EMISSIONS FROM UTILITY EQUIPMENT USE IN CALIFORNIA

FINAL REPORT

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However, the statements and conclusions in this report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with the material reported herein is not to be construed as either an actual or implied endorsement of such products.

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CHAPTER 1. SCOPE AND PURPOSE

The Air Resources Board (ARB) is required to maintain an inventory of air pollutant emissions by category of emitters; typical process categories are shown in Table 1-1. Utility equipment is an important class in the group called "Other Mobile Sources" and is the subject of this study. In the paragraphs which follow the utility equipment category is defined, the current inventory methodology is described and the objectives of the study are summarized.

DEFINITION OF UTILITY EQUIPMENT

The definition of utility equipment is derived from the definition adopted by the Bureau of the Census and modified by the Mobile Source Control Division staff of the ARB for use in emission inventories. The category includes equipment powered by internal combustion engines, but excludes all electrically powered devices since they are virtually non-polluting. The utility equipment category excludes all equipment powered by engines of more than 25 horsepower because they fall into one of the following categories:

On-road vehicles
Off-road vehicles
Mobile equipment
Fuel combustion, other mfg./ind.
Fuel combustion, other services and commerce
Miscellaneous processes, farming operations
Miscellaneous processes, construction and demolition

Table 1-1

EMISSION INVENTORY CATEGORIES

STATIONARY SOURCES

Fuel Combustion

- Agricultural
- Oil and Gas Production
- Petroleum Refining
- Other Mfg./Ind.
- Electric Utilities
- Other Services and Commerce
- Residential
- Other

Waste Burning

- Agricultural - Debris
- Range Management
- Forest Management
- Incineration
- Other

Solvent Use

- Dry Cleaning
- Degreasing
- Architectural Coating
- Other Surface Coating
- Asphalt Paving
- Printing
- Domestic
- Industrial Solvent Use
- Other

Petroleum Process, Storage and Transportation

- Oil and Gas Extraction
- Petroleum Refining
- Petroleum Marketing

Industrial Processes

- Chemical
- Food and Agriculture
- Mineral Processes
- Metal Processes
- Wood and Paper
- Other

STATIONARY SOURCES (Cont'd.)

Misc. Processes

- Pesticide Application
- Farming Operations
- Construction and Demolition
- Entrained Road Dust - Paved
- Entrained Road Dust - Unpaved
- Unplanned Fires
- Solid Waste Landfill
- Other

MOBILE SOURCES

On Road Vehicles

- Light-Duty Passenger
- Light- and Medium-Duty Trucks
- Heavy-Duty Gas Trucks
- Heavy-Duty Diesel Trucks
- Motorcycles

Other Mobile

- Off-Road Vehicles
- Trains
- Ships
- Aircraft - Government
- Aircraft - Other
- Mobile Equipment
- Utility Equipment

The utility equipment group is divided into three main categories: (1) lawn and garden, (2) chain saws, and (3) home utility. The lawn and garden category includes walk-behind mowers, riding mowers/lawn tractors, garden tractors, edgers, trimmers, blowers, and other miscellaneous lawn and garden implements. The chain saw category includes all gasoline-powered chain saws. The home utility category is a misnomer because it includes equipment that is used commercially as well as at home. It includes pumps, generators, compressors, grinders, refrigeration units, welding machines, and other miscellaneous utility engines.

Utility equipment may be used by households or commercial establishments. In general, the category includes all small gasoline-powered equipment except for off-road mobile sources such as mopeds, snow-mobiles, and the like.

CURRENT INVENTORY METHODOLOGY

Ideally, an inventory of emissions from utility equipment usage should be compiled from data on equipment population in California counties, usage of each type of equipment, and emission factors for each type of equipment. Unfortunately, the only information available prior to this study was equipment sales for the entire United States and usage and emission factor data for a very small sample of equipment. There are no specific data from California. The existing CARB inventory

was compiled from published data by making certain assumptions that are described in the following paragraphs.

Equipment Population

The Bureau of the Census[15] publishes yearly figures on the number of internal combustion engines under 50 hp that are produced in the U.S. The number of engines used in lawn and garden equipment is also given, and chain saws are identified as a percentage of the lawn and garden total. Information on shipments of specific categories of lawn and garden equipment is published in other Census Bureau documents.[14,16] This information is not broken down into shipments to individual states but is given for the nation as a whole. Some method must be devised for estimating the California portion of the total U.S. shipments before this Census Bureau information can be utilized. The ARB staff estimated the percentage of total U.S. shipments coming to California for the following types of equipment: walk-behind power mowers, riding mowers/lawn tractors, garden tractors, tillers, miscellaneous lawn and garden, chain saws, and general utility. To accomplish this they used information from the Engine Manufacturers Association (EMA) and the Outdoor Power Equipment Institute (OPEI) as well as their own best judgment.[1,5,6] From these data the ARB staff computed the annual California sales of each type of equipment for each year from 1964 to 1980.

In order to calculate the equipment population from yearly sales data, some estimates of equipment life and attrition were

needed. Separate attrition factors were developed for residential and commercial usage. The lawn and garden factors were based on an industry marketing study that showed that lawn mowers were replaced every five to six years. Factors for chain saws were based on a consultant's report to the Consumer Product Safety Commission that gave a five-year life for chain saws.[9] The same factors were also used for the miscellaneous lawn and garden category. Factors for commercial riding mowers and tillers were developed by the ARB staff. The attrition curves were applied to the yearly sales data to derive the equipment population figures shown in Table 1-2. This whole process is quite tedious since it involves applying 12 attrition factors to sales data for each of 17 years and summing the results for each equipment category.

Process Rate

Hourly use rates for each type of equipment must be known before emissions can be computed. Usage (process rate) is tabulated in Hp hours because emission factors, from which emissions are computed are expressed as $lb/10^3 HP\ hr$. In addition, usage is computed separately for 4-stroke and 2-stroke engines because there are two separate emission factors for these engine classes. Therefore, to completely define usage, it is necessary to know the horsepower rating and load factor of the equipment as well as the number of hours it is used.

Hours of use each year were estimated by the ARB staff from published data, in-house surveys, and information presented

Table 1-2

CALIFORNIA IN-USE SMALL UTILITY ENGINE EQUIPMENT POPULATION

	Attrition Factors (Fraction Still Operational)											
	Walk-Behind Mowers		Tractors		Tillers		Misc. Lawn & Garden		Chain Saws		General Utility	
Model Year	Res.	Comm.	Res.	Comm.	Res.	Comm.	Res.	Comm.	Res.	Comm.	Res.	Comm.
1979	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1978	.96	.79	.96	.89	.96	.94	.96	.79	.98	.94	.98	.94
1977	.89	.48	.89	.69	.89	.83	.89	.48	.94	.59	.94	.59
1976	.79	.24	.79	.48	.79	.69	.79	.24	.83	.24	.83	.24
1975	.69	.10	.69	.32	.69	.54	.69	.10	.59	.07	.59	.07
1974	.58	.07	.58	.18	.58	.42	.58	.07	.37	.01	.37	.01
1973	.48		.48	.10	.48	.32	.48		.24		.24	
1972	.40		.40	.08	.40	.23	.40		.16		.16	
1971	.32		.32	.04	.32	.14	.32		.07		.07	
1970	.24		.24		.24	.10	.24		.02		.02	
1969	.18		.18		.18	.09	.18		.01		.01	
1968	.13		.13		.13	.07	.13					
1967	.10		.10		.10	.04	.10					
1966	.09		.09		.09		.09					
1965	.08		.08		.08		.08					
1964	.07		.07		.07		.07					
1963	.04		.04		.04		.04					
Sales Split (Res,Comm)	.90	.10	.75	.25	.50	.50	.90	.10	.90	.10	.50	.50
1979 Population	2014243	92260	82788	15534	96643	76351	796508	36483	537374	39108	381751	233445

Source: California Air Resources Board, 1979 Emission Inventory

at workshops. Estimates were made for residential and commercial use. The data base ranged from results of informal surveys of less than a dozen respondents in any category to estimates based on judgement alone. The estimated values are shown in the first five columns of Table 1-3.

Average horsepower ratings and load factors for each equipment category were derived from data presented by the EMA and OPEI at workshops held by CARB in August 1980,[6] and June 1981,[5] and from information published in "Lawn and Garden Marketing" magazine.

The process rate for each equipment category, expressed as HP hr/yr for a single unit of equipment, can be computed from the information in columns one through six of Table 1-3. Process rates are computed separately for residential and commercial usage.

Emission Factors

Emission factors were taken from AP-42[17] which is based on experimental work carried out by the Southwest Research Institute[8] (SWRI). Five engines were tested: One 2 Hp 2-stroke engine, and four 4-stroke engines ranging from 3.5 to 18 HP. The engines were operated on small electric dynamometers at a variety of speeds and load conditions. The tests were not intended as a statistical sample of engines and use patterns. For purposes of determining emission factors, composite emissions from a 13-mode test were used, and engine groups were defined as follows:

Table 1-3

USAGE (PROCESS RATE) OF
UTILITY EQUIPMENT IN CALIFORNIA

	Residential			Commercial			Load Factor
	% Pop.	Hrs/Yr.	Avg.Hp	% Pop.	Hrs/Yr.	Avg.HP	(%)
LAWN AND GARDEN							
Walk-Behind Mowers	90	30	3.5	10	319	3.5	31
Riding Mowers/ Lawn Tractors	75	38	8.0	25	380	13.0	34
Garden Tractors	75	30	12.0	25	180	16.0	54
Tillers	50	18	4.0	50	72	6.0	40
Lawn Edgers and Trimmers	75	17	2.0	25	190	3.0	30
Miscellaneous	75	17	2.0	25	190	3.0	30
CHAIN SAWS	90	10	3.0	10	296	5.0	50
HOME UTILITY	50	48	6.0	50	96	14.0	50

Source: California Air Resources Board, 1979 Emission Inventory.

Lawn and garden, 2-stroke	100% Tecumseh AH520 Type 1448
Lawn and garden, 4-stroke	90% Briggs & Stratton 92908
	10% Briggs & Stratton 100202
Miscellaneous, 4-stroke	10% Briggs & Stratton 92908
	14% Wisconsin S-12D
	74% Briggs & Stratton 100202
	2% Kohler K482

The emission factors for these three categories are summarized in Table 1-4. The SWRI study also determined evaporative emissions as a function of fuel volatility and the number of tank fillings per year, but for reasons given on page 82 they will not be discussed in this study.

There are no emission factors for chain saws given in AP-42, so the ARB staff used factors from the AESI study of three saws.[2] Emissions were measured as the saws were being used to cut 10" logs. Horsepower ratings for these saws were estimated by AESI to be 5.5, 6, and 6, which differs substantially from the current ARB estimate of 3.0 (see Table 1-3). The emission factors in Table 1-4 appear to have been derived from the AESI factors by assuming a 3 HP rating for the average chain saw.

Computation of Emissions

Emissions are traditionally computed for each of the equipment categories shown in Table 1-3. However, emission factors were developed for somewhat different categories of equipment as shown in Table 1-4. The ARB staff reconciled these two sets of categories by making the following assumptions:

Table 1-4

EMISSION FACTORS (G/HP. HR)

	HC	Part	SO_x	NO_x	CO
Lawn and garden, 2 stroke	214	7.10	0.54	1.56	486
Lawn and garden, 4 stroke	23.2	0.44	0.37	3.17	279
Home utility (misc. 4 stroke)	15.2	0.44	0.39	4.97	250
Chain saws (2 stroke)	116.7	3.33	N/A	0.33	233

Source: AP-42 (reference 17) except for chain saws that were taken from the AESI Study (reference 2).

1. 4% of each subcategory of lawn and garden equipment has 2-stroke engines; the remainder is 4-stroke.*

2. The emission factor for "lawn and garden, 4-stroke" is representative of all the lawn and garden subcategories.

3. The emission factor for "Miscellaneous, 4-stroke" is representative of the "home utility" category

The statewide emissions for each equipment category were computed from equipment population data from Table 1-2, process rate data from Table 1-3, and emission factor data from Table 1-4. Sample calculations are shown in Table 1-5. Numerical values expressed as tons/year are shown in Table 1-6. Emissions of particulates and sulfur oxides are generally negligible. Emissions of other pollutants are small but in some situations may be of sufficient significance to justify efforts to improve the accuracy of the estimates.

OBJECTIVES OF THIS STUDY

The purpose of this study is to provide "hard" data on utility equipment use in California with particular emphasis on household and commercial equipment population and usage patterns. As discussed earlier in the chapter, the existing inventory is based on a reasonable, but completely subjective division of equipment into household and commercial categories. Usage patterns are based on extremely small samples or are estimated without any data at all. The equipment populations are estimated from yearly sales data and manufacturers' estimates of

*In the opinion of the authors, all 2-stroke engines should have been assigned to the walk-behind mower, edger/trimmer, and miscellaneous categories.

Table 1-5

EMISSIONS* CALCULATIONS FOR 1979 INVENTORY

$$\left[(\text{res.pop})(\text{res.process rate}) + (\text{comm.pop})(\text{comm.process rate})\right]\left[\text{emission factor}\right]$$

Equipment Category	Hydrocarbons	Part	SO_x	No_x	CO
Walk-Behind Mowers	$[(2014243)(32.6) + (92260)(346.1)][(214)(.04) + (23.2)(.96)]$	Calculate as for hydrocarbons except use emission factor for the desired pollutant.			
Riding Mowers	$[(60449)(103.4) + (11342)(1,679.6)][(214)(.04) + (23.2)(.96)]$				
Garden Tractors	$[(22339)(194.4) + (4192)(1,555.2)][(214)(.04) + (23.2)(.96)]$				
Tillers	$[(96643)(28.8) + (76351)(172.8)][(214)(.04) + (23.2)(.96)]$				
Misc. Lawn and Garden	$[(796508)(10.2) + (36483)(171.0)][(214)(.04) + (23.2)(.96)]$				
Chain Saws	$[(537374)(15.0) + (39108)(740.0)][116.7]$				
Home Utility	$[(381751)(144.0) + (233445)(672.0)][15.2]$				

*The computations, as shown, will give emissions in grams/year. It is customary to convert to tons/day or tons/year for most inventories.

Source: CIC Research and reference 1.

Table 1-6

STATEWIDE EMISSIONS IN 1979
(Tons/Year)

Category	HC*	PART	SO_x	NO_x	CO
LAWN AND GARDEN					
Walk-behind mowers	3,369	78	41	334	30,814
Riding mowers/lawn tractors	874	20	11	87	7,994
Garden tractors	375	9	5	37	3,430
Tillers	552	13	7	55	5,049
Miscellaneous	439	12	6	49	4,537
CHAIN SAWS	4,755	296	5	13	9,491
HOME UTILITY	3,654	19	45	1,154	58,358
Total of all categories	14,075	447	120	1,729	119,673

*Evaporative emissions are estimated to be 668 tons/year in addition to the exhaust hydrocarbons listed in this column.

Source: California Air Resources Board, 1979 Emission Inventory

equipment lifetimes based on some assumed use pattern. The ARB staff developed attrition curves for equipment in residential and commercial use using the manufacturers' estimates as a starting point, and applied these attrition curves to sales estimates to calculate equipment populations. This study will provide an independent measure of equipment attrition rates.

The major data items sought in this study are as follows: (1) types of equipment used by households and residences; (2) engine type and HP rating; (3) annual usage (in hours); (4) age of equipment; (5) annual fuel usage; and (6) appropriate demographic data to expand the sample to the general population. Information on emission factors, load factors, and other related topics will be obtained from published sources, the Engine Manufacturers Association, the Outdoor Power Equipment Institute, and the Air Resources Board staff. The final product of this study is to be an inventory, by county, of emissions from utility equipment and a recommended methodology for updating the inventory using published information.

This report contains summaries of the collected data. The complete data have been submitted separately to the ARB in the form of a data tape and hard-copy printouts of the tape. In addition, a collection of computer printouts, produced by analyzing the data tape using the SPSS computer program, have also been submitted to the ARB as a separate data book.

CHAPTER 2. SURVEY METHODOLOGY AND RESULTS

Two distinctly separate surveys were conducted to acquire the data required for this study. A telephone survey of a statistical sample of households was carried out to determine household equipment populations and use patterns. A mail survey of representative businesses was carried out to identify and characterize equipment use by various occupations such as gardeners, carpenters, etc. The survey procedures and results are described in the remainder of this chapter.

HOUSEHOLD SURVEY PROCEDURES

The survey involved a telephone interview of a random sample of 1,926 households in California. The households were apportioned among 22 selected counties according to the square root of the number of housing units in each county to lessen the dominance of very populous counties, and one quarter of the allotted interviews were made in each season -- fall, winter, spring, and summer. The selected counties and their allocated interviews are given in Table 2-1. Eighty-nine percent of the total households in the State were located in the areas covered by the survey. The number of interviews per county ranged from 37 to 280. The sample size was large enough to provide very accurate information for the State as a whole and to identify differences among three major areas of the State (Bay Area, South Coast, and Central

Table 2-1

HOUSEHOLD SAMPLE ALLOCATION

	1980 Census			Sample Per Wave				
	Number of Housing Units	Percent of Sample	Percent of Housing Units	Fall	Winter	Spring	Summer	Total
BAY AREA	2,062,201	24.97	34.82	168	168	167	168	671
Alameda	444,607	5.38	5.73	28	27	27	28	110
Contra Costa	252,226	3.05	4.32	20	21	21	21	83
Marin	92,903	1.12	2.62	12	13	12	13	50
Napa	40,052	0.48	1.72	9	9	9	8	35
San Francisco	316,609	3.83	4.84	24	23	23	23	93
San Mateo	233,494	2.82	4.15	20	20	20	20	80
Santa Clara	473,817	5.74	5.92	29	28	29	28	114
Solano	84,270	1.02	2.50	12	12	12	12	48
Sonoma	124,223	1.50	3.03	14	15	14	15	58
SOUTH COAST	5,145,615	62.31	42.70	205	206	206	205	822
Los Angeles	2,855,755	34.58	14.53	70	70	70	70	280
Orange	720,984	8.73	7.30	35	35	35	35	140
Riverside	295,119	3.57	4.67	22	23	23	22	90
San Bernardino	369,534	4.47	5.23	25	25	25	25	100
San Diego	720,346	8.72	7.30	35	35	35	35	140
Ventura	183,857	2.22	3.69	18	18	18	18	72
CENTRAL VALLEY	1,050,551	12.72	22.47	109	108	108	108	433
Fresno	193,771	2.35	3.78	18	18	18	19	73
Kern	155,702	1.89	3.39	17	16	16	16	65
Merced	50,050	0.61	1.92	9	10	9	9	37
Sacramento	323,702	3.92	4.89	23	24	23	24	94
San Joaquin	136,001	1.65	3.17	16	15	15	15	61
Stanislaus	102,537	1.24	2.75	13	13	14	13	53
Tulare	88,788	1.08	2.56	13	12	13	12	50
TOTAL SAMPLE UNIVERSE	8,258,367	100.00%	100.00%	482	482	481	481	1,926
TOTAL STATE	9,279,330							
PERCENTAGE OF STATE	89%							

Source: Data on housing units obtained from State Census Data Center, Sacramento.

Valley), but the sample was too small to differentiate among individual counties. Interviews were conducted in four seasonal waves to eliminate the bias that might otherwise have resulted from the respondent's tendency to report his usage of equipment at the time of the interview rather than the average usage for the whole year.

Telephone numbers for the survey were compiled by the CIC computer program that generates random four-digit numbers and allocates them to three-digit prefixes according to the numbers of households assigned to each prefix. This procedure provides a sample of households with unlisted as well as listed phone numbers. Interviews were conducted between 4:00 and 9:00 p.m. on weekdays and between 10:00 a.m. and 6:30 p.m. on weekends. Each seasonal wave of interviews was completed in less than ten days. Four attempts, at different times and different days, were made to reach each number. If no answer was obtained, or if the telephone number was for a business instead of a household, a new random number was selected to replace the first one. The procedure was continued until the assigned number of households had been interviewed in each county.

The household questionnaire is shown in Appendix A. In brief, each respondent was asked to indicate the items of utility equipment that he used and to provide information on the use patterns and age of the equipment. In addition, some demographic information was collected to characterize the household

and permit a comparison with published demographic data. Interviewers were instructed to assist the respondent in assigning equipment to the current categories (i.e., distinguishing riding mowers from garden tractors) and to encourage the respondent to go and look at equipment and report back on horsepower, fuel tank capacity, etc., if he did not know it. Respondents were generally very cooperative and tried to give accurate information.

The household questionnaire contained one question about the use of utility equipment on the job by any member of the household. This question was really a part of the commercial survey and will be discussed in a subsequent section of this chapter.

As the household questionnaires were completed, the responses were edited and coded. During this step, the numerical responses were reviewed and, if necessary, converted to the proper units for coding. For example, fuel tank capacities were always expressed in quarts, usage was expressed as times per month, and use periods were expressed in hours. Horsepower ratings were checked to see that they fell into the appropriate range for the type of equipment and the model. After the coding and keypunching were completed, the computer printout of responses was 100 percent verified on an item-by-item basis to insure that all items were accurately coded and keypunched.

