799	0	0
6 Solvent use	0	0	37	0	0	0	0	0
7 Road transport	7	112	108	2	601	8,907	0	0
8 Other mobile sources and machinery	17	63	15	1	30	4,227	0	0
9 Waste treatment and disposal	0	0	0	134	0	0	0	0
10 Agriculture	0	0	2	289	0	0	9	139
11 Nature	0	0	10	390	0	0	7	0
TOTAL	**212**	**301**	**196**	**838**	**868**	**61,600**	**18**	**139**

FRANCE	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	378	116	1	1	23	44,000	1	0
2 Commercial, institutional and residential combustion	128	97	236	165	2,081	129,360	4	0
3 Industrial combustion	566	182	8	7	658	95,370	2	0
4 Production processes	122	34	110	6	735	7,480	103	18
5 Extraction and distribution of fossil fuels	26	4	135	387	0	220	0	0
6 Solvent use	0	0	699	0	0	0	0	0
7 Road transport	160	1,142	1,287	25	7,493	107,140	4	1
8 Other mobile sources and machinery	27	142	134	1	563	12,870	0	0
9 Waste treatment and disposal	21	26	21	802	255	13,090	1	2
10 Agriculture	0	0	12	2,651	0	0	67	688
11 Nature	3	6	508	210	213	119,680	61	0
TOTAL	**1,430**	**1,749**	**3,150**	**4,256**	**12,023**	**529,210**	**245**	**710**

NOTE(S): The sums may not equal total due to rounding.

SOURCE: These final and preliminary tables are provided by Gordon McInnes of the European Environment Agency, Copenhagen, Denmark.

Table 7-12. CORINAIR90 Emissions for Former West Germany and Greece
(thousand short tons)

FORMER WEST GERMANY	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	278	301	7	7	64	243,100	9	0
2 Commercial, institutional and residential combustion	147	113	37	35	760	155,100	4	0
3 Industrial combustion	400	319	9	8	785	189,200	6	0
4 Production processes	59	18	127	9	666	24,200	103	2
5 Extraction and distribution of fossil fuels	22	2	189	1,625	0	1,100	0	0
6 Solvent use	0	0	1,133	0	0	0	0	0
7 Road transport	56	1,660	898	54	5,444	144,100	9	8
8 Other mobile sources and machinery	13	242	53	1	216	22,000	0	0
9 Waste treatment and disposal	0	0	0	1,967	0	0	4	0
10 Agriculture	0	0	0	1,658	0	0	51	589
11 Nature	0	0	298	0	0	0	0	0
TOTAL	**977**	**2,655**	**2,750**	**5,363**	**7,934**	**778,800**	**186**	**598**

GREECE	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	362	123	1	1	7	55,809	8	0
2 Commercial, institutional and residential combustion	42	1	0	0	1	2,155	0	0
3 Industrial combustion	29	3	0	0	0	1,531	0	0
4 Production processes	56	37	24	2	27	8,627	4	12
5 Extraction and distribution of fossil fuels	0	0	4	400	0	0	0	0
6 Solvent use	0	0	90	0	0	0	0	0
7 Road transport	15	125	151	4	775	11,394	0	0
8 Other mobile sources and machinery	200	300	51	1	73	9,348	0	0
9 Waste treatment and disposal	0	0	0	223	0	667	0	0
10 Agriculture	0	8	35	399	375	1	14	507
11 Nature	1	1	432	5,029	0	8,163	200	0
TOTAL	**705**	**598**	**790**	**6,058**	**1,258**	**97,694**	**226**	**519**

NOTE(S): The sums may not equal total due to rounding.
For Germany: Marine activities excluded. Airports - civil aviation only.

SOURCE: These final and preliminary tables are provided by Gordon McInnes of the European Environment Agency, Copenhagen, Denmark.

Table 7-13. CORINAIR90 Emissions for Ireland and Italy
(thousand short tons)

IRELAND	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	113	51	0	0	4	11,949	2	0
2 Commercial, institutional and residential combustion	33	7	9	4	88	8,645	1	0
3 Industrial combustion	43	12	0	0	1	5,974	0	0
4 Production processes	0	2	1	0	0	1,107	0	0
5 Extraction and distribution of fossil fuels	0	0	3	11	0	0	0	0
6 Solvent use	0	0	24	0	0	0	0	0
7 Road transport	6	48	69	1	335	4,452	0	0
8 Other mobile sources and machinery	1	5	1	0	4	486	0	0
9 Waste treatment and disposal	0	1	5	152	43	1,560	0	7
10 Agriculture	0	0	86	707	0	0	43	132
11 Nature	0	0	18	59	0	0	3	0
TOTAL	**196**	**127**	**217**	**935**	**474**	**34,173**	**50**	**139**

ITALY	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	844	448	4	4	25	117,889	18	0
2 Commercial, institutional and residential combustion	90	65	23	18	286	77,653	9	0
3 Industrial combustion	631	334	12	10	682	158,674	13	0
4 Production processes	115	14	112	8	418	30,352	16	25
5 Extraction and distribution of fossil fuels	0	0	146	382	0	0	0	0
6 Solvent use	0	0	591	0	0	0	0	0
7 Road transport	113	1,041	1,049	28	6,088	101,229	3	1
8 Other mobile sources and machinery	53	306	144	9	791	23,526	3	0
9 Waste treatment and disposal	5	38	124	1,433	1,876	5,959	2	12
10 Agriculture	0	1	435	1,941	30	0	63	384
11 Nature	627	13	167	320	1,187	56,621	29	0
TOTAL	**2,478**	**2,259**	**2,809**	**4,155**	**11,382**	**571,903**	**156**	**422**

NOTE(S): The sums may not equal total due to rounding.

SOURCE: These final and preliminary tables are provided by Gordon McInnes of the European Environment Agency, Copenhagen, Denmark.

Table 7-14. CORINAIR90 Emissions for Luxembourg and Netherlands
(thousand short tons)

LUXEMBOURG	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	0	0	0	0	0	2,071	0	0
2 Commercial, institutional and residential combustion	1	1	1	0	6	1,313	0	0
3 Industrial combustion	14	12	0	0	108	7,118	0	0
4 Production processes	0	0	1	0	19	644	0	2
5 Extraction and distribution of fossil fuels	0	0	2	2	0	0	0	0
6 Solvent use	0	0	4	0	0	0	0	0
7 Road transport	0	10	11	0	52	845	0	0
8 Other mobile sources and machinery	0	1	1	0	3	117	0	0
9 Waste treatment and disposal	0	0	0	4	0	145	0	0
10 Agriculture	0	0	0	19	0	0	1	6
11 Nature	0	0	2	1	0	116	0	0
TOTAL	**16**	**25**	**22**	**27**	**188**	**12,368**	**1**	**8**

NETHERLANDS	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	48	84	0	1	6	43,450	0	0
2 Commercial, institutional and residential combustion	5	34	18	2	111	34,650	0	1
3 Industrial combustion	48	44	1	2	13	30,360	0	0
4 Production processes	81	67	85	9	280	26,400	2	4
5 Extraction and distribution of fossil fuels	0	2	1	1	2	433	0	0
6 Solvent use	0	1	160	0	1	312	0	0
7 Road transport	14	299	202	7	743	26,180	5	0
8 Other mobile sources and machinery	19	54	25	0	23	2,970	0	0
9 Waste treatment and disposal	5	6	3	416	3	2,640	3	0
10 Agriculture	2	26	6	572	9	7,700	10	209
11 Nature	0	17	4	135	29	0	8	10
TOTAL	**221**	**633**	**505**	**1,144**	**1,217**	**175,096**	**28**	**225**

NOTE(S): The sums may not equal total due to rounding.

SOURCE: These final and preliminary tables are provided by Gordon McInnes of the European Environment Agency, Copenhagen, Denmark.

Table 7-15. CORINAIR90 Emissions for Portugal and Spain
(thousand short tons)

PORTUGAL	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	192	55	0	0	2	15,589	2	0
2 Commercial, institutional and residential combustion	5	3	11	8	129	3,865	0	0
3 Industrial combustion	60	26	4	3	363	15,286	2	0
4 Production processes	39	9	34	2	12	5,811	2	7
5 Extraction and distribution of fossil fuels	0	0	8	2	0	0	0	0
6 Solvent use	0	0	74	0	0	0	0	0
7 Road transport	15	117	89	2	676	9,403	0	0
8 Other mobile sources and machinery	3	26	7	0	13	1,638	0	0
9 Waste treatment and disposal	0	0	0	48	0	443	0	0
10 Agriculture	0	0	4	147	0	0	30	96
11 Nature	0	6	482	151	0	11,074	16	0
TOTAL	**314**	**243**	**714**	**363**	**1,195**	**63,109**	**54**	**102**

SPAIN	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	1,609	274	11	10	18	71,380	10	0
2 Commercial, institutional and residential combustion	108	23	65	49	979	31,820	3	0
3 Industrial combustion	526	186	12	8	446	72,364	7	0
4 Production processes	42	16	87	4	273	38,790	11	17
5 Extraction and distribution of fossil fuels	0	0	64	752	0	0	0	0
6 Solvent use	0	0	339	0	0	0	0	0
7 Road transport	76	563	494	13	2,871	53,577	2	0
8 Other mobile sources and machinery	19	271	43	2	122	16,060	0	0
9 Waste treatment and disposal	46	38	25	557	579	7,805	0	0
10 Agriculture	0	1	91	962	157	15,524	69	346
11 Nature	0	11	853	942	29	11,459	118	0
TOTAL	**2,426**	**1,383**	**2,083**	**3,298**	**5,475**	**318,778**	**222**	**364**

NOTE(S): The sums may not equal total due to rounding.
Emission estimates for Portugal are preliminary.

SOURCE: These final and preliminary tables are provided by Gordon McInnes of the European Environment Agency, Copenhagen, Denmark.

Table 7-16. CORINAIR90 Emissions for United Kingdom and European Union (EU-12 except Former East Germany)

(thousand short tons)

UNITED KINGDOM	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	3,002	854	14	0	55	218,900	3	0
2 Commercial, institutional and residential combustion	229	136	45	1	324	121,330	0	0
3 Industrial combustion	773	252	3	0	78	134,200	0	0
4 Production processes	20	10	325	0	0	8,140	93	17
5 Extraction and distribution of fossil fuels	0	71	485	1,332	2	13,860	0	0
6 Solvent use	0	0	827	0	0	0	0	0
7 Road transport	69	1,521	1,081	12	6,625	120,230	0	0
8 Other mobile sources and machinery	72	193	28	0	47	12,100	0	0
9 Waste treatment and disposal	0	14	53	1,197	242	9,680	0	4
10 Agriculture	0	0	0	1,184	0	0	90	494
11 Nature	0	0	88	0	0	0	0	53
TOTAL	**4,165**	**3,051**	**2,950**	**3,725**	**7,371**	**638,440**	**187**	**568**

EUROPEAN UNION (EU-12 except Former GDR)	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	7,080	2,471	41	25	247	877,902	56	0
2 Commercial, institutional and residential combustion	835	504	463	293	4,989	598,004	25	1
3 Industrial combustion	3,262	1,461	57	42	3,260	749,900	34	0
4 Production processes	578	212	969	56	2,595	159,284	340	107
5 Extraction and distribution of fossil fuels	48	83	1,057	4,954	41	16,412	0	0
6 Solvent use	0	1	4,071	0	1	312	0	0
7 Road transport	547	6,859	5,649	157	32,710	606,931	26	11
8 Other mobile sources and machinery	424	1,608	507	15	1,887	105,536	4	0
9 Waste treatment and disposal	80	124	232	6,938	3,005	43,281	10	25
10 Agriculture	2	36	673	10,818	571	23,225	457	3,672
11 Nature	630	54	2,895	7,254	1,458	207,112	447	63
TOTAL	**13,485**	**13,412**	**16,612**	**30,551**	**50,764**	**3,387,900**	**1,401**	**3,879**

NOTE(S): The sums may not equal total due to rounding.
Emission estimates for EU-12 are preliminary.

SOURCE: These final and preliminary tables are provided by Gordon McInnes of the European Environment Agency, Copenhagen, Denmark.

Table 7-17. CORINAIR90 Emissions for Austria and Bulgaria
(thousand short tons)

AUSTRIA	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	18	13	0	0	7	11,770	0	0
2 Commercial, institutional and residential combustion	21	13	110	9	858	13,750	1	0
3 Industrial combustion	43	40	12	1	30	14,520	0	0
4 Production processes	12	14	9	0	265	2,310	0	5
5 Extraction and distribution of fossil fuels	0	0	17	101	0	0	0	0
6 Solvent use	0	0	143	0	0	0	0	0
7 Road transport	7	168	124	3	624	15,290	1	1
8 Other mobile sources and machinery	0	0	0	0	0	0	0	0
9 Waste treatment and disposal	0	1	28	342	0	55	0	5
10 Agriculture	0	0	13	223	66	0	8	83
11 Nature	0	0	244	229	0	0	0	9
TOTAL	**102**	**248**	**701**	**908**	**1,851**	**57,695**	**10**	**104**

BULGARIA	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	1,598	95	1	1	15	35,004	8	0
2 Commercial, institutional and residential combustion	133	6	19	20	300	7,813	0	0
3 Industrial combustion	359	79	10	5	115	24,782	3	0
4 Production processes	89	32	33	3	53	5,656	3	11
5 Extraction and distribution of fossil fuels	1	0	5	288	0	11,810	0	0
6 Solvent use	0	0	45	0	0	0	0	0
7 Road transport	11	150	81	2	409	8,357	0	0
8 Other mobile sources and machinery	18	32	6	0	16	2,330	0	0
9 Waste treatment and disposal	0	1	7	68	71	2,940	0	28
10 Agriculture	0	1	33	260	1	1,269	23	317
11 Nature	0	0	194	2	11	198	14	0
TOTAL	**2,209**	**398**	**433**	**648**	**991**	**100,159**	**53**	**356**

NOTE(S): The sums may not equal total due to rounding.
Emission estimates for Austria are preliminary.

SOURCE: These final and preliminary tables are provided by Gordon McInnes of the European Environment Agency, Copenhagen, Denmark.

Table 7-18. CORINAIR90 Emissions for Czech Republic and Finland
(thousand short tons)

CZECH REPUBLIC	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	1,279	353	5	5	30	71,459	9	0
2 Commercial, institutional and residential combustion	504	114	64	64	551	56,194	6	0
3 Industrial combustion	191	159	4	4	303	29,840	2	0
4 Production processes	67	9	31	2	91	822	3	3
5 Extraction and distribution of fossil fuels	0	0	6	929	0	0	0	0
6 Solvent use	0	0	102	0	0	0	0	0
7 Road transport	0	157	58	3	157	8,434	1	0
8 Other mobile sources and machinery	6	57	8	0	10	3,433	0	0
9 Waste treatment and disposal	1	1	0	38	6	833	0	97
10 Agriculture	0	0	0	558	0	0	28	0
11 Nature	0	0	44	104	0	2,266	18	0
TOTAL	**2,049**	**850**	**323**	**1,707**	**1,148**	**173,280**	**68**	**100**

FINLAND	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	81	65	1	1	9	24,200	1	0
2 Commercial, institutional and residential combustion	22	15	36	7	67	10,230	0	0
3 Industrial combustion	86	34	1	2	39	26,400	1	0
4 Production processes	66	4	21	0	3	1,364	3	1
5 Extraction and distribution of fossil fuels	0	0	20	0	0	0	0	0
6 Solvent use	0	0	52	0	0	0	0	0
7 Road transport	4	131	80	2	437	13,006	0	0
8 Other mobile sources and machinery	8	61	15	8	46	5,599	1	0
9 Waste treatment and disposal	0	0	3	74	11	0	0	0
10 Agriculture	0	0	0	179	0	0	33	43
11 Nature	0	0	563	0	0	2,750	77	0
TOTAL	**267**	**311**	**793**	**274**	**612**	**83,549**	**116**	**45**

NOTE(S): The sums may not equal total due to rounding.
Emission estimates for Finland are preliminary.

SOURCE: These final and preliminary tables are provided by Gordon McInnes of the European Environment Agency, Copenhagen, Denmark.

Table 7-19. CORINAIR90 Emissions for Former East Germany and Norway
(thousand short tons)

FORMER EAST GERMANY	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	4,129	299	2	2	802	156,200	4	0
2 Commercial, institutional and residential combustion	505	11	88	88	1,498	69,300	2	0
3 Industrial combustion	392	151	11	11	208	93,500	3	0
4 Production processes	8	6	19	0	65	7,700	6	2
5 Extraction and distribution of fossil fuels	0	0	36	77	25	0	0	0
6 Solvent use	0	0	154	0	0	0	0	0
7 Road transport	29	151	473	24	1,079	19,800	0	0
8 Other mobile sources and machinery	20	68	31	1	70	5,500	0	0
9 Waste treatment and disposal	0	0	0	507	0	0	0	0
10 Agriculture	0	0	0	600	0	0	23	209
11 Nature	0	0	128	0	0	0	0	0
TOTAL	**5,082**	**685**	**942**	**1,310**	**3,748**	**352,000**	**39**	**211**

NORWAY	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	1	1	0	0	1	195	0	0
2 Commercial, institutional and residential combustion	3	3	10	12	138	2,749	1	0
3 Industrial combustion	8	30	2	3	12	10,650	1	0
4 Production processes	34	10	14	2	66	7,175	7	1
5 Extraction and distribution of fossil fuels	0	0	122	15	0	406	0	0
6 Solvent use	0	0	35	0	0	105	0	0
7 Road transport	4	92	97	2	792	8,865	1	0
8 Other mobile sources and machinery	9	109	16	1	36	5,674	0	0
9 Waste treatment and disposal	0	10	1	175	1	1,857	0	0
10 Agriculture	0	0	0	100	0	194	7	41
11 Nature	0	0	0	0	0	10	0	0
TOTAL	**59**	**256**	**297**	**310**	**1,046**	**37,879**	**17**	**42**

NOTE(S): The sums may not equal total due to rounding.
For Germany: Marine activities excluded. Airports - civil aviation only.

SOURCE: These final and preliminary tables are provided by Gordon McInnes of the European Environment Agency, Copenhagen, Denmark.

Table 7-20. CORINAIR90 Emissions for Poland and Slovakia
(thousand short tons)

POLAND	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	1,748	542	3	3	75	169,895	16	1
2 Commercial, institutional and residential combustion	488	48	109	103	1,478	68,893	5	0
3 Industrial combustion	1,106	383	12	18	3,728	162,074	7	0
4 Production processes	103	83	97	10	135	4,279	14	39
5 Extraction and distribution of fossil fuels	0	0	56	3,205	0	0	0	0
6 Solvent use	83	0	253	0	0	0	0	0
7 Road transport	71	267	272	5	2,346	21,538	1	0
8 Other mobile sources and machinery	1	175	80	1	99	12,837	0	0
9 Waste treatment and disposal	0	92	186	895	247	2,288	2	47
10 Agriculture	0	0	38	2,047	0	0	103	504
11 Nature	0	1	319	431	20	14,619	23	47
TOTAL	**3,601**	**1,590**	**1,425**	**6,718**	**8,128**	**456,423**	**171**	**639**

SLOVAKIA	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	267	60	1	0	10	17,450	1	0
2 Commercial, institutional and residential combustion	128	13	15	15	188	11,517	1	0
3 Industrial combustion	182	60	11	7	127	16,081	2	0
4 Production processes	13	16	7	0	21	3,460	0	3
5 Extraction and distribution of fossil fuels	0	6	16	136	2	1,316	0	0
6 Solvent use	0	0	61	0	0	0	0	0
7 Road transport	3	62	44	1	166	5,212	0	0
8 Other mobile sources and machinery	1	13	1	0	6	571	0	0
9 Waste treatment and disposal	1	1	12	106	0	517	0	0
10 Agriculture	0	0	0	133	0	0	1	68
11 Nature	0	0	0	0	0	4	0	0
TOTAL	**596**	**231**	**169**	**398**	**521**	**56,128**	**6**	**71**

NOTE(S): The sums may not equal total due to rounding.
Emission estimates for Slovakia are preliminary.

SOURCE: These final and preliminary tables are provided by Gordon McInnes of the European Environment Agency, Copenhagen, Denmark.

Table 7-21. CORINAIR90 Emissions for Sweden and Selected European Countries (EU-12 + Austria, Bulgaria, Czech Republic, Finland, Former East Germany, Norway, Poland, Slovakia, and Sweden)
(thousand short tons)

SWEDEN	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	16	15	3	1	6	7,609	1	0
2 Commercial, institutional and residential combustion	17	13	142	11	79	10,010	1	0
3 Industrial combustion	41	46	9	5	27	17,751	1	0
4 Production processes	19	11	34	0	7	2,198	3	0
5 Extraction and distribution of fossil fuels	0	0	19	0	0	0	0	0
6 Solvent use	0	0	82	0	0	0	0	0
7 Road transport	8	179	170	14	1,229	17,741	1	0
8 Other mobile sources and machinery	12	112	38	4	117	6,741	0	0
9 Waste treatment and disposal	2	2	0	198	15	32,556	0	31
10 Agriculture	0	0	0	226	0	0	9	49
11 Nature	0	0	297	1,860	2	92,816	20	1
TOTAL	**115**	**380**	**794**	**2,317**	**1,482**	**187,420**	**36**	**81**

SELECTED EUROPEAN COUNTRIES	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	16,218	3,915	56	38	1,201	1,371,685	97	2
2 Commercial, institutional and residential combustion	2,658	739	1,057	622	10,145	848,460	42	2
3 Industrial combustion	5,670	2,444	128	98	7,850	1,145,497	55	1
4 Production processes	987	397	1,234	72	3,301	194,248	380	171
5 Extraction and distribution of fossil fuels	49	90	1,354	9,705	69	29,943	0	0
6 Solvent use	0	1	4,998	0	1	417	0	0
7 Road transport	697	8,216	7,049	212	39,951	725,173	31	13
8 Other mobile sources and machinery	570	2,235	702	32	2,287	148,221	7	0
9 Waste treatment and disposal	85	233	470	9,341	3,357	84,326	12	137
10 Agriculture	2	37	757	15,142	637	24,688	694	5,084
11 Nature	630	55	4,684	9,880	1,491	319,776	600	118
TOTAL	**27,565**	**18,361**	**22,488**	**45,141**	**70,289**	**4,892,433**	**1,917**	**5,529**

NOTE(S): The sums may not equal total due to rounding.
Emission estimates for selected European countries (EU-12 plus 9 additional European countries) are preliminary.

SOURCE: These final and preliminary tables are provided by Gordon McInnes of the European Environment Agency, Copenhagen, Denmark.

Table 7-22. CORINAIR90 Estimates of the Percentage of Europe Emissions from Source Categories

(percentages)

EUROPEAN UNION (EU-12, except Former East Germany)	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	52	18	0	0	0	26	4	0
2 Commercial, institutional and residential combustion	6	4	3	1	10	18	2	0
3 Industrial combustion	24	11	0	0	6	22	2	0
4 Production processes	4	2	6	0	5	5	24	3
5 Extraction and distribution of fossil fuels	0	1	6	16	0	0	0	0
6 Solvent use	0	0	25	0	0	0	0	0
7 Road transport	4	51	34	1	64	18	2	0
8 Other mobile sources and machinery	3	12	3	0	4	3	0	0
9 Waste treatment and disposal	1	1	1	23	6	1	1	1
10 Agriculture	0	0	4	35	1	1	33	95
11 Nature	5	0	17	24	3	6	32	2

SELECTED EUROPEAN COUNTRIES (EU-12 + 9 additional countries)	SO_2	NO_x as NO_2	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
1 Public power, cogeneration and district heating	59	21	0	0	2	28	5	0
2 Commercial, institutional and residential combustion	10	4	5	1	14	17	2	0
3 Industrial combustion	21	13	1	0	11	23	3	0
4 Production processes	4	2	5	0	5	4	20	3
5 Extraction and distribution of fossil fuels	0	0	6	21	0	1	0	0
6 Solvent use	0	0	22	0	0	0	0	0
7 Road transport	3	45	31	0	57	15	2	0
8 Other mobile sources and machinery	2	12	3	0	3	3	0	0
9 Waste treatment and disposal	0	1	2	21	5	2	1	2
10 Agriculture	0	0	3	34	1	1	36	92
11 Nature	2	0	21	22	2	7	31	2

NOTE(S): The sums may not equal total due to rounding.

SOURCE: These final and preliminary tables are provided by Gordon McInnes of the European Environment Agency, Copenhagen, Denmark.

Table 7-23. Emissions in the Territory of Russia
(million short tons)

Source Category	Pollutant	1991	1992
Stationary sources			
	Total	32	28
	Particulate Matter		66
	Gaseous and liquid substances, including:	25	23
	Sulfur dioxide	9	8
	Carbon monoxide	8	7
	Nitrogen oxides	3	3
	Hydrocarbons (without VOC)	3	2
	VOC	2	2
Highway vehicles			
	Total	17	16
	Carbon dioxide	13	13
	Nitrogen oxides	1	1
	Hydrocarbons	3	2

SOURCE: V.B. Miliaev, Director, Scientific Research Institute of Atmospheric Air Protection, Ministry for Environmental Protection and Natural Resources, Russian Federation, St. Petersburg, Russia, 1994.

Table 7-24. Mexico Emissions in 1985
(tons)

CATEGORY		NO_X	SO_2	VOC	CO	TSP
Vehicles (Total)		954,966	402,638	1,752,576	17,151,780	55,666
	Cars	207,939	17,631	728,993	6,870,479	21,813
	Buses	165,829	115,211	48,747	118,903	5,299
	Trucks	581,198	269,796	974,836	10,162,398	28,554
Industry (Total)		829,551	6,133,401	629,850	813,768	409,548
	Manufacturing	152,675	347,459	211,339	83,603	54,139
	Electricity	635,340	5,596,041	10,856	53,802	340,583
	Oil Refining	41,536	189,901	407,655	676,363	14,826
Services (Total)		19,891	110,031	604	2,324	12,315
TOTAL		**1,804,408**	**6,646,070**	**2,383,030**	**17,967,872**	**477,529**

SOURCE: "Chapter 6, Integrated Environmental and Economic Accounting: A Case Study for Mexico," *Part 2: Applied Work and Case Studies in Developing and Industrial Countries*, World Bank, 1992.

SECTION 8.0

NATIONAL AND INTERNATIONAL GREENHOUSE GAS EMISSIONS

8.1 NATIONAL GREENHOUSE GAS EMISSIONS

8.1.1 Introduction

Naturally occurring greenhouse gases include water vapor CO_2, CH_4, nitrous oxide (N_2O), and O_3. Chlorofluorocarbons (CFCs [a family of human-made compounds]), its substitute hydrofluorocarbons (HFCs), and other compounds such as perfluorinated carbons (PFCs), are also greenhouse gases. Although CO_2, CH_4, and N_2O occur naturally in the atmosphere, their recent atmospheric build up appears to be largely the result of human activities. This growth has altered the composition of the Earth's atmosphere, and may affect future global climate.

The United States signed the Framework Convention on Climate Change (FCCC) at the United Nations Conference on Environment and Development in June 1992, and in October 1992, became the first industrialized nation to ratify the treaty. Since the mid-1980s, the United States has actively supported international cooperation to help implement the provisions of this agreement. In particular, the United States has worked with technical experts from over 50 countries, along with the Organization for Economic Cooperation and Development (OECD), as part of the inventory program of the Intergovernmental Panel on Climate Change (IPCC). This effort has helped facilitate agreement on methods for estimating emissions of greenhouse gases, which absorb reradiated energy from the sun. This trapped energy warms the earth's surface and atmosphere, leading to what is termed the "greenhouse effect." The purpose behind this cooperative effort is twofold: (1) to provide a basis for on-going development of a comprehensive and detailed methodology for estimating sources and sinks[j] of greenhouse gases and (2) to develop an international system of consistent national inventories of greenhouse gas emissions and sinks for all signatory countries to the FCCC.[k]

8.1.2 Methodology and Data

The U.S. greenhouse gas emissions presented in this report are taken from an EPA report, *Inventory of U.S. Greenhouse Gas Emissions: 1990-1993*, Final Report, September 1994.[1] Emissions of greenhouse gases for various source categories were developed using methods that are similar to those recommended by Volumes 1-3 of *IPCC Draft Guidelines for National Greenhouse Gas Inventories* (IPCC/OECD, 1994).[2] The IPCC's guidelines were followed whenever possible, to ensure that the U.S. emissions inventory is comparable to other countries' inventories submitted under the FCCC. It should be noted that the IPCC guidelines represent baseline methodologies. The methodologies are currently evolving, and efforts continue to refine the recommended procedures. For U.S. emission sources relating to energy consumption, forest sinks, and some CH_4 sources, the IPCC default methodologies were expanded, resulting in a more comprehensive estimation procedure. Details on the methods utilized to develop the U.S. emissions are available in the aforementioned September 1994, EPA report.

The 1990 to 1993 CO_2 emissions, including CO_2 sinks (represented by values in parentheses), are presented in Table 8-1. Total 1993 CO_2 emissions were not estimated because some data were unavailabile. Fossil-fuel combustion is the most significant source of CO_2 emissions in the United States. For example, 98 percent of total U.S. CO_2 emissions in 1990 resulted from the consumption of fossil fuels. The 1990 to 1993 trend in CO_2 emissions was largely a result of changes in energy consumption over this period caused by a general downturn and subsequent recovery in the U.S. economy. Carbon dioxide may also be emitted when raw materials are chemically transformed during certain industrial processes. From 1990 to 1992, industrial processes accounted for approximately 1 percent of total U.S. CO_2 emissions. Because certain natural processes remove (sequester) CO_2 from the atmosphere, total net CO_2 emissions are estimated by subtracting the amount of CO_2 sequestered by forest management and land-use activities from the amount produced. Over the 1990 to 1992 period, these activities removed approximately 10 percent of total CO_2 emissions.

It should be noted that these accountings of greenhouse gases focus only on those sources and sinks that significantly influence the net accumulation of these gases in the atmosphere. Major components of the carbon and nitrogen cycles, involving animal metabolism, seasonal plant photosynthesis and respiration, etc., are not included here because on the scale of years they are effectively in balance. For example, the approximately 100 million short tons per year of CO_2 exhaled by the human population of the United States derive from the carbon that has been extracted from the atmosphere by agricultural crops, a portion of which, directly or through animal feed, becomes our food.

Emissions for CH_4 and N_2O are displayed in Tables 8-2 and 8-3, respectively. As with carbon dioxide, data were not available to estimate total CH_4 and N_2O emissions in 1993. The 1990 CH_4 estimates were primarily taken from the U.S. EPA report, *Anthropogenic Methane Emissions in the United States: Report to Congress* (U.S. EPA, 1993).[3] The methodologies described in that report are conceptually similar to the IPCC's procedures. Estimates for 1991-1993 were also compiled using these metholodologies. Total estimated CH_4 emissions have remained essentially constant over the 1990 to 1992 period.

The largest single anthropogenic source of CH_4 emissions in the United States is landfills, accounting for approximately 37 percent of total CH_4 emissions. Municipal solid waste landfills are responsible for about 90 to 95 percent of these emissions, while the remainder comprise industrial landfills. Agricultural activities, which include management of domestic livestock and animal waste generation, also substantially contribute to CH_4 emissions. In 1990, domestic livestock and animal wastes were together responsible for approximately 30 percent of total anthropogenic CH_4 emissions.

Over the 1990 to 1992 period, total N_2O emissions increased slightly. The application of fertilizers to soil (both synthetic nitrogen fertilizer and organic fertilizer), is the most significant source of nitrous oxide emissions. Fertilizers were responsible for an estimated 44 percent of total U.S. N_2O emissions during 1990. Between 1991 and 1992, the annual average rate of increase was 2 percent. Additional activities that create significant amounts of N_2O emissions include fossil-fuel consumption and industrial processes such as adipic acid and nitric acid production.

Partially halogenated compounds (HFCs) and PFCs are used primarily as alternatives to the ozone depleting substances (ODSs) being phased out under the Montreal Protocol and CAAA. Ozone depleting substances which include CFCs and partially halogenated fluorocarbons (HCFCs) are used in a variety of industrial applications, including refrigeration, solvent cleaning, foam production, sterilization, and fire extinguishing. Although the ODS replacements (i.e., HFCs and PFCs) are not harmful to the stratospheric ozone layer, they are powerful greenhouse gases (for example, HFC-134a is 1,200 times more heat absorbent than an equivalent amount of CO_2 by weight in the atmosphere).

In 1990, HFCs and PFCs were not used widely as commercial chemicals. However, these gases were emitted as by-products from other industrial production processes. For example, HFC-23 was emitted as a by-product of HCFC-22 production, and CF_4 and C_2F_6 (two PFCs) were released during aluminum smelting. Emissions of these HFCs and PFCs totaled approximately 79.5 thousand short tons CO_2 equivalent in 1990. The manufacture and emissions of HFCs and PFCs are expected to rise as their use as ODS replacements increases.

Emissions of HFCs and PFCs: 1990 (thousand short tons)

Compound	Molecular Basis	GWP	CO_2 Emissions
HFCs			
HFC-23	0.00552	10,000	60.85
HFC-134a	0.0005	1,200	0.66
HFC-152a	0.0003	150	0.05
PFCs			
Total PFCs	0.003	5,400	17.86

Source: *Inventory of U.S. Greenhouse Gas Emissions: 1990-1993.* Final Report. U.S. Environmental Protection Agency. September 1994.

8.2 INTERNATIONAL GREENHOUSE GAS EMISSIONS

8.2.1 Carbon Dioxide Emissions

The CO_2 emissions presented in this section were obtained from the Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratories.[4] A systematic method for estimating the amount of global CO_2 emissions due to fossil-fuel combustion was first proposed in 1973. The methodology also accounts for CO_2 emissions from cement manufacturing and gas flaring. Since that date, both the data collection and the procedures for estimating CO_2 emissions have been refined and improved.[5] To derive global emissions, energy and population statistics were obtained from the United Nation's Department of International Economic and Social Affairs. The U.S. DOI's Bureau of Mines supplied cement manufacturing data, and gas flaring data were compiled from both the U.S. EIA and the United Nations.

8.2.2 Global Trends

Since 1860, when CO_2 emissions were estimated to be about 375 million short tons per year, global CO_2 emissions have risen dramatically. In 1991, approximately 25 billion short tons of CO_2 were emitted to the atmosphere as a result of fossil-fuel burning, cement manufacturing, and gas flaring.

Table 8-4 presents global CO_2 emissions for 1860 to 1991. Starting in 1950, estimates were developed using the methods of Marland and Rotty.[6] Figure 8-1 depicts the trend in CO_2 emissions over the 1950 to 1991 period. Total global CO_2 emissions continued their upward trend, increasing 2 percent between 1990 and 1991.

Table 8-5 displays regional world CO_2 emissions for 1950 to 1991. The nine regions are based on United Nations conventions and are defined in Table 8-5. Between 1990 and 1991, a decline in CO_2 emissions was evident for Eastern Europe and North America. An increase in CO_2 emissions over the same period was seen for regions experiencing much faster population growth (i.e., Africa, Centrally Planned Asia, Other America, Far East, and Oceania). In 1950, North America, and Western and Eastern Europe contributed approximately 89 percent of total CO_2 emissions. Presently, that percentage has dropped to only about 40 percent.

Figure 8-2 compares estimates of total global CO_2 per capita emissions with CO_2 per capita emissions for Mexico and Canada during 1950 to 1991. Per capita emissions for the United States are presented from 1950 to 1989. 1990 to 1993 CO_2 emissions for the United States are discussed in section 8.1. Per capita CO_2 emissions for Canada peaked in 1979 at 19.8 short tons, well above the global average, while Mexico's per capita emissions are significantly lower, exceeding the global average only once in 1982.

8.2.3 United States

Table 8-6 and Figure 8-3 present CO_2 emissions for the United States. The United States continues to be the largest single source of fossil-fuel-related CO_2 emissions, contributing approximately 38 percent more CO_2 emissions than the world's second largest emitter, the former USSR. Carbon dioxide emissions in 1989 were nearly twice those of 1950, although the United States' share of global emissions declined over the same interval due to higher growth rates in other countries. In 1989, CO_2 emissions from the United States reached an all-time high of 6 billion short tons of CO_2 and have since remained near this level. U.S. emissions for 1990 through 1993 are discussed in more detail in section 8.1.

8.2.4 Canada

Table 8-7 and Figure 8-4 present CO_2 emissions for Canada for the period 1950 to 1991. Total CO_2 emissions from Canada more than doubled between 1950 and 1974, and continued rising until 1980. In the early 1980s, CO_2 emissions declined, but then began to increase by 1986, peaking in 1989 at 488 million short tons of CO_2. By 1991, CO_2 emissions had decreased 7 percent from 1989 emission levels. Coal burning contributed to 63 percent of the total emissions in 1950, but declined in both absolute and relative terms until 1974. Beginning in 1974, a decline in CO_2 emissions from liquid fuels was accompanied by a steady increase in emissions from coal.[6]

8.2.5 Mexico

Carbon dioxide emissions for Mexico are displayed in Table 8-8 and Figure 8-5. From 1950 to 1982, total CO_2 emissions from Mexico increased at a rate of approximately 7 percent per year. Total emissions declined slightly and leveled off near 320 million short tons of CO_2 during the period 1983 to 1988. From 1989 to 1991, total emissions rose approximately 10 percent, peaking at 375 million short tons of CO_2 in 1991. The increase in emissions has been largely attributable to an increase in oil production. In 1991, petroleum products accounted for 74 percent of total CO_2 emissions, the highest fraction of any of the major CO_2-emitting countries. In recent years, natural gas has become increasingly important in Mexico and now accounts for 15 percent of CO_2 emissions.[6]

8.3 REFERENCES

1. *Inventory of U.S. Greenhouse Gas Emissions: 1990-1993.* Final Report. U.S. Environmental Protection Agency. September 1994.

2. *IPCC Guidelines for National Greenhouse Gas Inventories, 3 volumes: Vol. 1, Reporting Instructions; Vol. 2, Workbook; Vol. 3, Draft Reference Manual.* Intergovernmental Panel on Climate Change, Organization for Economic Co-Operation and Development. Paris, France. 1994.

