Acquisition and Analysis of Commercial and Institutional Lawn and Garden Population and Activity Data

FINAL REPORT

Prepared for:

The California Air Resources Board

Prepared by:

Eastern Research Group, Inc.

August 8, 2006

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Executive Summary

Under this contract, Eastern Research Group and its subcontractor NuStats Partners, conducted a study gathering detailed population and usage information from commercial and institutional gardeners operating in California in 2005. The study was conducted for the purposes of creating a database to update the State's estimate of the contribution of this equipment to the off-road emissions inventory.

The project consisted of two primary data collection procedures:

1)   A telephone survey to collect information on equipment populations and characteristics, and

2)   An instrumentation phase wherein data loggers were installed on selected lawn and garden equipment to determine activity and temporal profiles.

The study was designed to collect data from two distinct groups of equipment operators – commercial and institutional entities. For the purpose of this study, the following definitions were used to identify establishments for each sector:

- The commercial sector was defined as landscaping companies or companies that provide lawn and garden services.

- The Institutional sector was defined as federal, state and local (municipal and county) government agencies, school districts, golf courses, equipment rental facilities, vineyards, orchards, cemeteries, and airports that maintain tended acreage on their properties.

Phone Survey

The study design called for equal sized samples (N=150) from each sector, totaling 300 completed phone surveys. The sample was further stratified by geography/climate are to ensure representation of the different climate and rainfall amounts across the state. (The assumption here being that areas with more rainfall will require more frequent and/or more intensive equipment use.) Each commercial and institutional establishment identified for the survey was assigned to a climate zone for this analysis.

A phone survey questionnaire was designed to collect data on equipment by sector, fuel, model, model year, manufacturer, and typical useful life. The objectives of the survey were to collect data on equipment by sector (commercial or institution) and to identify participants for the instrumentation component of this project. The survey was conducted in English and Spanish. Copies of the questionnaires are included in Appendix A.

In order to maximize participation in the survey, an advance letter was sent to each prospective respondent (4,400 total).   The letter briefly described the purpose of the study and explained they may be randomly selected to participate in a telephone interview. The phone survey began on December 12, 2004 with a Pilot Test of the survey during which approximately 30 interviews were completed. At the completion of the Pilot Test, the data from completed interviews and comments from Interview Specialists on the questionnaire were reviewed.   Minor edits were made to the survey instrument and interviews continued through January 21, 2005 for Commercial establishments and January 25, 2005 for Institutional establishments.

As shown in Table ES-1, a total of 305 interviews were completed.

Table ES-1. Completed Questionnaires by Sample Type

Sample Type	Total Collected	Percent
Commercial	157	51%
Institutions	148	49%
Total	**305**	**100%**

The breakdown of participants by SIC Division is contained in Table ES-2.

Table ES-2. Survey Participants by SIC Division

SIC Division	Number of Participants	Percentage of Participants
Agriculture, Forestry, and Fishing*	180	59%
Transportation and Public Utilities	6	2%
Finance, Insurance and Real Estate	26	9%
Services	41	13%
Public Administration	52	17%
Total	**305**	**100%**

*Includes general landscaping services

Overall, the response rate was 13% and 12% for Commercial and Institutional establishments respectively. In total, the survey collected data on 1,395 pieces of equipment within fifteen types (including a miscellaneous "Other" category). As shown in Table ES-3, as expected, more pieces of equipment were reported by Commercial entities than from Institutions.

Table ES-3. Number of Equipment Pieces by Establishment

EQUIPMENT TYPE	COMMERCIAL ENTITIES	INSTITUTIONS	ALL
Leaf Blower (Backpack)	132	69	201
Leaf Blower (Handheld)	48	39	87
Chain Saw	118	69	187
Brush cutter	39	17	56
Lawn Edger	68	53	121
Lawn Mower	148	118	266
Riding Lawn Mower	51	88	139
Lawn & Garden Tractor	18	35	53
Shredder Chipper	8	10	18
Wood Splitter	3	2	5
Stump Grinder	1	1	2
Snow Blower	2	0	2
String Trimmer	98	93	191
Tiller	28	10	38
Other	12	17	29
Total	**774**	**621**	**1,395**

Equipment Instrumentation

The equipment instrumentation task involved the recruitment of survey respondents to participate in the instrumentation of their lawn and garden equipment. Recruitment was conducted during the survey interviews. The data loggers used for instrumentation collected equipment on-time, as well as time stamp, allowing for the development of activity estimates and temporal allocation profiles for different equipment types.