Representativeness of Household Sample

Before any computations of utility equipment prevalence and usage were undertaken, the demographic information from the questionnaire was compared with published information. Three variables were selected for comparison: (1) type of dwelling, (2) owned or rented, and (3) expected household income for 1982. The comparison of the survey results and published data is shown in Table 2-2. Conventional statistical tests were carried out to determine whether the survey results were the same or different from the published information. The distributions of dwelling types and incomes were found to match at the 99 percent confidence level, but the proportion of owned and rented dwellings were found to be different (at the 99% confidence level). The survey included a smaller proportion of rented dwellings than should have been found. Since the survey also showed that utility equipment prevalence rates were different for owner occupied and rental units, it was necessary to compute correction factors to adjust the prevalence to correspond to the true owner/rental data. These factors are explained in detail in Appendix B. All prevalence rates quoted in this chapter have been corrected.

HOUSEHOLD SURVEY RESULTS

Equipment Prevalence Rates

The prevalence rates (number of units per household) are given in Table 2-3 for each type of equipment identified. Walk-behind mowers are by far the most prevalent and are followed by chain saws, edgers, and tillers. These types of equipment are more prevalent in the Central Valley than in the Bay Area or

Table 2-2

COMPARISON WITH PUBLISHED DEMOGRAPHIC DATA

Characteristic	California			Bay Area			Central Valley			South Coast		
	Published 1979	Survey 1981	Sample Size	Published 1979	Survey 1981	Sample Size	Published 1979	Survey 1981	Sample Size	Published 1979	Survey 1981	Sample Size
Type of household dwelling units			1923			670			434			819
Single	.630	.670		.621	.679		.722	.707		.608	.642	
2 - 4	.093	.098		.115	.113		.080	.078		.089	.096	
5 or more	.234	.170		.241	.175		.150	.115		.268	.196	
Mobile home	.040	.057		.023	.028		.048	.099		.034	.059	
Other	--	.005		--	.004		--	--		--	.007	
Ownership of dwelling unit			1912			667			431			431
Own	.610	.658		.598	.657		.606	.689		.540	.644	
Rent	.390	.342		.402	.343		.394	.311		.460	.356	
Household Income			1438			510			334			594
Less than $10,000	.263	.182		.229	.157		.302	.234		.261	.175	
$10,000 - 19,999	.281	.250		.257	.208		.301	.281		.280	.268	
$20,000 - 29,999	.215	.242		.225	.263		.211	.231		.213	.231	
$30,000 - 39,999	.121	.146		.143	.149		.103	.150		.121	.141	
$40,000 - 49,999	.057	.084		.070	.112		.042	.057		.058	.076	
$50,000 or more	.064	.096		.075	.112		.041	.048		.067	.109	

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982, and Reference 12 for published data.

Table 2-3

HOUSEHOLD UTILITY EQUIPMENT PREVALENCE RATES
(Units/Household)

Type of Equipment	California	Bay Area	Central Valley	South Coast
Households Interviewed	1,930	673	435	822
Lawn and Garden				
Walk-behind mowers	.335 (.011)	.289 (.017)	.494 (.024)	.301 (.016)
2-cycle	.121 (.007)	.107 (.012)	.197 (.019)	.099 (.010)
4-cycle	.214 (.009)	.182 (.015)	.298 (.022)	.202 (.014)
Riding mowers	.007 (.002)	.004*(.002)	.015 (.006)	.005*(.002)
Tillers	.042 (.005)	.045 (.008)	.085 (.004)	.018 (.005)
Garden tractors	.009 (.002)	.005*(.003)	.021 (.007)	.005*(.002)
Blowers	.005 (.002)	.007 (.003)	.002*(.002)	.005*(.002)
Edgers	.058 (.005)	.014 (.005)	.097 (.014)	.063 (.008)
Trimmers	.011 (.002)	.007 (.003)	.027 (.008)	.007 (.003)
Shredders	.006 (.002)	.010 (.004)	.008*(.004)	.002*(.002)
Yard Vacuums	.004 (.001)	.003*(.002)	.007*(.004)	.004*(.002)
Chain Saws	.084 (.006)	.077 (.010)	.161 (.018)	.054 (.008)
HOME UTILITY				
Electric Generator	.009 (.002)	.011 (.004)	.012*(.005)	.006*(.003)
Air Compressor	.004 (.001)	.001*(.001)	.004*(.003)	.006*(.003)

*Indicates prevalence rate not statistically significant from zero at the 99% confidence level.

Values in ( ) indicate standard errors of the estimates.

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

the South Coast. For other types of equipment -- riding mowers, garden tractors, blowers, shredders, generators, compressors, etc.,-- the number of units identified was too small to provide statistically significant prevalence rates by area. Prevalence rates could be obtained, however, for the State as a whole. The proportion of two-cycle to four-cycle mowers was 1/1.79 for the entire State, 1/1.70 for the Bay Area, 1/1.51 for the Central Valley, and 1/2.04 for the South Coast. These proportions are substantially different from the 1/24 proportion that is assumed in the ARB inventory for the entire Lawn and Garden category. The responses to the survey question on two-cycle vs. 4-cycle engines are belived to be reliable because the replies were consistent in each survey wave and the corresponding responses were correct for chain saws, which are entirely two-cycle. CIC belives that this survey indicates that there is a significantly greater proportion of two-cycle lawn mowers in use than had previously been supposed. The impact of this finding on pollutant emissions will be discussed later when the computations of emissions are presented.

Equipment Populations

The actual numbers of utility equipment units may be computed by applying the prevalence rates from Table 2-3 to the numbers of households in the areas of interest. Data on numbers of households by county were available from the State Census Data Center for 1979[12] but not for 1981/1982, the years of

interest. The 1979 data were updated to 1981 by applying a growth factor for the State as a whole that was obtained from 1980 State-wide census data and a growth estimate obtained from National Decisions Systems, Inc.[11] The household estimates are shown below in Table 2-4. A growth factor of 1.0141 was applied to the 1979 data.

Table 2-4

HOUSEHOLDS IN STUDY AREAS

	1979 Census	1981 Estimate
California	8,644,633	8,766,000
Bay Area	1,973,880	2,002,000
Central Valley	964,893	978,000
South Coast	4,817,980	4,886,000

When the prevalence estimates of Table 2-3 are combined with the numbers of households from Table 2-4, the number of utility equipment units can be computed. The results are shown in Table 2-5. These numbers will be compared with the ARB inventory estimates in a later section of the report which will deal with commercial as well as houshold estimates.

Alternative Methods of Computation

The prevalence rates (see Table 2-3) were computed as equipment units/household for three different areas of the State. However, other systems might have been used such as units/owner occupied housing units, or a single prevalence rate might have

Table 2-5

ESTIMATED UNITS OF HOUSEHOLD UTILITY EQUIPMENT*

Type of Equipment	California	Bay Area	Central Valley	South Coast
Lawn and Garden				
Walk-behind mowers	2,937,000	578,000	483,000	1,471,000
2-cycle	1,063,000	214,000	192,000	482,000
4-cycle	1,874,000	364,000	291,000	989,000
Riding Mowers	61,000	--	--	--
Tillers	368,000	90,000	83,000	88,000
Garden Tractors	79,000	--	--	--
Blowers	44,000	--	--	--
Edgers	508,000	28,000	95,000	308,000
Trimmers	96,000	14,000	26,000	34,000
Shredders	53,000	--	--	--
Yard Vacuums	35,000	--	--	--
Chain Saws	736,000	154,000	158,000	264,000
Home Utility				
Electric Generators	79,000	--	--	--
Air Compressors	35,000	--	--	--

*Based on estimates of numbers of households for 1981

-- Indicates that no statistically valid prevalence rate was obtained for the area.

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

been derived for the State as a whole. It is appropriate to examine the consequences of some alternative methods of expressing prevalence rates and estimating equipment populations.

Households vs. Owner Occupied Housing Units. Prevalence rates were computed separately for owner occupied and rental housing units. These are shown in Table 2-6. Although owners use from two to three times as many units of equipment as renters, there is a significant population of utility equipment in rental households that cannot be ignored. The prevalence rates in Table 2-3 are consistent with the renter/owner proportions in 1980 for the State as a whole and in 1979 for each of the subareas (the most recent published data). If the proportion of renters/owners is predicted to change in future years, the prevalence rates should be corrected for this fact using the method described in Appendix B.

Single Statewide Prevalence Rate vs. Separate Area Rates. It is evident from an examination of Table 2-3, that higher prevalence rates are found in the Central Valley than in the more urban South Coast and Bay Areas. For example, the prevalence rate for lawn mowers is 61 percent higher in the Central Valley than in the South Coast. Since there are approximately five times as many households in the South Coast as in the Central Valley, the impact on a statewide inventory would not be great, but the difference is significant at the county level. Since separate prevalence rates for the various areas are available from this study, it is suggested that they be used in computing equipment populations; however, a single urban rate could

Table 2-6

EQUIPMENT PREVALENCE RATES FOR OWNER-OCCUPIED AND RENTAL HOUSEHOLDS

(Units/Households)

	California		Bay Area		Central Valley		South Coast	
Households Interviewed	Rent (658)	Own (1,259)	Rent (229)	Own (438)	Rent (134)	Own (297)	Rent (290)	Own (524)
Type of Equipment								
Lawn and Garden								
Walk-Behind Mowers	.162	.472	.122	.404	.261	.660	.148	.441
2-cycle								
4-cycle								
Riding Mowers	.003*	.010	-0-	.007*	.007*	.020	.003*	.006*
Tillers	.014	.064	.017	.064	.030	.128	.003*	.031
Garden Tractors	.002*	.014	-0-	.009*	.007*	.030	-0-	.010*
Blowers	-0-	.009	-0-	.011*	-0-	.003*	-0-	.010*
Edgers	.020	.079	.004*	.021	.030	.141	.028	.092
Trimmers	.006*	.015	.004*	.009*	.015*	.034	.003*	.011*
Shredders	-0-	.010	-0-	.011*	-0-	.013*	-0-	.004*
Yard Vacuums	.002*	.006	-0-	.005*	.007*	.007*	-0-	.008*
Chain Saws	.023	.133	.026	.121	.030	.266	.017	.090
Home Utility								
Electric Generators	.003*	.014	.004*	.011*	-0-	.020	.003*	.008*
Air Compressors	.002*	.006	-0-	.002*	-0-	.007*	.003*	.008*

*Indicates prevalence rate not statistically significant from zero at the 99% confidence level.

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

be derived by combining the data for the South Coast and Bay areas, if desired. The prevalence rate for the Central Valley could be considered as a rural rate and used for all counties that are predominately agricultural or rural. This is discussed in more detail in Chapter 4 of this report.

Horsepower Ratings

Average horsepower ratings for utility equipment in use by households is shown in Table 2-7. Ratings are broken down by geographic areas whenever the sample size is large enough to permit it. The horsepower ratings are reasonable and do not vary appreciably from one area of the State to the next. The significance of these results will be discussed in a later section along with the corresponding results from the survey of commercial equipment.

Annual Equipment Usage

The reported hours of annual use are given in Table 2-8 for the State as a whole and also for the separate study areas. Confidence intervals (99%) are shown for each usage estimate. There is some published evidence [5] to suggest that equipment operators tend to overestimate the time of use of equipment that is frequently turned on and off -- for example, chain saws. There is no precise way of adjusting the survey results to reflect this bias, but the reader should assume that the usage data of Table 2-8 represent maximum values. There are substantial differences in equipment usage in various areas of the

Table 2-7

AVERAGE HORSEPOWER RATINGS OF UTILITY EQUIPMENT IN HOUSEHOLD USE

Type of Equipment	Entire State			Bay Area			Central Valley			South Coast		
	Av. HP	99 Percent Confidence Interval	Sample Size	Av. HP	99 Percent Confidence Interval	Sample Size	Av. HP	99 Percent Confidence Interval	Sample Size	Av. HP	99 Percent Confidence Interval	Sample Size
Lawn and Garden												
Walk-Behind Mowers												
2-cycle	2.9	2.8 - 3.0	166	2.7	2.2 - 3.2	52	2.9	2.5 - 3.3	56	3.1	2.6 - 3.6	57
4-cycle	2.9	2.8 - 3.0	291	2.8	2.5 - 3.1	73	3.0	2.7 - 3.3	100	2.8	2.5 - 3.1	118
Riding Mowers	7.8	6.6 - 9.0	9	--	--	--	--	--	--	--	--	--
Tillers	5.3	5.1 - 5.5	78	5.7	4.9 - 6.5	27	5.2	4.4 - 6.0	36	4.7	3.3 - 6.1	15
Garden Tractors	11.5	9.3 - 13.7	11	--	--	--	--	--	--	--	--	--
Blowers	3.5	2.2 - 4.8	5	--	--	--	--	--	--	--	--	--
Edgers	2.0	1.9 - 2.1	75	1.7	1.0 - 2.4	5	1.9	1.5 - 2.3	34	2.1	1.8 - 2.4	36
Trimmers	1.3	1.0 - 1.6	11	1.2	0.5 - 1.9	2	1.5	0.4 - 2.6	7	0.5	--	2
Shredders	4.1	3.5 - 4.7	9	--	--	--	--	--	--	--	--	--
Yard Vacuums	2.8	2.2 - 3.4	7	--	--	--	--	--	--	--	--	--
Chain Saws	2.0	1.8 - 2.2	61	2.0	1.2 - 2.8	21	2.2	1.4 - 3.0	22	1.8	1.1 - 2.5	18
Home Utility												
Electric Generators	3.5	2.7 - 4.3	11	--	--	--	--	--	--	--	--	--
Air Compressors	2.9	2.5 - 3.3	6	--	--	--	--	--	--	--	--	--

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

Table 2-8

AVERAGE ANNUAL USAGE OF UTILITY EQUIPMENT BY HOUSEHOLDS

Type of Equipment	Entire State			Bay Area			Central Valley			South Coast		
	Hrs. Yr.	99 Percent Confidence Interval	Sample Size	Hrs. Yr.	99 Percent Confidence Interval	Sample Size	Hrs. Yr.	99 Percent Confidence Interval	Sample Size	Hrs. Yr.	99 Percent Confidence Interval	Sample Size
Lawn and Garden												
Walk Behind Mowers												
2-cycle	24.9	22.5 - 27.3	248	16.9	10.4 - 23.4	74	25.3	15.1 - 35.5	91	31.4	18.1 - 44.7	83
4-cycle	18.4	16.1 - 19.7	441	13.6	9.3 - 17.9	127	17.6	13.1 - 22.1	140	22.6	15.9 - 29.3	174
Riding Mowers	24.1	17.8 - 30.4	13	--	--	--	--	--	--	--	--	--
Tillers	17.5	12.3 - 22.7	84	4.7	1.6 - 7.8	28	30.2	4.1 - 56.3	42	4.7	0.0 - 9.6	14
Garden Tractors	24.9	16.1 - 33.7	15	--	--	--	--	--	--	--	--	--
Blowers	14.7	11.5 - 17.9	10	--	--	--	--	--	--	--	--	--
Edgers	11.1	9.3 - 12.9	102	2.5	0.0 - 5.0	7	7.8	3.7 - 11.9	43	15.0	6.7 - 23.3	52
Trimmers	16.2	10.8 - 21.6	22	24.4	0.0 - 86.4	4	17.1	0.3 - 33.9	12	9.1	0.0 - 19.8	6
Shredders	9.7	4.6 - 14.8	11	--	--	--	--	--	--	--	--	--
Yard Vacuums	15.0	1.8 - 28.1	9	--	--	--	--	--	--	--	--	--
Chain Saws	25.6	21.6 - 29.6	175	19.9	6.2 - 33.6	57	35.5	15.3 - 55.7	75	15.9	1.5 - 30.3	43
Home Utility												
Electric Generators	63.7	3.9 -123.5	16	--	--	--	--	--	--	--	--	--
Air Compressors	42.3	11.7 - 72.9	8	--	--	--	--	--	--	--	--	--

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

State that seem to be consistent with known differences in life-style. Other differences, such as the relative use of 2- and 4-cycle lawnmowers, cannot be explained on bases of any information collected by this survey. Tillers and chain saws receive much greater use in the Central Valley than in other areas. Annual lawn mower usage is greatest in the South Coast and least in the Bay Area. Edgers receive the greatest use in the South Coast, while trimmers receive the greatest use in the Bay Area. For some type of equipment, such as tractors, blowers, shredders, and yard vacuums, the sample size was too small to differentiate among areas of the State.

Respondents were asked to indicate the seasons of the year that they used each type of equipment most frequently. Their responses are summarized in Table 2-9. Seasonal patterns vary with the type of equipment, but 25 to 40 percent of the respondents stated that they used their equipment equally in all seasons. Lawn mowers and edgers/trimmers receive most frequent use in the summer but tillers are used most frequently in the Spring. Chain saws tend to be used throughout the year with slightly less usage in the Spring.

The survey respondents were asked to estimate the annual fuel consumption for each type of equipment as well as the number of hours it was used. The responses to this question are summarized in Table 2-10. These data are expected to be less

Table 2-9

SEASON OF GREATEST USE OF EQUIPMENT BY HOUSEHOLDS
(Proportion of Annual Usage)

Type of Equipment	Spring	Summer	Fall	Winter	Same All Year	Sample Size
Lawn and Garden						
Walk-Behind Mowers						
2-cycle	.07	.58	.02	.01	.32	303
4-cycle	.06	.58	.02	.03	.31	171
Riding Mowers	--	--	--	--	--	
Tillers	.37	.25	.04	.02	.32	61
Garden Tractors	--	--	--	--	--	
Blowers	--	--	--	--	--	
Edgers/Trimmers	.09	.48	.03	.00	.40	78
Shredders	--	--	--	--	--	
Yard vacuums	--	--	--	--	--	
Chain Saws	.08	.20	.26	.21	.25	119
Home Utility						
Electric Generators	--	--	--	--	--	
Air Compressors	--	--	--	--	--	

-- Indicates that sample size was too small to give a representative distribution.

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

Table 2-10

AVERAGE ANNUAL FUEL CONSUMPTION BY UTILITY EQUIPMENT IN HOUSEHOLD USE

Type of Equipment	Entire State			Bay Area			Central Valley			South Coast		
	Qts. Yr.	99 Percent Confidence Interval	Sample Size	Qts. Yr.	99 Percent Confidence Interval	Sample Size	Qts. Yr.	99 Percent Confidence Interval	Sample Size	Qts Yr.	99 Percent Confidence Interval	Sample Size
Lawn and Garden												
Walk-Behind Mowers	(34.2)	(32.1 - 36.3)	(542)									
2-Cycle	38.7	28.5 - 32.7	203	37.1	22.1 - 52.1	68	43.1	25.5 - 60.7	71	35.6	19.0 - 52.2	64
4-Cycle	31.1	35.0 - 42.3	336	27.6	15.6 - 39.6	92	28.0	20.4 - 35.6	102	35.7	22.9 - 48.5	142
Riding Mowers	98.9	71.5 -125.8	9	--	--	--	--	--	--	--	--	--
Tillers	45.0	28.1 - 61.9	62	23.7	1.1 - 46.3	21	73.4	0.0 -161.6	30	8.1	3.1 - 13.1	11
Garden Tractors	189.6	120.7 -258.5	11	--	--	--	--	--	--	--	--	--
Blowers	23.2	17.4 - 29.0	8	--	--	--	--	--	--	--	--	--
Edgers	21.9	16.4 - 27.5	86	6.8	2.0 - 11.6	7	15.2	7.9 - 22.5	38	30.6	1.3 - 59.9	41
Trimmers	27.8	16.3 - 39.3	15	19.0	0.0 - 56.8	3	31.2	0.0 - 80.3	8	27.6	0.0 - 87.2	4
Shredders	40.5	21.3 - 59.7	10	--	--	--	--	--	--	--	--	--
Yard Vacuums	9.9	8.0 - 11.8	8	--	--	--	--	--	--	--	--	--
Chain Saws	16.7	14.4 - 19.0	121	12.2	4.9 - 19.5	45	25.5	13.4 - 37.6	46	10.2	2.4 - 18.0	30
Home Utility												
Electric Generators	29.8	14.9 - 44.7	10	--	--	--	--	--	--	--	--	--
Air Compressors	4.0	0.0 - 8.0	3	--	--	--	--	--	--	--	--	--

*Values in ( ) represent both 2- and 4-cycle mowers.

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

accurate than the hourly usage estimates, but it is appropriate to see if they are consistent with each other. The fuel consumption rate was computed for each type of equipment by dividing the annual fuel consumption (Table 2-10) by the annual hourly usage (Table 2-8). The values, which are shown in Table 2-11 are similar for walk-behind lawn mowers, blowers, edgers, and trimmers and average about 0.4 gal/hr. Table 2-11 also includes fuel consumption as gallons per hour per rated horsepower. Accurate fuel consumption rates are not available for comparison, but Table 2-12 lists some approximate values that have been published.[2,5]

The values shown in Table 2-11 for various categories of lawn and garden equipment range from 0.165 to 1.904 gallons per hour with the highest rates corresponding to equipment with

Table 2-12

FUEL CONSUMPTION RATES FOR UTILITY EQUIPMENT
(Gal/Hr.)