3. *Anthropogenic Methane Emissions in the United States, Estimates for 1990: Report to Congress.* EPA/430-R-93-003. Office of Air and Radiation, U.S. Environmental Protection Agency, Washington, DC. 1993

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[j] A "sink" is a mechanism that leads to the removal and/or destruction of greenhouse gases.

[k] Article 4-1 of the FCCC requires that all parties "develop, periodically update, publish, and make available to the Conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties."

Table 8-1. Summary of U.S. Carbon Dioxide Emissions and Sinks by Source Category, 1990 to 1993
(thousand short tons)

Source Category	1990	1991	1992	1993
FOSSIL FUEL CONSUMPTION FOR ENERGY				
Electric Utilities	1,920,726	1,909,335	1,905,405	1,984,218
Oil	107,618	101,337	80,579	90,982
Gas	167,093	169,697	168,149	161,994
Coal	1,646,015	1,638,301	1,656,676	1,731,243
Industry	1,174,947	1,127,836	1,185,319	1,182,497
Oil	418,399	366,354	411,767	396,373
Gas	480,633	500,622	520,103	530,802
Coal	275,916	260,860	253,449	255,322
Transportation	1,656,345	1,620,723	1,644,036	1,661,142
Oil	1,616,495	1,583,689	1,607,785	1,624,111
Gas	39,849	37,034	36,251	37,031
Coal	0	0	0	0
Commercial	240,100	244,650	245,261	251,365
Oil	72,863	69,051	65,166	64,619
Gas	157,553	166,791	171,162	177,032
Coal	9,684	8,807	8,933	9,715
Residential	367,271	383,043	392,477	409,208
Oil	96,952	98,826	100,435	101,456
Gas	263,867	278,348	286,132	301,341
Coal	6,452	5,869	5,911	6,411
U.S. Territories	36,848	43,642	37,847	37,847
Oil	36,303	42,862	37,067	37,067
Gas	0	0	0	0
Coal	545	780	780	780
TOTAL FOSSIL FUEL CONSUMPTION	5,396,236	5,329,228	5,410,345	5,526,277
FUGITIVE FUEL	7,231	8,157	8,047	NA
INDUSTRIAL PROCESSES				
Cement Production	36,045	35,224	35,507	NA
Lime Production	13,117	12,909	13,329	NA
Limestone Use	5,622	5,340	5,491	NA
Soda Ash Production and Use	4,519	4,442	4,464	4,530
Carbon Dioxide Manufacture	1,323	1,389	1,455	1,543
TOTAL INDUSTRIAL PROCESSES	60,627	59,304	60,246	NA
TOTAL EMISSIONS	5,464,093	5,396,689	5,478,638	NA
FORESTRY/LAND USE	480,603	477,296	472,887	NA
TOTAL NET EMISSIONS	4,983,491	4,919,393	5,005,752	NA

NOTE(S): "NA" = Not available

Totals presented in this table may not equal the sum of the individual source categories due to rounding.

Table 8-2. Summary of U.S. Methane Emissions by Source Category, 1990 to 1993
(thousand short tons)

Source Category	1990	1991	1992	1993
WASTE				
Landfills	11,023	11,133	11,243	11,354
Wastewater	165	165	165	165
AGRICULTURE				
Dairy Cattle	1,642	1,664	1,653	1,653
Beef Cattle	4,469	4,497	4,552	4,630
Sheep	99	99	99	88
Goats	11	11	11	11
Pigs	88	88	99	99
Horses	99	99	99	99
Animal Wastes	2,506	2,348	2,403	2,480
Dairy	805	783	772	783
Beef	187	198	209	209
Swine	1,235	1,102	1,157	1,224
Other	276	265	265	265
Agricultural Waste Burning	87	94	90	94
Cereals	65	71	68	71
Pulse	17	18	17	17
Tuber and Root	2	2	2	2
Sugarcane	3	3	3	3
Rice Cultivation	473	495	495	505
TOTAL AGRICULTURE	9,475	9,400	9,489	9,663
FUGITIVE FUEL EMISSIONS	8,423	8,267	8,062	NA
Coal Mining	4,850	4,630	4,425	NA
Oil and Gas Systems	3,573	3,638	3,638	NA
MOBILE SOURCES	245	268	274	NA
STATIONARY COMBUSTION	466	456	425	NA
TOTAL EMISSIONS	29,797	29,690	29,660	NA

NOTE(S): "+" denotes negligible emissions.
"NA" = not available
Totals presented in this table may not equal the sum of the individual source categories due to rounding.

Table 8-3. Summary of U.S. Nitrous Oxide Emissions by Source Category, 1990 to 1993
(thousand short tons)

Source Category	1990	1991	1992	1993
AGRICULTURE				
Crop Waste Burning	6	6	6	NA
Cereals	2	3	3	NA
Pulse	2	2	2	NA
Tuber and Root	+	+	+	NA
Sugarcane	+	+	+	NA
Fertilizers	202	207	209	NA
TOTAL AGRICULTURE	207	213	215	NA
MOBILE SOURCES	101	112	116	NA
STATIONARY COMBUSTION	39	39	39	NA
MOBILE SOURCES				
Adipic Acid Production	62	65	60	60
Nitric Acid Production	44	44	44	47
TOTAL INDUSTRIAL PROCESSES	106	109	104	106
TOTAL EMISSIONS	453	472	473	NA

NOTE(S): "+" denotes negligible emissions.
"NA" = Not available
Totals presented in this table may not equal the sum of the individual source categories due to rounding.

Table 8-4. Global Carbon Dioxide Emissions
(million short tons)

Year	Coal	Lignite	Crude petroleum	Natural gas	Total
1860	370	7	0	0	378
1865	480	11	0	0	491
1870	568	15	4	0	587
1875	741	22	4	0	766
1880	880	26	15	0	917
1885	1,067	33	15	4	1,118
1890	1,331	44	33	7	1,415
1895	1,503	55	44	11	1,610
1900	1,962	81	62	15	2,123
1905	2,402	99	92	22	2,614
1910	2,959	121	139	33	3,252
1915	2,996	139	183	40	3,359
1920	3,340	176	308	51	3,876
1925	3,318	209	462	77	4,066
1930	3,410	220	612	114	4,356
1935	3,113	231	704	121	4,169
1940	3,817	356	909	172	5,254
1945	3,329	209	1,063	264	4,866

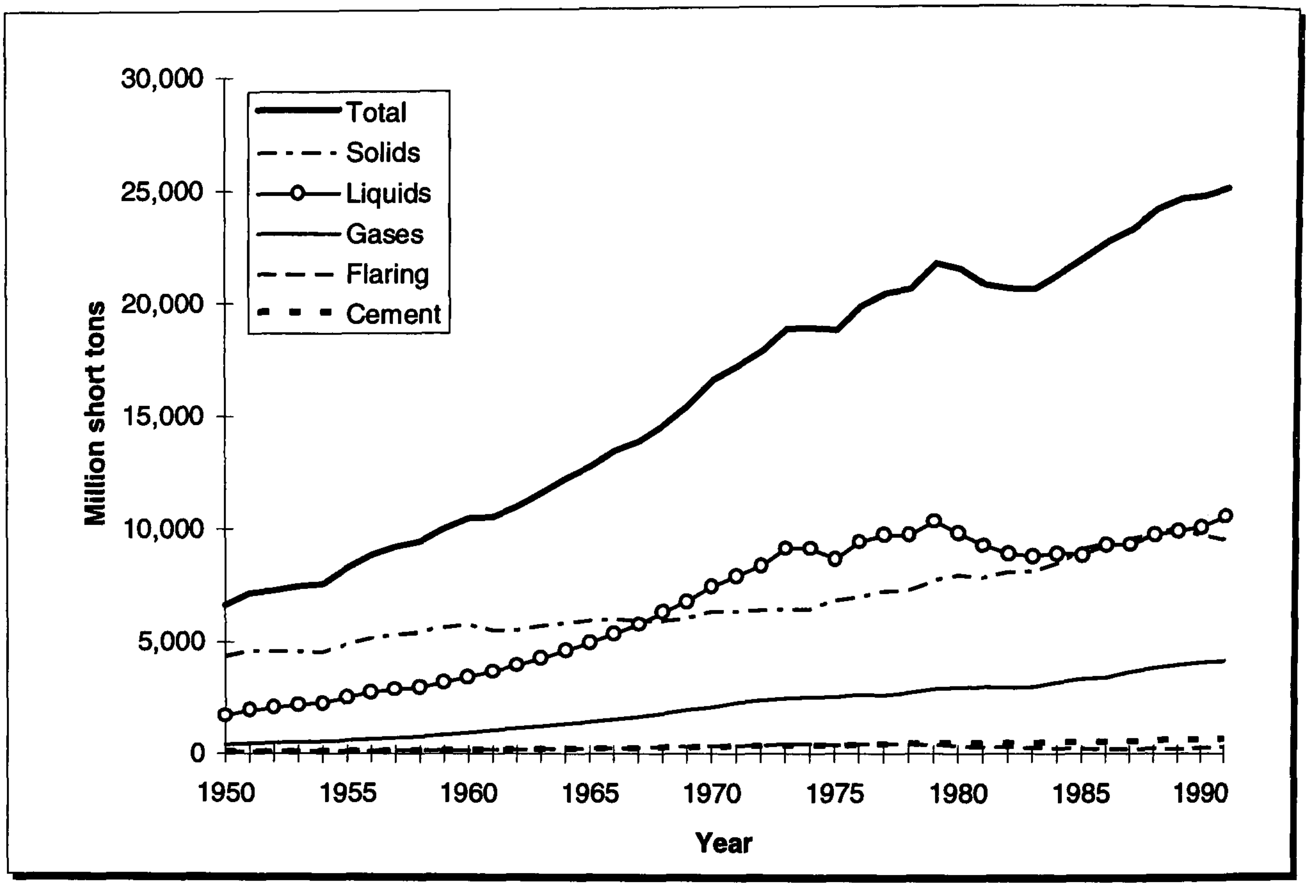
Year	Solids	Liquids	Gases	Cement	Flaring	Global per capita	Total
1950	4,353	1,710	392	73	93	3	6,620
1955	4,911	2,526	606	121	125	3	8,286
1960	5,735	3,435	950	174	158	3	10,452
1965	5,933	4,935	1,419	238	222	4	12,748
1970	6,321	7,429	2,086	315	352	4	16,506
1975	6,786	8,613	2,518	384	376	5	18,681
1980	7,881	9,728	2,934	485	360	5	21,389
1985	9,049	8,771	3,306	529	222	5	21,878
1990	9,672	10,032	4,058	635	251	5	24,646
1991	9,466	10,472	4,139	655	283	5	25,010

NOTE(S): The sums may not equal total due to rounding.

SOURCES: Keeling, C.D. 1994. Global historical CO_2 emissions. pp. 5-8. In T.A. Boden, D.P. Kaiser, R.J. Sepanski, and F.W. Stoss (eds.), *Trends '93: A Compendium of Data on Global Change.* ORNL/CDIAC-65. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tenn., U.S.A.

Marland, G., R.J. Andres, and T.A. Boden. 1994. Global, regional, and national CO_2 emissions. pp. 9-88. In T.A. Boden, D.P. Kaiser, R.J. Sepanski, and F.W. Stoss (eds.), *Trends '93: A Compendium of Data on Global Change.* ORNL/CDIAC-65. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tenn., U.S.A.

Figure 8-1. 1950 to 1991 Global CARBON DIOXIDE Emissions from Fossil Fuel Burning, Cement Production, and Gas Flaring



SOURCE: Keeling, C.D. 1994. Global historical CO_2 emissions. pp. 5-8. In T.A. Boden, D.P. Kaiser, R.J. Sepanski, and F.W. Stoss (eds.), *Trends '93: A Compendium of Data on Global Change.* ORNL/CDIAC-65. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tenn., U.S.A.

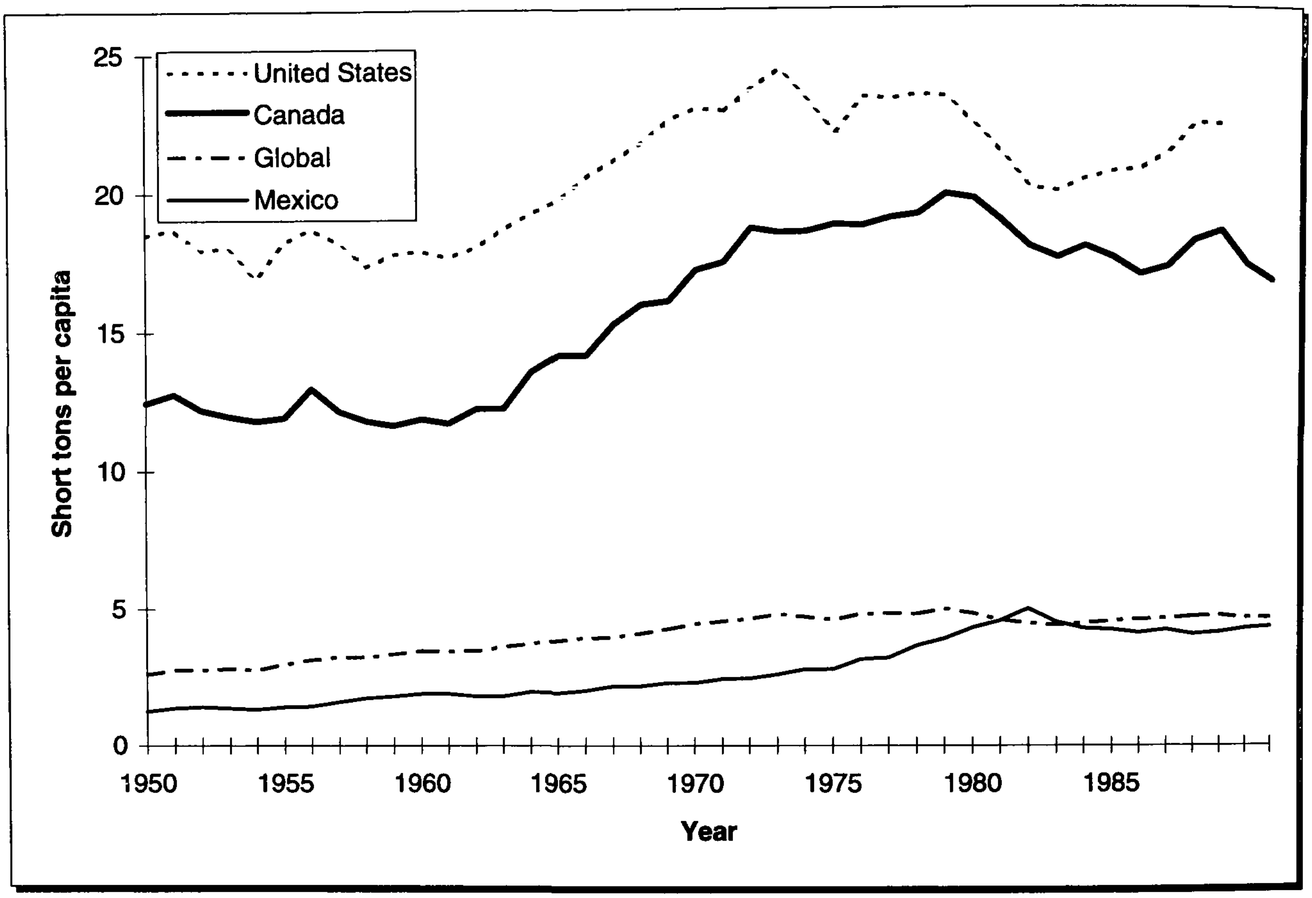
Table 8-5. Regional Carbon Dioxide Emissions
(million short tons)

	Total Emissions								
Year	Region 1 (AMD)	Region 2 (FEA)	Region 3 (AFR)	Region 4 (OCN)	Region 5 (MDE)	Region 6 (WEU)	Region 7 (CPE)	Region 8 (CPA)	Region 9 (NAM)
1950	182	115	105	185	19	1,549	1,185	91	2,984
1955	269	172	144	248	56	1,951	1,772	226	3,203
1960	339	230	174	370	101	2,170	2,390	906	3,445
1965	412	331	237	580	192	2,673	3,086	596	4,111
1970	582	478	331	1,000	299	3,203	3,665	971	5,077
1975	732	640	423	1,156	460	3,267	4,520	1,418	5,193
1980	983	951	571	1,282	564	3,562	5,235	1,807	5,574
1985	979	1,219	646	1,305	712	3,252	5,700	2,378	5,364
1990	1,107	1,719	727	1,519	924	3,353	5,378	2,970	5,905
1991	1,160	1,829	743	1,528	1,446	3,709	4,793	3,107	5,893

1 = Other America (AMD)
2 = Far East (FEA)
3 = Africa (AFR)
4 = Oceania & Japan (OCN)
5 = Middle East (MDE)
6 = Western Europe (WEU)
7 = Eastern Europe (CPE)
8 = Centrally Planned Asia (CPA)
9 = North America (NAM)

SOURCE: Marland, G., R.J. Andres, and T.A. Boden. 1994. Global, regional, and national CO_2 emissions. pp. 9-88. In T.A. Boden, D.P. Kaiser, R.J. Sepanski, and F.W. Stoss (eds.), *Trends '93: A Compendium of Data on Global Change*. ORNL/CDIAC-65. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tenn., U.S.A.

Figure 8-2. Comparison of Per Capita CARBON DIOXIDE Emissions



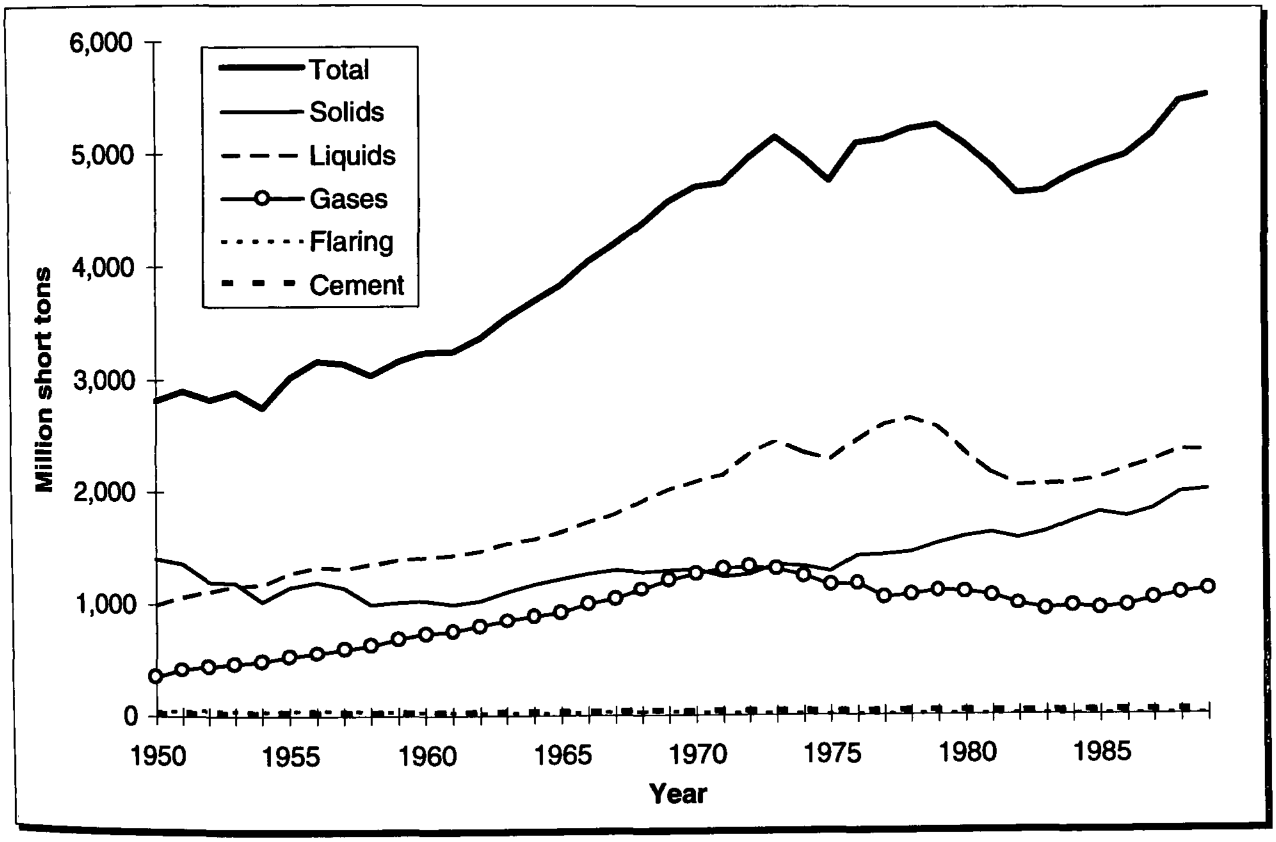
SOURCE: Marland, G., R.J. Andres, and T.A. Boden. 1994. Global, regional, and national CO_2 emissions. pp. 9-88. In T.A. Boden, D.P. Kaiser, R.J. Sepanski, and F.W. Stoss (eds.), *Trends '93: A Compendium of Data on Global Change.* ORNL/CDIAC-65. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tenn., U.S.A.

NOTE(S): U.S. per capita emissions data is not presented for 1990 or 1991. See section 8.1 for a discussion of 1990 to 1993 national CO_2 emission estimates.

Table 8-6. Carbon Dioxide Emissions for the United States
(million short tons)

Year	Gas Fuels	Liquid Fuels	Solid Fuels	Gas Flaring	Cement Production	National per capita	Bunker Fuels	Total
1950	352	989	1,403	48	21	18.47	33	2,813
1955	529	1,266	1,145	46	29	18.19	44	3,015
1960	729	1,414	1,024	33	31	17.91	47	3,232
1965	922	1,639	1,217	19	36	19.72	43	3,833
1970	1,261	2,081	1,303	29	36	22.96	54	4,711
1975	1,156	2,284	1,283	8	34	22.07	59	4,765
1980	1,101	2,358	1,595	7	38	22.39	123	5,100
1985	949	2,117	1,811	6	39	20.65	62	4,921
1989	1,116	2,361	2,012	8	38	22.35	68	5,537

Figure 8-3. CARBON DIOXIDE Emissions for the United States



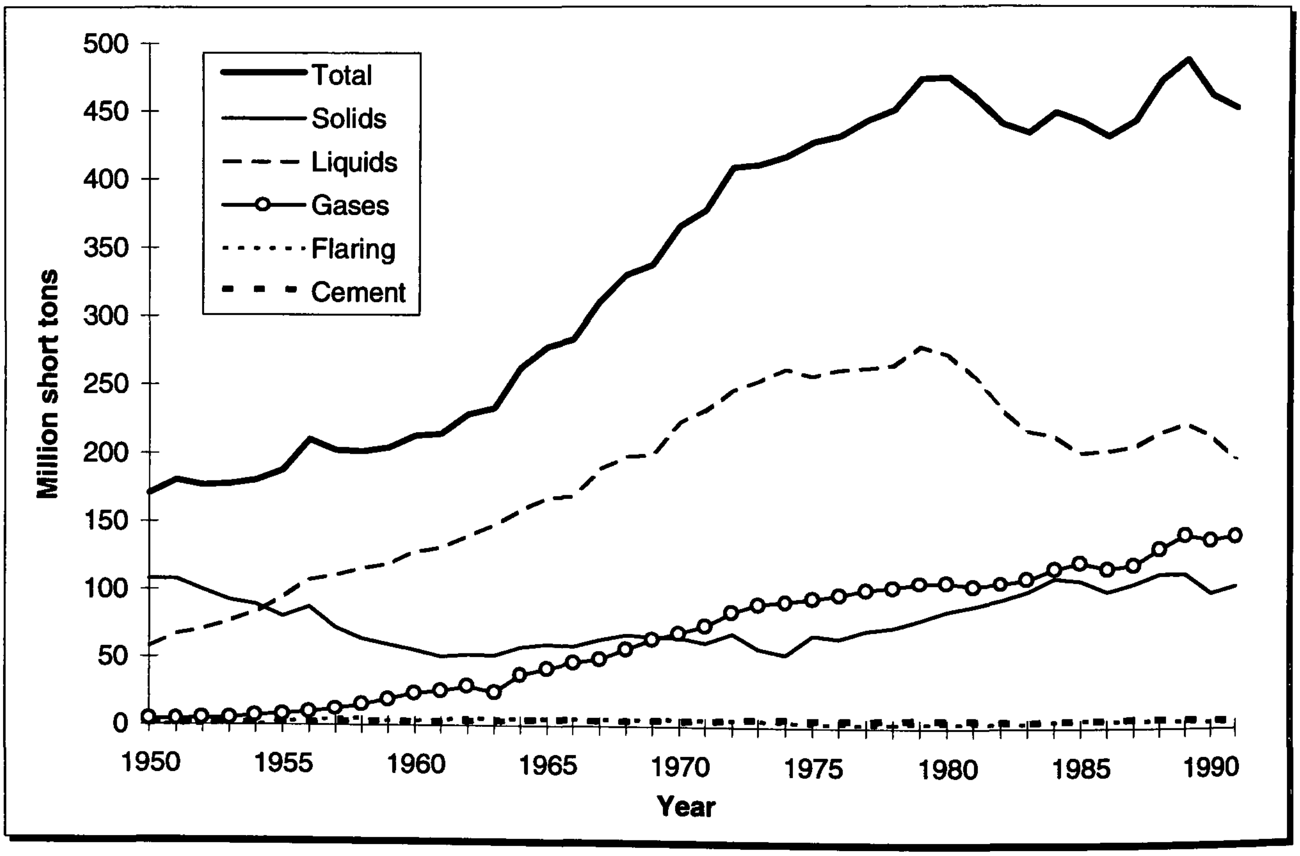
SOURCE: Marland, G., R.J. Andres, and T.A. Boden. 1994. Global, regional, and national CO_2 emissions. pp. 9-88. In T.A. Boden, D.P. Kaiser, R.J. Sepanski, and F.W. Stoss (eds.), *Trends '93: A Compendium of Data on Global Change.* ORNL/CDIAC-65. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tenn., U.S.A.

NOTE(S): U.S. emissions data is not presented for 1990 or 1991. See section 8.1 for a discussion of 1990 to 1993 national CO_2 emission estimates.

Table 8-7. Carbon Dioxide Emissions for Canada
(thousand short tons)

Year	Gas Fuels	Liquid Fuels	Solid Fuels	Gas Flaring	Cement Production	National per capita	Bunker Fuels	Total
1950	3,920	57,853	107,664	0	1,461	12.45	4,987	170,901
1955	8,205	94,597	80,277	2,309	2,197	11.92	5,998	187,585
1960	23,757	127,674	55,149	3,535	2,886	11.88	7,489	212,999
1965	41,957	167,392	60,145	4,644	4,165	14.15	9,931	278,302
1970	69,081	222,764	65,112	5,297	3,962	17.18	11,244	366,221
1975	94,771	256,593	67,663	2,943	5,478	18.79	9,765	427,450
1980	106,613	272,574	86,085	3,455	5,770	19.72	7,663	474,495
1985	121,684	201,299	108,246	5,525	5,602	17.58	3,064	442,360
1990	137,827	213,545	99,394	4,813	6,376	17.34	5,343	461,958
1991	141,048	196,436	104,459	4,972	6,046	16.77	5,000	452,961

Figure 8-4. CARBON DIOXIDE Emissions for Canada

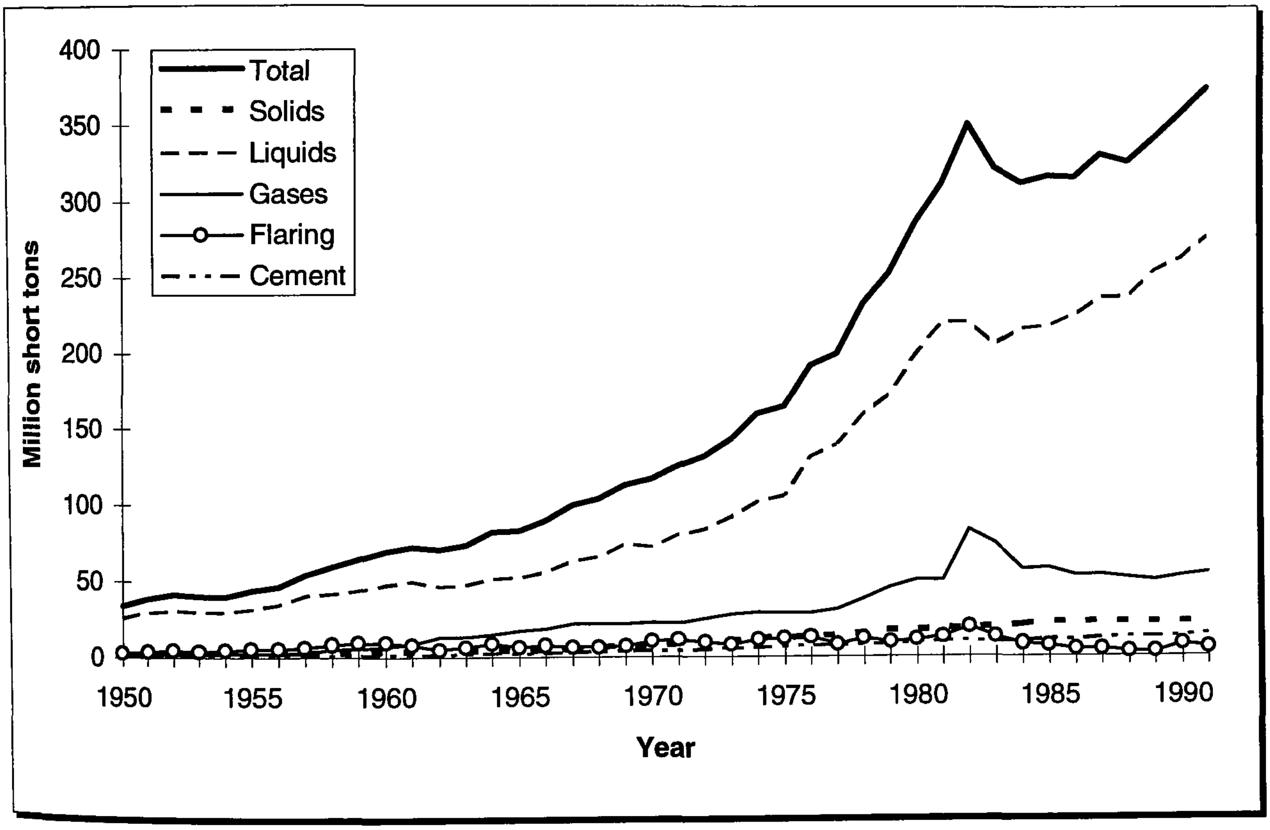


SOURCE: Marland, G., R.J. Andres, and T.A. Boden. 1994. Global, regional, and national CO_2 emissions. pp. 9-88. In T.A. Boden, D.P. Kaiser, R.J. Sepanski, and F.W. Stoss (eds.), *Trends '93: A Compendium of Data on Global Change.* ORNL/CDIAC-65. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tenn., U.S.A.

Table 8-8. Carbon Dioxide Emissions for Mexico
(thousand short tons)

Year	Gas Fuels	Liquid Fuels	Solid Fuels	Gas Flaring	Cement Production	National per capita	Bunker Fuels	Total
1950	1,693	26,122	2,073	2,955	840	1.25	0	33,680
1955	2,571	31,821	2,995	5,302	1,107	1.41	0	43,792
1960	7,037	47,397	3,896	9,585	1,698	1.90	0	69,611
1965	17,392	52,175	4,543	6,518	2,366	1.94	0	82,993
1970	22,735	72,020	7,554	10,606	3,947	2.30	0	116,863
1975	28,757	105,206	12,416	11,537	6,383	2.79	0	164,296
1980	50,283	199,597	17,258	10,905	8,929	4.28	0	286,967
1985	58,043	217,801	22,557	6,906	11,367	4.20	0	316,678
1990	52,801	262,369	22,351	7,754	13,137	4.24	0	358,405
1991	54,911	276,944	22,945	5,438	14,676	4.32	0	374,911

Figure 8-5. CARBON DIOXIDE Emissions for Mexico



SOURCE: Marland, G., R.J. Andres, and T.A. Boden. 1994. Global, regional, and national CO_2 emissions. pp. 9-88. In T.A. Boden, D.P. Kaiser, R.J. Sepanski, and F.W. Stoss (eds.), *Trends '93: A Compendium of Data on Global Change*. ORNL/CDIAC-65. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tenn., U.S.A.

SECTION 9.0

BIOGENIC EMISSIONS

Plants emit a variety of VOCs as a function of incident light intensity and temperature. Vegetation emissions have been determined to consist of numerous hydrocarbons, aldehydes, and alcohols. Lamb, Westberg, and Pierce have constructed a national biogenic emission inventory for eight landcover types for each month of the year based on statewide climatic data.[1] Emissions in this inventory are composed of isoprene, a-pinene, other identified monoterpenes, and other hydrocarbons. Emissions are calculated for oak forests, other deciduous forests, coniferous forests, grasslands, scrublands, urban vegetation, agricultural crops, and inland waters, as shown in Figures 9-1 through 9-8.

A forest canopy model is used to account for canopy effects on solar radiation, temperature, humidity, and wind speed. Agricultural emissions are shown assuming an emission factor of zero for corn. The results of recent field studies suggest that previous emission factors for corn have been overestimated by roughly a factor of a thousand. Total annual biogenic emissions from each state are shown in Figure 9-9, and the seasonal breakdown of total emissions is shown in Figure 9-10.

The 1990 total biogenic hydrocarbon emissions were 26.28 million short tons, while the 1990 *Trends* total anthropogenic VOC emissions were 23.67 million short tons.

9.1 REFERENCES

1. Lamb, B., D. Gay, H. Westberg, and T. Pierce. "*A Biogenic Hydrocarbon Emission Inventory for the USA Using a Simple Forest Canopy Model.*" *Atmospheric Environment*, N.27A, pp. 1673-1690. 1993.