A sampling plan was developed to yield successful instrumentations of ARB's data logger. Sample was drawn from those participants in the survey who indicated willingness to participate in the study. Prior to the survey, a goal of 30 recruits each from the commercial and institutional strata were identified as sample targets. It was estimated that this number of recruits could yield sufficient instrumentation data to produce statistically reliable modeling results. Upon completion of the survey, 51 commercial entities (170% of the recruitment goal) and 28 institutional entities (93% of the recruitment goal) agreed to participate in the instrumentation phase of the project. The 51 commercial entities reported operating 294 different pieces of equipment from 13 various equipment types, while the 28 institutional entities reported operating 172 different pieces of equipment from 14 various equipment types. Some of the entities originally agreeing to the instrumentation were expected to decline. As such, all 79 commercial and institutional recruits were recommended for instrumentation.

To achieve the goal of maximizing the diversity of equipment instrumented, an "importance" index was created.[1] This index gave priority to equipment types reported in smaller quantities (e.g., stump grinders), relative to common equipment types (lawn mowers) and was used to select five equipment types from those entities reporting more than five equipment types. The ultimate selection plan amply reflected the diversity of equipment available from the survey recruits. Under this plan, a total of 314 pieces of equipment (from the pool of 464) were targeted for instrumentation.

Based on ARB's experience using the data loggers in the previous residential lawn and garden study, it was estimated that approximately 65% of all recruited entities targeted for instrumentation would actually properly install the equipment and submit usable data. It was assumed that the remaining 35% would not install the loggers properly, would record their data incorrectly, or would simply choose not to participate even though they agreed to do so during the survey. Therefore a total of 51 entities were expected to participate, providing instrumentation on just over 200 pieces of equipment.

The materials included in the instrumentation packet mailed to the recruits contained a letter thanking them for their participation along with general instructions, and an information sheet on how to install the instrumentation. Materials were similar to those previously developed by ARB for their residential study, and were prepared in English and Spanish. Sufficient copies of these materials and mailing labels for returning instrumentation were supplied ARB. The items related to the instrumentation process are provided in Appendix E. During the course of the recruitment phase, a hotline was established and maintained to answer participant questions. Bilingual staff monitored the hotline.

Table ES-4 provides a summary of the data loggers that were mailed out by ARB between March and July of 2005, indicating the type of equipment targeted for instrumentation. Of the 312 instrumentation kits mailed out, 122 data loggers were received back for download, even after multiple attempts were made to contact recruits retaining loggers by phone. Of these 122 data loggers, only 53 were included in the final activity analysis for commercial lawn and garden equipment. The remaining 69 data loggers were excluded from analysis for a number of reasons, most often failure to download due to software/hardware problems. Many data loggers reported having a low battery, which made them unable to record the dates and times of usage. The data from these data loggers were sent to ARB project staff for review. ARB project staff applied an algorithm to convert the incorrect dates the appropriate time period.

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[1] To maximize the diversity of equipment data captured, only one piece of equipment per equipment type was instrumented per entity.

Table ES-4. Instrumentation Kit Mail Outs by Equipment Type

Equipment Type	Count
BRUSHCUTTER	15
CHAIN SAW	35
LAWN & GARDEN TRACTOR	13
LAWN EDGER	22
LAWN MOWER	57
LEAF BLOWER (BACK-PACK)	45
LEAF BLOWER (HAND-HELD)	20
OTHER	17
RIDING LAWN MOWER	28
SHREDDER/CHIPPER	3
SNOW BLOWER	1
STRING TRIMMER	44
TILLER	10
WOOD SPLITTER	2
Totals	**312**

Data Analysis and Findings

This task evaluated the data collected during the phone surveys and equipment instrumentation to establish populations, age distributions, and activity profiles by equipment and horsepower categories. An evaluation of major polluting source categories was made, and surrogates were developed for extrapolation across the different geographic and temporal resolutions required of the OFFROAD model.