	Rates		Reference
	Gal/Hr.	Gal/Hr. Per Rated HP	
Lawn and Garden - 4-cycle	0.177	0.051	2
Lawn and Garden - 2-cycle	0.400	0.114	2
Chain Saws	0.456	0.152	2
Home Utility	0.300	0.075	2
Tillers	0.24	0.048	5

Table 2-11

FUEL CONSUMPTION RATES FOR HOUSEHOLD UTILITY EQUIPMENT

Type of Equipment	Entire State		Bay Area		Central Valley		South Coast	
	Gal/Hr.	Gal./HP.HR	Gal/Hr.	Gal./HP.HR	Gal/Hr.	Gal./HP.HR.	Gal/Hr.	Gal./HP.HR.
Lawn and Garden								
Walk-Behind Mowers	(.403)	(.139)						
2-Cycle	.389	.134	.549	.203	.426	.147	.283	.091
4-Cycle	.423	.146	.507	.181	.398	.133	.395	.141
Riding Mowers	1.026	.132	--	--	--	--	--	--
Tillers	.643	.121	1.261	.221	.608	.117	.431	.092
Garden Tractors	1.904	.166	--	--	--	--	--	--
Blowers	.395	.113	--	--	--	--	--	--
Edgers	.493	.247	.680	.400	.487	.256	.510	.243
Trimmers	.429	.330	.195	.163	.456	.304	.758	1.516
Shredders	1.044	.255	--	--	--	--	--	--
Yard Vacuums	.165	.059	--	--	--	--	--	--
Chain Saws	.163	.082	.153	.077	.180	.082	.160	.089
Home Utility								
Electric Generators	.117	.033	--	--	--	--	--	--
Air Compressors	.024	.008	--	--	--	--	--	--

*Values in ( ) represent both 2- and 4-cycle mowers.

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982

the highest rated HP. The fuel consumption values computed as gallons per hour per rated horsepower range from 0.059 to .330 (see Table 2-11). The fuel consumption rates, as reported by survey respondents, seem generally reasonable and are of the same order of magnitude as published values. In contrast to Table 2-12, the survey results indicate that fuel consumption rates are approximately the same for 2- and 4-cycle mowers and average about 0.41 gallons per hour. Survey respondents indicated that fuel consumption by chain saws was 0.16 gallons per hour -- a rate substantially below the estimate given in Table 2-12.

Fuel consumption rates for generators and air compressors were reported as 0.117 and 0.024 gallons per hour by survey respondents. These rates are below the range that would be anticipated for 3 or 4 horsepower engines and may indicate that respondents overestimated the number of hours that the engines were actually operating. Responses to the annual hours of use and annual fuel consumption questions varied over wide ranges and the sample sizes were small, so an in-depth analysis of the responses is not justified.

Age of Equipment

The average reported age for each type of utility equipment is shown in Table 2-13. The values range from 8.3 years (shredder) to 3.1 years (trimmers) with lawn mowers averaging 5.6 years. There are minor differences among the three areas of the State, but there are more similarities than differences.

Table 2-13

AVERAGE AGE OF UTILITY EQUIPMENT IN HOUSEHOLD USE

Type of Equipment	Entire State			Bay Area			Central Valley			South Coast		
	Av. Age (Yrs)	99 Percent Confidence Interval	Sample Size	Av. Age (Yrs)	99 Percent Confidence Interval	Sample Size	Av. Age (Yrs)	99 Percent Confidence Interval	Sample Size	Av. Age (Yrs)	99 Percent Confidence Interval	Sample Size
Lawn and Garden												
Walk-Behind Mowers	(5.6)	(5.1 - 6.1)	(679)	--	--	--	--	--	--	--	--	6
2-Cycle	5.7	5.4 - 6.0	243	6.7	4.8 - 8.6	73	6.1	4.6 - 7.6	89	4.3	3.0 - 5.6	81
4-Cycle	5.6	5.4 - 5.8	423	5.8	4.7 - 6.9	126	5.4	4.4 - 6.4	128	5.8	4.7 - 6.9	169
Riding Mowers	5.9	2.5 - 9.3	13	--	--	--	--	--	--	--	--	--
Tillers	5.5	4.2 - 6.8	85	5.4	3.5 - 7.2	29	5.6	3.3 - 7.9	39	5.6	3.6 - 7.6	17
Garden Tractors	8.2	6.2 - 10.2	16	--	--	--	--	--	--	--	--	--
Blowers	3.3	.8 - 5.8	10	--	--	--	--	--	--	--	--	--
Edgers	6.5	5.1 - 7.9	105	7.7	2.9 - 12.5	9	6.4	4.3 - 8.5	44	6.4	4.5 - 8.3	52
Trimmers	3.1	1.3 - 4.9	23	1.4	.4 - 2.4	4	3.3	.7 - 5.8	12	3.8	.5 - 7.1	7
Shredders	8.3	1.8 - 14.8	12	--	--	--	--	--	--	--	--	--
Yard Vacuums	7.1	0.0* - 18.7	9	--	--	--	--	--	--	--	--	--
Chain Saws	4.2	3.4 - 4.9	190	5.5	3.4 - 7.6	58	3.4	2.6 - 4.2	81	3.9	3.0 - 4.8	51
Home Utility												
Electric Generators	4.5	1.5 - 7.5	13	--	--	--	--	--	--	--	--	--
Air Compressors	6.7	0.0* - 14.4	8	--	--	--	--	--	--	--	--	--

*Interval has been truncated at zero.

Values in ( ) represent both 2- and 4-cycle mowers.

Source: CIC Research, Inc., "California Utility Equipment Use Survey, 1981-1982.

These results will be discussed later when the results of this survey are compared with the existing CARB inventory.

As a matter of general interest, survey respondents were asked whether the equipment was new or used when they acquired it. The responses are summarized in Table 2-14. A substantial fraction of all equipment was acquired in a used condition -- 23 percent of the walk-behind mowers, 22 percent of the tillers, 29 percent of the edgers, and 12 percent of the chain saws. The significance of this finding is not clear in relation to the emissions inventory, but it may indicate that owners of utility equipment pass it on to others rather than store it when their lifestyles change in a manner that eliminates the need for utility equipment.

Other Miscellaneous Information

The survey collected responses to such questions as, "Is the equipment rented?"; "Does your home have a lawn or garden?"; "Who does the landscape and maintenance work (household or outside contractor)?". These responses are not discussed in the main body of this report because they have no effect on the emissions inventory. The responses to these questions are given in the data book and data tape that accompany this report.

Table 2-14

PREVALENCE OF UTILITY EQUIPMENT
PURCHASED NEW OR USED FOR HOUSEHOLD USE

Type of Equipment	Purchased New	Purchased Used	Sample Size
Lawn and Garden			
Walk-behind mowers*	(.771)	(.229)	(712)
2-cycle	.764	.236	445
4-cycle	.783	.217	254
Riding Mowers	.615	.385	13
Tillers	.778	.222	90
Garden Tractors	.389	.611	18
Blowers	.700	.300	10
Edgers	.725	.275	109
Trimmers	.957	.043	23
Shredders	.818	.182	11
Yard Vacuums	.556	.444	9
Chain Saws	.881	.119	193
Home Utility			
Electric Generators	.588	.412	17
Air Compressors	.500	.500	8

*Values in ( ) represent both 2- and 4-cycle mowers.

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

COMMERCIAL SURVEY PROCEDURES

A number of methodologies were evaluated in an attempt to select a survey procedure that would yield the maximum amount of information on equipment prevalance and usage. Two fundamentally different procedures were considered:

1. A survey of industries that use utility equipment and a determination of equipment prevalence and usage on a per-industry-basis in several industrial categories.

2. A survey of equipment users and a determination of equipment prevalence and usage on a per-user-basis in several occupational categories.

A truly random survey of businesses is difficult to accomplish because an appropriately stratified listing of businesses is not available as a starting point for random sampling. Telephone yellow pages are a poor substitute because many firms do not advertise at all, and advertising patterns vary widely in different sections of the State. A random sample of yellow page listings is certainly not equivalent to a random sample of businesses. In addition, government agencies are heavy users of utility equipment, and the random sample would have to include these agencies as well as private businesses.

The feasibility of conducting a survey of equipment users by a random telephone survey of households was explored as part of the household survey discussed earlier in this chapter. The results indicated that 2.5 percent of households report the use of utility equipment at work while 33.5 percent of households report the use of utility equipment at home. Assuming a sample size of 2,000 households, the response rate is sufficient to

provide a valid state-wide estimate of the prevalence and usage of utility equipment by businesses if all kinds of equipment are lumped together. The response rate is too low to give estimates for individual equipment categories. The size of the survey would have to be increased approximately 10-fold to provide data of comparable validity to the household use data, and this would have required more resources than were available. Accordingly, a compromise methodology was devised.

It was decided to survey equipment users but to make no attempt to select a random sample. Instead, it was assumed that equipment usage by individuals in particular occupational categories is approximately identical regardless of the type of industry that employs the individual. For example, it is assumed that a gardener will use the same equipment for the same number of hours whether he works for a local school board, or a landscape contractor, or is self-employed. Similarly, it is assumed that a carpenter will use the same equipment in the same way whether he works for a local public works agency, a general contractor, or a carpentry firm. The objective of the survey was, therefore, to obtain information from a representative number of equipment users (50 or more) in each occupational category that might be expected to use utility equipment. Published information on employment by occupational category is available for estimating the prevalence of utility equipment in commercial use after the typical usage patterns for each occupational category have been determined from the survey.

In the remainder of this chapter, the commercial survey procedures and results are described and discussed.

Commercial Sample Frame

A list of commercial firms was compiled from information in telephone books (white and yellow pages) for all of the survey areas. Appropriate yellow page headings were selected, and the number of firms was chosen to be roughly proportional to the total number listed under each heading. The final list included 1,317 firms. The distribution of firms by telephone book headings and by county is shown in Table 2-15 An initial telephone call was made to each firm to establish whether they actually used gasoline-powered utility equipment and to obtain the name of the appropriate individual to receive the questionnaire. If the firm used a telephone answering service or a message-recording device, no further effort was made to secure a name and send a questionnaire to that firm. Previous experience has shown that businesses seldom return calls to survey firms that are obviously not going to become paying customers. Approximately 60 percent of these firms (785) received questionnaires.

The commercial questionnaire and accompanying cover letter is shown in Appendix C. The questions on use patterns and age of equipment were similar to those in the household questionnaire. In addition, the respondent was asked to specify the occupation of each equipment user and also to report the total number of employees in each of the 16 occupational categories.

Table 2-15

SAMPLE FRAME AND RESPONSES, COMMERCIAL SURVEY

(No. of Firms on List; No. of Questionnaires Mailed; No. of Responses Received)

Yellow Page Headings	Alameda	Contra Costa	Fresno	Kern	Los Angeles	Marin	Merced	Napa	Orange	River-Side	Sacramento	San Bernardino
Auto Body Repair	3, 0, 0	1, 1, 0	1, 1, 0	1, 0, 0	4, 2, 0	1, 0, 0	1, 0, 0	1, 1, 0	4, 0, 0	1, 0, 0	3, 0, 0	1, 0, 0
Auto Repair	3, 1, 0	2, 1, 0	2, 0, 0	1, 0, 0	7, 2, 0	2, 0, 0	1, 0, 0	1, 1, 0	8, 1, 0	3, 0, 0	4, 0, 0	3, 0, 0
Carpenter	2, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	2, 1, 0	2, 2, 0	2, 2, 0	1, 1, 0	2, 0, 0	0, 0, 0	1, 1, 0	0, 0, 0
Cemeteries	2, 1, 1	1, 1, 0	2, 2, 0	2, 2, 1	2, 2, 0	2, 2, 0	2, 2 1	2, 1, 0	2, 1, 0	2, 2, 1	2, 1, 0	2, 1, 0
Concrete Contractor	2, 1, 0	2, 2, 0	2, 0, 0	2, 0, 0	8, 3, 0	3, 2, 0	2, 2, 0	2, 1, 0	8, 5, 0	2, 2, 1	2, 1, 0	2, 2, 1
Contractor, Alteration	4, 4, 1	2, 1, 0	2, 1, 1	2, 1, 0	11, 2, 0	2, 2, 0	2, 2, 1	2, 2, 0	11, 6, 0	2, 1, 0	2, 1, 0	1, 1, 1
Contractor, Building Gen.	6, 1, 0	2, 0, 0	2, 1, 0	2, 2, 0	20,11, 2	2, 1, 0	2, 1, 0	2, 1, 0	17, 5, 1	6, 4, 1	5, 5, 0	4, 2, 1
Contractor, Engineering, Gen.	1 1, 0	1, 0, 0	1, 1, 0	1, 0, 0	2, 2, 1	1, 1, 0	1, 1, 0	1, 1, 0	2, 1, 0	1, 1, 0	1, 1, 0	1, 0, 0
Contractor, Foundation	1, 0, 0,	0, 0, 0,	0, 0, 0	0, 0, 0	1, 1, 0	0, 0, 0	0, 0, 0	0, 0, 0	1, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0
Contractor, Heating & Ventilation	2, 1, 1,	2, 2, 1	0, 0, 0	2, 2, 1	6, 3, 0	2, 2, 0	0, 0, 0	2, 0, 0	2, 1, 0	2, 2, 0	1, 0, 0	0, 0, 0
Contractor, Masonry	1, 0, 0	1, 0, 0	1, 1, 0	1, 1, 0	3, 1, 1	1, 1, 0	1, 1, 0	1, 0, 0	1, 1, 0	1, 1, 0	2, 1, 0	1, 1, 0
Demolition Contractor	2, 0, 0	2, 0, 0	2, 1, 0	2, 1, 0	6, 1, 0	1, 0, 0	2, 1, 0	1, 1, 0	2, 2, 0	2, 1, 0	2, 1, 0	1, 1, 0
Drywall Contractor	2, 1, 0	2, 0, 0	2, 1, 0	2, 1, 0	2, 2, 1	2, 2, 0	2, 2, 0	2, 2, 0	2, 1, 0	2, 2, 1	2, 2, 0	1, 1, 0
Gardeners	1, 1, 0	1, 0, 0	0, 0, 0	1, 0, 0	2, 1, 0	1, 1, 0	0, 0, 0	0, 0, 0	3, 3, 0	1, 1, 1	1, 1, 0	1, 0, 0,
Golf Courses	2, 2, 0	2, 2, 0	2, 2, 0	2, 2, 0	3, 3, 1	2, 2, 0	2, 2, 1	2, 2, 1	4, 4, 1	2, 2, 0	2, 2, 0	1, 1, 1
Landscape Contractor	2, 0, 0	2, 2, 1	2, 1, 1,	2, 1, 1	4, 4, 1	2, 2, 0	2, 2, 1	2, 1, 0	10, 4, 1	2, 2, 0	4, 3, 1	1, 0, 0
Lathing Contractor	0, 0, 0,	0, 0, 0,	0, 0, 0	0, 0, 0	2, 1, 0	0, 0, 0	0, 0, 0	0, 0, 0	2, 2, 0	0, 0, 0	0, 0, 0	1, 1, 0
Metal Cutting	1, 0, 0,	0, 0, 0	0, 0, 0	0, 0, 0	1, 1, 1	0, 0, 0	0, 0, 0	0, 0, 0	1, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0
Painting Contractor	6, 2, 0	2, 2, 0	2, 1, 0	2, 0, 0	12, 6, 0	2, 2, 0	2, 2, 0	2, 0, 0	8, 4, 1	4, 4, 0	4, 0, 0,	2, 1, 0
Plumbing Contractor	6, 2, 0	2, 1, 0	2, 1, 0	2, 1, 0	14, 9, 0	2, 1, 1	2, 1, 0	2, 2, 0	12, 9, 2	2, 0, 0	6, 5, 0	3, 2, 0
RV Repair	1, 0, 0	1, 1, 0	1, 0, 0	1, 0, 0	1, 0, 0	1, 1, 0	1, 1, 1	0, 0, 0	1, 1, 0	1, 1, 0	1, 1, 1	1, 1, 0
Tractor Repair	0, 0, 0	0, 0, 0	1, 0, 0	1, 0, 0	0, 0, 0	0, 0, 0	1, 0, 0	1, 1, 0	1, 0, 0	0, 0, 0	1, 1, 0	0, 0, 0
Truck Repair	2, 1, 0	2, 0, 0	2, 1, 0	2, 0, 0	8, 3, 0	2, 2, 0	2, 2, 0	2, 2, 0	4, 2, 0	3, 3, 0	4, 3, 0	2, 1, 0
Trucking	3, 3, 0	2, 0, 0	2, 0, 0	2, 1, 0	14, 7, 1	2, 1, 1	2, 2, 1	1, 0, 0	6 1, 0	3, 1, 0	4, 2, 0	2, 2, 0
Trucks, Industrial	2, 1, 0	2, 1, 0	2, 2, 1	2, 2, 0	8, 5, 0	1, 0, 0	0, 0, 0	1, 1, 1	4, 4, 1	1, 1, 1	3, 1, 0	2, 1, 0
Welding	2, 1, 0	2, 1, 0	2, 0, 0	2, 2, 0	8, 4, 0	2, 2, 0	2, 1, 0	2, 1, 0	8, 6, 1	2, 2, 1	2, 1, 0	2, 2, 0
Electric Company	1, 1, 0	1, 1, 0	1, 0, 0	1, 1, 0	2, 2, 2	1, 0, 0	1, 1, 0	0, 0, 0	2, 2, 0	1, 1, 0	1, 1, 0	1, 1, 1
Telephone Company	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0
Schools	1, 1, 1	1, 1, 1	1, 1, 0	1, 1, 0	1, 1, 1	1, 0, 0	1, 1, 1	1, 1, 1	1, 1, 1	1, 1, 0	1, 1, 0	1, 1, 1
Parks and Recreation	1, 1, 1	1, 1, 1	3, 2, 1	1, 1, 0	2, 2, 0	0, 0, 0	2, 2, 1	1, 1, 1	1, 1, 1	2, 2, 1	1, 1, 1	0, 0, 0
Public Works	2, 2, 2,	1, 1, 0	0, 0, 0	0, 0, 0	0, 0, 0	1, 1, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	2, 2, 1
Street Maintenance	0, 0, 0,	0, 0, 0	0, 0, 0	2, 2, 2	1, 1, 1	0, 0, 0	1, 1, 0	1, 1, 0	0, 0, 0	2, 2, 2	1, 1, 1	0, 0, 0
Tree Maintenance	0, 0, 0	0, 0, 0	0, 0, 0,	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	1, 0, 0	1, 1, 0	1, 1, 1	1, 1, 1
Water and Sewer	0, 0, 0	1, 0, 0	1, 1, 1	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	1, 0, 0	1, 1, 0	0, 0, 0	1, 1, 1	0, 0, 0
State Highway Maint.	1, 1, 1	1, 1, 0	0, 0, 0	1, 1, 0	1, 1, 1	1, 1, 0	1, 1, 0	1, 1, 0	1, 0, 0,	1, 0, 0	0, 0, 0	0, 0, 0
State Parks	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	1, 0, 0	0, 0, 0	1, 1, 1	0, 0, 0	0, 0, 0
Total	65,30, 8	42,23, 4	41, 21,5	43,25, 5	158,84,14	42,31, 2	40,33, 8	39,26, 4	133,69,10	54,41,11	65 40 6	40 26 8

Source: CIC Research, Inc.,"California Utility Equipment Use Survey," 1981-1982.

Table 2-15 (Cont'd.)

