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Air

# EPA Nonroad Engine and Vehicle Emission Study—Report



NATIONAL VEHICLE AND FUEL EMISSIONS LABORATORY OFFICE OF TRANSPORTATION AND AIR QUALITY ANN ARBOR MI



Nonroad Engine and Vehicle Emission Study Report

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#### ACKNOWLEDGEMENTS

The Nonroad Engine and Vehicle Emission Study relied extensively on the participation of numerous organizations both within and outside of the U.S. Environmental Protection Agency. A Technical Review Group consisting of industry and state-level government representatives was convened to provide a forum for resolving discrepancies in data used in the analysis. Members of this group are listed in Appendix F. The authors and editors of this report wish to express their sincere appreciation for the efforts of all participants.

The study also relied on analyses developed by EPA contractors. Under the direction of Mr. Charles T. Hare, a review of existing data on the emission characteristics of nonroad engines<sup>14</sup> was conducted by the Southwest Research Institute, which also tested the emissions of several lawn and garden engines that had been used in the field.<sup>4</sup> The EPA Project Officer for this contract was Mr. Craig A. Harvey of the Emission Control Technology Division. The EPA Technical Work Assignment Managers were Mr. Todd L. Sherwood and Mr. Kenneth L. Zerafa, both of the Certification Division. Estimates of local area equipment populations and usage for most nonroad engines and vehicles were developed by Energy and Environmental Analysis, Inc. (EEA) under the direction of Mr. K.G. Duleep.<sup>9</sup> An analysis of commercial marine vessel emissions in six nonattainment areas was developed by Booz - Allen & Hamilton, Inc. (BA&H) under the direction of Ms. Barbara Kuryk.<sup>4</sup> The EPA Project Officers for these two contracts were Ms. Celia Shih (EEA) of the Emission Control Technology Division and Ms. Patricia L. Cox (BA&H) of the Health and Environmental Management Division. The EPA Technical Work Assignment Manager for the EEA and BA&H analyses was Mr. Kevin A.H. Green of the Certification Division.

Many members of the Certification Division in Ann Arbor, MI were instrumental in the completion of this study. Ms. Gay MacGregor, Assistant Director, and Mr. John M. German, Project Manager, provided general and technical oversight, respectively, for the study. Ms. Cheryl F. Adelman provided legal interpretation and guidance in the area of nonroad equipment classification. Ms. Kathy E. Carter managed the production of the draft report and accompanying appendices. Mr. Kevin A.H. Green developed estimates of total emissions from nonroad engines and vehicles for the areas included in the study. Ms. Betsy Lyons McCabe coordinated revisions and additions to the draft and managed the production of the final report and appendices. Ms. Deanne R. North and Ms. Sujan V. Srivastava analyzed state eatimates of emissions from nonroad sources. Ms. Clare Ryan coordinated communications inside and outside EPA. With technical guidance from Mr. Michael A. Sabourin, Project Manager, Mr. Jeffrey T. Prince and Mr. Kenneth L. Zerafa developed a data base of evaporative and tailpipe emission factors for nonroad engines and vehicles. Ms. Paula Van Lare reviewed studies of ozone formation and transport and considered their implications for nonroad engines and vehicles. All of the above staff members are especially appreciative of the typing and production assistance provided by Ms. Rae Benedetti and by Ms. Janis S. Hagen, a contractor with the Computer Science Corporation, and of the general assistance from Mr. Donald J. Kachman and Ms. Sherie N. Williams, both student aides in the Certification Division, and also of the assistance with file sharing and orinting provided by the Computer Support Section.

<sup>1</sup>Booz - Allen & Hamilton, Inc. Commercial Marine Vessel Contributions to Emission Inventories. Los Angeles, CA. October 1991.

Ingalis, Melvin N. Nonroad Emigsion Factors. Southwost Research Institute, San Antonio, TX, Subramy 1991.

<sup>&</sup>lt;sup>1</sup>Ingulia, Melvin N. Nonroad Emission Factors of Air Toxics, Southwest Research Institute, San Antonio, TX, June 1991.

<sup>&</sup>lt;sup>1</sup>Carroll, J.N. Emission Tests of In-Use Small Utility Engines, Report 3426-006. Southwest Research Institute, San Antonio, TX, September 1991.

<sup>&</sup>lt;sup>1</sup>Energy and Environmental Assilysis, Inc. Methodology to Estimate Nonroad Equipment Populations by Nonattainment Areas. Arlington, VA, September 1991.

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# **Reading and Using the Study Report and Appendixes**

The Nonroad Engine and Vehicle Emission Study has been bound into two volumes the report and its appendixes. The report contains five chapters which provide information on the purpose and goals of the study, the approach, the results, and a discussion and analysis of those results. Throughout the report, the reader is provided with the basic information needed to understand what was done to obtain the results presented. More detailed information has been put into a series of sixteen appendixes, which are bound separately from the report.

In both the report and the appendixes, the reader will find annotated notes, indicated by a superscript symbol, at the bottom of the page. These notes are provided where it was felt some explanatory information might be needed. Reference citations are indicated by a superscript number. A list of the references cited in the report is located on the last page of the report. In the appendixes, a list of references can be found at the end of each appendix.

Many acronyms are used in the report. While they are defined when first used, a list of acronyms and their meanings is also provided in Appendix A. Appendix A also contains a glossary of some of the terms used in the report.

# Executive Summary

#### **Congressional Mandate**

This study is a response to the Congressional directive<sup>\*\*</sup> that EPA quantify the contribution of nonroad sources to ozone and carbon monoxide air pollution and to other pollutants believed to endanger public health. The Clean Air Act (CAA), as amended, directs EPA to complete a study of emissions from nonroad engines and vehicles by November 15. 1991. The CAA further requires EPA to regulate emissions from nonroad engines and vehicles and vehicles within twelve months after completion of the study if the Agency determines that these sources are significant contributors to ozone or carbon monoxide (CO) concentrations in more than one area which has failed to attain the National Ambient Air Quality Standards (NAAQS) for these pollutants. This report does not constitute EPA's determination of significance. Any determination EPA makes relative to the significance of nonroad contributions to air quality will be included as part of any regulations proposed for nonroad engines and vehicles. Opportunities for public comment on any determination of significance will be provided through the regulatory process if the Agency proposes nonroad regulations.

#### Nonroad Engines and Vehicles

The terms "nonroad engines" and "nonroad vehicles" cover a diverse collection of equipment ranging from small equipment like lawnmowers and chain saws, to recreational equipment, to farm equipment and construction machinery. EPA considered more than 80 different types of equipment in this report. To ease analysis and reporting EPA has grouped equipment into 10 equipment categories listed in Table ES-01.<sup>††</sup>

<sup>&</sup>quot;Section 213(a) of the Clean Air Act, as amended, directs EPA to conduct a study of emissions from neuroast engines and vehicles and to determine if such emissions cause, or significantly contribute to, air pollution which may be reasonably anticipated to endanger public health or welfare.

<sup>&</sup>quot;Locomotives and aircraft are not included in this study because the CAA provides for them separately

<b>Nonroad Equipme</b>	ent Categories
Lawn and Garden Equipment	Industrial Equipment
Airport Service Equipment	Construction Equipment
Recreational Equipment	Agricultural Equipment
Recreational Marine Equipment	Logging Equipment
Light Commercial Equipment	Commercial Marine Vessels

#### Table ES-01. Equipment Categories Included in Study

Nonroad engines are not regulated for emissions, and very few nonroad engines currently use emission control technology. Because of the diversity of nonroad equipment, characterization of the emissions from nonroad engines is a complex task. A comprehensive analysis of the air quality benefits potentially available from reducing nonroad engine emissions has never before been undertaken.

Congress asked EPA to focus on quantifying emissions from unregulated nonroad sources after 20 years of highway mobile sources regulation and increasingly costly controls on the automotive industry. As a group, nonroad engines represent the last uncontrolled mobile source. Potential emission reductions from this source may help resolve local air quality problems. A comparison between pollution emitted by individual pieces of new nonroad equipment and pollution emitted by today's typical in-use passenger car illustrates the logic behind the Congressional mandate.

 
 Table ES-02. Examples of Emissions from New Nonroad Equipment Relative to a Typical In-Use Passenger Car

1 Hour of Use	Pollutant	Car Miles
1 lawnmower	VOC	50
1 chain saw	VOC	200
1 outboard motor	voc	800
1 crawler tractor	NOx	900

#### State and Industry Participation

EPA's ability to complete this study has been greatly enhanced by contributions of the nonroad equipment industry and by many state air quality planners. A public workshop was held April 3-4, 1991, and individual meetings were held with many nonroad manufacturing groups. An informal group of technical experts, including industry and state representatives, provided valuable data and technical feedback throughout this study process. In many cases the nonroad manufacturers invested resources to provide detailed information to help construct nonroad emission inventories. On October 30, 1991, EPA held a public meeting on the full draft of this report.

#### Study Approach

To estimate the contribution of nonroad sources to air pollution, EPA constructed national emission inventories of nonroad sources, as well as local inventories for 19 ozone and 16 carbon monoxide (CO) nonattainment areas. Since it was not possible to construct inventories for all nonattainment areas within the time allowed for this study, these areas were selected to represent a spectrum of demographic and geographic characteristics. They also represent most of the nation's most severe air pollution problems.

Because Congress specified that EPA study the nonroad source contribution to ozone and CO nonattainment, the study primarily focuses on CO and on the pollutants that contribute to ozone formation, volatile organic compounds (VOC) and oxides of nitrogen  $(NO_x)$ . However, the study addresses all the pollutants listed in Table ES-03.

Pollutant	5
Volatile Organic Compounds (VOCs)	Benzene
Oxides of Nitrogen (NO <sub>x</sub> )	Aldehydes
Carbon Monoxide (CO)	1,3-butadiene
Particulate Matter (PM)	Gasoline Vapors
Sulfur Dioxide (SO <sub>2</sub> )	Nitrosamines

Table ES-03. Pollutants Included in the Study

# **Constructing Emission Inventories**

Emission inventories are detailed listings of the amount of pollution generated by different sources in a given area over a specific period of time. In constructing nonroad inventories, several factors must be estimated: (1) equipment populations in a given nonattainment area, (2) annual hours of use of each type of equipment adjusted for geographic region and for the season of interest for each pollutant studied, (3) average rated horsepower of each type of equipment, (4) typical load factor for each type of equipment, and (5) an emission factor (EF), or average emissions of each pollutant per unit of use (e.g., g/hp-hr) for each category of equipment.

Given the number of engine types and equipment included in the study and the limited amount of data available characterizing emissions from nonroad sources, EPA chose to construct two sets of inventories. In the first set, EPA constructed inventories that incorporate commercially and publicly available data so that the method could be repeated by interested states. The second set of inventories incorporated industry-provided data that might not be publicly available to states (e.g., confidential sales data to estimate populations), but would give EPA a valuable cross check for the first set of inventories. This report presents both sets of inventories:

Inventory A which relies heavily on a commercially available marketing research data base<sup>‡‡</sup> and publicly available indices of commercial activity to estimate equipment populations;

and

Inventory B which incorporates manufacturer-provided data in almost all high usage categories.

Both inventories use the same emission factors for all pollutants except particulates. EPA and its contractors, with the assistance of industry, updated nonroad emission factors for this study using all available test data, including evaporative and refueling (spillage) emission data. Most of the emission data for nonroad engines are based on tests of new engines. The limited information EPA does have on in-use nonroad engines shows that in-use emissions

<sup>&</sup>lt;sup>33</sup>Power Systems Research maintains a marketing research data base that includes most types of nonroad equipment.

could be as much as two times higher for some types of equipment than emission estimates using emission factors based on new engine test data. Consequently, inventories calculated using new engine emission factors (new engine EFs) will underestimate the contribution of nonroad engines to air pollution. EPA has developed a second set of emission factors (in-use EFs) for VOC and CO that includes a gross adjustment for in-use deterioration. Because of the uncertainty involved in making in-use adjustments, the report presents estimates for both Inventories A and B with and without the adjustment. In-use adjustments assume very little deterioration by diesel engines. Hence, category-specific inventories (e.g., Construction Equipment) for categories dominated by diesel engines show very little difference between the inventories estimated using new engine EFs and in-use EFs. The estimates using the new engine EFs should be considered the conservative lower bound of nonroad contribution in each nonattainment area.

#### Highlights of Study Results

Results are presented for all nonroad sources and for each equipment category. Aggregate Nonroad Contributions to Inventories

The results of Inventories A and B are similar. Chart ES-01 shows the median contributions to total inventories in the 19 ozone and 16 CO nonattainment areas studied. In general, Inventory B estimates lower emissions than Inventory A.



Chart ES-01. Comparison of Median Contributions - Inventory A & B

Under the most conservative assumptions, using the new engine EFs and choosing the lowest estimate from Inventories A and B combined, minimum contributions by pollutant for all cities studied were as follows: 2.9% VOC, 7.6% NO<sub>x</sub>, and 2.2% CO. It is often useful to look at the second highest and second lowest values in the range to avoid any "outliers" that might skew the data. For example, the second lowest contribution of VOC in any nonattainment area studied was 4.5%, for NO<sub>x</sub> 9.7%, and for CO 2.3%.

It is also useful to look at the nonattainment area with the second highest contribution since Congress requires EPA to regulate nonroad engines if it finds that nonroad engines are significant contributors to pollution in more than one nonattainment area. Chart ES-02 shows, for VOC,  $NO_x$ , and CO, the level of contribution in the nonattainment area with the second highest contribution from nonroad sources.

light-duty trucks, heavy-duty vehicles). Most large sources, like motor vehicles, have substantially reduced emissions because of regulatory requirements over the past two decades. Because many of the technologically and economically feasible reductions available from large sources have already been realized, a number of emission control programs recently mandated by Congress are aimed at achieving marginal inventory reductions. These reductions are relatively small compared to past reductions taken from an uncontrolled baseline. Since marginal reductions tend to be costly, the EPA has begun to focus on controlling many small sources of pollution. Because nonroad engines are uncontrolled, it is reasonable to expect that introduction of controls on sources emitting 1% of the total inventory would at least achieve benefits in the range of many other control programs now mandated by Congress in the CAA.

Table ES-05 shows, using the new engine EFs, the number of nonattainment areas in Inventories A and B in which specific nonroad categories contribute at least 1% of total inventory. Many of these areas exceed the 1% contribution by a wide margin.

Number of Areas > 1           Nonroad Category         Inventory A/B		> 1% /B	
	VOC	NOx	CO
Lawn and Garden	19-18	0-0	5-3
Recreational Marine	17-17	2-1	0
Commercial Marine	1-1	10-9	2-2
Recreational Equipment	2-0	0	3-2
Light Commercial Equipment	2-2	0	15-15
Construction Equipment	11-5	19-19	3-0
Agricultural Equipment	l-1	12-13	0
Airport Service Equipment	0	12-12	0
Industrial Equipment	0	13-13	12-10

Table ES-05. Number of Areas in Which Category Contributes at Least 1% of Total Inventory in the 19 Ozone and 16 CO Nonattainment Areas Studied

Charts ES-03 through ES-08 show VOC, NO<sub>x</sub>, and CO emission inventories for nonattainment areas typical of those included in the study.<sup>§†</sup> For comparison, the national emission inventories are also shown.

The nonroad portion of each chart is based on the average between Inventories A and B with and without adjustments for increased in-use emissions. The key at the bottom of each page lists the other sources included in the charts.

The nonroad contribution to the summertime VOC inventory for the New York CMSA/NECMA is greater than the combined contribution from all highway vehicles except light-duty gasoline vehicles. For the Philadelphia CMSA, the nonroad summertime  $NO_x$  contribution is larger than that from all heavy-duty highway vehicles. The nonroad contribution to the wintertime CO inventory for the Denver CMSA is greater than the combined contribution from all other sources except highway vehicles.

Nationally, the nonroad summertime VOC and  $NO_x$  contributions are greater than those from any other single source categories except solvent evaporation (VOC) and electrical generation (NO<sub>x</sub>). The national nonroad CO contribution is greater than the combined contributions from all highway mobile sources except light-duty vehicles.

<sup>&</sup>lt;sup>11</sup> For each pollutars, the area shown is that for which the nonroad portion of the inventory was nearest to the median value for the different areas included in the study.

Chart ES-02. Percent Contribution from Nonroad Sources in the Nonattainment Area with the Second Highest Contribution Level



#### Nonroad Contribution to Inventories by Equipment Category

The individual nonroad categories contributing most heavily to the inventories vary by pollutant. Both Inventory A and B show substantial summertime VOC emissions from nonroad sources. These emissions are primarily from lawn and garden equipment and from the recreational marine category. About 7.5% of the lawn and garden contribution to nonroad VOC inventories is due to evaporative emissions from spilling fuel when refueling equipment.

The nonroad portion of total summertime  $NO_x$  emissions is estimated to be about the same, on a percentage basis, as the portion of total VOC emissions from nonroad sources. By far the largest contributor to nonroad  $NO_x$  emissions is construction equipment. Inventory A shows in all areas studied that construction equipment contributions exceed 6% of the total  $NO_x$  inventory. Inventory B shows that in 15 of the 19 areas,  $NO_x$  emissions from construction equipment exceed 5% of the total inventory. Agricultural, industrial, airport service, and commercial marine engines are also important contributors of  $NO_x$  in some areas.

Unlike VOC and NO<sub>x</sub> emissions, no one category dominates the nonroad CO emission contribution. Light commercial, lawn and garden equipment, industrial, commercial marine, and recreational equipment categories each contribute a minimum 1.4-2.2% of total wintertime CO in at least two areas.

Table ES-04 shows the contributions of the different nonroad engine and vehicle categories to total inventories of VOC, CO, and  $NO_x$  emissions. The contributions are expressed in percent of total emissions from *all* sources. The values given are medians of the contributions in the various nonattainment areas studied. These are given for both inventories A and B, using emission factors first based on new engines and second incorporating EPA's estimate of in-use effects. Finally, the median contribution from all nonroad engines and vehicles is shown.

	% Total	VOC tpsd	% Total NO <sub>x</sub> tp		ped % Total CO spwd		Total NO <sub>x</sub> tpad % Total	
Source Category	lov. A	Înv. B	Inv. A	lov, B	Inv. A	Inv. B		
Lawn and Garden	2.6-4.7	2.4-4.1	0.2	0.2	0.6-1.1	0.5-0.9		
Airport Service	0.1-0.1	0.1-0.1	1.1	<u> </u>	0.2-0.2	0.2-0.2		
Recreational	0.2-0.4	0.2-0.3	0.0	0.0	0.4-0.8	0.4-0.7		
Light Commercial	0.6-1.0	0.6-1.1	0.2	0.2	2.0-3.6	2.0-3.7		
Industrial	0.4-0.5	0.4-0.4	1.7	1.3	1.3-1.5	1.1-1.4		
Construction	1.0-1.1	0.8-0.8	9.7	8.4	0.5-0. <del>6</del>	0.4-0.5		
Agricultural	0.2-0.2	0.2-0.2	1.6	1.7	0.1-0.1	0.1-0.1		
Logging	0.0-0.0	0.0-0.0	0.0	0.01	0.0-0.0	0.0-0.0		
Recreational Marine	3.4-4.0	2.2-2.5	0.3	0.2	0.1-0.1	0.1-0.1		
Commercial Marine	0.1-0.1	0.1-0.1	0.7	1.0	0.1-0.1	0.1-0.1		
Total Nonroad	9.1-12.6	7.4-10,3	17.3	14.5	5.9-9.4	5.2-8.5		

Table ES-04. Median Contributions of Nonroad Categories to VOC,  $NO_x$  and CO Emission Inventories A and B, with New Engine/In-use Estimate Emission Factors

# **Relative Contributions of Nonroad and Other Emission Sources**

One of the difficulties in improving air quality is that a multitude of small sources contribute to air pollution. In fact, many of what are considered "large" sources are actually groups of smaller sources (e.g., motor vehicles are categorized into light-duty vehicles,



# Chart ES-03. National Summertime VOC Inventory





#### Highway Mobile Sources

LDGV - light-duty gasoline vehicles LDV - light-duty vehicles LDGT - light-duty gasoline trucks LDT - light-duty trucks HDGV - heavy-duty gasoline vehicles HDDV - heavy-duty diesel vehicles DSLV - diesel vehicles

#### Area and Point Sources

- A1 petroleum refining
- A2 solvent evaporation
- A3 petroleum product storage/transfer
- A4 electrical generation
- A5 industrial combustion
- A6 industrial processes
- A7 residential fuel use





# Chart ES-06. Philadelphia CMSA Summertime NO<sub>x</sub> Inventory



#### Highway Mobile Sources

LDGV - light-duty gasoline vehicles LDV - light-duty vehicles LDGT - light-duty gasoline trucks LDT - light-duty trucks HDGV - beavy-duty gasoline vehicles HDDV - beavy-duty diesel vehicles DSLV - dieset vehicles

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#### Highway Mobile Sources

LDGV - light-duty gasoline vehicles LDV - light-duty vehicles LDGT - light-duty gasoline trocks LDT - light-duty trocks HDGV - heavy-duty gasoline vehicles HDDV - heavy-duty dissel vehicles DSLV - dissel vehicles

#### Area and Point Sources

- A1 petroleum refining
- A2 solvent evaporation
- A3 petroleum product storage/transfer
- A4 electrical generation
- A5 industrial combustion
- A6 industrial processes
- A7 residential fuel use

<sup>&</sup>quot;Corrections for wintertime increases in CO emission factors were not made for either nonroad sources or highway vehicles due to limitations in national-level data.

Because nonroad sources are among the few remaining uncontrolled sources of pollution, their emissions appear large in comparison to the emissions from sources that are already subject to substantial emission control requirements. For example, the CAA requires extreme ozone nonattainment areas to employ Reasonably Available Control Technology (RACT) on all stationary sources with VOC or NO<sub>x</sub> emissions above 10 tons per year (tpy). Annual operation of only 10 crawler tractors or 24 agricultural tractors will produce 10 tpy of NO<sub>x</sub>. Typical annual operation of only 74-142 boats with outboard motors or 730-1,630 chain saws will emit 10 tpy of VOC.<sup>\*\*\*</sup> In contrast, it takes 700 new, current-technology passenger cars driving an average of 13,000 miles each in a year (a total of more than 9 million miles) to produce 10 tpy of VOC.

### Areas of Further Study

In the process of constructing the study, EPA identified a number of areas where estimates were developed using limited data or were not developed at all because of lack of data altogether. While existing nonroad emission factors estimate tailpipe emissions from relatively new engines, more work needs to be done to quantify the effects of in-use deterioration, crankcase and evaporative emissions, toxic and particulate emissions, and emissions under cold start conditions. Because these emissions are not totally captured by the emission factors used in this study, the inventories presented in the study, particularly those calculated using the new engine emission factors, are likely to be conservative estimates of the nonroad contribution to air pollution.

<sup>&</sup>quot; These numbers indicate the range between data used to develop A and B national inventories.

# Chapter 1. Overview and Background

The cornerstone of the Clean Air Act (CAA) is the effort to attain and maintain National Ambient Air Quality Standards (NAAQS).<sup>1</sup> <sup>†††</sup> Prior to the enactment of the 1990 CAA Amendments (CAAA), efforts to achieve and maintain air quality standards focused on regulation of emissions from on-highway, area, and stationary sources. As a result of these efforts, significant progress has been made in reducing such emissions. However, due to the growth in air pollution sources, many air quality regions have failed to attain the NAAQS, particularly those for ozone and carbon monoxide (CO).

The CAAA contain numerous provisions that are intended to remedy these continuing air quality problems, through the application of new controls on currently regulated mobile and stationary sources of emissions and the promulgation of regulations for new sources. As part of the effort to identify and control unregulated sources of air pollution, the CAAA direct the U.S. Environmental Protection Agency (EPA) to study contributions to air quality from nonroad engines<sup>‡‡‡</sup> and nonroad vehicles<sup>‡‡‡</sup> (other than locomotives or engines used in locomotives).<sup>£££</sup> This study is the result of that directive.

### 1.1. The Air Pollution Problem

The CAA requires the EPA to set air quality standards for common and widespread pollutants after preparing "criteria documents" summarizing scientific knowledge on their health effects. Currently, six "criteria" pollutants are regulated by primary and secondary

<sup>944</sup> Section 216(11) of the CAA, as amended, defines "nonroad vehicle" as a vehicle that is powered by a nonroad engine and that is not a motor vehicle or a vehicle used solely for competition.

<sup>*fff*</sup> Emissions from locomotives and new engines used in locomotives are being addressed in a separate study. as required under section 213(a)(5) of the CAA, as amended.

<sup>&</sup>lt;sup>14</sup> Reference citations are indicated by a superscripted number. A list of citations can be found at the end of the report.

<sup>&</sup>lt;sup>\*\*\*</sup> Section 216(10) of the CAA, as amended, defines "nonroad engine" as an internal combustion engine (including the fuel system) that is not used in a motor vehicle or a vehicle used solely for competition, or that is not subject to standards promulgated under section 111 (new stationary sources) or section 202 (motor vehicles) of the CAA. As defined in section 216(2) of the CAA, "motor vehicle" means any self-propeiled vehicle designed for transporting persons or property on a street or highway.

NAAQS.<sup>\*\*\*\*</sup> As of 1989, over one-half of the population of the United States was still exposed to levels of these pollutants which were considered unhealthful by EPA.

Based on air quality data from 1988-1989, more than 33 million people resided in the 41 areas that failed to meet the NAAQQS for  $CO.^2$  An area is considered to have failed to attain the NAAQS for CO if it exceeds 9 parts per million (ppm) two or more times in a two year period. Carbon monoxide, formed as a result of the incomplete combustion of fuel, is emitted during the combustion process.

In contrast to CO, ozone is formed in the atmosphere as a result of a complex series of chemical reactions between oxides of nitrogen  $(NO_x)$  and volatile organic compounds (VOCs). In most urban nonattainment areas, both  $NO_x$  and VOCs must be substantially reduced to bring the area into attainment of the ozone standard. Further, since airborne ozone and  $NO_x$ , and possibly VOCs, can be transported from one area to another, attainment of the ozone standard in some areas may require control of  $NO_x$  and VOC emissions in upwind regions.

An area is in nonattainment for ozone if it exceeds 0.12 ppm more than three times in a three year period. In 1987-1989, 96 U.S. cities exceeded the standard for ozone. Of these cities, nine were classified as "severely" polluted, experiencing peak ozone levels that exceeded the standard by 50 percent or more. Based on 1989 air quality data, over 66 million people lived in counties not meeting the ozone standard.<sup>3</sup> Appendix B contains a description of ozone formation and a bibliography of the literature on ozone. A list of carbon monoxide and ozone nonattainment areas can be found in Appendix C.

As with CO and ozone, many areas are in nonattainment for particulate matter (PM). At the time the CAAA were enacted, 73 areas failed to meet the NAAQS for PM. Over 28 million people lived in areas not meeting the particulate standard in 1989.<sup>4</sup> <sup>titt</sup>

In addition to problems associated with nonattainment of the NAAQS, EPA is concerned with the health risks associated with air toxics. Most air toxics are hydrocarbon compounds capable of causing adverse health effects. Benzene, formaldehyde, and 1.3-

<sup>&</sup>lt;sup>\*\*\*\*</sup> NAAQS have been established for particulate matter (PM), sulfur dioxide (SO<sub>2</sub>), carbon monoxide (CO), nitrogen dioxide (NO<sub>2</sub>), ozone, and lead.

<sup>&</sup>lt;sup>1111</sup> The estimate for particulate matter is considered a lower bound estimate, because the PM<sub>10</sub> monitoring network is still evolving.

butadiene are emitted by motor vehicles and are considered to be human or probable human carcinogens. Some air toxics, such as benzene, are components of gasoline and can be emitted as unburned fuel or as fuel that evaporates. Other air toxics, such as formaldehyde, which results from the same reactions that form ozone, and 1,3-butadiene, are not present in fuel, but are by-products of incomplete combustion. A summary of cancer risk estimates associated with motor vehicle pollutants of most concern can be found in Appendix C.