Figure 9-1. Oak Forest 1990 VOLATILE ORGANIC COMPOUND Emissions by State

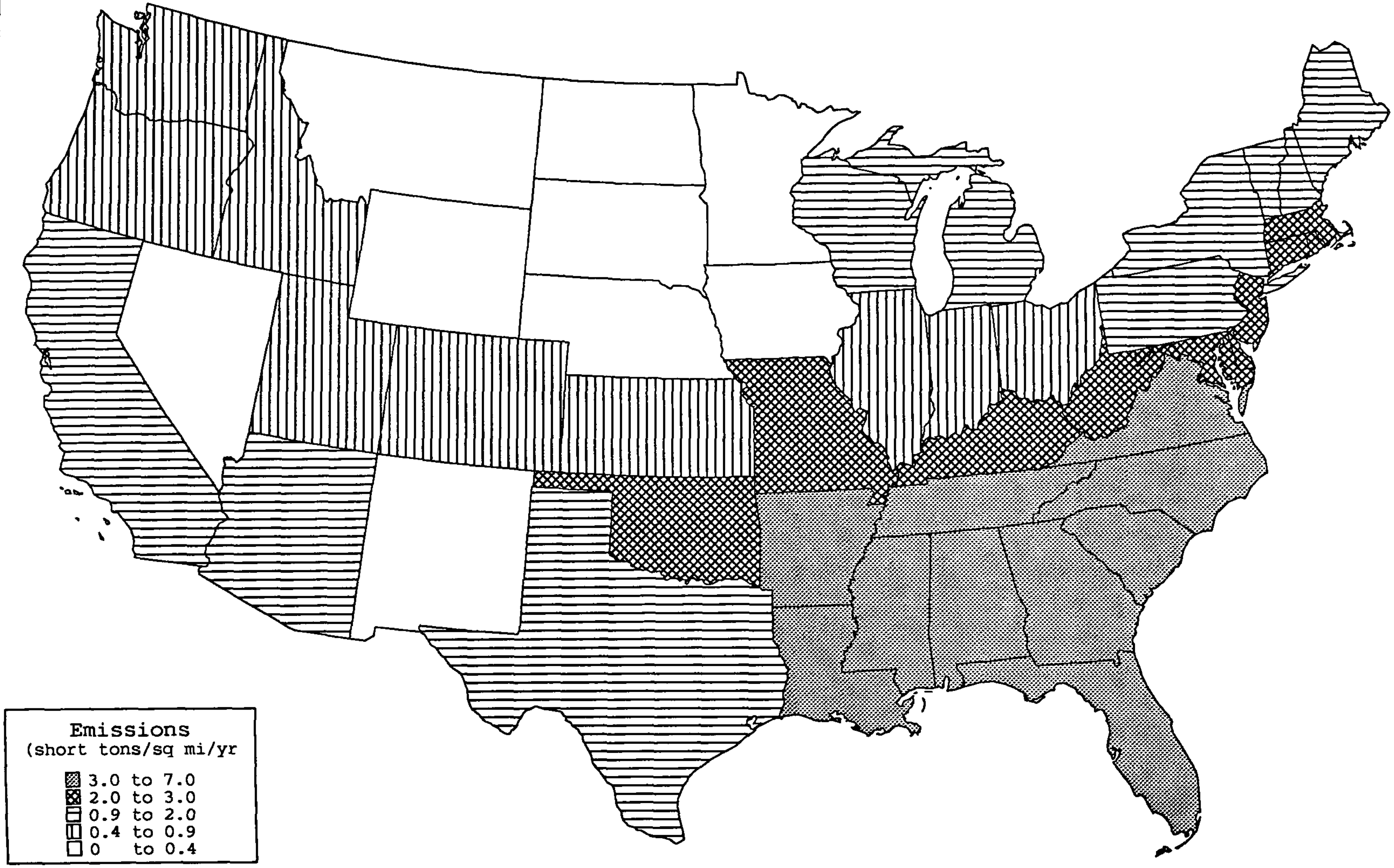


Figure 9-2. Other Deciduous Forest 1990 VOLATILE ORGANIC COMPOUND Emissions by State

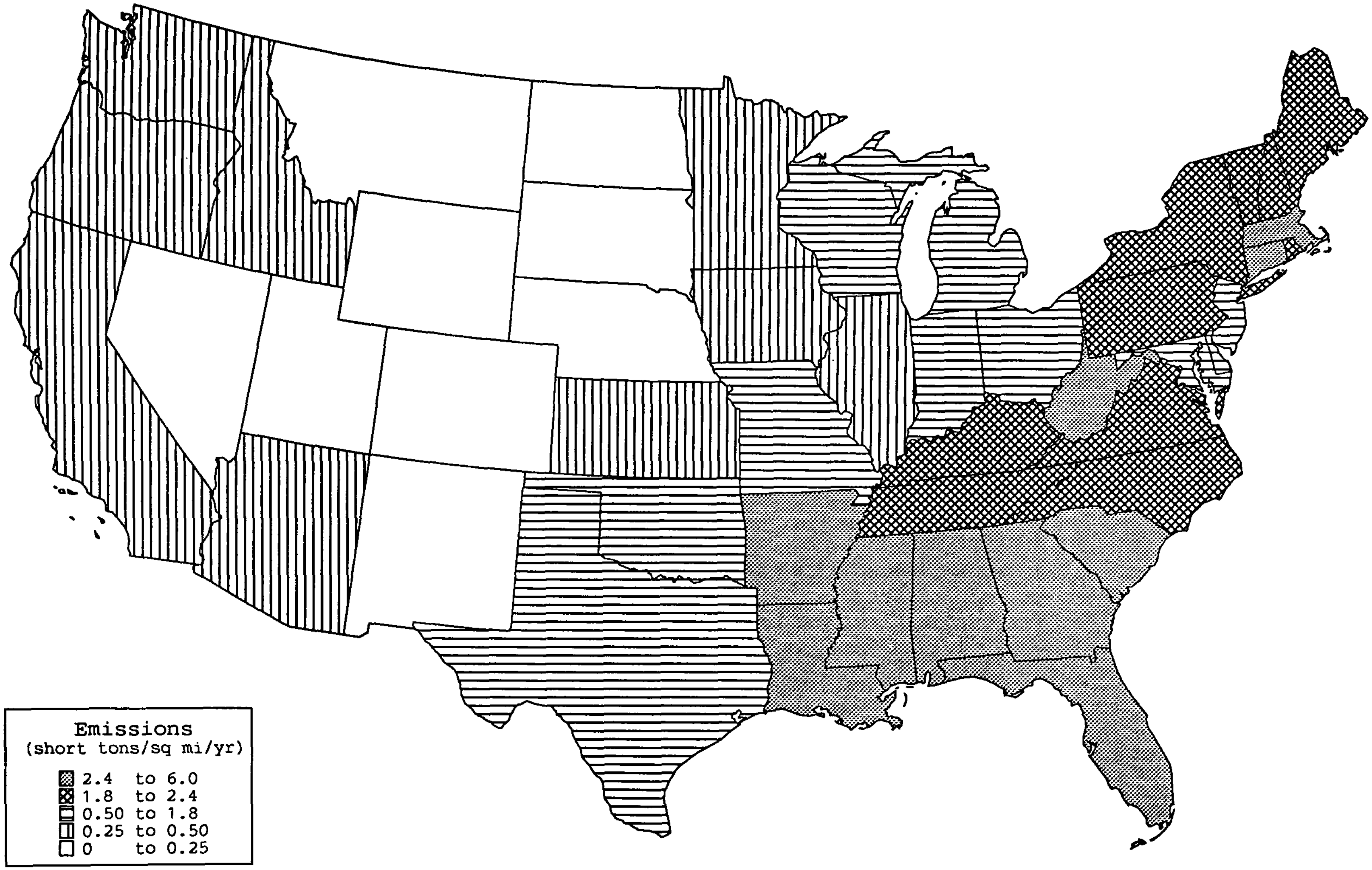


Figure 9-3. Coniferous Forest 1990 VOLATILE ORGANIC COMPOUND Emissions by State

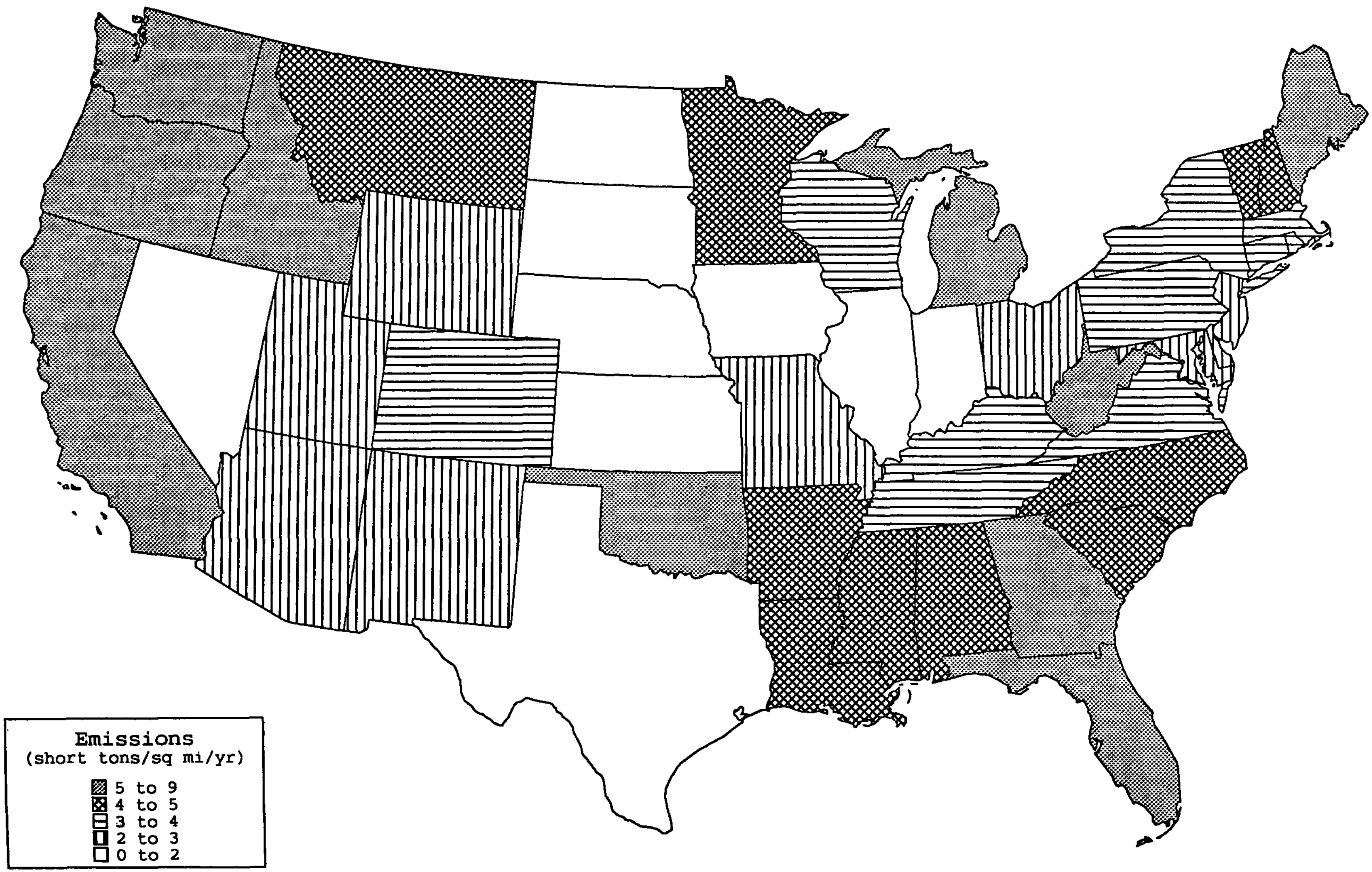


Figure 9-4. Grassland 1990 VOLATILE ORGANIC COMPOUND Emissions by State

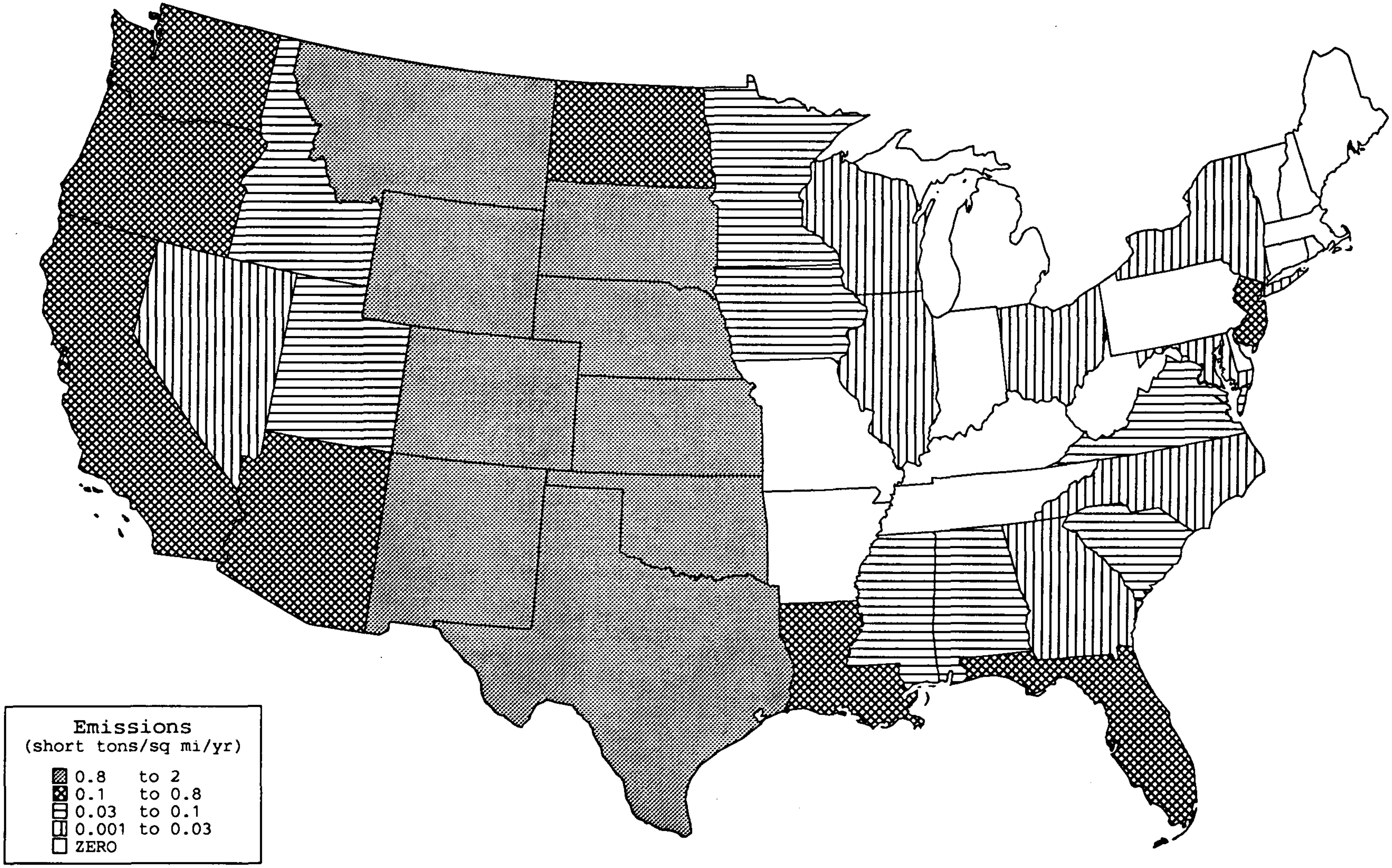


Figure 9-5. Scrubland 1990 VOLATILE ORGANIC COMPOUND Emissions by State

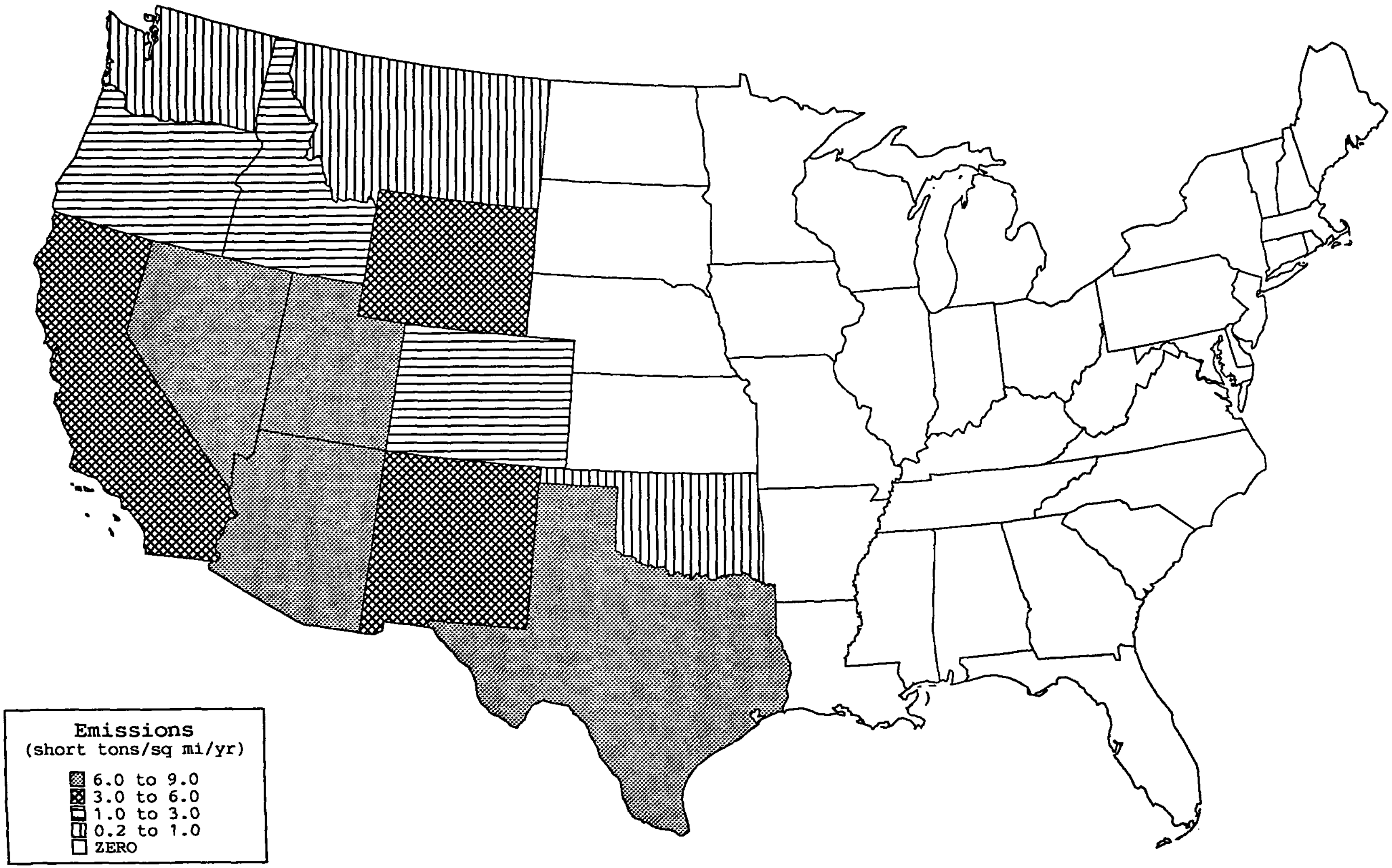


Figure 9-6. Urban Vegetation 1990 VOLATILE ORGANIC COMPOUND Emissions by State

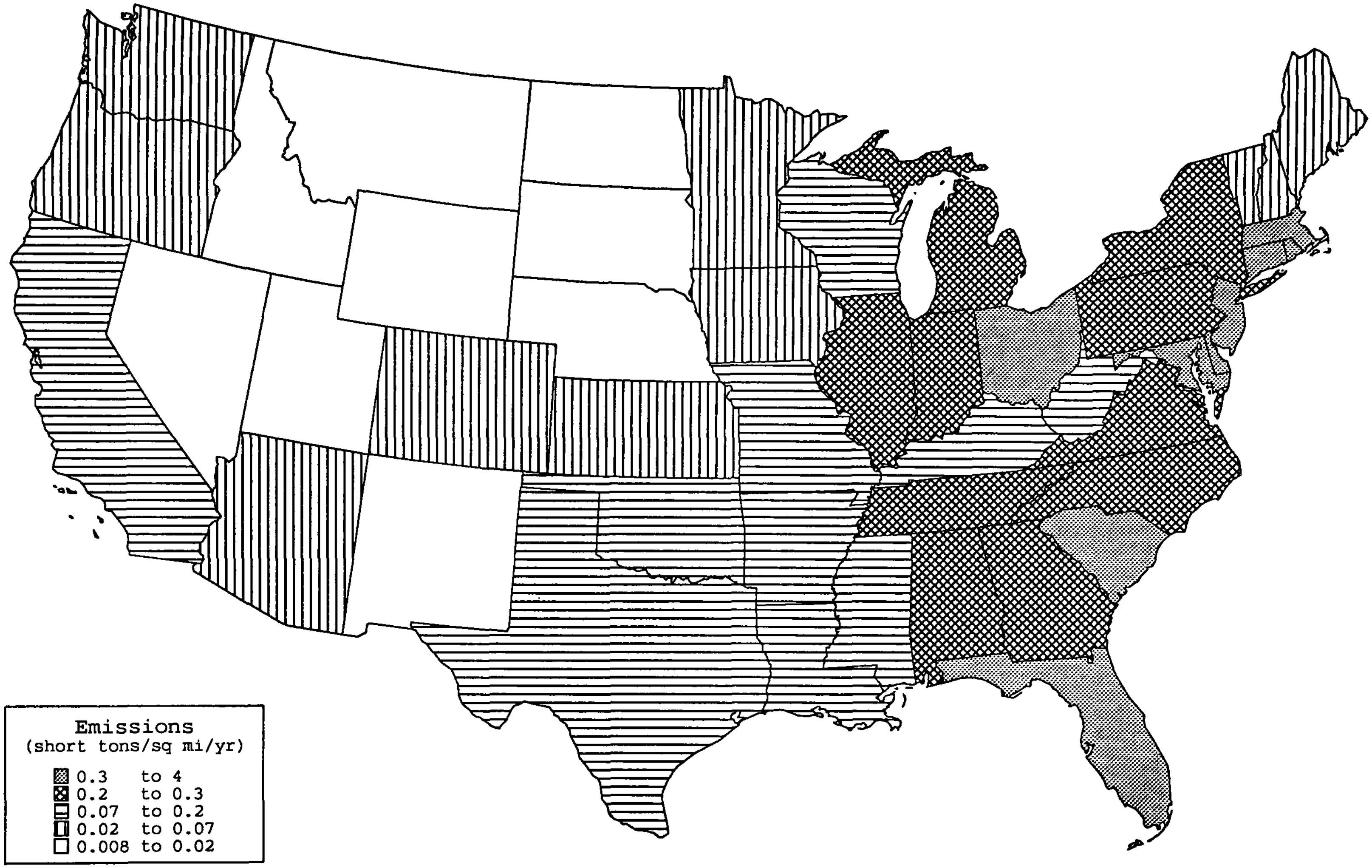


Figure 9-7. Agricultural Crop 1990 VOLATILE ORGANIC COMPOUND Emissions by State

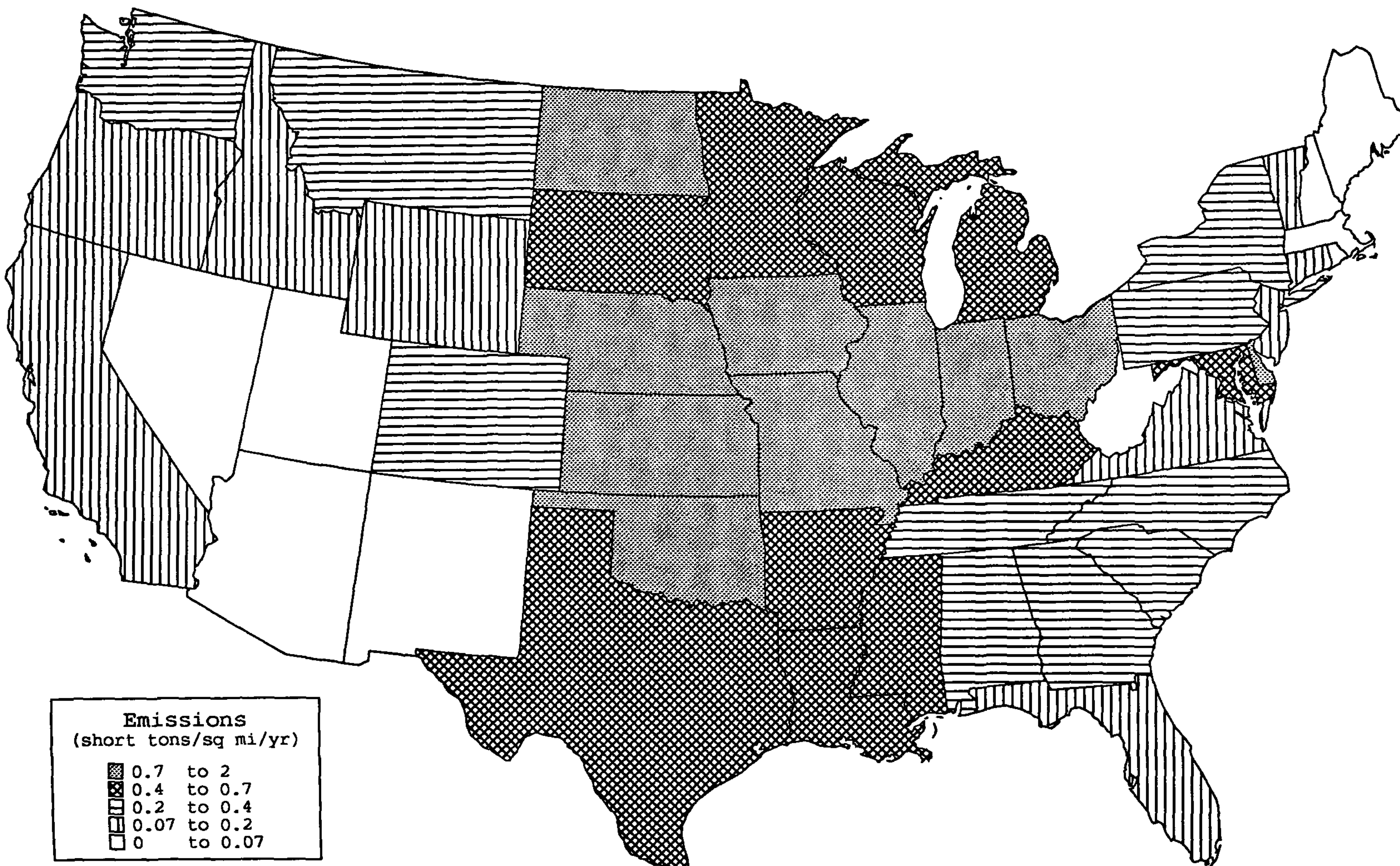


Figure 9-8. Inland Water 1990 VOLATILE ORGANIC COMPOUND Emissions by State

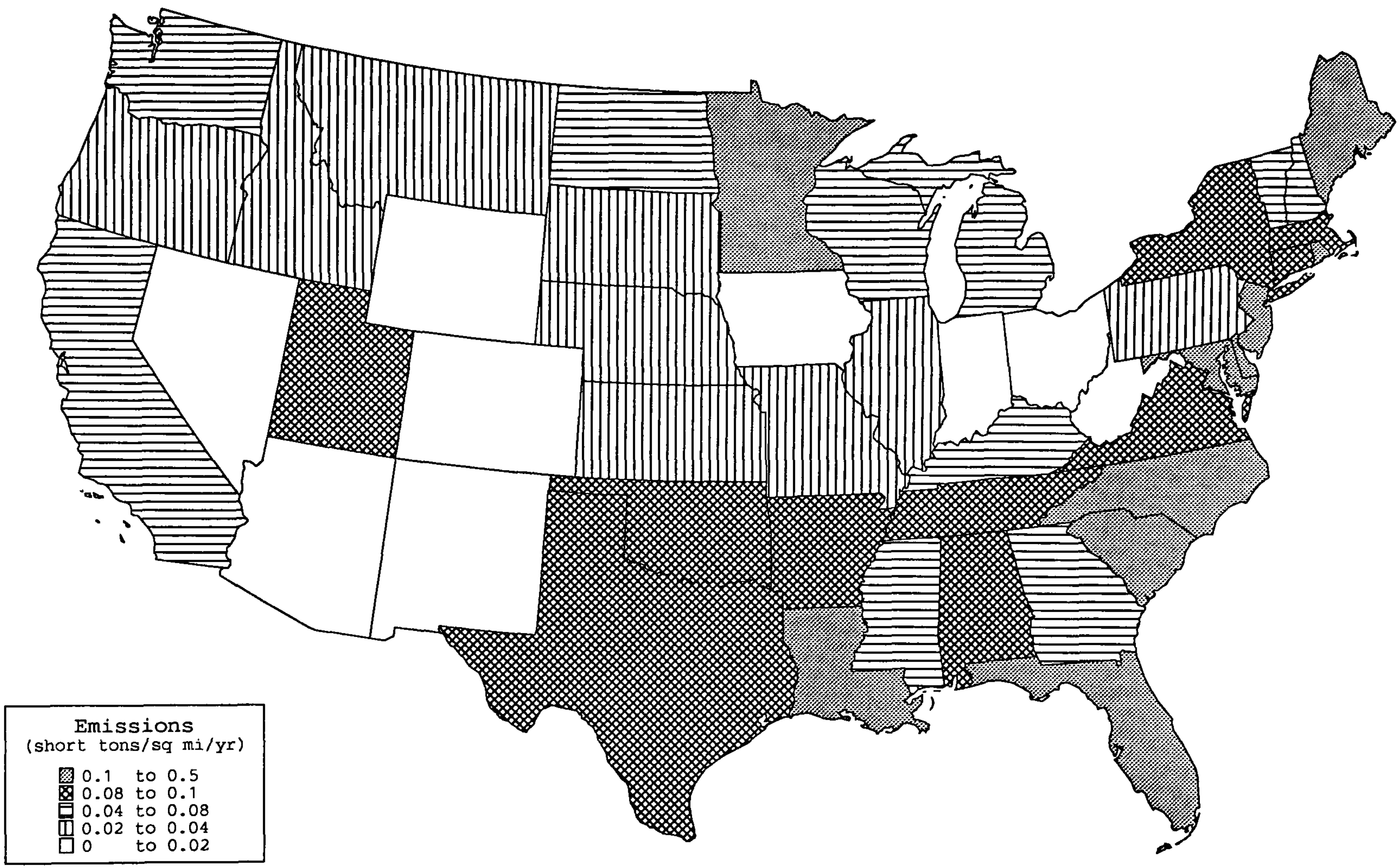


Figure 9-9. Total 1990 VOLATILE ORGANIC COMPOUND Emissions by State

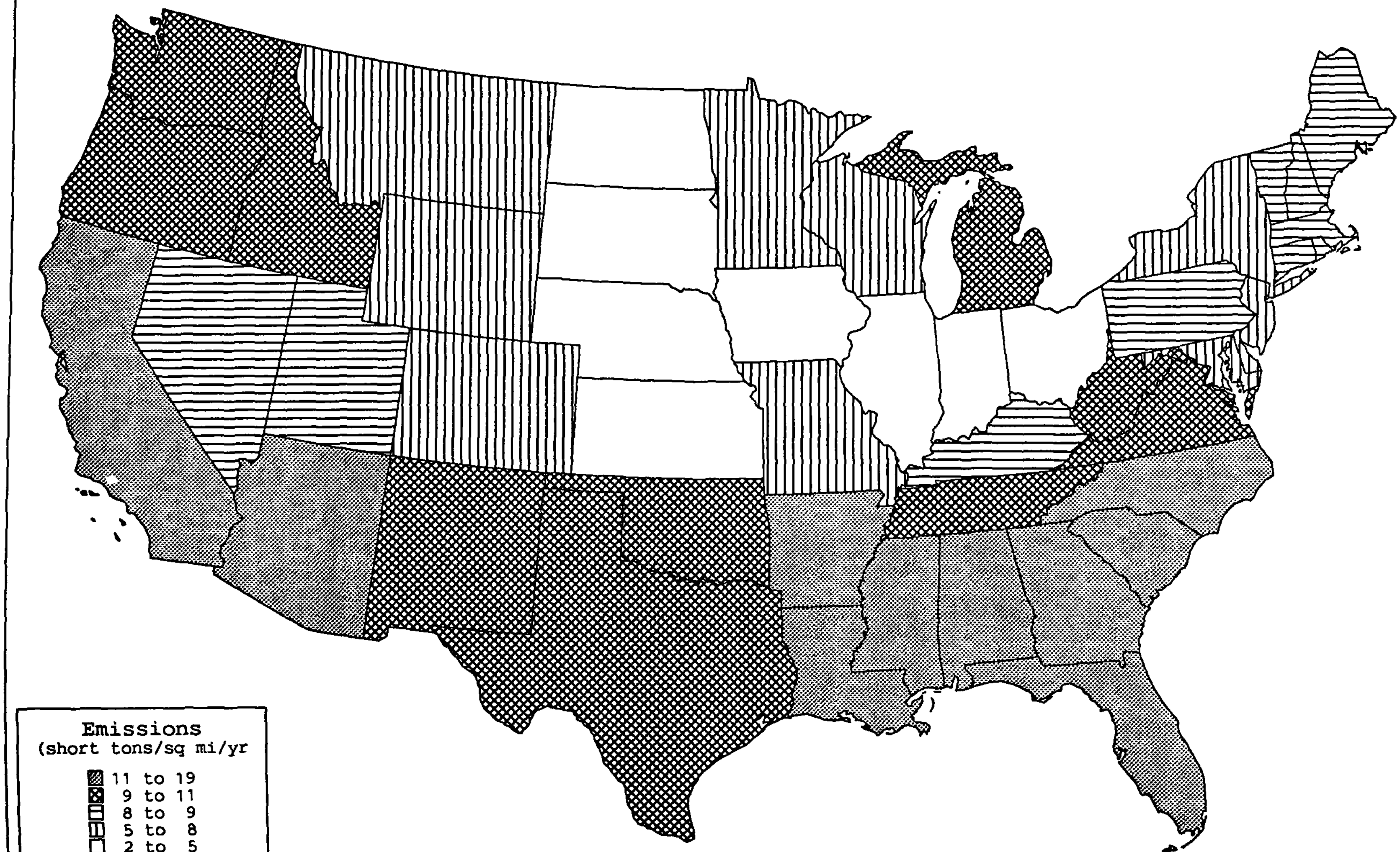
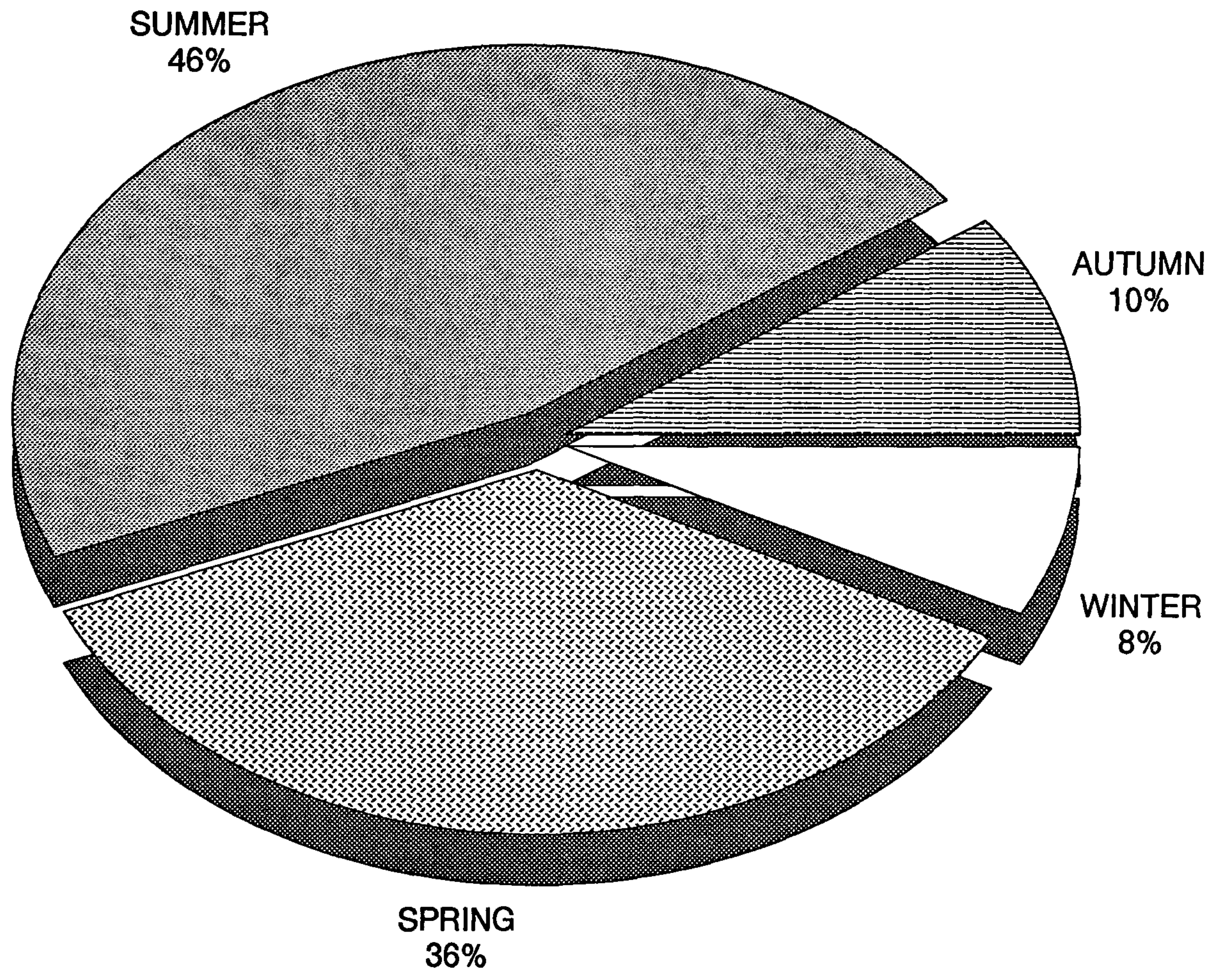


Figure 9-10. Seasonal Breakdown of Total 1990 Biogenic VOLATILE ORGANIC COMPOUND Emissions



SECTION 10.0

AIR TOXIC EMISSIONS

10.1 INTRODUCTION

This chapter presents the available emissions data for toxic air pollutants. The data are much less comprehensive than those for the criteria air pollutants, because an extensive and long-term monitoring and emissions tracking program similar to that for criteria pollutants has not been established for air toxics. Although the CAAA made sweeping changes to the way toxic air pollutants will be regulated, a complete national inventory of toxics was not mandated. This chapter therefore presents emissions culled from three different program areas.

The scope of the inventories developed for these programs varies because each program was designed to meet a particular need. Because the emissions data were not collected in the same manner for each program, the estimates may differ among programs. The three types of toxic emission inventories cited in this chapter are:

- Toxics Release Inventory (TRI) estimates for over 300 chemicals submitted annually since 1988 to EPA by certain manufacturing facilities;

- national inventories for specific pollutants prepared by EPA to support special studies called for by the CAAA; and

- inventories of all Hazardous Air Pollutants ([HAPs] 189 chemicals currently listed) emitted by specific source categories being regulated under Title III of the 1990 CAAA.

The term "toxic" was used by legislators drawing up the TRI list, which covers all media — air, land, and water. In this section, all TRI data presented correspond to the relase of specific chemicals to air only. "Hazardous" refers to the list of air pollutants targeted for regulation under section 112(b)(1) of the CAA.

Because it is the only one of the three inventory types which is regularly updated, the TRI data discussed in section 10.2 may be used as an indication of toxic emission trends. However, the TRI does not present a complete picture of toxic air emissions because only manufacturing facilities with 10 or more employees must report emissions. The national inventories for specific pollutants presented in section 10.3 provide a more comprehensive picture for a limited number of air toxics because they include estimates for all source categories emitting those pollutants. For some toxic air pollutants, the mobile, commercial, residential, and consumer sectors can be much more significant sources of emissions than the manufacturing sector. It should be noted that these estimates have been prepared for only a single year, 1990. The inventory data presented in section 10.4 are also national in scope, but are focused on specific source categories, rather than on specific pollutants. The estimates are presented in terms of total HAP emissions, and include emissions of all relevant pollutants from the list of 189 HAPs defined in the CAAA. Section 10.4 is presented primarily as a status report on EPA's efforts to reduce HAP emissions according to Title III of the CAAA.

The development of comprehensive toxics data is complicated by several factors, including the number of chemical compounds involved, the number and variety of sources emitting the compounds, the low concentrations sometimes involved, and the potential for secondary formation of one hazardous compound from other, often nonhazardous, 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. As more information is collected on air toxic emissions, EPA will attempt to modify the baseline estimates to accurately reflect the effectiveness of Title III regulations in reducing toxic air emissions.

10.2 TOXICS RELEASE INVENTORY SUMMARIES

Manufacturing facilities meeting specified activity thresholds are required to report their estimated releases and transfers of listed toxic chemicals to EPA each year. The reports are compiled by EPA into a publicly available data base called the Toxics Release Inventory (TRI). This inventory was established under the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA). The EPA has collected information for the TRI since 1987. The list of chemicals for which releases and transfers must be reported has seen additions and deletions each year, and now includes over 300 chemicals in 20 chemical categories.

While the TRI is the only data base available for assessing air toxic emission trends, this data base does have some limitations. Facilities with SIC codes outside the range of 20 to 39 (the manufacturing SIC range) are not required to report. Under this exemption, facilities such as mining operations, electric utilities, and oil and gas production operations are not required to report to the TRI. Emissions from small manufacturing facilities (those with fewer than 10 employees) as well as commercial, residential, and mobile sources are also not included in the TRI. The TRI data are self-reported by the emitting facilities, and the TRI does not require facilities to perform any actual monitoring or testing to develop their estimates. The accuracy of the reported data may vary from facility to facility and year to year. Despite these limitations, the TRI estimates are being used here as indicators of the trend in toxic air emissions, at least in the manufacturing sector. Efforts are underway to enhance the TRI data base by expanding both the types of facilities which must report their releases and the list of chemicals which must be reported.