San Diego	San Francisco	San Joaquin	San Mateo	Santa Clara	Solano	Sonoma	Stanislaus	Tulare	Ventura	Total
2, 0, 0	3, 0, 0	1, 0, 0,	2, 0, 0	3, 0, 0	1, 0, 0	1, 0, 0	1, 0, 0	1, 0, 0	1, 0, 0	38, 5, 0
7, 5, 0	5, 0, 0	1, 0, 0	3, 0, 0	5, 0, 0	1, 0, 0	1, 0, 0	1, 0, 0,	1, 0, 0	1, 0, 0	63, 11, 0
1, 0, 0	2, 0, 0	0, 0, 0	2, 2, 1	2, 1, 0	0, 0, 0	2, 1, 0	0, 0, 0	0, 0, 0	0, 0, 0	21, 11, 1
2, 2, 2	2, 2, 1	2, 2, 2	2, 2, 0	3, 2, 1	2, 1, 0	2, 1, 0	2, 1, 1	2, 2, 1	0, 0, 0	42, 33, 12
5, 2, 1	1, 0, 0	2, 1, 1	2, 2, 0	5, 3, 0	2, 1, 0	2, 2, 0	2, 1, 0	2, 1, 0	2, 0, 0	62, 34 4
10, 2, 0	4, 2, 1	2, 0, 0	4, 1, 0	6, 1, 0	2, 1, 0	2, 1, 1	2, 2, 0	2, 1, 1	2, 2, 0	79, 37, 7
11, 7, 11	13, 9, 1	0, 0, 0	6, 3, 2	6, 5, 2	2, 1, 0	2, 1, 0	2, 1, 0	2, 2, 0	2, 1, 0	116, 64, 11
1, 1, 0	1, 1, 0	1, 1, 0	1, 1, 0	1, 0, 0	1, 1, 1	1, 1, 0	1, 1, 0	1, 1, 0	1, 1, 0	24, 19, 2
1, 1, 0	1, 1, 0	0, 0, 0	0, 0, 0	1, 1, 0	0, 0, 0	1, 1, 1	0, 0, 0	0, 0, 0	0, 0, 0	7, 5, 1
2, 2, 0	2, 2, 0	2, 1, 0	2, 2, 0	2, 1, 0	2, 1, 0	1, 1, 0	2, 0, 0,	0, 0, 0	2, 0, 0	38, 23, 3
1, 1, 0	1, 1, 0	1, 1, 0	1, 1, 0	1, 0, 0	0, 0, 0	1, 0, 0	1, 1, 0	1, 0, 0	1, 1, 0	24, 15, 1
2, 1, 0	2, 1, 1	2, 1, 0	2, 2, 0	2, 1, 0	2, 1, 0	0, 0, 0	0, 0, 0	2, 2, 0	0, 0, 0	39, 19, 1
1, 1, 0	2, 2, 1	2, 1, 0	1, 1, 0	2, 1, 0	2, 1, 0	2, 1, 0	2, 2, 0	2, 1, 0	2, 1, 0	41, 29, 3
4, 2, 2	1, 1, 0	1, 1, 0	1, 1, 0	2, 1, 0	0, 0, 0	1, 1, 0	1, 1, 0	1, 1, 0	1, 1, 0	25, 18, 3
3, 3, 0	1, 1, 0	2, 1, 0	2, 2, 1	2, 2, 2	1, 1, 0	2, 2, 0	2, 1, 1	2, 1, 0	2, 2, 1	45, 42, 10
10, 6, 1	2, 0, 0	3, 3, 1	4, 2, 0	4, 4, 0	2, 2, 0	2, 1, 0	2, 1, 1	2, 1, 0	2, 1, 0	68, 43, 10
0, 0, 0	1, 1, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	2, 2, 2	0, 0, 0	0, 0, 0	8, 7, 2
1, 0, 0	0, 0, 0	0, 0, 0	1, 0, 0	1, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	6, 1, 1
7, 3, 1	6, 3, 0	2, 1, 0	4, 1, 0	6, 3, 1	2, 2, 2	2, 0, 0	2, 1, 0	2, 1, 0	2, 1, 0	83, 40, 5
10, 7, 0	6, 5, 1	2, 1, 0	4, 3, 1	6, 5, 0	2, 2, 1	2, 1, 0	2, 2, 1	2, 2, 0	2, 0, 0	93, 62, 7
1, 0, 0	0, 0, 0	0, 0, 0	1, 1, 0	1, 1, 0	1, 0, 0	1, 1, 0	1, 0, 0	1, 1, 0	1, 0, 0	19, 11, 2
0, 0, 0	0, 0, 0	1, 1, 0	0, 0, 0	1, 1, 1	0, 0, 0	0, 0, 0	1, 1, 0	1, 1, 0	0, 0, 0	10, 6, 1
5, 2, 1	2, 0, 0	2, 2, 0	2, 0, 0	2, 1, 0	2, 0, 0	2, 1, 0	2, 1, 0	2, 1, 0	2, 1, 0	58, 29, 1
3, 1, 0	4, 2, 0	2, 2, 0	4, 2, 0	6, 2, 0	2, 2, 0	2, 1, 1	1, 0, 0	2, 1, 1	2, 2, 0	71, 35, 5
4, 2, 0	1, 1, 0	2, 2, 1	2, 2, 0	2, 1, 0	0, 0, 0	2, 2, 0	2, 2, 2	2, 1, 0	2, 2, 0	47, 34, 7
4, 2, 1	2, 1, 0	2, 0, 0	2, 1, 1	4, 2, 0	2, 2, 0	2, 1, 0	2, 2, 0	2, 2, 1	2, 2, 0	60, 38, 5
1, 0, 0	1, 1, 0	1, 1, 0	2, 2, 0	1, 1, 0	0, 0, 0	1, 1, 1	1, 1, 1	2, 2, 0	1, 1, 0	24, 21, 5
1, 1, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	1, 1, 0
1, 1, 0	1, 1, 0	1, 0, 0	1, 1, 0	1, 1, 0	1, 0, 0	1, 1, 1	2, 2, 0	1, 1, 0	2, 2, 0	24, 21, 8
1, 1, 1	1, 1, 0	2, 2, 1	1, 1, 0	2, 2, 1	1, 1, 1	1, 1, 1	1, 1, 0	1, 1, 0	0, 0, 0	26, 25, 14
0, 0, 0	0, 0, 0	0, 0, 0	1, 0, 0	1, 1, 0	1, 1, 1	0, 0, 0	1, 1, 0	1, 1, 0	0, 0, 0	11, 10, 4
1, 1, 1	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	1, 1, 1	0, 0, 0	0, 0, 0	1, 1, 0	11, 11, 8
1, 1, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	5, 4, 2
0, 0, 0	0, 0, 0	1, 1, 0	0, 0, 0	1, 1, 1	0, 0, 0	1, 1, 1	0, 0, 0	0, 0, 0	1, 1, 0	9, 7, 4
1, 1, 0	1, 1, 1	0, 0, 0	0, 0, 0	0, 0, 0	1, 0, 0	1, 1, 0	1, 1, 0	1, 1, 0	1, 1, 0	16, 13, 3
0, 0, 0	1, 1, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	3, 2, 1
105 59 12	70 41 7	40 26 6	60 36 6	82 45 9	35 21 6	42 27 8	42,29,10	41,29, 4	38,24, 1	1317, 786, 154

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1932

Respondents were asked to follow a selected classification scheme in reporting occupational categories because CIC planned to use published employment data from the California Employment Development Department to expand the survey results. It was essential, therefore, that the occupational categories match those used by the State.

The questionnaires and postpaid reply envelopes were mailed in two waves -- half in March 1982 and the remainder in June and July 1982. If a response had not been received within three weeks, a telephone call was made to determine whether the questionnaire had been received or whether there was a problem. Up to three reminder calls were made in an effort to secure a completed questionnaire. A total of 154 responses was received for a response rate of 20 percent. The relatively low response rate is understandable in view of the fact that the survey asked for information that was not already at hand. The effort of compiling the data was considerable for firms with many employees and items of equipment, and numerous firms said they could not afford the time required for the task. Table 2-15 shows the responses by county and type of business.

Responses were received from all types of firms except auto body and auto repair shops and telephone companies. It was evident from the initial telephone calls to auto body and repair shops, that very few of them used any gasoline-powered utility equipment, so the lack of response is not expected to have a serious impact on the emission inventory. The lack of response

from telephone companies is a result of an initial offer by Pacific Telephone headquarters to provide information for many of their offices, and a subsequent decision that the required effort was more than they could afford. By the time this final refusal was received, it was too late to secure information on telephone companies by alternate means. A limited amount of information for the "telephone line installer" occupational category was received from other types of businesses so it is hoped that this compensates for the lack of response from telephone companies.

As questionnaires were received, they were edited and coded according to procedures developed by the survey supervisor and project director. The coded information was then entered on computer tape via remote keyboard terminal using a data entry program that monitors the data, as it is entered, for correct range, completeness and illogical responses. Coding errors were checked against the original questionnaire and corrected. After coding and data entry were completed, the computer printout of responses was 100 percent verified on an item-by-item basis to insure that all items were correctly coded and entered.

Responses and Equipment Use by Occupational Category

The original objective of the survey design was to obtain a minimum of 50 responses on equipment use for each of 21 occupational categories. The actual number of responses is shown in Table 2-16. Well over 50 responses were received for all categories except auto body repair (12), telephone line

Table 2-16

SAMPLE SIZES BY OCCUPATIONAL CATEGORY

Occupational Category	Total Number Surveyed
Auto Mechanic	350
Auto Body Repair	12
Carpenter	375
Cement	133
Delivery	139
Drywall/Lather	135
Electrician	82
Electric Pipeline Installer	148
Gardeners, Grounds Keepers	3,314
Heavy Equipment Mechanic	354
Painter	139
Plumbers, Pipefitters	1,616
Sheet Metal Worker	65
Telephone Line Installer	7
Truck Driver	937
Welder	80
Engineer, Other	68
Forester	13
Excavator, Grading Operator	261
Stationary Engineer	14
Janitor	91

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

installers (7), foresters (13), and stationary engineers (14). Unfortunately, many respondents did not follow the instructions and used their own job titles instead of the listed occupations. As part of the questionnaire coding process, the coders forced the reported occupations into selected categories. This was particularly troublesome in dealing with questionnaires from government agencies that have no counterpart in the private sector.

Descriptions such as "highway maintenance man," "back-hoe operator," "yard man," "laborer," "tree topper," and many others were converted to the State classification. In general, skilled occupations were classified as one of the following State categories:

Engineer, other

Excavating, grading machine operator

Forester

Stationary Engineer

The unskilled occupations correspond to one of the following, depending on whether the work is performed indoors or outside:

Gardener, groundskeeper (except farm)

Janitors and sextons

Every effort was made to follow the procedures of the California Employment Development Department in assigning occupations to appropriate categories:

The number of firms that reported use of various types of utility equipment are shown in Table 2-17. For each type of

Table 2-17

NUMBER OF FIRMS REPORTING USE OF UTILITY EQUIPMENT*

Type of Equipment	No. of Reporting Firms	No. of Equipment Units Reported
Lawn and Garden		
Walk Behind Mowers		
2-cycle	57	365
4-cycle	79	551
Riding Mowers	88	325
Tillers	17	19
Garden Tractors	43	93
Blowers	13	113
Edgers, Trimmers, Shredders	50	336
Yard Vacuums	15	36
Other	17	83
Chain Saws	138	948
Home Utility		
Electric Generators	86	340
Air Compressors	74	200
Other	206	791

*Many firms owned multiple units so the total number of units is greater than the total number of reporting firms.

Source: CIC Research, Inc., "California Utility Equipment Survey," 1981-1982.

equipment usage patterns were reported by at least 13 different firms (for blowers) and as many as 138 different firms (for chain saws). The average use patterns deduced from this survey are representative of a broad industrial cross-section. The occupational groups that use each type of utility equipment are shown in Table 2-18. As might be expected, all types of lawn and garden equipment are used primarily by gardeners. Chain saws are used primarily by gardeners (82%), to a lesser extent by carpenters (7%) and infrequently by eight other occupational groups. Electric generators are used by gardeners (37%), plumbers (22%), truck drivers (13%), and in lesser amounts by eleven other occupational groups. Air compressors are used by many occupations, with gardeners (20%), heavy equipment mechanics (17%) and truck drivers (12%) heading the list. (The discussion above refers to the number of units of equipment used -- not the hours of usage.)

In addition to the usual types of utility equipment listed on the survey questionnaire, a wide variety of other equipment was listed by respondents. These items of equipment and the occupational categories of their users are listed in Table D-1 of Appendix D. For the purposes of this study, all these miscellaneous equipment items will be assigned to the "Lawn and Garden, Other" and the "Home Utility, Other" categories, and no attempt will be made to disaggregate either category.

COMMERCIAL SURVEY RESULTS

Equipment Prevalence Rates

Prevalence rates for each type of equipment were computed as illustrated in the following example for chain saws and carpenters:

Table 2-18

PROPORTION OF COMMERCIAL UTILITY EQUIPMENT USE BY OCCUPATIONAL GROUPS

	Proportion of Utility Equipment Use							
Type of Equipment	Used by Entire Firm	Auto Mechanics	Auto-Body Repairers	Carpenters	Cement Finishers	Foresters	Drywall Installers	Electric Power Line Installers
Lawn and Garden								
Walk-Behind Mowers								
2-Cycle	--	--	--	--	--	--	.003	--
4-Cycle	.018	--	--	--	.002	--	--	--
Riding Mowers	.025	--	--	--	--	--	.003	--
Tillers	--	--	--	--	--	--	--	--
Garden Tractors	.022	--	--	.011	--	--	--	--
Blowers	--	--	--	--	--	--	--	--
Edgers / Trimmers	--	--	--	--	.003	--	--	--
Shredders								
Yard Vacuums	--	--	--	--	--	--	--	--
Other	--	--	--	.007	--	--	.007	--
Chain Saws	.017	--	--	.070	--	--	--	.003
Home Utility								
Electric Generators	.056	.012	--	.065	.006	--	.003	.041
Air Compresssors	.030	.055	.015	.105	--	--	.035	--
Other	.008	.063	--	.066	.059	.003	.016	.005

*Based on numbers of units of equipment, not hours of use.

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

Table 2-18 (Cont'd.)

Type of Equipment	Proportion of Utility Equipment Use									
	Gardeners	Heavy Equipment Mechanics	Painters	Plumbers	Sheet Metal Workers	Truck Drivers	Welders	Exc. Grading Operators	Janitors	Electricians
Lawn and Garden										
Walk-Behind Mowers										
2-Cycle	.964	.011	.003	.003	.003	.011	.003	--	--	--
4-Cycle	.924	.004	--	.002	--	.018	--	.011	.022	--
Riding Mowers	.914	.003	--	.003	--	.012	--	--	.034	--
Tillers	1.000	--	--	--	--	--	--	--	--	--
Garden Tractors	.925	.011	--	--	--	.032	--	--	--	--
Blowers	.885	--	--	.035	--	.080	--	--	--	--
Edgers / Trimmers	.994	--	--	.003	--	--	--	--	--	--
Shredders										
Yard Vacuums	.972	--	--	--	--	--	--	--	.028	--
Other	.959	--	.027	--	--	--	--	--	--	--
Chain Saws	.819	.042	--	.022	.002	.019	--	.005	.001	--
Home Utility										
Electric Generators	.374	.059	.009	.224	--	.132	--	.009	.003	.009
Air Compresssors	.195	.170	.035	.005	--	.120	--	.230	.005	--
Other	.392	.051	.002	.219	.005	.025	.056	.026	.002	.002

* Based on number of units of equipment, not hours of use

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982

Number of chain saws principally used by carpenters	66	
Total carpenters employed by all firms surveyed	375	
Chainsaws per carpenter 66/375		.176

Other equipment items and occupations were treated similarly. The results are summarized in Table 2-19. Since the number of chain saws per carpenter is known, it is possible to compute the total number of chain saws in commercial use by carpenters by multiplying the number of carpenters in the area of interest. This information is available from the California Employment Develpment Department for the State as a whole and for Standard Metropolitan Statistical Areas within the State.

Before these computations are presented, a number of comments about the prevalence rates of Table 2-19 are in order. Some of the results are unexpected -- for example, the use of lawn mowers by dry wall installers, painters, and welders. This situation arises in very small businesses where employees actually work at several different occupations, but are listed under their principal occupations. The reported prevalence rates are based on reliable survey data and do not represent errors in coding or data processing.

Statewide estimates of utility equipment usage by occupational groups are given in Table 2-20. Breakdowns for the equipment listed as "Other" are given in Table D-2 of Appendix D. The estimates were made by applying the prevalence rates of Table 2-20 to the population estimates of the California

Table 2-19

PREVALENCE OF COMMERCIAL UTILITY EQUIPMENT BY OCCUPATIONAL GROUP

Type of Equipment	Units Per Employee							
	Auto Mechanic	Auto Body Repairers	Carpenters	Cement Finishers	Foresters	Dry Wall Installers	Electric Power Line Installers	Gardeners
Lawn and Garden								
Walk-Behind Mowers								
2-Cycle	--	--	--	--	--	.007** (.007)	--	.106(.025)
4-Cycle	--	--	--	.008** (.007)	--	--	--	.154(.030)
Riding Mowers	--	--	--	--	--	.007** (.007)	--	.090(.024)
Tillers	--	--	--	--	--	--	--	.006*(.006)
Garden Tractors	--	--	.003** (.004)	--	--	--	--	.026(.013)
Blowers	--	--	--	--	--	--	--	.030(.014)
Edgers/Trimmers	--	--	--	.008* (.007)	--	--	--	.101(.025)
Shredders	--	--	--	--	--	--	--	.003(.004)
Yard Vacuums	--	--	--	--	--	--	--	.011*(.009)
Other	--	--	.003* (.004)	--	--	.007* (.007)	--	.043 (.017)
Chain Saws	--	--	.176 (.031)	--	--	--	.020*(.012)	.234(.035)
Home Utility								
Electric Generators	.011*(.009)	--	.059 (.019)	.015** (.010)	--	.007** (.007)	.095 (.024)	.038(.016)
Air Compressors	.031 (.014)	.250(.036)	.056 (.019)	--	--	.052 (.018)	--	.012*(.009)
Other	.109 (.026)	--	.107 (.025)	.291 (.037)	.154 (.030)	.074 (.022)	.020 (.012)	.072(.021)

*Indicates prevalence rate not statistically significant from zero at the 95% confidence level.

**Only one firm reporting.

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

Values in ( ) indicate standard errors of the estimates.

Table 2-19 (Cont'd.)

Type of Equipment	Units Per Employee								
	Heavy Equipment Mechanic	Painters	Plumbers	Sheet Metal Workers	Truck Drivers	Welders	Exc. Grading Machine Operator	Janitors	Electricians
Lawn and Garden									
Walk-Behind Mowers									
2-Cycle	.011**(.009)	.007**(.007)	.001**(.003)	.015*(.010)	.004**(.005)	.013*(.009)	--	--	--
4-Cycle	.006**(.006)	--	.001**(.003)	--	.011*(.009)	--	.023**(.012)	.132**(.028)	--
Riding Mowers	.003**(.004)	--	.001**(.003)	--	.004**(.005)	--	--	.121**(.027)	--
Tillers	--	--	--	--	--	--	--	--	--
Garden Tractors	.003**(.004)	--	--	--	.003*(.004)	--	--	--	--
Blowers	--	--	.002*(.004)	--	.010**(.008)	--	--	--	--
Edgers/Trimmers	--	--	.001**(.003)	--	--	--	--	--	--
Shredders	--	--	--	--	--	--	--	--	--
Yard Vacuums	--	--	--	--	--	--	--	--	--
Other	--	.029(.014)	--	--	--	--	--	--	--
Chain Saws	.113(.026)	--	.013*(.009)	.031**(.014)	.019(.011)	--	.019**(.011)	.011**(.009)	--
Home Utility									
Electric Generators	.056(.019)	.021(.012)	.047(.017)	--	.048**(.018)	--	.011**(.009)	.011**(.009)	.037(.016)
Air Compressors	.096(.024)	.050(.018)	.001**(.003)	--	.026**(.013)	--	.176**(.031)	.011**(.009)	--
Other	.088(.023)	.007*(.007)	.083(.023)	.046(.017)	.016*(.010)	.425(.041)	.061(.010)	.011**(.009)	.012*(.009)

*Indicates prevalence rate not statistically significant from zero at the 95% confidence level.

**Only one firm reporting.

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982

Values in ( ) indicate standard errors of the estimates.

Table 2-20

1980 STATEWIDE USAGE OF UTILITY EQUIPMENT BY OCCUPATIONAL GROUP

Number of Units in Use

Type of Equipment	Occupational Group (1980 Employment)								
	Auto Mechanic (119,119)	Auto-Body Repair (15,111)	Carpenters (102,190)	Cement Finishers (14,658)	Foresters (4,362)	Drywall Installers (14,651)	Electric Power Line Installers (8,679)	Gardeners, Grounds Keepers (99,168)	Heavy Equipment Mechanic (85,670)
Lawn and Garden									
Walk-Behind Mowers									
2-Cycle	--	--	--	--	--	--	--	10,500	--
4-Cycle	--	--	--	--	--	--	--	15,300	--
Riding Mowers	--	--	--	--	--	--	--	9,000	--
Tillers	--	--	--	--	--	--	--	600	--
Garden Tractors	--	--	--	--	--	--	--	2,600	--
Blowers	--	--	--	--	--	--	--	3,000	--
Edgers / Trimmers	--	--	--	100	--	--	--	10,000	--
Shredders	--	--	--	--	--	--	--	300	--
Yard Vacuums	--	--	--	--	--	--	--	1,100	--
Other	--	--	300	--	--	100	--	4,300	--
Chain Saws	--	--	18,000	--	--	--	--	23,200	9,700
Home Utility									
Electric Generators	1,300	--	6,000	--	--	--	800	3,800	4,800
Air Compressors	3,700	3,800	5,700	--	--	800	--	1,200	8,200
Other	13,000	--	11,000	4,300	700	1,100	200	7,100	7,500

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

Table 2-20 (Cont'd.)

Type of Equipment	Painters (51,887)	Plumbers (48,438)	Sheet-Metal Workers (23,407)	Truck Drivers (159,594)	Welders (70,903)	Exc. Grading Machine Operator (25,028)	Electricians (66,968)	Total
Lawn and Garden								
Walk-Behind Mowers								
2-Cycle	--	--	--	--	--	--	--	10,500
4-Cycle	--	--	--	1,800	--	--	--	17,100
Riding Mowers	--	--	--	--	--	--	--	9,000
Tillers	--	--	--	--	--	--	--	600
Garden Tractors	--	--	--	500	--	--	--	3,100
Blowers	--	100	--	--	--	--	--	3,100
Edgers / Trimmers	--	--	--	--	--	--	--	10,100
Shredders	--	--	--	--	--	--	--	300
Yard Vacuums	--	--	--	--	--	--	--	1,100
Other	1,500	--	--	--	--	--	--	6,200
Chain Saws	--	600	--	3,000	--	--	--	54,500
Home Utility								
Electric Generators	1,100	2,300	--	--	--	--	2,500	22,600
Air Compressors	2,600	--	--	--	--	--	--	26,000
Other	400	4,000	1,100	2,600	30,100	1,600	800	85,500

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982

Employment Development Department. The computations show that equipment usage by certain occupational groups has only a small impact on the total because the occupational groups are so small or because so little equipment is used. The following occupational groups appear to have little impact:

Autobody repair

Cement finisher

Foresters

Drywall installers

Electric powerline installers

Painters

Plumbers

Sheet metal workers

Excavating, grading machine operators

Electricians

Auto mechanics and welders are significant users of equipment in the "Home Utility, other" category, but are unimportant users of other types of equipment. The following occupational groups have the greatest impact on the total:

Carpenters

Gardeners, groundskeepers

Heavy equipment mechanics

Truck drivers

Janitors

According to the survey results, janitors use 4-cycle walk behind lawn mowers and riding mowers, but do not use 2-cycle

mowers or edgers/trimmers. This does not seem logical, and one feels more comfortable with the assumption that janitors use the same equipment as gardeners whenever their duties include gardening or grounds keeping. Since there are approximately twice as many janitors as gardeners in the State, any uncertainty in prevalence rate would be magnified even more when the survey results were expanded. The estimates of utility equipment usage by janitors (in Table 2-20) was derived from the survey response from a single firm that employed 12 janitors. Other firms in the survey reported on 79 janitors that used no utility equipment at all. Consequently, there is a high degree of uncertainty in this estimate and in all the other estimates that are based on responses from only one firm. In Chapter 4 of this report, methods will be recommended for dealing with these uncertainties.