#### 1.2. Congressional Mandate and Scope of Study

Section 213(a) of the CAA, as amended, directs EPA to conduct a study of emissions from nonroad engines and vehicles and to determine if such emissions cause, or significantly contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare. Within 12 months after the completion of the study, the Administrator of EPA must determine whether the emissions of CO,  $NO_x$ , and VOCs from such new or existing engines or vehicles are significant contributors to ozone or CO concentrations in more than one area which has failed to attain the NAAQS for ozone or CO. If an affirmative determination is made, the Administrator is required to promulgate regulations containing standards applicable to emissions from those classes or categories of new nonroad engines and vehicles which in the Administrator's judgment cause, or contribute to, such air pollution.

This study is the result of the directive in section 213(a) that EPA conduct a study of nonroad emissions. The study quantifies, through the use of nonroad equipment emission inventories, the contributions of nonroad sources to air quality problems. The study does not make a determination of the significance of emissions from nonroad sources. Such a determination will be included as part of any regulations promulgated for nonroad engines and vehicles.

### 1.3. Nonroad Equipment Categories Included in the Study

EPA considered over 80 different types of equipment in this analysis. To ease analysis and reporting and to assist the disaggregation of national or state equipment populations to the local level, EPA grouped the equipment types into the 10 equipment categories listed in Table 1-01. Additional information on these equipment types and equipment categories can be found in Chapter 2. It should be noted that these categories were developed only for use in this study and are not intended to represent potential regulatory categories. Aircraft and locomotives were not included in this study.<sup>‡‡‡‡</sup>



Table 1-01. Equipment Categories Included in Study

# 1.4. Pollutants Considered in the Study

Although numerous pollutants have the potential to meet the criteria set forth in the CAAA for inclusion in the study, EPA chose to limit the number of pollutants examined in this study to those listed in Table 1-02.

<sup>&</sup>lt;sup>2233</sup>Aircraft are already regulated under a separate subpart of the Clean Air Act and, hence, are not classified as nonroad engines or vehicles. Locomotives were specifically excluded from inclusion by Congress in the CAAA.



Table 1-02. Pollutants Included in Study

Section 213(a) of the CAA, as amended, requires that VOCs, CO, and NO<sub>x</sub> be included in the nonroad study. Of the three other NAAQS criteria pollutants (PM, SO<sub>2</sub> and lead), EPA chose to include PM and SO<sub>2</sub>, since both are currently regulated for on-highway sources and have been identified as contributing to air quality conditions that are dangerous to public health or welfare. The last criteria pollutant, lead, although highly toxic, was not included in the study because the CAAA prohibit the production of motor vehicle engines and nonroad engines that require leaded gasoline after model year 1992.

Nonroad sources also emit other pollutants commonly referred to as air toxics, which include carcinogens, mutagens, and reproductive toxins. Currently, little information exists regarding air toxic emissions from nonroad engines and vehicles or the health effects of such emissions. Moreover, none of these pollutants from on-highway sources have been regulated on the basis of carcinogenicity.

EPA's authority to include air toxics in this study is derived from section 213(a)(4) of the CAA. In determining which air toxics to examine. EPA considered three sources of information: compounds suggested by contractors which show the greatest cancer incidences and other risks,<sup>5</sup> pollutants to be included in EPA's CAA-mandated study of mobile source-related air toxics, and those pollutants emitted from nonroad sources which are found in Title III of the CAA. After reviewing the availability of data and the cancer risk incidences, EPA chose to address the following air toxics in this study: benzene; aldehydes; I,3-butadiene; gasoline vapors; and nitrosamines. Appendix D contains a listing of the air toxics considered in this study.

#### 1.5. Geographic Areas Considered in the Study

In determining which geographic areas to include in the study, EPA decided to focus on the 24 areas, listed in Table 1-03, which failed to attain the NAAQS for either ozone, CO, or both. Nineteen of the areas were evaluated for VOCs and  $NO_x$ , and 16 areas for CO. A primary reason for selecting these areas is the severity of their local air quality problems. EPA also believes these areas are representative of other urban areas with air pollution problems due to their diverse geographic and demographic characteristics.

Nonattainment Areas		
Allanta, GA MSA	Minneapolis-St. Paul, MN-WI MSA	
Baltimore, MD MSA	New York-Northern NJ-Long Island, NY-NJ- CT CMSA/NECMA <sup>1999</sup>	
Baton Rouge, LA MSA	Philadelphia-Wilmington-Trenton, PA-NJ-DE- MD CMSA	
Boston-Lawrence-Salem-Lowell-Brockton, MA NECMA	Provo-Orem, UT MSA	
Chicago-Gary-Lake County IL-IN-WI CMSA	St. Louis, MO-IL MSA	
Cleveland-Akron-Lonio, OH CMSA	San Diego, CA Air Basin <sup>6454</sup>	
Denver-Boulder, CO CMSA	San Joaquin, CA Air Basin	
El Paso, TX MSA	Seattle-Tacoma, WA CMSA	
Hartford-New Britain-Middletown-Bristol, CT NECMA	South Coast, CA Air Basin	
Houston-Galveston-Brazoria, TX CMSA	Spokane, WA MSA	
Miami-Fort Lauderdale, FL CMSA	Springfield, MA NECMA	
Milwaukee-Racine, WI CMSA	Washington, DC-MD-VA MSA	

Table 1-03.	Geographic	Areas Inc	luded	l in	Study
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HHI Consolidated Metropolitan Statistical Area (CMSA) and North East County Metropolitan Statistical Area (NECMA) definitions are given in <u>State and County Metropolitan Area Data Book</u>, U.S. Bureau of the Census, 1986.

<sup>&</sup>lt;sup>cess</sup> California air basins are defined for the purposes of this study as in the 1990 version of the 1987 emission inventory prepared by the California Air Resources Board (CARB) for the State of California.

# 1.6. Public Participation

EPA recognizes that involvement by the manufacturing and environmental communities is essential in ensuring the effective implementation and enforcement of any policies and regulations which may be developed. Therefore, throughout the nonroad engine and vehicle study process, EPA actively solicited information and comment from interested parties. The information supplied by these parties enabled EPA to use the best available data in developing estimates of the contribution of nonroad engines to air quality problems.

A public workshop was held on April 3-4, 1991, with over 200 persons in attendance. The purpose of the workshop was to discuss the nonroad engine and vehicle study and the Agency's regulatory process. Presentations were made by EPA, state agency representatives, and industry representatives.<sup>\*\*\*\*\*</sup> EPA requested that manufacturers submit population inventory and emission data for the nonroad equipment to be considered in the study. In addition, a briefing for environmental groups on general air quality issues held in Washington, D.C., on May 14, 1991, included a presentation on the nonroad study.

Following the public workshop, EPA held individual meetings with a number of manufacturers and manufacturer groups, including: Outdoor Power and Equipment Institute (OPEI), Industrial Truck Association (ITA), Engine Manufacturers Association (EMA), the Equipment Manufacturers Institute (EMI), Portable Power Equipment Manufacturers Association (PPEMA), John Deere Company, National Marine Manufacturers Association (NMMA), Manufacturers of Emission Controls Association (MECA), Ford Motor Company, Ford/New Holland, and Tecumseh Products Company. At these meetings, manufacturers provided EPA with up-to-date information which assisted EPA in the development of the inventories in the study. Association descriptions and membership lists are in Appendix E.

An informal external technical review group, composed of representatives from a variety of manufacturer associations and state agencies, was convened by EPA to provide technical review and feedback throughout the development of the study. The review group provided informal feedback on the nonroad population inventory methodology, emission factors, and per-source usage rates for the study. A complete list of the Technical Review Group members is included in Appendix F.

Presentation materials and other comments are available for public review in Docket #A-91-24.

EPA published a draft of this report for public review in October 1991, and held a public meeting on the nonroad study on October 30, 1991. This report reflects EPA's consideration of comments received on the draft report. A discussion of EPA's response to public comments is found in Appendix Q.

# Chapter 2. Methods and Approach

The goal of the EPA Nonroad Engine and Vehicle Emission Study was to develop an inventory of nonroad engine and vehicle emissions within the Congressionally mandated time period. To achieve this goal, EPA used the limited data that was available. Where feasible, these data were updated or new data were developed.

In developing emission inventories for nonroad engines, EPA found that comparisons between existing data were not always direct or easy. One of the biggest challenges was to find a way to present, compare, and analyze data from a variety of sources. Given the number of types of engines and equipment included in the study, and the amount of data available that characterized emissions from nonroad sources, EPA chose to construct two sets of inventories, both of which are presented in this report.

In the first set of inventories (Inventory A), EPA incorporated commercially and publicly available data so that the method of inventory construction could be repeated by interested states. The second set of inventories (Inventory B) incorporated industry-provided data that might not be publicly available to states (e.g., confidential sales data to estimate populations) but which provided EPA with a means of validating the first set of inventories. A discussion of the methodology and data used for both inventories is presented later in this chapter. Each inventory is based, at least in part, on specific data sources:

- Inventory A relies primarily on data provided by contractor studies; in particular, on population and per-source usage rate data derived from recent work contracted by EPA for this study. For most categories of equipment, populations are drawn from a commercially available market research data base. Inventory A also includes some data supplied by states and manufacturers.
- Inventory B incorporates population and per-source usage rate data supplied to EPA by manufacturers and manufacturer associations. For most categories, population estimates were supplied by the manufacturers or are derived from confidential sales data provided by manufacturers. Where gaps existed, data from Inventory A were used, so that a complete inventory could be developed.

The study also considers a third set of inventories, Inventory C, which is based on data developed by individual states for their 1987 State Implementation Plans (SIPs).<sup>†††††</sup> At the time the study was initiated, SIPs provided the most comprehensive source of nonroad engine and vehicle emission data. Each SIP contains a state-developed inventory which considered population and per-source usage rate estimates. However, two factors restricted the ability of EPA to utilize this inventory as a basis of comparison with Inventories A and B. First, the SIPs considered a limited number of nonroad equipment types. Second, a substantial amount of new data on nonroad sources was developed after the states constructed their 1987 draft inventories. Nevertheless, the SIPs still constitute a valuable point of reference. Further discussion of this inventory is found in Appendix G.

### 2.1. Structure of Emission Inventories

Emission inventories are detailed listings of the amount of pollution generated by different sources in an area during a specific period of time and are used to account for the various sources of different air pollutants. For example, a CO emission inventory might appear as shown in Table 2-01.

Source	1987 tpy*
Light-Duty Highway Vehicles	400
Other Highway Vehicles	200
Nonroad Mobile Sources	300
Other Area and Point Sources	100
Total (All Sources)	1000

Table 2-01. Sample CO Emission Inventory.

\* tons per year

<sup>&</sup>quot;" Title I of the CAA requires states to develop plans to demonstrate how they intend to meet the NAAQS.

In developing emission inventories for nonroad engines and vehicles, EPA used the following formula to calculate emissions from most nonroad sources<sup>‡‡‡‡‡</sup>:

$$M_i = N \times HRS \times HP \times LF \times EF_i$$

where:

M,	=	mass of emissions of i" pollutant during inventory period
N	æ	source population (units)
HRS	=	annual hours of use
HP	=	average rated horsepower
LF	=	typical load factor
$\mathbf{EF}_{t}$	=	average emissions of it pollutant per unit of use (e.g., grams per horsepower-
		hour)

For this study, the product of the annual hours of use, the average rated horsepower. and the load factor is referred to as the *per-source usage rate*. The product of the population and the per-source usage rate is referred to as the *activity level*. Nonroad engine emissions are expressed as tons per year (tpy), except when emissions are adjusted for seasonal usage patterns to reflect tons per summer day (tpsd) or tons per winter day (tpwd).

#### 2.2. Developing Equipment and Engine Categories

The development of an emission inventory requires the estimation of activity levels, which is facilitated by the use of categories that group together types of *equipment*, such as tractors, balers, harvesters, and other types of agricultural equipment, which have common function and use characteristics. Emission factors, on the other hand, are generally best developed for different types of *engines*, such as diesel, gasoline, 4-stroke, and 2-stroke, used within an equipment type. Consequently, EPA estimated activity levels by *equipment* type, while applying emission factors appropriate to corresponding *engine* types.

EPA developed the ten equipment categories listed in Table 2-02. The primary purpose of equipment categories is to simplify the distribution of equipment populations and annual usage to the local nonattainment area level. Over 80 different types of equipment were considered in this analysis, many of which are highly specialized and have low sales

<sup>&</sup>lt;sup>1224\*</sup>Note that EPA used grams/hour emission factors for most recreational equipment and grams/gallon of fuel for recreational and commercial marine equipment.

volumes. EPA recognizes that many of the 80 equipment types, such as chain saws, generator sets, forklifts, and crawler tractors, are used in more than one industry or application (e.g., farming, construction, general industry or recreation) and that, consequently, the ten equipment categories are not mutually exclusive with respect to equipment type. Nevertheless, the definition of the ten categories is consistent with the methodology used to distribute equipment populations geographically and to estimate activity levels, and so it is considered to be valid for that purpose. Equipment types used for similar purposes were grouped into categories and a methodology was developed for distributing state or national population data to the local level for each equipment category. While these categories were used for distributing population data, activity levels were developed for each equipment type. Grouping equipment types into categories also provides a convenient means of reporting the results in a format which is more readily understood.<sup>\$3304</sup> A detailed list of equipment types included in each equipment category is found in Appendix H.

Equipment Category	Examples of Included Types of Equipment		
Lawn and Garden	lawnmowers, snowblowers, trimmers, tillers, chain saws < 4 hp		
Airport Service	aircraft and baggage towing tractors, airport service vehicles		
Recreational	ATVs, off-road motorcycles, golf carts, snowmobiles		
Recreational Marine	inboard and outboard recreational boats		
Light Commerciai	air and gas compressors, welders, generator sets, pumps		
Industrial	aerial lifts, forklifts, self-propelled elevating platforms, sweepers		
Construction	asphalt pavers, rollers, scrapers, rubber-tired dozers		
Agricultural	agricultural tractors, combines, baters, harvesters		
Logging	chain saws > 4 hp, delimbers, log skidders		
Commercial Marine	harbor vessels, fishing vessels, ocean-going commercial vessels		

Table 2-02. Nonroad	Mobile Source E	quipment	Categories.
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<sup>&</sup>lt;sup>1014</sup> These categories are neither definitions of "farm equipment" or "construction equipment" (terms that will be defined by EPA in a future rulemaking) not necessarily appropriate for the classification of new nonroad engines and new nonroad vehicles for which regulations may be promulgated under section 213(a)(3) or 213(a)(4) of the CAA.

For the categories in Table 2-02, EPA developed separate emission factors for equipment types using diesel, gasoline 4-stroke, and 2-stroke and LPG engines where appropriate. A detailed discussion of the development of emission factors is contained in Appendix I.

# 2.3. Development of Emission Factors

A key element necessary to determine emission inventories for nonroad sources is the emission factor. An emission factor is the average emission rate when a vehicle or unit of equipment is operated in an average manner. Emission factors are commonly mass-based and expressed in units of mass per unit of work (e.g., grams per horsepower hour), mass per unit of fuel consumed, or, in the case of on-highway vehicles, mass per mile traveled.

For this study, Inventories A and B were calculated with a common set of emission factors, except for diesel particulate emission factors, which are different for the two inventories. A list of the emission factors selected by EPA is presented in "2.7. Comparison of Data Used in Inventories A and B." Emission factors for Inventory C required special aggregation to be compatible with SIP guidance.

EPA used data available from past studies and testing, as well as new information supplied by the engine manufacturers, to develop emission factors for tailpipe exhaust, refueling, evaporative, and crankcase emissions.<sup>Effff</sup> Appendix I describes the various methodologies used to determine and select the most appropriate emission factors for each type of equipment. The emission factors developed for this study were reviewed by the technical review group.

The test data on which the emission factors are based consist almost exclusively of tests on new engines. While more testing needs to be completed before in-use emissions can be fully characterized, EPA believes that inventories incorporating emission factors based

EFFEE EPA contracted with Southwest Research Institute (SwRI) to perform a study to recommend categorization of nonroad sources and the best available exhaust emission factors for nonroad sources. SwRI completed this task in two parts. The first part focused on emission factors for VOC, CO, and NO<sub>x</sub>, while the second part focused on particulate matter and air toxic emission factors. The final reports, "Non-Road Emission Factors Interim Report" and "Non-Road Emission factors of Air Toxics" can be found in the public docket (#A-91-24). Appendix I provides detail on emission factors and how they were used. EPA received emission factor information from a number of industry sources. Appendix J indicates the sources of additional data.

solely on new engine data would grossly understate the contribution of nonroad engines to air pollution. Therefore, to estimate the magnitude of the effect of in-use emissions, which includes engine malfunctions, improper maintenance, and engine wear, EPA also developed a second set of emission factors that takes into account these effects.

Two sources of data were used to estimate in-use adjustment factors. One source was recent testing of in-use small utility engines performed by Southwest Research Institute (SwRI) under contract by EPA. The limited testing that has been done thus far suggests that in-use emissions could be 2 times higher, for some engines, than the emission factors based on new engines. The second source of data was a joint Engine Manufacturers Association (EMA)/EPA program conducted in 1983 which developed in-use emission factors for heavy-duty diesel and heavy-duty gasoline engines. The data obtained from this program suggests that, while in-use impacts are minimal for pre-controlled diesel engine emissions (i.e., diesel engine emissions do not increase with mileage/hours of operation), heavy-duty gasoline engine emissions increase with in-use operation. A detailed discussion of the in-use adjustments to emission factors is contained in Appendix I. Inventories A and B were calculated using both the new engine emission factors and the in-use emission factors. The results are presented so that the reader can clearly distinguish the estimated in-use portion of each inventory.

Another issue which is necessary to consider in the assessment of the magnitude of emission rates for nonroad equipment is whether the test cycle is representative of in-use operation. There is an ongoing debate regarding the appropriateness of using a steady state or a transient test cycle for testing the emissions of nonroad engines. This is an important issue, since measured emissions of most pollutants, especially particulate matter (PM), are sensitive to the test cycle. For instance, a steady state cycle used on a piece of equipment that experiences transient operation in-use may misrepresent the level of in-use emissions. EPA adjusted the PM, CO, and VOC emission factors which were developed using steady state procedures to account for in-use transient operation for those equipment types expected to encounter such operation. The equipment types that were adjusted are indicated by Footnote "a" in Table 2-07a. The adjustments were only made to diesel engines since the only data available was on diesel engines. A more detailed discussion of these adjustments for transient operation is contained in Appendix I.

# 2.4. Development of Activity Levels for Inventory A

Due to limitations in the existing guidance for developing emission inventories for nonroad mobile sources, EPA contracted to develop improved methodologies for all nonroad sources. The equipment populations, annual hours of use, average horsepower ratings, and load factors used in Inventory A are primarily based on a market research data base commercially available though Power Systems Research (PSR). This data base is continually updated through surveys of equipment manufacturers and end users. For the study, population data were disaggregated to individual nonartainment areas using commonly available economic indicators and census data.<sup>\*\*\*\*\*\*</sup> The emissions analysis for commercial marine vessels was handled separately from other categories of equipment,<sup>######</sup> as discussed in Section 2.8.

The development of emission inventories for recreational boats relied on local registrations of pleasure craft. Because boats are often used outside areas where they are registered, adjustments to registration data were made based on a survey of boat owners in eight nonattainment areas conducted by Irwin Broh and Associates, Inc. for the National Marine Manufacturers Association (NMMA).<sup>6</sup> Annual fuel consumption from the same survey was also used in calculating recreational boat emissions.

While relying primarily on contractor input, EPA also used other data and information in calculating Inventory A. Documentation of adjustments to the contractor data are contained in Appendix K. Documentation of adjustments to the data to reflect variations in usage patterns by region of the country and season of the year is contained in Appendix L. Summaries of the data used to develop Inventory A are presented in "2.7. Comparison of Data Used in Inventories A and B," with more detailed information presented in Appendix M.

<sup>&</sup>quot;The methodology is documented in the Energy and Environmental Analysis final report entitled "Methodology to Estimate Nonroad Equipment Populations by Nonattainment Areas," available for review in Docket #A-91-24.

<sup>&</sup>lt;sup>111111</sup> This is due to the fact that the types of commercial marine vessels are not as diverse as other nonread categories, and to the fact that records of specific levels and types of vessel activities are more readily available
### 2.5. Development of Activity Levels for Inventory B

In developing emission inventories for Inventory B, EPA incorporated data submitted by the following manufacturers and associations:

- Outdoor Power Equipment Institute nonhandheld lawn and garden equipment
- Portable Power Equipment Manufacturers Association handheld lawn and garden equipment
- Industrial Truck Association forklifts
- Equipment Manufacturers Institute agricultural and construction equipment
- National Marine Manufacturers Association recreational marine equipment
- International Snowmobile Industry Association snowmobiles
- Motorcycle Industry Council ATVs, off-road motorcycles

Some of the equipment populations used in Inventory B were based on confidential sales data that are not commercially available. Where gaps existed, EPA used data from Inventory A; however, for most high volume categories the data used in Inventory B were submitted by manufacturers.

In some cases, it was necessary to adjust the data provided by manufacturers for use in constructing Inventory B. The use of and adjustment to manufacturer data is documented in Appendix N. EPA made seasonal adjustments to data in Inventory B similar to those made for Inventory A, as documented in Appendix L. In cases where manufacturers only supplied annual hours of use at the national level, these hours of use were used for all areas without regional adjustments. Summaries of the data used to develop Inventory B are presented in "2.7. Comparison of Data Used in Inventories A and B." More detailed information is presented in Appendix O.

### 2.6. Comparison of Results from October Draft and Final Study

EPA made some adjustments to the data used to construct Inventories A and B for this final report in response to public comments on the October draft study report. The most significant adjustments to Inventory B data impacting inventory results included revisions to the recreational marine inventory methodology, revisions to annual hours of use for

lawnmowers, revisions to the methodology for distributing handheld equipment (trimmers, blowers, and chain saws) to the local level, revisions to population estimates for agricultural tractors and combines, and emission factors for outboard motors and crankcase emission from lawn and garden equipment. Some of these adjustment were also made to Inventory A, but with less impact on overall inventory results. A summary of the comments received to the October draft is in Appendix Q.

Charts 2-01 and 2-02 depict the results from Inventory A and Inventory B before and after adjustments were made to the draft results. Each chart shows the median local nonroad contributions to total VOC,  $NO_x$ , and CO inventories.



Chart 2-01. Median Contributions -- Draft Inventory A and B



Chart 2-02. Median Contributions -- Final Inventory A and B

### 2.7. Comparison of Data Used in Inventories A and B

The national equipment population estimates used in constructing Inventories A and B are compared in Table 2-03. As discussed above, Inventory A incorporated population estimates developed by EPA contractors, while Inventory B incorporated, to the extent possible, data from manufacturer associations. Local population estimates used in developing Inventories A and B are included in EPA Technical Memorandum - Nonroad Inventory Tables: Inventory A and B, November 15, 1991. The equipment populations are presented by equipment and fuel type, including diesel, LPG/CNG, 4-stroke gasoline, and 2-stroke gasoline.

Comparisons of equipment horsepower and load factor estimates used in Inventory A and Inventory B are presented in Tables 2-04 and 2-05, respectively. Reported ranges of annual hours of use estimates, which vary by region, are compared in Table 2-06. Emission factors for diesel engines and gasoline 2- and 4-stroke engines, which were used in both Inventories A and B, are presented in Table 2-07. Seasonal adjustments, which were used in both Inventories A and B, are presented in Table 2-08, expressed in terms of the percentage of yearly activity occurring during summer and winter.

									<u> </u>		
<b></b>	Pertinual Populations Squipment Type	Direct Lav. A	Divid Lav. S	LPG/CNG Lev. A	LMGACNG : Inv. B	4-cyclu gan Iav. A	f-cyclo gas Lav. B	1-syste på Lav. A	3-cychigan Lav. B	l etal Insta	tale Ja S
1	Trimmana/Edgen/Brads Caring	0	ø	0	0	21,921	21,991 t	11,150,361	13,561,414	18.172.282	15200.035
1	Lang Menour	Ð	- · ·	a	•	32,149,997	28,784,172	3,594,099	3,215.828	35,764,096	1 <u>1,1210,000</u>
	Lad Blown Wenner		•	1		229	273	2,015,554	2,270,930	2,025.784	1,171,164
1	Rose English Richting Monwers	8,713	9,480	P	•	1.575,407	1,710,540	0	0	1,344,120	1.720.000
	Prore Merson	•	D	0	0	257,500	140,000			257,680	280,000
t	Chain Sama K 4 hp	0	D	•		a	D	16,124,970	1,395_302	:4,134,970	7 191.302
L	Streetiens < 1 top	•		0		87.107	87,107	20,215	20,215	101.735	107 122
1	Tillers < Shp	0	0	a	1	3,194,437	2,724,966	17,543	12.5978	3,812,000	1.737,564
ι	Lawy and Gautan Tractors	211,691	134.347	•	Þ	5,903,349	3,140,433	0	0	6,111.000	5,233.000
-	Wood Spillorm	79	79			302,181	901,181	•		901_260	977.260
	Sec-bio-ere	Û	0		¢	3,537,374	3,537,374	1.244,424	1,244,624	4 78 2,000	4,711.000
-	Chippersolitance Ortenters	17,017	17,017	0 1		14 791	14,791	0	01	13.67t	23.478
-	Commencial Tool Equipment	¢	0	0		569,711	368,792	D	0	568,732	568,773
-	Other Lown and Garden Exclusion	t <b>#0</b>	E <b>30</b>	. a	٥	215,979	285,10 <del>9</del>	L 10.545	110.545	396,634	796 434
2	Airenit Support Septement	9,529	9379		0	1,767	2,707	0	0	12,294	1129
2	Testinal Transm	64,9 <b>9</b>	64,794	130	130	6,396	6,340	Ð	•	71 \$14	71 ' ! .
,	All Termin Veldeler (ATVs)	C	0	0		1,100.001	וס, פו, ו	131,940	(3 <u>3,</u> 940)	(31291)	1,512,9
3	Marinkas	0	0			43,990	44,990	0		ek,940	4.8,29
,	Off-Rami Manacepties	,	D	0	•	63.540	63.34#	157,577	137,777	201,125	201.12
3	Colf Cara		0	0	Ċ	93.450	y1,450	21,120	28,820	122,670	122.67
3	Jaowashia		•	•	0	0	D	714,359	1,200,000	778,559	1.270.00
3	Specialty Vebicies Carts	1,344	1,344	Ċ Û	0	91,025	91,024	175,070	175,070	269,440	2:944
•	Verando - Ala banad Kagistan	73,948	73,945	0		438,014	436,913	D	0	109,961	109,96
4	Vacada w/Omboard Regions	٩	Ð	ů.	•	41,226	41,72	3,304,304	1,214,304	3,145,533 i	0.245.53
•	Versels v/Strandstva Regime	g	0	•	9	2,713,420	2,713,430	đ	a	2,713.420	2,713,42
4	Sallow Auxiltury Internet English	40,014	40,004	0	D	130,764	1 10,744	C	*	3\$3,320	117.92
٠	Saibon Analitary Outboard Tingings	٥	¢	D	0	3,738	5,730	141,151	141,152	144,690	144,85
,	Currentine Sala 4 50 kg	195.391	191,391		-	2.921.263	2,911,361	12,073	22,093	3,141,677	1415
1	Panage « SH bay (	65,910	41,410	91, <b>23</b> 4	91,236	10,61	540.457	0	0	*13, <b>49</b> 8	1.1.6
3	Alt Compression 4 50 kg	13,713	15,715	a	D	174,124	176,124	•	, D	191.837	:91 **
t	Gas Companyine State	0	Ģ	434	43	0	B	0	D	438	
5	Weidens 🛛 < 70 hp	100,490	t <b>00,499</b>	0	0	350,545	350,546	D	D	451.755	41.00
,	Pressure Warberrit 50 kg	3,943	3,545	0	0	290.959	290,939		0	ing and	_ 14 at
4	Avrial Life	t2,110	12310	3.497	3,407	34,941	24,981	0	, D	40.608	11 St
•	Postilita	140,593	47,044	42,117	191.327	100 385	130,597	0	0	142.065	:49.4
4	Sampan/Sandian	H.977	36,977	9,962	9.063	16,830	16,850	0	v	42.869	1
¢	Other General Industria Repairment	11,366	18,366	0	D	21,753	21,753	1. <b>9</b> 71	L,971	42,090	1.07
•	Odier Meseriet Handling Berleman	5,258	5,234	0	•	2,03	2016	0	a	7,294	
T	Asphak Pavara	13.594	12,000	9	0	3,022			9		