Figure 10-1 shows the trend in toxic air emissions as reported by manufacturing facilities to EPA's TRI data base. In order to reduce the effects of changing reporting requirements on the underlying trend in toxic emissions, the totals shown are for a set of 278 chemicals that have been on the TRI list since its inception in 1987. The original TRI list included 173 of the 189 chemicals subsequently defined by the CAAA as HAPs, and these are graphed as a subset in Figure 10-1. These HAPs have shown the same trend in reductions as the larger TRI set, representing approximately 72 percent of the declining TRI total for each year.

The 10 HAPs ranked highest in emissions (based on 1988 reported air releases) have accounted for approximately 56 percent of total TRI air emissions and approximately 79 percent of the total HAP air emissions in each reporting year. The sums of the emissions for these 10 HAPs are shown for 1988 through 1992 in Figure 10-1; the 5-year trend for each individual HAP is shown in Figure 10-2.[1] A generally declining trend is evident for 9 of the 10 HAPs; hydrochloric acid shows slight increases for the first 2 years and then slight decreases for the last 2 years.

Sixteen of the 189 HAPs defined by the CAAA were not included in the original TRI list. Two of the 16, acetophenone and ethylidene dichloride, have been added to the TRI list, with the first reports to be submitted by July 1, 1995 for the 1994 reporting year. Nine other HAPs were proposed for addition to the TRI on January 12, 1994. The 9 HAPs are:

- hexane
- caprolactam
- triethylamine
- mineral fibers

- polycyclic organic matter (polycyclic aromatic compounds)
- phosphine
- isophorone
- dimethyl formamide
- hexamethylene-1,6-diisocyanate

The five remaining HAPs were not proposed for addition to the TRI list for various reasons, such as being produced in quantities too low to meet the TRI thresholds or being emitted by sources which do not have to report to the TRI. These HAPs include:

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

Table 10-1 shows total TRI-reported air emissions for each State for 1988 through 1992.[1] Only 4 States (Montana, Nevada, North Dakota, and South Dakota) reported greater emissions in 1992 than in 1988. Most States show a steady downward trend through all years. Figure 10-3 shows the trend in TRI emissions for each of the 20 SIC groups required to report to TRI.[1] Only 3 SIC groups (Food, Tobacco, and Apparel) reported greater emissions in 1992 than in 1988.

10.3 NATIONAL INVENTORIES FOR SPECIFIC POLLUTANTS

EPA's OAQPS has developed a number of nationwide toxic emissions inventories for individual chemicals to help address specific requirements of the CAAA. For the pollutants addressed, these inventories are more comprehensive than the TRI in that they attempt to identify and quantify all source categories and air emissions of these pollutants, whether from manufacturing facilities, commercial facilities, mobile sources, or residential and consumer sources. These inventories also include emissions from facilities with fewer than 10 employees and emissions from sources with very low concentrations of toxics, which are exempted from the TRI reporting requirements. These considerations can be extremely important for estimating the total emissions of some pollutants.

These inventories have been compiled by using existing national estimates for a specific chemical from a specific source category (e.g., for development of a NESHAP) wherever possible. Other EPA inventories such as the TRI were used as well. If no suitable inventory was available, an average emission factor and national activity data were used to estimate emissions. In general, the emissions estimates are based on national activity data for an entire source category, rather than data for individual facilities. Details on how the estimates for each source category were derived can be found in the references cited.

Inventories are available for only 13 HAPs at this time, and most of these inventories are still in draft form. Since these inventories have been prepared for a single year, no evaluation of a trend is possible. However, they are valuable as an initial assessment of the potential magnitude of risks posed by certain pollutants and source categories. They also provide an initial baseline for evaluating potential methods for reducing identified risks. A projected trend can be estimated by examining the major sources of the emissions, assessing whether these source categories are growing or shrinking, and whether or not they are regulated or scheduled to be regulated.

10.3.1 Section 112(k) Inventories (Urban Area Source Program)

Section 112(k) of the CAA requires the EPA to identify source categories and subcategories of HAPs in urban areas that pose a threat to human health. Area sources accounting for at least 90 percent of total emissions of at least 30 HAPs that present the greatest threat to urban populations must be identified. Emission standards for these HAP species are to be developed by the year

2000. The work being performed in support of section 112(k) is referred to as the Urban Area Source Program.

In order to meet the requirements of section 112(k), national inventories of toxic pollutants are needed. This information, in conjunction with risk factors for the specific toxics, can be used to determine the specific pollutants and source categories that need to be controlled. Thus far, national inventories have been developed for seven HAPs under the Urban Area Source Program. These HAPs are thought to be ubiquitous in most urban areas, regardless of the type of industries present in the local area.

Table 10-2 presents the national estimates for three HAPs emitted primarily from combustion source categories.[2,3] Table 10-3 presents the national totals for four HAPs used primarily as solvents.[4] The emissions values given in these tables for a specific SIC code have been taken from the TRI data base. The two tables show that manufacturing industries (SICs 20 through 39) are a major contributor for only two of the seven chemicals, methylene chloride and carbon tetrachloride.

10.3.2 Section 112(c)(6) Inventories

Section 112 (c)(6) of the CAA requires EPA to identify and characterize all source categories and subcategories that emit any of seven specified pollutants by November 15, 1995. Section 112 (c)(6) also requires the subsequent development of emission standards for the largest-emitting source categories of each pollutant. The categories to be regulated must account for at least 90 percent of the national emissions of that pollutant. The 7 pollutants specified in section 112 (c)(6) are:

- polycyclic organic matter (POM);
- hexachlorobenzene (HCB);
- alkylated lead compounds (TEL and TML);
- polychlorinated biphenyl compounds (PCBs);
- 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD);
- 2,3,7,8-tetrachlorodibenzofuran (TCDF); and
- mercury.

All of these pollutants, except for TCDF, are included in the list of 189 HAPs defined in section 112(b)(1) of the CAA.

In addition to the source category emissions estimates called for by section 112(c)(6), national emissions were estimated for major and area source contributors and were allocated to urban and rural areas, in order to support the section 112(k) Urban Area Source Program. Regional emissions were also developed to support work required by section 112(m) of the CAA, which mandates the quantification of atmospheric deposition to the Great Lakes, Chesapeake Bay, Lake Champlain, and coastal waters.

1990 base year national emissions are summarized below for the first four of the seven pollutants listed in section 112 (c)(6). The inventories for TCDD and TCDF are still under development, and the inventory for mercury has been prepared as part of a Locating & Estimating (L&E) document series.

In Table 10-4, estimates of extractable organic matter (EOM) are presented as a surrogate for POM emissions.[5] Extractable organic matter is a gravimetric-based measurement which correlates with the POM class of compounds in terms of compound carcinogenicity and mutagenicity.

Table 10-5 shows that the 2 major source categories which emit hexachlorobenzene (HCB) are pesticides application and chlorinated solvents production.[6] Seven pesticides were identified as containing HCB as an impurity, but data sufficient to develop an emissions estimate were lacking for 2 of the pesticides. Application of the remaining 5 pesticides is estimated to release 202 short tons of HCB per year. Production of 5 chlorinated hydrocarbons is estimated to release a little more than a half ton of HCB per year as a by-product. Emissions from chlorinated solvents production would all be from major point source facilities, while all of the pesticide emissions would be from area sources.

The only known commercial use of alkylated lead compounds is in the manufacture of leaded gasoline anti-knock compounds, which raise the octane levels in leaded motor vehicle gasoline and aviation gasoline. The phase-down of lead in highway motor vehicle gasoline began in 1973. Section 211(n) of the CAA prohibits the manufacture of engines requiring leaded gasoline after 1992. The deadline for the abolishment of all lead-containing highway vehicle fuels is December 31, 1995.

The two most common lead anti-knock compounds are tetraethyl lead (TEL) and tetramethyl lead (TML). The potential for TEL and TML emissions is limited to evaporative losses from the distribution, marketing, and use of leaded motor vehicle gasoline and aviation gasoline. National evaporative loss emissions are presented in Table 10-6 for pipelines, bulk terminals, bulk plants, service stations, and off-highway engines and vehicles.[7]

The source category emissions listed in Table 10-7 are those for which reliable PCB emissions could be developed.[8] The following categories were identified as potential sources of PCB emissions for which sufficient data were not available to develop national emissions estimates:

- Treatment, Storage, and Disposal Facilities (TSDFs) and Landfills;
- Superfund Sites;
- Steel and Iron Reclamation (auto scrap burning);
- Accidental Releases (spills, leaks and transformer fires); and
- Environmental Sinks of Past PCB Contamination.

Table 10-8 presents emissions for 2 key metallic HAPs, mercury and cadmium. Mercury is 1 of the 7 pollutants specified in section 112(c)(6) of the CAA. The estimates for mercury and cadmium are taken from 2 EPA documents which are part of the series known as L&E documents.[9,10] Over the last 10 years, 33 L&E documents have been published by EPA to assist state and local air pollution control agencies in their efforts to prepare inventories of toxic air pollutants. The documents provide a compilation of available information, including emission factors, on the sources and emissions of specific toxic air pollutants. Only those L&E documents completed in the last year have provided emissions on a national level. Several L&E documents expected to be published in the next year will also include national emissions.

10.4 SOURCE CATEGORY ESTIMATES AND MAXIMUM ACHIEVABLE CONTROL TECHNOLOGY STATUS

The CAAA of 1990 mandated fundamental changes in air toxics regulation, listing 189 HAPs that must be regulated according to a stringent schedule. The process of regulation entails the development of emission standards based upon the MACT for each point source category emitting one or more HAPs. These emission standards apply to all major sources and are to be developed over a period of 10 years. Standards also must be developed for area sources, although these can be based on Generally Available Control Technologies (GACT). Prior versions of the Act resulted in a cumbersome process for individually listing and regulating HAPs. Between 1970 and 1990, only 8 pollutants (arsenic, asbestos, benzene, beryllium, mercury, radionuclides, radon-22, and vinyl chloride) were regulated under a program known as the National Emission Standards for Hazardous Air Pollutants (NESHAPs). Table 10-9 provides information on 15 NESHAPs that have either been recently promulgated or are under development. Baseline toxic emissions estimates and the expected reductions due to the MACT standards are included.

The health effects of the HAPs emitted by the source categories listed in Table 10-9 vary. Animal and some human studies indicate that the possible health effects of the solvents emitted from the aerospace manufacturing, halogenated solvent cleaning, and magnetic tape manufacturing industries include cancer as well as developmental, respiratory, and neurological effects. Emissions of benzene, toluene, ethylbenzene, and xylenes (BTEX) from the petroleum refinery, marine vessel loading, and gasoline distribution source categories have been shown to contribute to cancer, liver and kidney damage, and neurological and developmental effects in animal and some human studies. Benzene is a known human carcinogen.

Epichlorohydrin is emitted by some polymers and resins facilities and is a suspected carcinogen, based on animal studies and some human studies. The two major toxic pollutants emitted from pulp and paper facilities are chloroform and methanol. Animal studies have shown that chloroform causes cancer and methanol exposure results in reproductive and developmental effects. Ethylene oxide sterilization facilities use and emit a probable human carcinogen. Hexavalent chromium is a known potent human carcinogen and is emitted by large numbers of chromium electroplating operations and industrial process cooling towers. Perchloroethylene is a probable human carcinogen that is emitted by many dry cleaning facilities.

The pollutants of primary interest from coke ovens with respect to long-term or chronic health effects are various carcinogenic polycyclic organic compounds, such as benzo(a)pyrene. Secondary lead smelters emit lead compounds, arsenic compounds, and 1,3-butadiene, which are known or suspected carcinogens. Up to 150 of the 189 HAPs may be emitted from the synthetic organic chemical manufacturing industry (SOCMI). Many of these HAPs are known or suspected carcinogens.

10.4.1 Aerospace Manufacturing and Rework Industry

Aerospace manufacturing and rework facilities emit approximately 208,000 short tons per year of HAPs. Emission sources include paint and coating operations, chemical stripping, and clean-up solvents. Most of the HAPs emitted by this industry are solvents such as methyl ethyl ketone (MEK), 1,1,1-trichloroethane (TCA), toluene, and methylene chloride. Many of the primers used for aerospace vehicles also contain heavy metals such as chromium and cadmium. The EPA proposed a NESHAP to control HAP emissions from this industry in June 1994. More than 2,800 facilities will be subject to this regulation. Hazardous air pollutant emissions are expected to be reduced by approximately 127,800 short tons per year. Approximately 89,000 short tons of the HAPs being eliminated are also considered VOCs.

10.4.2 Petroleum Refineries

A MACT standard for petroleum refineries was proposed under court order in June 1994. The standard must be promulgated by June 30, 1995. All of the 192 refineries in the United States are covered by the proposed rule. The primary HAPs emitted from refineries are BTEX, methyl tert-butyl ether (MTBE), 2,2,4-trimethyl pentane (iso-octane), and hexane. The regulations will reduce emissions of HAPs from petroleum refineries by 54,000 short tons per year. This represents a 69 percent reduction in current refinery HAP emissions. As an additional benefit, the regulations will reduce VOC emissions from refineries by 72 percent, or 350,000 short tons per year. The greatest emission reductions will result from requiring refiners to implement an effective program to detect and repair leaks from pumps, valves, compressors, and other equipment. Additional significant reductions will be achieved by requiring efficient emission controls on storage tanks, process vents, and wastewater collection and treatment systems.

10.4.3 Halogenated Solvent Cleaning

Emissions from halogenated solvent cleaning machines include methylene chloride, perchloroethylene, trichloroethylene, TCA, carbon tetrachloride, and chloroform. The estimated total HAP emissions for 1990 were 141,400 short tons. The EPA rule proposed in November 1993 is based on equipment and work practices standards, with an alternative compliance standard based on an overall solvent emissions limit. It is estimated that approximately 25,400 batch vapor and in-line solvent cleaning machines, and 100,000 batch cold cleaning machines will be affected by the standards. The EPA rule would reduce annual emissions of the targeted air toxics by 88,400 short tons. The final rule is scheduled to be promulgated on November 15, 1994.

10.4.4 Magnetic Tape Manufacturing

Emissions of HAPs from the magnetic tape manufacturing industry are primarily solvents used in the coating process. The primary solvents are MEK, methyl isobutyl ketone (MIBK), and toluene. Particulate HAP emissions may also result during the transfer of magnetic particles to the coating mix. Based on 1992 information, major sources are estimated to emit about 4,500 short tons per year of HAPs. The EPA proposed standards in March 1993 to reduce these emissions to about 2,200 short tons per year. The proposed rule would require 95 percent control for the majority of the emission points in a facility. Most facilities are expected to achieve this standard with a solvent recovery device, such as a carbon adsorber. Other emission points would be required to meet work practice or equipment specifications. The final rule is scheduled to be promulgated in November 1994.

10.4.5 Marine Vessel Loading Operations

Marine vessel loading and unloading operations are believed to emit as many as 60 of the 189 HAPs, including BTEX. Emissions at marine terminal loading operations result from the displacement of vapors as liquids are loaded into cargo holds. The EPA proposed the Marine Vessel rule in May 1994. Approximately 350 facilities will be affected by the rule. The estimated 1990 HAP emissions of 8,800 short tons per year are expected to be reduced by 8,400 short tons per year.

10.4.6 Polymers and Resins II

The EPA proposed the NESHAP for Epoxy Resin Production and Non-Nylon Polyamides Production in May 1994. The proposed rule affects manufacturers that produce basic liquid epoxy resin (three facilities) and wet strength resins (17 facilities). Emissions occur at these facilities from process vents, storage tanks, wastewater collection and treatment systems, and equipment leaks. Estimated baseline HAP emissions are 160 short tons per year. The proposed rule sets HAP emissions limitations based on the amount of resin produced, and requires operators to implement leak detection and repair programs for control of equipment leaks. The estimated reduction in HAP emissions is 110 short tons per year.

10.4.7 Pulp, Paper, and Paperboard Manufacturing Processes

Pulp and paper mills emit several HAPs, including chloroform and methanol. In addition, toxic and other Clean Water Act pollutants are discharged into the nation's waters (e.g., dioxins and furans). There are about 160 chemical pulping mills emitting approximately 187,000 short tons per year of HAPs into the air from process vents and evaporation from wastewater units. The EPA proposed emission standards and effluent guidelines in December 1993 which will reduce HAP emissions by 132,000 short tons per year and VOC emissions by 788,000 short tons per year. Air emission reductions are achieved by venting process equipment to combustion devices and by steam stripping certain wastewater streams. An additional MACT rule covering HAP emissions from combustion sources at kraft mills will be proposed in early 1994. Both NESHAPs are planned to be promulgated together with the water effluent guidelines in early 1996.

10.4.8 Gasoline Distribution Industry (Stage I)

Major sources of HAPs in the gasoline distribution network include about 380 medium and large-sized gasoline bulk terminals and about 20 large pipeline breakout stations. Emissions of HAPs from these facilities occur during gasoline tank truck loading, gasoline storage, and from leaking pumps, valves, flanges and other equipment. Gasoline vapors contain BTEX, naphthalene, cumene, hexane, and 2-2-4-trimethylpentane. In addition, MTBE is used in some gasolines as an oxygenate during the winter months to meet the CAAA's requirements for CO nonattainment areas. Residual HAP and VOC emissions after current VOC control measures are estimated to be 55,000 and 880,000 short tons per year, respectively. The EPA proposed a rule in February 1994 which is estimated to reduce HAP and VOC emissions by 3,000 and 48,000 short tons per year, respectively.

10.4.9 Ethylene Oxide Sterilization Facilities

Ethylene oxide is used as a sterilant for heat or moisture sensitive materials and as a fumigant to control microorganisms or insects in the production of medical equipment supplies and in miscellaneous sterilization and fumigation operations. Sterilization may be carried out at the facility that produces or uses the product, or by contract sterilizers (i.e., firms under contract to sterilize products manufactured by other companies). About 200 commercial ethylene oxide sterilization facilities emit an estimated 1,200 short tons of ethylene oxide per year in the United States. In March 1994, EPA proposed a NESHAP to control main sterilizer vent and aeration vent emissions at major sources and to control main sterilizer vents at area sources. The proposed regulation will reduce emissions by approximately 1,100 short tons annually. The regulation is scheduled for promulgation in November 1994.

10.4.10 Chromium Electroplating Operations

Hexavalent chromium is discharged to the atmosphere from each of the three types of chromium electroplating processes: decorative chromium electroplating, hard chromium electroplating, and chromium anodizing. During 1988, an estimated 175 short tons of hexavalent chromium were emitted from approximately 5,000 chromium electroplating operations in the United States. The regulation will require the use of add-on air pollution control systems or fume suppressants in the plating solution in order to reduce emissions by 99 percent. The standard will reduce hexavalent chromium emissions from chromium electroplating operations to less than three short tons per year in the third year after promulgation. The proposed NESHAP for these operations is scheduled for promulgation at the end of 1994.

10.4.11 Coke Oven Batteries

Emissions from coke batteries include organic and inorganic PM, VOCs, and gases such as hydrogen disulfide, SO_2, NO_x, CO, and ammonia. A NESHAP for coke ovens was promulgated in October 1993. The rule requires operators to limit the percentage of leaking doors, lids, and offtake systems, limit the duration 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 rule is expected to reduce emissions from the current estimated level of 1,830 short tons per year to no more than 320 short tons per year by the end of 1995.

10.4.12 Perchloroethylene Dry Cleaning Facilities

There are about 25,000 perchloroethylene dry cleaning operations in the United States, of which 3,700 are industrial or large commercial dry cleaners. Perchloroethylene is a probable human carcinogen. A NESHAP for the 3,700 large dry cleaning operations was promulgated in September

1993. The regulation requires the use of a refrigerated condenser (or carbon adsorber, if already installed) in order to reduce emissions. By 1996, perchloroethylene emissions will be reduced by 7,300 short tons per year from a 1988 baseline of 50,000 short tons.

10.4.13 *Secondary Lead Smelters*

About 23 secondary lead smelters provide the United States domestic capacity for recycling automotive batteries. The smelters emit metallic HAPs, organic HAPs, and hydrochloric acid. The NESHAP for these operations was proposed in May 1994, and is expected to be promulgated by May 1995. Total HAP emissions are estimated to be 2,900 short tons per year. The standard would require control of furnace combustion gases, process fugitive emission sources, and fugitive dust sources which are windblown or vehicle-induced emissions from storage piles, roadways, and other areas of the facility. The NESHAP would result in reducing emissions by 2,200 short tons per year.

10.4.14 *Industrial Process Cooling Towers*

Chromium-based water treatment chemicals are currently used in approximately 800 industrial process cooling towers (IPCTs) located at 300 chemical and industrial facilities nationwide to protect process heat exchangers from corrosion. An estimated 25 short tons per year of hexavalent chromium are currently emitted from IPCTs in the United States. The rulemaking will require the use of nonchromium based water treatment programs, resulting in a 100 percent reduction in chromium emissions from IPCTs within approximately 18 months after promulgation. Final regulations for IPCTs was promulgated in July 1994.

10.4.15 *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, wastewater collection and treatment operations, and equipment leaks. The EPA promulgated the Hazardous Organic NESHAP (HON) final rule in April 1994. Approximately 370 facilities and 1,050 chemical manufacturing processes will be affected by the HON. The 1989 estimated HAP emissions from SOCMI facilities of 550,000 short tons are projected to be reduced to 110,000 short tons per year by 1998.

10.5 REFERENCES

1. *1992 Toxic Release Inventory*, (Tables 3-12 to 3-15). EPA-745/R-94-001. Office or Pollution Prevention and Toxics, U.S. Environmental Protection Agency, Washington, DC. April 1994.

2. *Motor Vehicle-Related Air Toxics Study*, (Tables 5-3, 6-4, 7-4). EPA-420/R-93-005. Office of Mobile Sources, U.S. Environmental Protection Agency, Ann Arbor, MI. April 1993.

3. *Nonroad Engine and Vehicle Emission Study-Report*, (Table 3-02). EPA 21A-2001. Office of Mobile Sources, U.S. Environmental Protection Agency, Ann Arbor, MI. November 1991.

4. *National Urban Area Source Emissions of Benzene, 1,3-Butadiene, Formaldehyde, Trichloroethylene, Methylene Chloride, and Carbon Tetrachloride*, (Table 2-1) , Interim Draft Report. U.S. Environmental Protection Agency. September 1993.

5. *Emissions Inventory of Section 112(c)(6) Pollutants, Extractable Organic Matter (EOM),* Draft Report, U.S. Environmental Protection Agency. September 1993.

6. *Estimation of National Hexachlorobenzene Emissions for 1990,* (Table I), Final Report. U.S. Environmental Protection Agency. October 1993.

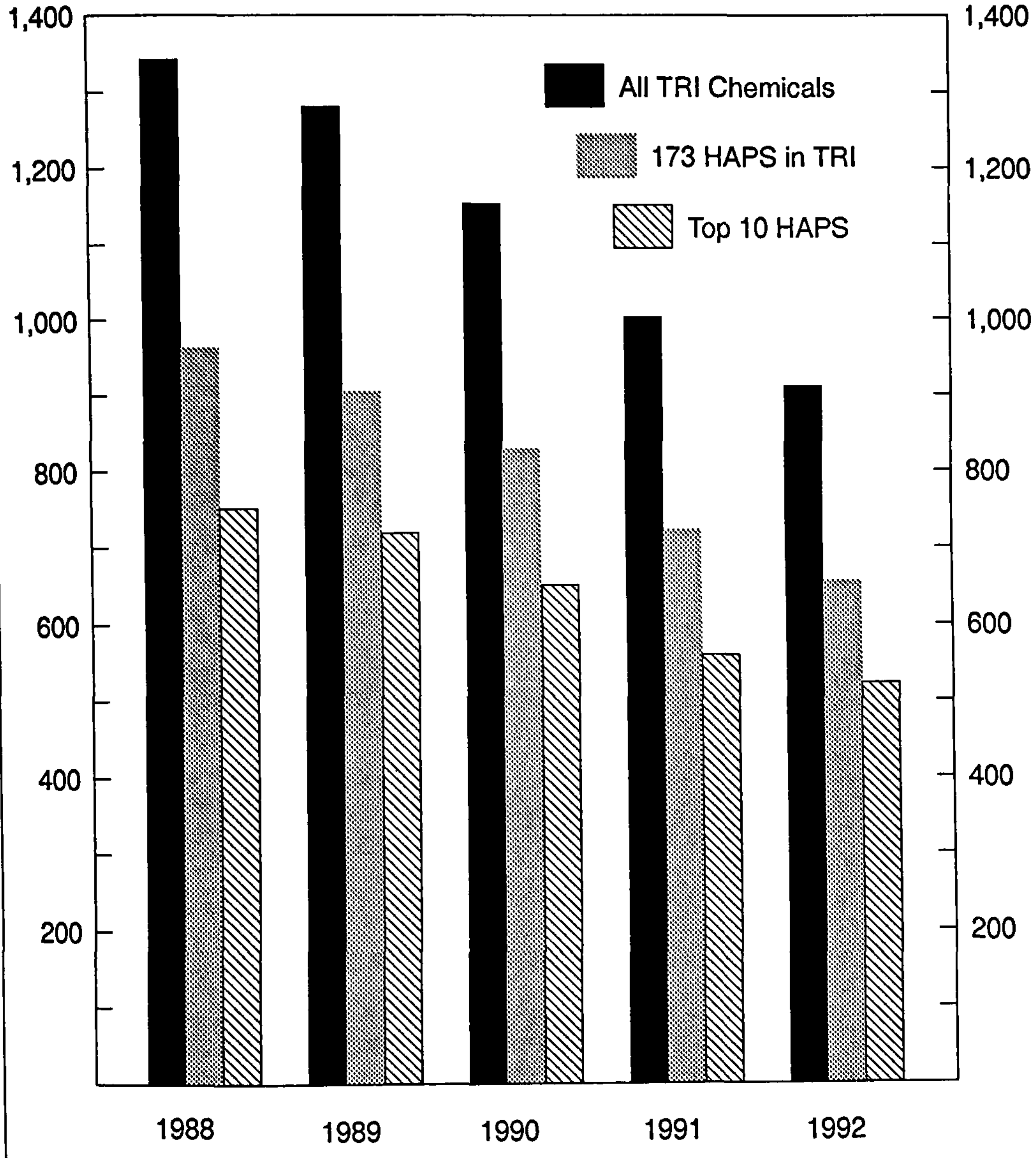
7. *Estimation of Alkylated Lead Emissions,* (Table I), Final Report. U.S. Environmental Protection Agency. September 1993.

8. *Emissions Inventory of Section 112(c)(6) Pollutants, Polychlorinated Biphenyl Compounds (PCBs),* (Table 3-1), Draft Report. U.S. Environmental Protection Agency. September 1993.

9. *Locating and Estimating Air Emissions from Sources of Cadmium and Cadmium Compounds,* (Table 3-3), EPA-454/R-93-040. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1993.

10. *Locating and Estimating Air Emissions from Sources of Mercury and Mercury Compounds,* (Table 3-4), EPA-454/R-93-023. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1993.

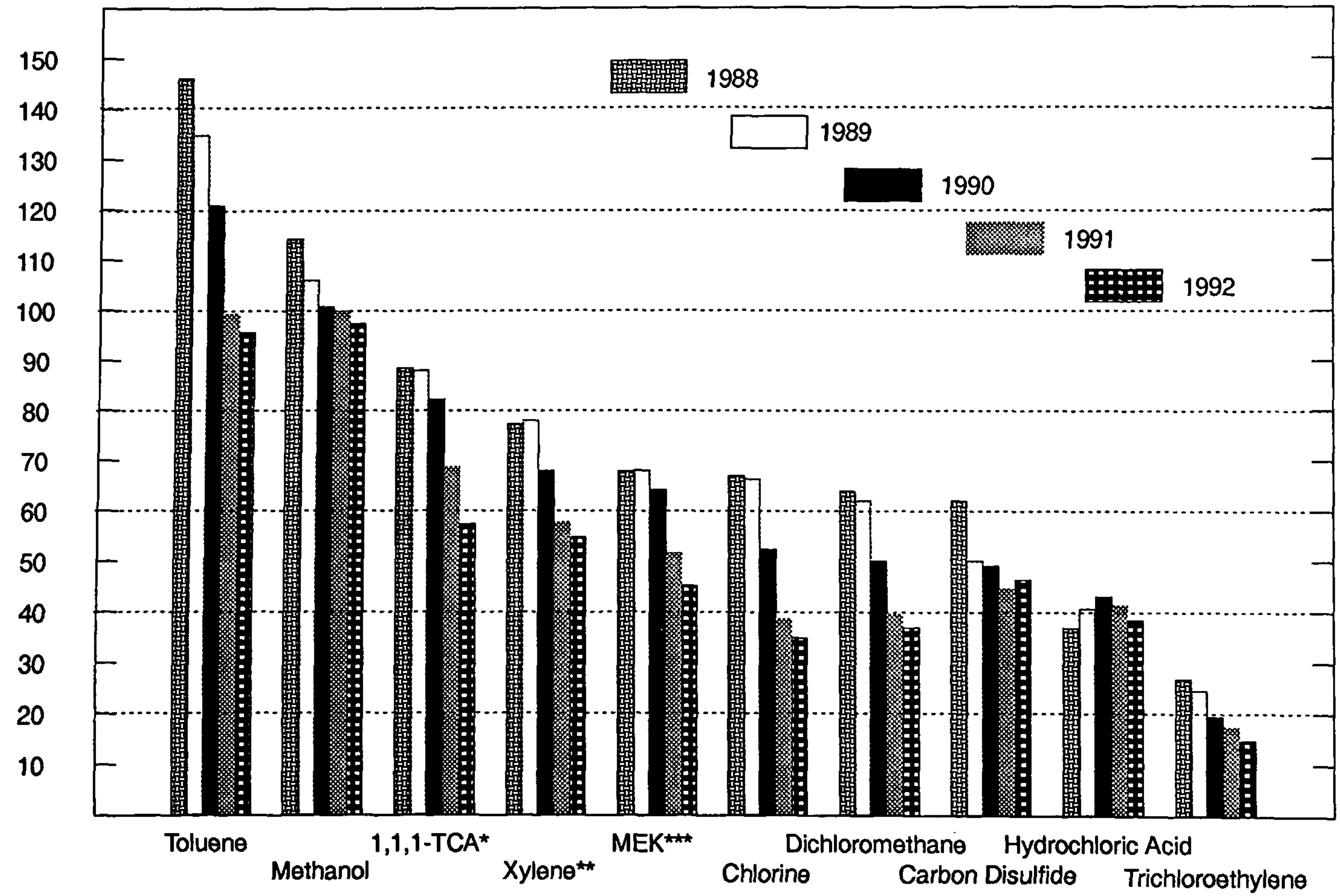
Figure 10.1. TOXIC RELEASE INVENTORY Air Emissions Trends



TRI Air Emissions in thousand short tons/year

Source: 1992 Toxic Release Inventory, Table 3-14. EPA 745-R-94-001, April 1994

Figure 10-2. Top 10 HAZARDOUS AIR POLLUTANTS - 1988 Basis

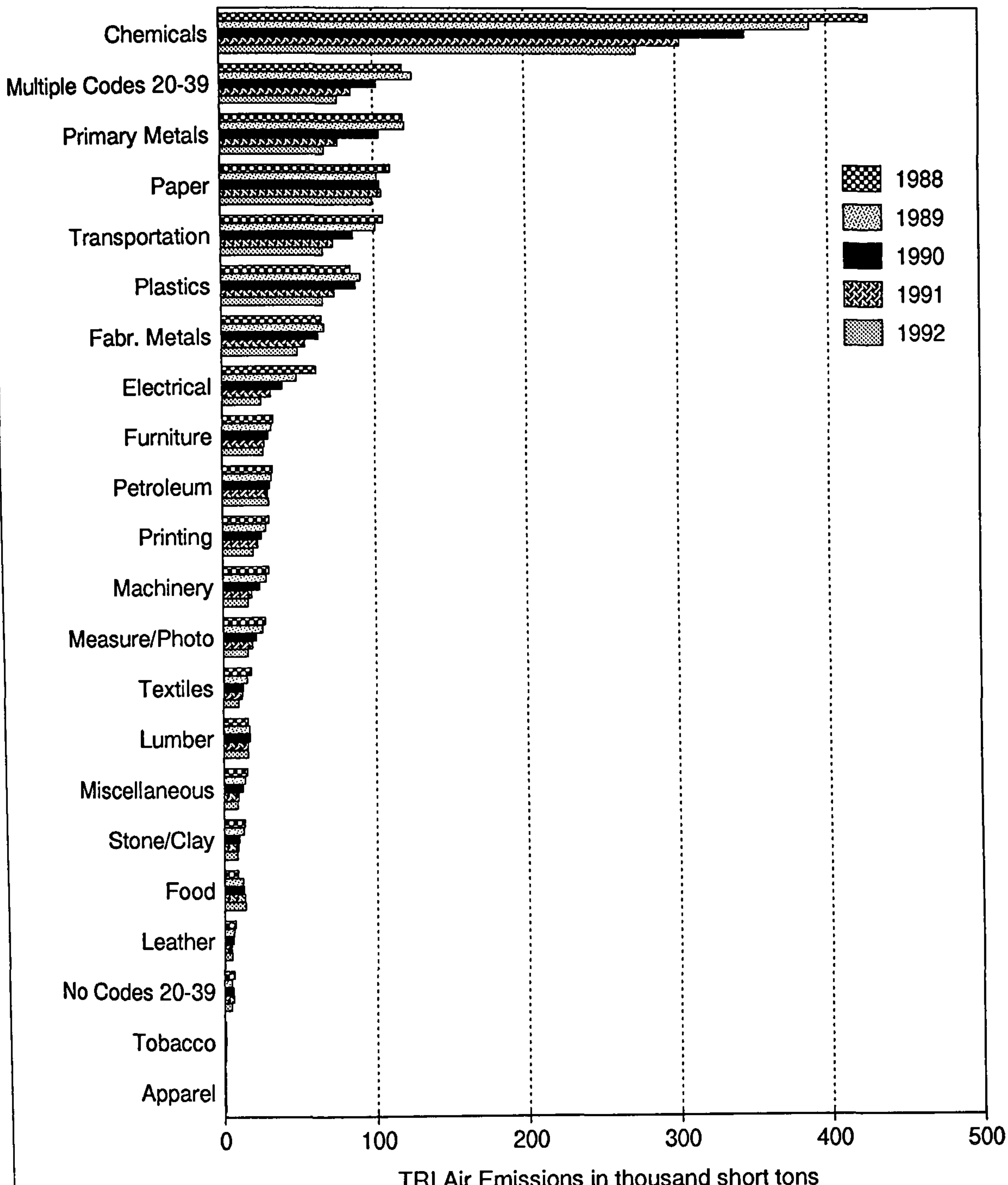


TRI Air Emissions in thousand tons/year

* 1,1,1-Trichloroethane
** Mixed Isomers only
*** Methyl Ethyl Ketone

Source: 1992 Toxics Release Inventory, Table 3-15.
EPA 745-R-94-001, April 1994.

Figure 10-3. TOXIC RELEASE INVENTORY Releases by Industry, 1988 - 1992



Source: 1992 Toxics Release Inventory, Table 3-13. EPA 745-R-94-001, April 1994.

Table 10-1. State Total Air Emissions from TRI*, 1988 to 1992
(short tons/year)

State	1988	1990	1991	1992	Reduction (88-92) Tons	Reduction (88-92) Percent
Texas	105,793	89,337	83,395	77,540	28,252	27
Tennessee	73,865	74,454	71,932	63,501	10,363	14
Ohio	71,423	58,080	49,856	44,718	26,705	37
Louisiana	68,580	55,722	49,116	43,808	24,772	36
Virginia	62,833	39,133	33,600	31,674	31,159	50
Utah	60,809	53,159	37,244	34,457	26,351	43
Indiana	56,732	54,461	46,193	42,337	14,395	25
Illinois	55,021	44,896	40,590	36,039	18,981	34
Alabama	53,003	51,954	49,661	47,109	5,894	11
New York	50,662	37,883	32,034	27,370	23,292	46
North Carolina	49,813	45,099	41,431	40,016	9,797	20
Michigan	49,657	41,988	35,186	32,910	16,747	34
California	46,391	41,346	33,560	27,131	19,260	42
Pennsylvania	45,960	38,378	33,062	30,319	15,641	34
Georgia	42,528	37,347	29,116	25,038	17,490	41
South Carolina	34,207	34,644	30,883	30,856	3,351	10
Mississippi	30,783	30,156	28,212	26,663	4,120	13
Minnesota	27,461	25,446	19,528	14,608	12,852	47
Florida	25,861	23,648	19,123	16,630	9,231	36
Missouri	25,276	22,955	17,479	18,095	7,181	28
Arkansas	24,380	17,136	15,978	13,839	10,541	43
Kentucky	24,264	20,905	18,918	18,493	5,771	24
Wisconsin	23,815	22,080	18,568	18,345	5,470	23
Iowa	22,410	19,786	17,237	16,234	6,176	28
New Jersey	19,829	12,824	10,637	9,945	9,884	50
West Virginia	18,923	15,690	13,578	11,219	7,704	41
Oklahoma	17,889	15,336	12,993	12,081	5,809	32
Kansas	16,344	15,227	14,402	12,411	3,932	24
Washington	14,849	14,239	12,933	10,936	3,913	26
Massachusetts	13,967	10,644	8,260	7,091	6,876	49
Connecticut	13,124	8,803	7,979	6,618	6,507	50
Alaska	11,523	7,984	6,613	5,473	6,050	53
Oregon	10,595	9,410	8,934	8,155	2,440	23
Nebraska	9,345	8,460	7,396	6,282	3,062	33
Maryland	9,191	6,778	5,845	5,274	3,917	43
Maine	8,718	6,991	6,901	6,472	2,246	26
Arizona	8,155	6,414	4,773	4,161	3,994	49
Puerto Rico	7,150	8,716	7,923	6,755	395	6
New Hampshire	6,157	4,060	2,645	2,968	3,189	52
Colorado	6,017	3,362	2,876	2,456	3,560	59
Rhode Island	3,890	2,610	2,178	1,659	2,231	57
Delaware	3,782	3,010	2,920	2,484	1,299	34
Idaho	2,683	2,870	3,152	2,604	79	3
Wyoming	1,446	2,365	1,439	1,146	299	21
SouthDakota	1,286	1,406	1,369	1,447	(162)	-13
Montana	1,194	1,226	1,180	1,394	(200)	-17
New Mexico	1,067	1,284	1,077	932	134	13
Virgin Islands	853	606	555	777	75	9

(continued)

Table 10-1. State Total Air Emissions from TRI, 1988 to 1992 (continued)

					Reduction (88-92)	
State	**1988**	**1990**	**1991**	**1992**	**Tons**	**Percent**
Vermont	784	469	450	413	371	47
North Dakota	636	741	903	878	(241)	-38
Hawaii	437	340	290	298	139	32
Nevada	352	373	425	416	(64)	-18
American Samoa	15	10	11	6	9	62
Total	**1,341,726**	**1,152,240**	**1,002,544**	**910,483**	**431,243**	**32**

*Source: 1992 Toxic Release Inventory, Table 3-12. EPA 745-R-94-001, April 1994.