The reader is reminded that the population of utility equipment in commercial use is only a small fraction of the population of equipment in residential use (refer to Table 2-5). When viewed from this perspective, the uncertainties in commercial population estimates may not seem serious, but the hours of use and the horsepower ratings are also important variables to be considered. All these factors are considered later in this chapter.

Commercial Use Data from Household Survey

As part of the household survey, the respondents were asked whether they used utility equipment at their jobs.

Those who replied affirmatively were asked to provide information about the type of equipment and usage patterns. The questionnaire is shown in Appendix A. Affirmative responses were received from 48 households, and the prevalence rates and expanded estimates of Table 2-21 were computed for those types of equipment that were identified in sufficient numbers. The equipment populations estimated from only 48 responses were not expected to be highly accurate, but it is reassuring to note that the estimates are of the same order of magnitude whether based on a survey of households or commercial establishments. The single exception is the population of blowers which is 31,600 from the household survey and 4,700 from the commercial survey. However, a population uncertainty of this magnitude will have little impact on the overall emission inventory.

Horsepower Ratings

Average horsepower ratings for utility equipment in use by commercial establishments are shown in Table 2-22. Similar information for the "Other" equipment categories is given in Table D-3 of Appendix D. The values are reasonable and slightly higher than the horsepower ratings for household equipment given in Table 2-7. In the case of shredders and yard vacuums, the commercial horsepower ratings are sufficiently higher than the household ratings to suggest that a different type of equipment may be used rather than a similar model with a larger engine. The sample sizes were sufficient to give a reliable estimate for almost all types of equipment.

Table 2-21

COMMERCIAL EQUIPMENT POPULATIONS ESTIMATED FROM HOUSEHOLD SURVEY INFORMATION

Type of Equipment	Units Per Household	Units For Total State (8,766,000 Households)	Estimate From Table 2-20
Lawn and Garden			
Walk-Behind Mowers	.0047	41,200	58,000
Tillers	.00052*		
Garden Tractors	.00052*		
Blowers	.0036	31,600	4,700
Edgers	.0041	35,900	10,200
Trimmers	.0026*		
Yard Vacuums	.00052*		
Chain Saws	.0130	114,000	58,100
Home Utility			
Electric Generators	.0104	91,200	33,100
Air Compressors	.0067	58,700	36,800
Other	.0026*		

*Not significantly different from zero at 95% confidence level.

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

Table 2-22

AVERAGE HORSEPOWER OF
COMMERCIAL UTILITY EQUIPMENT

Type of Equipment	Average Horsepower	99 Percent Confidence Interval	Sample Size
Lawn and Garden			
Walk-Behind Mowers			
2-cycle	3.8	3.1 - 4.5	49
4-cycle	4.6	3.9 - 5.2	75
Riding Mowers	17.3	14.8 - 19.8	85
Tillers	6.6	4.3 - 8.9	14
Garden Tractors	22.2	17.3 - 27.1	41
Blowers	3.5	.5 - 6.5	13
Edgers	2.3	1.8 - 2.8	43
Trimmers			
Shredders (Brush Clippers)	22.8	--	3
Yard Vacuums (Parking Lot Vacuums)	10.4	5.8 - 15.0	15
Other	8.9	--	38
Chain Saws	2.7	2.2 - 3.2	107
Home Utility			
Electric Generators	4.8	3.3 - 6.2	72
Air Compressors	9.3	6.7 - 11.9	59
Other	8.9	--	151

Source: CIC Research, Inc.,"California Utility Equipment Use Survey," 1981-1982

Annual Equipment Usage

The reported hours of annual use are given in Table 2-22 for commercial utility equipment and in Appendix D (Table D-4) for the "Other" category. As expected, commercial usage is from 20 to 50 times greater than household usage. These estimates may tend to represent maximum values for reasons that have already been mentioned in the discussion of the household survey. There is no accurate way to correct for this, so the reader must remember to use these values with appropriate judgement.

Annual usage varies with occupational category, and the ideal inventory would incorporate a separate use factor for each occupation/equipment combination. Unfortunately, the survey did not provide large enough sample sizes to give statistically significant annual use factors for all occupations. For the Lawn and Garden equipment categories, the overwhelming usage is by gardeners (refer to Table 2-20), and the annual usage rates given in Table 2-23 represent essentially the gardener occupational category. Any error that is introduced by applying this use factor to other occupational categories is certainly neglible compared to the rest of the uncertainties in the overall inventory. This situation is somewhat different for chain saws, electric generators and air compressors. In this case, the survey did provide significant annual use estimates for several occupational categories. These are summarized in Table 2-24. The 99 percent

Table 2-23

AVERAGE USAGE OF COMMERCIAL UTILITY EQUIPMENT

Type of Equipment	Average No. of Hours Used Per Year	99 Percent Confidence Interval	Sample Size
Lawn and Garden			
Walk-Behind Mowers			
2-cycle	578.0	379.5 - 776.5	53
4-cycle	618.4	467.6 - 769.2	73
Riding Mowers	901.3	714.0 - 1,088.6	86
Tillers	150.7	0* - 306.1	17
Garden Tractors	711.5	474.2 - 948.8	41
Blowers	414.0	105.8 - 722.2	12
Edgers / Trimmers	552.0	252.5 - 851.5	45
Shredders (Brush Clippers)	500.0	--	3
Yard Vacuums Parking Lot Vacuums)	382.3	74.1 - 690.5	15
Other	368.2	--	38
Chain Saws	349.4	254.3 - 444.5	122
Home Utility			
Electric Generators	243.7	139.7 - 347.7	68
Air Compressors	293.6	183.2 - 404.0	68
Other	348.1	--	153

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.
*Interval has been truncated at zero.

Table 2-24

ANNUAL COMMERCIAL USAGE
ACCORDING TO OCCUPATIONAL CATEGORY

Equipment and Occupation	Avg. No. of Hours Used Per Year	99% Confidence Interval	Sample Size
Chain Saws			
Gardeners	436.3	310.8 - 561.8	86
Carpenters	120.4	26.4 - 214.4	14
Plumbers	185.3	6.9 - 363.7	8
Heavy Equipment Op.	156.0	0*- 332.1	6
Electric Generators			
Gardeners	218.6	2.6 - 434.6	24
Carpenters	242.2	0*- 509.6	11
Plumbers	82.4	0*- 231.2	8
Heavy Equipment Op.	217.7	0*- 451.0	7
Compressors			
Gardeners	163.6	37.4 - 289.9	21
Carpenters	266.3	50.1 - 482.5	13
Heavy Equipment Op.	351.3	164.0 - 538.6	11
Drywall Installers	169.7	0*- 381.6	7

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

*Interval has been truncated at zero.

confidence intervals are large and in all cases overlap those in Table 2-23. The reliability of the overall inventory might be increased if the use factors from Table 2-24 were substituted, where applicable, for the factors in Table 2-23; but in the opinion of the authors, the uncertainties in all annnual usages are so great that no real improvement would result from using the Table 2-24 factors. All computations in this report are based on the Table 2-23 factors.

The responses to the question on annual fuel use are shown in Table 2-25 and Table D-5. This table also includes hourly average fuel consumption that was calculated by dividing the fuel use by the hours of use (from Table 2-23). Hourly fuel consumption per horsepower is also given. The commercial fuel consumption rates are all lower than the reported household fuel consumption rates (refer to Table 2-11) even after they have been corrected for differences in average horsepower, but they are still of the same order of magnitude as published values (refer to Table 2-12). It is hard to know whether commercial establishments are really able to operate their equipment more efficiently and conserve fuel or whether the reported differences merely reflect the fact that accurate records of fuel use are seldom kept by businesses or households.

Table 2-25

AVERAGE FUEL USE AND FUEL CONSUMPTION RATE
OF COMMERCIAL UTILITY EQUIPMENT

Type of Equipment	Average Fuel Use Per Year (Gallons)	99 Percent Confidence Interval	Sample Size	Gallons Per Hour	Gallons Per Hour HP.
Lawn and Garden					
Walk-Behind Mowers					
2-Cycle	146.0	69.4 - 223.0	43	.253	.067
4-Cycle	144.1	85.1 - 203.1	52	.233	.051
Riding Mowers	392.6	259.5 - 525.7	67	.436	.025
Tillers	132.6	85.8 - 179.4	13	.880	.133
Garden Tractors	602.3	465.5 - 739.1	33	.847	.038
Blowers	55.8	33.3 - 78.3	10	.135	.039
Edgers / Trimmers	64.5	54.7 - 74.3	33	.117	.051
Shredders	472.0	--	3	.944	.041
Yard Vacuums	241.1	130.7 - 351.7	14	.631	.061
Other	271.3	--	37	.737	.083
Chain Saws	63.0	50.8 - 75.2	95	.180	.067
Home Utility					
Electric Generators	81.6	56.4 - 106.8	49	.335	.070
Air Compressors	99.4	85.4 - 113.4	46	.339	.036
Other	149.8	--	106	.430	.048

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

Age of Equipment

The average age reported for each type of utility equipment in commercial use is shown in Table 2-26 and Table D-6. The values range from 2.7 years (edgers/trimmers) to 7.5 years (shredders) with lawn mowers averaging about 3.8 years. Generally, the commercial equipment is slightly newer than similar equipment in household use. These results will be discussed later when the results of the survey are compared with the CARB inventory.

MISCELLANEOUS COMMENTS

Relative Reliabilities of Residential and Commercial Survey Results

To help the reader judge the comparative reliabilities of the two surveys, the standard errors of the estimates of prevalence rates were given in Tables 2-3 and 2-19. For the other important variables such as annual usage and horsepower, 99 percent confidence intervals for the mean values were listed in the tables. These estimated uncertainties will be used in Chapter 3 to compute the uncertainties associated with the emissions estimates, but some general remarks are appropriate at this point.

In general, all of the information on residential use is highly significant because the sample sizes were large and not associated with any systematic bias. Most of the information on commercial use is equally significant, but, as shown in Table 2-19, some information was based on responses from

Table 2-26

AVERAGE AGE OF COMMERCIAL UTILITY EQUIPMENT

Type of Equipment	Average Age (Years)	99 Percent Confidence Interval	Sample Size
Lawn and Garden			
Walk-Behind Mowers			
2-Cycle	3.9	2.9 - 4.9	54
4-Cycle	3.6	2.8 - 4.4	72
Riding Mowers	4.0	3.3 - 4.7	85
Tillers	3.0	1.8 - 4.2	15
Garden Tractors	5.4	4.0 - 6.8	41
Blowers	4.3	0.1 - 8.5	12
Edgers / Trimmers	2.7	2.0 - 3.4	43
Shredders	7.5	--	2
Yard Vacuums	4.0	1.4 - 6.6	14
Other	7.0	--	38
Chain Saws	3.3	2.5 - 4.1	123
Home Utility			
Electric Generators	5.7	4.3 - 7.1	69
Air Compressors	6.2	4.3 - 8.1	61
Other	6.4	--	150

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

only one firm. In most cases this was not serious -- for example, the report of 2-cycle mowers being used by drywall installers, painters, plumbers, welders, etc., -- because the equipment used by these occupational groups was only a small fraction of the total. However, in a few instances, there may be significant problems. The use by janitors of 4-cycle mowers, riding mowers, and yard vacuums was estimated from the response of a single firm. Since janitors represented a very large occupational group, the expansion of the data indicated that more of these types of equipment were used by janitors than gardeners. In the case of riding mowers with their high HP ratings and hours/years of use, this results in an appreciable impact on estimated emissions. The effect is also significant for 4-cycle mowers but is less important for yard vacuums because the total equipment population is so small. Solutions to this problem will be suggested in Chapter 3 when the computation of emissions is presented.

Use Patterns by County or Air Basin

The survey was designed to collect primary data from the 22 most populous counties in California and to expand the results to estimate utility equipment usage in all 58 counties and for the State as a whole. Obviously, there are certain assumptions that have to be made when the survey results are extrapolated to counties where data was not actually collected. These assumptions and their effect on the accuracy of the inventory are discussed in the paragraphs that follow.

The household survey provided enough responses to differentiate among three large areas of the State. Slightly different uses patterns were found for each area, but the results generally support the assumption that household equipment usage is similar in all the counties surveyed. If these same household use patterns are also applicable to the 36 counties that were not surveyed, the survey results may be used to derive inventories for all counties. This study does not provide any insight into the equipment use patterns in counties that were not surveyed, but it does suggest that use patterns may be related in a general way to weather conditions. The survey included very few households from areas with winter snows and, therefore, may not be applicable to the following counties with severe winter weather: Lassen, Modoc, Nevada, Placer, Plumas, Sierra, Siskiyou, and parts of El Dorado and Trinity. If it is necessary to compile accurate, detailed inventories for these counties, additional surveys should be carried out to establish use patterns for areas with severe winters. Since most of these counties are sparsely populated, the impact on the statewide inventory is negligible.

The commercial survey does not provide any systematic information on use patterns by geographic area because it was not possible to conduct a large enough survey so that responses from all types of businesses were received in all counties. This was recognized at the time the survey was designed and

has already been discussed. Within the limits of the basic assumption that use patterns are related to occupational category and independent of type of industry and geographic location, the survey results can be extended to the 36 counties that were not surveyed if prevalence rates and use patterns are available for all occupations that use utility equipment. Generally, this is true, but there is at least one occupation, timbercutting, that is negligible in the 22 counties that were surveyed, but importtant in 17 of the counties that were not surveyed. This has a very small impact on the overall State inventory, but a larger impact on the affected counties. Since the number of timbercutters employed in each county is known, the emissions from their activities can be estimated if we know the types of equipment used, the average number of units used by each timbercutter, and the annual usage for each type of equipment. According to information developed by the Mobile Source Control Division of the ARB, timbercutters use chainsaws for 3 hours/day for six months of the year for a total of 360 hours/year. If we can make a reasonable estimate of the average number of chainsaws per timbercutter, we can estimate emissions. Somewhat arbitrarily, a value (prevalence rate) of 0.5 chainsaws per timbercutter was selected. This is slightly higher than any of the prevalence rates found for the occupational categories listed in Table 2-19, but timber cutting is quite a specific activity that always involves the use of some type of gasoline-powered equipment. A

relatively high prevalence rate is clearly indicated, and 0.5 seems like a reasonable value.

According to the California Employment Development Department, there were 3,241 individuals employed as timbercutters in California in 1980. This means that there were 1,621 chain saws each of which was used for an average of 360 hours/year. These quantities will be used to compute emissions from timbercutting activities. Chapter 3 explains the procedures for computing emissions.

CHAPTER 3. COMPUTATION OF EMISSIONS

In this chapter, the equipment population and usage data from Chapter 2 are used as a basis for computing the quantities of pollutants emitted by utility equipment. This is a three-step process as follows:

1. The emission factors that are currently in use are evaluated for their accuracy and applicability, and possible improvements are suggested.

2. The equipment population and usage data are evaluated, taking into account the uncertainties in the emission factors, and methods are recommended for simplifying and improving the estimates of equipment populations.

3. The pollutant emissions are computed according to the procedures developed in steps 1 and 2, and the results are compated with the most recent ARB inventory.

The remainder of this chapter describes the accomplishment of this three-step process.

EMISSION FACTORS

The current emission factors and their technical basis were described in Chapter 2 in the CURRENT INVENTORY METHODOLOGY section. In brief, the emission factors are based on experimental evaluations of a limited number of engines that were published in 1973. It was, therefore, appropriate to search the literature to see if any additional studies had been carried out since 1973. A thorough search of the literature did not reveal any more recent work. Individuals at EPA[10] and at Southwest Research

Institute,[7] who were involved in the earlier studies, were contacted and asked if they knew of any more recent work. They knew of none. Some very rough experiments had been carried out by the ARB at El Monte,[13] but the results could not be released because the experiments were not intended to produce emission factors and had not been carefully controlled. The ARB staff did indicate that their experiments showed that the current emission factors were of the right order of magnitude. It is concluded that there is no basis for revising the current emission factors to take into account more recent work. There have been no dramatic changes in small utility engines in recent years, so the earlier tests are still reasonably representative of present day engines.

Emission factors were derived from experimental programs that include certain assumptions about duty cycles, mixture settings, and horsepower ratings for typical applications. It is appropriate to examine the data base to see how well these assumptions match the real world situations.

There are two fundamentally different ways of testing small engines. In one method the entire piece of utility equipment is tested while it is actually performing the job it was designed to do. This method was used by AESI (reference 2) in tests on three lawn mowers and two tillers. In the other method, the engine alone is tested on a dynamometer. The loads and speeds are set to cover the range of conditions that might be

encountered in all applications. This method was used by the Bureau of Mines (reference 3) and by Southwest Research Institute (reference 8). In the first method, the experimenter obtains accurate emissions data for a particular implement performing a particular job, but it is sometimes difficult to know whether the job is truly representative. In addition, the horsepower output of the implement was not recorded in the AESI tests. In contrast, the dynamometer method provides accurate emisisons data over a wide range of loads and speeds, but the experimenter does not know what the real world duty cycles are for the implement/engine combinations that he is actually attempting to evaluate.

It is difficult to compare the results of the three published studies because different variables were measured in each instance; however, Table 3-1 shows a comparison that was published in reference 2. Note that emission factors in Table 3-1 are expressed as grams per hour per item of equipment. It is assumed that the equipment that was tested was typical of the real world population. It is not possible to compute confidence intervals for the emission factors because of the multitude of assumptions that had to have been made to convert all results to a comparable set of units, but factors from different studies frequently differ by a factor of two. In the Bureau of Mines experiments (reference 3), tests were performed on six identical models of a 4 HP, 4-cycle engine, and the emission factors varied by about 50 percent at the same load and mixture settings. For our

Table 3-1

SUMMARY OF RESULTS OF MAJOR SMALL ENGINES EMISSIONS TESTING PROGRAMS

Equipment type; Emissions Type	Emissions, Grams Per Hour: Average Grams Per Hour Donohue, et al.*	Average Grams Per Hour SWRI**	Average Grams Per Hour, AESI Test Results	Average Donohue, SWRI and AESI Results	AESI Emission Factors***
Lawn and Garden 4-stroke					
HC	18.93	31.83	44.80	31.85	40.0
CO	332.71	382.79	391.91	369.13	380.0
NO_x	5.21	4.35	1.64	3.73	4.0
Lawn and Garden 2-stroke					
HC	174.93	293.61	--	236.77	280.0
CO	418.46	666.79	--	542.63	650.0
NO_x	1.17	2.17	--	1.67	2.0
Chain Saws					
HC	153.00	--	588.82	370.94	350.0
CO	366.00	--	819.96	592.98	700.0
NO_x	1.02	--	0.61	0.82	1.0
Home Utility					
HC	21.31	23.47	114.90	53.23	50.0
CO	374.42	386.00	2,026.42	928.95	600.0
NO_x	5.87	7.67	29.50	14.35	10.0

*Factor developed by multiplying average emissions in grams per rated hp.hr x avg. rated hp.

**Factor developed by multiplying average grams per hp hr x avg. rated hp x estimated load factor (3.43 hp for Lawn and Garden, 3.86 hp for Home Utility and 40% load factor for all categories).

***Basis for development of factors given in reference 2 (AESI Study).

Source: Reference 2 (AESI Study).

purposes, it is sufficient to be aware that emission factors are reproducible only to about 50 percent under controlled conditions, and that substantial additional uncertainties are encountered in attempting to estimate load conditions and mixture settings that correspond to actual equipment use in the field.