# Table 2-03. Inventory A and B National Population Estimates



### Table 2-03 (Continued)

a	National Populations Equipment Type	Dissel Est. A	Diesel Jav. B	2.PG/CNG Let. A	LPA/CNG Lev. V	4-cycle gas Lav. A	4-sysia gan Terr, D	3-cycle gas Inv. A	2-syste gan Eur. B	Tutaj Inv. A	Total Inc. B
7	Terper/Research	D D	d	0		1,043	1.043	12,546	Z2,566	23.611	22 612
,	Plata Complexities	2,312	1.312	ą	¢	117,50	117,507	27,726	27.726	107,555	147.555
7;	Constan Farms	5.511	6,400		D	a	0		¢	5,511	4,400
۲	Rollers	36.100	42,300	0	0	\$1,999		D	0	58,299	42300
7	Serapera	26,700	16.400	D	D	0	0		9	26,700	:6.400
,	Paring Bengamm	47,615	43,815	0	D	218,942	218,942	11,258	11,369	274,423	174,425
,	Sentiaring Beylecout	•	ő	0	D	30,613	30,293	•	0	10,855	20,423
1	Signal Boards	70,344	20,3 <b>W</b>	¢	Ð	1,559	1.559	0	0	21.545	21 941
1	Transform	50,310	51,390	•	•	27,170	27.I TO	0	D	TT.660	N260
7	BerryDrill High	7,761	1,761	6		1.395	1.195	10	108	18,262	16,262
7	Enter and	61,336	52,295	đ	0	1∎	·	e	0	61.354	52,295
7	Concentral Industrial Serve	135	61.354	D	¢	36,900	36,900	0	. 0	37,535	95,234
1	Counce and Monter Million	4,016	4,01e	D	0	232,152	131,197	0	0	236,148	330,ida
7	Crawer	ગામા	96,357	D	0	3.541	2,511		0	I (III), IP(M	*00 <b>5</b> 98
7	Grain	70,043	64,000	0	D		0	D	¢	70,043	64,000
7	Off-Highway Trade	1433	19,400	0	0	•		9	9	16,579	19.400
1	Crucking/Free. Bepleparent	7,367	1,307	0	¢	1,007	1,077	D	¢.	L214	F,714
1	Raugh Terrate Parking	13,879	23,132	9	0	2,217	2,217	0	0	34,070	\$7,549
7	Rakhar Tirad Landers	209,454	130,000	۵.	0	3,431	a	0	0	212,007	190,000
1	Rubber Tired Desses	7,757	7,797	0		a	0		0	1,751	1,197
1	Transelanter/Beckler	291,243	189,000	٥	0	<b>1,745</b>		0	0	900,630	139.000
7	Creater Transm	200,923	1,59,059	0	D	Ð	0	0	Þ	285,923	1 59,050
7	Stat Steer Landers	157,054	140,000	•	0	27,865	0	•		177,159	140,000
7	Off-Highway Tracem	34,911	31,921	. 0	•	0	0	a	0	33,921	38,921
' :	Daspen/Tealare	ř.	194	•	0	24,341	24,301	a	0	24,485	24.495
1	Other Construction Reptyment	11,647	11,107	ą	0	L, 103	1,103		Ď	מלקיבו	12,970
•	2-Wheel Trades	D	0	9	•	13,003	13.801	0	D	13,402	13.802
-	Appleational Tractory	2,519,299	2,519,395	0	0	5, <b>101</b>	S,ant	0	0	2,515,103	2,525 103
;	Cushiere	254,854	200,054	9	0	teith, c	1.09	0	Ó	200,409	216,689
	Sympos	9.093	9,007	9	0	72,721	73,711	Þ	Ş	82,413	12,413
•	مىك 8	4.260	4,260	e	0	0	¢	D	0	4,260	4.260
•	Tillen > 5 kg	73	25	0	9	785,102	362,407	0	a	îm,100 -	\$62,416
• [	5-abas	50,072	30,031	٥	0	32,817	321.97	\$	0	12,699	A T WWW
•	Rydro Forwer Units	1,164	2,366	a	a	15.042	15,042	Q	٥	17,404	11.408
'	Other Apricalizati Reprint	18,042	18.043	•	a	4,405	6,405	C	đ	24,447	34,447
4	Chain Serre > 4 hp	0	¢	0	0		٥	\$1,775	25,351	\$1,775	25,391
	Standard > 5 hap	Q		0	0	100,271	100.271	9	0	100.271	100,271
9	Riddens	30,911	30,911	0	0	0	Ð	0	0	30.911	30 9 I I
9	Pattern Begettern	15.541	15,581	0	đ	0	Û	3	0	15.5\$1	15590

Key:

1 = Lawn and Garden

4 = Recreational Marine

2 = Airport Service

5 = Light Commercial 6 = Industrial

7 = Construction8 = Agricultural

9 = Logging

3 = Recreational Equipment

Church	Harmpester Equipment Type	Disat Let. A	Diens Lav. B	LPG/CNG Lpv. A	LPG/CNG Let. #	4-cycle gas Tav. A	4-cycle gw Lart, B	2-cycle gau Eat. A	2 -sycle gas lov. 9
1	Trimmers/Edgens/Brush Cutters	NA	NA	NA	NA	0.1	13	1.0	Ī.
1	[awanower)	NA	NA	NA	NA	4.0	3.5	4.0	i
1	Losf Blowm/Yecusne	NA	NA	NA	NA	2.0	2.0	2.0	2
1	Rear Engine Riding Mowers	17.0	10.2	NA	NA	9.0	10.2	NA	N
1	Pron Mowers	NA	NA	NA	NA	12.0	13-3	NA	8
t	Chain Seam < 4 bp	NA	NA	NA	NA	NA	NA	2.0	,
ι	Shreddore < 5 bp	NA	NA	NA	NA	4,0	4,0	4,0	4
	Tillara < 5 hp	NA	NA	NA	NA	4,0	4.3	4.0	4
	Lawn and Oarden Tractors	16.0	13.3	NA	NA	t 2.0	13.3	NA	Ň
1	Wood Splittere	58.0	58.0	NA	NA	5.0	5.0	NA	5
1	Spowbiowers	NA	NA	NA	NA	6.0	9.t :	6.0	
	Chippen/Steens Genders	99.0	99.0	NA	NA	62.0	62.0	NA	· · · · · · · · · · · · · · · · · · ·
1	Commercial Terr Bouloment	NA	NA	NA .	NA	13.0	11.4	NA	
1	Other Laws and Garden Equipment	i#.0 i	(EO	NA .	NA	3.0	3.0	3.0	· · · · ·
2	Agonal Support Baulgment	157.0	[37.0	NA NA	NA	48.0	45.0	NA	N
2	Топпаний Таноноги	96.0	96.0	12.0	87.0	82.0	\$2.0	NA	
3	All Termin Vehicles (ATVs)	NA	NA	NA	NA	NA	NA	NA	
3	Menibilan	NA	NA	NA	NA	NA	NA	NA	
3	Off-Road Motorevalas	NA	NA	NA	NA	NA	NA	NA	
-	Qelf Carta	NA	NA	NA	NA.	NA	NA	NA	<u></u>
3	Spownobile	NA	NA	NA	NA	NA	NA	26.0	
<del>,</del> (	Seeclelty Voldclos Carta		NA	NA	NA	NA	NA	NA	<u> </u> ;
<u>.</u>	Versely withhard D.	WA.	NA	NA	NA NA	NA NA	NA	NA NA	
-	Versels and balanced Theorem	A10	NA .	NA.		MA	NA NA	NA	
-	Versite auffert fahre fan i	4 A				17A		17A 1	
	Ventra Wolderbertve Engliste		MA						<u> </u>
•	Bagines					<b></b>			
1	Seiheet Auxillery Outward Engines	NA	NA	NA	MA.	NA	6.0 	NA	
5	Genomics Setia < 50 hp	22.0	22.0	NA	NA	Q.1.)	11.0	61.0	
5	Pennye < 50 hp	23.0	23.0	7.0	7.0	7.0	7.0	NA	
5	Air Compressions < 50 lap	37.0	37.0	NA	NA	0.0	9.0	NA	
5	Gas Compressors < 50 hp	NA	NA	30.0	30.0	NA	NA	NA	
5	Woldens < 30 hap	35.D	35.0	NA	NA	19.0	19.0	NA	<u> </u>
5	Promote Wathers < 50 by	21.0	21.0	NA	NA	7.0	7.0	NA	
6	Antini Life	43.0	35.0	36.0	36.0	36.0	36.0	NA.	<b>i</b>
6	Pochilife	\$3.0	83.0	62.0	62.0	62.0	62.0	NA	<b></b>
	SwappingGersbbwy	97.0	97.0	39.0	39.0	39.0	39.0	NA	
6	Other General Industrial Equipment	107.0	107.0	NA	NA	19.0	19.0	19.0	
5	Other Material Handling Equipment	0,011	£11.0	NA	NA	51.0	51.0	NA	
7	Asphalt Parents	91.0	0,77	NA	NA	310	NA	NA	1
7	ТапретиКелитич	NA	NA	NA	NA	4.0	70	40	1
7	Plain Comparis	6.0	8.0	NA	NA	5.0	5.0	1.0	<u> </u>
<del>-,-</del>	Concrete Pevers	130.0	77.0	NA	NA	NA	NA	NA	<u> </u>
,	Loller.	99.0	99.0	NA	NA	17.0	NA	NA	<u>+</u> -
	Schorp	11.0	2900 D	NA	NA.	NA	NA	NA	<u>+-</u>
,	Paving Bouloment	900.0	09.0	NA	NA NA	7.0	7.0	± 1	┿━───
		77.0	17.0	11/4				+ · <del></del>	<b></b>

# Table 2-04. Inventory A and B Average Rated Horsepower Estimates

### Table 2-04 (Continued)

(1==	Horsepower Equipatent Type	Dissoi Lav. A	Diesei Lav. D	LIPG/CNG Tev. A	LPG/CNG Lav. B	4-cycle gas Lev. A	4-cycle gas Lav. B	2-cycle gas Jaw. A	2-creie gab Int. B
7	Signal Boards	6,0	6.0	NA	NA	8.0	8.0	NA	NA
7	Translate	60.0	27.0	NA	NA	27.0	27.0	NA	NA
7	Bore/Drill Rigs	209.0	209.0	NA	NA	54.0	\$4.0	54.0	54,0
7	Bacavatora	143.0	143.0	NA	NA	60.0	NA	NA	NA
7	Concrete/Industrial Saws	56.0	56.0	NA	NA	13.0	13.0	NA	NA
7	Comment and Mortuz Misson	11.0	11.0	NA	NA 1	7.0	7,0	NA	NA
7	Стален	194.0	194.0	NA	NA	55.0	55.0	NA	NA
7	Gradere	172.0	147.0	NA	NA	NA	NA	NA	NA
7	Off-Highway Trucks	489.0	658.0	NA	NA	NA	NA	NA	NA
7	Crushing/Proc. Equipment	127.0	127.0	NA	NA	60.0	60.0	NA	NA
7	Rough Terrain Forklifts	93.0	84.0	NA	NA	88.0	52.0	NA NA	
7	Rubber Tred Londors	0.82]	(75 <b>.</b> 0	NA	NA	67.0	NA	NA -	NA NA
1	Rubber Tirad Dezero	356.0	356.0	NA		NA	NA	ŇĀ	NA
7	Trectors/Loaders/Beckhors	77.0	71.0	NA	NA	63.0	NA	NA	NA
1	Cruwler Treatons	157.0	134.0	NA	NA	NA	NA	NA	NA
ד ]	Shid Steer Londers	42.0	44.0	NA	NA	33.0	NA	NA	NA
7	Off-Highway Tractors	214.0	214.0	NĂ	NA	NA	NA	NA	NA
7	Dempere Trades	23.0	23.0	NA	NA	9.0	9.0	NA.	NA
Ť	Other Construction Equipment	161.0	161.0	NA	NA	1,50,0	1 50.0	NA	NA
8	2-Wheel Traciora	NA	NA	NA	NA	7,0	7.0	NA	NA
8	Agricultural Tractore	98,0	98.0	NA	NA	87.0	\$7.0	NA	,NA
6	Agricultural Mowers	NA	NA	NA	NA	11.0	ti <b>.0</b>	NA	NA
8	Combia	152.0	192.0	. NA	NA	131.0	131.0	NA NA	NA
8	Serayera	92.0	92.0	NA	NA	24.0	24.0	NA.	NA
	Balare	74.0	98.0	NA	NA	NA	NA	NA	NA
	Tillers > 5 hp	7.0	<u>ف</u> 7	NA	NA	T,Q T	5.6	NA	NA
B	Sentare	79,0	82.0	NA	- NA	106.0	0.801	NA	NA
6	Hydro Power Units	35.0	35.0	NA	NA	14.0	14.0	NA	NA
	Other Agricultural Equipment	57.0	57.0	NA	NA	55.0	53.0	NA NA	ŇĂ
9	Churte Sawe > 4 hp	NA	NA	NA	NA	NA	NA	6.0	6.4
9	Sheeddara > 3 bay	NA	NA	NA	NA	0.8	60	NA	NA
9	Skidders	t <b>90</b> -0	131 <i>A</i>		NA.	ŇA	NA	NA	NA NA
\$	Follow/Bunchers	t <b>\$3.0</b>	169.0	NA	NA	NA	NA	NA	NA
NA + N	fot applicable								

Key:

1 = Lawn and Garden

2 = Airport Service

3 = Recreational Equipment

NA = Not applicable

- 4 = Recreational Marine
- 5 = Light Commercial
- 6 = industrial

- 7 = Construction
- 8 = Agricultural
- 9 = Logging

Class	Land Factors Replaced Type	Diesei Lev. A	Diesei Iav. B	LPG/CNG Lav. A	LPG/CNG Lav. D	4-cycle gan Lav. A	6-cycle gaa Iav. 2	2-cycle gan Inv. A	2-cycle gas Inv. B
<u> </u>	TrimmenyBdgwn/Brush Cutters	NA	NA	NA	NA	36%	36%	50%	50%
ι ι	Lawage wet	NA	ŇA	NA	NA	34%	30%	36%	10%
	Leef Blowers/Vectoring	NA	NA	NA	NA	36%	36%	\$0%	50%
	Rear Engine Riding Mowers	389.	38%	NA	NA	36%	38%	NA	NA
1	Front Marrow	NA	NA	NA	NA	50%	38%	NA	NA
1	Chuin Setel < 4 hp	NA	NA	NA :	NA	NA	NA	50%	50%
,	Shreeddens < 5 hp	NA	NA	NA	NA	36%	36%	16%	16%
, ,	Tillen <5 hp	NA	NA	NA	NA	40%	40%	40%	40%
1	Lawn and Garden Treators	50%	38%	NA	NA	50%	38%	NA	NA
1	Wood Splitters	50%	50%	NA	NA	50%	50%	NA	NA
1	Spowblowin	NA	NA	NĄ	NA	33%	3.5%	35%	154
	Chippen/Stump Grinden	375	379	NA	NA	395	195	NA	NA
	Commercial Turf Berlproent	NA	NA	NA	NA	504	50%	NA	NA
<b>—</b> ,	Other Lows and Garden	50%	50%	NA	NA	30%	50%	.50%	50%
	Equipment						]		
2	Atoma Support Bandgement	51%	519	NA	NA	56%	56%	NA	NA
2	Terminal Transm	82%	42%	78%	7 <b>5%</b> -	78%	75%	NA	NA
3	All Torrein Vehicles (ATVs)	NA	NA	ŇA	NA	NA	NA	NA	NA
3	Misibline	NA	NA	NA	NA	NA	NA	NA	NA
3	Off-Road Memorcycles	NA	NA	NA	NA	NA	NA	NA	NA
3	Goff Carts	NA	NA	ЖК	NA	NA	NA	NA	NA
3	Seconstiles	NA	NA	NA	NA	NA	NA	814	81%
3	Speciality Vehicles Carte	NA	NA	NA	NA	NA	NA	NA	NA
4	Vessele w/Inboard Engine	NA	NA	NA	NA	NĂ	NA	NA	NA
•	Vessela */Outboard Begines	NA	NA	NA	NA	NA	NA	NA	NA
4	Vecente */Stemárive Englace	NA	NA	NA	NA	NA	NA	NA	NA
•	Selfort Auxiliary Internet Baginer	NA	NA	NA	NA	NA	NA	NA	NA
•	Sailbout Anziliary Outboard Enginee	NA	NA	NA	NA	NA	NA	NA	NA
5	Concrator Sata < 50 be	74%	74%	NĄ	NA	68%	68%	68%	68%
<b></b>	Parane < 30 be	744	74%	69%	69%	69%	691	NA	NA
5	Air Compressors < 50 kp	475	48%	NA	NA	56%	56%	NA	NA
5	Gen Consension < 50 kg	NA	NA	50%	60%	NA	NA	NA	NA
5	Walders < 50 kg	45%	4,5%	NA	NA	314	315	NA	NA
5	Pressure Wathers < 50 kg	30%	30%	NA	NA	83%	835	NA	NA
6	Arrial Life	46%	55%	469	46%	40%	46%	NA	NA
6	fontile	30%	30%	10%	30%	30%	30%	NA	NA
6	Swapers/Scrubbers	68%	68%	71%	7(	71%	71%	NA	NA
6	Other General Industrial Boyingment	51%	51%	NA	NA	54%	5496	5496	34%
6	Other Meterial Handling Registration	59%	39%	NA	. NA	53%	53%	NA	NA
7	Analali Pavers	62%	56%	NA	NA	56%	NA	NA	NA NA
<b></b>	Tammara	N.	NA	NA	NA	554	514	15%	5.5%
μ÷-		130	414			544	55%	154	150
<u></u> <u>⊢</u>	Comme Rever	417		.•A	N.4	NA	NA	NA	NA
	Dellere			.18	NA	430		NA	NA NA
<u> </u>	5.018 <b>00</b>	200				NA NA	NA NA	NA	NA NA
<u> </u>		4.19	6076	NA NA		1 100	100		40g
	revus operations	9199	33%	NA NA			450	N.	
. '	Solacul Solabusar	A	E NA	J "^^	1NA	1 1/10	4979		1 00

# Table 2-05. Inventory A and B Typical Operating Load Factor Estimates

# Table 2-05 (Continued)

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]	¢	9	4	9				[]							7			<b>ب</b>	7				,			-1		Ĵ						Ģ I
ŝ										H																				~	4	-		
1 Mp Heable	Et Inny Burchara	Skidden	Strudden > 3 hy	Chailer Server > 4 hp	Other Agricultural Equipment	Kydya Parker Uttilii	Swethern	Tillana > 5 kg	(Fallers)	Sprayer	Combine	Agricultural Momen	Agricultured Theorem	2-Wheel Tractors	Other Conservedon Bentrement	DurapentyTenders	Off-Highmay Transites	Stid Stor London	Crawler Transford	Tractored London of Black history	Rubber Tired Depen	Rubber Three Leaders	Rough Tonnia Potkildu	Crushing/Proc. Experiment	Off-Hightony Truchs	Grader	Crutes	Connet and Mortes Missen	Concrete/Industrial Saws	Вденчиона	BorryDrill Riga	Linkpan	Signal Bourda	Lond Factors Repárator Type
	14	244	NN	NN	214	45%	334	1	385	aor	101	NN.	70	NA	625	306	635	554	50%	55%	199 <b>0</b>	5415	50 <b>%</b>	785	1	414	434	š	DE.	374	739.	7394	429L	Dintel Int. A
	71#	491	NN.	NA	319	47	57	\$	384	2076	705	NA	104	٨N	627	314	11 11 11	13	37.6	365	39%	3496	35%	75%	254	344	134	X	PE4	39-5	107 F	6456	125	
	VN	NN	NN.	Υ.K	Ň	NA	NA	NA	NN	NN	NA	Ň	VN.	NA	NA	NA	NN	NA	NA	NN.	N <sub>N</sub>	٨N	٨N	NN	NA	NN.	NA	NN.	VN.	NN.	YN.	NA	NN.	LPO'CNG LPA A
	٧N	NN	٨N	NN .	NA	NA	AN.	٨N	NA	NN.	VИ	VN.	YN.	٧N	٨N	NA	NN.	NA	NN	NN	YN	YK.	NN	VN.	VN.	¥N.	NN.	VN	٨N	VN	VN.	NA	NA	LPR/CNIJ
ļ	NN.	NA	100	NA	201	Xex	8°¢5	7194	NA	207	745	485	62%	629	17	4195	NA	188	NN.	5	NA	349	- 634	55%	NA	VN	174	<b>1</b> 66	784	53%	79	144	764	4-cycle gan Lav. A
	VN.	NA	<b>1</b> .0K	VH	534	56 <b>%</b>	3216	104	NA	100	74%	<b>1</b>	625	62%	43%	414	NN	AN.	AK.	NA	NA	NA	469	1888 1	AN.	NN NN	475	394	1561	NN	794	0	764	4-cycle gas Inv. 3
i	нл	NA	N'A	22	٨٨	NN	ž	Ň	NA	NN.	NN	NN.	ž	NA	NN.	NN	V.S.	NA	NN	NN	NN	NN	NN	٨N	NA	NA	NN .	٨ĸ	NN.	NA	261	NA	٨N	Z-cycle gay Lars A
	NN.	٨N	VN	100	NA	NA	NN.	NN	NN.	NN	YN	AN.	NA	NN	VN.	YK	YK	<b>VN</b>	NN	NN.	NN	NN	NN.	٨N	NA	VN.	ΝK	×,	VN	VN.	<b>1</b> 66.0	<b>VN</b>	NN.	Jerycle gen Lav. D

Key

NA = Not applicable

1 = Lawn and Gurden 2 = Airport Service 3 = Recreational Equipment

4 = Recreational Marine 5 = Light Commercial 6 = Industrial

7 = Construction 8 = Agricultural 9 = Logging

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### Table 2-06. Inventory A and B Annual Use Estimates

			· · · · · · · · · · · · · · · · · · ·						
	Hours'Year (* = Gallens'Year) Equipment Type	Diesel Env. A	Diesei Lav. B	LPG/CNG Lav. A	LPG/CNd Zev. B	4-cycle gas Lov. A	4-cycle gan Env. B	2-cycle gas Eart A	2-cycle gas Jaz. B
1	Trimmers/Edgers/Brush Cathers	NA	NA	NA	NA	8-21	19-19	8-21	L <b>9</b> -19
1	Lawarative	NA .	NA	NA	NA	27-73	33-49	33-91	41-51
1	Leaf Blowers/Vacuums	NA	ŇA	NA	NA	7-30	25-25	7-20	25-25
	Rear Engine Riding Movers	22.50	28-45	- NA	NA	22-50	2845	NA	NA
1	Front Mowers	NA	NA	NA	NA	25-46	28-45	NA	УA
1	Chaim Sevel < 4 bp	NA	NA	NA	NA	NA	NA	13-21	23-23
1	Stueddere < 5 tep	NA	NA	NA	NA	3-5	75-75	3.5	3.5
1	Tillers < 5 hp	NA	NA	NA	NA	16-25	27-31	16-25	27-33
1	Lawn and Garden Transora	173-340	37-340	NA	NA	33-65	35-65	NA	NA
1	Wood Spilmers	64-93	64-95	NA	NA	18-27	16-27	NA	NA
1	Seawblowers	NA	NA	NA	NA	8-1 <b>8</b>	5.18	8-10	8-18
1	Chippens/Sterray Orindess	367-52.5	367-523	NA	NA	385-551	386-551	NA	NA
1	Commercial Twif Soulpoint	NA	ŇA	NA	NA	410-931	4 (0-931	NA	NA
i i	Other Laws and Garden	101-197	101-197	NA	NA	14-28	i4-20	14-28	14-28
	Bqutpremt								
2	About Support Equipment	651-856	651-456	NA	NA	606-797	606-797	NA	NA
2	Terminal Tractore	1001-1433	1061-1433	711-943	7t1-943	711-943	711-943	NA	NA
,	All Termin Vehicles (ATVs)	NA	NA	NA	NA	<b>#1-142</b>	9-[3	88-142	9-11
3	Minfolium	NA	NA	NA	NA	25-67	9-15	NA	NA
3	Off-Read Motoreysian	NA	NA	NA	NA	62-139	9-15	62-139	9-15
	Gelf Carte	NA	NA	NA	NA	637-1231	637-1231	637-1231	637-1231
,	Snowmobiles	NA	NA	NA	NA	NA	NA	77-189	90-99
,	Specialty Volucies Carts	370-496	370-496	NA	NA	55-74	55-74	33-74	55.74
-	Vessela w/Inboard Enginala < 250 hp <sup>a</sup>	343-959	100-1113	NA	NA	157-524	93-637	NA	NA
4	Verseja w/Outboard Bogines*	NA	NA	NA	NA	<del>69</del> -134	63-213	110-214	63-213
4	Vossals w/Sterndrive Engineer	NA	NA	АК	NA	206-576	164-416	NA	NA
4	Sailtont Auxiliary Inboad Beginser*	17-50	12-102	NA	NA	9-28	19-55	NA	NA
4	Selfbost Asziliary Outcomi Enginee*	NA	NA	NA	NA	44	2-54	7-14	2-54
t	Oevenmor Sera < 50 hp	345-483	345-443	NA	NA	117-164	117-164	117-164	£17-164
5	Parapet < 50 hp	31 <b>2-481</b>	318-484	175-267	175-267	175-267	175-267	NA	NA
5	Air Compressors < 50 hp	395-954	595-954	NA	NA	353-566	353-566	NA	NA
5	Ges Compression < 30 kg	NA	NA	\$500-\$500	8500-8500	NA	NA	NA	NA
• •	Weidara < 30 kp	418-759	418-759	NA	NA	135-245	135-245	NA	NA
,	Pressure Weekare < 50 kp	93-183	93-183	NA	NA	74-145	74-145	NA	SA
6	Annial Life	265-407	2013-2587	249-343	2053-2587	249-383	2053-2547	NA	NA
6	Forklifts	1513-1751	850-850	1602-1654	850-850	1602-1854	\$30-\$50	NA	NA
6	Sweepers/Scrubbers	1183-1318	1183-1318	501-557	501-357	501-557	501-557	NA	NA
6	Other General Industrial Equipment	571-1089	571-1089	NA	NA	463-884	463-884	463.884	463-884
6	Other Material Handling Equipment	366-463	366-463	NA	NA	336-425	336-425	NA	NA
7	Asphalt Payora	334-646	594-1016	NA	NA	255-404	NA	NA	NA
-;-	Тепрета/Конзиста	NA	NA	NA	NA	110-186	10-185	110-186	110. 86
7	Ріне Сопреснога	286-610	286-010	NA	NA	98-209	98-209	98-209	94,279
7	Concrete Pavers	\$34-854	194-1016	NA	NA	NA.	NA	NA	NA
T	Rollers	454-775	647-1016	ŇA	NA	179-646	NA	NA	NA
			der sole				114		