Table 10-2. 1990 National Emissions for 3 Hazardous Air Pollutants
(short tons/year)

Source Category	Benzene	Formaldehyde	1,3-Butadiene
Utility Combustion		1685	
Industrial Combustion		921	
Commercial/Institutional Comb.		497	
Residential Combustion		2399	
Structural Fires		7610	
On-Road Motor Vehicles	174,326	81,431	30,833
Nonroad Mobile Sources	109,783	41,663	47,816
Sewage Sludge Incineration	313		
Publicly Owned Treatment Works	55	40	
Landfills	45		
Gas Processing Glycol Dehydrators	15,401		
Petroleum Distribution	14,089		
SIC 24: Lumber & Wood Products	1	2249	
SIC 28: Chemicals & Allied Products	3184	1667	2348
SIC 29: Petroleum Refining	2980	169	174
SIC 32: Stone, Clay, Glass & Concrete	<1	1083	
SIC 33: Primary Metal Industries	5537	126	
Other Industrial Processes (SIC 20-39)	115	863	4
TOTAL	**325,830**	**142,403**	**81,175**

Sources: On-Road from EPA 420-R-93-005, Motor Vehicle-Related Air Toxics Study, April 1993 (Tables 5-3, 6-4, 7-4); Nonroad from EPA 21A-2001, Nonroad Engine and Vehicle Emission Study-Report, November 1991 (Table 3-02); All other estimates from National Urban Area Source Emissions of Benzene, 1,3-Butadiene, Formaldehyde, Trichloroethylene, Methylene Chloride, and Carbon Tetrachloride, Interim Draft Report, September 30, 1993 (Table 2-1).

Table 10-3. 1990 National Emissions for 4 Chlorinated Hazardous Air Pollutants
(short tons/year)

Source Category	Perchloro-ethylene	Trichloro-ethylene	Methylene Chloride	Carbon Tetrachloride
Dry Cleaners	79,091			
Commercial/Consumer Products	88	32	1756	
Unspecified Solvent Use	3819	21,714		
Sewage Sludge Incineration	4	3	9	0.03
Publicly Owned Treatment Works	127	90	168	346
Landfills	121	58	257	
SIC 20: Food & Kindred Products			152	
SIC 22: Textile Mill Products	484	564	208	
SIC 23: Apparel & Other Textile Prod	31		69	0.003
SIC 24: Lumber & Wood Products	66	1	111	
SIC 25: Furniture & Fixtures	6	132	240	
SIC 26: Paper & Allied Products	262	18	625	
SIC 27: Printing & Publishing	141	56	158	
SIC 28: Chemicals & Allied Products	582	336	13,448	770
SIC 29: Petroleum Refining	1	48	3	23
SIC 30: Rubber & Misc. Plastics	460	853	16,498	
SIC 31: Leather & Leather Products	15		68	
SIC 32: Stone, Clay, Glass & Concrete	74	543	738	0.256
SIC 33: Primary Metal Industries	1451	2133	781	0.003
SIC 34: Fabricated Metals	1447	5023	1953	
SIC 35: Industrial Machinery & Equipt	1063	2380	1235	
SIC 36: Electronic & Other Elec Equipt	1298	1915	2366	
SIC 37: Transportation Equipment	2663	3749	3048	
SIC 38: Instruments & Related Products	299	682	4646	
SIC 39: Miscellaneous Manufacturing Ind	80	568	457	
TOTAL	**93,672**	**40,895**	**48,994**	**1,139**

Source: National Urban Area Source Emissions of Benzene, 1,3-Butadiene, Formaldehyde, Trichloroethylene, Methylene Chloride, and Carbon Tetrachloride, Interim Draft Report, September 30, 1993 (Table 2-1).

Table 10-4. 1990 National Extractable Organic Matter Emissions
(short tons/year)

Source Category	EOM
Residential Wood Combustion	475,830
Industrial Wood Combustion	97,848
On-Road Vehicles	56,157
Utility Coal Combustion	38,628
Nonroad Vehicles	25,116
Residential Natural Gas Combustion	4,143
Diesel IC Engines & Turbines	3,660
Commercial Coal Combustion	2,746
Industrial Coal Combustion	2,411
15 Other Categories Estimated*	11,830
TOTAL	**718,369**

Source: *Emissions Inventory of section 112(c)(6) Pollutants,* Extractable Organic Matter (EOM), Draft Report, September 1993 (Table 3-1).

NOTE(S): *Includes additional combustion sectors, municipal and medical waste incineration, coke ovens, and primary aluminum production.

No estimates available for the following potential sources of EOM emissions:

- Iron and Steel Foundries
- Carbon Black Manufacturing
- Hazardous Waste Incineration
- Wood Treatment and Preserving
- Asphalt Roofing Manufacturing
- Locomotives, Aircraft, and additional Nonroad Vehicles
- Petroleum Refining
- Charcoal Manufacturing
- Secondary Lead Smelting
- Pulp and Paper Production
- Asphalt Hot-Mix Production

Of the above listed categories, iron and steel foundries and petroleum refineries are likely to be major sources of EOM emissions based on the air emissions for individual POM compounds reported in the TRI data base.

Table 10-5. 1990 National Hexachlorobenzene Emissions
(pounds/year)

State	Pesticides	Solvent Prod.	Total
Florida	72,199	0	72,199
California	65,779	2	65,781
Texas	31,524	562	32,086
Illinois	25,330	0	25,330
Iowa	22,693	0	22,693
Nebraska	19,429	0	19,429
Indiana	15,688	0	15,688
Kansas	15,283	29	15,312
Ohio	12,879	0	12,879
Michigan	9,622	0	9,622
Missouri	8,483	0	8,483
North Carolina	8,686	0	8,386
Minnesota	8,066	0	8,066
Maryland	7,902	0	7,902
Wisconsin	7,632	0	7,632
Washington	7,610	0	7,610
New York	6,661	0	6,661
Louisiana	6,224	299	6,523
Virginia	5,192	0	5,192
Pennsylvania	5,125	0	5,125
Kentucky	5,015	40	5,055
Georgia	4,425	0	4,425
Colorado	4,297	0	4,297
Tennessee	3,857	0	3,857
Oregon	3,489	0	3,489
Alabama	3,156	222	3,378
New Jersey	2,602	0	2,602
New Mexico	2,045	0	2,045
South Carolina	1,742	0	1,742
South Dakota	1,644	0	1,644
Arkansas	1,591	0	1,591
Delaware	1,370	0	1,370
Oklahoma	1,314	0	1,314
Hawaii	1,135	0	1,135
Mississippi	941	0	941
Utah	707	0	707
Arizona	589	0	589
North Dakota	501	0	501
West Virginia	422	7	429
Idaho	391	0	391
Vermont	379	0	379
Maine	213	0	213
Wyoming	213	0	213
Connecticut	204	0	204
Massachusetts	173	0	173
Montana	28	0	28
New Hampshire	28	0	28
Rhode Island	20	0	20
Nevada	0	0	0
TOTAL	**404,197**	**1,161**	**405,358**

Source: Estimation of National Hexachlorobenzene Emissions for 1990, Final Report, October 1993 (Table I).

Table 10-6. 1990 National Tetraethyl Lead and Tetramethyl Lead Emissions
(pounds/year)

Source Category	TEL	TML
Bulk Plants - Aviation Gas	750	N/A
Nonroad Vehicles	38	293
Service Stations	13	102
Bulk Plants - Motor Vehicle Gas	5	40
Bulk Terminals	4	30
Pipelines	2	16
TOTAL	**811**	**481**

Source: Estimation of Alkylated Lead Emissions, Final Report, September 1993 (Table 1).

Table 10-7. 1990 National Polychlorinated Biphenyl Emissions
(pounds/year)

Source Category	PCB Emissions
Municipal Waste Combustion	175
Hazardous Waste Incineration	134
Medical Waste Incineration	84
Sewage Sludge Incineration	11
Waste Tire Incineration	1
Residual Oil Combustion	1
TOTAL	**406**

Source: Emissions Inventory of Section 112(c)(6) Pollutants, Polychlorinated Biphenyl Compounds (PCBs), Draft Report, September 1993 (Table 3-1).

NOTE(S): The following categories were identified as potential sources of PCB emissions for which sufficient data were not available to develop national emissions estimates:

- Treatment, Storage, and Disposal Facilities (TSDFs) and Landfills;
- Superfund Sites;
- Steel and Iron Reclamation (auto scrap burning);
- Accidental Releases (spills, leaks and transformer fires); and
- Environmental Sinks of Past PCB Contamination.

Table 10-8. 1990 National Emissions for Cadmium and Mercury
(short tons/year)

Source Category	Cadmium	Mercury
Coal Combustion	240.4	122
Oil Combustion	26.0	14.9
Municipal Waste Incineration	7.7	63.8
Sewage Sludge Incineration	6.9	1.8
Medical Waste Incineration	3.9	64.7
Wood Combustion	0.4	0.3
Geothermal Power Plants		1.4
Metal & Metal Compound Production	10.1	6.3
Major Uses of Metal	3.6	20.2
Primary Lead Smelting	15.8	9.0
Primary Copper Smelting	6.2	NA
Primary Zinc Smelting	6.3	
Secondary Copper Smelting	4.8	
Secondary Zinc Smelting	1.7	
Iron and Steel	1.5	
Portland Cement Production	3.3	6.2
Paint		14.6
Miscellaneous Sources	0.1	1.9
Mobile Sources	na	5.0
TOTAL	**338.7**	**332.1**

Sources: Locating and Estimating Air Emissions from Sources of Cadmium and Cadmium Compounds, EPA-454/R-93-040, September 1993 (Table 3-3); Locating and Estimating Air Emissions from Sources of Mercury and Mercury Compounds, EPA-454/R-93-023, September 1993 (Table 3-4).

TABLE 10-9. Summary of Proposed or Promulgated Maximum Achievable Control Technology Standards

MACT Source Category	HAP Emissions (short tons/year)		Number of Facilities	Date of:		Primary Toxics Emitted
	Baseline Emissions	Expected Reduction		Proposal	Final	
Aerospace Manufacturing and Rework	208,000	127,800	2,800	6/94		MC, TCA, MEK, Toluene, Chromium, Cadmium
Petroleum Refineries	78,000	54,000	192	6/94		BTEX
Halogenated Solvent Cleaning	141,400	88,400	125,400	11/93		MC, TCA, Perc, TCE, Carbon Tetrachloride, Chloroform
Magnetic Tape Manufacturing	4,500	2,300		3/93		MEK, MIBK, Toluene
Marine Vessel Loading Operations	8,800	8,400	350	5/94		BTEX
Polymers and Resins II	160	110	20	5/94		Epichlorohydrin
Pulp, Paper, and Paperboard Manufacture	187,000	132,000	160	12/93	3/96	Chloroform, Methanol
Gasoline Distribution Industry (Stage I)	55,000	3,000	400	2/94		BTEX
Ethylene Oxide Sterilization Facilities	1,200	1,100	200	3/94	11/94	Ethylene Oxide
Chromium Electroplating Operations	175	172	5,000		11/94	Chromium
Coke Oven Batteries	1,830	1,510	30		10/93	POM
Perchloroethylene Dry Cleaning Facilities	94,000	7,300	3,700		9/93	Perc
Secondary Lead Smelters	2,900	2,200	23	5/94	5/95	Lead, Arsenic, Butadiene
Industrial Process Cooling Towers	25	25	300		7/94	Chromium
Synthetic Organic Chemical Manufacturing	550,000	440,000	370		4/94	Up to 150 Different HAPs
Total	**1,428,990**	**868,317**	**138,945**			

NOTE(S): MC = Methylene Chloride, TCA = 1,1,1-Trichloroethane, MEK = Methyl Ethyl Ketone, Perc = Perchloroethylene, TCE = Trichloroethylene, MIBK = Methyl Isobutyl Ketone
BTEX = Benzene, Toluene, Ethylbenzene, and Xylenes, POM = Polycyclic Organic Matter

APPENDIX A

NATIONAL EMISSIONS (1970 TO 1993) BY SUBCATEGORY

Table A-1. Carbon Monoxide Emissions
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
FUEL COMB. ELEC. UTIL.	237	322	316	292	291	300	313	319	314	314	313	322
Coal	106	188	220	208	208	217	229	231	233	233	235	245
Oil	41	48	25	18	24	20	25	26	20	19	15	16
Gas	90	85	72	56	48	53	48	51	51	51	51	49
Internal Combustion	NA	NA	NA	10	11	10	11	11	11	11	11	11
FUEL COMB. INDUSTRIAL	770	750	732	670	650	649	669	672	677	682	671	667
Coal	100	58	74	86	87	85	87	87	86	86	78	73
Oil	44	35	23	47	46	46	46	46	46	46	46	46
Gas	462	418	385	257	242	252	265	271	276	284	277	278
Other	164	239	249	167	172	171	173	173	171	169	170	170
Internal Combustion	NA	NA	NA	113	103	96	98	96	98	98	99	100
FUEL COMB. OTHER	3,625	6,230	6,760	6,686	6,571	6,338	6,172	5,942	5,726	5,583	5,033	4,444
Commercial/Institutional Coal	12	13	22	14	14	14	15	15	15	15	15	15
Commercial/Institutional Oil	27	21	17	18	18	19	18	17	16	16	17	17
Commercial/Institutional Gas	24	26	25	42	42	43	47	49	50	51	50	51
Misc. Fuel Comb. (Except Residential)	NA	NA	NA	57	60	59	55	55	52	50	52	52
Residential Wood	2,932	5,992	6,485	6,393	6,280	6,046	5,868	5,654	5,435	5,290	4,750	4,161
fireplaces	686	1,402	1,517	NA	NA	NA	NA	NA	NA	NA	NA	NA
woodstoves	2,246	4,590	4,967	NA	NA	NA	NA	NA	NA	NA	NA	NA
Residential Other	630	178	212	162	157	157	168	153	158	161	150	149
CHEMICAL & ALLIED PRODUCT MFG	3,397	2,151	2,082	1,845	1,853	1,798	1,917	1,925	1,940	1,953	1,964	1,998
Organic Chemical Mfg	340	543	599	251	261	260	278	285	286	282	288	289
ethylene dichloride	11	17	20	0	0	0	0	0	0	0	0	0
maleic anhydride	73	103	122	16	16	15	16	16	16	16	16	16
cyclohexanol	36	37	39	5	5	5	6	6	6	6	6	6
other	220	386	418	230	240	240	256	264	264	261	266	268
Inorganic Chemical Mfg	190	191	167	89	94	89	95	95	95	96	96	96
pigments; TiO2 chloride process: reactor	18	34	37	77	82	77	83	84	83	84	84	84
other	172	157	129	12	12	11	12	12	12	12	12	12
Polymer & Resin Mfg	NA	NA	NA	19	19	18	18	18	19	19	19	19
Agricultural Chemical Mfg	NA	NA	NA	16	16	16	17	17	17	17	18	18
Pharmaceutical Mfg	NA	NA	NA	0	0	0	0	0	0	0	0	0
Other Chemical Mfg	2,866	1,417	1,316	1,471	1,463	1,415	1,509	1,510	1,522	1,538	1,542	1,574
carbon black mfg	2,866	1,417	1,316	1,078	1,068	1,034	1,098	1,112	1,126	1,140	1,142	1,170
carbon black furnace: fugitives	NA	NA	NA	155	165	161	185	180	179	184	185	190
other	NA	NA	NA	238	231	219	226	219	218	214	215	214

(continued)

Table A-1. Carbon Monoxide Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
METALS PROCESSING	3,644	2,246	1,734	2,223	2,079	1,984	2,101	2,132	2,080	1,992	2,044	2,091
Nonferrous Metals Processing	652	842	741	694	650	614	656	677	681	656	665	676
aluminum anode baking	326	421	371	41	40	38	40	41	41	40	41	42
prebake aluminum cell	326	421	371	257	243	232	248	254	255	245	251	256
other	NA	NA	NA	396	367	344	368	382	384	371	373	378
Ferrous Metals Processing	2,991	1,404	993	1,523	1,423	1,365	1,439	1,449	1,394	1,331	1,373	1,410
basic oxygen furnace	440	80	64	694	640	617	650	662	642	615	635	652
carbon steel electric arc furnace	181	280	235	19	17	17	18	18	17	16	17	17
coke oven charging	62	43	29	9	9	8	9	9	8	8	8	8
gray iron cupola	1,203	340	201	302	294	281	288	280	262	249	254	261
iron ore sinter plant windbox	1,025	600	418	304	280	266	287	293	283	269	280	287
other	81	61	46	194	184	176	188	187	181	174	180	185
Metals Processing NEC	NA	NA	NA	6	6	6	6	6	6	6	6	6
PETROLEUM & RELATED INDUSTRIES	2,179	1,723	383	462	451	455	441	436	435	439	410	398
Oil & Gas Production	NA	NA	NA	11	9	8	8	8	8	9	8	8
Petroleum Refineries & Related Industries	2,168	1,723	383	449	440	445	431	427	425	429	400	388
fcc units	1,820	1,680	362	403	398	408	393	390	389	392	364	352
other	348	44	21	46	41	37	38	37	36	37	36	36
Asphalt Manufacturing	11	0	0	2	2	2	2	2	2	2	2	2
OTHER INDUSTRIAL PROCESSES	620	830	908	694	715	713	711	716	717	711	719	732
Agriculture, Food, & Kindred Products	NA	NA	NA	0	0	0	0	0	0	0	0	0
Textiles, Leather, & Apparel Products	NA	NA	NA	0	0	0	0	0	0	0	0	0
Wood, Pulp & Paper, & Publishing Products	610	798	877	627	647	646	649	655	657	653	661	672
sulfate pulping: rec. furnace/evaporator	NA	NA	NA	475	491	489	491	497	498	496	502	510
sulfate (kraft) pulping: *lime kiln*	610	798	877	140	145	144	145	146	146	145	146	149
other	NA	NA	NA	12	12	13	13	13	13	13	13	13
Rubber & Miscellaneous Plastic Products	NA	NA	NA	0	0	0	0	0	0	0	0	0
Mineral Products	10	32	31	43	44	44	44	43	43	41	42	44
Machinery Products	NA	NA	NA	0	0	0	0	0	0	0	0	0
Electronic Equipment	NA	NA	NA	18	18	18	13	12	12	11	11	11
Transportation Equipment	NA	NA	NA	0	0	0	0	0	0	0	0	0
Miscellaneous Industrial Processes	NA	NA	NA	6	5	5	5	5	5	5	5	5
SOLVENT UTILIZATION	NA	NA	NA	2	2	2	2	2	2	2	2	2
Degreasing	NA	NA	NA	1	1	1	1	1	1	1	1	1
Graphic Arts	NA	NA	NA	0	0	0	0	0	0	0	0	0
Surface Coating	NA	NA	NA	0	0	0	1	1	1	1	1	1
Other Industrial	NA	NA	NA	0	0	0	0	0	0	0	0	0

(continued)

Table A-1. Carbon Monoxide Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
STORAGE & TRANSPORT	NA	NA	NA	49	51	50	56	55	55	56	55	56
Bulk Terminals & Plants	NA	NA	NA	0	0	0	0	0	0	0	0	0
Petroleum & Petroleum Product Storage	NA	NA	NA	0	0	0	0	0	0	0	0	0
Petroleum & Petroleum Product Transport	NA	NA	NA	0	0	0	0	0	0	0	0	0
Organic Chemical Storage	NA	NA	NA	42	45	44	51	49	49	50	49	50
Inorganic Chemical Storage	NA	NA	NA	0	0	0	0	0	0	0	0	0
Bulk Materials Storage	NA	NA	NA	6	5	5	5	5	5	5	5	5
WASTE DISPOSAL & RECYCLING	7,059	2,300	2,028	1,941	1,916	1,850	1,806	1,747	1,686	1,644	1,717	1,732
Incineration	2,979	1,246	1,089	958	949	920	903	876	849	830	864	872
conical wood burner	1,431	228	150	17	18	18	19	19	18	18	18	18
municipal incinerator	333	13	7	34	35	34	35	35	35	34	35	35
industrial	NA	NA	NA	9	9	9	10	9	9	9	9	9
commmercial/institutional	108	60	41	32	33	35	38	39	40	40	40	41
residential	1,107	945	891	865	852	822	800	773	745	726	759	766
other	NA	NA	NA	2	2	2	2	2	2	2	2	2
Open Burning	4,080	1,054	939	982	966	930	903	870	836	814	852	859
industrial	1,932	1,007	909	20	21	21	21	21	21	20	21	22
commmercial/institutional	2,148	47	30	4	4	4	4	5	5	5	5	5
residential	NA	NA	NA	958	941	905	877	845	811	789	826	833
Landfills	NA	NA	NA	0	0	0	0	0	0	0	0	0
Other	NA	NA	NA	0	0	0	0	0	0	0	0	0
HIGHWAY VEHICLES	88,034	78,049	78,881	77,387	73,347	70,645	71,081	66,050	62,858	62,074	59,859	59,989
Light-Duty Gas Vehicles & Motorcycles	64,031	53,561	50,698	49,451	46,698	44,860	45,553	42,234	40,502	40,267	39,370	39,452
light-duty gas vehicles	63,846	53,342	50,518	49,273	46,522	44,682	45,367	42,047	40,316	40,089	39,190	39,265
motorcycles	185	219	180	178	175	179	186	187	187	177	180	187
Light-Duty Gas Trucks	16,570	16,137	19,124	18,960	17,789	17,151	17,133	15,940	15,084	15,014	14,567	14,879
light-duty gas trucks 1	10,102	10,395	12,207	11,834	10,795	10,096	9,890	9,034	8,511	8,450	8,161	8,286
light-duty gas trucks 2	6,468	5,742	6,917	7,126	6,995	7,056	7,244	6,906	6,573	6,565	6,407	6,593
Heavy-Duty Gas Vehicles	6,712	7,189	7,789	7,716	7,601	7,343	7,072	6,506	5,930	5,459	4,569	4,292
Diesels	721	1,161	1,270	1,261	1,259	1,289	1,322	1,369	1,342	1,334	1,352	1,366
heavy-duty diesel vehicles	721	1,139	1,246	1,235	1,232	1,260	1,290	1,336	1,307	1,298	1,315	1,327
light-duty diesel trucks	NA	4	4	4	4	5	5	6	6	6	6	6
light-duty diesel vehicles	NA	19	20	22	23	24	26	28	29	30	31	33
OFF-HIGHWAY	10,605	12,681	13,427	13,706	13,984	14,131	14,500	14,518	14,642	14,621	14,904	15,272
Non-Road Gasoline	9,478	11,004	11,599	11,815	12,057	12,286	12,465	12,538	12,655	12,661	12,886	13,164
recreational	268	299	309	312	314	316	318	321	324	327	330	333
construction	250	368	409	421	416	402	401	398	395	376	395	423
industrial	732	970	1,061	1,104	1,137	1,164	1,207	1,227	1,228	1,196	1,234	1,285
lawn & garden	4,679	5,366	5,623	5,685	5,749	5,808	5,866	5,929	6,001	6,074	6,145	6,214

(continued)

Table A-1. Carbon Monoxide Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
OFF-HIGHWAY (continued)												
Non-Road Gasoline (continued)												
farm	46	77	82	84	85	47	92	63	63	66	68	70
light commercial	2,437	2,680	2,814	2,894	3,028	3,203	3,219	3,223	3,254	3,220	3,296	3,402
logging	9	25	28	28	27	33	31	33	33	32	33	34
airport service	80	116	125	129	133	137	144	147	149	148	151	157
recreational marine vessels	976	1,102	1,147	1,157	1,167	1,175	1,185	1,195	1,207	1,221	1,233	1,245
other	1	2	2	2	2	2	2	2	2	2	2	2
Non-Road Diesel	543	801	880	910	912	797	930	845	841	818	853	903
recreational	0	0	0	0	0	0	0	0	0	0	0	0
construction	336	479	535	553	552	538	538	535	528	500	526	564
industrial	33	43	47	49	50	51	53	54	54	53	54	56
lawn & garden	3	3	3	3	3	3	3	3	3	3	4	4
farm	127	214	229	237	237	131	259	175	176	183	189	196
light commercial	10	11	12	12	13	14	14	14	14	14	14	15
logging	1	2	3	2	2	3	3	3	3	3	3	3
airport service	33	48	52	54	55	57	60	61	62	62	63	65
Aircraft	506	743	803	831	858	887	931	955	966	962	980	1,019
Marine Vessels	14	37	42	44	47	50	56	59	58	58	60	62
coal	2	4	5	5	5	6	6	7	6	6	7	7
diesel	12	32	37	39	41	44	48	52	51	51	53	54
residual oil	0	1	1	1	1	1	1	1	1	1	1	1
Railroads	65	96	103	106	109	112	118	121	122	122	124	124
MISCELLANEOUS	7,909	8,344	7,011	6,116	6,161	6,203	6,332	6,290	12,623	9,826	8,679	9,506
Other Combustion	7,909	8,344	7,011	6,116	6,161	6,203	6,332	6,290	12,623	9,826	8,679	9,506
structural fires	101	217	198	242	242	242	242	242	242	242	242	242
agricultural fires	873	501	492	396	441	483	612	571	552	487	559	573
slash/prescribed burning	1,146	2,226	2,226	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300
forest wildfires	5,620	5,396	4,093	1,178	1,178	1,178	1,178	1,178	7,529	4,798	3,578	4,391
other	169	4	2	0	0	0	0	0	0	0	0	0
TOTAL ALL SOURCES	128,079	115,625	114,262	112,072	108,070	105,117	106,100	100,806	103,753	99,898	96,368	97,208

NOTE(S): Methodologies to estimate 1970 to 1984 and 1985 to 1993 emissions differ except for transportation sources. Because of these differences, the allocation of emissions among source categories could result in significant changes in the emissions between the years, particularly at the more detailed source category level. The break is illustrated by the black line. Details on the different methodologies are provided in section 6.0.

NA = not available. For several source categories, emissions either prior to or beginning with 1985 are not available at the more detailed level but are contained in the more aggregate estimate.

"Other" categories may contain emissions that could not be accurately allocated to specific source categories.

Zero values represent less than 500 short tons/year.

No data was available after 1984 to weigh the emissions from residential wood burning devices.

Table A-2. Nitrogen Oxides Emissions
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
FUEL COMB. ELEC. UTIL.	4,900	7,024	7,268	6,916	6,909	7,128	7,530	7,607	7,516	7,482	7,473	7,782
Coal	3,888	6,123	6,515	6,051	6,061	6,278	6,668	6,708	6,698	6,662	6,694	7,005
bituminous	2,112	3,439	3,820	4,438	4,427	4,529	4,623	4,665	4,600	4,522	4,564	4,758
subbituminous	1,041	1,694	1,882	1,340	1,290	1,411	1,659	1,650	1,692	1,732	1,707	1,831
anthracite & lignite	344	542	597	272	344	337	387	392	406	408	423	416
other	391	447	217	NA	NA	NA	NA	NA	NA	NA	NA	NA
Oil	1,012	901	752	177	246	204	260	272	210	201	160	177
residual	40	39	23	174	242	200	257	269	207	198	158	175
distillate	972	862	729	4	4	4	4	4	3	3	3	3
Gas	NA	NA	NA	640	552	599	551	578	558	569	568	550
natural	NA	NA	NA	640	552	599	551	578	558	569	568	550
Internal Combustion	NA	NA	NA	48	50	48	50	49	50	50	50	50
FUEL COMB. INDUSTRIAL	4,325	3,555	3,415	3,209	3,065	3,063	3,187	3,209	3,256	3,309	3,206	3,176
Coal	771	444	573	608	613	596	617	615	613	610	557	520
bituminous	532	306	397	430	439	435	447	446	445	438	404	377
subbituminous	164	94	122	14	14	14	15	14	14	14	13	12
anthracite & lignite	75	44	54	33	31	27	29	30	30	30	27	26
other	NA	NA	NA	131	129	119	126	124	124	127	112	105
Oil	332	286	175	309	300	292	296	294	297	306	300	297
residual	228	179	100	191	181	172	175	176	177	185	180	179
distillate	104	63	52	89	89	89	91	88	90	91	92	91
other	NA	44	24	29	30	31	31	29	30	30	28	27
Gas	3,060	2,619	2,457	1,520	1,433	1,505	1,584	1,625	1,656	1,708	1,658	1,664
natural	3,053	2,469	2,329	1,282	1,206	1,285	1,360	1,405	1,436	1,485	1,444	1,453
process	8	5	3	227	216	210	214	209	211	212	205	202
other	NA	145	125	11	10	10	10	10	10	10	9	9
Other	162	205	209	118	120	119	121	120	119	117	118	118
wood/bark waste	102	138	144	89	92	92	93	92	91	90	91	91
liquid waste	NA	NA	NA	12	12	12	12	12	12	12	12	12
other	60	67	64	17	16	15	16	16	16	16	15	15
Internal Combustion	NA	NA	NA	655	599	552	569	556	570	568	573	577
FUEL COMB. OTHER	836	741	670	701	694	710	737	730	732	745	735	732
Commercial/Institutional Coal	23	25	37	37	36	37	39	38	39	40	38	38
Commercial/Institutional Oil	210	155	96	106	110	121	117	106	99	100	101	102

(continued)

Table A-2. Nitrogen Oxides Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
FUEL COMB. OTHER (continued)												
Commercial/Institutional Gas	120	131	126	145	139	144	157	159	164	169	166	167
Misc. Fuel Comb. (Except Residential)	NA	NA	NA	11	12	11	11	11	11	11	11	11
Residential Wood	44	74	81	77	76	73	71	68	66	64	58	50
Residential Other	439	356	331	326	320	323	343	347	352	361	361	363
distillate oil	118	85	64	75	76	79	80	78	81	82	85	86
natural gas	242	238	228	248	241	241	259	267	269	275	274	275
other	79	33	40	3	3	3	3	3	3	3	2	2
CHEMICAL & ALLIED PRODUCT MFG	271	216	161	374	381	371	398	395	399	401	411	414
Organic Chemical Mfg	70	54	57	37	38	38	42	42	42	42	43	43
Inorganic Chemical Mfg	201	159	104	22	19	17	18	18	19	19	19	19
Polymer & Resin Mfg	NA	NA	NA	22	22	22	23	23	23	23	24	24
Agricultural Chemical Mfg	NA	NA	NA	255	262	256	276	274	277	278	287	289
Paint, Varnish, Lacquer, Enamel Mfg	NA	NA	NA	0	0	0	0	0	0	0	0	0
Pharmaceutical Mfg	NA	NA	NA	0	0	0	0	0	0	0	0	0
Other Chemical Mfg	NA	NA	NA	38	38	37	40	39	38	38	38	39
METALS PROCESSING	77	65	54	87	80	76	82	83	81	79	80	82
Nonferrous Metals Processing	NA	NA	NA	16	15	15	16	16	15	15	15	15
Ferrous Metals Processing	77	65	54	58	53	48	53	54	53	51	53	54
Metals Processing NEC	NA	NA	NA	13	13	13	13	14	13	12	12	13
PETROLEUM & RELATED INDUSTRIES	240	72	70	124	109	101	100	97	100	103	96	95
Oil & Gas Production	NA	NA	NA	69	55	48	48	47	50	52	48	48
Petroleum Refineries & Related Industries	240	72	70	55	53	52	51	49	50	50	47	46
Asphalt Manufacturing	NA	NA	NA	1	1	1	1	1	1	1	1	1
OTHER INDUSTRIAL PROCESSES	187	205	203	327	328	320	315	311	306	298	305	314
Agriculture, Food, & Kindred Products	NA	NA	NA	5	5	5	5	5	5	5	5	5
Textiles, Leather, & Apparel Products	NA	NA	NA	0	0	0	0	0	0	0	0	0
Wood, Pulp & Paper, & Publishing Products	18	24	26	73	76	76	76	77	77	76	78	79
Rubber & Miscellaneous Plastic Products	NA	NA	NA	0	0	0	0	0	0	0	0	0
Mineral Products	169	181	177	239	238	230	225	220	216	209	214	222
cement mfg	97	98	101	137	136	130	126	124	121	117	119	124
glass mfg	48	60	57	48	48	47	46	45	44	42	44	46
other	24	23	19	54	54	53	53	51	51	49	51	52

(continued)

Table A-2. Nitrogen Oxides Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
OTHER INDUSTRIAL PROCESSES (continued)												
Machinery Products	NA	NA	NA	2	2	2	2	2	2	2	2	2
Transportation Equipment	NA	NA	NA	0	0	0	0	0	0	0	0	0
Miscellaneous Industrial Processes	NA	NA	NA	8	8	7	7	7	7	7	7	7
SOLVENT UTILIZATION	NA	NA	NA	2	3	3	3	3	2	2	3	3
Degreasing	NA	NA	NA	0	0	0	0	0	0	0	0	0
Graphic Arts	NA	NA	NA	0	0	0	0	0	0	0	0	0
Surface Coating	NA	NA	NA	2	2	2	2	2	2	2	2	2
Other Industrial	NA	NA	NA	0	0	0	0	0	0	0	0	0
STORAGE & TRANSPORT	NA	NA	NA	2	2	2	2	2	2	2	3	3
Petroleum & Petroleum Product Storage	NA	NA	NA	1	1	1	1	1	1	1	1	1
Petroleum & Petroleum Product Transport	NA	NA	NA	0	0	0	0	0	0	0	0	0
Organic Chemical Storage	NA	NA	NA	1	1	1	1	1	1	1	1	1
Inorganic Chemical Storage	NA	NA	NA	0	0	0	0	0	0	0	0	0
Bulk Materials Storage	NA	NA	NA	0	0	0	1	1	1	1	1	1
WASTE DISPOSAL & RECYCLING	440	111	90	87	87	85	85	84	82	81	83	84
Incineration	110	37	24	27	29	29	31	31	32	32	32	32
Open Burning	330	74	66	59	58	56	54	52	50	49	51	52
Landfills	NA	NA	NA	0	0	0	0	0	0	0	0	0
Other	NA	NA	NA	0	0	0	0	0	0	0	0	0
HIGHWAY VEHICLES	7,390	8,621	8,387	8,089	7,773	7,662	7,661	7,682	7,488	7,373	7,440	7,437
Light-Duty Gas Vehicles & Motorcycles	4,158	4,421	3,993	3,806	3,602	3,501	3,500	3,494	3,437	3,464	3,614	3,685
light-duty gas vehicles	4,156	4,416	3,984	3,797	3,592	3,491	3,489	3,483	3,425	3,453	3,602	3,673
motorcycles	2	5	8	9	10	10	11	11	12	11	12	12
Light-Duty Gas Trucks	1,278	1,408	1,582	1,530	1,457	1,438	1,419	1,386	1,341	1,339	1,356	1,387
light-duty gas trucks 1	725	864	977	926	867	844	824	803	780	782	792	812
light-duty gas trucks 2	553	544	604	603	590	595	595	584	561	557	564	575
Heavy-Duty Gas Vehicles	278	300	329	330	332	333	336	343	335	326	308	304
Diesels	1,676	2,493	2,484	2,423	2,383	2,390	2,406	2,458	2,375	2,244	2,163	2,061
heavy-duty diesel vehicles	1,676	2,463	2,451	2,389	2,347	2,352	2,366	2,416	2,332	2,199	2,116	2,014
light-duty diesel trucks	NA	5	5	6	6	6	7	7	7	8	8	8
light-duty diesel vehicles	NA	25	27	28	29	31	33	35	36	37	39	39

(continued

Table A-2. Nitrogen Oxides Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
OFF-HIGHWAY	1,628	2,423	2,644	2,734	2,777	2,664	2,914	2,844	2,843	2,796	2,885	2,986
Non-Road Gasoline	81	102	110	113	116	118	122	123	124	122	125	129
recreational	1	1	1	1	1	1	1	1	1	1	1	1
construction	2	3	3	4	3	3	3	3	3	3	3	4
industrial	46	61	67	70	72	74	76	78	78	76	78	81
lawn & garden	5	6	6	6	6	6	7	7	7	7	7	7
farm	0	1	1	1	1	0	1	1	1	1	1	1
light commercial	3	4	4	4	4	4	4	4	4	4	5	5
logging	0	0	0	0	0	0	0	0	0	0	0	0
airport service	2	2	3	3	3	3	3	3	3	3	3	3
recreational marine vessels	16	18	18	19	19	19	19	19	20	20	20	20
other	6	6	7	7	7	7	7	7	7	7	7	7
Non-Road Diesel	941	1,374	1,510	1,562	1,569	1,416	1,597	1,485	1,478	1,434	1,494	1,582
recreational	0	0	0	0	0	0	0	0	0	0	0	0
construction	599	854	952	986	984	959	961	955	944	895	940	1,007
industrial	75	99	108	112	116	119	123	125	125	122	126	131
lawn & garden	4	5	5	5	5	5	5	5	5	6	6	6
farm	166	280	299	309	309	172	340	228	230	239	248	256
light commercial	17	18	19	20	21	22	22	22	22	22	23	23
logging	2	5	5	5	5	6	6	7	7	6	7	7
airport service	78	113	121	125	129	133	140	143	144	144	146	152
Aircraft	72	106	115	119	123	128	134	138	139	139	141	147
Marine Vessels	40	110	125	131	140	149	165	175	173	174	179	183
coal	0	0	0	0	0	0	0	0	0	0	0	0
diesel	34	93	105	110	118	125	138	147	145	146	151	154
residual oil	6	17	19	20	22	24	26	28	27	27	28	29
Railroads	495	731	784	808	829	854	897	923	929	928	946	945
MISCELLANEOUS	330	248	210	201	202	203	206	205	384	305	272	296
Other Combustion	330	248	210	201	202	203	206	205	384	305	272	296
TOTAL ALL SOURCES	20,625	23,281	23,172	22,853	22,409	22,386	23,221	23,250	23,192	22,977	22,991	23,402

NOTE(S): Methodologies to estimate 1970 to 1984 and 1985 to 1993 emissions differ except for transportation sources. Because of these differences, the allocation of emissions among source categories could result in significant changes in the emissions between the years, particularly at the more detailed source category level. The break is illustrated by the black line. Details on the different methodologies are provided in section 6.0.