Emission factors have been presented in different sets of units by different experimenters. They are expressed as mass emission rates (g/hr), brake specific emission rates (g/loaded hp. hr) or rated HP rates (g/rated hp. hr). By analogy with automotive emission factors, it is by no means obvious that the emissions should be directly proportional to the brake hp or the rated hp as implied by the last two emission factor expressions. It is instructive to examine the raw data and see whether there is compelling evidence for expressing factors on a "per hp" basis. Table 3-2 shows data from the SWRI study (reference 8) and Table 3-3 shows data from the Bureau of Mines study (reference 3). It is fairly obvious that NO_x emissions increase as horsepower increases, but is less clear that HC and CO emissions increase with increasing horsepower except for one 18-HP engine that was tested by SWRI. By comparison with similar engines in the Bureau of Mines tests, one is led to the conclusion that the SWRI test engine may have been atypical. There is little evidence to suggest that emission factors based on brake horsepower are more accurate than factors based on rated horsepower, or even whether they are any more accurate than simple mass emission rates that do not include horsepower at all. If the emission factors are used to compute emissions

Table 3-2

SUMMARY OF 13-MODE COMPOSITE EMISSIONS RESULTS FOR SMALL ENGINES

Engine	Run	Rated/ Intermediate Speeds, Rpm	Composite Mass Emissions, G/Hr				Composite Brake Specific Emissions G/HpHr			
			HC	CO	NO_x	RCHO	HC	CO	NO_x	RCHO
B & S 92908	2	3600/2600	29.4	475	3.22	0.51	25.8	417	2.82	0.45
4-stroke	3	3600/2600	32.6	381	1.97	0.66	26.9	315	1.63	0.55
3.5 HP, rated	4	3600/2600	34.7	360	3.55	0.56	28.4	295	2.91	0.46
1.14 HP, obs.	5	2200/3100	19.3	153	5.21	--	16.8	133	4.53	--
	Avg.		29.0	342	3.49	0.58	24.5	290	2.98	0.49
B & S 100202	1	3600/2600	13.5	208	10.60	0.61	11.7	181	9.22	0.53
4-stroke	2	3600/2600	11.8	199	13.40	0.55	9.67	163	11.00	0.45
4 HP, rated	3	3100/2200	18.8	244	9.95	--	17.4	226	9.21	--
1.15 HP, obs.	Avg.		14.7	217	11.30	0.58	12.9	190	9.81	0.49
Kohler K482	2	3600/2300	122.0	1840	29.20	2.45	22.9	345	5.49	0.46
4-stroke	3	3000/1800	198.0	1980	13.70	3.61	43.1	429	2.97	0.78
18 HP, rated	4	3600/2300	136.0	2010	11.50	--	25.3	375	2.13	--
5.33 HP, obs.	Avg.		152.0	1940	18.10	3.03	30.4	383	3.53	0.62
Tec. AH520	1	4500/3500	176.0	426	0.96	1.58	232.0	561	1.26	2.07
2-stroke	2	4500/3500	140.0	291	1.35	1.43	197.0	410	1.90	2.01
2 HP.rated	Avg.		158.0	358	1.16	1.50	214.0	486	1.58	2.04
0.76.HP obs.										
Wisc. S-12D	1	3600/2300	52.6	1250	20.4	1.45	15.6	369	6.04	0.43
4-stroke	2	3000/1850	40.7	840	20.4	1.13	12.7	262	6.35	0.35
12.5 HP.rated										
3.39 HP, obs.	Avg.		46.6	1040	20.4	1.29	14.2	316	6.20	0.39

Source: Hare, C.T., and K.J. Springer, "Exhaust Emissions from Uncontrolled Vehicles and Related Equipment Using Internal Combustion Engines. Part 4, Small Air-Cooled Spark Ignition Utility Engines," Environmental Protection Agency publication, No. APTD - 1493, 1973.

Table 3-3

SUMMARY OF 9-MODE COMPOSITE EMISSIONS RESULTS FOR SMALL ENGINES

Engine	Mixture Setting	Load	Composite Emissions, G/Hr.			Brake Specific Emissions G/Meas. Hp/Hr.			Composite Emissions, G/Rated Hp.Hr.		
			HC	CO	NO_x	HC	CO	NO_x	HC	CO	NO_x
4-stroke, 2 - 6 rated HP, average of 17 engines	Lean	Full	22	290	26	8	110	9	6	74	6
		Partial	21	310	13	11	160	7	5	79	3
		Minimum	15	170	4	--	--	--	4	44	1
	Best power, lean	Full	28	540	12	10	190	4	7	140	3
		Partial	26	480	7	14	250	4	7	120	2
	"	Minimum	19	290	3	--	--	--	5	74	1
	Rich	Full	41	1,000	4	15	350	1	11	250	1
	"	Partial	44	1,000	2	23	530	1	11	260	--
	"	Minimum	39	603	2	--	--	--	10	150	--
4-stroke 8 - 12 rated HP, average of 6 engines	Lean	Full	39	660	100	5	80	12	4	66	10
	"	Partial	28	480	45	8	140	11	3	52	4
	"	Minimum	23	240	4	--	--	--	2	24	--
	Best power, lean	Full	48	1,450	47	6	170	6	5	140	5
	"	Partial	35	850	30	9	220	7	4	87	3
	"	Minimum	28	420	2	--	--	--	3	39	--
	Rich	Full	67	2,730	19	8	320	2	7	260	2
	"	Partial	57	1,880	10	14	470	2	6	190	1
	"	Minimum	57	790	3	--	--	--	6	75	--
4-stroke 14 - 18 rated HP average of 4 engines	Lean	Full	48	1,100	130	4	81	10	3	69	9
	"	Partial	19	690	40	3	97	6	1	48	2
	"	Minimum	23	440	4	--	--	--	1	28	--
	Best power, lean	Full	69	2,250	72	5	170	5	4	140	3
		Partial	49	1,200	34	7	180	5	3	81	2
	"	Minimum	43	960	4	--	--	--	3	60	--
	Rich	Full	92	3,820	31	7	280	2	6	240	2
	"	Partial	72	2,230	19	11	330	3	5	150	1
	"	Minimum	93	1,390	5	--	--	--	6	88	--
2-stroke 3 - 6 rated HP average of 6 engines	Lean	Full	260	170	10	130	94	3	64	46	2
	"	Partial	230	210	4	140	100	2	57	48	1
	"	Minimum	150	230	5	--	--	--	41	57	--
	Best power, lean	Full	260	400	5	140	250	2	68	110	1
	"	Partial	230	510	2	150	300	1	60	130	--
		Minimum	380	450	1	--	--	--	45	100	--
	Rich	Full	330	730	2	160	360	1	80	170	--
	"	Partial	300	820	2	190	490	1	74	190	--
	"	Minimum	250	550	6	--	--	--	61	130	--
2-stroke, 22 rated HP, one engine	Lean	Full	1,747	277	423	87	14	21	79	13	20
	"	Partial	293	356	43	28	34	4	13	16	2
	"	Minimum	60	22	2	--	--	--	3	1	--
	Best power, lean	Full	1,677	1,874	221	79	89	10	76	85	10
	"	Partial	437	2,054	10	43	201	1	20	93	--
	"	Minimum	624	699	2	--	--	--	28	32	--
	Rich	Full	2,639	5,967	25	113	284	3	120	271	1
	"	Partial	362	2,029	8	37	205	1	16	92	--
	"	Minimum	127	419	2	--	--	--	6	19	--

Source: Eccleston, B.H. and R.W. Hurn, "Exhaust Emissions from Small Utility, Internal Combustion Engines," Paper 720197 presented at SAE Automotive Engineering Congress, Detroit, January 1972

from engines that are approximately the same horsepower as the test engines, then any form of the emission factor expression is suitable. Additional uncertainties may arise if the emission factors are used for engines of significantly different horsepower than the test population. This will be discussed more in the paragraphs that follow.

In view of the above discussion, it is appropriate to compare the horsepower ratings of the test engines with the ratings of the utility equipment engines that are of interest in this study. Ideally, one would like to have emission factors for the following equipment categories and horsepower ratings:

Walk-Behind Mowers - 2-Cycle (2.9 - 3.8 HP)
Walk-Behind Mowers - 4-Cycle (2.9 - 4.6 HP)
Riding Mowers (7.3 - 7.8 HP)
Tillers (5.3 - 6.6 HP)
Garden Tractors (11.5 - 22.2 HP)
Blowers (3.5 HP)
Edgers/Trimmers (1.3 - 2.3 HP)
Shredders (4.1 - 22.8 HP)
Yard Vacuums (2.8 - 10.4 HP)
Chain Saws (2.0 - 2.7 HP)
Electric Generators (3.5 - 4.8 HP)
Air Compressors (2.9 - 9.3 HP)
Other (8.9 HP)

(The listed HP ratings are taken from the results of this study as summarized in Tables 2-7 and 2-22.) If one assumes that emissions are dependent primarily on the characteristics of the engine and not on the type of equipment with which the engine is associated, then a certain amount of aggregation is possible as shown below:

Small 2-Cycle Engines (1 - 3HP) -- Edgers/Trimmers, Chain Saws

Medium 2-Cycle Engines (3 - 4 HP) -- Walk-Behind Mowers

Medium 4-Cycle engines (3 - 6 HP) -- Walk-Behind Mowers, Blowers, Generators, Tillers

Large 4-Cycle Engines (7 - 22 HP) -- Riding Mowers, Tractors, Heavy Duty Shredders, Vacuums, and Compressors, "Other Home Utility"

The emission factors for chain saws (small 2-cycle engines) that were used in the ARB inventory were derived from the AESI study (reference 2) that tested three saws of 5.6, 6.0, and 6.0 horsepower. This is clearly outside the desired range of 1 - 3 horsepower. On the other hand, the emission factors used for 2-cycle walk-behind mowers (medium 2-cycle engines) are derived from tests on one 2-horsepower engine (see Table 3-2) that corresponds more closely to the small engine category. Factors used for 4-cycle lawn and garden (medium and large 4-cycle engines) are derived from tests on four engines from 3.5 to 18 horsepower (see Table 3-2) weighted according to an estimate of typical engine populations averaging 3.4 horsepower. Factors for 4-cycle home utility are derived similarly except that a different weighting scheme is used corresponding to an average of 3.9 horsepower. It appears that the existing emissions test data could be used to derive alternative emission factors that would correspond more closely to the derived horsepower ranges than the factors presently used to compute the ARB inventory. These factors are presented

in Table 3-4. The numerical values are not drastically different from those presently in use, and the two sets of values are probably identical in view of the large uncertainties associated with the experimental programs. In addition, Table 3-4 lists emission factors expressed as g/hr as well as the conventional epression as g/hp.

Emission factors for particulates (TSP), sulfur oxides (SO_x) and evaporative hydrocarbons are not listed in Table 3-4 for the following reasons. Factors for TSP were derived as part of the SWRI study (reference 8), but reliable techniques for measuring particulate emissions had not yet been developed at the time the study was done. The authors themselves recommend that the factors be used with utmost caution. Particulate emissions from utility equipment represent a very small fraction of the total particulate burden. Since it was neither possible nor necessary to improve the emission factors presently used by the ARB for TSP, no computations of particulate emissions were made in the study.

A similar situation exists with respect to emission factors for SO_x and evaporative emissions. In this instance, no experimental basis exists at all. The SO_x emission factors given in reference 17 are estimated by assuming that that the fuel contains 0.043 percent sulfur and that fuel consumption is known for all types of equipment. Evaporative emission factors are given in reference 17 and are based on the number of times the fuel tank is filled per year. This methodology includes assumptions about fuel consumption and fuel tank volume for each type of equipment. The current study did not provide any information

Table 3-4

EMISSION FACTORS FOR REVISED EQUIPMENT CATEGORIES

Engine Type	Pollutant	Emission Factors G/Hr	Emission Factors G/Hp Hr*	Reference	No. of Engines Tested	Avg. Rated HP	Avg. Brake HP
Small 2-cycle (1 - 3 hp)	HC	160	210	SWRI (8)	1	2.0	0.74
	CO	360	490				
	NO_x	1.2	1.6				
Medium 2-cycle (3 - 4 hp)	HC	230	150	Donohue (3)	6	3.9	1.53
	CO	510	300				
	NO_x	2	1				
Medium 4-cycle (3 - 6 hp)	HC	32	23	SWRI (8)	4	3.4	1.37
	CO	380	280				
	NO_x	4.3	3.2				
Large 4-cycle (7 - 22)	HC	37	9.7	SWRI (8)	1	12.5	3.39
	CO	880	230	Donohue (3)	6	9.8	3.80
	NO_x	29	6.9				

*Hp indicates brake hp or rated hp x load factor

that could be used to improve these estimates. In view of the tremendous uncertainties in the estimates of SO_x and evaporative emissions and their relatively minor impact on the total industry, these emissions were not computed as part of this study.

The current version of the ARB emission inventory lists two different classes of hydrocarbons: total organic gases (TOG) and reactive organic gases (ROG). The major difference between the two classes is that methane is included in TOG but not in ROG. In order to compute emissions of TOG and ROG from utility equipment, the proportion of methane in the exhaust would have to be known. None of the laboratory evaluations of utility equipment have included the measurement of methane as well as total hydrocarbons in the exhaust. By analogy with studies on larger internal combustion engines, it is reasonable to assume that utility equipment exhaust contains a small amount of methane. In compiling the 1979 inventory, the ARB staff assumed that methane accounted for 3.2 percent of the total weight of hydrocarbons in utility equipment exhaust. This value seems reasonable, but it is not based on experiments performed on utility equipment. In view of the large uncertainties associated with emission factors for TOG, an accurate value for percent methane is not really necessary.

Aldehydes were measured in some of the experimental studies of utility equipment, and emission factors for aldehydes are given in Reference 17. Since aldehydes are not included as a separate category in the ARB inventory, they are not categorized separately in this study.

COMPUTATION OF EXHAUST EMISSIONS

The equipment population data from this survey are summarized in Table 3-5 along with load factors that were taken from the current ARB inventory. Emissions as tons per year, can be computed by applying emission factors to the information contained in Table 3-5. This has been done using three sets of emission factors:

1. Factors used by the ARB to compute the current inventory (refer to Table 1-4) except that the 2-stroke lawn and garden factors were used only for 2-stroke walk-behind mowers and edger/trimmers.

2. Factors from Table 3-4 expressed as g/hp hr.

3. Factors from Table 3-4 expressed as g/hr. In this instance the information on average horsepower and load factors is not used.

The results are shown in Table 3-6 for exhaust emissions from statewide utility equipment use. Although the emissions from individual equipment categories vary somewhat from one set of factors to the next, the totals are amazingly similar.

	Tons/Year		
Pollutant	Set 1	Set 2	Set 3
HC	21,675	22,299	22,109
CO	126,511	126,564	119,674
NO_x	1,600	2,249	2,197

In every case, the majority of the hydrocarbon (HC) emissions come from 2-cycle engines and the majority of the nitrogen

Table 3-5

SUMMARY OF STATEWIDE EQUIPMENT POPULATIONS AND USAGE

Type of Equipment	Household				Commercial			
	Population	Annual Hours	Average HP	Load Factor*	Population	Annual Hours	Average HP	Load Factor*
Lawn and Garden								
Walk-Behind Mowers								
2-Cycle	1,063,000 (61,000)	25 (1)	2.9 (0.1)	.31	10,500 (2,500)	578 (76)	3.8 (0.3)	.31
4-Cycle	1,874,000 (79,000)	18 (1)	2.9 (0.1)	.31	17,100 (4,400)	618 (58)	4.6 (0.2)	.31
Riding Mowers	61,000 (18,000)	24 (6)	7.8 (1.2)	.34	9,000 (2,400)	901 (72)	17.3 (2.5)	.34
Tillers	368,000 (44,000)	18 (5)	5.3 (0.2)	.40	600 (600)	151 (60)	6.6 (0.9)	.40
Garden Tractors	79,000 (18,000)	25 (9)	11.5 (2.3)	.54	3,100 (1,900)	712 (91)	22.2 (1.9)	.54
Blowers	44,000 (18,000)	15 (3)	3.5 (1.3)	.30	3,100 (1,600)	414 (118)	3.5 (1.2)	.30
Edgers/Trimmers	604,000 (61,000)	12 (2)	1.9 (0.1)	.30	10,100 (2,600)	552 (115)	2.3 (0.2)	.30
Shredders	53,000 (18,000)	10 (5)	4.1 (0.6)	.30	300 (400)	500 (236)	22.8 (18.6)	.30
Yard Vacuums	35,000 (9,000)	15 (13)	2.8 (0.6)	.30	1,100 (900)	382 (118)	10.4 (1.8)	.30
Other	-0-	--	--	--	6,200 (2,900)	368 (177)	8.9	.30
Chain Saws	736,000 (53,000)	26 (4)	2.0 (0.2)	.50	54,500 (8,800)	349 (37)	2.7 (0.2)	.50
Home Utility								
Electric Generators	79,000 (18,000)	64 (60)	3.5 (0.8)	.50	22,600 (7,400)	244 (40)	4.8 (0.6)	.50
Air Compressors	35,000 (9,000)	42 (31)	2.9 (0.5)	.50	26,000 (6,400)	294 (42)	9.3 (1.0)	.50
Other	-0-	--	--	--	85,500 (18,000)	348 (173)	8.9	.50

*Taken from the current ARB inventory.

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

Values in ( ) indicate the standard errors of the estimates.

Table 3-6

STATEWIDE EXHAUST EMISSIONS FROM UTILITY EQUIPMENT
AS CALCULATED USING THREE SETS OF EMISSION FACTORS

Tons Per Year (Emission Factor)

	Factors From Current ARB Inventory			Factors From Table 3-4 g/hp hr			Factors From Table 3-4 g/hr		
	HC	CO	NO_x	HC	CO	NO_x	HC	CO	NO_x
Lawn and Garden									
Walk-Behind Mowers									
2-Cycle	7,321 (214)	16,626 (486)	54 (1.58)	5,132 (150)	10,263 (300)	34 (1)	8,219 (230)	18,226 (510)	71 (2)
4-Cycle	1,169 (23.2)	14,056 (279)	160 (3.17)	1,159 (23)	14,106 (280)	161 (3.2)	1,575 (32)	18,705 (380)	212 (4.3)
Riding Mowers	612 (23.2)	7,360 (279)	84 (3.17)	256 (9.7)	6,072 (230)	182 (6.9)	388 (37)	9,235 (880)	304 (29)
Tillers	362 (23.2)	4,358 (279)	50 (3.17)	360 (23)	4,377 (280)	50 (3.2)	237 (32)	2,815 (380)	32 (4.3)
Garden Tractors	988 (23.2)	11,877 (279)	135 (3.17)	414 (9.7)	9,818 (230)	294 (6.9)	170 (37)	4,037 (880)	133 (29)
Blowers	51 (23.2)	614 (279)	7 (3.17)	51 (23)	615 (280)	7 (3.2)	69 (32)	815 (380)	9 (4.3)
Edgers/Trimmers	1,813 (214)	4,116 (486)	13 (1.58)	1,779 (210)	4,150 (490)	14 (1.6)	2,245 (160)	5,051 (360)	16 (1.2)
Shredders	43 (23.2)	522 (279)	6 (3.17)	43 (23)	517 (280)	6 (3.2)	23 (32)	278 (380)	3 (4.3)
Yard Vacuums	43 (23.2)	522 (279)	6 (3.17)	43 (23)	517 (280)	6 (3.2)	33 (32)	389 (380)	4 (4.3)
Other	156 (23.2)	1,872 (279)	21 (3.17)	65 (9.7)	1,543 (230)	46 (6.9)	93 (37)	2,202 (880)	73 (29)
Chain Saws	5,905 (116.7)	11,790 (233)	17 (0.33)	10,626 (210)	24,794 (490)	81 (1.6)	7,107 (160)	15,992 (360)	(1.2)
Home Utility									
Electric Generators	368 (15.2)	6,050 (250)	120 (4.97)	557 (23)	6,782 (280)	78 (3.2)	373 (32	4,426 (380)	50 (4.3)
Air Compressors	629 (15.2)	10,339 (250)	205 (4.97)	401 (9.7)	9,513 (230)	285 (6.9)	369 (37)	8,793 (880)	290 (29)
Other	2,215 (15.2)	36,409 (250)	722 (4.97)	1,413 (9.7)	33,497 (230)	1,005 (6.9)	1,208 (37)	28,708 (880)	946 (29)
Total	21,675	126,511	1,600	22,299	126,564	2,249	22,109	119,674	2,197

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

oxides (NO_x) come from large 4-cycle engines. Carbon monoxide (CO) emissions are distributed among all types of equipment.

The use of Set 3 emission factors (gm/hr) is recommended because this avoids the uncertainties associated with the basic assumption that emissions from utility engines are directly proportional to horsepower. As discussed above, the authors of this report do not believe that there is strong evidence to support the conventional gm/hp hr form for emission factors. The recommended procedure for computing emissions, described in the following paragraphs, uses emission factors expressed as g/hr.

At this point it is instructive to examine the uncertainties in the emissions computations that are associated with estimating process rate. The recommended procedure starts with published information on numbers of households and employees in specified categories and requires two additional values that are obtained from the survey responses:

1. Prevalence rates
2. Annual usage

These two values are multiplied together in the emissions computation; therefore, an estimate of the uncertainty of this product is a measure of the uncertainty of the emissions estimate. The standard errors of estimate for prevalence rates were given in Tables 2-3 and 2-19, and the standard errors for annual usage was shown in Table 3-5. Table 3-7 lists the standard error of

Table 3-7

STANDARD ERRORS OF ESTIMATES OF PROCESS RATES AND EMISSIONS

Type of Equipment	Household						Commercial					
	Population	Hrs.	(Pop)(Hrs)(10^{-6})	Emissions, Tons/Yr. HC	CO	NO_x	Population	Ann. Hrs.	(Pop)(Hrs)(10^{-6})	Emissions Tons/Yr. HC	CO	NO_x
Lawn and Garden												
Walk-Behind Mowers												
2-Cycle	61,000	1	3.23	817	1,812	7	2,500	76	.01	3	7	0
4-Cycle	79,000	1	3.04	107	1,271	14	4,400	58	.02	1	6	0
Riding Mowers	18,000	6	0.70	28	678	22	2,400	72	.01	0	8	0
Tillers	44,000	5	2.30	582	1,290	5	600	60	.001	0	1	0
Garden Tractors	18,000	9	0.89	36	862	28	1,900	91	.006	0	5	0
Blowers	18,000	3	0.27	10	113	1	1,600	118	.01	0	4	0
Edgers/Trimmers	61,000	2	1.00	176	396	1	2,600	115	.02	3	6	0
Shredders	18,000	5	0.33	12	138	2	400	236	.01	0	2	0
Yard Vacuums	9,000	13	0.55	20	232	3	900	118	.003	0	1	0
Other	none reported		--	--	--	--	2,900	177	.01	1	13	0
Chain Saws	53,000	4	3.94	693	1,560	5	8,800	37	.03	5	12	0
Home Utility												
Electric Generator	18,000	60	5.15	181	2,153	24	7,400	40	.02	1	7	0
Air Compressors	9,000	31	1.16	47	1,123	37	6,400	42	.02	1	20	1
Other	none reported		--	--	--	--	18,000	173	.09	4	88	3
Total Uncertainty:				2,709	11,628	149		Total Uncertainty:		19	180	4

Source: CIC Research, Inc.

the population estimates derived from the prevalence rates and also lists the standard error of the process rate. The procedure for computing the standard error of the process rate is described at the end of this report in the "Statistical Procedures" section. The standard error of the emissions estimate is also shown for a scenario in which the emission factors are assumed to be constants with no uncertainties.