Nonroad Engine and Vehicle Emission Study

# Table 2-06 (Continued)

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3	Houndfear (* = (adioundfear) Equipment Type	ľ		LPG/CNG Lef. A	LINGICNG Line, B	ر دند هم دند به	4-gride get	2-cycle man	2-crick gan	
	Screpces	667-1024	667-1647	YN.	¥2	<b>V</b> N	NA NA	Y.	¥8	
	Paving Equipmont	348-722	111-111	<b>V</b> N	NN N	<b>507-56</b>	507-16	94-203	697.1%	
1	Surfaciang Belaipmen	¥2	VN	N.N	42	218-912	278-512	V N	¥2	
	Signal Boards	449-97E	448-976	NN	٧ĸ	133-269	135-289	NA	٧ĸ	_
[	Tractors	409-602	E66 192	NN	YN.	277-442	100-0	¥¥	¥	_
[	Born/DelD Righ	261-150	261-350	NA.	NN	内 - 今	R0-138	60-126	80-126	_
	Eucarrettors.	116-665	1051-1358	N N	VN.	261-401	NA.	¥.	47.	_
	Constantinductrial Serve	400-603	500-00e	MA	VN	769-127	421-634	YZ	٩N	_
Γ.	Constat and Mortee Millers	(57-305	157-203	¥Ν	ЧY	16-17	11.93	ž	٧N	
	Creater	628-414	1 (F-62)	NA	٧N	61 <del>7</del> -92£	614-425	٧N	ž	_
[	Onder	\$91-837	611-11 <del>1</del> 0	A M	MA	ž	٧N	VN	¥۲.	_
	Off-Highway Tranks	1149-1871	1149-3931	N.	NA.	N.N	NN	ž	N.	_
	CrutingProc. Bquipment	392-1165	2011-1265	YN.	¥N.	149-294	102 01	4	¥.	_
Γ_	Rough Tensin Foridita	410-775	1201-299	Y N	¥ Z	194-957	NN.	¥,	ž	
	Rubber Tred Loaders	624-850	1191-1547	¥N.	YN.	4/30-394	NA	٧N	YK.	_
	Rubber Tred Doore	101-110	NO1-149	NA	VN.	N.	¥N	YN.	NA	_
	Tream for dary Becklose	772-1209	154-659	VN.	NN	114-166	¥	ž	YN.	_
	Cowier Triation	695-1067	2211-128	VV.	NN	YN	¥¥.	ž	Y N	
	Skid Steer Lowins	524-659	062-519	NN	VN	905-961	NA	VN.	YZ	
	Off-Higherty Tractors	266-977	766-911	MM M	NN.	VN.	NA	VN.	¥۲	
	Durpmericanters	266-685	1166-685	NN.	YN	\$0-12T	60-134	YN	XX	
<u> </u>	Difteer Construction Biguipment	N19-115	103-111	YN	¥.	237-382	297. JH2	VN	12	
F	2-Wiggel Traction	ž	NA	XX	NA.	975-121	177-346	۲N	٧N	
Η	Agricultural Treaton	309-542	309-342	NA	NA	334-627	131-027	Ź	V N	_
	Agricultural Movern	VN N	٧N	NA	NA	062-28	62-23	٧N	NA NA	
	Combine	<b>981-1</b> 22	74-196	NA	NA	61-139	. 651-19	YN	٧N	
Η	Sprayara	53-121	121-55	NA.	NA.	101-14	47-107	YK.	AN.	
	Baltre	23-142	306-306	YN.	NA	Y N	NA	VN	¥K.	
t-	Tibon > 5 kg	442-681	61-0 <b>4</b>	NN.	NA.	47-72	1642	VN N	Y N	
H	Switter.	<del>66</del> 1-75	665-001	¥ N	٧N		0-100	VN.	NA	_
H	Hydro Power Units	605-230	60-E0	NA N	HA	507-70E	50-03	NA.	NA	_
	Other Agricultural Berlpowerk	CST-9C2	236-446	NA.	<b>NN</b>	<b>T</b> ]-12	TT-148	VN	<b>V</b> N	
	Chaits Same > 4 hp	VN	NN.	NA	NA	VX.	74	12-24	105-401	_
	Sindim >3 he	NA.	NA	НA	NA	154-132	7\$-75	٧N	¥4	
	Silder.	6141-965	994-1454	NA	NA	N.	NA	VX X	NA	_
-	Pillsen/Durcher	1971-088	1467-1467	NN.	٩N	٧N	٧N	VN	¥K.	_
Ţ,	ot upplicable					1				

\* = Velues reported are gallocatjeer - not inversioned

Key:

L = Lawn and Garden
 2 = Airport Service
 3 = Recreational Equipment

NA = Not applicable

4 = Recreational Marine 5 = Light Commercial 6 = Industrial

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November 1941

### Table 2-07. Emission Factors for Inventories A and B

### a. DIESEL EQUIPMENT (grams/hp-hr)

		1		1	łC						
Cless	Equipment Types		<b>R</b> x <b>haus</b> t	Creak	E-mp*	Refailing	co.	NOx	PM	Aldehydes	<b>\$</b> 0,
1	Telmmera/Edgera/Brush Cuttere		NA	NA	NA	NA	NA	NA	NA	NA	NA
1			NA.	NA	NA	NA	NA	NA	NA	NA	NA
· ·	Less Blowers/Vecaures		NA	NA	NA	NA	NA	NA	NA.	.NA	NA
L	Rear Engine Riding Movers		1.20	0.02	NA	0.005	<b>5.00</b>	8.00	t.00	0.06	0.91
I	Front Mowern		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Chuin Sawa < 4 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Shroddors < 3 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Tillera < 3 hp		NA	NA	NA	NA	NA	NA	NA	NA	SA
	Lawn and Garden Trectors		1.20	0.02	NA	0.005	5.00	90.8	1.00	0.06	0.93
1	Wood Splitters		1.20	0.02	NA	0.003	5.00	8.00	1.00	0.05	0.93
1	Snowblowma		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Chippers/Stamp Grinders		1.20	0.02	NA	0_003	5.00	00.8	1.00	0.06	0.93
i	Commercial Terf Benipment	1	NA	HA	NA	NA	NA	NA	NA	NA	NA
1	Other Laws and Garden Equipment	[	1.20	0.02	NA	0.005	3.00	8.00	1.00	0.06	0.91
2	Aircraft Support Benjamore		1.57	60.03	NA	0,003	6.06	14.00	1.60	0.06	0.93
2	Terminal Tractory	•	1.57	0.03	NA	0.003	6.06	14.00	1.60	0.06	0,93
3	All Termin Yshieles (ATYs)	1.	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Minfbike	•	NA	NA	NA	ŇA	NA	NA	NA	NA	NA
3	Off-Road Motorcycles	•	NA	NA	NA	NA .	NA	NA	NA	NA	NA
3	Golf Carte	•	NA	NA	NA	NA	NA	NA	NA	NA	- NA
3	Snowmobiles		NA	NA	NA	NA	NA	NA	SA.	NA	SA
3.	Specialty Vehicles Carts	•	1.20	0.02	NA	0.350	5.00	90.8	1.00	0.06	0 93
•	Vecesia w/Inboard Engines	••	24.39	NA	NA	0,040	37.01	172.49	10.89	0.92	12.20
•	Venuela w/Dutboard Engines	••	24.39	0.49	NA	0.000	37.01	172.49	10.89	0.92	12.20
4	Vennels w/Steendrive Enginee	••	24.39	NA	NA	9,008	37.01	172.49	10.89	0.92	12.20
•	Selfore Auxiliary fabourd Engine	**	122,45	NA	NA	0,040	217.72	163.29	10.89	0.92	12.20
•	Seifbool Auxiliary Outboard Engine	**	122.45	2,45	NA	0,040	217.72	163.29	10.89	0,92	12.20
5	Generator Sets < 50 hp		1_20	0.02	NA	0.003	5.00	8.00	t. <b>00</b>	0.06	0.93
5	Pumps < 50 hp		1.20	0.02	NA	0.003	\$.00	8.00	1.00	0.06	0.91
,	Air Compression < 50 hp	Ī	1.20	0.02	NA	0.003	5.00	80.H	1.00	0.06	15,94
5	Our Comprision < 50 bp	]		NA	NA	NA	NA	NA	NA	NA	NA
2	Weiden < 30 hp	1	1.20	0.02	NA	0,003	5.00	8.00	1.00	9.06	0.43
,	Pressure Westers < 50 hp		1.20	0.02	NA	0.003	5.00	8,00	1.00	0.06	0.93
6	Acrial Lifts	•	1.57	0.03	NA	0.005	6.06	14.00	t.60	0.21	0.53
6	Parkitfa	•	1.57	0.03	NA	0.003	6.06	14.00	1.60	0\$1	eja v
6	Swaepers/Serabbera	•	1.57	0.03	NA	0.003	6.06	14.00	1.60	0.21	19.95
6	Other General Industrial Equipment	•	1.57	0.03	NA	0.003	6.06	4.00	1.60	0 2 I	0.01
6	Other Material Handling Benippent	1.	1.57	0.03	NA	0.003	6.06	14.00	1.60	9.21	ղու
,	Asphalt Paren		0.60	0.01	NA	600.0	3.20	10.30	0.90	0.20	nar
7	TamperaRemmers	1	0.00	0.00	NA	NA	00.0	9.00	0.00	0.00	6.00
7	Plate Compactors	<u>†                                    </u>	0.89	0.02	NA	9,007	3.10	9.30	0.90	9.20	0.92
7	Concrete Pavers		1.10	0.02	NA	0.005	72.4	t0.02	0.90	0.20	ų ar

### Table 2-07a, (Continued)

					нс						
Class	Equipment Types		Exhausi	Creek	E-mp*	Reforming	CO	NOt	PM	Aldehydes	sor
7	Rafters	[	0.80	0.02	NA	0,003	3.10	9.30	0.78	0.20	1.20
7	Sempera	•	0.70	10.0	NA	0.003	5.00	5.70	(.26	0.26	0.99
7	Paving Basipment		1.01	0.0 <b>7</b>	NA	0,003	4,60	11.01	0,90	0.20	0.90
7	Surfacing Equipment		000	0.00	NA	NA	0.00	<b>00</b> .0	0.00	0.00	0.00
7	Signal Bounds		1.20	0.02	NA	0.007	5.00	8.00	1.00	0 20	0.93
7	Trenchera	•	1,54	0,03	NA	0,003	9.14	10.02	1,44	0.20	0,91
7	Bore/Deill Rige		1.41	0.03	NA	0,003	9.20	11.01	1.44	0.20	0.97
7	ELELTING	•	0.70	0.01	NA	0,003	5.20	10.75	1.44	0.20	0.93
7	Concerce/Indentrial Saws	•	1.41	6.03	NA	0,003	9-20	11.01	1.44	0.20	0.93
7	Constit and Morter Misses		1.91	20.0	NA	0,005	4.60	11.01	0.90	0.20	0.93
7	Crone	•	1.26	£QLD	NA -	0,003	4.20	10.30	1.44	0.20	0.93
1	Gradern		1.54	0.03	NA .	0.003	3.80	9.60	1.00	0.12	0.97
7	Off-Highway Tracks	•	0.84	0.02	NA	0.003	2.80	9,60	0.90	0,22	0.99
7	Crushing@roc. Equipment	•	I.K.	0.03	NA	0.003	9.20	11.01	L,44	0.20	0.93
7	Rough Terrein Forklifts	•	1.64	0.03	NA	0,005	10.00	1.00	1.60	0.20	0.93
1	Rubber Tired London		0.84	0.02	NA	0.009	4.30	10.30	1.29	0.20	0. <b>56</b>
1	Rubber Tired Dotent	•	0.84	0.02	NA	0.003	2.80	9.60	0.66	0.16	0.93
ד	Transvel.oaders/Beckhow	-	1.40	6.03	NA NA	0,003	6.80	10.10	1.05	0.10	0.85
Ť	Crawler Treators	•	1.26	0.03	NA	0,003	4,30	10,30	1.11	0.17	0.85
	Skid Smer Londers		2 10	0.04	NA	0.003	9.00	9.60	1.44	0.20	0.95
7	Off-Highway Tractors		2,46	0.05	NA	0,003	14.6	11.91	2.03	0.20	0.93
7	Dumptre/Tenders	•	0.84	0.02	NA	0.005	2.80	9.60	1.44	0.20	0.89
7	Other Construction Equipment	•	1.41	0.03	NA	0.003	9_20	11.09	T.44	9.20	0.93
8	2-Wheet Tractors		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Agriceland Tractors	•	2.23	0.04	NA	0,003	8.94	11.21	2.05	0.34	0.87
5	Agricultural Mowers		NA	NA	NA	NA	NA	NA	NA	NA	NA
-,	Combinet	•	1.26	0.03	NA	0,003	4.20	11.50	2.42	0.30	0.92
	Sprayers		2.23	0.04	NA	: 0.003	3.78	7.78	1.51	0.30	0.92
•	Baim	<u> </u>	2.23	0.04	NA	0.003	3.76	7.70	1.51	96_0	0.92
5	Tillion > 3 kg		1.20	0.02	NA	0,007	3.00	8.00	1.00	0.06	0.92
	Swelmen		0.90	0.02	NA	0.003	2.10	11.30	1.51	0.30	0.92
	Kydro Power Units		2.23	0.04	NA	Etan, O	3.78	7,74	اك إ	0.30	0.92
8	Other Agricultural Equipment		1,#2	0.04	NA	0.003	4.37	11.12	1.31	0.30	P 92
<u>,</u>	Chanta ≥ 4 hp.		NA	NA	NA	NA	NA	NA	NA	NA	NA
,	Skreddara > 5 hp	<u> </u>	NA	NA	NA	NA	NA	NA	NA	NA	NA NA
	Skidden	•	0.54	20.0	NA	0.003	1.20	11.30	1.44	2.20	n 94
9	Feilers/Bencharn		0.84	0.02	NA	0.000	1.20	11.30	1.44	0.20	0.94
-			L	t		<u> </u>		1.1.54		1	

Evep\* = g/day

enr.

\*\* g/gallon

s = Exhaust RC. CO, and FM adjusted for transient speed and/or respirat load operation NA = Not applicable

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# Table 2-07. (Continued)

# b. GASOLINE 4-STROKE EQUIPMENT (grams/hp-hr) Not Adjusted for In-Use Effects

ſ			Ĭ		HC						
Class	Bquipment Types		External	Crank	Evap*	Refeeling	со	NOx	РМ	Aldehydes	so,
1	Trimmen/Edgers/Brush Cutara		24.19	7.9 <b>8</b>	0.54	21.98	393.34	2.92	9.41	0.53	0.37
ī	Lewnmowers		37,70	12.44	1.16	R.60	430.00	2. <b>02</b>	0.74	0.53	0 37
1	Leaf Blowers/Vacuums		(9.40	6.40	0.61	5.51	380.30	2.03	0.29	0.53	D,37
1	Reer Engine Riding Mowers		9_30	3.07	3.30	3.21	3\$3.00	2.03	0.05	0.24	0.37
1	From Mowers		9.30	3.07	18.60	1.30	353.00	2.03	0.05	6,24	n yî
1	Chain Sawa < 4 hp	i	NA	NA	NA	NA	NA	NA	NA	NA	NA
I	Shreedere < 5 hp		37.70	12.44	1.75	7.68	430.00	2.82	0.74	n 53	n 37
ι	Tilleen <5 hp		37.70	12.44	1.35	9,59	430.00	2.02	0.74	(L0	0,87
1	Lawn and Garden Treeses		9.40	3.10	7.13	1.84	354.00	2.11	0.10	0.24	0.37
L	Wood Splitters	:	37.70	12.44	L.16	5.50	430.00	2.02	0.74	0.53	0.37
L	Snewblowers		37.70	12.44	2.50	5.82	430.00	2.02	0.74	0.53	0.37
1	Chippers/Stump Orinders		37.70	12.44	94.85	0.42	430.00	2.02	0.05	0.53	0.37
1	Commercial Torf Equipment		9,40	3.10	15.50	1.38	354.00	2.t1	0.10	0,24	0.37
1	Other Lawn and Danken Equipment		37.70	12.44	1.16	8.60	430.00	2.02	0.05	0.53	0.37
2	Aircreft Support Equipment		6.68	2.20	73,44	0.44	199.00	5,16	0.06	0.27	0.27
2	Terminal Tractors		6.68	2.20	17.13	0.32	199.00	5,16	0.06	0.22	0.27
3	All Terrain Vehicles (ATVs)	•	100,00	13.00	6.00	31.15	975.00	9.00	1.15	1.18	n 57
±.	Mindbikes	•	100.00	33.00	1.50	21.68	975.00	9.00	4.15	1.18	0.55
,	Off-Read Motorcycles		100.00	31.00	6.00	30.92	975.00	9.00	1.15	1.14	0.55
3	Golf Certe	•	100.00	33.00	18.00	5,44	975.00	9.00	1.13	1.18	0.55
3	Snowmobiles		NA	NA	NA	NA	NA	NA	NA	NA	NA
,	Specialty Vehicles Carts	•	100.00	33.00	28.00	7,04	975.00	9.00	1.15	1.15	0.55
4	Vessels winboard Engines	••	12.46	NA	260.10	5.13	1214.03	45,79	0.74	3.07	2.90
4	Venets w/Outboard Engines	h	87.71	28.94	NA	8.75	1421.95	66.58	0.74	3.07	2.90
4	Vessels w/Storndate Carsing		72.46	NA	63,00	5.26	1214.03	45.79	0.74	3.07	7.90
4	Seillerst Augultury folgoerd Brachete		72.46	NA	18.00	8.75	1214.03	45.79	0.74	3.07	2.90
	Seilbart Augiliery Outboard Bagines		<b>\$7.7</b>	28.94	NA	8.75	1421.95	56.58	0.74	3.07	2.90
4	Generator Sets < 50 bit		9.50	3.14	3.06	3.45	353.00	2.03	0.05	0.22	0 27
	Pursue < 50 hp		9.50	3.14	1.25	6.33	353.00	2.03	0.06	0.22	1 21
-	Att Compression < 50 kp		9.50	3.14	1.30	3.20	353.00	2.03	0.06	0.22	0.27
-	Gen Commission < 50 hp		NA	NA	NA	NA	NA	NA	34	NA	NA
5	Watters < 50 hp		9.50	3.14	9,71	1.72	113.00	2.03	0.06	0.2Z	0.27
	Pressure Washers 2 63 has		9 50	3.14	2.54	611	333.00	2.03	0.06	0.27	0.17
	Amint 1 iAu		4.40	7 10		0.49	109.00	114	0.04	0.22	0.17
			40.0	220	34.00	0.49	[00.04	4 16	ante	1 22	0.17
a 6	6		6 6 F	1 2.20 7.70	50.00	0.49	100.00	116	0.00	n ??	p.27
	Other Connert Setuction Services		6.68	2.20	29.07	0.00	- 100 494	4.14	0.06		h
	Orders Managine Internations Configuration	<u> </u>	0,04	2.10	79.01	0.42	100.00		1.114	0.22	<u> </u>
<u> </u>	touter maneral runding coupment		0.08	4.40	17.47		100.00	4.70	0.04	,	1 114
<u> </u>	T De con		6.44			0,43	196,09	4.77	0.04	0.11	
	Leonperny X Antonii 75	<b> </b>	0.49	414	4.81		198.00	4.14	0.00	0.22	
7	Plain Comparison	┣	PA8	2.14	1	5.34	198.00		80.08	0.12 N 4	1 · · ·
	Concrete Pavera	<u> </u>		NA NA	NA - 42		NA				1 112
17	Kollan		925	3.05	1 9.00	1.61	202.00	5.28	0.06	0.26	1

### Table 2-07b. (Continued)

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	·			HÇ						'
Case	Equipment Types	Rzhawi	Creat	Evap*	Refaeling	<u>co</u>	NO	PM	Aldehydes	50 g
7	Screptio	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Paving Boulpress	6.49	2.14	3.00	5.02	198.00	4.79	0.06	0.22	8 25
7	Surfacing Equipment	6.49	2.14	3.00	4.84	DQ.891	4.79	0.06	0.22	0.25
۲ ۲	Signal Boards	6,49	2.14	3.06	4.94	198.00	4.79	0.06	0.22	0.25
7	Trenchere	6.49	2.14	. 7.69	2.94	198.00	4.79	D.D <b>6</b>	0.22	0.25
7	Bare/Detil Rigs	5.49	Z.14	52.62	0,42	198.00	4.79	0.06	0.22	0.29
7	Exervited	6.49	2.14	122.40	0.42	199.00	4.79	0.06	0.22	0.25
7	Concrete/Industrial Saws	6.49	2.14	4.13	2.74	198.00	4.79	0.06	0.22	0.25
7	Country and Mostar Miners	6,49	2,14	3.75	4.09	(98.00	4.79	0.04	0.22	0.25
7	Степлен	6.49	2.14	\$4.15	0.42	195.00	4,79	0.06	0.22	0.25
7	Graders	NA	NA	NA.	NA NA	NA	NA	NA	NA	NA
7	Off-Highway Trinks	ŇA	NA	×.	NA	NA	NA	NA	NA	NA
7	Crushing/Pres. Bestpromt	6.49	2.14	91.00	0.42	198.00	4.79	80.0	<i>0.22</i>	0.25
7	Rough Torrein Postliffs	6.49	Z.14 -	134.64	0.42	198.00	4.79	0.06	0.22	0.71
7	Rubber Thest London	3.56	(L)	102.51	9.42	163.00	5,42	0.06	0.21	0.24
7	Rabber Tired Desers	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Transver[Londors/Seckboss	5.49	2.14	96.39	0.42	196.00	4.79	0.06	0.22	0.25
7	Crewler Tractors	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Skid Same London	6.49	2.14	25.01	0.44	198.00	4.79	0.06	0.22	0.25
7	Off-Highway Tractors	NA.	NA	NA	NA	NA	NA	NA	NA	NA
7	Dumpers/Conduct	6.49	2.14	9.00	1.74	198.00	4.79	0.06	0.22	0.25
7	Other Construction Equipment	6.49	2.14	229.50	0.41	196.00	4.79	0.06	0.22	0.25
8	2-Wheel Tractore	5,49	1.81	7.13	2.69	(43.00	6.62	0.06	00	0.23
5	Agricatorel Tractore	5.49	181	133.11	0.42	143.00	6.62	0.05	0.30	6.23
8	Agricultural Mowers	7.18	2.37	\$.0T	1.84	215.00	5.24	0.06	0.22	0.2R
	Combine	7.18	2.37	200.43	0.41	218.00	5.24	0.06	0.22	0.28
-	Sprayers	7.18	2.37	4.50	1.39	218.00	3.24	0.06	0.22	0.28
1	Balan	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Tillers > J iy	37.70	12.44	3.63	4.38	430.00	2.02	0.74	0.22	0.37
1	Swatters	1.18	2.37	162.12	0.42	218.00	5.24	0.06	0.22	0.28
	Hydro Power Units	7.18	2.37	15.90	1.40	218.00	5.24	0.05	0.22	0.28
	Other Agricultural Benigment	7.14	2.37	\$4.15	D.42	218.00	5.24	0.06	0.22	0.25
9	Chebs Same > 4 bp	NA	NA	NA	NA	NA	NA	NA	NA	NA
9	Shredden > 5 bp	9.30	3.07	3.00	5.02	353.00	2.02	0.03	0.24	0.11
9.	Strider.	NA	NA	NA	NA	NA	NA	NA	NA	NA
•	Polers/Bergberg	NA	NA	NA	NA	NA	NA	NA	NA NA	NA
Event = a	/day	4			<u> </u>		•	•	*** <u>*</u>	