NA = not available. For several source categories, emissions either prior to or beginning with 1985 are not available at the more detailed level but are contained in the more aggregate estimate.

"Other" categories may contain emissions that could not be accurately allocated to specific source categories.

Zero values represent less than 500 short tons/year.

Table A-3. Volatile Organic Compound Emissions
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
FUEL COMB. ELEC. UTIL.	30	45	45	32	33	34	36	37	35	35	34	36
Coal	18	31	37	24	24	25	27	27	27	27	27	29
Oil	7	9	4	5	7	6	7	7	6	5	4	5
Gas	5	5	4	2	2	2	2	2	2	2	2	2
Internal Combustion	NA	NA	NA	1	1	1	1	1	1	1	1	1
FUEL COMB. INDUSTRIAL	150	157	156	248	254	249	271	266	266	270	271	271
Coal	4	3	3	7	7	7	7	7	7	7	7	6
Oil	4	3	2	17	16	16	16	16	16	16	16	16
Gas	77	62	59	171	178	175	197	192	192	197	198	198
Other	65	89	91	35	36	36	36	36	35	35	35	35
Internal Combustion	NA	NA	NA	18	16	15	15	15	15	15	15	15
FUEL COMB. OTHER	541	848	917	508	499	482	470	452	437	426	385	341
Commercial/Institutional Coal	1	1	2	1	1	1	1	1	1	1	1	1
Commercial/Institutional Oil	4	3	2	4	4	4	4	4	4	4	4	4
Commercial/Institutional Gas	6	7	7	6	6	6	6	7	7	7	7	7
Misc. Fuel Comb. (Except Residential)	NA	NA	NA	4	4	4	4	4	4	4	4	4
Residential Wood	460	809	875	477	468	451	438	422	405	394	354	310
fireplaces	107	189	205	NA	NA	NA	NA	NA	NA	NA	NA	NA
woodstoves	353	620	671	NA	NA	NA	NA	NA	NA	NA	NA	NA
Residential Other	70	28	32	16	16	16	17	15	15	16	15	14
CHEMICAL & ALLIED PRODUCT MFG	1,341	1,595	1,620	1,579	1,640	1,633	1,752	1,748	1,771	1,778	1,799	1,811
Organic Chemical Mfg	629	884	909	612	635	624	674	678	684	686	692	694
ethylene oxide mfg	8	10	12	2	3	2	3	3	3	3	3	3
phenol mfg	NA	NA	NA	0	0	0	0	0	0	0	0	0
terephthalic acid mfg	29	60	60	108	113	109	113	114	117	118	118	118
ethylene mfg	70	111	121	41	43	42	48	47	47	48	49	49
charcoal mfg	48	40	36	39	41	42	45	46	46	44	46	47
socmi reactor	81	118	138	164	169	167	181	186	187	187	189	189
socmi distillation	NA	NA	NA	10	11	10	11	11	12	12	12	12
socmi air oxidation processes	NA	NA	NA	2	2	2	2	2	2	2	2	2
socmi fugitives	194	254	251	203	208	205	221	220	222	223	223	224
other	199	291	293	43	45	44	49	48	48	49	50	50
Inorganic Chemical Mfg	65	93	77	34	36	35	39	38	38	39	40	40
Polymer & Resin Mfg	271	384	369	283	291	287	312	309	313	317	324	330
polypropylene mfg	0	1	1	13	14	13	15	15	15	15	16	16
polyethylene mfg	17	22	27	80	83	81	90	88	89	90	93	95
polystyrene resins	10	15	17	7	8	8	8	8	8	8	8	8

(continued)

Table A-3. Volatile Organic Compound Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
CHEMICAL & ALLIED PRODUCT MFG (continued)												
Polymer & Resin Mfg (continued)												
synthetic fiber	112	199	152	60	62	61	64	64	66	65	66	66
styrene/butadiene rubber	77	70	73	59	61	60	66	65	65	66	67	69
other	55	77	99	63	64	64	69	69	71	72	74	76
Agricultural Chemical Mfg	NA	NA	NA	22	23	23	25	25	25	26	27	27
Paint, Varnish, Lacquer, Enamel Mfg	61	65	74	10	10	10	11	11	11	11	11	11
paint & varnish mfg	61	65	74	10	10	10	11	11	11	11	11	11
other	NA	NA	NA	0	0	0	0	0	0	0	0	0
Pharmaceutical Mfg	40	77	93	212	226	244	247	247	254	252	254	255
Other Chemical Mfg	275	92	98	407	420	411	443	440	446	448	452	454
carbon black mfg	275	92	98	26	25	24	26	26	27	27	27	28
printing ink mfg	NA	NA	NA	13	13	13	13	13	13	13	14	14
fugitives unclassified	NA	NA	NA	16	17	16	18	18	18	18	18	18
carbon black furnace: fugitives	NA	NA	NA	4	4	4	5	5	5	5	5	5
other	NA	NA	NA	348	360	353	381	378	383	384	388	389
METALS PROCESSING	394	273	182	76	73	70	74	74	72	69	72	74
Nonferrous Metals Processing	NA	NA	NA	18	18	18	19	19	19	19	19	20
Ferrous Metals Processing	394	273	182	57	54	51	54	54	52	50	51	53
coke oven door & topside leaks	216	152	101	12	12	11	12	12	11	10	11	11
coke oven by-product plants	NA	NA	NA	3	3	3	3	3	3	3	3	3
other	177	121	81	41	39	37	39	39	38	37	38	39
Metals Processing NEC	NA	NA	NA	1	1	1	1	1	1	1	1	1
PETROLEUM & RELATED INDUSTRIES	1,194	1,440	1,253	797	764	752	733	731	737	745	729	720
Oil & Gas Production	411	379	392	107	79	70	71	68	72	73	68	69
Petroleum Refineries & Related Industries	773	1,045	847	687	682	679	659	659	662	669	657	648
vaccuum distillation	24	32	30	15	14	14	13	13	13	13	12	11
cracking units	27	21	8	34	33	33	32	31	31	32	29	28
process unit turnarounds	NA	NA	NA	15	14	14	13	13	14	14	13	12
petroleum refinery fugitives	NA	NA	NA	128	131	129	120	124	126	127	121	118
other	721	992	809	496	490	489	480	479	478	484	482	478
Asphalt Manufacturing	11	16	14	3	3	3	3	3	3	3	3	3

(continued)

Table A-3. Volatile Organic Compound Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
OTHER INDUSTRIAL PROCESSES	270	237	227	439	445	460	479	476	478	475	482	486
Agriculture, Food, & Kindred Products	208	191	168	218	221	241	248	249	254	255	258	260
vegetable oil mfg	59	81	85	96	96	115	120	123	127	129	131	132
whiskey fermentation: aging	105	64	34	24	24	24	24	23	23	24	24	24
bakeries	45	46	49	51	52	51	52	51	51	50	50	51
other	NA	NA	NA	49	50	51	52	52	52	53	53	54
Textiles, Leather, & Apparel Products	NA	NA	NA	10	10	10	10	10	10	10	10	10
Wood, Pulp & Paper, & Publishing Products	NA	NA	NA	42	44	44	44	44	44	43	44	45
Rubber & Miscellaneous Plastic Products	60	44	58	41	43	43	46	46	46	46	45	46
rubber tire mfg	60	44	58	10	10	10	11	11	11	11	11	11
green tire spray	NA	NA	NA	5	5	5	6	6	6	6	6	6
other	NA	NA	NA	26	28	28	29	29	29	29	29	29
Mineral Products	2	2	2	15	15	15	14	14	14	14	14	14
Machinery Products	NA	NA	NA	4	4	4	4	4	3	3	3	3
Electronic Equipment	NA	NA	NA	0	0	0	0	0	0	0	0	0
Transportation Equipment	NA	NA	NA	1	1	1	0	0	0	0	0	0
Miscellaneous Industrial Processes	NA	NA	NA	108	108	103	112	109	106	103	106	106
SOLVENT UTILIZATION	7,174	6,584	6,309	5,779	5,710	5,828	6,034	6,053	6,063	6,064	6,121	6,249
Degreasing	707	513	500	756	634	681	754	757	757	755	745	762
open top	NA	NA	NA	28	28	28	29	29	28	27	28	28
conveyorized	NA	NA	NA	5	5	5	5	4	4	4	4	4
cold cleaning	NA	NA	NA	31	33	31	34	35	34	32	34	34
other	707	513	500	691	568	618	687	689	690	691	678	695
Graphic Arts	319	373	360	363	373	390	415	417	419	416	427	441
letterpress	NA	NA	NA	2	2	2	2	2	2	2	2	2
flexographic	NA	NA	NA	18	19	19	20	20	20	20	21	21
lithographic	NA	NA	NA	4	4	4	4	4	4	4	4	5
gravure	NA	NA	NA	131	138	140	148	150	151	150	151	156
other	319	373	360	208	211	225	241	241	241	240	249	258
Dry Cleaning	263	320	248	169	217	216	216	212	209	206	216	218
perchloroethylene	NA	NA	NA	85	111	110	109	107	105	103	109	110
petroleum solvent	NA	NA	NA	84	106	106	106	105	104	102	107	108
other	263	320	248	0	0	0	0	0	0	0	0	0

(continued)

Table A-3. Volatile Organic Compound Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
SOLVENT UTILIZATION (continued)												
Surface Coating	3,570	3,685	3,655	2,549	2,602	2,606	2,646	2,635	2,619	2,598	2,623	2,687
industrial adhesives	52	55	58	381	353	353	366	375	383	391	378	392
fabrics	161	186	186	34	34	35	35	35	35	34	35	36
paper	652	626	631	106	109	110	114	114	114	113	114	117
large appliances	49	36	30	22	19	19	19	18	18	18	18	18
magnet wire	7	5	4	0	0	0	0	0	0	0	0	0
autos & light trucks	165	165	138	85	86	88	87	87	86	85	80	80
metal cans	49	73	65	97	96	95	96	95	95	94	93	94
metal coil	18	21	19	50	50	49	50	50	49	49	48	50
wood furniture	211	231	202	132	140	142	143	140	138	137	138	148
metal furniture	35	52	50	41	44	44	44	44	43	43	43	46
flatwood products	64	82	56	4	4	4	4	4	4	4	4	5
plastic parts	17	25	32	11	11	11	11	11	11	10	10	10
large ships	21	20	18	15	16	15	16	15	15	15	15	15
aircraft	1	2	3	27	29	26	31	34	33	31	33	33
misc. metal parts	NA	NA	NA	14	14	14	14	14	14	13	13	14
architectural	442	477	489	473	502	503	504	500	495	493	505	510
traffic markings	NA	NA	NA	100	106	106	107	106	105	104	107	108
maintenance coatings	108	106	91	79	80	80	80	80	79	79	78	81
railroad	5	9	9	4	3	3	3	3	3	3	3	3
auto refinishing	83	186	240	111	132	132	133	132	130	130	137	140
machinery	39	62	51	37	28	28	29	28	28	28	26	27
electronic & other electrical	NA	NA	NA	79	79	79	80	79	78	78	77	80
general	79	52	36	146	147	148	158	154	153	148	157	160
miscellaneous	942	799	861	104	109	108	105	103	98	93	98	98
thinning solvents	NA	NA	NA	90	92	94	97	96	95	93	96	98
other	372	415	385	306	317	318	320	317	315	312	315	324
Other Industrial	640	690	690	159	167	167	169	165	159	155	157	157
miscellaneous	39	44	37	25	29	29	29	29	28	28	28	29
rubber & plastics mfg	309	327	350	NA	NA	NA	NA	NA	NA	NA	NA	NA
other	292	319	303	134	137	138	140	136	131	128	129	128
Nonindustrial	1,674	1,002	856	1,783	1,717	1,768	1,834	1,867	1,900	1,934	1,953	1,982
cutback asphalt	1,045	323	198	191	175	186	199	199	199	199	207	214
pesticide application	241	241	258	212	263	262	262	260	258	255	272	280

(continued)

Table A-3. Volatile Organic Compound Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
SOLVENT UTILIZATION (continued)												
Nonindustrial (continued)												
adhesives	NA	NA	NA	345	332	332	345	353	361	369	368	372
consumer solvents	NA	NA	NA	1,035	947	988	1,030	1,056	1,083	1,111	1,106	1,116
other	387	437	400	0	0	0	0	0	0	0	0	0
STORAGE & TRANSPORT	1,954	1,975	1,810	1,836	1,767	1,893	1,948	1,856	1,861	1,868	1,848	1,861
Bulk Terminals & Plants	599	517	416	606	620	632	652	651	658	646	626	614
fixed roof	14	12	9	14	14	14	15	15	15	15	15	16
floating roof	45	39	31	46	47	48	50	50	49	47	49	51
variable vapor space	1	1	0	1	1	1	1	1	1	1	1	1
underground tanks	NA	0	0	0	0	0	0	0	0	0	0	0
area source: gasoline	509	440	354	512	526	537	554	553	560	550	527	512
other	30	26	21	32	32	32	33	33	33	33	33	34
Petroleum & Petroleum Product Storage	300	306	275	223	217	214	215	210	212	214	216	215
fixed roof gasoline	47	43	35	26	25	25	24	23	24	24	24	24
fixed roof crude	135	148	139	26	24	22	21	21	21	21	21	21
floating roof gasoline	49	45	36	27	26	26	25	24	25	25	25	25
floating roof crude	32	36	33	5	5	5	5	5	5	5	5	5
efr / seal gasoline	3	3	3	2	2	2	2	2	2	2	2	2
efr / seal crude	1	2	1	0	0	0	0	0	0	0	0	0
ifr / seal gasoline	1	1	1	1	1	1	1	1	1	1	1	1
ifr / seal crude	2	2	2	0	0	0	0	0	0	0	0	0
variable vapor space gasoline	3	3	2	1	1	1	1	2	2	2	2	2
other	25	23	23	133	132	131	135	132	133	134	136	135
Petroleum & Petroleum Product Transport	92	61	46	126	123	123	125	125	125	125	128	131
gasoline loading: normal / splash	3	0	0	3	3	3	3	3	3	3	3	3
gasoline loading: balanced / submerged	20	2	1	21	20	21	21	22	21	20	21	22
gasoline loading: normal / submerged	39	3	2	41	41	40	41	42	42	42	43	45
gasoline loading: clean / submerged	2	0	0	2	2	2	2	2	2	2	2	2
marine vessel loading: gasoline & crude	26	50	38	24	23	23	23	22	22	23	23	24
other	2	6	5	35	34	34	35	35	35	35	35	36
Service Stations: Stage I	416	461	457	207	213	219	223	223	230	234	233	240
Service Stations: Stage II	521	583	560	485	400	511	522	441	428	436	434	446
Service Stations: Breathing & Emptying	NA	NA	NA	49	48	51	52	52	53	54	54	56
Organic Chemical Storage	26	46	57	123	129	127	142	139	139	142	140	142
Organic Chemical Transport	NA	NA	NA	17	17	16	16	15	16	16	16	16

(continued)

Table A-3. Volatile Organic Compound Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
STORAGE & TRANSPORT (continued)												
Inorganic Chemical Storage	NA	NA	NA	0	0	0	0	0	0	0	0	0
Inorganic Chemical Transport	NA	NA	NA	0	0	0	0	0	0	0	0	0
Bulk Materials Storage	NA	NA	NA	0	0	0	0	0	0	0	0	0
WASTE DISPOSAL & RECYCLING	1,984	758	687	2,310	2,293	2,256	2,310	2,290	2,262	2,217	2,268	2,271
Incineration	548	366	331	64	63	61	60	59	57	56	58	58
Open Burning	1,424	372	331	309	304	292	284	274	263	256	268	270
industrial	NA	NA	NA	6	6	6	6	6	6	6	6	6
commmercial/institutional	NA	NA	NA	1	1	1	2	2	2	2	2	2
residential	NA	NA	NA	302	297	285	277	266	256	249	260	262
other	1,424	372	331	NA	NA	NA	NA	NA	NA	NA	NA	NA
POTW	NA	NA	NA	10	11	11	11	11	11	11	11	11
Industrial Waste Water	NA	NA	NA	1	2	1	2	2	2	2	2	2
TSDF	NA	NA	NA	1,925	1,913	1,890	1,953	1,945	1,929	1,893	1,929	1,929
Landfills	NA	NA	NA	0	0	0	0	0	0	0	0	0
Other	11	20	25	0	0	0	0	0	0	0	0	0
HIGHWAY VEHICLES	12,972	8,979	9,441	9,376	8,874	8,201	8,290	7,192	6,854	6,499	6,072	6,094
Light-Duty Gas Vehicles & Motorcycles	9,193	5,907	5,914	5,864	5,537	5,092	5,189	4,462	4,285	4,069	3,832	3,854
light-duty gas vehicles	9,133	5,843	5,860	5,810	5,483	5,040	5,136	4,412	4,234	4,033	3,799	3,820
motorcycles	60	64	54	54	54	52	53	50	51	37	33	34
Light-Duty Gas Trucks	2,770	2,059	2,437	2,425	2,279	2,122	2,129	1,867	1,769	1,688	1,588	1,612
light-duty gas trucks 1	1,564	1,229	1,476	1,437	1,316	1,193	1,173	1,018	960	906	849	860
light-duty gas trucks 2	1,206	830	960	988	963	929	956	849	809	781	739	752
Heavy-Duty Gas Vehicles	743	611	703	716	700	637	626	517	470	423	334	314
Diesels	266	402	387	370	357	350	345	346	330	319	318	315
heavy-duty diesel vehicles	266	392	378	360	346	338	332	332	316	304	302	298
light-duty diesel trucks	NA	2	2	2	2	2	2	3	3	3	3	3
light-duty diesel vehicles	NA	8	7	8	9	9	10	11	12	12	13	14
OFF-HIGHWAY	1,542	1,869	1,973	2,008	2,039	2,038	2,106	2,103	2,120	2,123	2,160	2,207
Non-Road Gasoline	1,284	1,474	1,541	1,561	1,582	1,601	1,620	1,631	1,646	1,655	1,678	1,704
recreational	138	151	155	156	157	158	159	160	161	163	164	166
construction	22	32	36	37	37	36	35	35	35	33	35	37
industrial	46	61	66	69	71	73	75	77	77	75	77	80
lawn & garden	574	655	684	691	699	706	713	720	728	737	745	754
farm	4	7	8	8	8	4	9	6	6	6	7	7
light commercial	142	158	167	171	178	188	189	190	191	189	194	200

(continued)

Table A-3. Volatile Organic Compound Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
OFF-HIGHWAY (continued)												
Non-Road Gasoline (continued)												
logging	3	7	8	8	8	10	9	10	10	9	10	10
airport service	4	6	6	6	7	7	7	7	7	7	7	8
recreational marine vessels	350	395	410	413	416	419	422	425	429	434	438	442
other	1	1	1	1	1	1	1	1	1	1	1	1
Non-Road Diesel	129	191	209	216	217	188	223	200	200	195	203	214
construction	75	106	118	123	122	119	120	119	118	111	117	125
industrial	9	12	13	13	14	14	14	15	15	14	15	15
lawn & garden	1	1	1	1	1	1	1	1	1	1	1	1
farm	33	56	60	61	62	34	67	45	46	48	49	51
light commercial	3	3	3	3	3	3	3	3	3	3	4	4
logging	0	0	0	0	0	0	0	1	1	0	1	1
airport service	9	13	14	15	15	15	16	17	17	17	17	18
Aircraft	97	146	159	165	170	176	185	190	192	192	195	203
Marine Vessels	9	25	29	30	32	34	38	40	39	40	41	42
coal	0	0	1	1	1	1	1	1	1	1	1	1
diesel	8	23	26	28	29	31	35	37	36	37	38	38
residual oil	1	2	2	2	2	2	2	3	3	3	3	3
Railroads	22	33	36	37	38	39	41	42	42	42	43	43
MISCELLANEOUS	1,101	1,134	951	428	435	440	458	453	1,320	937	780	893
Other Combustion	1,101	1,134	951	428	434	440	458	452	1,319	936	779	892
structural fires	19	40	36	44	44	44	44	44	44	44	44	44
agricultural fires	131	70	68	55	61	67	85	79	77	68	78	79
slash/prescribed burning	147	285	285	167	167	167	167	167	167	167	167	167
forest wildfires	770	739	561	162	162	162	162	162	1,032	657	490	602
other	34	1	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
Health Services	NA	NA	NA	0	1	0	1	1	1	1	1	1
TOTAL ALL SOURCES	30,646	25,893	25,572	25,417	24,826	24,338	24,961	23,731	24,276	23,508	23,020	23,312

NOTE(S): Methodologies to estimate 1970 to 1984 and 1985 to 1993 emissions differ except for transportation sources. Because of these differences, the allocation of emissions among source categories could result in significant changes in the emissions between the years, particularly at the more detailed source category level. The break is illustrated by the black line. Details on the different methodologies are provided in section 6.0.

NA = not available. For several source categories, emissions either prior to or beginning with 1985 are not available at the more detailed level but are contained in the more aggregate estimate.

"Other" categories may contain emissions that could not be accurately allocated to specific source categories.

Zero values represent less than 500 short tons/year.

No data was available after 1984 to weigh the emissions from residential wood burning devices.

Table A-4. Sulfur Dioxide Emissions
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
FUEL COMB. ELEC. UTIL.	17,398	17,469	16,023	16,273	15,701	15,715	15,990	16,218	15,898	15,784	15,417	15,836
Coal	15,799	16,073	15,315	15,630	14,860	15,034	15,224	15,408	15,227	15,101	14,840	15,185
bituminous	9,574	NA	9,291	14,029	13,454	13,513	13,546	13,576	13,365	13,203	12,900	13,199
subbituminous	4,716	NA	4,577	1,292	1,048	1,182	1,311	1,423	1,425	1,381	1,456	1,509
anthracite & lignite	1,509	NA	1,446	309	357	338	368	409	438	517	484	477
Oil	1,598	1,395	707	612	811	651	734	779	639	652	546	620
residual	1,578	NA	692	604	799	640	722	765	629	642	537	614
distillate	20	NA	15	8	12	11	12	14	10	10	9	6
Gas	1	1	1	1	1	1	1	1	1	1	1	1
Internal Combustion	NA	NA	NA	30	30	29	31	30	31	30	31	31
FUEL COMB. INDUSTRIAL	4,568	2,951	2,723	3,169	3,116	3,068	3,111	3,086	3,106	3,139	2,947	2,830
Coal	3,129	1,527	1,805	1,818	1,828	1,817	1,856	1,840	1,843	1,821	1,681	1,575
bituminous	2,171	1,058	1,254	1,347	1,375	1,374	1,395	1,384	1,382	1,357	1,263	1,184
subbituminous	669	326	386	28	29	29	29	29	29	28	26	24
anthracite & lignite	289	144	165	90	82	73	79	79	81	80	73	68
other	NA	NA	NA	353	341	341	353	348	351	355	319	298
Oil	1,229	1,065	597	862	828	807	806	812	823	874	832	824
residual	956	851	464	671	637	617	614	625	633	684	645	641
distillate	98	85	69	111	109	106	108	107	108	109	111	110
other	175	129	64	80	82	84	84	80	82	81	76	73
Gas	140	299	264	397	370	356	360	346	352	357	348	346
Other	70	60	57	86	84	82	83	82	82	81	80	79
Internal Combustion	NA	NA	NA	7	6	6	6	6	6	6	6	6
FUEL COMB. OTHER	1,490	971	728	578	611	663	660	623	597	608	600	600
Commercial/Institutional Coal	109	110	195	158	161	164	172	169	176	180	173	171
Commercial/Institutional Oil	883	637	312	239	267	310	295	274	233	237	238	241
Commercial/Institutional Gas	1	1	1	2	2	2	2	2	2	2	2	2
Misc. Fuel Comb. (Except Residential)	NA	NA	NA	1	1	1	1	1	1	1	1	1
Residential Wood	6	13	14	11	11	10	10	10	9	9	8	7
Residential Other	492	211	206	167	169	175	180	167	175	179	177	178
distillate oil	212	157	131	128	129	134	137	132	137	139	144	145
bituminous/subbituminous coal	260	43	63	29	30	32	33	27	30	30	26	25
other	20	11	13	10	10	10	10	8	9	9	8	8

(continued)

Table A-4. Sulfur Dioxide Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
CHEMICAL & ALLIED PRODUCT MFG	591	280	229	456	432	425	449	440	440	442	447	450
Organic Chemical Mfg	NA	NA	NA	16	16	17	19	17	17	17	18	18
Inorganic Chemical Mfg	591	271	212	354	329	322	341	334	333	335	338	341
sulfur compounds	591	271	212	346	320	314	333	326	325	326	330	332
other	NA	NA	NA	8	8	8	8	8	9	8	9	9
Polymer & Resin Mfg	NA	NA	NA	7	7	6	7	7	7	7	7	7
Agricultural Chemical Mfg	NA	NA	NA	4	4	4	4	4	4	4	4	4
Pharmaceutical Mfg	NA	NA	NA	0	0	0	0	0	0	0	0	0
Other Chemical Mfg	NA	10	16	76	77	75	78	77	79	79	80	81
METALS PROCESSING	4,775	1,842	1,387	1,042	888	616	702	657	578	544	557	580
Nonferrous Metals Processing	4,060	1,279	1,004	853	710	447	523	475	401	375	383	401
copper	3,507	1,080	779	655	525	266	337	289	216	199	200	213
lead	77	34	40	121	112	111	113	113	112	106	111	114
aluminum	80	95	83	62	59	57	59	60	60	58	59	60
other	396	71	102	14	13	13	14	13	13	13	13	13
Ferrous Metals Processing	715	562	383	172	161	153	162	165	160	152	158	162
Metals Processing NEC	NA	NA	NA	18	17	15	16	17	17	17	17	17
PETROLEUM & RELATED INDUSTRIES	881	734	707	505	469	445	443	429	440	444	417	409
Oil & Gas Production	111	157	166	204	176	155	159	156	164	167	156	155
natural gas	111	157	166	202	175	154	157	155	163	165	154	154
other	NA	NA	NA	2	1	1	1	1	1	1	1	1
Petroleum Refineries & Related Industries	770	577	541	300	291	289	283	272	274	276	260	253
fluid catalytic cracking units	480	330	310	212	207	207	202	195	196	197	183	177
other	290	247	231	88	84	82	81	77	78	79	77	76
Asphalt Manufacturing	NA	NA	NA	1	1	1	1	1	1	1	1	1
OTHER INDUSTRIAL PROCESSES	846	918	923	425	427	418	411	405	401	391	401	413
Agriculture, Food, & Kindred Products	NA	NA	NA	3	3	3	3	3	3	3	3	3
Textiles, Leather, & Apparel Products	NA	NA	NA	0	0	0	0	0	0	0	0	0
Wood, Pulp & Paper, & Publishing Products	169	223	245	131	135	135	135	136	137	137	139	141
Rubber & Miscellaneous Plastic Products	NA	NA	NA	1	1	1	1	1	1	1	1	1
Mineral Products	677	694	678	286	285	276	268	261	257	247	255	265
cement mfg	618	630	621	192	190	183	177	172	169	163	169	176
other	59	64	57	95	95	93	91	89	87	84	86	89
Machinery Products	NA	NA	NA	0	0	0	0	0	0	0	0	0
Electronic Equipment	NA	NA	NA	0	0	0	0	0	0	0	0	0
Miscellaneous Industrial Processes	NA	NA	NA	3	3	3	3	3	3	2	3	3

(continued)

Table A-4. Sulfur Dioxide Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
SOLVENT UTILIZATION	NA	NA	NA	1	1	1	1	1	1	1	1	1
Degreasing	NA	NA	NA	0	0	0	0	0	0	0	0	0
Graphic Arts	NA	NA	NA	0	0	0	0	0	0	0	0	0
Surface Coating	NA	NA	NA	1	1	1	1	1	1	1	1	1
Other Industrial	NA	NA	NA	0	0	0	0	0	0	0	0	0
STORAGE & TRANSPORT	NA	NA	NA	4	4	4	5	5	5	5	5	5
Petroleum & Petroleum Product Storage	NA	NA	NA	0	0	0	0	0	0	0	0	0
Petroleum & Petroleum Product Transport	NA	NA	NA	1	1	1	1	1	1	1	1	1
Organic Chemical Storage	NA	NA	NA	1	1	1	1	1	1	1	1	1
Inorganic Chemical Storage	NA	NA	NA	0	0	0	0	0	0	0	0	0
Inorganic Chemical Transport	NA	NA	NA	0	0	0	0	0	0	0	0	0
Bulk Materials Storage	NA	NA	NA	1	2	2	2	2	2	2	2	2
WASTE DISPOSAL & RECYCLING	8	33	25	34	35	35	36	36	36	36	37	37
Incineration	4	21	14	25	26	26	28	28	29	29	29	29
industrial	NA	NA	NA	10	10	10	11	10	10	11	10	10
other	4	21	14	15	16	16	17	18	18	18	18	19
Open Burning	4	12	11	9	8	8	8	8	7	7	7	7
industrial	NA	NA	NA	0	0	0	0	0	0	0	0	0
other	4	12	11	8	8	8	8	7	7	7	7	7
Landfills	NA	NA	NA	0	0	0	0	0	0	0	0	0
industrial	NA	NA	NA	0	0	0	0	0	0	0	0	0
other	NA	NA	NA	0	0	0	0	0	0	0	0	0
Other	NA	NA	NA	0	0	0	0	0	0	0	0	0
HIGHWAY VEHICLES	345	429	445	446	449	457	468	480	480	478	483	438
Light-Duty Gas Vehicles & Motorcycles	132	155	148	146	145	145	147	148	148	146	150	151
light-duty gas vehicles	132	155	147	146	145	145	147	148	147	146	149	151
motorcycles	0	0	0	0	0	0	0	0	0	0	0	0
Light-Duty Gas Trucks	43	47	52	53	53	55	57	58	59	59	59	59
light-duty gas trucks 1	28	31	35	35	35	37	38	39	39	39	39	39
light-duty gas trucks 2	14	16	18	18	18	19	19	20	20	20	20	20
Heavy-Duty Gas Vehicles	7	9	9	9	9	10	10	10	10	10	10	10
Diesels	164	218	236	237	241	247	254	264	264	262	265	218
heavy-duty diesel vehicles	164	201	225	226	230	235	242	251	250	249	251	206
light-duty diesel trucks	NA	3	2	2	2	2	2	2	2	2	2	2
light-duty diesel vehicles	NA	14	9	9	10	10	11	11	11	11	12	10

(continued)

Table A-4. Sulfur Dioxide Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
OFF-HIGHWAY	83	175	198	208	221	233	253	267	265	266	273	278
Aircraft	4	6	6	6	6	7	7	7	7	7	7	8
Marine Vessels	43	117	135	143	154	164	181	193	190	191	197	201
Railroads	36	53	57	59	60	62	65	67	68	68	69	69
MISCELLANEOUS	110	11	9	7	7	7	7	7	14	11	10	11
Other Combustion	110	11	9	7	7	7	7	7	14	11	10	11
TOTAL ALL SOURCES	31,096	25,813	23,396	23,148	22,361	22,085	22,535	22,653	22,261	22,149	21,592	21,888

NOTE(S): Methodologies to estimate 1970 to 1984 and 1985 to 1993 emissions differ except for transportation sources. Because of these differences, the allocation of emissions among source categories could result in significant changes in the emissions between the years, particularly at the more detailed source category level. The break is illustrated by the black line. Details on the different methodologies are provided in section 6.0.

NA = not available. For several source categories, emissions either prior to or beginning with 1985 are not available at the more detailed level but are contained in the more aggregate estimate.

"Other" categories may contain emissions that could not be accurately allocated to specific source categories.

Zero values represent less than 500 short tons/year.

The 1985 fuel combustion, electric utility category is based on the *National Allowance Data Base Version 2.11*, Acid Rain Division, U.S. EPA, released March 23, 1993. Allocations at the Tier 3 levels are approximations only and are based on the methodology described in section 6.0, paragraph 6.2.1.1.