In general, the standard errors of estimates of equipment populations are greater for household equipment than for commercial equipment. The standard errors of annual hours of use are greater for commercial than for household. The standard errors of the product of equipment population and annual hours (i.e., process rate) are substantially greater for household equipment than for commercial. The standard errors of process rates were multiplied by the appropriate emission factors to give standard errors of emissions as shown in Table 3-7. To illustrate the significance of this estimate, it is helpful to recall that we can be 68 percent confident that the true estimate of emissions lies between the mean value plus or minus one standard error. Specifically, we can be 68 percent confident of the following:

Emissions from Household Usage (tons/year)

HC	13,147 ± 2,709
CO	49,829 ± 11,628
NO_x	474 ± 149

Emissions from Commercial Usage (tons/year)

HC	8,962 ± 19
CO	69,845 ± 180
NO_x	1,723 ± 4

When we consider the uncertainties associated with the emission factors themselves, it is likely that the emission estimates given in Table 3-6 may be in error by as much as 25 percent or 5,500 tons/year of HC, 29,900 tons/year of CO, and 550 tons/year of NO_x. The standard errors listed in Table 3-7 are substantially less than these emission factor uncertainties, so the major uncertainties in estimating emissions are asociated with emission factors rather than process rates.

Figure 3-1 shows a worksheet that has been designed to facilitate the estimation of emissions from utility equipment. The computations are accomplished in a straightforward manner as follows:

Step 1. Assemble the following information from published sources for the county of interest and the year of interest:

- Number of households and owner/renter ratio. If the owner/renter ratio is the same as it was in 1980, only the number of households is required.
- Employment in each of the occupational categories listed on the worksheet.*

*Note that janitors are not listed. The prevalence rates for equipment used by janitors are not statistically different from zero and it is recommended that this occupational category be deleted.

Figure 3-1

WORKSHEET FOR COMPUTING EMISSIONS
FROM UTILITY EQUIPMENT

County _____

Year _____

No. of Households _____

Type of Equipment	Prevalence Rate*	Equipment Population	Hrs.** / Yr.Unit	Emissions, tons/year
Small 2-Cycle				
edgers				
trimmers				
chain saws				
$\sum(\text{Eq.Pop.})\left(\frac{\text{Hrs.}}{\text{Yr.unit}}\right)(10^6)$				x 160 x 1.1 _____ HC; x 360 x 1.1 _____ CO; x 1.2 x 1.1 _____ NO_x
Medium 2-Cycle				
walk-behind mowers				
$(\text{Eq.Pop.})\left(\frac{\text{Hrs.}}{\text{Yr.Unit}}\right)(10^6)$				x 230 x 1.1 _____ HC; x 510 x 1.1 _____ CO; x 2 x 1.1 _____ NO_x
Medium 4-cycle				
walk-behind mowers				
tillers				
blowers				
shredders				
yard vaccuums				
electric generators				
$\sum(\text{Eq.Pop.})\left(\frac{\text{Hrs.}}{\text{Yr.Unit}}\right)(10^6)$				x 32 x 1.1 _____ HC; x 380 x 1.1 _____ CO; x 4.3 x 1.1 _____ NO_x
Large 4-Cycle				
riding mowers				
garden tractors				
lawn & garden, other				
air compressors				
home utility, other				
$\sum(\text{Eq.Pop.})\left(\frac{\text{Hrs.}}{\text{Yr.Unit}}\right)(10^6)$				x 37 x 1.1 _____ HC; x 880 x 1.1 _____ CO; x 29 x 1.1 _____ NO_x

*Selected from Table 2-3 and adjusted for owner/renter ratio if necessary.
**Selected from Table 2-8.

Emissions from All Utility Equipment

Tons/Year

Household	_____	HC
	_____	CO
	_____	NO_x
Commercial (from p.2)	_____	HC
	_____	CO
	_____	NO_x
Grand Total	_____	HC
	_____	CO
	_____	NO_x

County _____

Year _____

Type of Equipment \ Employment	Foresters	Carpenters	Cement Finishers	Electricians	Ex. Grading Machine Operators	Painters	Plumbers	Sheet Metal Workers	Auto Body Repairers	Auto Mechanics	Heavy Equipment Mechanics	Electric Power Line Installers	Welders	Dry Wall Installers	Truck Drivers	Gardeners	Equipment Population	hrs./yr.unit	Emissions, tons/yr.
Small 2-Cycle																			
edgers/trimmers			.008													.101		552	x160x1.1 _____ HC
chain saws		.176					.013				.113				.019	.234		394	x360x1.1 _____ CO; x1.2x1.1 _____ NO_x
																$\sum$ (Equip.pop.) $\left(\frac{\text{hrs.}}{\text{yrs.unit}}\right)$ (10^{-6})			
Medium 2-Cycle																			
walk-behind mowers																.106		578	
											(Equip.pop.) $\left(\frac{\text{hrs.}}{\text{yrs.unit}}\right)$ (10^{-6})								
Medium 4-Cycle																			
walk-behind mowers															.011	.154		618	x230x1.1 _____ HC; x510x1.1 _____ CO; x2x1.1 _____ NO_x
tillers																.006		151	
blowers							.002									.030		414	
shredders																.003		500	
yard vaccuums																.011		382	x32x1.1 _____ HC; x380x1.1 _____ CO; x4.3x1.1 _____ NO_x
electric generators		.059		.037		.021	.047			.011	.056	.095				.038		244	
																$\sum$ (Equip.pop.) $\left(\frac{\text{hrs.}}{\text{yrs.unit}}\right)$ (10^{-6})			
Large 4-Cycle																			
riding mowers																.090		901	
garden tractors															.003	.026		712	x37x1.1 _____ HC; x880x1.1 _____ CO; x29x1.1 _____ NO_x
lawn & garden, other		.003				.029								.007		.043		368	
air compressors		.056				.050			.250	.031	.096			.052		.012		294	
home utility, other	.154	.107	.291	.012	.061	.007	.083	.046		.109	.088	.020	.425	.074	.016	.072		348	
																$\sum$ (Equip.pop.) $\left(\frac{\text{hrs.}}{\text{yrs.unit}}\right)$ (10^{-6})			

Total Commercial Emissions _____ HC

_____ CO

_____ NO_x

Step 3. Select the appropriate annual usage rates from Table 2-8 and record them on the worksheet. The guidance for Step 2 also applies to Step 3.

Step 4. Compute household equipment population by multiplying prevalence rates by the number of households.

Step 5. Compute total annual hours of use for the entire equipment population and multiply by the appropriate emission factor to derive tons/yr of pollutant emitted by household utility equipment.

Step 6. Compute commercial equipment populations by multiplying the prevalence rates by the number of employees in each of the relevant categories. Sum the populations over all employment categories.

Step 7. Compute annual hours of use and emissions as in Step 5 above.

Step 8. Add the household and commercial emissions to derive total emissions.

Emissions from timbercutting are listed separately because they were not derived from survey data. Figure 3-2 shows the computations for the State as a whole. The values should be rounded off to no more than three significant figures, but more were carried through the computational steps. Computations for individual counties are given in Appendix E.

The average annual emissions (tons/year) from utility equipment exhaust in the entire state are shown below along with emissions from several other source categories taken from the most recent ARB inventory (reference 1).

Figure 3-2

WORKSHEET FOR COMPUTING EMISSIONS
FROM UTILITY EQUIPMENT

County ENTIRE STATE

Year 1981

No. of Households 8,766,000

Type of Equipment	Prevalence Rate*	Equipment Population	Hrs.** / Yr.Unit	Emissions, tons/year
Small 2-Cycle				
edgers	.058	508,428	11.1	
trimmers	.011	96,426	16.2	
chain saws	.084	736,344	25.6	
$\sum$(Eq.Pop.)(Hrs./Yr.unit)(10^{-6})			26.058	x 160 x 1.1 4586 HC; x 360 x 1.1 10,319 CO; x 1.2 x 1.1 34 NO_x
Medium 2-Cycle				
walk-behind mowers	.121	1,060,686	24.9	
(Eq.Pop.)(Hrs./Yr.Unit)(10^{-6})			26.411	x 230 x 1.1 6682 HC; x 510 x 1.1 14,817 CO; x 2 x 1.1 58 NO_x
Medium 4-cycle				
walk-behind mowers	.214	1,875,924	18.4	
tillers	.042	368,172	17.5	
blowers	.005	43,830	14.7	
shredders	.006	52,596	9.7	
yard vaccuums	.004	35,064	15.0	
electric generators	.009	78,894	63.7	
$\sum$(Eq.Pop.)(Hrs./Yr.Unit)(10^{6})			47.666	x 32 x 1.1 1,678 HC; x 380 x 1.1 19,924 CO; x 4.3 x 1.1 225 NO_x
Large 4-Cycle				
riding mowers	.007	61,362	24.1	
garden tractors	.009	78,894	24.9	
lawn & garden, other	-o-	-o-		
air compressors	.004	35,064	42.3	
home utility, other	-o-	-o-		
$\sum$(Eq.Pop.)(Hrs./Yr.Unit)(10^{6})			4.927	x 37 x 1.1 201 HC; x 880 x 1.1 4769 CO; x 29 x 1.1 157 NO_x

*Selected from Table 2-3 and adjusted for owner/renter ratio if necessary.
**Selected from Table 2-8.

Emissions from All Utility Equipment

Tons/Year

Household	13,147	HC		
	49,829	CO		
	474	NO_x		
Commercial (from p.2)	8,962	HC		
	69,845	CO		
	1,723	NO_x		
Grand Total	22,109	HC	TIMBER CUTTING 103	
W/O TIMBER CUTTING	119,674	CO	231	
	2,197	NO_x	1	
GRAND TOTAL W TIMBER CUTTING	22,212	HC		
	119,905	CO		
	2,198	NO_x		

Figure 3-2 (Cont.)

County ENTIRE STATE

Year 1981

Type of Equipment \ Employment	Foresters	Carpenters	Cement Finishers	Electricians	Ex. Grading Machine Operators	Painters	Plumbers	Sheet Metal Workers	Auto Body Repairers	Auto Mechanics	Heavy Equipment Mechanics	Electric Power Line Installers	Welders	Dry Wall Installers	Truck Drivers	Gardeners	Equipment Population	hrs. / yr.unit	Emissions, tons/yr.
	4362	102190	14656	66361	25027	51227	42427	33407	15111	119119	15570	26579	70103	14651	159593	99167			
Small 2-Cycle																			
edgers/trimmers			.008													.101	10,133	552	x160x1.1 4,766 HC
chain saws		.176					.013				.113				.019	.234	54,533	394	x360x1.1 10,724 CO
																	27,020		x1.2x1.1 36 NO_x
$\sum$ (Equip.pop.) (hrs./yrs.unit) (10^{-6})																			
Medium 2-Cycle																			
walk-behind mowers																.106	10,512	578	x230x1.1 1537 HC
																	6,076		x510x1.1 3409 CO
(Equip.pop.) (hrs./yrs.unit) (10^{-6})																			x2x1.1 13 NO_x
Medium 4-Cycle																			
walk-behind mowers															.011	.154	17,027	618	
tillers																.006	535	151	
blowers							.002									.030	3072	414	
shredders																.003	292	500	
yard vaccuums																.011	1091	382	x32x1.1 632 HC
electric generators		.059		.037		.021	.047			.011	.056	.095				.038	28,574	244	x380x1.1 7506 CO
																	17,958		x4.3x1.1 85 NO_x
$\sum$ (Equip.pop.) (hrs./yrs.unit) (10^{-6})																			
Large 4-Cycle																			
riding mowers																.090	8,925	901	
garden tractors															.003	.026	3,057	712	
lawn & garden, other		.003				.029								.007		.043	6,178	368	x37x1.1 2027 HC
air compressors		.056				.050			.250	.031	.096			.052		.012	25,964	294	x880x1.1 48206 CO
home utility, other	.154	.107	.291	.012	.061	.007	.083	.046		.109	.088	.020	.425	.074	.016	.072	85,870	348	x29x1.1 1589 NO_x
																	49,799		
$\sum$ (Equip.pop.) (hrs./yrs.unit) (10^{-6})																			

TIMBERCUTTERS
chainsaws (3241)(.500)(360)(10^{-6})
- x160x1.1 103 Tons/yr HC
- x360x1.1 231 Tons/yr CO
- x1.2x1.1 1 Ton/yr NO_x

Total Commercial Emissions

8962	HC
69845	CO
1723	NO_x

	HC	CO	NO_x
Utility Equipment Exhaust (This study)	22,212	119,905	2,198
Utility Equipment Exhaust & Evap. (ARB Inventory)	14,272	119,720	1,720
Passenger Cars (ARB)	464,000	3,088,000	351,000
Other Off-Road Vehicles (ARB)	189,000	1,670,000	315,000
Petroleum Marketing (ARB)	79,600	-0-	-0-
Total, All Sources (ARB)	1,603,000	6,256,000	1,294,000

Emissions from utility equipment are a very small fraction of the statewide total (from 0.13 to 1.9 percent, depending on the pollutant) and represent equally small fractions of emissions when considered on an individual county basis. The estimates of utility equipment emissions in the recent 1979 ARB inventory were based on a completely different set of assumptions and a different set of emission factors than were used in this study. In spite of differences, the final estimates are almost identical. This is extremely reassuring and suggests that either method is satisfactory. The methods differ considerably in their input data requirements, and the availability of these data might determine the choice of method. Any uncertainties in estimating emissions from utility equipment are so small that they will introduce negligible uncertainties in the overall inventory.

COMPARISON OF RESULTS OF THIS STUDY WITH ARB INVENTORY

It is of interest to compare the computations made in this study with the computations used by the ARB for their inventory. It has already been shown that the choice of emission factors has very little impact on emissions (refer to Table 3-6), so this discussion will deal mainly with other variables. The following are the most important:

- Equipment populations -- household and commercial
- Annual usage -- household and commercial
- Proportion of 2-stroke and 4-stroke engines

Table 3-8 shows the value of these variables from this study and the ARB inventory. Equipment populations are of the same order of magnitude in the CIC and ARB inventories, but there is seldom close agreement. The CIC survey identified 900,000 more push mowers than the ARB had estimated; however, the annual usage of these mowers, according to the CIC study, was less than the ARB estimate. These two differences tend to cancel each other out, and the total hours of use by all push mowers is fairly similar in both studies. It is believed that the CIC study identified push mowers that were in storage and seldom used, while the ARB methodology assumed that these mowers were so old that they had been discarded. For other types of equipment, the CIC survey identified fewer units in commercial use than the ARB estimated, but the hours of commercial use were greater than the ARB estimates. As in the push mower case, these differences tend to cancel out, and the total hours of

Table 3-8

COMPARISON OF THIS SURVEY AND PREVIOUS ARB ESTIMATES

	Equipment Population				Annual Hours of Use				Annual Use	
	Residential		Commercial		Residential		Commercial		Res.& Comm. Hrs. Per 10^6 Units	
Type of Equipment	CIC	ARB	CIC	ARB	CIC	ARB	CIC	ARB	CIC	ARB
Walk-Behind Mower	2,968,000	2,014,240	27,600	99,262	20.5	30	603	319	77.5	92.1
Riding Mower	61,000	60,445	9,000	11,338	24	38	901	380	9.6	6.6
Garden Tractor	79,000	22,341	3,100	4,191	25	30	712	180	4.2	1.4
Tiller	368,000	96,641	600	76,352	18	18	151	72	6.7	7.2
Misc. Lawn and Garden	702,000	796,508	20,800	36,484	12	17	500	190	18.8	20.5
Chain Saws	780,000	537,374	54,500	39,106	26	10	349	296	39.3	16.9
General Utility	114,000	381,752	134,100	233,442	57	48	320	96	49.4	40.7
Percent of Lawn and Garden with 2-Stroke Engines	39.2%	4.0%	33.7%	4.0%						

Source: CIC Research, Inc., "Survey of Utility Equipment Use," 1981-1982 and Air Resource Board 1979 Emission Inventory

use for the entire equipment population is similar in the CIC and ARB estimates. There is, however, one difference that has an important impact on the emissions inventory. The CIC survey indicates that 39 percent of all lawn and garden equipment is powered by 2-stroke engines. The ARB estimate is 4 percent. It is believed that there has been a recent trend toward more 2-stroke engines, and the ARB figure should be revised upward to 39 percent. Such a change would cause a significant increase in the estimated emissions of hydrocarbons but would have much smaller effects on the estimates of CO and NO_x. It is believed that the primary reason that CIC estimates more hydrocarbon emissions than the ARB (refer to page 94) is because of the increased percentage of 2-stroke engines in the CIC equipment population. The CIC study indicates that almost all tillers were in residential use, while the ARB estimated that 44 percent of tillers were used commercially. The number of tillers is so small that this discrepancy will have little impact on the inventory.

The CIC survey was designed to collect information that could be used to check the ARB's assumptions about useful life of utility equipment. This information was not needed to compute emissions by the CIC method, but it is needed if the equipment population is estimated from sales data. Table 3-9 compares the estimated attrition rates used by the ARB with data from the CIC survey. Sufficient information was available for the residential population of walk-behind mowers and chain saws but not for other types of equipment. In general, the ARB's

Table 3-9

COMPARISON OF ASSUMED AND MEASURED ATTRITION RATES FOR RESIDENTIAL USE

Model Year	Percent of Population Still in Service			
	Walk-Behind Mower		Chain Saw	
	CIC	ARB	CIC	ARB
1979	100	100	100	100
1978	93	96	93	98
1977	81	89	78	94
1976	70	79	60	83
1975	58	69	43	59
1974	46	58	32	37
1973	35	48	26	24
1972	29	40	19	16
1971	24	32	13	7
1970	20	24	9	2
1969	18	18	8	1
1968	11	13	--	--
1967	11	10	--	--
1966	9	9	4	--
1965	8	8	--	--
1964	7	7	3	--
1963	4	4	--	--
1944	0.1	--	0.5	--

Source: CIC Research, Inc., "Survey of Utility Equipment Use," 1981-1982.

assumptions about attrition rates correspond fairly well to the observed situation. CIC identified a small percentage of old equipment that would not be predicted by the ARB methodology, but this would have a very small impact on the overall estimates of equipment population. According to the CIC survey, approximately 20 percent of the walk-behind mowers and 10 percent of the chain saws were acquired used. It is difficult to know whether this has any influence on the attrition rate associated with the equipment, except that it suggests that a substantial number of equipment owners pass that equipment on to others instead of storing it when they no longer need to use it.

Additional information is included in the data book that will allow the reader to compare the age distributions and compute attrition rates for equipment purchased new as compared with equipment acquired used. Intuitively, one might assume that owners who acquired their equipment used would not know the age as accurately as owners who acquired new equipment; however, the survey cannot confirm or refute this assumption.

CHAPTER 4. RECOMMENDATIONS FOR UPDATING INVENTORIES

Inventories need to be updated periodically to take into account changes in population and the associated changes in utility equipment use. In addition, utility equipment inventories may require updating to take into account the marketing of new types of utility equipment or design changes in conventional types of equipment. Recommendations are presented for accomplishing both types of updates.

If the household and commercial use patterns remain the same, then the inventory may be updated by securing more recent information on numbers of households and number of employees in the appropriate occupational categories. This information is available from the State Census Data Center, Department of Finance (for households) and the California Employment Development Department (for employment). At the present time, data are available for each year and are published after a delay of about two years. Forecasts of future employment are also published by the Employment Development Department. The inventory may be updated by the simple procedure of replacing the existing information on households and employment with more current information and re-computing the emissions. In the experience of CIC, this method is adequate for updating inventories for a period of about five years following the

compilation of the initial inventory. During a five-year period, use patterns will not change sufficiently to invalidate the prevalence rates and annual usage data from the original survey.

If more than five years has elapsed since the original survey, it is appropriate to investigate changes in use patterns. In the opinion of CIC, commercial use patterns will not change dramatically unless some new type of equipment comes on the market or some dramatic change in technology occurs. By referring to the tabulations of equipment type vs. occupational category, the effects of any anticipated changes in commercial use patterns can probably be estimated without collecting any new primary data. Household use patterns are more difficult to estimate. If the number of households and the types of dwellings have shown only small changes in a given area, then it is probably safe to assume that utility equipment use has not changed appreciably unless some new type of equipment has become available and is widely used. On the other hand, if housing patterns are changing significantly, the utility equipment use may also change significantly. The changes in household use patterns can best be evaluated by conducting a small survey (no more than 300 households) and testing the responses against the original survey responses to see if they are different. If they are different, it will be necessary to adjust the equipment prevalence rates and annual use data to reflect the results of the new survey.