NA - Net applicable

### Table 2-07. (Continued)

### c. GASOLINE 4-STROKE EQUIPMENT - (grams/hp-hr) Adjusted for In-Use Effects

Cross         Registrest Type         Extents         Crost         Serget         Respecting         CO         VO.         PM         Attrivies           1         Trinservillagenet/Reine/Cuters         b         50.78         7.78         0.54         21.08         747.33         0.81         1.48         0.933           1         Lastings were         b         79.77         12.44         1.30         6.60         6.01         0.81         0.81         0.81         0.931           1         Learding were         b         19.33         3.07         3.30         3.21         670.76         0.81         0.18         0.24           1         New Moneys         b         19.33         3.07         1.30         670.76         0.81         0.18         0.24           1         Stondard         c         NA			F			ЯC						
I         TrimmendEdgene@exah Conters         b         20.78         7.79         0.54         21.08         74.735         9.81         1.48         0.53           I         Lavingsovert         b         77.77         12.44         1.16         6.66         6100         0.81         2.64         0.63           I         Loof Movert/Vaccom         b         40.73         3.27         3.20         3.21         670.70         0.81         0.18         0.24           I         From Moverty         b         19.33         3.27         1.86         1.10         670.70         0.81         0.18         0.24           1         From Moverty          b         79.71         12.44         1.38         670.70         0.81         0.18         0.24         0.35           1         Strender         b         79.17         12.44         1.38         9.39         817.00         0.81         2.66         0.53           1         Lawn and Graden Trietrey         b         79.17         12.44         1.45         6.04         399.00         2.02         0.03         0.35           1         Connecold Trategenere         b         79.17         12.44	Class	Equipment Types		Exhaust	Crunk	Втар*	Reflecting	C0	NOL	em.	Aldebydez	50,
1         Lasnansern         is         70.17         72.44         5.16         6.60         617.00         0.81         2.45         0.931           1         Rent Blowern("sexuan         is         40.74         6.60         0.81         70.27         0.81         1.04         6.931           1         Rent Blowern ("sexuan"         is         1.933         3.07         1.8.60         1.30         670.70         0.81         0.18         0.14           1         Chain Sawa         <4 Ap         NA	I	Trimmers/Edgers/Break Cutters	b	50.78	7.98	0.54	21.98	747.35	D. <b>Š</b> I	1,48	0.53	0,17
Leef Blowers/Varuan         b         40.74         6.40         0.41         6.41         722.37         0.41         1.04         0.53           1         Kerr Engior Ridge Mawers         b         15.55         3.07         3.30         53.21         670.70         0.81         0.18         0.24           1         From Maser         b         19.33         3.07         13.40         1.10         670.70         0.81         0.18         0.24           1         Chin Saw         <4.4 p	E	LANDOWER	ь	79.17	12.44	1.16	8.60	\$17.00	. 0. <b>8</b> 1	2.66	FLA	0,17
I         Rure Engliss Riding Mouvers         b         19.33         3.07         3.30         3.21         670.76         0.81         0.15         0.24           1         From Mouvers         b         [19.3]         3.07         18.00         1.13         670.76         0.81         0.16         0.24           1         Chain Seve          AN         NA	L	Leef Blowers/Vacuums	Ъ	40.74	6.40	0.61	6,61	722.37	0.81	1.94	0.53	0,17
From Maxem         b         19.33         3.07         14.60         1.10         670.70         0.81         0.18         0.24           1         Chain Save         < 4 Ap	·	Reir Englise Riding Mowers	6	19.53	3.07	9710	3.21	670.70	0.81	0.18	0.24	0.37
1         Chain Sawa         < 4 kp         NA	1	Front Mowers	6	9.53	3.07	18.60	<b>9L</b> 1	670.70	0.BL	Ð.E <b>S</b>	0 24	6.37
Specklar   < <t< td=""><td>1</td><td>Chain Sawa &lt; 4 hp</td><td></td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>SA</td><td>NA</td><td>NA</td></t<>	1	Chain Sawa < 4 hp		NA	NA	NA	NA	NA	NA	SA	NA	NA
1       Tilses       < 5 hp	1	Shyreddana < 5 hap	ь	79.17	12.44	1,75	7.68	\$17.00	r <b>k</b> .0	2.66	0.53	4,37
Lawn and Garden Trestor         b         19.74         3.10         7.13         1.84         672.60         0.84         0.26         0.26           1         Wood Spinser         b         79.17         12.44         1.16         6.60         817.00         0.81         2.66         0.53           1         Snowblower         b         79.17         12.44         94.86         0.42         597.00         0.81         2.66         0.53           1         ChapterodTump Orbiders         c         19.74         3.10         15.50         1.18         672.60         0.84         0.36         0.24           1         Other Lawn and Garden Equipment         b         19.74         3.10         15.50         1.18         672.60         0.84         0.36         0.32           2         Comparcial Turf Equipment         b         19.74         3.10         1.50         1.86         0.81         0.31	1	Tillera < 5 hp	ь	79.17	12.44	t.38	9.39	8(7.00	0,81	2. <b>66</b>	0.53	6.07
None         Spectra         b         79.17         12.44         1.16         8.00         917.00         0.81         2.60         0.53           1         Snowtkower         b         79.17         12.44         2.50         5.82         817.00         0.81         2.66         0.53           1         Cheppeng/Amp Orbider         c         56.55         12.44         94.86         0.42         379.00         2.02         0.05         0.53           1         Cheppeng/Amp Orbiders         b         19.74         2.14         1.16         8.60         817.00         0.81         0.18         0.52           2         Alreaft SupportEner         b         19.74         7.244         1.16         8.60         817.00         0.81         0.18         0.52           2         Alreaft SupportEner         c         10.02         2.20         17.13         0.52         258.70         5.16         0.06         0.22           3         Altrent SupportEner         -, b         210.00         33.00         6.00         20.92         1.15         1.14           3         Minibitim         -, b         210.00         35.00         1.50         21.62         3	1	Lawn and Garden Treeton	6	[9.74	3.10	7,13	1.84	672.60	0.84	0.36	9.24	0.17
Instruction         b         79.17         12.44         2.50         5.42         817.00         0.61         2.66         0.51           1         Chippent/Shurp Orights         c         50.53         12.44         94.86         0.42         59.00         2.02         0.05         0.53           1         Commercial Tarl Equipment         b         19.74         3.10         15.59         1.18         672.60         0.84         0.36         0.24           1         Other Lawn and Gertion Equipment         b         79.77         12.44         1.16         8.60         817.00         0.81         0.18         0.38         0.22           2         Terminal Tantors         c         10.02         2.20         77.44         0.048         238.70         3.60         4.14         1.18           3         Minibras         c         10.02         3.20         6.00         31.13         1852.00         3.60         4.14         1.18           3         Off-Road Materryohn         ~, b         210.00         33.00         16.00         3.42         1852.50         3.60         4.14         1.14           3         Off-Road Materryohn         ~, b         210.00	1	Wood Selman	ь	79.17	12.44	1.16	8.60	817.00	18.0	2.66	0.53	8.J7
1         Chippent/Snump Ortoken         c         56.53         12.44         94.85         0.42         399.00         2.02         0.05         0.33           1         Commercial Tarf Equipment         b         19.74         3.10         15.50         1.38         672.60         0.84         0.36         0.24           1         Other Lawn and Garden Equipment         b         79.17         17.44         1.16         8.60         817.00         0.81         0.36         0.24           2         Atrent Support Equipment         c         10.02         2.20         78.44         0.46         258.70         5.16         0.06         0.22           2         Terming Trackos         c         10.02         2.20         17.13         0.32         258.70         5.16         0.06         0.22           3         All Termin Velicles (ATVs)         4, b         210.00         33.00         6.00         31.13         182.50         3.60         4.14         1.18           3         Minibhum         -, c         150.00         33.00         16.00         3.44         1832.50         3.60         4.14         1.14           3         Monibhum         -, c         150.00 </td <td>1</td> <td>Snowblewers</td> <td>ь</td> <td>79.17</td> <td>12.44</td> <td>2.50</td> <td>5.42</td> <td>817.00</td> <td>0.81</td> <td>2.66</td> <td>. 0.53</td> <td>0.32</td>	1	Snowblewers	ь	79.17	12.44	2.50	5.42	817.00	0.81	2.66	. 0.53	0.32
1         Corgregetial Turf Equipment         b         19,74         2.10         15.50         1.18         672.60         0.84         0.35         0.24           1         Other Lawn and Geneen Equipment         b         79.17         12.44         1.16         8.60         \$17.00         0.81         0.18         0.35           2         Alvenit Support Equipment         c         10.02         2.20         (7.13         0.32         288.70         5.16         0.06         0.22           3         All Terminal Turticos         c         10.02         2.20         (7.13         0.32         288.70         5.16         0.06         6.22           3         All Terminal Turticos         c         10.02         3.20         1.50         216.80         1822.30         3.60         4.14         1.18           3         Minishum         *, b         210.00         33.00         6.00         3.41         1327.50         9.00         1.15         1.14           3         Dorif Carta         *, b         210.00         33.00         18.00         5.44         45.79         9.74         3.07           4         Vesch w/Inducer Carta         *, b         210.00	1 1	Chippen/Source Orisdate	e	50.55	12.44	94.86	0.42	539.00	2.02	0.05	0.53	a șr
I         Other Lawn and Genten Equipment         b         79,17         12.44         1.16         8.60         817.00         0.81         0.18         0.33           2         Alreent Support Equipment         c         10.02         2.20         73.44         0.48         238.79         5.15         0.06         0.122           2         Termine Transfor         c         10.02         2.20         73.44         0.48         238.79         5.15         0.06         0.122           3         Altrention         c         10.02         2.20         73.44         0.48         238.79         5.16         0.06         0.22           3         Altrention         c         10.00         33.00         6.00         31.13         1832.50         3.60         4.14         1.18           3         Off-Road Mainmychen         -, c         120.00         33.00         6.50         20.52         1267.50         9.00         1.15         1.17           3         Ord-Road Mainmychen         -, c         120.00         33.00         18.00         5.44         1852.50         3.66         4.14         1.14           3         Specialty Vettalew Carts         -, c         106.69 </td <td>1</td> <td>Compareial Tarf Equiprotet</td> <td>b</td> <td>19,74</td> <td>3.10</td> <td>15.<i>5</i>0</td> <td>1_30</td> <td>672.60</td> <td>0.84</td> <td>0.36</td> <td>9 24</td> <td>6,3*</td>	1	Compareial Tarf Equiprotet	b	19,74	3.10	15. <i>5</i> 0	1_30	672.60	0.84	0.36	9 24	6,3*
2         Altrent: Support Equipment         c         10.02         2.20         73.44         0.48         238.70         5.16         0.06         0.22           2         Terming Tractors         c         10.02         2.20         (7.13)         0.32         238.70         5.16         0.06         0.22           3         All Termin Vehicles (ATVs)         4, b         210.00         33.00         6.60         31.13         1852.50         3.60         4.14         1.18           3         Minibilities         *, b         210.00         33.00         6.60         20.52         126.75         9.00         1.15         1.17           3         Off-Read: Metersprise         *, c         150.00         33.00         6.60         20.52         126.75         9.00         1.15         1.17           3         Ord-flows         *, c         120.00         33.00         16.00         5.44         1832.50         3.66         4.14         1.18           3         Ord-flows         Termin Vehicles Carts         *, b         210.00         35.00         18.00         7.64         1832.50         3.66         4.14         1.18           4         Vessits «Cherbard Engisse		Other Lawn and Gerden Equipment		79.17	12.44	1.16	8.60	\$17.00	. D.BI	81.0	0.33	0.12
2         Terminal Tunctors         c         10.02         2.29         17.13         0.52         258.75         5.16         0.06         0.22           3         All Termin Vehiclos (ATVs)         4, b         210.00         33.00         6.00         31.13         1832.30         3.60         4.14         1.18           3         Minibhum         *, b         210.00         33.00         6.00         30.92         1267.50         9.00         1.15         1.14           3         Off-Road Matemyolus         *, c         150.00         33.00         6.00         90.92         1267.50         9.00         1.15         1.14           3         Onf-Road Matemyolus         *, b         210.00         33.00         16.00         5.44         1857.50         9.00         1.15         1.14           3         Specialty Vehicles Carts         *, b         210.00         35.00         18.00         7.04         1857.30         3.60         4.14         1.18           4         Venuels w/Duchoard Engines         **, c         121.57         28.94         NA         6.73         1848.34         66.58         0.74         3.07           4         Venuels w/Duchoard Engines         *	2	Aircraft Support Boulprant	¢	10.02	2.20	73.44	0.48	251.70	5.16	0.06	n.22	0 21
3       All Terrein Vehicles (ATVs)       4, b       210.00       33.00       6.00       31.13       1832.50       3.60       4.14       1.18         3       Minibilizes       *, b       210.00       33.00       6.00       20.52       1267.50       9.00       1.15       1.18         3       Off-Road, Materreyches       *, c       150.00       33.00       6.00       20.52       1267.50       9.00       1.15       1.18         3       Orf-Road, Materreyches       *, b       210.00       33.00       18.00       5.44       1632.50       3.60       4.14       1.18         3       Streamphiles       *, b       210.00       33.00       18.00       7.04       1632.50       3.60       4.14       1.18         4       Venaria v/Zaboard Engines       *, c       106.69       NA       260.10       5.13       1578.24       45.79       0.74       3.07         4       Venaria v/Zaboard Engines       **, c       101.69       NA       63.00       5.26       1578.24       45.79       0.74       3.07         4       Venaria v/Zaboard Engines       **, c       101.69       NA       18.00       6.75       1578.24       45.79	2	Terminal Tractors	e	10.02	1.20	(7.[3	0.52	258.70	5.16	0.06	0.22	P.17
3         Ministen         *, b         210.00         33.00         1.50         21.68         1852.55         3.60         4.14         1.18           3         Off-Read Momenyolas         *, c         150.00         33.00         6.00         30.02         1267.50         9.00         1.15         1.18           3         Ooff Carts         *, b         210.00         33.00         16.00         5.44         1852.50         3.60         4.14         1.14           3         Specialty Visicles Carts         *, b         210.00         33.00         18.00         5.44         1852.50         3.60         4.14         1.14           3         Specialty Visicles Carts         *, b         210.00         35.00         18.00         7.04         1852.50         3.60         4.14         1.18           4         Venues w/Duboard Engines         **, c         108.69         NA         260.10         5.13         1974.24         45.79         0.74         3.07           4         Venues w/Duboard Engines         **, c         121.57         28.94         NA         8.73         1848.54         66.38         0.74         3.07           4         Sallboat Auxiliary Inboard Engines	3	All Terrain Vehicles (ATVs)	<b>4</b> , b	219.00	33.00	6.00	31.13	1832.30	3.60	4.14	1.18	0.55
3       Off-Road: Memoryphen       =, c       150.00       35.00       6.01       20.92       1267.50       9.00       1.15       1.14         3       Colf Carta       =, b       210.00       35.00       18.00       5.44       1857.50       3.60       4.14       1.14         3       Snowrpolities       NA       SA	•	Minibilian	• •	210.00	33.00	1.50	21.65	1852.30	3.60	4.14	1.18	6.55
3       Oolf Carta       ", b       210.00       35.00       18.00       5.44       1857.50       3.60       4.14       1.14         3       Srowmolilies       NA       1852.50       3.60       4.14       1.18         4       Venuts w/Inboard Engines       **, c       108.69       NA       65.00       5.25       1578.24       45.79       0.74       3.07         4       Venuts w/Inboard Engines       **, c       1184.59       0.44       1.600       6.75       1578.24       45.79       0.74       3.07         4       Sailboat Auxiliary Unboard Engines       **, c       1184.59       0.12       0.22       0.22       0.2	3	Off-Road Meansystem		1 50.00	33.00	6.00	36.92	1267.50	9.00	1.15	1.19	6.55
3         Snowmobiles         NA           3         Specialty Verjeker Carts         ", b         210.00         35.00         18.00         7.04         1852.20         3.60         4.14         1.18           4         Veranis w/Enboard Engines         **, c         108.69         NA         260.10         5.13         1578.24         45.79         0.74         3.07           4         Veranis w/Enboard Engines         **, c         131.57         28.94         NA         8.73         1648.34         66.58         0.74         3.07           4         Veranis w/Enboard Engines         **, c         131.57         28.94         NA         8.73         1648.34         66.58         0.74         3.07           4         Veranis w/Enerriting         **, c         131.57         28.94         NA         8.75         1578.24         45.79         0.74         3.07           4         Saliboar Auxillary Ourboard Engines         **, c         131.57         28.94         NA         8.75         158.24         64.35         0.74         3.07           5         G		Oolf Carts	<b>.</b>	210.00	33.00	16.00	5.44	1857.50	3.60	4.14	1.14	h.15
3       Speciality Veriablev Carca       *, b       210.00       33.00       18.00       7.04       1852.30       3.60       4.14       1.18         4       Veranda w/Enboard Engines       **, c       108.69       NA       260.10       5.13       1576.24       45.79       0.74       3.07         4       Veranda w/Enboard Engines       **, c       131.37       28.94       NA       8.73       1848.34       66.58       0.74       3.07         4       Veranda w/Engines       **, c       131.37       28.94       NA       8.73       1848.34       66.58       0.74       3.07         4       Veranda w/Engines       **, c       100.69       NA       63.00       5.26       1578.24       45.79       0.74       3.07         4       Sailboat Auxiliary Inboard Engines       **, c       131.37       28.94       NA       8.75       1848.54       66.38       0.74       3.07         4       Sailboat Auxiliary Outboard Engines       **, c       131.37       28.94       NA       8.75       1848.54       66.38       0.74       3.07         5       Genovator Sets       <50 bp	3	Snowmobiles		NA	NA	NA	NA	NA	NA	NA	NA NA	- SA
4       Venacha w/Inboard Engines       **, c       106,69       NA       260.10       5.13       1578.24       45.79       0.74       3.07         4       Venacha w/Duchoard Engines       **, c       131.57       28.94       NA       8.75       1848.34       66.58       0.74       3.07         4       Venacha w/Duchoard Engines       **, c       131.57       28.94       NA       8.75       1848.34       66.58       0.74       3.07         4       Venacha w/Duchoard Engines       **, c       108.69       NA       63.00       5.26       1578.24       45.79       0.74       3.07         4       Sallboat Auxiliary Outboard Engines       **, c       108.69       NA       18.00       6.75       1578.24       45.79       0.74       3.07         4       Sallboat Auxiliary Outboard Engines       **, c       131.57       28.94       NA       6.75       1848.54       66.38       0.74       3.07         5       Generator Sette       <50 tap	i	Specialty Vehicles Carts	<b>•</b> , b	210.00	33.00	18.00	7.04	t 652.50	3.60	4.14	L.18	0.55
4       Venues w/Outboard Bagines       **, c       131,57       28.94       NA       8.75       1948_34       66.58       0.74       3.07         4       Venues w/Sternstrive Begins       **, c       108.69       NA       63.00       5.26       1578_24       45.79       0.74       3.07         4       Selfboat AuxIllary Inboard Engines       **, c       108.69       NA       18.00       6.75       1578_24       45.79       0.74       3.07         4       Selfboat AuxIllary Unboard Engines       **, c       131.57       28.94       NA       6.75       1578_24       45.79       0.74       3.07         4       Selfboat AuxIllary Unboard Engines       **, c       131.57       28.94       NA       6.75       1578_24       45.79       0.74       3.07         5       Generator Sets       < 50 tp	•	Venaria w/Initeerd Enginee	**. e	108.69	NA NA	260.10	5.13	1576.24	45.79	9.74	3.07	2.90
4       Vassels w/Sterndelva Bagizen       **, α       108.69       NA       63.00       5.26       1578.24       45.79       0.74       3.07         4       Sallboot Auxiliary Inboard Engizen       **, c       108.69       NA       16.00       0.75       1578.24       45.79       0.74       3.07         4       Sallboot Auxiliary Inboard Engizen       **, c       131.57       28.94       NA       6.75       1578.24       45.79       0.74       3.07         5       Consensor Sets       < 50 tp	4	Venate w/Outboard Bagines	·· .	131.57	28.94	NA	8.75	1646_34	66.58	0,74	<u>у от</u>	2,97
4       Sailboat Auxiliary Inboard Engine       **. c       108.69       NA       18.00       6.75       1578.24       45,79       0.74       3.01         4       Sailboat Auxiliary Onboard Engine       **. c       131.57       22.94       NA       8.75       1848.54       66.38       0.74       3.01         4       Sailboat Auxiliary Onboard Engine       **. c       131.57       22.94       NA       8.75       1848.54       66.38       0.74       3.01         5       Occorrator Sets       < 50 hp		Vesatis w/Standariva England		109.69	NA	63.00	5.26	1578.24	45.79	0.74	3 07	2.90
4       SadPoost Auxiliary Outboard Engines       ***, c       131.57       22.94       NA       0.75       1848.54       661.38       0.74       3.07         5       Occorrator Sets       < 50 hp	4	Sailboat Auxiliary Inboard Engine		108.49	NA	16.00	8.75	1578.24	45.79	0.74	3.01	2,99
5       Clementator Serie       < 50 hp       b       19.95       3.14       3.08       3.43       670.70       0.01       0.22       0.22         5       Pampa       < 50 hp	4	Saliboat Autiliary Outboard Souther	<b>**</b> .e	131.57	78.94	NA	8,75	1848.54	64.38	9,74	3.07	2.90
5         Pumps          50 hp         b         19.95         3.14         2.25         6.33         670.70         0.81         0.22         0.22           3         Air Compressors         <30 hp	5	Occernitor Sets < 50 hg	ь	19.95	3.14	3.06	3.43	670.70	0.01	0.22	0.22	0.27
1       Air Compression       < 30 hp	,	Parage < 50 her	6	19.95	3.14	2.25	6.13	670.70	0.01	0.22	0.22	0.27
5         Gas. Compression         < 50 hp         c         NA         State	,	Air Compromote < 30 ha	6	19.93	3.14	3.38	3.20	670.70	0.81	0.22	n 12	0.27
\$         Weldars         < 50 hg         b         19.95         3.14         9.75         1.72         670.70         0.81         0.22         9.22           \$         Pressure Washins         < 50 hg         b         19.95         3.14         2.25         6.33         670.70         0.81         0.22         0.22         0.22           \$         Pressure Washins         < 50 hg         b         19.95         3.14         2.25         6.33         670.70         0.81         0.22         0.12           \$         Aerial Lifts         a         10.02         2.20         55.06         0.49         258.70         5.16         0.06         0.22         0.12           \$         Pressure Vacuum Vac	- 5	Gas Compressors < 50 kg	•	MA	NA	NA	NA	NA	NA	NA	NA	NA
5         Premure Washers         < 50 hp         b         19.95         3.14         2.25         6.33         670.70         0.81         0.22         0.12           6         Acrial Lifts         n         10.02         2.20         55.06         0.49         258.70         5.16         0.06         0.22           6         Forklifts         c         10.02         2.20         55.00         0.49         238.70         3.16         0.06         0.22           6         Forklifts         c         10.02         2.20         56.00         0.49         238.70         3.16         0.06         0.22           6         Sweepera/Scrubbers         c         10.02         2.20         59.67         0.48         258.70         5.16         0.06         0.22           6         Sweepera/Scrubbers         c         10.02         2.20         59.67         0.48         258.70         5.16         0.06         0.22	5	Welders c 50 hp	6	19.95	3.14	9.75	1.72	670.70	<b>0.8</b> 1	0.22	9.22	0.17
6         Aerial Lifts         n         10.02         2.20         55.06         0.49         258.70         5.16         0.06         0.22           6         Focklifts         c         10.02         2.20         55.06         0.49         258.70         5.16         0.06         0.22           6         Focklifts         c         10.02         2.20         55.00         0.49         238.70         5.16         0.06         0.22           6         Sweepara/Scrubbers         c         10.02         2.20         59.67         0.48         258.70         5.16         0.06         0.22           6         Sweepara/Scrubbers         c         10.02         2.20         59.67         0.48         258.70         5.16         0.06         0.22	5	Pressure Wathers < 50 hp		19.95	3.14	2.25	6.33	670.70	0.01	0.22	0.12	7 2-
6         Forkliffs         c         10.02         2.20         56.00         0.49         230.70         3.16         0.06         0.22           6         Sweeppara/Scrubbers         c         10.02         2.20         59.67         0.48         238.70         3.16         0.06         0.22           6         Sweeppara/Scrubbers         c         10.02         2.20         59.67         0.48         238.70         51.6         0.06         0.22	5	Actial Life		10.02	2.20	55.06	0.49	258.70	5.10	0.06	0 22	1.17
6         Sweepers/Scrubbers         c         10.02         2.20         59.67         0.48         258.70         5.16         0.06         0.22           6         Other Council Level Library         10.02         2.20         59.67         0.48         258.70         5.16         0.06         0.22	6	Forkilta		10.02	2.20	54.00	0.49	2,50,70	3.16	0.06	0.22	- <u>-</u>
	•	Sweepure/Scrubbers		10.02	2.20	\$9.6T	0,44	256 70	1 3 16	0.06	0 22	7 2-
D (Vener Venom: Industrial Educament)   e   [0.02 ] 1,20 } 29 07 1 0.01 1 158.70   5.16   0.06   9.22	6	Other General Industrial Boutament		10.02	1.1	19.67	0.91	158.70	5.16	0.06	9.22	
fi Other Mending Baulamena c (19.02 3.20 78.03 0.44 259.20 5.16 0.06 0.17		Other Mentriel Hendline Baulamen		10.07	1.20	78.03	11 d.R	258.70	5.16	0.04	D.27	
7 Asphel Pavers c 9.74 2.16 47.43 0.45 247.40 4.79 0.06 0.32	7	Asphak Pavers	<b>_</b>	9.74	7.14	47.43	04-0 74 A	257.40	4.79	0.04	0.72	<u> </u>
7 Tunpersiti b 13.63 2.14 2.87 5.34 176.20 1.92 0.27		Tempers Remmers		13.63	2.14	2.8/	5.34	176.20	1.97	0.27	0.21	<b>+</b>
7 Plate Compactors h 13.63 2.14 2.93 6.34 376.00 1.63 0.03 0.33	,	Plate Compactors		13.63	2.14	2.01	6.74	376 20	1.01	0.22	0.11	
7 Concrete Parena NA NA NA NA NA NA NA NA NA		Concrete Paren	·	NA	NA NA	N4		NA	NA NA	N.A	NA	<u> </u>
7 Bollem 5 1643 200 000 141 2020 011 011	7	Bollen	1	100	105			202.00	210	0.13		+

# Table 2-07c. (Continued)

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					HC	ļ					
Ê	Equipment Types		Exhaut	Crank	Brag*	Refue	Ş	NO <sub>2</sub>	¥	Aldebydee	1 50
~- 1	Screpert	i	NN.	¥N.	NA	N,	NN.	ž	N.	NA	ž
٢	Paving Equipment	-	EV'CI	1.5	3.00	5:02	376.20	- 22	27.0	0.22	12 <u>5</u>
-	Surfacing Bajalyment	7	13.61	2.14	3.00	4.34	376.20	1.92	0.22	0.22	0.25
-	Sippel Boards	-	13,63	112	AD <b>G</b>	4.9M	379°50		0 <b>22</b> 0	0.22	Ð.25
7	Translari?	2	9.74	2.14	1,49	0.9M	257.40	67.9	900	0.12	ĥ
-	BorryDrill Rips	•	<b>1</b> 12.6	2.14	<b>\$2.6</b> 2	0.42	217.0	47.e	<b>9</b> 00	0.22	9.2.5
۲	Bacaverborn	-	9.74	2-14	122,40	. <b>T</b> Y'0	257.40	4.79	80.0	n.22	0.23
ŗ	ConstructIndustrial Sawa	٠	13.63	2.14	4.13	174	376.20	1.92	0.77	9.22	0
-	Cenant and Morter Misors	7	13.63	214	3.75	4.09	376.20	ŝ	0.22	0.22	P.25
7		a i	9.74	2,14	84.15	0.42	257.40	4.79	<del>\$</del> 0,0	. п. <b>2</b> 2	÷25
-	Oraden		AN AN	NA	NA	NA	ž	٨N	N,	٧N	2
L	Off-Highway Transa		Ν	NN.	٨N	VK	3	٨N	N,	٨X	ž
-	Creating/Proc. Squipment	•	9.74	2.14	91.80	27.0	0F 157	4.79	90.0	. 0.22	325
7	Rough Terrain Forklifts	•	9,74	2.14	134,64	0.42	257.40	4,79	90.0	27 D	0.25
1	Rebber Tired Londers	•	<b>K</b> .34	sir i	102.51	0.42	211.90	5.4Z	9010	0.22	0.24
1	Rubber Tired Deares		NA	٨N	VN	NN.	NN NN	ž	٨ĸ	VN.	N.
ч	Transforder Smithese	1	9.74	2.14	6C 96	240	2517-40	4.74	90.0	tt D	0.25
7	Crawler Tractore		NA.	NN.	NA	NA	NN	AN A	٨N	ΥN N	z
1	Stid Stor Landon	•	9,74	112	10,01	0.44	157.AQ	4.79	90.0	0.22	0.25
7	Off-Highway Incom		ž	NN.	٨N	ΥK	75	٨N	NN.	VK.	N X
۲.	Dumpers/Tenders	•	13.63	2.14	QU 6	1.74	376.20	1.92	22.0	A 22	
1	Other Connection Equipment	•	9.J4	2.14	229-30	0.41	257.40	4.79	9.06	0.22	57.0
•	2-Wheel Transon	5	11.53	1.UI	El'L	69'2	271.70	2,65	22.0	0.30	623
8	Appendent Transm	•	8.24	1.21	133.11	0.42	185.90	5.6.2	0.06	0.30	0.23
8	Agricultural biovers	5	15.0	2,37	B.Ot	rti'l	414.20	2.10	0.22	0.22	<b>M</b> 1.U
	Combinate	q	10.77	2.37	200.43	0.41	203.40	3,24	900	0.22	0 29
	Sprayers	•	10.77	1.37	4,50	4E1 1	263.40	3.24	90.0	P.22	1 29
-	Bahna		AN	VN.	NN.	٨N	NN	NN	NA	NA	N A
•		-	79.17	12.44	3.63	- 4.JE	817.00	0.81	2,66	0.22	614
		D	10,77	2.37	102.10	0.42	245.40	1.24	0.06	۹ <u>۲</u> ۲	0.2
•	Hydro Power Units	٠	BO'61	2.17	15.00	1.40	414.20	2.10	0.22	0.12	0.28
	Other Apricultural Equipment	•	10.77	2.37	£1.18	2r0	243.40	5.24	0.06	0.12	n X
å	Chain Serve > 4 bp		NN.	NA	NN	NN	٨N	N.N	NA	٨N	۲. ۲
6	Shanddara > 5 hap	e.	19.53	3.07	3.00	101 (	670.70	110	0.18	0 24	
6	Shinkdares		NA.	NA	NN.	NA	NN	AN.	NN.	N.	5
ه	Fellow/Gureture		NN	٧N	N N N	NN.	NN.	NA .	77	NA	2
	Alger A.										
	en aud for in-we affocts asing small willing ang										
		•									

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NA = Not appli

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### Table 2-07. (Continued)

# d. GASOLINE 2-STROKE EQUIPMENT (grams/hp-hr) Not Adjusted for In-Use Effects

				······	10						
	Teningent Trees		Prismut	t Constr	IC Frant	Reflection	co	NO.	<b>P</b> 24	Aldebriks	50.
			774 54	Na	0.4	21 64	778 77	0.91	1.85	7.04	0.14
			208.00	N	1 16	8.60	485.00	0.71	7.20	2.04	0.14
			211 10	NA		1.6.6	716 81	0.04		2.04	D 14
	Dues Destas Biddes Monary		NA	NA	NA	NA NA	N.A.	NA	NA NA	NA	NA NA
1	These Manual Manual		N.A.	NA	Na	NA NA	Na Na	NA NA	NA	NA NA	Na
	The second se		200.00	NA	0 12	11.01	608.00	n PK	.16	1.60	0.54
_ <u>_</u>	Chan Sales Chan		208.00	NA.	179	7.63	486.00	0.79	7 70	2.04	0.54
			200.00	NA NA	1.19	0.10	485.00	0.20	7.70	2.64	0.14
<u> </u>	Low and Garden Trackers		NA.	NA	NA.	NA	NA	NA	NA	NA	NA
_ <u>;</u>	Mars Batters		N4	NA	NA.	NA -	NA NA	NA 1	Na	NA	NA
<u>.</u>			208.00	NA	2 50	1 4 2 2	406.00	0.29	110	204	0.54
			N	NA	. 1.N	J.BL NA	-00.00	NA NA	N.0	NA NA	0.54
1 1	Company and the Real-		208.05	NA	14 40	1.38	435.00	0.70	7 70	104	
. <u>.</u>	Construction Later Equipment				13.30	1.30	496.00	0.10	7.10	2.04	0.34
1			500 M	NA.				0.29 NA		6.04 M A	
			30	30	17.14		61.75	12.00	0.01		0.00
			5400	0.39	11.13	0.32	03.70	17.90	0.03	1 0.42	0.00
3	All Turnin Vehicles (ATVs)		600.00	NA	0119	31.15	600,00	1.30	6.20	2./3	0.93
<u>,</u>	Mitchinika	•	NA	NA	NA	21.04	NA	NA I	NA		~~
3	Off-Road Motorcycles		600.00	NA	6.00	30.92	00.00	1.30	5.20	2,73	0.97
3	Golf Carts	•	600.00	NA	18.00	5,44	800,00	1.30	8,20	2.7.5	0.97
3	Snowmobiles		109.00	NA	24.24	0.67	169,00	1.70	4,00	040	01
	Speciality Vehicles Carts.	•	600.00	NA	16.00	7,04	600.00	1.50	8,20	2.75	0.95
4	Vessels w/Inboard Engines		728.06	NA	260.10	5.13	1337.34	6.77	44,10	3.07	2.9
4	Vessela #/Outboard Engines		721.06	NA	. NA	8.75	1357.34	8.77	48.10	3.07	2.90
4	Venerie soSterndrive Enginee		728.06	NA	63.00	5.26	1337.34	<u></u> μ <i>π</i>	41.10	3.07	2.90
4	Sailboat Auxiliary Inboard Bruitsen	į	HA	NA	NA	NA NA	NA.	NA	NA	NA .	NA NA
4	Seilbost Autiliery Outboart Engines	•••	728.06	NA	NA	8.75	1357.54	6.77	45.10	3.07	2.91
5	Generator Sets < 50 hp		208.00	NA	3.06	3.43	486.00	0.29	7,70	2,04	0.23
5	Puompa < 50 hp	**	4.28	1,41	2.25	6.33	113.00	7.04	0.05	0.22	0.00
5	Air Compressions < 50 hp		NA	NA	NA	NA.	NA	NA	NA	NA NA	N/
5	Ges Compressons < 50 hp	••	4.28	1.41	NA	NA	113.00	1.04	0.05	0.22	0.0
5	Weldana < 50 he		NA	NA	NA	NA	NA	NA	NA	NA NA	N/
5	Presenare Westers < 50 kp	<u> </u>	NA	NA	NA	NA	NA	NA	NA	NA	87
6	Aerial Life	••	3.00	0.99	55.08	0.49	63.70	17.90	0.05	0.22	0.0
6	fortage	••	3.00	0.99	\$4.00	0.49	63.70	17.90	0.05	0.22	00
6	Sweepen/Scrubber	••	3.00	0.99	59.67	0.45	63.70	17.90	0.05	0.22	00
6	Other General Industrial Equipment		206.00	NA	29.07	D.93	486.00	0.29	2,70	2.94	0.2
6	Other Material Handling Equipment		NA	NA	NA	NA	NA	NA	NA	NA	N/
7	Asphalt Pavers		NA	NA	NA	NA	NA	NA	NA	NA	N/
7	Tempers/Bammers		208.00	NA	2.81	5.34	496.00	0.29	7)70	2.04	P.2
7	Plan Compatitors		206.00	NA	2-31	5.34	486.00	0.29	7.70	2.04	0.2
7	Constate Payon		NA	NA	NA	NA	NA	NA	NA	NA NA	N.
7	Kollera		NA	NA	NA	NA	NA	NA	NA	NA	- 87