Table A-5. Particulate Matter (PM-10) Emissions
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
FUEL COMB. ELEC. UTIL.	1,775	879	633	284	289	282	278	278	291	253	255	270
Coal	1,680	796	602	272	274	268	263	262	278	239	243	257
bituminous	1,041	483	366	222	223	216	193	201	198	177	178	191
subbituminous	513	238	180	34	31	33	48	37	38	38	42	42
anthracite & lignite	126	75	57	16	19	20	22	23	41	24	23	23
other	NA	NA	NA	0	0	0	0	0	0	0	0	0
Oil	89	76	26	8	11	9	10	11	9	10	8	9
residual	85	74	26	8	11	9	10	11	9	10	8	9
distillate	3	2	1	0	0	0	0	0	0	0	0	0
Gas	7	7	5	1	1	1	1	1	1	1	1	1
Internal Combustion	NA	NA	NA	3	3	3	3	3	3	3	3	3
FUEL COMB. INDUSTRIAL	641	679	615	234	231	226	230	229	228	229	223	219
Coal	83	18	18	56	56	53	55	55	55	54	50	46
bituminous	52	12	13	34	34	34	34	35	34	34	31	29
subbituminous	16	4	4	1	1	1	1	1	1	1	1	1
anthracite & lignite	15	2	2	7	6	6	6	6	6	6	6	5
other	NA	NA	NA	15	15	13	14	14	13	14	12	11
Oil	89	67	34	52	50	48	48	48	48	50	49	48
residual	83	63	32	43	41	39	39	39	39	41	40	40
distillate	6	4	3	5	5	5	5	5	5	5	5	5
other	0	0	0	4	4	4	4	4	4	4	3	3
Gas	27	23	21	47	45	44	45	44	45	45	44	44
natural	24	20	18	24	23	23	24	24	24	24	24	24
process	4	3	3	22	21	21	20	20	20	20	20	19
other	NA	NA	NA	0	0	0	0	0	0	0	0	0
Other	441	571	542	75	77	77	79	78	77	76	77	77
wood/bark waste	415	566	538	67	69	70	71	71	70	69	70	70
liquid waste	NA	NA	NA	1	1	1	1	1	1	1	1	1
other	26	5	4	6	6	6	6	6	6	6	6	6
Internal Combustion	NA	NA	NA	4	4	3	3	3	3	3	3	3
FUEL COMB. OTHER	455	887	975	896	902	910	918	922	930	942	819	723
Commercial/Institutional Coal	13	8	7	10	10	10	10	10	10	10	10	10
Commercial/Institutional Oil	52	30	13	13	15	17	16	14	13	13	13	13
Commercial/Institutional Gas	4	4	2	4	4	4	5	5	5	5	5	5
Misc. Fuel Comb. (Except Residential)	NA	NA	NA	3	3	3	3	3	3	3	3	3

(continued)

Table A-5. Particulate Matter (PM-10) Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
FUEL COMB. OTHER (continued)												
Residential Wood	384	818	927	848	853	859	866	872	881	892	770	674
fireplaces	90	191	217	NA	NA	NA	NA	NA	NA	NA	NA	NA
woodstoves	294	626	710	NA	NA	NA	NA	NA	NA	NA	NA	NA
Residential Other	3	27	26	18	18	18	19	18	18	19	18	18
CHEMICAL & ALLIED PRODUCT MFG	235	148	143	67	68	68	73	74	74	72	75	75
Organic Chemical Mfg	43	19	19	31	32	33	36	36	36	35	37	37
Inorganic Chemical Mfg	61	25	13	6	6	6	7	7	7	6	7	7
Polymer & Resin Mfg	NA	NA	NA	4	4	4	4	4	4	4	4	4
Agricultural Chemical Mfg	46	61	67	9	9	9	9	9	9	9	10	10
Paint, Varnish, Lacquer, Enamel Mfg	NA	NA	NA	0	0	0	0	0	0	0	0	1
Pharmaceutical Mfg	NA	NA	NA	0	0	0	0	0	0	0	0	0
Other Chemical Mfg	86	42	44	17	16	16	17	17	17	17	17	17
METALS PROCESSING	1,316	622	419	147	137	131	141	142	140	136	137	141
Nonferrous Metals Processing	593	130	99	50	48	45	49	49	48	47	47	48
copper	343	32	28	4	4	3	4	4	4	4	4	4
lead	53	18	13	4	3	3	3	3	3	3	3	3
zinc	20	3	2	2	2	2	2	2	2	2	2	2
other	177	77	56	40	38	37	39	39	39	38	38	39
Ferrous Metals Processing	198	322	195	92	84	81	87	89	88	84	86	88
primary	31	271	161	70	63	60	65	67	67	64	65	67
secondary	167	51	34	22	21	21	22	22	21	20	20	21
other	NA	NA	NA	0	0	0	0	0	0	0	0	0
Metals Processing NEC	525	170	125	5	5	4	5	5	4	4	4	5
PETROLEUM & RELATED INDUSTRIES	286	138	124	32	31	30	29	28	28	28	27	26
Oil & Gas Production	NA	NA	NA	0	0	0	0	0	0	0	0	0
Petroleum Refineries & Related Industries	69	41	21	28	26	26	25	24	24	25	23	22
fluid catalytic cracking units	69	41	21	24	23	23	22	21	21	21	20	19
other	NA	NA	NA	4	4	3	3	3	3	3	3	3
Asphalt Manufacturing	217	97	102	4	4	4	4	4	4	4	4	4
OTHER INDUSTRIAL PROCESSES	5,832	1,846	1,633	317	321	314	314	308	306	300	303	311
Agriculture, Food, & Kindred Products	485	402	442	23	23	24	24	24	24	24	25	25
country elevators	257	258	275	1	1	1	1	1	1	1	1	1
terminal elevators	147	86	104	0	0	0	0	0	0	0	0	0
feed mills	5	3	3	2	2	2	2	2	2	2	2	2
soybean mills	25	22	28	7	7	7	7	7	7	7	8	8

(continued)

Table A-5. Particulate Matter (PM-10) Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
OTHER INDUSTRIAL PROCESSES (continued)												
Agriculture, Food, & Kindred Products (continued)												
wheat mills	5	1	1	0	0	0	0	0	0	0	0	0
other grain mills	9	6	4	5	5	5	6	6	6	6	6	6
other	38	26	27	8	8	8	8	8	8	8	8	8
Textiles, Leather, & Apparel Products	NA	NA	NA	0	0	0	0	0	0	0	0	0
Wood, Pulp & Paper, & Publishing Products	727	183	168	93	96	97	99	98	98	97	99	101
sulfate (kraft) pulping	668	142	125	73	75	75	76	76	76	76	77	78
other	59	41	43	20	21	22	23	22	21	21	22	22
Rubber & Miscellaneous Plastic Products	NA	NA	NA	4	4	4	4	4	4	4	4	4
Mineral Products	4,620	1,261	1,023	170	171	164	162	158	156	151	152	157
cement mfg	1,731	417	303	40	40	38	37	36	35	34	35	36
surface mining	134	127	142	22	20	18	17	16	17	16	16	17
stone quarrying/processing	957	421	396	26	27	27	28	27	27	26	25	26
other	1,798	296	182	83	84	81	80	79	77	75	76	79
Machinery Products	NA	NA	NA	4	4	4	4	4	4	4	4	4
Electronic Equipment	NA	NA	NA	1	1	1	0	0	0	0	0	0
Transportation Equipment	NA	NA	NA	0	0	0	0	0	0	0	0	0
Miscellaneous Industrial Processes	NA	NA	NA	23	22	20	20	19	19	18	19	19
SOLVENT UTILIZATION	NA	NA	NA	2	2	2	2	2	2	2	2	2
Degreasing	NA	NA	NA	0	0	0	0	0	0	0	0	0
Graphic Arts	NA	NA	NA	0	0	0	0	0	0	0	0	0
Dry Cleaning	NA	NA	NA	0	0	0	0	0	0	0	0	0
Surface Coating	NA	NA	NA	2	2	2	2	2	2	1	2	2
Other Industrial	NA	NA	NA	0	0	0	0	0	0	0	0	0
STORAGE & TRANSPORT	NA	NA	NA	57	56	54	54	54	54	53	53	55
Bulk Terminals & Plants	NA	NA	NA	0	0	0	0	0	0	0	0	0
Petroleum & Petroleum Product Storage	NA	NA	NA	0	0	0	0	0	0	0	0	0
Petroleum & Petroleum Product Transport	NA	NA	NA	0	0	0	0	0	0	0	0	0
Organic Chemical Storage	NA	NA	NA	1	1	1	1	1	1	1	1	1
Organic Chemical Transport	NA	NA	NA	0	0	0	0	0	0	0	0	0
Inorganic Chemical Storage	NA	NA	NA	0	0	0	0	0	0	0	0	0
Bulk Materials Storage	NA	NA	NA	56	54	53	53	52	53	51	52	53
storage	NA	NA	NA	20	21	20	20	20	19	19	19	19
transfer	NA	NA	NA	35	33	32	32	32	33	32	33	33
combined	NA	NA	NA	1	1	1	1	1	1	1	1	1
Bulk Materials Transport	NA	NA	NA	0	0	0	0	0	0	0	0	0

(continued)

Table A-5. Particulate Matter (PM-10) Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
WASTE DISPOSAL & RECYCLING	999	273	226	279	275	265	259	251	242	245	246	248
Incineration	229	75	49	52	52	51	51	50	49	50	50	51
residential	51	42	40	39	38	37	36	35	34	34	34	35
other	178	32	9	13	14	14	15	15	16	16	16	16
Open Burning	770	198	177	226	222	214	208	200	192	194	196	197
residential	770	198	177	222	218	209	203	195	188	190	191	193
other	NA	NA	NA	4	4	4	5	5	5	4	5	5
Industrial Waste Water	NA	NA	NA	0	0	0	0	0	0	0	0	0
Landfills	NA	NA	NA	0	0	0	0	0	0	0	0	0
Other	NA	NA	NA	0	0	0	0	0	0	0	0	0
HIGHWAY VEHICLES	237	275	277	271	265	261	256	253	239	223	210	197
Light-Duty Gas Vehicles & Motorcycles	63	47	35	35	35	35	35	35	34	33	33	32
light-duty gas vehicles	62	47	35	35	35	35	35	35	34	33	33	32
motorcycles	0	0	0	0	0	0	0	0	0	0	0	0
Light-Duty Gas Trucks	16	13	12	12	12	12	12	12	12	11	11	10
light-duty gas trucks 1	11	8	7	7	7	8	8	8	7	7	7	7
light-duty gas trucks 2	5	5	4	4	4	5	4	4	4	4	4	4
Heavy-Duty Gas Vehicles	2	2	3	3	3	3	3	4	4	4	4	4
Diesels	156	213	227	221	216	211	206	202	189	175	162	150
heavy-duty diesel vehicles	156	204	219	213	207	202	197	193	180	165	153	141
light-duty diesel trucks	NA	1	1	1	1	1	1	1	1	1	2	2
light-duty diesel vehicles	NA	8	7	7	7	7	7	8	8	8	8	8
OFF-HIGHWAY	223	329	357	368	372	350	387	372	372	367	379	395
Non-Road Gasoline	35	41	42	43	43	43	44	44	45	45	46	46
recreational	3	3	3	3	3	3	3	3	3	3	3	3
construction	0	0	0	0	0	0	0	0	0	0	0	0
industrial	0	0	0	0	0	0	0	0	0	0	0	0
lawn & garden	10	11	12	12	12	12	13	13	13	13	13	13
farm	0	0	0	0	0	0	0	0	0	0	0	0
light commercial	1	1	1	1	1	1	1	1	1	1	1	1
logging	0	0	0	0	0	0	0	0	0	0	0	0
airport service	0	0	0	0	0	0	0	0	0	0	0	0
other	21	24	25	25	25	26	26	26	26	26	27	27

(continued)

Table A-5. Particulate Matter (PM-10) Emissions (continued)
(thousand short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Non-Road Diesel	135	202	220	227	227	200	231	212	211	205	214	227
recreational	0	0	0	0	0	0	0	0	0	0	0	0
construction	85	123	137	141	139	135	135	134	133	127	133	142
industrial	11	14	15	16	16	17	17	18	18	17	18	18
lawn & garden	1	1	1	1	1	1	1	1	1	1	1	1
farm	29	49	52	53	54	30	60	40	40	42	43	45
light commercial	2	2	2	2	3	3	3	3	3	3	3	3
logging	0	1	1	1	1	1	1	1	1	1	1	1
airport service	8	12	13	13	14	14	15	15	15	15	16	16
Aircraft	21	33	36	37	38	40	42	43	44	44	44	46
Marine Vessels	6	17	19	20	21	23	25	27	26	26	27	28
coal	1	2	2	2	2	3	3	3	3	3	3	3
diesel	4	10	11	12	13	13	15	16	16	16	16	16
residual oil	2	5	6	6	6	7	7	8	8	8	8	8
Railroads	25	37	40	41	42	43	45	47	47	47	48	48
NATURAL SOURCES	NA	NA	NA	3,565	9,390	1,457	17,509	11,826	4,192	10,054	4,655	628
Geogenic	NA	NA	NA	3,565	9,390	1,457	17,509	11,826	4,192	10,054	4,655	628
wind erosion	NA	NA	NA	3,565	9,390	1,457	17,509	11,826	4,192	10,054	4,655	628
MISCELLANEOUS	839	852	724	41,859	41,281	41,411	43,221	42,247	42,059	40,126	41,245	42,200
Agriculture & Forestry	NA	NA	NA	7,108	7,184	7,338	7,466	7,334	7,380	7,328	7,238	7,236
agricultural crops	NA	NA	NA	6,833	6,899	7,008	7,090	6,937	6,999	6,965	6,852	6,842
agricultural livestock	NA	NA	NA	275	285	330	376	397	381	363	386	394
Other Combustion	839	852	724	724	730	737	756	750	1,322	1,053	947	1,027
wildfires	385	514	390	142	142	142	142	142	717	457	341	418
managed burning	390	315	314	523	530	536	555	549	546	537	547	549
other	64	23	20	59	59	59	59	59	59	59	59	59
Fugitive Dust	NA	NA	NA	34,028	33,367	33,336	34,999	34,163	33,356	31,746	33,060	33,937
wind erosion	NA	NA	NA	0	0	0	0	0	0	0	0	0
unpaved roads	NA	NA	NA	14,719	14,672	13,960	15,626	15,346	15,661	14,267	14,540	14,404
paved roads	NA	NA	NA	6,299	6,555	6,877	7,365	7,155	7,299	7,437	7,621	8,164
other	NA	NA	NA	13,009	12,139	12,499	12,008	11,662	10,396	10,042	10,899	11,368
TOTAL ALL SOURCES	12,838	6,928	6,126	48,377	53,620	45,761	63,672	56,984	49,158	53,029	48,629	45,489

NOTE(S): Methodologies to estimate 1970 to 1984 and 1985 to 1993 emissions differ except for transportation sources. Because of these differences, the allocation of emissions among source categories could result in significant changes in the emissions between the years, particularly at the more detailed source category level. The break is illustrated by the black line. Details on the different methodologies are provided in section 6.0.

NA = not available. For several source categories, emissions either prior to or beginning with 1985 are not available at the more detailed level but are contained in the more aggregate estimate.

"Other" categories may contain emissions that could not be accurately allocated to specific source categories.

Zero values represent less than 500 short tons/year.

No data was available after 1984 to weigh the emissions from residential wood burning devices.

See section 6.2.4.1 for explanation of wide variation in Geogenic - wind erosion emissions.

Table A-6. Lead Emissions
(short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
FUEL COMB. ELEC. UTIL.	327	129	88	64	69	64	66	67	64	61	59	62
Coal	300	95	71	51	50	48	46	46	46	46	47	48
bituminous	181	57	43	31	30	29	28	28	28	28	28	29
subbituminous	89	28	21	15	15	14	14	14	14	14	14	14
anthracite & lignite	30	9	7	5	5	5	4	4	4	4	4	5
Oil	28	34	17	13	19	16	20	21	18	15	12	14
residual	27	34	17	13	19	16	20	21	18	15	12	14
distillate	0	0	0	0	0	0	0	0	0	0	0	0
FUEL COMB. INDUSTRIAL	237	60	29	30	25	22	19	18	18	18	18	18
Coal	218	45	21	22	17	14	14	14	14	15	14	14
bituminous	146	31	14	15	12	10	10	10	10	10	10	10
subbituminous	45	10	4	5	4	3	3	3	3	3	3	3
anthracite & lignite	27	4	2	2	2	1	1	1	1	1	1	1
Oil	19	14	8	8	8	8	5	4	3	3	4	4
residual	17	14	8	7	7	7	5	3	3	2	3	3
distillate	1	1	1	1	1	1	1	1	1	1	1	1
FUEL COMB. OTHER	10,052	4,111	424	421	422	425	426	420	418	416	414	417
Commercial/Institutional Coal	1	12	7	6	6	5	5	4	4	3	4	3
bituminous	1	6	5	4	4	3	3	3	3	2	2	2
subbituminous	NA	2	1	1	1	1	1	1	1	1	1	1
anthracite, lignite	NA	4	1	1	1	1	1	1	0	0	0	0
Commercial/Institutional Oil	4	10	4	4	5	5	5	4	4	4	4	4
residual	3	9	3	3	4	4	4	3	3	3	3	3
distillate	NA	1	1	1	1	1	1	1	1	1	1	1
other	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Misc. Fuel Comb. (Except Residential)	10,000	4,080	400	400	400	400	400	400	400	400	400	400
Residential Other	47	9	13	11	11	14	16	12	10	9	7	9
CHEMICAL & ALLIED PRODUCT MFG	103	104	133	118	108	123	136	136	136	132	93	109
Inorganic Chemical Mfg	103	104	133	118	108	123	136	136	136	132	93	109
lead oxide and pigments	103	104	133	118	108	123	136	136	136	132	93	109

(continued)

Table A-6. Lead Emissions (continued)
(short tons)

Source Category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
METALS PROCESSING	24,224	3,026	1,919	2,097	1,820	1,818	1,917	2,153	2,138	1,939	2,042	2,118
Nonferrous Metals Processing	15,869	1,826	1,244	1,376	1,161	1,204	1,248	1,337	1,409	1,258	1,316	1,362
primary lead production	12,134	1,075	709	874	660	673	684	715	728	623	628	636
primary copper production	242	20	20	19	16	16	17	19	19	19	20	21
primary zinc production	1,019	24	17	16	11	7	8	9	9	11	11	12
secondary lead production	1,894	481	304	288	296	347	353	433	449	414	470	496
secondary copper production	374	116	79	70	63	31	61	37	75	65	66	71
lead battery manufacture	41	50	67	65	66	73	73	74	78	77	77	80
lead cable coating	127	37	34	43	47	56	50	50	50	48	44	45
other	38	24	15	3	2	1	1	1	1	1	1	1
Ferrous Metals Processing	7,395	911	530	577	553	499	554	582	576	517	560	572
coke manufacturing	11	6	4	3	3	3	4	4	4	3	3	3
ferroalloy production	219	13	3	7	13	14	14	20	18	14	16	17
iron production	266	38	23	21	16	17	18	19	18	16	18	18
steel production	3,125	481	219	209	200	128	157	138	138	145	145	147
gray iron production	3,773	373	282	336	320	337	361	401	397	339	378	387
Metals Processing NEC	960	289	144	144	107	115	115	234	153	163	166	184
metal mining	353	207	129	141	106	114	114	234	153	163	165	183
other	606	82	15	3	1	1	1	1	1	1	1	1
OTHER INDUSTRIAL PROCESSES	2,028	808	483	316	199	202	172	173	169	167	54	54
Mineral Products	540	93	48	43	25	28	23	23	26	24	24	24
cement manufacturing	540	93	48	43	25	28	23	23	26	24	24	24
Miscellaneous Industrial Processes	1,488	715	435	273	174	174	149	150	143	143	30	30
WASTE DISPOSAL & RECYCLING	2,200	1,210	901	871	844	844	817	765	804	582	416	518
Incineration	2,200	1,210	901	871	844	844	817	765	804	582	416	518
municipal waste	581	161	74	79	52	52	49	45	67	55	11	45
other	1,619	1,049	828	792	792	792	768	720	738	528	405	472
HIGHWAY VEHICLES	171,961	62,189	35,930	15,978	3,589	3,121	2,700	2,161	1,690	1,519	1,452	1,383
Light-Duty Gas Vehicles & Motorcycles	142,918	48,501	27,737	12,070	2,689	2,325	2,018	1,614	1,263	1,134	1,084	1,033
Light-Duty Gas Trucks	22,683	11,996	7,448	3,595	841	748	637	512	400	364	348	331
Heavy-Duty Gas Vehicles	6,361	1,692	745	313	59	48	44	36	28	20	20	19
OFF-HIGHWAY	8,340	3,320	2,310	229	219	222	211	207	197	186	193	206
Non-Road Gasoline	8,340	3,320	2,310	229	219	222	211	207	197	186	193	206
TOTAL ALL SOURCES	219,471	74,956	42,217	20,124	7,296	6,840	6,464	6,099	5,635	5,020	4,741	4,885

NOTE(S): NA = not available.

APPENDIX B

REGIONAL EMISSIONS (1985 TO 1993)

Table B-1. Regional Emissions of Carbon Monoxide, 1985 to 1993

(million short tons)

Region	1985	1986	1987	1988	1989	1990	1991	1992	1993
I	5.13	4.87	4.77	4.67	4.51	4.24	4.19	4.14	4.05
II	7.84	7.60	7.43	7.40	6.88	6.48	6.41	6.19	5.80
III	10.96	10.68	10.45	10.28	9.57	9.16	9.09	8.94	8.81
IV	22.37	21.95	21.53	22.16	20.89	20.87	20.69	20.48	20.72
V	20.97	20.13	19.31	19.64	18.77	17.77	17.60	17.38	17.62
VI	15.72	14.99	14.45	14.60	13.67	13.77	13.13	13.11	13.67
VII	5.53	5.29	5.07	5.12	4.95	5.23	5.40	4.70	5.19
VIII	5.22	4.74	4.50	4.41	4.15	4.25	4.81	3.72	4.12
IX	12.23	11.92	11.90	11.97	11.67	12.02	11.38	10.06	10.25
X	6.10	5.90	5.71	5.84	5.75	9.97	7.20	7.65	6.98
Total	112.07	108.07	105.12	106.10	100.81	103.75	99.90	96.37	97.21

Table B-2. Regional Emissions of Nitrogen Oxides, 1985 to 1993

(million short tons)

Region	1985	1986	1987	1988	1989	1990	1991	1992	1993
I	0.72	0.72	0.73	0.74	0.74	0.70	0.69	0.68	0.66
II	1.21	1.19	1.20	1.23	1.24	1.19	1.16	1.14	1.11
III	2.33	2.31	2.31	2.36	2.38	2.28	2.23	2.23	2.26
IV	4.32	4.35	4.34	4.50	4.49	4.50	4.51	4.57	4.73
V	4.57	4.54	4.52	4.65	4.69	4.65	4.63	4.60	4.75
VI	4.50	4.32	4.21	4.37	4.36	4.36	4.36	4.37	4.48
VII	1.42	1.38	1.40	1.46	1.48	1.49	1.48	1.45	1.48
VIII	1.11	1.05	1.09	1.18	1.17	1.20	1.22	1.23	1.23
IX	2.03	1.93	1.97	2.08	2.05	2.04	2.00	1.98	1.98
X	0.64	0.62	0.63	0.65	0.66	0.78	0.71	0.75	0.73
Total	22.85	22.41	22.39	23.22	23.25	23.19	22.98	22.99	23.40

Table B-3. Regional Emissions of Volatile Organic Compounds, 1985 to 1993

(million short tons)

Region	1985	1986	1987	1988	1989	1990	1991	1992	1993
I	1.02	0.97	0.97	0.97	0.92	0.88	0.87	0.85	0.86
II	1.85	1.79	1.78	1.79	1.67	1.61	1.57	1.55	1.55
III	2.77	2.71	2.70	2.71	2.55	2.52	2.46	2.44	2.45
IV	5.20	5.18	5.10	5.29	5.00	5.04	4.94	4.80	4.87
V	4.58	4.39	4.35	4.43	4.23	4.13	4.06	4.03	4.10
VI	4.80	4.66	4.49	4.67	4.42	4.47	4.41	4.38	4.46
VII	1.21	1.18	1.15	1.18	1.13	1.17	1.18	1.09	1.15
VIII	0.75	0.70	0.69	0.68	0.65	0.68	0.76	0.62	0.68
IX	2.39	2.40	2.29	2.39	2.33	2.36	2.23	2.16	2.19
X	0.85	0.84	0.83	0.85	0.83	1.41	1.04	1.11	1.02
Total	25.42	24.83	24.34	24.96	23.73	24.28	23.51	23.02	23.31

Table B-4. Regional Emissions of Sulfur Dioxide, 1985 to 1993

(million short tons)

Region	1985	1986	1987	1988	1989	1990	1991	1992	1993
I	0.58	0.61	0.58	0.63	0.62	0.56	0.54	0.51	0.47
II	0.87	0.83	0.84	0.85	0.88	0.86	0.81	0.76	0.70
III	3.39	3.31	3.37	3.45	3.45	3.36	3.45	3.45	3.44
IV	5.32	5.37	5.37	5.49	5.52	5.57	5.55	5.58	5.96
V	7.26	7.08	6.93	7.01	7.04	6.93	6.86	6.44	6.49
VI	2.27	2.11	2.10	2.13	2.18	2.16	2.17	2.19	2.21
VII	1.66	1.52	1.59	1.54	1.54	1.45	1.39	1.29	1.26
VIII	0.59	0.50	0.49	0.54	0.55	0.57	0.61	0.57	0.56
IX	0.96	0.82	0.58	0.67	0.64	0.55	0.53	0.53	0.54
X	0.26	0.21	0.23	0.23	0.24	0.25	0.25	0.27	0.26
Total	23.15	22.36	22.09	22.54	22.65	22.26	22.15	21.59	21.89

Table B-5a. Regional Emissions of Particulate Matter (PM-10) from Point and Fugitive Process Sources, 1985 to 1993

(million short tons)

Region	1985	1986	1987	1988	1989	1990	1991	1992	1993
I	0.12	0.12	0.12	0.13	0.12	0.12	0.12	0.11	0.11
II	0.18	0.18	0.18	0.18	0.18	0.17	0.17	0.16	0.15
III	0.36	0.36	0.35	0.36	0.36	0.35	0.35	0.32	0.31
IV	0.89	0.91	0.91	0.92	0.92	0.94	0.92	0.88	0.90
V	0.61	0.60	0.59	0.60	0.60	0.61	0.59	0.55	0.53
VI	0.50	0.49	0.48	0.49	0.47	0.54	0.48	0.50	0.52
VII	0.23	0.20	0.19	0.20	0.19	0.23	0.25	0.19	0.21
VIII	0.16	0.15	0.14	0.15	0.15	0.17	0.23	0.13	0.16
IX	0.35	0.33	0.32	0.33	0.33	0.36	0.31	0.32	0.34
X	0.27	0.33	0.33	0.34	0.34	0.73	0.47	0.52	0.45
Total	3.67	3.68	3.63	3.70	3.66	4.23	3.90	3.68	3.69

Table B-5b. Regional Emissions of Particulate Matter (PM-10) from Fugitive Dust Sources, 1985 to 1993

(million short tons)

Region	1985	1986	1987	1988	1989	1990	1991	1992	1993
I	1.50	1.41	1.42	1.43	1.26	1.20	1.18	1.21	1.16
II	2.45	2.22	2.22	1.93	1.90	1.78	1.76	1.71	1.78
III	2.44	2.33	2.47	2.42	2.31	2.35	2.44	2.52	2.39
IV	6.34	6.26	6.61	6.99	6.83	6.10	6.75	6.72	7.30
V	7.80	7.41	7.43	7.34	6.78	6.89	6.63	6.37	6.44
VI	9.00	15.53	8.56	22.30	19.01	12.72	12.29	10.68	8.81
VII	4.98	5.11	4.24	7.32	6.25	5.37	8.17	6.02	4.59
VIII	3.53	3.08	3.19	4.22	3.35	3.15	3.34	3.90	3.57
IX	4.46	4.48	3.83	4.01	3.60	3.20	3.61	3.14	3.12
X	2.19	2.11	2.15	2.02	2.03	2.17	2.96	2.69	2.65
Total	44.70	49.94	42.13	59.97	53.32	44.93	49.13	44.95	41.80

Table B-5c. Regional Emissions of Particulate Matter (PM-10) from All Sources, 1985 to 1993

(million short tons)

Region	1985	1986	1987	1988	1989	1990	1991	1992	1993
I	1.62	1.53	1.54	1.55	1.38	1.32	1.30	1.32	1.27
II	2.63	2.40	2.40	2.11	2.07	1.96	1.93	1.86	1.94
III	2.80	2.69	2.83	2.78	2.67	2.71	2.79	2.84	2.70
IV	7.24	7.17	7.52	7.91	7.75	7.04	7.67	7.60	8.21
V	8.41	8.01	8.02	7.94	7.38	7.50	7.22	6.92	6.96
VI	9.49	16.02	9.05	22.79	19.48	13.26	12.78	11.17	9.32
VII	5.21	5.31	4.43	7.52	6.44	5.61	8.42	6.21	4.81
VIII	3.69	3.23	3.33	4.37	3.50	3.32	3.57	4.02	3.73
IX	4.81	4.81	4.15	4.34	3.93	3.55	3.92	3.46	3.46
X	2.46	2.44	2.48	2.36	2.37	2.90	3.44	3.21	3.10
Total	48.38	53.62	45.76	63.67	56.99	49.16	53.03	48.63	45.49

Table B-6. Regional Emissions of Lead, 1985 to 1993

(thousand short tons)

Region	1985	1986	1987	1988	1989	1990	1991	1992	1993
I	0.93	0.30	0.28	0.24	0.22	0.19	0.17	0.16	0.16
II	1.54	0.54	0.50	0.44	0.38	0.35	0.26	0.19	0.21
III	1.83	0.59	0.52	0.47	0.41	0.37	0.32	0.28	0.29
IV	3.57	1.16	1.11	1.07	1.00	0.93	0.86	0.82	0.84
V	3.98	1.68	1.55	1.53	1.45	1.40	1.25	1.21	1.26
VI	2.58	0.87	0.81	0.74	0.68	0.64	0.60	0.58	0.59
VII	1.88	1.00	0.99	0.98	1.08	0.99	0.86	0.84	0.86
VIII	0.74	0.27	0.26	0.24	0.23	0.21	0.19	0.19	0.19
IX	2.39	0.68	0.64	0.57	0.50	0.42	0.40	0.36	0.36
X	0.68	0.21	0.19	0.17	0.15	0.13	0.13	0.12	0.12
Total	20.12	7.30	6.84	6.46	6.10	5.63	5.02	4.74	4.88

APPENDIX C

NATIONAL TOTAL PARTICULATE EMISSIONS (1940 TO 1993) BY SUBCATEGORY

Table C-1. Total Particulate (TSP) Emissions

(thousand short tons)

	1940	1950	1960	1970	1980	1985	1990	1991	1992
FUEL COMB. ELEC. UTIL.	1,431	2,179	3,122	2,603	919	479	456	445	454
Coal	1,419	2,142	3,089	2,475	797	432	394	394	407
bituminous	822	1,240	1,847	1,492	483	262	239	239	247
subbituminous	405	611	910	735	238	129	118	118	122
anthracite and lignite	192	291	333	247	75	41	37	37	39
Oil	11	36	30	121	116	42	56	47	42
residual	11	34	29	117	113	40	54	45	41
distillate	0	2	1	4	3	1	2	2	2
Gas	0	1	3	7	7	6	5	5	5
FUEL COMB. INDUSTRIAL	3,870	3,334	1,960	2,436	1,503	1,355	1,071	1,058	1,030
Coal	3,598	2,934	1,659	1,444	272	132	92	98	99
bituminous	2,227	1,756	1,103	982	188	92	64	68	69
subbituminous	686	541	340	303	58	28	20	21	21
anthracite and lignite	685	638	217	159	26	12	8	9	9
Oil	44	82	76	106	80	43	22	20	15
residual	33	62	56	83	63	35	14	13	8
distillate	0	2	2	9	6	5	5	5	5
other	11	17	18	14	11	4	3	3	3
Gas	6	15	25	27	23	20	26	26	27
natural	5	13	22	24	20	17	22	21	22
process	1	2	3	4	4	3	5	5	5
Other	222	302	200	859	1,129	1,159	930	914	889
wood/bark waste	171	252	187	818	1,121	1,156	926	911	885
other	51	50	13	40	7	3	4	3	4
FUEL COMB. OTHER	2,678	2,062	1,247	509	937	900	538	523	493
Commercial/Institutional Coal	415	480	58	47	36	21	14	13	13
Commercial/Institutional Oil	25	45	63	71	44	19	20	20	19
Commercial/Institutional Gas	0	1	2	4	4	4	4	4	4
Residential Wood	1,716	1,128	850	384	818	821	469	457	429
fireplaces	402	264	199	90	191	192	110	107	100
woodstoves	1,315	864	651	294	626	629	359	350	328
Residential Other	522	408	275	4	36	35	30	29	29

(continued)

Table C-1. Total Particulate (TSP) Emissions (cont'd)

(thousand short tons)

	1940	1950	1960	1970	1980	1985	1990	1991	1992
CHEMICAL & ALLIED PRODUCT MFG	330	456	310	238	150	129	121	118	127
Organic Chemical Mfg	6	9	18	45	21	23	22	22	23
Inorganic Chemical Mfg	68	31	45	62	25	13	12	12	12
Agricultural Chemical Mfg	19	15	16	46	61	48	41	42	43
Other Chemical Mfg	237	401	230	86	42	45	45	43	48
METALS PROCESSING	4,478	4,853	3,170	2,781	782	496	486	461	487
Nonferrous Metals Processing	620	385	443	731	151	112	99	100	105
copper	238	120	146	428	38	34	33	32	33
lead	168	82	46	57	19	13	16	14	15
zinc	188	89	52	24	3	4	4	4	4
other	26	94	199	222	91	61	47	50	52
Ferrous Metals Processing	3,446	4,189	2,247	1,473	430	242	248	217	237
primary	3,287	3,858	2,083	1,304	379	201	198	173	188
secondary	159	331	164	169	51	41	50	43	49
Metals Processing NEC	411	279	481	577	201	142	138	144	146
PETROLEUM & RELATED INDUSTRIES	389	547	1,219	687	166	144	152	147	148
Petroleum Refineries & Related Industries	2	23	50	70	41	16	13	13	13
fluid catalytic cracking units	2	23	50	70	41	16	13	13	13
Asphalt Manufacturing	387	524	1,169	617	125	128	139	133	134
OTHER INDUSTRIAL PROCESSES	4,366	8,152	9,042	7,949	2,542	2,196	1,994	1,878	1,919
Agriculture, Food, & Kindred Products	882	898	1,036	872	629	834	639	574	563
country elevators	371	417	512	426	388	465	404	344	342
terminal elevators	351	313	346	310	152	252	142	121	120
feed mills	24	26	27	20	10	27	18	16	12
soybean mills	48	60	53	30	22	27	16	29	25
wheat mills	12	11	9	10	2	3	1	2	2
other grain mills	17	19	20	20	11	10	6	7	9
other	58	53	69	56	43	52	52	56	53
Wood, Pulp & Paper, & Publishing Products	550	866	1,031	788	229	220	202	202	208
sulfate (kraft) pulping	470	729	886	668	142	124	90	92	95
other	80	137	145	120	87	96	112	110	114

(continued)

Table C-1. Total Particulate (TSP) Emissions (cont'd)

(thousand short tons)

	1940	1950	1960	1970	1980	1985	1990	1991	1992
OTHER INDUSTRIAL PROCESSES (cont'd)									
Mineral Products	2,934	6,388	6,975	6,289	1,684	1,142	1,153	1,103	1,148
cement mfg	1,363	1,998	2,014	1,731	417	287	226	212	217
surface mining	175	307	403	388	385	392	444	428	442
stone quarrying/processing	482	764	1,411	1,582	500	206	275	255	276
other	914	3,319	3,147	2,587	382	256	207	209	213
WASTE DISPOSAL & RECYCLING	550	659	962	1,210	365	318	304	288	334
Incineration	330	327	417	440	167	141	127	111	125
residential	98	86	115	134	112	105	101	101	101
other	232	241	302	306	55	35	26	10	24
Open Burning	220	333	544	770	198	177	178	177	209
other	220	333	544	770	198	177	178	177	209
HIGHWAY VEHICLES	220	329	582	1,004	1,161	1,233	1,412	1,451	1,451
Light-Duty Gas Vehicles & Motorcycles	169	232	442	681	637	594	698	726	726
ldgv	169	232	441	677	629	591	694	722	722
motorcycles	0	0	1	4	7	4	4	4	4
Light-Duty Gas Trucks	23	36	56	111	171	189	234	238	238
ldgt1	18	28	45	91	96	112	148	163	163
ldgt2	5	8	11	20	75	76	86	75	75
Heavy-Duty Gas Vehicles	29	51	68	71	61	51	52	43	43
Diesels	0	9	15	141	291	400	427	444	444
hddv	0	9	15	141	279	375	410	427	427
lddt	0	0	0	0	3	4	4	3	3
lddv	0	0	0	0	9	21	13	14	14
OFF-HIGHWAY	2,762	2,014	245	317	281	286	285	274	278
Non-Road Gasoline	2	16	19	17	14	13	11	10	11
recreational	0	0	0	2	3	3	2	2	2
construction	0	5	5	1	1	1	1	1	1
industrial	0	3	2	3	2	1	2	2	2
farm	0	7	10	9	5	5	3	3	4
other	0	1	2	2	2	3	3	2	3

(continued)

Table C-1. Total Particulate (TSP) Emissions (cont'd)

(thousand short tons)

	1940	1950	1960	1970	1980	1985	1990	1991	1992
OFF-HIGHWAY (cont'd)									
Non-Road Diesel	1	16	22	71	94	107	112	110	112
construction	0	12	12	14	19	20	23	22	23
industrial	0	0	3	19	18	14	16	16	14
farm	0	4	7	38	57	73	73	72	75
Aircraft	0	0	40	110	82	96	86	80	81
Marine Vessels	107	1,982	45	49	32	30	35	36	37
coal	94	87	28	32	0	0	0	0	0
diesel	6	7	7	7	11	17	20	20	21
residual oil	7	13	10	9	22	13	15	16	16
Railroads	2,651	1,874	119	70	60	40	41	38	37
MISCELLANEOUS	4,081	2,791	1,903	1,210	1,186	1,114	1,312	1,087	1,116
Other Combustion	4,081	2,791	1,903	1,210	1,186	1,114	1,312	1,087	1,116
wildfires	2,774	1,353	544	490	654	597	807	581	613
managed burning	881	987	903	581	472	471	471	471	471
other	426	451	456	139	59	47	34	35	32
TOTAL ALL SOURCES	25,157	27,375	23,761	20,944	9,992	8,651	8,131	7,730	7,836

NOTE(S): NA = not available

Zero values represent less than 500 short tons/year.

APPENDIX D

NATIONAL EMISSIONS (1940 TO 1993) FROM THE REPORT IN METRIC UNITS

Table D-1. Total National Emissions of Carbon Monoxide, 1940 through 1993 in Metric Units
(thousand short tons)

Source Category	1940	1950	1960	1970	1980	1990	1992	1993
FUEL COMB. ELEC. UTIL.	**3**	**100**	**100**	**215**	**292**	**285**	**284**	**292**
FUEL COMB. INDUSTRIAL	**395**	**498**	**600**	**699**	**680**	**614**	**608**	**605**
FUEL COMB. OTHER	**13,508**	**9,667**	**5,670**	**3,288**	**5,652**	**5,195**	**4,566**	**4,031**
Residential Wood	10,232	7,000	4,303	2,660	5,436	4,930	4,309	3,775
fireplaces	2,394	1,638	1,007	622	1,272	NA	NA	NA
woodstoves	7,838	5,362	3,296	2,038	4,164	NA	NA	NA
Residential Other	3,176	2,570	1,367	572	162	143	136	135
CHEMICAL & ALLIED PRODUCT MFG	**3,801**	**5,301**	**3,612**	**3,082**	**1,951**	**1,760**	**1,781**	**1,812**
METALS PROCESSING	**2,495**	**2,640**	**2,600**	**3,306**	**2,037**	**1,887**	**1,854**	**1,897**
PETROLEUM & RELATED INDUSTRIES	**201**	**2,405**	**2,800**	**1,977**	**1,563**	**395**	**372**	**361**
OTHER INDUSTRIAL PROCESSES	**104**	**210**	**310**	**562**	**753**	**650**	**652**	**664**
SOLVENT UTILIZATION	**NA**	**NA**	**NA**	**NA**	**NA**	**2**	**2**	**2**
STORAGE & TRANSPORT	**NA**	**NA**	**NA**	**NA**	**NA**	**50**	**50**	**51**
WASTE DISPOSAL & RECYCLING	**3,293**	**4,279**	**5,078**	**6,404**	**2,086**	**1,530**	**1,557**	**1,571**
HIGHWAY VEHICLES	**24,830**	**37,533**	**52,887**	**79,864**	**70,806**	**57,025**	**54,304**	**54,422**
Light-Duty Gas Vehicles & Motorcycles	18,017	25,537	38,650	58,089	48,591	36,744	35,716	35,791
light-duty gas vehicles	18,007	25,491	38,598	57,922	48,392	36,574	35,554	35,621
Light-Duty Gas Trucks	2,355	3,836	4,889	15,032	14,640	13,684	13,215	13,498
light-duty gas trucks 1	1,807	2,949	3,751	9,165	9,430	7,721	7,403	7,517
light-duty gas trucks 2	547	887	1,139	5,867	5,209	5,963	5,812	5,981
Heavy-Duty Gas Vehicles	4,458	8,133	9,233	6,089	6,521	5,379	4,145	3,893
Diesels	NA	26	114	654	1,054	1,218	1,227	1,239
heavy-duty diesel vehicles	NA	26	114	654	1,033	1,186	1,193	1,204
OFF-HIGHWAY	**7,304**	**10,533**	**10,501**	**9,621**	**11,504**	**13,283**	**13,521**	**13,855**
Non-Road Gasoline	3,426	6,650	7,941	8,598	9,983	11,481	11,690	11,943
industrial	708	1,414	1,251	664	880	1,114	1,120	1,166
lawn & garden	NA	NA	NA	4,245	4,868	5,444	5,575	5,637
light commercial	NA	NA	NA	2,211	2,431	2,952	2,990	3,086
recreational marine vessels	54	109	470	885	999	1,095	1,119	1,129
Aircraft	4	847	1,600	459	674	876	889	925
Railroads	3,704	2,790	301	59	87	111	112	112
MISCELLANEOUS	**26,499**	**16,452**	**9,988**	**7,175**	**7,570**	**11,451**	**7,873**	**8,624**
Other Combustion	0	0	0	0	0	0	0	0
forest wildfires	22,798	10,123	4,071	5,098	4,895	6,830	3,246	3,984
TOTAL	**82,433**	**89,618**	**94,146**	**116,193**	**104,895**	**94,125**	**87,425**	**88,187**

NOTE(S): Categories displayed below Tier 1 do not sum to Tier 1 totals because they are intended to show major contributors.
NA = not available
Change in methodology indicated by vertical lines. Transportation methodologies changed in 1970. All other methodologies changed in 1985.
1990 to 1993 emission estimates are preliminary and will be updated in the next report.
Tier 1 source categories and emissions are in bold type face.