In the case of utility equipment, it is believed that there are large uncertainties -- at least 50 percent -- associated with

the emission factors, so it is not really necessary to update the inventory to account for a change of a few percent in housing or employment. In most cases, it would probably be adequate to assume that changes in utility equipment emissions are proportional to changes in population, and go through the more tedious updating procedures only for those counties that are undergoing rapid changes in housing patterns.

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    Anaheim-Santa Ana-Garden Grove SMSA, Southern Area Labor Market Information Group, 1525 South Broadway, Los Angeles, CA 90015, September 1979 (213) 477-2527

    Bakersfield SMSA, Central Area Labor Market Information Group, 1525 South Broadway, Los Angeles, CA 90015, September 1979 (213) 477-2409

    Fresno SMSA, Northern Area Labor Market Information Group, 800 Capitol Mall, MIC 57, Sacramento, CA 95814, September 1979 (916) 322-8791

    Los Angeles-Long Beach SMSA, Southern Area Labor Market Information Group, 1525 South Broadway, Los Angeles, CA 90015, September 1979 (213) 744-2519

    Modesto SMSA, Northern Area Labor Market Information Group, 800 Capitol Mall, Sacramento, CA 95814, December 1980 (916) 322-8846 or (916) 322-8848

Oxnard-Simi Valley-Ventura SMSA, Central Area Labor Market Information Group, 1525 South Broadway, Los Angeles, CA 90015, September 1979 (213) 744-2528

Riverside-San Bernardino-Ontario SMSA, Southern Area Labor Market Information Group, 1525 South Broadway, Los Angeles, CA 90015, September 1979 (213) 744-2512

Sacramento SMSA, Northern Area Labor Market Information Group, 800 Capitol Mall, MIC 57, Sacramento, CA 95814, September 1979 (916) 322-8850 or (916) 322-8858

Salinas-Seaside-Monterey SMSA, Coastal Area Labor Market Information Group, P.O. Box 7774, San Francisco, CA 94120, September 1979 (415) 557-3072 or (415) 557-3035

San Diego SMSA, Southern Area Labor Market Information Group, 1525 South Broadway, Los Angeles, CA 90015, September 1979 (213) 744-2526

San Francisco-Oakland SMSA, Coastal Area Labor Market Information Group, P.O. Box 7774, San Francisco, CA 94120, September 1979 (415) 557-3174 or (415) 557-2249

San Jose SMSA, Coastal Area Labor Market Information Group, P.O. Box 7774, San Francisco, CA 94120, September 1979 (408) 277-1722 or (415) 557-2249

Santa Barbara-Santa Maria-Lompoc SMSA, Central Area Labor Market Information Group, 1525 South Broadway, Los Angeles, CA 90015, September 1979 (213) 744-2410

Santa Cruz SMSA, Coastal Area Labor Market Information Group, P.O. Box 7774, San Francisco, CA 94120, December 1980 (415) 557-2040 or (415) 557-3035

Santa Rosa SMSA, Coastal Area Labor Market Information Group, P.O. Box 7774, San Francisco, CA 94120, December 1980 (415) 557-1273 or (415) 557-2249

Stockton SMSA, Northern Area Labor Market Information Group, 800 Capitol Mall, MIC 57, Sacramento, CA 95814, September 1979 (916) 322-8844 or (916) 322-8853

Vallejo-Fairfield-Napa SMSA, Coastal Area Labor Market Information Group, P.O. Box 7774, San Francisco, CA 94120, December 1980 (415) 557-0511 or (415) 557-2249

Humboldt/Del Norte Counties, Northern Area Labor Market Information Group, 800 Capitol Mall, Sacramento, CA 95814, December 1980 (916) 322-8842 or (916) 322-8854

Imperial County, Southern Area Labor Market Information Group, 1525 South Broadway, Los Angeles, CA 90015, December 1980 (213) 744-2519

Merced County, Northern Area Labor Market Information Group, 800 Capitol Mall, Sacramento, CA 95814, December 1980 (916) 322-8850 or (916) 322-8845

Mount Shasta Region (Lassen, Modoc, Plumas, Shasta, Siskiyou, Tehama and Trinity Counties), Central Area Labor Market Information Group, 800 Capitol Mall, Sacramento, CA 95814, September 1978 (916) 322-8850 or (916) 322-8846

San Luis Obispo County, Central Area Labor Market Information Group, 1525 South Broadway, Los Angeles, CA 90015, December 1980 (213) 744-2528

Sutter Buttes Region (Buttes, Colusa, Glen, Sutter, and Yuba Counties) Central Area Labor Market Information Group, 800 Capitol Mall, Sacramento, CA 95814, September 1978 (916) 322-8846 or (916) 322-8850

Tulare/Kings Counties, Central Area Labor Market Information Group, 1525 South Broadway, Los Angeles, CA 90015, December 1980 (213) 744-2409

California, Occupational Information Group [(916) 322-8879] and Economic Analysis Group [(916) 322-8876] 800 Capitol Mall, MIC 57, Sacramento, CA 95814, September 1982

STATISTICAL PROCEDURES

Conventional statistical procedures were used throughout this report as summarized below. If any readers are unfamiliar with these tests, they can consult a variety of elementary statistical texts for additional information. The authors of this report have found the following text to be exceptionally clear and easy to follow:

> Yamane, Taro, Statistics: An Introductory Analysis, 2nd Edition, Harper & Row, Publishers, New York, NY, 1967.

Standard errors of proportions, i.e., prevalence rates and owner/rental ratios, were computed by the standard formula as given in Sections 7.5 and 7.6 of Yamane. Standard hypothesis testing methods as described in Sections 8.3 and 8.6 of Yamane were used to determine whether certain of these proportions were different from each other or different from zero. Values of Z were computed and compared to standard Z tables.

Standard errors of means, i.e., HP, annual usage and age, were computed by standard formulas as given in Section 7.4 of Yamane. Confidence intervals were computed by using the conventional "t" statistic as discussed in Sections 17.4 and 17.7 of Yamane.

Equivalence of two distributions, i.e., type of dwelling or household income, were evaluated by computing χ^2 and comparing

the value with standard tables as discussed in Section 20.3 of Yamane.

Standard errors of the product of equipment populations and annual usage were computed based on the exact variance of products. This procedure assumes that equipment populations (x) and annual usage (y) are statistically independent. Let $\bar{x}$ and $\bar{y}$ be the sample means of the x's and y's respectively, and let $s^2(x)$ and $s^2(y)$ be the usual unbiased estimates of V(x) and V(y) respectively. Then $\bar{x}\,\bar{y}$ will be an unbiased estimate of XY whose variance is:

$$V(\bar{x}\,\bar{y}) = X^2V(\bar{y}) + Y^2V(\bar{x}) + V(\bar{x})V(\bar{y})$$

An unbiased estimate of $V(\bar{x}\,\bar{y})$ will be:

$$v(\bar{x}\,\bar{y}) = (\bar{x})^2 \frac{s^2(y)}{n(y)} + (\bar{y})^2 \frac{s^2(x)}{n(x)} - \frac{s^2(x)s^2(y)}{n(x)n(y)}$$

where n(x) and n(y) are respective sample sizes. For a complete discussion, the reader is referred to:

> Goodman, Leo A., "On the Exact Variance of Products," Journal of the American Statistical Association, Volume 55 (1960), pp. 708-713.

Use of Standard Errors. The standard errors determine the potential degree of discrepancy between the sample measure of central tendency (e.g., mean) and the population measure of central tendency. The standard errors may be used in certain tests of statistical significance and for creating confidence intervals. (See Yamane, Chapter 8 and Section 10.8, respectively.) All other things remaining equal, relatively small

standard errors tend to give the researcher greater confidence in his estimates.

As an illustration, suppose chainsaws are considered. Table 3-5 indicates that the estimated number of chainsaws found in California households is 736,000. Table 3-7 indicates the the standard error of this estimate is 53,000 chainsaws. With the given information, we can calculate a range in which the true number of chainsaws is expected to fall. Should we add and subtract one standard error from this estimate, this range would be from 683,000 to 789,000 chainsaws. Standard normal statistical tables tell us that we can only be 68 percent confident that our calculated interval contains the true population of chainsaws. Specifically, if we identically performed this study 100 times and calculated such an interval each time, only 68 of these intervals would be expected to contain the true population of chainsaws.

Suppose we calculate an interval around our chainsaw estimate which is two times the standard error, i.e., plus or minus two standard errors. This interval would be from 630,000 to 842,000. Note that this interval is wider than the previously calculated interval which implies that we should be more confident that the wider interval contains the true population of chainsaws. As it turns out, we can be more than 95 percent confident in our new interval. Specifically, if we identically perform this study 100 times and calculated such a new interval each time, at least 95 of these intervals can be expected

to contain the true population of chainsaws. In short, the standard errors provided in the present study can be used to develop confidence intervals within which the true population parameter is expected to fall.

APPENDIX A

HOUSEHOLD SURVEY QUESTIONNAIRE

ID# _____ Date _____

ID#_____

Date_____

CALIFORNIA UTILITY EQUIPMENT USE SURVEY - CARB #625

Hello. I'm calling for a survey being sponsored by the State of California Air Resources Board. We're conducting a survey of the use of gasoline powered equipment by California households. May I verify that you do live in _____ County? (IF CORRECT COUNTY, PROCEED. IF WRONG COUNTY, THANK RESPONDENT AND TERMINATE.) Now I would like to speak to the person in your household who would be most familiar with any powered gardening or utility equipment you use. (IF RESPONDENT IS THAT PERSON, ASK Q1. IF RESPONDENT IS NOT THAT PERSON, ASK TO SPEAK WITH HIM OR HER AND IF NECESSARY MAKE AN APPOINTMENT TO CALL BACK.)

Cnty_____

SECTION 1

Q1. I am going to read a list a tools and other items. Please tell me if you use any of the following items at home that are powered by a gasoline engine. We are not interested in any equipment you use at home which is powered by electricity. Let's start with lawn mowers. Do you use a walk behind or riding lawn mower which is powered by a gasoline engine? How many? (INDICATE #)

Number		
_____	Lawn mower - walk behind (1)	1)_____
_____	Lawn mower - riding (2)	2)_____
_____	Tiller (3)	3)_____
_____	Garden tractor (4)	4)_____
	Lawn & garden equipment, such as:	
_____	• Blowers (5)	5)_____
_____	• Edgers (6)	6)_____
_____	• Trimmers (7)	7)_____
_____	• Shredders (8)	8)_____
_____	• Others (SPECIFY) _____ (9)	9)_____
_____	_____ (10)	10)_____
_____	_____ (11)	11)_____
_____	Chain saw (12)	12)_____
_____	Air compressor (gasoline or diesel) (13)	13)_____
_____	Electric generator (gas or diesel) (14)	14)_____
	Other (SPECIFY)	
_____	_____ (15)	15)_____
_____	_____ (16)	16)_____
_____	_____ (17)	17)_____

(IF RESPONDENT OWNS ONE OR MORE PIECES OF EQUIPMENT LISTED ABOVE, COMPLETE ONE SALMON SECTION (SECTION 2) OF THE QUESTIONNAIRE FOR EACH PIECE OF EQUIPMENT BEFORE RETURNING TO Q2. BE SURE TO INCLUDE THE ID# ON THE TOP OF EACH PAGE. IF NO EQUIPMENT IS USED, GO TO PAGE 2.)

Q2. At your job, do you or any other working member of your household use any of the types of gasoline or diesel powered equipment or tools I have just mentioned? (READ LIST AGAIN IF NECESSARY. IF YES, ASK:) May I have that family member's first name? What is that person's (your) occupation? What industry do they (you) work in?

Household Member	Occupation	Industry	Tool or Equipment

(IF REPSONDENT USES EQUIPMENT AT HIS OR HER JOB, COMPLETE ONE VERSION OF SECTION (BLUE SECTION) FOR EACH PIECE OF EQUIPMENT MENTIONED. THEN GO ON TO PAGE 3 (NEXT PAGE). IF OTHER FAMILY MEMBERS USE EQUIPMENT AT THEIR JOBS, ASK TO SPEAK TO THEM AFTER FINISHING SURVEY WITH RESPONDENT. REMEMBER TO INCLUDE OCCUPATION AND INDUSTRY ON EACH BLUE SECTION.)

Q3. Now, to group your answers with those of others, I need to know what type of dwelling unit you live in. Is it a single detached home, a mobile home, or a building with multiple units? (IF MULTIPLE, ASK:) How many units are attached together?

1	Single unit	4	5 or more units
2	Mobile home	5	Other (dorm, etc.)
3	2 - 4 units		

18)_____

Q4. Does your home have a lawn or garden?

1 No (SKIP TO Q6)

2 Yes, lawn

3 Yes, garden

4 Yes, both

19)_____

Q5. Who does the landscape maintenance, you or someone outside your family?

1 Own household

2 Outside service

20)_____

Q6. Do you rent or own your home?

1 Rent

2 Own

9 DK/Refused

21)_____

Q7. How many people 18 years of age or older are living in your household?

_____ Persons 18 or older

22)_____

Q8. How many children below the age of 18 years are living in your household?

_____ Children under 18 years of age

23)_____

Q9. Which of the following groups includes your household's total income expected in 1982?

1	Less than $10,000	5	$40,000 - $50,000
2	$10,000 - $20,000	6	Over $50,000
3	$20,000 - $30,000	9	DK/Refused
4	$30,000 - $40,000		

24)_____

Thank you very much for your time and cooperation.

(RECORD SEX OF RESPONDENT: 1 Male 2 Female)

25)_____

County _____ (1) ID# _____

SECTION 2 - Salmon

1) _____

EQUIPMENT TYPE (SPECIFY) _____ (2) 2) _____

Q1. During the past 3 months, that is, April, May, and June, how often have you used your (name of item) ? (months were changed for each wave)

_____ (no.) times per _____ (week, month, etc.) -1 DK 3) _____

Q2. Is that true during all seasons of the year? 1 Yes (SKIP TO Q5)

2 No (ASK Q3) 4) _____

Q3. During what months of the year do you use your (name of item) most often?

1 Spring (March, April, May) 3 Fall (Sept, Oct, Nov) * Other _____ 5) _____

2 Summer (June, July, August) 4 Winter (Dec, Jan, Feb) _____

Q4. How frequently do you use it during this period? (CHECK FOR INCONSISTENCY WITH Q1)

_____ (no.) times per _____ (week, month, etc.) -1 DK 6) _____

Q5. Each time you run your (name of item) , about how many hours do you run the engine? (IF RESPONDENT GIVES MINUTES, DO NOT CONVERT TO HOURS)

_____ hours or _____ minutes -1 DK 7) _____

Q6. What is the name of the company that made your (name of item) ? (IF DK, ASK RESPONDENT TO LOOK AT THE ITEM, MAKE A GUESS, OR ASK WITH A FRIEND WHO HAS SEEN THE ITEM. IF RESPONDENT STILL DOESN'T KNOW, ASK FOR ANY NAME THAT SOUNDS LIKE A COMPANY NAME.)

Name of Company _____ 99 DK 8) _____

Q7. What model is it? (NOTE: MODEL NUMBER IS THE NUMBER AND/OR LETTERS AFTER THE NAME USUALLY GIVEN SOMEWHERE ON THE ITEM. IF DK, DESCRIBE THE EQUIPMENT FULLY.)

Model # _____ or Description _____ 9) _____

Q8. How many horsepower is your (name of item) ? 2 DK

_____ horsepower -1 DK 10) _____

Q9. Does it have a 2- or 4-cycle engine? (IF DK ASK:) Do you add oil to the gasoline when you add fuel?

2 2-cycle or or 2 Yes, add oil 11) _____

1 4-cycle 1 No, don't add oil

Q10. Did you acquire it new or was it used:

1 New 2 Used 9 DK 12) _____

Q11. How old is it? (NOT HOW LONG HAVE THEY HAD IT)

_____ Years, or _____ months (if less than 1 year) -1 DK 13) _____

Q12. Approximately how much fuel does the tank hold? (EX: 4 QTS.)

_____ No. & units -1 DK 14) _____

Q13. How often do you fill the fuel tank?

_____ (no.) times per _____ (week, month, etc.) -1 DK 15) _____

SECTION 3 (BLUE) County _____ (1)

ID# _____

OCCUPATION _____ 1) _____

INDUSTRY _____ 2) _____

EQUIPMENT ITEM _____ 3) _____

4) _____

Q1. How frequently do you normally use the (name of item)?

_____ times per _____ 5) _____
(no.) (week, month, etc.)

Q2. Each time you use the (item), about how many hours do you run the engine?

_____ hours 6) _____

Q3. What company made the (item)?

Name of company _____ 7) _____

Q4. What model is it?

Model _____ 8) _____

Q5. How many horsepower is the (item)?

_____ horsepower 9) _____

Q6. Does it have a 2-cycle or 4-cycle engine? (IF DON'T KNOW, ASK:) Do you add oil to the gasoline when you add fuel?

No. of Cycles _____ or ____ Yes, add oil 10) _____

____ No, don't add oil

Q7. How old is it?

_____ Years , or _____ months (if less than 1 year) 11) _____

Q8. Approximately how much fuel does the tank hold? (EX: 3 QUARTS)

____ (units) _____ 12) _____
(no.) (measure)

Q9. How often do you fill the fuel tank? (EX: 3 TIMES PER WEEK)

____ times per _____ 13) _____
(no.) (time period)

EXPLANATION OF THE SURVEY

"The voters require the California Air Resources Board to inventory all emissions of air pollutants -- including emissions from small utility equipment. Up to now the Board has based its inventory on information obtained in the eastern U.S., and they want to find out about California use patterns so that they can improve the inventory. The Board will also use some of this information to estimate whether the pollutant emissions represent a health hazard to the equipment operator ."

APPENDIX B

ADJUSTMENT FACTOR COMPUTATIONS

The survey results indicated that ownership of utility equipment was different in rental and owner-occupied housing. In addition, the percentage of renters interviewed in this survey was less than the percentage of renters in the overall housing population. Accordingly, it was necessary to correct the survey results so that they would represent equipment populations that should have been identified if a truly representative sample of households had been interviewed. This was accomplished as follows:

1. From the survey results, equipment prevalence rates were computed separately for rental and owner-occupied housing units for the state as a whole and for three sub-areas. These are tabulated in Table B-1.

2. Weighted average prevalence rates were computed using published data on the proportion of owner- and renter-occupied housing units in the area of interest.

Table 2-3 in the main body of the report gives prevalence rates that have been corrected to correspond to published data on owner/renter ratios. As a matter of general interest, Table B-2 shows the prevalence rates before and after correction. The reader should be aware that some prevalence rates for sub-areas of the state are not statistically different from zero, and corrections of these rates would be meaningless.

Table B-1

HOUSEHOLD UTILITY EQUIPMENT PREVALENCE RATES
FOR RENTAL AND OWNER-OCCUPIED HOUSING UNITS

(Units/Household)

	California		Bay Area		Central Valley		South Coast	
Type of Equipment	Rent	Own	Rent	Own	Rent	Own	Rent	Own
LAWN AND GARDEN								
Walk-Behind Mowers	.162	.476	.122	.403	.261	.651	.148	.437
Riding Mowers	.003	.010	0*	.007*	.007*	.020	.003*	.006*
Tillers	.014	.064	.017	.064	.030	.127	.003*	.031
Garden Tractors	.002	.014	0*	.009*	.007*	.030	0*	.010*
Blowers	0*	.009	0*	.011	0*	.003*	0*	.010*
Edgers	.020	.079	.004*	.021	.030	.141	.028	.092
Trimmers	.006	.016	.004*	.009	.015*	.034	.003*	.011
Shredders	0*	.010	0*	.016	0*	.013*	0*	.004*
Yard Vacuums	.002	.006	0*	.005*	.007*	.007*	0*	.008*
CHAIN SAWS	.023	.141	.026	.120	.030	.261	.017	.097
HOME UTILITY								
Electric Generators	.003	.014	.004*	.016	0*	.020*	.003*	.008*
Compressors	.002	.006	0*	.002*	0*	.007*	.003*	.008*

*Not statistically different from zero.

Table B-2

HOUSEHOLD UTILITY EQUIPMENT PREVALENCE RATES
BEFORE AND AFTER CORRECTION FOR OWNER/RENTER RATIO

(Units/Household)

Type of Equipment	California[a]		Bay Area[b]		Central Valley[c]		South Coast[d]	
	Uncorr.	Corr.	Uncorr.	Corr.	Uncorr.	Corr.	Uncorr.	Corr.
LAWN AND GARDEN								
Walk-Behind Mowers	.369	.338	.307	.298	.530	.497	.334	.304
Riding Mowers	.007	.007	--	--	.016	.015	--	--
Tillers	.047	.042	.048	.045	.097	.089	.021	.018
Garden Tractors	.010	.009	--	--	.023	.021	--	--
Blowers	.006	.005	.007	.007	--	--	--	--
Edgers	.058	.053	.015	.014	.106	.097	.069	.063
Trimmers	.012	.012	.007	.007	.028	.027	.007	.007
Shredders	.007	.006	.010	.010	--	--	--	--
Yard Vacuums	.005	.004	--	--	--	--	--	--
CHAIN SAWS	.095	.089	.088	.082	.189	.170	.069	.060
HOME UTILITY								
Electric Generators	.010	.009	.012	.011	--	--	--	--
Air Compressor	.004	.004	--	--	--	--	--	--

a. Corrected from owner/renter .658/.342 to .559/.441
b. Corrected from owner/renter .657/.343 to .598/.402
c. Corrected from owner/renter .689/.311 to .606/.394
d. Corrected from owner/renter .644/.356 to .540/.460