Nonroad Engine and Vehicle Emission Study

# Table 2-07d. (Continued)

			*	2						
j,	Equipment Types	Britaited		ET4*	Bulating	3	ğ	ž	Aldubran	30,
*	Scrapers	MN I	NA	NA	NA	N.	٩v	NA	NA	NA
•	Permer Beruhamat	204.00	47.	3,00	3.02	486.00	0.29	1.70	2.04	0.25
~	Sarfisting Equipment	NA	VN.	٧N	NA.	NA.	NA.	٨K	¥¥	٩N
4	Signal Bounds	YN I	٧N	<b>VN</b>	VN	٧N	٧N	٧N	VN	ž
-	Terrethera	VN	٧N	¥z	¥N.	47.	¥	NN	5	٩N
-	Borw/Drift Alga	208/00	NA.	62,62	24.0	486.00	0.29	7.70	1.04	0.25
۲.	BROWNOR	MA I	¥¥	NA	NA	NN.	٧N	٧N	NN N	<b>N</b>
1	Concrete/Enduatrial Serve	¥۲	NA	NA	NA.	¥¥	ž	ź	¥.	ž
۲	Commut and Morner Mittern	¥z	۲N	N.	۲N	¥N.	ž	٧V	¥.	¥,
Ŧ	Chana	ž	¥.	ž	٩L	٧N	ž	ž	VN	٧N
-	Oradian	2	¥¥.	۲N	YK X	N.	ž	¥7.	<b>A</b> N	ź
5	Off-Highwary Tracks	¥K	<b>V</b> N	۲N	NN.	VN	M	¥.	¥2	ž
4	CrushingProv. Benjeusers	¥N.	٧N	NN	NN N	٩N	ž	N.	¥Ν	ž
-	Rough Tarrain Faridith	YN N	¥N.	¥.	VN	٧N	ž	Ň	¥ N	¥2
r	Rubber Paul London	V.V	VN .	NA	YN	ž	ž	N.	₹¥	ž
-	Rubber True Doesen	¥	¥ X	ž	NA.	VN	ź	ž	ž	X
Ŀ	Tructured and any flam before	ž	YN	NA	NA .	NЛ	ž	¥ z	MM	Ă
4	Crewise Trectors	<b>V</b> N	۲¥	NA	NA	VN	٧N	NA	<b>Y</b> N	¥N
7	Skid Steer Londers	V.N	٧N	<b>N</b> A	KA K	NA	٧N	NA	¥N N	N.
7	Of-Kighway Trucker	<b>AN</b>	NA	NN	<b>N</b> A	٧N	NА	NA	ΥN	٧N
F.	Durgens/Teachers	Ź	¥۲	V N	YX X	¥Z.	ž	NA	٧N	ž
2	Other Construction Equipation	¥¥.	٧N	NA	NN.	ž	٩N	NA	ž	ź
*	2-Wheel Tractors	V R	VN.	NA	NA.	¥ N	ž	NA	٧N	ź
٠	Agriculture: Trectore	ž	VN	NA	TN.	ž	ž	٧V	¥K.	ž
*	Agriculturel Mowers	<b>N</b> N	YN.	NA	N.N	YN.	¥.	٧N	N.	۲Ň
*	Combran	VN I	VN .	٧N	٧N	<b>N</b>	٧N	٧N	YK.	NA.
*	\$612.0mm	NN	A M	NA.	NA.	NN	¥,	٨٨	<b>NN</b>	A N
в¢	Sales	W	NA	NA	MA	NA	NA	NA	NA	NA
*	211have > 3 kg	<b>M</b> M	NA	٧N	NA	NA	٨N	NA	YN	NN.
8	Swethers	٧N	MA	NA	NA	NA	NA	NA	<b>V</b> N	NA.
¥	Nydro Power Units	<b>V</b> N	۸A	NA	NN	NA	NA	٨N	<b>VN</b>	NA.
*	Odust Agricultural Equipment	¥N N	¥N.	NA	N.N.	NA.	NA	NA	¥N	ХX
\$	Claim Surre > 4 Mp	152,00	٧V	0.66	11.21	513.00	960	3.60	1.60	037
6	Streetiers > 5 kg	VN	NA.	NA	NA	A M	ЧV	ΝA	NA.	ΝA
6	Stidders	MN I	<b>NA</b>	NA	٨N	NN	NA	NA	NA	NA
9	Fellens/Beenhers	YN I	NA.	NA	AN N	NA	NA	NA	٧N	NA
BVE	- (/diry									
5 Å	inion factors for 4-stroks propaga-facing again	Ĭ								

November 1991

••• gigslen NA • Not spelkable

### Table 2-07. (Continued)

### e. GASOLINE 2-STROKE EQUIPMENT - (grams/hp-hr) Adjusted for In-Use Effects

<u> </u>					ic.			_			
Casa .	Equipment Types		Extract	Crank	Emp'	Reteeling	60	NOx	т	Aldehydes	50,
1	Trimmers/Edgars/Bresh Cutters	4	471.55	NA	0.54	21.98	1383.62	0.91	3.69	2,04	0.54
<b>-</b>	Lawrumowers		436.80	NA -	1.16	8.60	923.40	0.29	7.70	Z.04	0.54
1	Leaf Blowers/Veccume	4	452.11	NA	0.61	6.61	1361.94	0.96	3.60	2,04	0.54
1	Roar Engine Riding Movers		NA	NA	NA	NA	NA	NA	NA	NA	NA
,	Front Mowers		NA	NA	NA	NA NA	NA	NA	NA	NA	NA
1	Chain Sawa < 4 hap	4	625.80	NA	0_32	35.93	1328.10	0.96	3,60	1.60	9.54
1	Shreddere < 5 top	- d	436.80	NA	1.75	7.68	923.40	0.29	7.70	2,04	0.54
-	Tillens < 3 hp	•	436.00	NA	1.38	9.39	923.40	0.29	7.70	2.64	0.54
	Laws and Garden Tractors		NA	NA	NA	NA	NA	NA	NA	NA NA	NA
	Wood Splitters		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Snowbiowers	4	435.80	NA	2.50	5.82	923.40	0.39	7.70	2.04	0.54
	Chippens/Starop Grinders		NA	NA	NA	NA	NA	NA	NA	NA	· NA
1	Commercial Turf Equipment	đ	436,80	NA	t 1.50	1.30	923,40	0.29	7.70	2.04	0.54
-	Other Lawn and Garden Boulparant	d	436.80	NA	1.16	8.60	923.40	0.29	7.70	2.04	0.54
2	Aircraft Support Equipment		NA	NA	NA	NA	NA	NA	NA	NA	NA
2	Terminal Tractors		4.30	0.99	17.13	0.52	\$2.81	(7. <b>90</b>	0.05	0.22	0.00
3	All Temain Vahicles (ATVs)	•. d	1260.00	NA	6.00	31.15	1520.00	1.50	8.20	2.75	0.95
3	b Can also Quant		NA	NA	NA	NA NA	NA	NA	NA	NA	NA
,	Off-Read Meteroycise	•. a	1260.00	NA	6.00	30.92	1520.00	1.50	1.20	2.75	0.95
3	Golf Carts	•.4	1260.00	NA	18.00	5.44	1520.00	1.30	8.20	2.75	0.95
3	Seewnobles	d	228,90	NA NA	24.24	0.67	321.10	1.70	4.80	0,40	0.15
3	Specialty Vehicles Carts	*, d	1260.00	NA	18.00	7.04	1520.00	01.1	8.20	2.75	0.95
4	Vesanta w/Inboard Bagiree	***,*	\$73.57	NA	260.10	5.13	1628.81	8.77	48.10	3.07	2.90
4	Venete w/Ontboard Engines		873.67	NA	NA	8.75	1625.81	1,77	48.10	3.07	2,90
4	Vesetis w/Staradrive Regimes	***. e	\$73.67	NA	63.00	5.26	1628.81	8.77	48.10	3.07	2.90
4	Stiftmat Antibiny Inboard Engines		NA	NA .	NA	NA	NA	NA	NA	NA	NA
4	Saliboat Auxiliary Outboard Baghase	***.*	#73.6T	NA	NA	2.75	[628.81	8.77	44.10	, <u>3.07</u>	2.90
5	Generator Sets < 50 hp.	d	436.00	NA	3.06	3.43	923.40	0.29	7.70	2.04	0.27
5	Parraga < 50 kp	••. •	1.97	1.41	2.25	6.33	214.70	2.02	0.18	0.22	0.00
5	Air Comprissions < 50 kp		NA	NA	NA	NA	NA	NA	NA	NA	NA
,	Ges Compression < 50 hp	••. •	6.42	1.41	NA	NA	146.90	7.04	0.05	0.22	0.00
5	Waldona < 50 kp		NA	NA	NA	NA	NA	ŃA	NA	NA	NA
5	Pressure Washins < 50 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
6	Actial Life	••, •	4.50	1.49	55.08	9.49	\$1.81	17.90	0.05	0 22	0.00
6	Fortilita	**. c	4.50	1.49	34.00	0.49	52,51	17.90	0.05	0.22	0.00
6	Swaper/Scrubbers	. a	4.50	1.49	19.67	0.46	82.81	17.90	0.05	0.22	0.00
6	Other General Industrial Equiperant	÷	312.00	NA	29.07	0.93	631.60	0.29	770	2.04	( T
6	Other Material Handling Equipment	<u> </u>	NA	NA	NA	NA	NA	NA	NA	NA	NA NA
7	Asphelt Pevers		NA NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Temperallemmera	d	436.80	NA	Z.81	5.34	923.40	0.29	7.70	2.04	0.2
7	Place Compectore	d	436.60	NA	Z.81	534	923.40	0.29	7.70	2.04	0.25
, ,	Concrete Pavera	<u> </u>	NA	NA	NA	NA	NA	NA	NA	NA.	- SA
7	Rollan	<u> </u>	NA	NA	NA	NA	NA	NA	NA	NA	Na



### Table 2-07e, (Continued)

,				· · · ·	HC .						
Charl	Squipment Types	ĺ '	Externet	Creati	Emp	Refeeling	. CO	NO.	I PM	Aldehydee	so,
7	Scrapen		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Paving Equipment	d	436.80	NA	00.F	5.02	923.40	0,29	01.1	2.04	0.25
<b>T</b>	Surfacing Benjamont		NA	NA	NA	NA	NA	NA.	NA	NA	NA
7	Signal Boarda		NA	NA	NA	NA	NA	NA	NA	NA	NA
	Tyestchern		NA	NA	NA	NA	NA	NA	NA	NAI	NA
7	Bone/Drift Rige	в	436.00	NA ·	82.62	0.42	923-40	0.29	7.70	2.04	0.2
T	Escavetors		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Concrete/Industrial Sears		NA	NA	NA	- NA	NA	NA	NA	NA	NA
1	Cerrorit and Morter Milants		NA	NA	NA	NA	NA	NA	NA	NA	NA
· ۲	Стания		NA	NA	NA	NA	ž	NA	NA	AR.	NA
	Onden	Ĺ	NA	NA	NA	NA	NA	NA	NA	NA	NA .
7	Off-Highway Trucks			NA	_NA	NA	NA.	NA	NA	NA	NA
7	Creating Proc. Baylpoint		NA NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Rough Turnin Porklitte		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Rubber Thed London		NA	NA	NA	NA	NA	NA	NA	NA.	NA
7	Rubber Tired Dogers		NA NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Trectors/Londers/Backhoos		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Crawler Trackers		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Shid Statt Londers	<b></b> _	NA	NA NA	NA	NA	NA	NA	NA	NA	NA
7	Off-High way Tructors		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Dumper#Tensiles		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Other Construction Equipment	<b></b> _	NA	NA	NA	NA (	NA	NA	NA	NA	. NA
	2-Wiend Tructors		NA	NA	NA	NA	NA	NA	NA	NA	NA
	Agricultural Transm		NA	NA	NA	NA :	NA	NA	NA	NA	NA
*	Agricultural Mewara	<b></b>	NA	NA	NA	NA NA	NA	NA	NA	NA	NA
•	Combian		NA	NA	NA	NA	NA	NA	NA	NA	NA
5	Sprayers		NA	NA	NA	NA	NA	NA.	NA	NA	NA
-	Balan		NA	NA	NA	NA	NA	NA	NA	AK	NA
	Tiljum > 3 hp		NA	NA	NA	NA.	NA	NA	NA	NA '	NA
8	Smathare		NA	NA	NA	NA	NA	NA	NA.	NA	NA
•	Kydro Power Units		NA.	NA	. NA	NA NA	NA	NA	NA	NA	NA N
	Other Apricalitiesi Squiqeanet		NA	NA	NA	NA	NA	NA	NA	NA	NA
	Chain Save > 4 hp	4	319.20	NA	0.66	10.22	914.70	0,96	12.96	1.60	0.37
9	Structions > 5 top		NA	NA	NA.	NA	NA	NA	NA	NA	NA
9	Sujden	r	NA	NA	NA	NA	NA	NA	NA	NA	NA 1
9	Pollen/Buncharia		NA	NA	NA	NA	NA	NA	NA	NA NA	NA.
Brap <sup>a</sup> 1 gilor 	and the income state of the second se	10gara471	·	•	ots edj d = edj ne c = edj Na – N	when for in-w unted for in-w NO <sub>2</sub> or FM a unted for in-w	n office o office of djustment o office b	ving has ving any y a facto	vy daty ( il utility v of 1.2	ragine data e engine data e for HC and C	acepi ID

Key:

1 = Lawo and Garden

2 = Airport Service

3 = Recreational Equipment

4 = Recreational Marine

5 = Light Commerciai 6 = Industrial

7 = Construction8 = Agricultural

9 = Logging

	Cold/No	orthern	Medium	/Central	Warm/S	outhern
Equipment Class	Summer (%)	Winter (%)	Summer (%)	Winter (%)	Summer (%)	Winter (%)
Agricultural	50	6	40	6	34	6
Construction	43	10	38	15	33	20
Industrial	30	20	25	25	25	25
Lawn and Garden (excl. chain saws)	50	6	40	6	34	5
Snowblowers/Snowmobiles	0	100	0	100	0	- 10KD
Commercial Marine	25	25	25	25	25	25
Airport Service	25	25	25	25	25	25
Logging (including chain saws)	25	25	25	25	25	25
Light Commercial	25	25	25	25	25	25

Table 2-08a. Summer and Winter Percentages of Yearly Activity.

### Table 2-08b. Summer and Winter Percentages of Yearly Activity for Recreational Marine Equipment

Region	% During Summer	% During Winter
Northeast	68	l
Southeast	48	7
Mid-Atlantic Coast	57	2
Great Lakes	70	0
Southwest	48	7
Rocky Mountains	69	0
Northwest	57	5
West Coast	48	7

Region	% During Summer	% During Winter
East	42%	12%
Midwest	46%	8%
South	36%	15%
West	44%	11%
New England	44%	14%
Mid-Atlantic Coast	41%	12%
East Central	48%	9%
West Central	44%	8%
Southeast	35%	17%
Southwest	37%	12%
Rocky Mountains	44%	8%
Pacific	43%	13%
National Average	42%	12%

### Table 2-08c. Summer and Winter Percentages of Yearly Activity for Recreational Equipment.<sup>######</sup>

\*\*\*\*\*\*Excluding snowmobiles.

### 2.8. Emissions from Commercial Marine Vessels

A detailed analysis of commercial marine vessel activity and emissions was developed for the following nonattainment areas:<sup>\$\$\$\$558</sup>

- 1. Baltimore, MD MSA
- 2. Baton Rouge, LA MSA
- 3. Houston-Galveston-Brazoria, TX CMSA
- 4. New York-Northern New Jersey-Long Island, NY-NJ-CT CMSA/NECMA
- 5. Philadelphia-Wilmington-Trenton, PA-NJ-DE-MD CMSA
- 6. Seattle-Tacoma, WA CMSA

For other nonattainment areas, estimates of emissions from commercial vessels were based on information obtained from different sources, including SIP emission inventories and the 1985 National Emission Report.<sup>7</sup>

When the latter was used, marine vessel activity was assumed to be uniform during the year. Emissions from commercial marine vessels are shown in Table 2-09.

<sup>&</sup>lt;sup>551555</sup> This analysis is documented in the Booz-Allen & Hamilton final report entitled "Commercial Manne Vessel Contributions to Emission Inventories," which may also be found in the public docket.

Commercial Vessel Equation	2												
	Ł	E.	5	5	ē	Č,		7	Party		0.00	OLIGER	
	2	ž	8	Ē		i Ö	ŝ	Č.	8	00 Q	ĝ	8	ŐS.
Bakinow CMSA	1,623	5,970	30,332	200	2	1.718.54	4.45	16.36	01.10		•	•	•
Chinago CMBA	£	2	2	2	2	2		28.47		- e	• •	3	<b>n</b> -
Derman Child.	9	9	9	2	2	2	2	2	1	-	-	-	•
Housen Case	3	12.442	1.718	192	2	5,152,10		1111		•	۲	- •	•
Millionary CMBA			9	2	2	5	×.	9	5	• •	•	n	D
Senton NECMA	2	2	2	Ē	9	1		1	ļ	•	••	•	•
Hardond HECKIN	Ξ	25	1	9	2	1	1	17.0					-
Her Yes, CARANECIAN	2	12,001	14 14 14	8	9	1210.50	1	10			- 1		•
Present Clark	ŧ	A 101	1.87	22	2	1.000							
Beel-Tee, CHRA	2,404	17,263	31, IMO	1,017	9	7.577.74	10	47.27		7 4			
Assess Child.	•	•	9	2	2	2	000	0.00	5	• -	۰.	•	P
Bajan Rauge Child.	į	1.04	ł	ä	2	720.40	80	5.07			•		4
Cleveland CMBA	1,005	ţ	a,707	2	2	2	2.75	050			•	•	,
El Paso CMBA	•	¢	•	•	•	¢	80	000	8	• -	•	त	•
きょう ちょうき	ł	2	Ŷ	9	Ş	401.50	20	2.64		• -	, -	• •	•
South Const AB	9	2	9	1,515	2	12,796,60		10.93	10.41		• •	• ••	
Linnin CMBA	1	1,310	9	2	9	2	2	3	9			•	-
MinSt. Paul CMSA	2	2	8	-	2	2	2	2		•	•	•	•
Prove-Oner CMBA	ł	2	316	9	2	9	9	9					-
San Diego AB	9	2	2	3	9	6.070.00	2.5	1		Ŧ	•	• •	•
Spoterre CABA	2	2	72	2	12	1	1	9		•	•	• •	-
St. Look CARA	2.44	1 PCM	2	1	9		28	1		•	•	,	
Whethinsten DC CALSA		101	2,020	9	19	29	1		į	° •	•	,	
Springleid NECLAN	•	•	-		9 -	<b>;</b> -	1		1	• •	••	•	
	543,444	256,700	121.221.4	11,204	2	24,403.71	1,488,91	500,45	1 993 22	- 4		15	4
									•	,	I	I	,
Z	D - No Celt							÷.	Sume Implements	June Plan	CARB	Contractor	Stud
								ni a	Phone II Volume	Contral of	upport	2	
								**	Cold Control (14)			,	
										1	50.	,	
								•				-	

### Table 2-09. Emissions from Commercial Marine Vessels

### 2.9. Emissions from Other Sources

EPA compared its estimates of emissions from nonroad engines and vehicles to emissions from highway and other area and point sources. At the national level, 1989 emissions were obtained from the *National Air Pollutant Emission Estimates: 1940-1989.*<sup>®</sup> For all but five nonattainment areas, *fiffee* emissions from highway and other sources were available from the following sources:

- VOC: Phase II Volatility Control Support Runs, April 5, 1990 VOC emissions were reported in tons per summer day for 1990.
- CO: Support computer runs for Cold CO Rulemaking documentation, Jan. 18, 1991 - CO emissions were reported in tpy for 1987. To estimate tons per winter day, highway vehicle CO emissions were divided by 365 and corrected for decreased driving during the winter. Emissions from other area and point sources were simply divided by 365.
- NO<sub>x</sub>: 1985 National Emission Report<sup>9</sup> NO<sub>x</sub> emissions were reported in tons per year for 1985. To estimate tons per summer day, highway vehicle NO<sub>x</sub> emissions were divided by 365 and corrected for increased summer driving. Emissions from other area and part sources were simply divided by 365.
- PM: 1985 National Emission Report PM emissions were reported in tons per year for 1985.
- SO<sub>x</sub>: 1985 National Emission Report SO<sub>x</sub> emissions were reported in tons per year for 1985.

<sup>&</sup>quot;""For five areas (Boston NECMA, Springfield NECMA, Hartford NECMA, South Coast Air Basin, and San Joaquin Valley Air Basin), the geographical definition of the nonattainment areas differed slightly from that uses in the analyses discussed above. In these cases, EPA relied on estimates of emissions from highway and other sources that were developed in the most recent State Implementation Plans.

For both VOC and CO, the original estimates of nonroad mobile source emissions from the Phase II and Cold CO emission inventories could not be readily distinguished from other area sources. To avoid counting nonroad sources among other area and point sources, EPA computed the ratio of nonroad to the sum of nonroad and other area and point sources for both VOC and CO emissions in each nonattainment area using data from the 1985 *National Emission Report*. These ratios were applied to the VOC and CO emissions from all nonhighway sources reported in the Phase II and Cold CO emission inventories. It was thus possible to estimate emissions from all other area and point sources without including nonroad engines and vehicles.

Emissions from highway vehicles and other area and point sources are shown in Tables 2-10 and 2-11, respectively. The data sources are also indicated by area in these tables.

These total inventories do not include emissions of VOCs from vegetation (biogenic VOCs). Although recent studies have shown that, in some cities, emissions of VOCs from plants may be more important in ozone formation than previously thought, EPA has only recently completed a computer model for estimating biogenic emissions in urban areas and has determined that reliable biogenic inventories do not exist for most areas. While the biogenic inventories to be included in future State Implementation Plans will affect the fine-tuning of nonattainment areas' pollution control strategies, the magnitude of VOC inventories from biogenic sources will not alter the need to reduce anthropogenic VOCs substantially to bring many urban areas into attainment of the ozone standard.