Table D-2. Total National Emissions of Nitrogen Oxides, 1940 through 1993 in Metric Units
(thousand short tons)

Source Category	1940	1950	1960	1970	1980	1990	1992	1993
FUEL COMB. ELEC. UTIL.	**599**	**1,194**	**2,301**	**4,445**	**6,372**	**6,819**	**6,779**	**7,060**
Coal	424	1,014	1,849	3,528	5,555	6,076	6,073	6,355
bituminous	231	530	1,047	1,916	3,120	4,173	4,140	4,316
subbituminous	113	261	516	944	1,537	1,535	1,549	1,661
anthracite & lignite	53	112	185	312	492	369	383	378
FUEL COMB. INDUSTRIAL	**2,307**	**2,896**	**3,697**	**3,923**	**3,225**	**2,954**	**2,908**	**2,881**
Coal	1,825	976	709	699	403	556	505	472
bituminous	1,180	624	483	482	278	403	366	342
Gas	332	1,593	2,680	2,776	2,376	1,503	1,504	1,510
natural	306	1,535	2,581	2,769	2,240	1,302	1,310	1,318
FUEL COMB. OTHER	**480**	**587**	**690**	**759**	**672**	**664**	**667**	**664**
CHEMICAL & ALLIED PRODUCT MFG	**5**	**57**	**100**	**246**	**196**	**362**	**373**	**376**
METALS PROCESSING	**4**	**100**	**100**	**70**	**59**	**74**	**73**	**74**
PETROLEUM & RELATED INDUSTRIES	**95**	**100**	**200**	**218**	**66**	**91**	**87**	**86**
OTHER INDUSTRIAL PROCESSES	**97**	**84**	**119**	**169**	**186**	**278**	**276**	**285**
SOLVENT UTILIZATION	**NA**	**NA**	**NA**	**NA**	**NA**	**2**	**2**	**2**
STORAGE & TRANSPORT	**NA**	**NA**	**NA**	**NA**	**NA**	**2**	**2**	**2**
WASTE DISPOSAL & RECYCLING	**99**	**195**	**300**	**399**	**101**	**75**	**76**	**76**
HIGHWAY VEHICLES	**1,382**	**2,225**	**4,012**	**6,705**	**7,821**	**6,793**	**6,750**	**6,747**
Light-Duty Gas Vehicles & Motorcycles	1,002	1,462	2,692	3,772	4,011	3,118	3,278	3,343
light-duty gas vehicles	1,002	1,461	2,691	3,770	4,006	3,107	3,268	3,332
Light-Duty Gas Trucks	149	246	382	1,159	1,277	1,216	1,230	1,258
Heavy-Duty Gas Vehicles	231	442	542	252	272	304	280	276
Diesels	NA	76	397	1,521	2,262	2,155	1,962	1,870
heavy-duty diesel vehicles	NA	76	397	1,521	2,235	2,115	1,920	1,827
OFF-HIGHWAY	**899**	**1,396**	**1,309**	**1,477**	**2,198**	**2,579**	**2,617**	**2,708**
Non-Road Diesel	94	170	224	853	1,247	1,341	1,356	1,435
construction	64	143	142	543	775	857	853	913
Railroads	596	900	700	449	663	843	858	857
MISCELLANEOUS	**898**	**603**	**400**	**299**	**225**	**348**	**247**	**268**
TOTAL	**6,865**	**9,438**	**13,228**	**18,711**	**21,120**	**21,040**	**20,857**	**21,230**

NOTE(S): Categories displayed below Tier 1 do not sum to Tier 1 totals because they are intended to show major contributors.
NA = not available
Change in methodology indicated by vertical lines. Transportation methodologies changed in 1970. All other methodologies changed in 1985.
1990 to 1993 emission estimates are preliminary and will be updated in the next report.
Tier 1 source categories and emissions are in bold type face.

Table D-3. Total National Emissions of Volatile Organic Compounds, 1940 through 1993 in Metric Units
(thousand short tons)

Source Category	1940	1950	1960	1970	1980	1990	1992	1993
FUEL COMB. ELEC. UTIL.	**2**	**8**	**8**	**27**	**40**	**32**	**31**	**33**
FUEL COMB. INDUSTRIAL	**98**	**88**	**96**	**136**	**142**	**241**	**246**	**246**
FUEL COMB. OTHER	**1,694**	**1,212**	**697**	**491**	**769**	**396**	**349**	**309**
Residential Wood	1,279	880	511	417	734	368	321	282
fireplaces	308	210	119	97	172	NA	NA	NA
woodstoves	971	670	391	320	562	NA	NA	NA
CHEMICAL & ALLIED PRODUCT MFG	**802**	**1,201**	**899**	**1,217**	**1,447**	**1,607**	**1,632**	**1,643**
Organic Chemical Mfg	53	100	223	571	802	620	628	629
METALS PROCESSING	**295**	**401**	**310**	**357**	**247**	**66**	**65**	**67**
PETROLEUM & RELATED INDUSTRIES	**518**	**498**	**938**	**1,084**	**1,306**	**669**	**661**	**653**
OTHER INDUSTRIAL PROCESSES	**118**	**167**	**184**	**245**	**215**	**433**	**437**	**441**
SOLVENT UTILIZATION	**1,788**	**3,338**	**3,995**	**6,508**	**5,973**	**5,500**	**5,553**	**5,669**
Surface Coating	960	1,984	1,931	3,239	3,343	2,376	2,380	2,438
Nonindustrial	444	NA	1,079	1,519	909	1,724	1,772	1,798
consumer solvents	NA	NA	NA	NA	NA	983	1,003	1,013
STORAGE & TRANSPORT	**579**	**1,105**	**1,598**	**1,772**	**1,792**	**1,688**	**1,677**	**1,688**
Bulk Terminals & Plants	168	328	479	543	469	597	568	557
area source: gasoline	143	279	408	462	399	508	478	464
WASTE DISPOSAL & RECYCLING	**898**	**1,001**	**1,402**	**1,799**	**688**	**2,052**	**2,057**	**2,060**
HIGHWAY VEHICLES	**4,331**	**6,506**	**9,407**	**11,768**	**8,146**	**6,218**	**5,508**	**5,529**
Light-Duty Gas Vehicles & Motorcycles	3,374	4,836	7,461	8,340	5,359	3,888	3,477	3,497
light-duty gas vehicles	3,371	4,820	7,443	8,286	5,301	3,841	3,447	3,466
Light-Duty Gas Trucks	460	754	982	2,513	1,868	1,605	1,440	1,462
Heavy-Duty Gas Vehicles	497	906	923	674	554	426	303	285
Diesels	NA	10	42	241	365	300	288	285
heavy-duty diesel vehicles	NA	10	42	241	356	286	274	270
OFF-HIGHWAY	**706**	**1,100**	**1,102**	**1,399**	**1,695**	**1,923**	**1,960**	**2,002**
Non-Road Gasoline	188	384	477	1,165	1,337	1,493	1,522	1,546
lawn & garden	NA	NA	NA	521	594	661	676	684
MISCELLANEOUS	**3,700**	**2,296**	**1,427**	**999**	**1,029**	**1,198**	**707**	**810**
Other Combustion	0	0	0	0	0	0	0	0
forest wildfires	3,103	1,370	697	699	671	936	445	546
TOTAL	**15,530**	**18,921**	**22,065**	**27,802**	**23,490**	**22,023**	**20,884**	**21,149**

NOTE(S): Categories displayed below Tier 1 do not sum to Tier 1 totals because they are intended to show major contributors.
NA = not available
Change in methodology indicated by vertical lines. Transportation methodologies changed in 1970. All other methodologies changed in 1985.
1990 to 1993 emission estimates are preliminary and will be updated in the next report.
Tier 1 source categories and emissions are in bold type face.

Table D-4. Total National Emissions of SULFUR DIOXIDE, 1940 through 1993 in Metric Units
(gigagrams)

Source Category	1940	1950	1960	1970	1980	1990	1992	1993
FUEL COMB. ELEC. UTIL.	**2,202**	**4,096**	**8,404**	**15,783**	**15,848**	**14,422**	**13,986**	**14,367**
Coal	2,065	3,679	8,058	14,333	14,581	13,814	13,463	13,776
bituminous	1,233	2,202	4,869	8,686	NA	12,124	11,703	11,975
subbituminous	606	1,085	2,397	4,278	NA	1,293	1,321	1,369
anthracite & lignite	226	392	792	1,369	NA	397	439	432
Oil	137	417	345	1,450	1,266	580	495	562
residual	132	411	341	1,432	NA	571	487	557
FUEL COMB. INDUSTRIAL	**5,498**	**5,194**	**3,505**	**4,144**	**2,677**	**2,818**	**2,673**	**2,567**
Coal	4,706	4,012	2,452	2,838	1,385	1,672	1,525	1,429
bituminous	3,151	2,672	1,685	1,970	960	1,254	1,145	1,075
subbituminous	971	823	520	607	296	26	24	22
Oil	503	882	836	1,115	966	747	755	747
residual	360	654	601	868	772	574	585	581
Gas	132	164	171	127	271	319	316	314
Other	157	136	46	64	54	75	73	72
Internal Combustion	NA	NA	NA	NA	NA	5	6	6
FUEL COMB. OTHER	**3,304**	**3,596**	**2,104**	**1,352**	**881**	**542**	**544**	**544**
Residential Other	2,283	1,886	1,134	446	191	159	161	161
bituminous/subbituminous coal	2,057	1,595	788	236	39	27	23	23
CHEMICAL & ALLIED PRODUCT MFG	**195**	**388**	**406**	**536**	**254**	**399**	**405**	**409**
METALS PROCESSING	**3,002**	**3,399**	**3,616**	**4,332**	**1,671**	**525**	**506**	**526**
Nonferrous Metals Processing	2,504	2,805	3,013	3,683	1,161	364	347	364
copper	2,079	2,149	2,515	3,182	980	196	181	193
PETROLEUM & RELATED INDUSTRIES	**203**	**309**	**614**	**799**	**666**	**399**	**378**	**371**
OTHER INDUSTRIAL PROCESSES	**303**	**541**	**609**	**768**	**832**	**364**	**363**	**375**
SOLVENT UTILIZATION	**NA**	**NA**	**NA**	**NA**	**NA**	**1**	**1**	**1**
STORAGE & TRANSPORT	**NA**	**NA**	**NA**	**NA**	**NA**	**4**	**4**	**4**
WASTE DISPOSAL & RECYCLING	**3**	**3**	**9**	**7**	**30**	**33**	**33**	**33**
HIGHWAY VEHICLES	**3**	**94**	**103**	**313**	**389**	**436**	**438**	**397**
OFF-HIGHWAY	**2,894**	**2,170**	**291**	**75**	**159**	**241**	**248**	**252**
Railroads	2,699	1,972	195	33	48	61	63	62
MISCELLANEOUS	**494**	**494**	**503**	**100**	**10**	**13**	**9**	**10**
TOTAL	**18,101**	**20,283**	**20,164**	**28,210**	**23,418**	**20,195**	**19,589**	**19,857**

NOTE(S): Categories displayed below Tier 1 do not sum to Tier 1 totals because they are intended to show major contributors.
NA = not available
Change in methodology indicated by vertical lines. Transportation methodologies changed in 1970. All other methodologies changed in 1985.
1990 to 1993 emission estimates are preliminary and will be updated in the next report.
Tier 1 source categories and emissions are in bold type face.

Table D-5. Total National Emissions of Particulate Matter (PM-10), 1940 through 1993 in Metric Units
(gigagram)

Source Category	1940	1950	1960	1970	1980	1990	1992	1993
FUEL COMB. ELEC. UTIL.	**873**	**1,331**	**1,920**	**1,611**	**797**	**264**	**231**	**245**
Coal	865	1,306	1,898	1,524	722	252	221	233
bituminous	520	785	1,169	944	438	180	161	173
FUEL COMB. INDUSTRIAL	**642**	**548**	**300**	**581**	**616**	**207**	**202**	**199**
FUEL COMB. OTHER	**2,121**	**1,518**	**1,010**	**413**	**805**	**843**	**743**	**656**
Residential Wood	1,557	1,023	771	348	742	799	698	612
CHEMICAL & ALLIED PRODUCT MFG	**299**	**413**	**280**	**213**	**134**	**67**	**68**	**68**
METALS PROCESSING	**1,096**	**932**	**931**	**1,194**	**564**	**127**	**125**	**128**
Nonferrous Metals Processing	533	314	340	538	118	44	43	44
copper	196	95	111	312	29	3	3	3
Ferrous Metals Processing	223	388	194	180	292	79	78	80
Metals Processing NEC	339	230	397	476	154	4	4	4
PETROLEUM & RELATED INDUSTRIES	**332**	**374**	**625**	**259**	**125**	**25**	**24**	**24**
OTHER INDUSTRIAL PROCESSES	**3,625**	**6,308**	**6,542**	**5,290**	**1,674**	**277**	**275**	**282**
Agriculture, Food, & Kindred Products	711	632	627	440	364	22	23	23
Wood, Pulp & Paper, & Publishing	463	724	869	659	166	89	89	91
Mineral Products	2,451	4,953	5,046	4,191	1,144	142	138	143
cement mfg	1,236	1,812	1,827	1,571	378	32	32	33
surface mining	57	98	127	121	115	15	15	15
stone quarrying/processing	437	602	943	868	382	25	23	24
SOLVENT UTILIZATION	**NA**	**NA**	**0.**	**NA**	**NA**	**2**	**2**	**2**
STORAGE & TRANSPORT	**NA**	**NA**	**0.**	**NA**	**NA**	**49**	**48**	**50**
WASTE DISPOSAL & RECYCLING	**356**	**458**	**693**	**906**	**248**	**219**	**223**	**225**
HIGHWAY VEHICLES	**190**	**284**	**502**	**215**	**250**	**216**	**190**	**178**
OFF-HIGHWAY	**2,250**	**1,622**	**182**	**202**	**298**	**338**	**344**	**358**
NATURAL SOURCES	**NA**	**NA**	**0.**	**NA**	**NA**	**3,803**	**4,223**	**570**
* Geogenic - wind erosion	NA	NA	0.	NA	NA	0	0	0
MISCELLANEOUS	**2,692**	**1,754**	**1,129**	**761**	**773**	**38,156**	**37,417**	**38,283**
Agriculture & Forestry	NA	NA	0.	NA	NA	6,696	6,566	6,565
* agricultural crops	NA	NA	0.	NA	NA	6,350	6,216	6,207
* agricultural livestock	NA	NA	0.	NA	NA	346	350	358
Other Combustion	2,692	1,754	1,129	761	773	1,200	859	931
wildfires	1,977	965	388	349	466	651	309	380
managed burning	536	601	550	354	286	496	497	498
Fugitive Dust	NA	NA	0.	NA	NA	30,261	29,992	30,788
* unpaved roads	NA	NA	0.	NA	NA	14,208	13,191	13,068
* paved roads	NA	NA	0.	NA	NA	6,622	6,913	7,407
* other	NA	NA	0.	NA	NA	9,431	9,888	10,313
TOTAL	**14,475**	**15,543**	**14,114**	**11,646**	**6,285**	**44,596**	**44,116**	**41,268**

NOTE(S): Categories displayed below Tier 1 do not sum to Tier 1 totals because they are intended to show major contributors.
NA = not available
Change in methodology indicated by vertical lines. Transportation methodologies changed in 1970. All other methodologies changed in 1985.
1990 to 1993 emission estimates are preliminary and will be updated in the next report.
Tier 1 source categories and emissions are in bold type face.
* Fugitive dust sources

Table D-6. Total National Emissions of Lead 1970 through 1993 in Metric Units
(megagrams)

Source Category	1970	1975	1980	1985	1990	1992	1993
FUEL COMB. ELEC. UTIL.	**297**	**208**	**117**	**58**	**58**	**53**	**56**
FUEL COMB. INDUSTRIAL	**215**	**68**	**54**	**27**	**16**	**16**	**17**
FUEL COMB. OTHER	**9,119**	**9,110**	**3,729**	**382**	**379**	**376**	**378**
Misc. Fuel Comb. (Except Residential)	9,072	9,072	3,701	363	363	363	363
Residential Other	42	15	8	10	9	6	8
CHEMICAL & ALLIED PRODUCT MFG	**93**	**109**	**95**	**107**	**123**	**85**	**99**
Inorganic Chemical Mfg - lead oxide and pigments							
METALS PROCESSING	**21,976**	**9,002**	**2,745**	**1,902**	**1,940**	**1,852**	**1,921**
Nonferrous Metals Processing	14,397	6,525	1,656	1,248	1,279	1,194	1,236
primary lead production	11,008	5,117	975	792	661	569	577
primary copper production	219	155	18	17	18	18	19
primary zinc production	925	203	22	14	8	10	11
secondary lead production	1,719	745	436	261	407	426	450
secondary copper production	339	182	105	64	68	60	65
lead battery manufacture	38	44	45	59	71	70	72
lead cable coating	115	50	34	39	46	40	41
Ferrous Metals Processing	6,708	1,992	826	523	522	508	519
ferroalloy production	199	94	12	6	17	15	15
iron production	241	84	34	19	17	16	16
steel production	2,835	982	436	190	125	131	134
gray iron production	3,423	825	338	305	361	343	351
OTHER INDUSTRIAL PROCESSES	**1,840**	**1,213**	**733**	**287**	**153**	**49**	**49**
Mineral Products	490	197	84	39	23	22	21
cement manufacturing							
Miscellaneous Industrial Processes	1,350	1,016	649	248	130	28	27
WASTE DISPOSAL & RECYCLING	**1,996**	**1,447**	**1,098**	**790**	**730**	**377**	**470**
Incineration							
municipal waste	527	359	146	72	61	10	41
other	1,469	1,088	952	718	669	368	429
HIGHWAY VEHICLES	**156,003**	**118,123**	**56,418**	**14,495**	**1,534**	**1,317**	**1,255**
Light-Duty Gas Vehicles & Motorcycles	129,655	96,951	44,000	10,950	1,145	984	937
OFF-HIGHWAY	**7,566**	**4,547**	**3,012**	**208**	**179**	**175**	**186**
Non-Road Gasoline							
TOTAL	**199,104**	**143,829**	**68,000**	**18,257**	**5,112**	**4,301**	**4,431**

NOTE(S): *Categories displayed below Tier 1 do not sum to Tier 1 totals because they are intended to show major contributors.*
1993 emission estimates are preliminary and will be updated in the next report.
Tier 1 source categories and emissions are in bold type face.

APPENDIX E

DENSITY MAPS OF 1993 COUNTY-LEVEL EMISSIONS BY POLLUTANT

Figure E-1. Density Map of 1993 County-level CARBON MONOXIDE Emissions

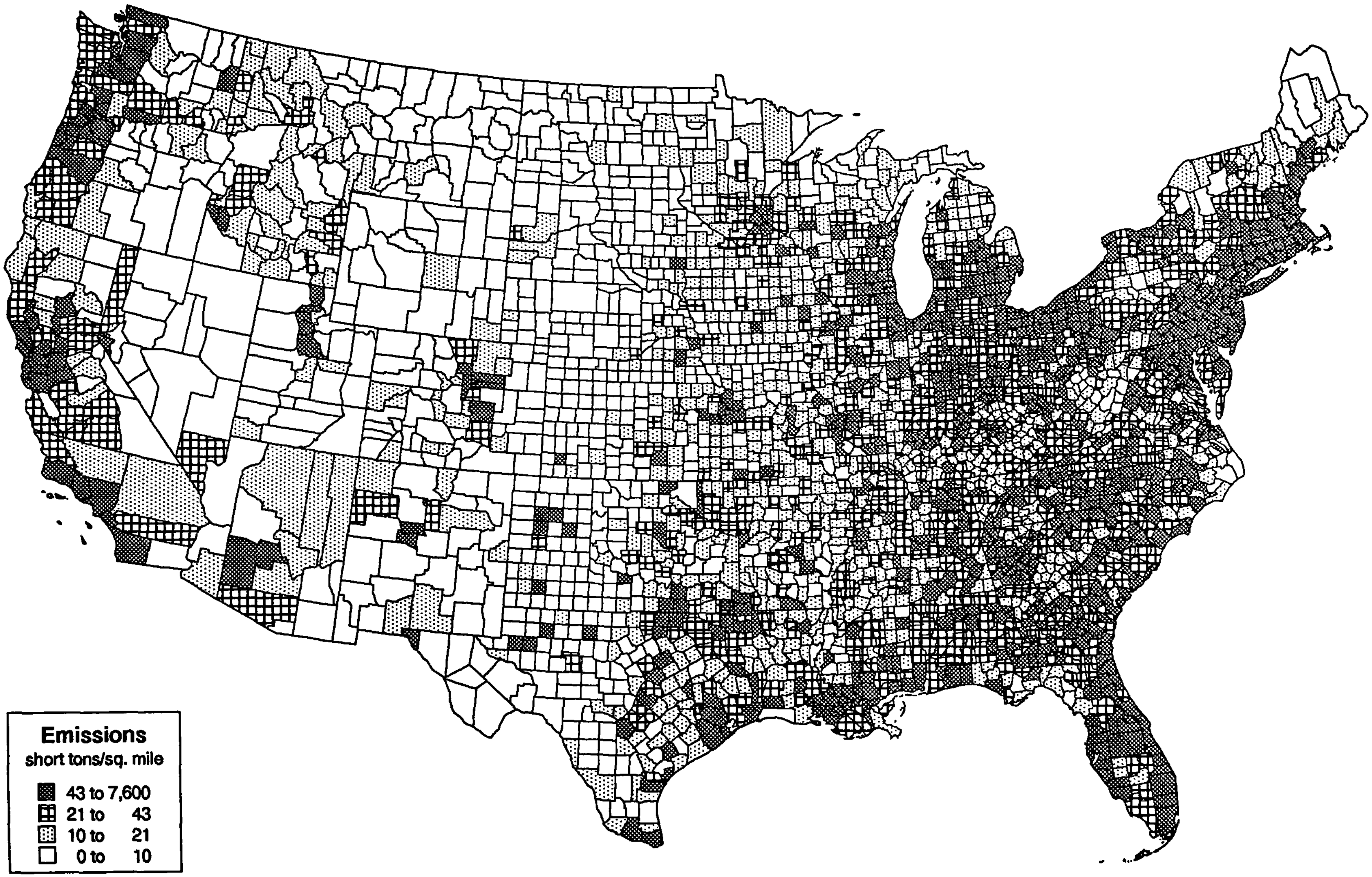


Figure E-2. Density Map of 1993 County-level NITROGEN OXIDES Emissions

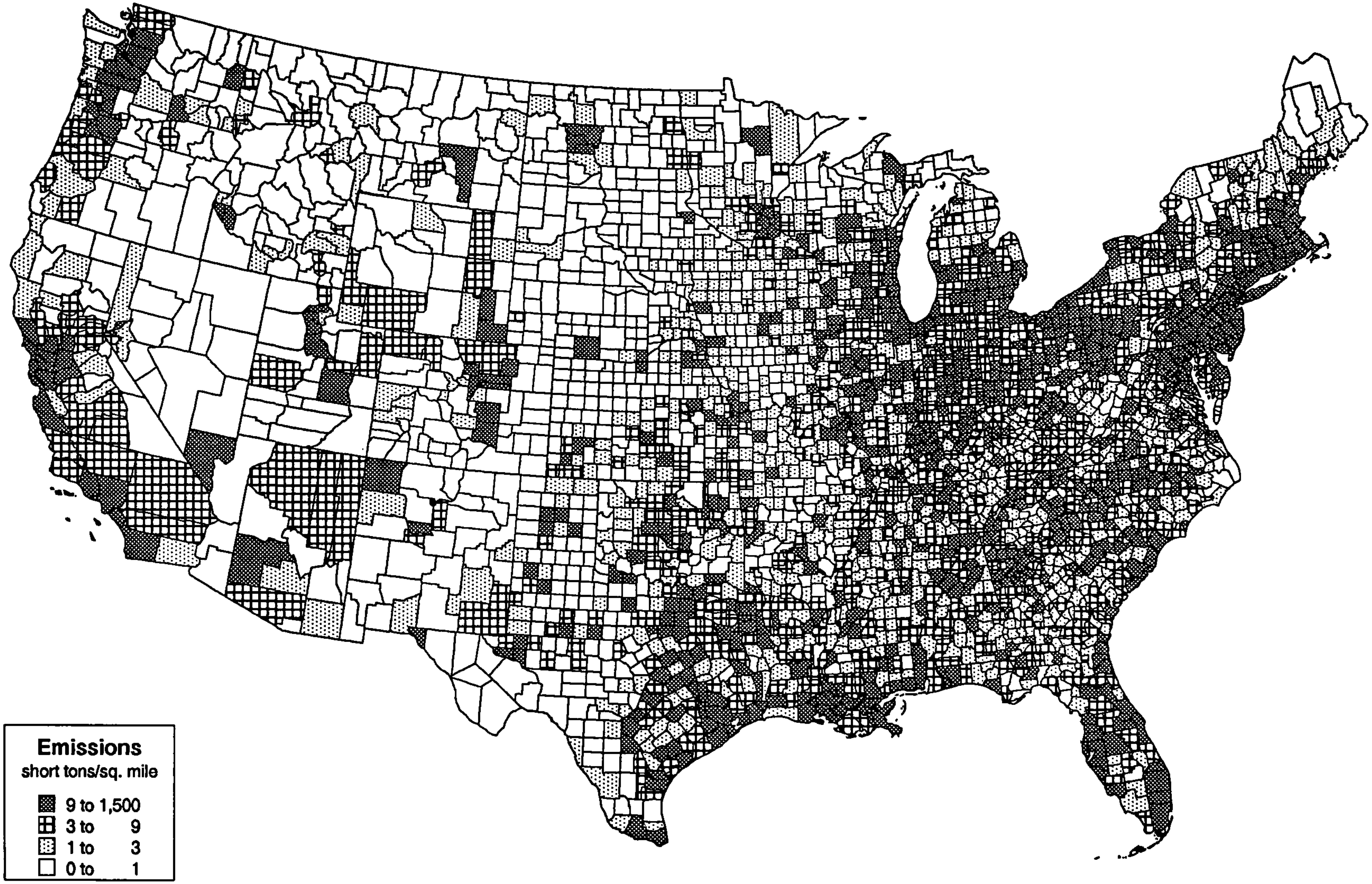


Figure E-3. Density Map of 1993 County-level VOLATILE ORGANIC COMPOUND Emissions

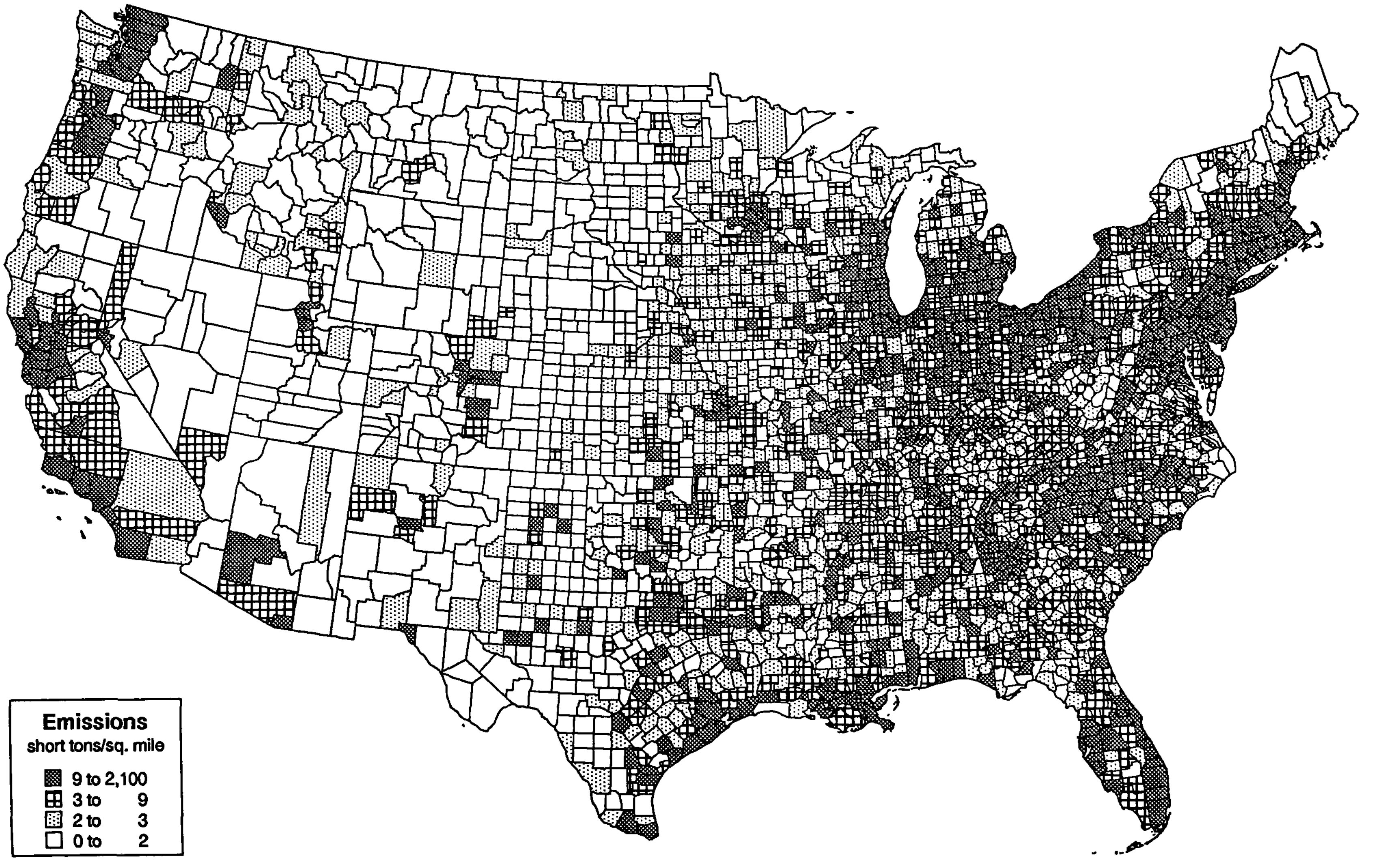


Figure E-4. Density Map of 1993 County-level SULFUR DIOXIDE Emissions

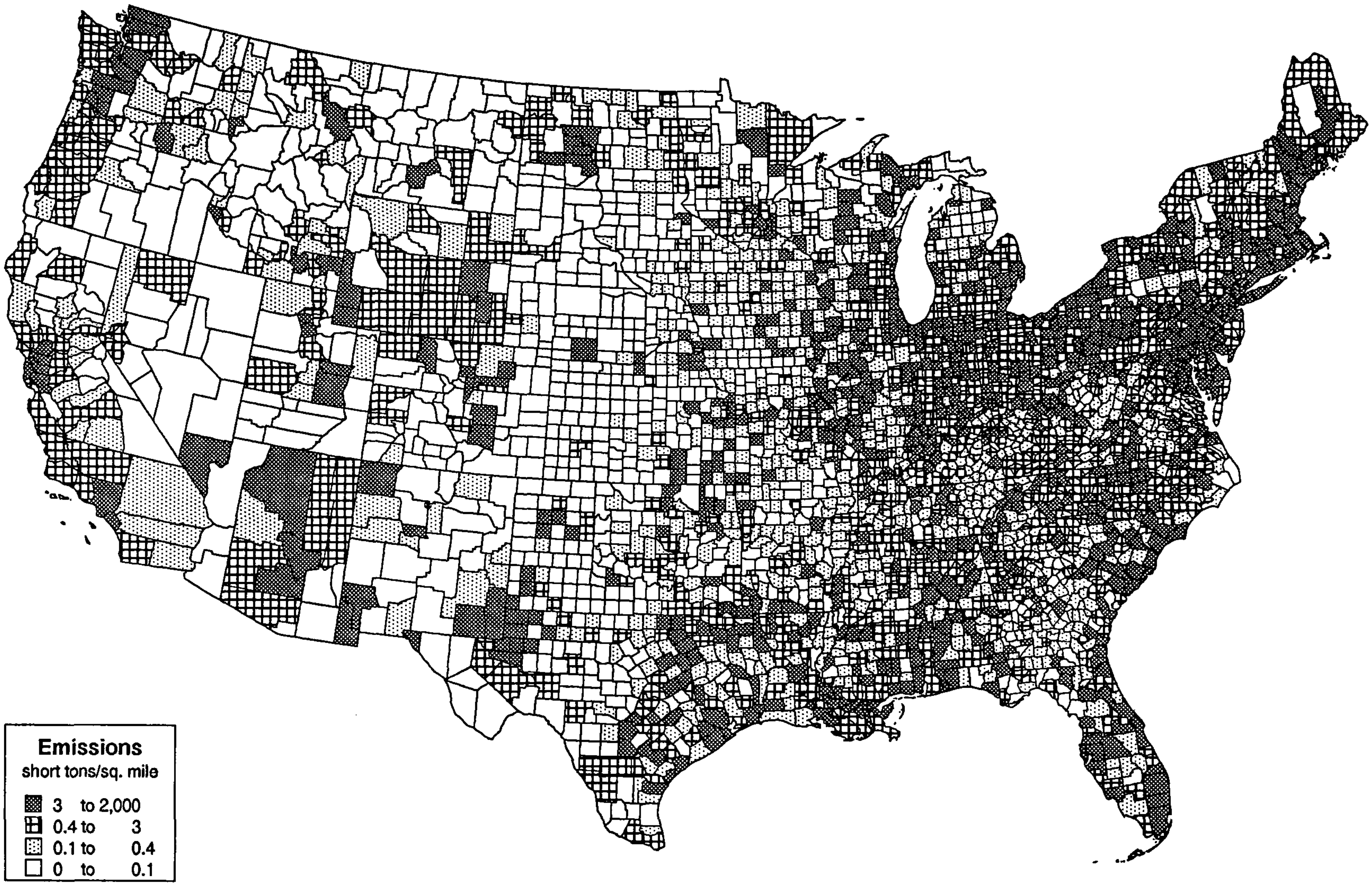
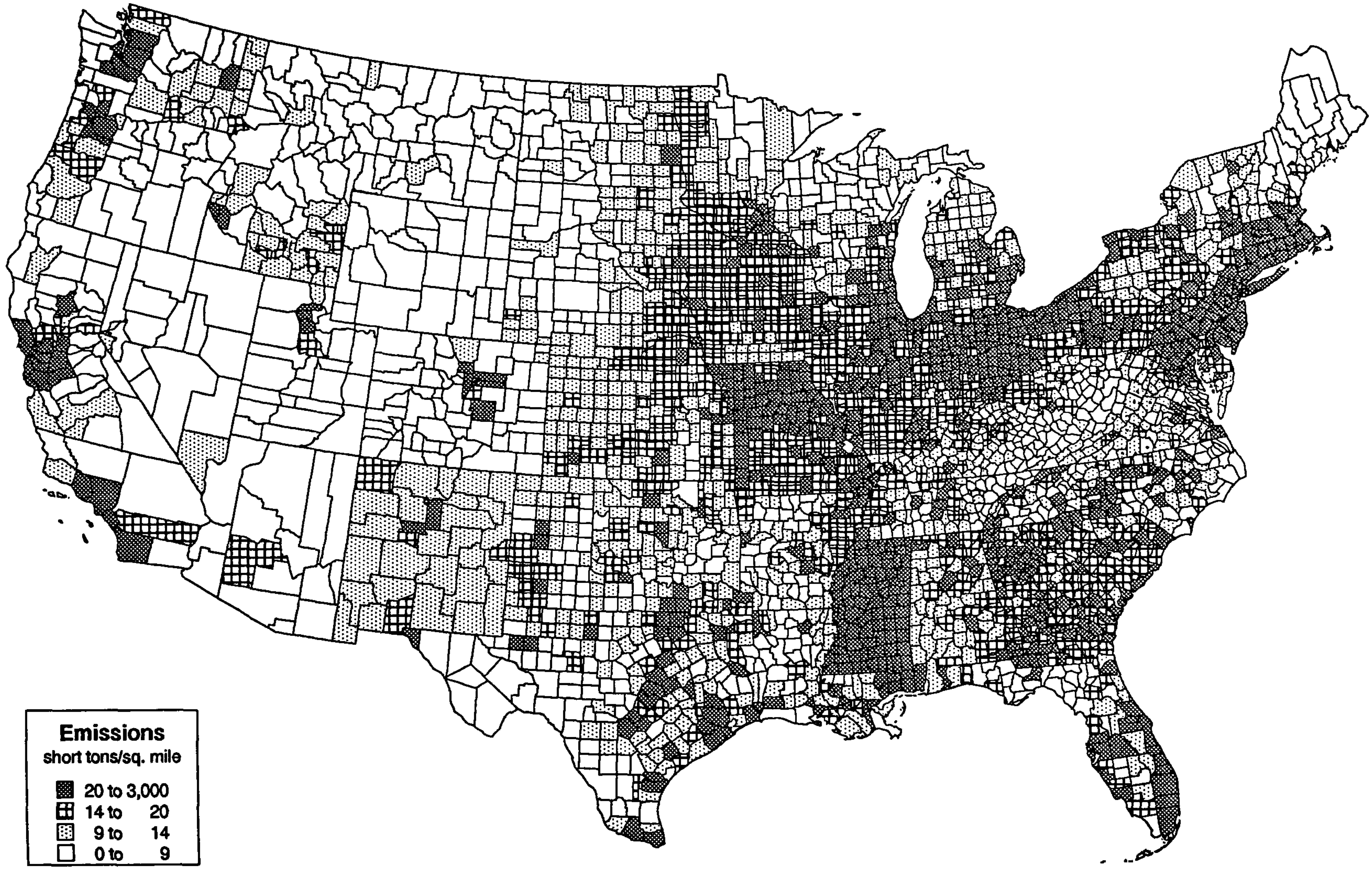


Figure E-5. Density Map of 1993 County-level PARTICULATE MATTER (PM-10) Emissions



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16. ABSTRACT

This report presents the latest estimates of national and regional emissions for criteria air pollutants: carbon monoxide, lead, nitrogen oxides, fine particulate matter, sulfur dioxide, total suspended particulate matter, and volatile organic compounds. Estimates are presented for the years 1900 to 1993, with greater detail in more recent years. This report also includes sections on air toxics, international emissions, greenhouse gases, projections, and biogenics.

17. KEY WORDS AND DOCUMENT ANALYSIS

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