# Table 2-10. Emissions from Highway Vehicles

Component         V(0)	Manuar Venicle Emissio	ž	8	ž	5	5	Ň	999		towd		Data S	Duffelie-	
Memory Calify Interver	Geographical Area	P P	Ū,	:8	Z	Addetrydes	ğ	20	Ő	8	Ŷ	ġ	₹ 8	NSON
Change (26)         ND         53.11         ND         13.230         ND	Building Childh	9	54,317	Ŷ	Ŷ	ł	2	200.00	163.70	1,327.60	£4		•	
Money C455         Mo         Mo         Mo         Mo         27/13         22/13         Mo         22/13         Mo         22/13         Mo         Mo         Mo         Mo         Mo         Mo         Mo         22/13         Mo         Mo         Mo         Mo         Mo         22/13         Mo         Mo         Mo         Mo         Mo         Mo         Mo         Mo         22/13         Mo	Chicago CMSA	2	153,216	2	113,426	9	9	04.70	441.74	Ŧ	ŝ	Ð		
Noneno (dB), Interinsical, Barrines(chi, Barrines	Denver CMSA	2	£	417,404	17.14	9	Ŷ	ł	9	237120			-	•
Minimum C(E)         No         Set         No         No         167.70         167.70         167.70         167.70         167.70         177.70	Housen Class	9	100,0015	2	9	Ż	Ŷ	9,014 9	300.000	Ż	2	<b>m</b>		
Mean register         NO	Mertine Class	2	237,482	2	2	£	2	100,70	100.94	9	N	~		
Interent NEC(A)         No.	Bodian MECANA	2	2	2	9	£	£	114,94	206.03	1.470.00	-	-	-	
Human Calify, MECLAN         ND         317.287         3.12.967         3.12.967         3.12.964         1.0         317.267         3.12.964         2.27.160         2.2         3         4         2         3         4         2         3         4         2         4         2         3         3	Hardoni NECILA	2	20.511	104.340	9	9	2	1 <b>11</b> .50	<b>BAL</b> 33	00.000	-	•	-	
Mediant Califyi Insurface         No         73,770 (1,1,1,1)         Mediant (1,1,1,1)         No         73,70 (1,1,1,1)         Mediant (1,1,1,1)         No         73,70 (1,1,1,1)         Mediant (1,1,1,1)         No         73,70 (1,1,1,1)         Mediant (1,1,1,1)         No	Hun York CLISARECILL	Ŷ	317,257	3, 125,400	272.73	2	2	1,114.10	966.12	1.173.40		-	+	•
Bits:         Tar.         Model:         Mode:         Mode:         Mode:	Photom. Carlon	2	123,770		9	2	2	2.12	372.06	Ŷ	Ċ.			
Manual CMRA, Internet CMRA, Brane CMRA, Manual CMRA, Manua CMRA, Manual CMRA, Manual CMRA, Manual CMRA, Manual C	Sent - Leo. Carlan	2	2	201,670	30,151	2	£	£	9	1.514.80	•		•	
Hear Program (Revge C(R), N)         I (556)         HD	Allertia CMSA	9	#	2	2	2	9	014.60	208.30	£	•	e,		
Claneter Čideň         NO	Bunn Rouge CASA	2	14,506	2	2	Ŷ	2	60.14	18 E	£	N	•*		
B Pare Cates, ND 11/154 200,700 7,271 NO 740 7,271 NO 24,610 25,00 23,62 756,60 2 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Cleveland Class	Ŷ	1000,110	04C,214	<b>46</b> , 720	£	9	241.00	100-31	Z, 359, 90	N	•	•	
Stark Vir, AB       H0       N0       N12500       15000       24000       110000       1	G Pare CASA	Ŷ	11.144	320.700	7,27	£	ł	88	33.62	755.00	CI	-	-	63
Stant Court (d)         ND         H,D         24,873         ND         11,800.05         460.00         61,720.00         1 <th1< th=""> <th1< td="" th<=""><td>Sen Jay Val AB</td><td>¥</td><td>Ŷ</td><td>Ŷ</td><td>11,506</td><td>Ŧ</td><td>0.125.00</td><td>150.00</td><td>240.00</td><td>1,100.00</td><td>-</td><td>-</td><td>-</td><td>-</td></th1<></th1<>	Sen Jay Val AB	¥	Ŷ	Ŷ	11,506	Ŧ	0.125.00	150.00	240.00	1,100.00	-	-	-	-
Maxel CutCh         HD         53,266         HD         HD         ND	South Court AB	2	9	2	291	2	11,980.05	160.091	00.0 <b>0</b> 0	9,732,00	-	-	-	
Min. St Paul Calify         HD         H(1)         4(1,16)         42,222         ND         ND         4(1,16)         42,222         ND         ND         4(1,16)	ALANY CHERK	9	10,24	Ŧ	9	2	9		100.04	£	**	e		
Prono-Chemic calify         HD         T13.04         3.441         ND         ND         ND         ND         442.40         4.0         4         1           Sundbage AB         ND         -1/1.156         57.010         150.55         ND         120.05         124.320         2         3         1         1           Sundbage AB         ND         -1/1.156         57.010         150.55         ND         120.05         124.320         2         3         4         1           Sundbage AB         ND         -1/1.156         57.01         169.57         ND         120.05         124.320         2         3         4         1           Sundbage AB         ND         ND         ND         ND         ND         ND         261.27         3         4         1         1         1         1         1         1         1         1         1         1         1         1         1         1         3         3         4         3         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1	tion, of Periodical Control	7	9	410,140	42,212	Ŷ	Ż	ŧ	£	Z,421.70			4	
San Diego AB         ND         -1/136         F/A, 106         6,925         MD         2,406;00         128,70         1,413,20         2         3         1           Spotumer CARSA         ND         ND         2,406;00         128,70         142,20         2         3         1         3           Spotumer CARSA         ND         ND         2,406;00         128,70         1,043,200         2         3         4         3           Spotumer CARSA         ND         ND         2,006;0         ND         ND         26/3;00         16,203         2,160;00         2         3         4         3           Spotuger CLASA         ND         ND         ND         ND         ND         ND         26/3;10         18,732;66         8,400;10         2         3         4         3           Spotuger RCLAA         ND         ND         ND         ND         ND         26/3;11         30,300         ND         1         1         1         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3	Provo-Onen ChildA	Ŷ	2	100 EL		â	ŧ	ŧ	9	01.014			•	-
Spectrum Califold ND ND 8:021 3,311 ND ND ND ND 261,20 2.1 4 3 No. 2012 ND 2012 2012 0.0 10 2012 1.1 106,01 2.2 3 4 3 No. 2012 ND 2012 0.1 10,122,01 10,12	San Diego AB.	2		570,100	6,926	£	2,400,00	129.70	12.08	(,)43.20	¢.	<b>6</b> 11	•	-
Ri, Luin Cuiti M     ND     20,770     168.87     1,706.60     2     3     4     3       Musimment Officia     ND     ND     ND     ND     ND     20,770     168.87     1,706.60     2     3     4     3       Musimment Officia     ND     ND     ND     ND     ND     ND     20,34     2,160.60     2     3     4     3       Spirituation NECLIA     ND     ND     ND     ND     ND     ND     1     1     1     1       Materia     S400.464     6,677,733     36,004,733     1,097,733     ND     ND     8     6     5     5       Materia     S400.464     6,677,733     36,004,733     ND     ND     8     6     5     5       Materia     S400.464     6,677,733     36,004,734     ND     4     0     5     5     5       Materia     ND     ND     ND     ND     16,772,745     84,000,716     5     5     5     5       Materia     S400.464     6,677,733     36,004,746     16,796,610     16,772,524     84,000,717     5     5     5       MD     ND     ND     ND     16,272,100     16,866,610	Spokum CMSA	£	£	9,001		Ŧ	2	9	9	261.20			•	-
Ministregate DC CLASA         HD         RD         ND         ND         946.201         2 (40.50)         2         3         4           Spingleto NECLAA         HD         ND         HD         ND         ND         ND         345.201         2 (40.50)         2         3         4           Spingleto NECLAA         HD         ND         HD         ND         ND         ND         1         1         1         5	St Look Child A	9	000	ž	100.10	2	9	297.25	198.97	1.706.60	N	~1	•	e
Spannaderica Keicala MD MD MD MD MD MD MD KEI 20.30 MD 1 1 Nameri S,433,444 S,647,713 34,004,743 (,397,714 ND K62.572,00 IS,966,61) 16,732,96 B4,900.71 5 5 5 5 5 Munice Manuel Manuel Voluminy Come a Support Plan ND MD	Weakington DC CMSA	2	ED, DEJ		9	9	9	345.00	260.34	2,160,60	~	69	•	
Network S, 45%, 46%, 7, 783 3%, 004, 743 (, 207, 754 NU) 66, 2472,00 (6, 966,6) (9, 723, 66 84, 903, 71 5 6 5 5 1. Sum Implementation Plan 2. Phase II: Vacient Strepton Runs 3. 1966 National Empiricity Runs 4. Goad Carbon Monorder Surport Pure	Solingleth NECLAR	Ŧ	2	9	2	2	Ż	14.00	83	Ŷ	-	-		
ND - Nor Deam Implementation Plan 2. Phaye 11-Yotadiity Connet Support Funs 3. 1965 National Empirical Report 4. Cost Carlino Menovidin Support Purta	Ţ	5,428,464	£,647,793	36.00H,743	BTT, 70C, )	Ŧ	B62.572.00	15,005.61	10,732.46	84,900.71	¢	•	uş	•
2. Phone is Variable Control Support Furth 3. 1945 Material Enterthion Report 4. Cost Cartest Monorkin Support Pure		100 M									- 0		a militari Di	5
3. 1965 National Entrywood Report 4. Coad Carthon Monouffin Support Rura												Vete	C.	d Support P
4. Cold Carbon Menorida Support Rura											1996	National I		Reor
											1. Gold	N COLUMN	<b>Onor</b>	Support Run

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Other Area and Poers Squitz	+ Emisalum												
Geographical Area	٢Ş	59 24	<b>\$</b> 8	6ž	tpy Auderhyder	£§	10	NČN AN	<b>]</b> 8	×00	and and a		NSO N
Battimore CMBA	2	920,978	3H,482	2	2	Ŷ	226.00	164.32	225.86	•	-	•	
Chicago CatSA	9	302,107	2	101,246	9	9	1,029,00	603.01	9			•	
Dennie CLEA	£	2	64,670	148,877	2	2	2	2	167.54	I	•	-	
Harrison CMBA	£	140,025	9	Ŧ	Ŷ	2	1,301,00	04,028	2	~	Ċ		
Minister CMSA	₽	( <b>1</b> ) 621	£	Ŷ	3	¥	195,00	109.45	2	N	প		
Bower NECKA	2	Ŧ	2	9	Ŧ	7	DAL NOC	164.62	5.000 S.4	-			
Harring NECHAA	Ŷ	11,066	51,907	2	2	2	76.00	16.01	210.00	-	-	-	
New York CHEANECHA	Ŷ	212,002	544,600	019,873	2	9	1,578,00	638-00	1001.06	N	-	+	
Princel CLICA	Ŷ	137.570	17.172	2	2	2	011.00	376.00	9	~			
Beat -Tan CMSA	2	2	190,879	81,070	Ŷ	2	Ŷ	2	264.82		,	•	
Ningthe Child.	2	33.55	2	2	£	2	207,00	240.24	9	en e	•		
Beton Rouce CMSA	Ŧ	17.1	2	9	2	£	270.00	224.70	Ŷ				
Cleveland Calify	9	100 21	197 W	64,267	2	물	001580	170.00	291.62	-	9	•	
El Parto CMBA	2	20,342	11,000	129,930	2	3	\$0.00	24.67	24.91	-	-	-	
Ber Ja Vel AB	2	9	2	731,780	2	16,790,00	1,022.10	248.70	02.1586	-	-	-	-
South Cost AB	2	₽	9	746,500	9	18,213,50	1,400,00	333.60	205.00	-	-	-	-
Mischi Cursia	9	191(H)	9	2	Ŷ	2	236.00	97.16	2	N	e		
Min-SCP and CMSA	2	53,307	10,001	214,300	2	2	2	173.44	386.71			4	
Prove-Onth CMBA	2	2	30,273	45,815	2	Ŧ	2	Ŧ	PC 99			-	
Ban Dingo A6	Ŷ	9	000 <sup>0</sup> W	179,215	2	3,723,00	271,00	04.10	153.02	N		+	-
Spokane CMBA	2	9	7,74	0.837	2	Ŧ	Z	2	223.70			*	
St. Louis CldSA	ł	15.6.51	2	90,626	9	9	360,030	434.27	41.10	2	•	4	
Wathington OC Class	9	305, 20	28,93	2	9	9	202.00	242.02	166.74	2	-	•	
Springheld NECKAA	2	Ŷ	2	9	2	2	10.01	20.62	Q	-			
	13,664,163	13,966,333	24,460,414	0.344,620	9	22,311,900,00	37,400,04	S\$,233.76	19790278	10	5	5	÷
-	9 9							ન્યયના	Biate Inglaman Phase I Volatio 1996 National E Cold Carton M	cation Plan by Control S Interation Pap Interation Pap Interation Pap	upport F port port Aur		
								ŗ					4

### Table 2-11. Emissions from Other Area and Point Sources

### Chapter 3. Results

As described in Chapter 2, EPA developed two new sets of inventories for nonroad engines and vehicles. Inventory A was developed from data supplied by EPA contractors, and Inventory B incorporated information supplied by manufacturers.

Both inventories were developed by multiplying the activity levels by the appropriate emission factors. Where possible, the resulting data were compared to emission inventories for highway mobile sources and other area and point sources.

The results of Inventories A and B are summarized in this chapter. Detaned presentations of both inventories can be found in Appendixes M (Inventory A) and O (Inventory B). This chapter also contains a summary of the results from EPA's analysis of SIP and CARB inventories.

### 3.1. VOC, NO<sub>11</sub>, CO, and Particulate Nonroad Inventories

Table 3-01 presents nonroad emissions of VOC, NO<sub>x</sub>, CO, and particulates as percentages of the total emission inventory for each of the 24 nonattainment areas studied. For each entry, a range is provided. The lower end of each range was calculated using new engine emission factors, while the upper end utilized in-use emission factors.

Due to the seasonal nature of ozone and CO nonattainment in many areas, EPA made adjustments to the emission inventories developed for VOC, NO<sub>x</sub>, and CO. The results are reported as percentage tons per summer day for VOC and NO<sub>x</sub> and percentage tons per winter day for CO. Table 3-01 also provides a comparison of results from Inventory A and Inventory B.

To help visualize the nonroad contribution to total local emission inventories, stacked bar charts are used to display the distribution of the results from Table 3-01 in eight charts following the table. Calculations using both new engine and in-use emission factors are presented in each chart to illustrate the range of potential nonroad emission contributions. Of the 24 nonattainment areas included in the inventories, 19 were studied for NO<sub>x</sub> and VOC. 15 were studied for CO, and 13 were studied for particulates.

Nonattainment Area	Inventory A				Inventory B			
	VOC tpsd (%)	NO <sub>x</sub> tpsd (%)	CO tpwd (%)	PM tpy (%)	VOC tpsd (%)	NÖ <sub>x</sub> tpad (%)	CO tpwd (%)	PM tpy (%)
Atlanta	10-14*	13			7-10	13		
Baltimore	10-14	19	11-14		9-12	18	11-14	
Baton Rouge	7-10	13			4-6	8		
Boston	7-11	19	9-15		12-16	25	8-13	
Chicago	6-9	16		2	5-8	12		1
Cleveland	7-9	15	5-8	2	7-10	12	4-7	I
Denver			6-9	L			5-8	0.5
Ei Paso	8-12	22	5-8	0.4	6-9	15	4-7	0.2
Hartford	10-14	25	9-13		11-16	31	4-11	
Houston	7-10	15			6-8	10		
Miami	12-16	18			7-10			
Milw aukee	10-14	16			9-13	13		
Minneapolis			4-7	1			3-6	0.7
New York	9-13	20	9-14	3	8-11	14	8-13	2
Philadelphia	9-12	17		_	6-8	14	-	_
Prove-Orem	Ţ		3.4	0.4			2-4	0.3
San Diego	14-20	39	9-14	2	8-11	31	7-11	1
Seattle	1		9-12	5	·		9-11	3
South Coast, CA	13-19	29	8-13	2	6-9	20	6-9	0.7
San Joaquin	4-5	19	6-10	0.6	3-4	17	5-8	0.4
	· <del>  ·</del> · · · · · · · · · · · · · · · · · ·							
Springfield, MA	9-12	15			9-13	15		
Spokane			2-4	2			2-4	ł
St. Louis	11-14	12	5-8	2	10-14	10	4-7	1
Washington, DC	10-14	17	5-8		11-16	13	6-9	

# Table 3-01. Total Nonroad Emissions by Nonattainment Area and Pollutant (%)









# 3.2. VOC, NOx, CO, and Particulate Nonroad Inventories by Categories

The following charts summarize the contribution of each category of nonroad equipment to total emission inventories. Each chart presents the VOC,  $NO_x$ , CO, and particulate contribution determined by each of the two inventory methods for one equipment category.


















Commercial Marine VOC tpsd











'n

























Results






























#### 3.3. National PM, SO<sub>x</sub>, and Air Toxics Inventories

Table 3-02 summarizes national emission inventories for particulate matter, formaldehyde, benzene, 1,3-butadiene, gasoline vapors, and oxides of sulfur for all nonroad sources. Inventories from highway vehicles and other area and point sources are presented where available and the contribution of nonroad sources to total inventory is calculated. Due to the extremely limited availability of data for toxic inventories for highway and other area and point sources, the data in the table are from the most recent year for which data was available. Therefore, the data can only be used for approximate comparisons of the contributions from the various sources of air toxic emissions. The nonroad inventories for air toxics in Table 3-02 are the in-use adjusted Inventory A numbers. The formaldehyde and benzene inventories for highway and other area and point sources were taken from an EPA technical report by P. Carey.<sup>10</sup> The PM and SO<sub>x</sub> inventories were derived from EPA's 1989 emission trends report.<sup>11</sup> The highway vehicle value for 1,3-butadiene was based on assuming that this toxic accounted for 0.35% of the total exhaust hydrocarbons emitted from highway vehicles.<sup>12</sup> The aldehyde emission factors used in this study for nonroad sources are in terms of total aldehydes. To compare formaldehyde inventories from nonroad to other sources, EPA assumed that 60% of the total nonroad aldehyde emissions were formaldehyde.\*\*\*

<sup>&</sup>quot;"" The 60% estimate was typical for engines which had separate formaldehyde, as well as total aldehyde, emission measurements reported in Nonroad Emission Factors of Air Toxics by Melvin N. Ingalla, Southwest Research Institute, SwRI 08-3426-005.

	Nonroad So		Highway Sources		Other Are Point So		
Toxic	tpy	% of Total	tpy	% of Total	tpy	% of Total	Total tpy
particulate*	457,396	5.55	1,397,738	16.96	6,384,620	77.49	8,239,754
formaldebyde	41,663	13.05	74,961	23.48	202,670	63.47	319.294
benzese	109,783	25.37	275,579	63.68	47,400	10.95	432.762
1.3-butadiene	47,816		9,869				
gasoline vapors	237,048**		2,819,727				
so <sub>x</sub>	230,495	0.99	652,572	2.81	22,311,998	96.19	23,195,065
* Does not inclu	ide fugitive du	st from une	aved roads an	d ainstrips	which account	ts for about	t 77% of total

Table	3-02.	Air	Toxics	Emission	Inventories
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suspended particles. \*\* Does not include running losses or hot soak evaporative emissions.

#### 3.4. SIP and CARB Inventory Analysis

As discussed in Chapter 2, inventories were prepared using data from SIPs and CARB analyses. The following tables summarize the results from the SIP- and CARB-based inventories. It should be noted that the emission factors used to develop SIP- and CARBbased inventories do not include in-use or transient operation adjustments. A discussion of the emission factors used to develop these inventories can be found in Appendix I. A discussion of the methodology used to create these inventories and a more detailed report of the results can be found in Appendix G.

	VOC		NOx		CO	
CMSA/NECMA	tpy (%)	tped (%)	<b>tру</b> (%)	tpsd. (%)	tpy (%)	tpwd (%)
Atlanta, GA Beaumont-Port Arthur, TX Boston, MA Chicago, II Connecticut	3	4 1 6 5 10	7	8 18 9 7.6 21		6
Dallas, TX Denver, CO Duluth, MN El Paso, TX Fort Collins, CO		4		14 18	6	3
Hartford, CT Houston, TX Louisville, KY Minneapolis, MN New Jersey	б	7 4 12	13	25 6 44	16 16	4
Seattle, WA Springfield, MA State of Mass.		12 8		9 8	9 6	

Table 3-03. SIP-Based Inventory Summary

Air Basin	VOC tpsd (%)	NO <sub>x</sub> tpsd (%)	CO tpwd (%)
Mountain Counties	5	31	6
Sacramento Valley	4	19	10
San Diego	3	29	10
San Francisco Bay Area	2	21	11
San Joaquin	2	13	13
South Central Coast	2	13	12
South Coast	3	17	11

Table 3-04.	CARB-Based	Inventory	Summary
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#### Chapter 4. Discussion and Analysis of Results

Chapter 3 presented a summary of the inventories calculated from the data collected for this study. This chapter contains EPA's analysis of these inventories and its interpretation of the results. Specifically, the first section contains an analysis of nonroad contributions to total emissions by pollutant and equipment categories. A discussion of the methodologies used to calculate the inventories and their potential impact on the results is presented in the second section. Last, the contribution of nonroad emissions is compared to other categories that are currently regulated.

#### 4.1. Discussion of Inventory Results

Following are discussions of the results for emissions of VOC, NO<sub>x</sub>, CO, and other pollutants, and the relative contribution of equipment categories. The overall nonroad emission contributions are summarized by pollutant.

#### 4.1.1. Volatile Organic Compounds (VOC) Inventories

Both Inventory A and Inventory B estimate that substantial summertime VOC emissions derive from nonroad sources. Inventory A estimates that 18 of the 19 ozone nonattainment areas examined have nonroad contributions over 6-9% (lower limit represents new engine and upper limit represents in-use emission factors) of total summertime VOC inventories, with a median contribution of 9.1-12.6%. The estimates in Inventory B are about 15-20% lower than those in Inventory A. However, Inventory B still estimates that 14 of the 19 areas have nonroad contributions over 6-9%, with a median contribution of 7.4-10.3%.

The largest contributors to nonroad VOC emissions are the lawn and garden and recreational marine categories. In Inventory A, the median contribution of lawn and garden equipment to total summertime VOC inventories is 2.7-4.7%, with the lowest reported contribution being 1.1-1.9%. Inventory B is slightly lower, on average, with estimates of the median lawn and garden contribution at 2.4-4.2%, and 18 areas above 1.1-1.9%.

Contributions of recreational marine equipment to nonroad VOC emissions are similar to lawn and garden contributions. Inventory A estimates the median contribution of recreation marine equipment to be 3.4-4.0%, with 15 of the 19 areas above 2%. Inventory B estimates are about a third lower, overall, but still estimates a median contribution of 2.2-2.5%, with 10 of the 19 areas above 2%.

The light commercial and construction categories each contribute at least 0.5% of total summertime inventories in 17 of the 19 nonattainment areas. Table 4-01 shows the number of nonattainment areas in which the equipment category listed contributes at least 1% of the VOC inventory.

	Number of Areas			
Equipment Category	Inventory A	Inventory B		
Lawn and Garden	19	18-19		
Recreational Equipment	2-3	0-2		
Recreational Marine	17	17		
Light Commercial	2-11	2-12		
Construction	11-14	5-6		
Agricultural	1	1		
Commercial Marine	1	l		

 
 Table 4-01. Equipment Categories Contributing at least 1% of Total Summertime VOC Inventory

It should be noted that exhaust emissions account for less than three-quarters of the total VOC emissions from the lawn and garden category. The remaining VOC emissions from this category are due to crankcase, evaporative, and refueling spillage emissions. Spillage during refueling of the equipment is estimated to contribute 7.5% of the total lawn and garden VOC inventories and 8.9% of the lawnmower VOC inventories.

#### 4.1.2, Nitrogen Oxide (NO<sub>x</sub>) Inventories

Total summertime NO<sub>x</sub> emissions from nonroad sources are estimated to be larger, as a percentage of total emissions, than nonroad VOC emissions. Nonroad NO<sub>x</sub> emissions in all of the ozone nonattainment areas in Inventory A are estimated to be greater than 12% of the total summertime NO<sub>x</sub> inventory, with a median contribution of 17.3%. Although lower, Inventory B still estimates that nonroad emissions contribute over 11% of total summertime NO<sub>x</sub> emissions in 16 of the 19 nonattainment areas studied, with a median contribution of 14.5%.

Construction equipment is the largest contributor to nonroad NO<sub>x</sub> emissions in 17 of the 19 nonattainment areas studied. Inventory A estimates that construction equipment contributes at least 6.4% of total summertime NO<sub>x</sub> emissions in each area, with a median contribution of 9.7%. Inventory B is more than 15% lower, but still estimates that 15 of the 19 areas have construction equipment contributions of over 5%, with a median contribution of 8.4%.

 $NO_x$  contributions from airport service equipment, industrial equipment, and agricultural equipment are each estimated to be at least 1% in most of the nonattainment areas studied. However, only in one case (agricultural equipment in the San Joaquin Valley) does the contribution from any of these categories exceed 3.6% in any nonattainment area. The commercial marine vessel contributions are more variable, with larger contributions in a limited number of areas. The inventories estimate contributions of over 4% in three nonattainment areas for the commercial marine category. Table 4-02 shows the number of nonattainment areas in which the category listed contributes at least 1% of the  $NO_x$  inventory.

	Number of Areas			
Equipment Category	Inventory A	Inventory <b>B</b>		
Airport Service Equipment	12	12		
Recreational Marine	2	1		
Industrial	13	13		
Construction	19	19		
Agricultural	12	13		
Commercial Marine	10	9		

# Table 4-02. Equipment Categories Contributing at least 1% ofTotal Summertime NOx Inventory

# 4.1.3. Carbon Monoxide (CO) Inventories

Inventory A estimates that nonroad emissions contribute at least 9-12% of total wintertime CO emissions in 7 of the 16 CO nonattainment areas studied, with a median contribution of 5.9-9.4%. Although slightly lower, with a median contribution of 5.2-8.5%, Inventory B estimates that nonroad emissions contribute at least 6.9-10.5% of total wintertime CO emissions in 6 areas.

Unlike nonroad emission contributions to VOC and  $NO_x$ , the nonroad emission contribution to CO is not dominated by any one or two equipment categories. The lawn and garden, light commercial, industrial, recreational, and commercial marine equipment categories each contribute a minimum of 1.4-2.2% of total wintertime CO emissions in at least 2 nonattainment areas. The single largest nonroad contributor to winter CO emissions is light commercial equipment. Both Inventory A and Inventory B estimate that this category contributes at least 2.0-3.6% of total emissions in 8 of the 16 nonattainment areas studied. Table 4-03 shows the number of nonattainment areas in which the category listed contributes at least 1% of the CO inventory.

	Number of Areas			
Equipment Category	Inventory A	Inventory B		
Lawn and Garden	5-9	3-6		
Recreational Equipment	3-7	2-5		
Commercial Marine	2	2		
Light Commercial	15	15		
Industrial	12-13	10-11		
Construction	3-4	0-1		

 Table 4-03. Equipment Categories Contributing at least 1% of

 Total Wintertime CO Inventory

# 4.1.4. Particulate (PM) Inventories

Inventory A estimates that nonroad emissions contribute over 3% of total PM inventories in 2 of the 13 PM nonattainment areas studied, with a median contribution of 1.8%. Inventory B is substantially lower, with a median contribution of about 1.0%, and only estimates that 1 area has nonroad contributions of over 3%.

Table 4-04 shows the number of nonattainment areas in which the category listed contributes at least 1% of the PM inventory.

	Number of Areas		
Equipment Category	Inventory A	Inventory B	
Construction	2	0	
Commercial Marine	l	1	

Table 4-04. Equipment Categories Contributing at least 1% of Total PM Inventory

### 4.1.5. National Air Toxics Inventories

Section 3.3 presented estimates of toxic emissions from nonroad sources (Table 3-02). The limited availability of toxic emission data for nonroad sources made it difficult to quantify precisely the inventory from these sources. Uncertainties also exist as to the health effects (example: number of cancer incidences per year) of toxic emissions. A summary table of cancer risk estimates for air toxics is provided in Table 4-05. In this section, PM is treated as a toxic emission because of its long-term health effects (carcinogenicity) and its status as a criteria pollutant.

A rough approximation of the cancer risk from nonroad toxic emissions relative to highway toxic emissions can be determined from the ratio of nonroad inventory to highway inventory which is derived from Table 3-02. Table 4-06 shows the ratio using this method for 1986. These risk estimates are intended to be used to rank the nonroad toxic pollutants and should not be viewed as actual numbers of cancer cases per year. In addition, the model used to derive the values in Table 4-05 was developed for national highway vehicles which are more likely to be used in populated urban areas than nonroad engines and vehicles on a national level. Therefore, the accuracy of the nonroad estimates is dependent on the differences in urban/rural usage of on-highway vehicles and nonroad equipment.

	U.S. Cancer Incidences/Year**				
Motor Vehicle Pollutant	1986	1995	2005		
1,3-butadiene	236-269	139-172	144-171		
Diesel Particulate	178-860	106-662	104-518		
Benzene	100-155	60-107	67-114		
Formaldehyde	46-86	24-43	27-48		
Gasoline Vapors	17-68	24-95	30-119		
Asbestos	5-33	ND***	ND		
Acetaldehyde	2	1	1		
Gasoline Particulate	1-176	1-156	1-146		
Ethylene Dibromide	1	< 1	< l		
Cadmium	< 1	< 1	< 1		
Dioxins	ND	ND	ND		
Vehicle Interior Emissions	ND	ND	ND		

Table 4.05.	Summary	of Risk	Estimates	from Motor	Vehicle Ai	ir Toxics.*******
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The risk estimates are 95% upper confidence limits.

\*\* The risk estimates for asbestos, cadmium and ethylene dibromide are for urban exposure only. Risks for the other pollutants include both urban and rural exposure.

\*\*\* ND = Not Determined.

<sup>&</sup>quot;""""The risk estimates are upper bound estimates; therefore, they are not intended to represent actual numbers of cancer cases but rather can be used to rank the mobile source pollutants and to guide further study. Table taken from "Air Toxics Emissions and Health Risks from Motor Vehicles," presented by J.M. Adler and P.M. Carey at the AWMA Annual Meeting, 1989.

Nonroad/Highway Inventory Ratio				
1,3-Butadiene	4.85			
Particulates	0.33			
Benzene	0.40			
Formaldehyde	0.56			

Table 4-06.	Risk	Estimates	for	Nonroad	Toxic	Emissions.
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As Table 4-06 shows, 1,3-butadiene cancer risk estimates are extremely high for nonroad sources compared to on-highway sources. This is due primarily to two factors. The first factor relates to emission levels of 1,3-butadiene and the use of catalysts. Most onhighway vehicles use catalysts and have 1,3-butadiene emissions that are about 0.35% of total exhaust emissions. In comparison, few nonroad engines are so equipped, and as a result, have 1,3-butadiene emissions that comprise about 1.3% of total exhaust hydrocarbons. Further discussion of this difference is found in Appendix I. The second factor relates to crankcase use. While the majority of on-highway vehicles use a closed crankcase system, most nonroad engines do not and, as a result, have higher 1,3-butadiene emissions.

Many toxics such as benzene, 1,3-butadiene, aldehydes, and gasoline vapors are included in the broad category of pollutants referred to as volatile organic compounds (VOCs). Measures to control VOC emissions should reduce emissions of these air toxics. However, the magnitude of reduction will depend on whether the control technology reduces the individual toxics in the same proportion that total VOCs are reduced.

As evidenced by the 1990 Clean Air Act Amendments, Congress recognized the need to study and regulate emissions of air toxics from motor vehicles and fuels. The Amendments require that EPA complete a study of emissions that pose the greatest risk to human health or about which significant uncertainties remain by May 15, 1992. Also, EPA must promulgate vehicle or fuel standards containing reasonable requirements to control toxic emissions, applying at the minimum to benzene and formaldehyde, by May 15, 1995.

#### 4.2. Analysis of Inventory Methodologies

As outlined in Chapter 2, many of the inputs used to generate Inventory A and Inventory B are based upon different sources of information. This section discusses the effect that these differences could have on the inventory estimates. The results of this study could also be affected by methodologies which overestimate or underestimate emission inventories, as well as factors such as photochemical modeling, nonseasonal temporal adjustments, photochemical reactivity and transport. The potential impact of these factors on emission inventories is also discussed in this section.

#### 4.2.1. Data Differences

The results and analysis presented in Chapters 3 and 4 reveal that Inventory A generally estimates higher nonroad emissions than Inventory B. This difference in emissions is primarily due to different local amounts of boat usage and annual fuel consumption estimates for the recreational marine category, activity level estimates for lawnmowers and population estimates for the construction category. The following highlights the differences in each category.

Lawn and Garden Equipment-Both the Outdoor Power Equipment Institute (OPEI) and the Portable Power Equipment Manufacturers Association (PPEMA) submitted local and national population estimates, annual hours of use, average horsepower, and load factors for lawn and garden equipment. This data was used to estimate the emissions inventory for Inventory B. Although there are several differences between the national populations, annual hours of use, average horsepowers, and load factors for lawn and garden equipment in Inventories A and B, these tend to offset one another in most cases, resulting in similar estimates of emissions from most lawn and garden equipment. The primary exception is lawnmowers. Inventory A estimates for lawnmower populations, annual hours of use, horsepower, and load factor are higher than those for Inventory B by 10%, 20%, 5%, and 20%, respectively, leading to activity level estimates for Inventory A that are, in general, about 70% higher than for Inventory B. Overall, Inventory B. **Recreational Equipment**--The Motorcycle Industry Council (MIC) submitted survey results for actual miles driven and seasonal activity for off-road motorcycles and all-terrain vehicles. The seasonal activity levels were used by EPA to make seasonal adjustments for both inventories. The International Snowmobile Industry Association (ISIA) submitted national population and annual hours of use estimates for snowmobiles. The only substantial difference between Inventories A and B, is the latter's lower annual usage estimates. While this caused Inventory B's emission estimates from recreational equipment to be significantly lower than Inventory A's, the impact on total nonroad emissions is small due to the relatively low contribution of the category.

Recreational Marine-Both inventories used local boat registration data as the basis for making population estimates. However, the methods of allocating the number of boats actually used in the nonattainment areas differ significantly. Inventory A relies on survey results submitted by the National Marine Manufacturers Association (NMMA) from eight nonattainment areas to establish the ratio of boats used to boats registered in the nonattainment area. For Inventory B, NMMA supplied a method of estimating the ratio of boats used to boats registered based on the amount of water surface area in the nonattainment are per registered boat. The methodology used for Inventory B yields estimates of boat usage in the nonattainment areas that are about 10% lower than those in Inventory A. Another factor accounting for the difference between the two inventories is the estimate of annual gallons of fuel consumed. The average fuel use calculated for Inventory A from annual hour of use, average horsepower, and load factor estimates is very similar to the fuel use survey results reported by NMMA. However, NMMA believes that the reported fuel use in the survey is overstated. Thus, for Inventory B, EPA adjusted the average amount of fuel reported in the survey by the ratio of a national average fuel use calculation for outboard motors, 91 gallons/year, to the average reported in the NMMA survey for outboard motors. 142 gallons/year, before applying the results to the unsurveyed areas. Overall, emission estimates in Inventory B are about a third lower than those in Inventory A.

Industrial--The Industrial Truck Association (ITA) submitted population, annual hours of use, load factor, and engine type estimates for forklifts. The load factor estimates were adopted by EPA for both inventories. Overall, ITA's estimates yield emission inventory estimates substantially lower than the forklift estimates in Inventory A, primarily due to much lower annual hours of use estimates. Due to the relatively small amount of emissions from forklifts compared to some other equipment types, the impact on the overall  $NO_x$  inventory was less than 3% (the impact on the VOC and CO inventories is much lower yet). No information was submitted by industry for the other equipment types in this category.

Construction--Equipment Manufacturers Institute (EMI) submitted national horsepower, national load factor, regional hours of use, and regional population estimates for most of the equipment types in this category. Overall, the horsepower, load factor, and annual hours of use estimates are similar to the estimates used in Inventory A. However, EMI's population estimates are lower than those in Inventory A.

Agricultural, Airport Service, Light Commercial, Logging, and Commercial Marine--No substantial amount of information was submitted by industry for these equipment categories.

#### 4.2.2. Factors Causing Overestimation or Underestimation

EPA had sufficient information in several areas to know that methodologies used to quantify emission inventories could tend to overstate or understate the actual inventories. Where sufficient data was available to quantify the bias, corrections were incorporated into the data used for the inventories developed for this study. However, in some cases, which are discussed in this section, sufficient data was not available to make adjustments.

The estimates used for  $NO_x$  emissions from highway vehicles and other area and point sources are taken from the 1985 National Emission Report. While more recent  $NO_x$  data is available on the national level, no general source of local  $NO_x$  emissions is available after 1985. The level of emissions from highway vehicles in 1990 is actually somewhat lower due to the replacement of older vehicles with new vehicles having more effective emission controls.<sup>‡‡‡‡‡‡‡</sup> In this study, use of the 1985 data has the effect of overestimating  $NO_x$ emissions from other sources and, hence, underestimating the proportion of  $NO_x$  emissions from nonroad engines.

tittitiBased on National Atr Pollutant Emission Estimates: 1940-1989, highway NO<sub>x</sub> emissions dropped 16% between 1985 and 1989.

No estimates of emissions from personal watercraft (e.g., Jet Skis) are included in this study due to lack of data. PSR does not compile information on personal watercraft and the survey conducted by Irwin Broh and Associates for NMMA contained numerous cases where the respondent obviously misunderstood the category. This omission has the effect of slightly understating the inventory estimates.

The emission factors developed by EPA for this study include new and more extensive test data than previously incorporated into emission factor estimates. For the first time, the emission factors also consider evaporative and refueling emissions. In addition, in-use deterioration estimates were incorporated into a second set of emission estimates for each inventory. Nevertheless, the potential for inaccuracies still exist due to lack of data in some areas.

Factors that may cause the emission factors and, hence, the inventories to be understated are:

- Spillage factor. Application of the spillage factor for on-highway vehicles to large nonroad engines could result in underestimation of emission factors, since on-highway users are likely to be more conscious of spilling fuel on themselves and/or damaging the car's finish. Further, spillage from all equipment is likely to be underestimated due to the fact that all refuelings were assumed to be complete fill-ups.
- Evaporative emissions. The absence of data on hot soak or running loss emissions for nonroad vehicles and vapor displacement for gas can refueling may have resulted in underestimation of total evaporative emissions.
- Wintertime CO emissions. All emission factor testing has occurred at typical summertime temperatures (roughly 75°F). CO emissions, however, increase at colder temperatures due to additional fuel enrichment and longer warmup times. This effect was not accounted for in the determination of CO tpwd for nonroad engines due to lack of data. The proportion of cold start operation on nonroad engines is unknown, but is likely to be much lower than for

automobiles due to the tendency for most nonroad engines to be used for extended periods of time. It should be noted that the on-highway mobile source inventories used to determine the relative contribution of nonroad emissions did include the effect of wintertime temperatures on emissions.

Crankcase CO and NO<sub>x</sub> emissions. Exclusion of crankcase CO and NO<sub>x</sub> emissions could result in slight underestimation of nonroad emissions, even though their contribution is relatively small.

#### 4.2.3. Additional Considerations

Several factors that could potentially offset the contribution of nonroad engines to air quality nonattainment were not incorporated into this study. Some were not included because it was determined that to do so would not improve the validity of the results, while for others, insufficient information was available to develop methodologies within the timeframe mandated by Congress. This section discusses these factors, the reasons why they were excluded, and the potential impact (if any) on the results.

Non-Seasonal Temporal Adjustments--As previously discussed, EPA adjusted nonroad equipment activity levels for seasonal variation in usage. The inventories in this study are expressed in average daily emissions during summer (tpsd) and winter (tpwd), which are the seasons associated most strongly with ozone and CO nonattainment, respectively. As discussed in Appendix L, ozone and CO exceedences occur during both weekdays and weekends. Consequently, variations in source activity during the week and during the day were not considered.

Photochemical Modeling-As has been noted elsewhere in this report, the formation of ozone is an extremely complex process. It is difficult to understand the exact role played by emissions from the thousands of sources inside and upwind of a particular nonattainment area without a detailed photochemical model that takes into account not only manmade emissions but also local wind and weather patterns and biogenic emissions. Only recently have reliable photochemical models come into widespread use. The Regional Oxidant Model (ROM) for large, multi-state areas and the Urban Airshed Model (UAM) for individual urban areas represent the state of the art in air quality modeling for attainment planning. Congress has mandated that the worst nonattainment areas use photochemical modeling as a tool in developing individual customized plans for attaining the ozone standard.

EPA has not included photochemical modeling in this study for two reasons. First, developing and calibrating these models for even one nonattainment area would not have been possible within the deadline and budget for completion of this study. Second, the detailed, localized information available from photochemical models of individual cities would have added little additional relevant information to the overall question of the importance of nonroad emissions to attainment problems nationwide. Photochemical models are useful in deciding such questions as "On the margin, which kind of additional control would be more effective in reducing ozone in a particular area, NO<sub>x</sub> or VOC?" Thus photochemical modeling is important in severe nonattainment areas, where very large emission reductions are needed and each additional emission reduction strategy is likely to be costly. Detailed photochemical modeling of all nonattainment cities is not required to reach the conclusion that the ozone problem in urban areas across the United States is serious and attainment of the ozone standard will require large reductions of both VOC and  $NO_x$  emissions nationwide; that conclusion has already been reached in the establishment of the CAA itself. The photochemical modeling of alternative emission control strategies contained in the recent ROMNET report<sup>13</sup> offers additional support: ROMNET found that reductions in both VOC and NO<sub>x</sub> emissions beyond the minimum requirements of the CAA and across the northeastern U.S. would be required to bring the major East Coast cities into attainment of the econe standard. Thus, EPA is satisfied that if nonroad sources are found to be a significant contributor of either NO<sub>x</sub> or VOCs, then they are a significant contributor to nonattainment of the ozone standard.

Photochemical Reactivity--An issue related to photochemical modeling is whether nonroad VOC emissions are, on average, more or less photochemically reactive than emissions from other sources. As is evident from the discussion of toxic emissions from nonroad engines, very little data exists on the amount of individual species of VOCs emitted by nonroad engines. For the purposes of this study, EPA has assumed that the photochemical reactivity of nonroad VOC emissions is the same, on average, as VOC emissions from other sources. This is a reasonable assumption given that most nonroad engines are related to onhighway engines and that on-highway engines are the single most important source of VOC emissions in nonattainment areas.

Transport--During the past few years, it has become more apparent that ozone is a regional and not a local air quality problem. Recent studies <sup>14-15-16</sup> have shown that ozone and ozone precursors can travel long distances and affect air quality in areas at least two hundred miles from the source of ozone-forming emissions under some circumstances. Obviously, ozone does not respect the political boundaries enclosed by city, county, state, or nonattainment area lines.

Ozone transport complicates the assessment of nonroad emission contribution to urban nonattainment. To keep this study to a manageable size, EPA decided to include only equipment usage within the nonattainment areas in the inventory estimates. However, EPA is aware that emissions from equipment outside the nonattainment area boundaries also will affect the ozone level within nonattainment areas. Because emissions from equipment used outside nonattainment area boundaries may affect air quality, but are not accounted for in the inventories included here, the contribution of this equipment to urban nonattainment will be underestimated in this study. Underestimation of the air quality impact of nonroad equipment will be greatest for those types of equipment that have a substantial portion of their usage outside urban areas, such as agricultural equipment and recreational equipment (including marine pleasure craft).

It is difficult to quantify the underestimation of the nonroad impact on urban nonattainment that is due to transport for several reasons. First, EPA does not have current detailed information on nonroad populations and usage rates outside the areas considered in this study. County-by-county inventories for nonroad equipment are contained in national emission data bases, such as the inventories used in the National Acid Precipitation Assessment Program (NAPAP), but these inventories are at a rather broad level of categorization (such as "nonroad-diesel"), and use some obsolete emission factors. Second, it is difficult to estimate exactly what proportion of the emissions outside nonattainment areas affect nonattainment area air quality. It would seem reasonable to assume that emissions from sources 50 miles from a nonattainment area would have a greater impact than an identical source 150 miles from the nonattainment area, but currently no accepted "distance discount factor" is available that could be applied to inventories outside nonattainment areas. Third, the impact of transported emissions in any given area may vary considerably with meteorological conditions, particularly wind speed and direction. A study of transport in California found that, in some air basins, transport may have an "overwhelming" impact on ozone levels under one set of meteorological conditions, but an "inconsequential" impact under another set of meteorological conditions. Finally, local topography would be expected to influence the partern and importance of transport in different areas. Transport characteristics in a nonattainment area surrounded by mountains and valleys would be different from those in nonattainment areas surrounded by flat land.

To adequately assess the impact of transport on individual areas, detailed regional oxidant models (ROMs) must be constructed. These models include thousands of parameters, such as spatially distributed emission inventories for manmade and biogenic emissions over a wide area, detailed meteorological data, and topographical characteristics. Construction of these models was beyond the scope of this study. However, EPA's Office of Air Quality Planning and Standards, in association with EPA regions and state authorities, has recently completed a five-year study of transport and ozone formation in the Northeast, the Regional Oxidant Model for Northeast Transport (ROMNET). ROMNET concluded that emissions outside the heavily urbanized northeast coastal "Corridor" contributed to nonattainment in the Corridor. The ROMNET report states: "The results suggest that without stringent upwind controls, ozone levels in parts of the Corridor may not be reduced to below the concentration specified in the NAAQS even with stringent controls along the entire length of the Corridor." (p. ES-11).

The ROMNET inventories and modeling results may be used to make an "order-of-magnitude" assessment of the potential impact of transported nonroad emissions on nonattainment. By looking at the effect of reducing upwind emission inventories on ozone levels in particular nonattainment areas and at the proportion of nonroad emissions in the upwind inventories, a rough estimate of the impact of transported nonroad emissions on these cities under one set of meteorological conditions may be obtained. According to control measure simulations in the ROMNET study, a reduction of 65% of the non-Corridor VOC inventory and 60% of the non-Corridor NO<sub>x</sub> inventory resulted in an average peak ozone reduction in the nonattainment areas of Washington/Baltimore and Philadelphia. This implies that 1% of

the non-Corridor VOC and NO<sub>x</sub> inventories account for 0.14 ppb of the peak ozone concentration in the Corridor cities on average and about 0.18 ppb of the peak ozone concentration in the Washington/Baltimore and Philadelphia areas. The ROMNET Study assumed that nonroad engines accounted for 2.3% of the non-Corridor VOC inventory and 4.4% of the non-Corridor NO<sub>x</sub> inventory in 1985. Very roughly, this implies that transported pollutants from nonroad sources account for 0.5 ppb of the peak ozone concentrations in the Corridor cities as a whole and 0.6 ppb of the peak ozone concentration in the Baltimore/ Washington and Philadelphia areas under the meteorological conditions modeled. If nonroad sources are not controlled, transported pollutants from non-Corridor nonroad sources would account for roughly 0.3-0.45% of the ozone level along the East Coast during nonattainment episodes after implementation of the other measures in the 1990 CAAA. These estimates are not included in the estimates of the impact of nonroad emissions on urban nonattainment in the rest of this report, because they were available for only a few cities under specific circumstances and because the ROMNET nonroad emission estimates are likely to be greatly understated.

EPA and state and local air quality authorities are continuing their study of the impact of transported emissions on urban nonattainment. Efforts are currently underway to further characterize ozone formation and transport in the Northeast, and comprehensive ROMs covering the Midwest and Southeast are also planned. A comprehensive study of ozone transport in the Lake Michigan area has been launched by EPA's Region V and the states surrounding Lake Michigan.

A more complete description of existing transport studies is contained in Appendix P.

#### 4.3. Analysis of Nonroad Emission Impact

A great deal of effort and money has been expended on reducing emissions from a wide variety of sources, from the automobile to area sources such as dry cleaning and bakeries. The CAAA of 1990 mandate additional controls in many areas and more stringent controls on most of the equipment currently regulated. The purpose of this section is to help put the nonroad emission contribution into context by comparing nonroad emissions to currently regulated sources.

The nonroad emission inventories developed for this study estimate that the median nonroad contribution to total VOC and  $NO_x$  emissions for the nonattainment areas studied is over 7% for VOC and over 14% for  $NO_x$ . Based on emission inventories for all sources given in *National Air Pollutant Emission Estimates: 1940-1989*, the only source categories with larger VOC contributions at the national level are on-highway mobile sources and solvent evaporation. Also at the national level, the only source categories with greater  $NO_x$  contributions are on-highway mobile sources and electrical generation. Among the source categories with lower estimated contributions are industrial combustion, industrial processes, petroleum refining, and petroleum product storage and transfer. All of these other source categories are currently subject to emission control regulations. The estimated contributions of these categories are presented in Table 4-07.

Pollutant	Source Category	% contribution <sup>\$\$\$\$\$\$\$</sup>
VOC	On-highway Mobile	25
	Solvent Evaporation	24
	Nonroad	7-13
i	Petroleum Refining	3
l.	Petroleum Product	7
	Storage and Transfer	
NOx	On-highway Mobile	29
	Electrical Generation	32
	Nonroad	14-17
	Industrial Combustion	14
	Industrial Processes	3

Table 4-07. Contribution to Total Inventory

Another comparison of nonroad emissions to other sources can be made by examining the 1990 CAAA requirements for Reasonably Available Control Technology (RACT) on stationary sources. RACT controls will now be required on all stationary sources with either VOC or NO<sub>x</sub> emission above 50 tpy in serious nonattainment areas, 25 tpy in severe areas.

<sup>&</sup>lt;sup>1000</sup> Nonroad based on median contribution determined by this study; ranges reflect the largest and smallest local contributions calculated by Inventories A and B with new engine and in-use emission factors. All other contribution estimates are based on data from National Air Pollution Emission Estimates: 1940-1989, and are given at the national level for 1989.

and 10 tpy in extreme areas. This means, for example, that an area designated as an extreme ozone nonattainment area is required to install RACT control on every stationary source over 10 tpy. By comparison, Table 4-08 provides the number of new vehicles or pieces of equipment that it would take to generate 10 tpy, based on their typical yearly operation. For the nonroad sources, the chart indicates the range between data used to develop A and B national inventories.

Vehicles or Equipment	No. for 10 tpy		
Off-highway trucks	1.6-2.1		
Crawler tractors	10		
On-highway heavy-duty diesel truck*	20		
Agricultural tractors	24		
Boats with outboard motors	74-142		
Passenger Cars*	700		
Chain saws	730-1,630		
Lawnmowers	1,680-2,380		
String trimmers	2,810-4,630		
* Based on first-year emissions of a current technology vehicle.			

 Table 4-08. Comparison of Ozone Precursor Emissions from Various Vehicles

 and Equipment

Because CO nonattainment is usually more localized than ozone nonattainment, comparisons of national CO emissions may be misleading. A comparison of nonroad and highway CO emissions may, however, be made at the local level. Inventories developed for this study indicate that the median nonroad contribution to local wintertime CO emissions ranged from 5.2% to 9.4%, while the median contribution from highway vehicles was 81%.

# Chapter 5. Conclusions

A significant quantity of new information was generated by CARB, EPA, EPA contractors, and the industry in response to California's proposed nonroad regulations and this study. EPA used this new information and existing data to develop Inventories A and B. As a result, these inventories provide a more comprehensive picture of nonroad emission contributions to VOC,  $NO_x$ , CO and PM, than previously available. Among the findings of this study are the following:

 Median nonroad contributions to the total emission inventory for the 24 areas are estimated to be:

	VOC (%)	NO <sub>1</sub> (%)	CO (%)	PM (%)
Inventory A	9.1-12.6	17.3	5.9-9,4	1.8
Inventory B	7.3-10.3	14.5	5.2-8.5	1.0

2. Congress mandated that EPA study emissions from nonroad sources to determine whether such emissions cause or significantly contribute to air quality problems, and in particular whether they are contributors to ozone or CO concentrations in more than one CO or ozone nonattainment area. Of the nonattainment areas studied, the second highest contribution to total inventories from nonroad engines and vehicles for VOC, NO<sub>x</sub>, and CO is as follows:

	VOC (%)	NO <sub>x</sub> (%)	CO (%)
Inventory A	13.1-18.7	29.3	9.0-14.2
Inventory B	11.4-16.0	31.1	8.5-13.3

3. The results discussed throughout this report do not include the transport of ozone into the nonattainment areas. The effect of ozone transport would be to increase the emission contribution of typically nonurban equipment, such as agricultural, recreational marine, and logging equipment. While this effect may be relatively small, it is not insignificant.

Only on-highway vehicles, electric generation, and solvent evaporation have NO<sub>x</sub> and/or VOC emissions that exceed those of nonroad equipment.

#### **Recommendations for Inventory Improvements**

The study identified a number of areas where inventory estimates could be affected by the absence of data or the use of limited information. Nonroad inventory estimates could be enhanced by collection of additional data, particularly in the area of emission factors. For example, existing nonroad emission data allows an adequate assessment of tailpipe emissions from relatively new engines. More information, however, is needed to quantify other types of emissions, such as evaporative, crankcase, and toxic emissions, and the effect of in-use deterioration. Specifically, data should be obtained for the following areas:

- In-use emissions. Additional testing needs to be conducted on in-use engines to further quantify the effects of deterioration on the different types of nonroad engines.
- 2. Hot soak and running loss evaporative emissions. Currently, no hot soak and running loss evaporative emission data exist for nonroad engines. Such emissions are substantial for on-highway vehicles and can vary significantly according to the type of equipment on which an engine is installed. Therefore, tests should be conducted to determine whether these emissions from nonroad equipment need to be controlled.
- 3. Toxic emissions. EPA used the limited data that was available on toxic emission from nonroad engines to make the assumptions regarding such emissions. Such assumptions, particularly those for 1,3-butadiene, should be verified through further testing.

- Crankcase emissions. Further studies should be conducted to improve the measurement of crankcase emission levels from nonroad engines and to determine which engines use open and closed crankcases.
- 5. Cold start emissions. Currently, no data are available on the contribution of cold starts to nonroad emissions. Work should be undertaken to assess the proportion of cold start fuel enrichment operation on different types of nonroad equipment, and then to measure the impact of such operation on total emissions.
- 6. Emission data representativeness. Currently, nonroad emission data are uniformly applied to all similar nonroad engines. More accurate emission factors could be developed if emission testing were performed on engines representative of the population.
- 7. Cycle representativeness. Steady state test cycles do not adequately represent VOC, CO, and particulate emissions generated during in-use transient operation. To the extent that nonroad equipment encounters transient operation in-use, steady state cycles could significantly understate emissions, especially particulate matter. The adjustments made in this study to account for transient operation were based on very limited test data which applied only to diesel engines. More work should be done to assess the typical operating cycles of nonroad equipment. Such characterizations would facilitate the assessment of the amount and importance of transient operation on nonroad engines, as well as improve load factor estimates.

# References

- 1. U.S. Congress. House. Report of the Committee on Energy and Commerce U.S. House of Representatives. 101 Cong., 2d Sess., 1990. H.Rept. 490, Pt 1, p.145.
- U.S. Environmental Protection Agency. National Air Quality and Emissions Trends Report, 1989. EPA-450/4-91-003. Research Triangle Park, NC:Office of Air Quality Planning and Standards, February, 1991.
- 3. U.S. EPA, Trends Report.
- 4. U.S. EPA, <u>Trends Report</u>.
- Ingalls, Melvin N. Nonroad Emission Factors of Air Toxics. Report 08-3426-005. San Antonio, TX:Southwest Research Institute. June 1991.
- Irwin Broh & Associates, Inc. NMMA Boat Usage Survey. Prepared for the National Marine Manufacturers Association, Des Plaines, IL. August 1991.
- U.S. Environmental Protection Agency. 1985 National Emissions Report. Research Triangle Park, NC:Office of Air Quality Planning and Standards, September, 1988.
- U.S. Environmental Protection Agency, National Air Pollutant Emission Estimates: 1940-1989. EPA-450/4-91-004. Research Triangle Part, NC:Office of Air Quality Planning and Standards, March 1991.
- 9. U.S. Environmental Protection Agency. 1985 National Emissions Report. Research Triangle Park, NC:Office of Air Quality Planning and Standards, September, 1988.
- 10. Carey, P.M. Air Toxics Emissions From Motor Vehicles, EPA-AA-TSS-PA-86-5, Ann Arbor, MI:U.S. Environmental Protection Agency, September, 1987.
- U.S. Environmental Protection Agency. National Air Pollutant Emission Estimates 1940 -1989. EPA-450/4-91-004. Research Triangle Park, NC:Office of Air Quality Planning and Standards, March 1991.
- Adler, J.M., and P.M. Carey. Air Toxics Emissions and Health Risks from Mobile Sources. AWMA 89-34A.6, presented at the Air & Waste Management Association 82nd Annual Meeting, Anabeirn CA, June 1989. Ann Arbor, MI:U.S. Environmental Protection Agency, June 1989.
- 13. U.S. Environmental Protection Agency. Regional Oxidant Modeling for Northeast Transport (ROMNET). EPA-450/4-91-002a. Research Triangle Park, NC:Office of Air Quality Planning and Standards, June 1991.
- 14. U.S. EPA, ROMNET.
- Sillman, S., J. Logan, and S. Wofsy. "Sensitivity of Ozone to Nitrogen Oxides and Hydrocarbons in Regional Ozone Episodes." Harvard University, Cambridge, MA. Revised Manuscript, July 7, 1989.

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16. California Air Resources Board. Assessment and Mitigation of the Impacts of Transported Pollutants on Ozone Concentrations within California. El Monte, CA:State of California, June 1990.

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# Makeup of the Non-road Diesel Engine Industry (over 37kW (50 Hp))

	(010	1 01 A 11 (00 11)	P//		
			Aver	Load	
<u>P</u>	opulation	<u>Hrs/Year</u>	Hp	<u>(f)</u>	<u>g/Bhp-hr</u>
Agricultural Tractors	2,519k	411	98	70%	11.2
Tractors/Loaders	189	700	71	38	10.1
Terminal Tractors	65	1,200	96	82	14.0
Concrete/Industrial Saw	s 61	487	56	73	11.0
Swathers	50	100	82	62	11.5
Forklifts	47	850	83	30	14.0
Paving Equipment	44	507	99	53	11.0
Rollers	43	682	99	59	9.3
Sweepers/Scrubbers	37				
Rough Terrain Forklifts	25				
Other Agric Equipment	18				
Chippers/Stump Grinder	rs; 17				
Asphalt Pavers	12	814	77	56%	10.3
Sprayers	10	88	92	50	7.8
All Others	12				
	=====				
50-100 Hp	3,149k				
•	-,				
Combines	285k	812	107	51%	14.0
Crawlers/Tractors	159	1.021	134	57	10.3
Graders	64	924	147	54	9.6
Excavators	52	1.190	143	59	10.8
Skidders	31	1.398	131	49	11.3
Geni Industrial Equip	18	812	107	51	14.0
Other Construction Eq	12			-	
Aircraft Support Edulp	10				
Crushing/Processes	7				
Mati Handling	5				
·····	====				
100-175 Hp	643k				
<b>Rubber-tired Loaders</b>	130k	1.398	175	54%	10.3
Cranes	98	701	194	43	10.3
Off-hiway Tractors	39	859	214	65	11.9
Off-hiway Trucks	19	3.293	658	25	9.6
Scrapers	16	1,385	290	60	8.7
Feliers/Bunchers	16	1,110	183	71	11.3
Rubber-tired Dozers	8	818	356	59	9.6
Bora Drill Bigs	Ř	389	209	75	11 0
			200		
over 175 Ho	334k				
ALAL LA LA	0040				