Institutional and commercial survey respondents were asked about their tended properties and their overall equipment use patterns. Survey results found that of the 148 institutional respondents, 139 indicated they did not contract out their services, while an additional 7 did so only intermittently for specialty services. Commercial and institutional respondents also exhibited very different equipment use patterns, in terms of acres tended, hours of use, fuel use, and even geographic location. The analyses clearly show that commercial entities are much more intensive users of lawn and garden equipment than institutional users, with one exception – diesel fuel use is substantially more common among institutional than commercial entities.

Acres tended are more evenly distributed among institutions than commercial entities, with commercial activity much more heavily centered in the more populated regions of the state (e.g., the drier climate zones of Southern California). In addition, the average hours required to tend an acre of land varied substantially by climate zone, with the wetter regions requiring the most labor and equipment use, as expected.

Survey responses were evaluated for a number of equipment characteristics, including fuel type and age distributions, average horsepower, fuel tank volume and type, refueling method, throttle position, and replacement frequency. Depending on the robustness of the responses, these results will allow for updating the OFFROAD supporting files at the equipment and/or fuel type level. The following briefly summarizes the findings for key parameters.

Fuel Type Distribution -- The distribution of fuel type by equipment category indicates that in most instances the observed gas-to-diesel ratio corresponds very closely to the default OFFROAD values. One exception is found in the Riding Mower category, which had a non-trivial amount of diesel units reported, where none are assumed in OFFROAD.

Equipment Age -- An "average age" distribution was developed for each equipment type based on reported values. Only five equipment categories were observed with great enough frequency to confidently develop by-year age distributions – blowers/vacuums, chainsaws, trimmers/edgers/brushcutters, lawn mowers, and riding mowers). The data clearly show that the vast majority of these equipment are retired within four to five years of use. These data may be used to update the age distribution for these equipment types in the OFFROAD model.

Fuel Tank Characteristics -- The survey collected data on the size and composition of fuel tanks by equipment type. Average fuel tank size and composition (metal or plastic) were estimated for a number of different equipment categories. Although plastic tanks were somewhat more common, metal tanks were frequently reported for most equipment types, with the exception of blowers and trimmers.

Throttle Position -- The survey asked respondents for the throttle position most used when operating their equipment. Possible responses were restricted to "high/medium/low". With the exception of brushcutters, which had a non-trivial fraction of operation at a low throttle position, operation was common for all equipment types at medium and high settings. (Although there were a substantial number of responses to this set of questions, it remains unclear how to translate these qualitative responses into the quantitative load factor values used in the OFFROAD model.)

Equipment Scrappage and Growth -- The survey asked respondents if they planned on replacing existing, or buying additional, lawn and garden equipment in the subsequent 12 months. 25% of the 277 respondents answering this question indicated they had such plans. The survey differentiated between replacements and new additions to their inventories, allowing for an estimation of scrappage and growth rates. In order to improve the data sample size, responses were pooled across all equipment categories. Accordingly, for all commercial lawn and garden

equipment categories the survey results indicate a 3.9% scrappage/replacement rate, with an additional 2.0% growth rate.

Refueling Practices -- Respondents were asked how they refueled their equipment. To improve the data sample size, responses were pooled across all equipment categories. The findings indicate that equipment refueling via portable cans is significantly more common for gasoline equipment compared to diesel. This information may be used to update the refueling can emissions data in the OFFROAD model.

Activity Profiles -- Instrumentation data was used to characterize equipment activity in terms of annual hours of use, as well as temporal distributions for weekday versus weekend operation. Each equipment type with downloaded data was analyzed separately to obtain the temporal allocation for equipment activity. Summaries of the analyses for each equipment type are presented in Table ES-5, along with annual hours of use defaults from the OFFROAD model.

Table ES-5. Instrumentation Activity Summary

Equipment Category*	# Units logged	24-hr average hrs:mins/day						Hr/Yr – Logger	Hr/Yr - OFFROAD
		M-Th		Fri		S-Su			
		Duration	Unit-days	Duration	Unit-days	Duration	Unit-days		
Riding Mowers	7	1:34	18	0:01	1	1:03	6	345	271
Lawn Mowers	11	1:15	42	1:26	3	0:26	10	302	229
Blowers (Handheld)	5	0:19	33	0:33	10	0:07	5	85	196
Blowers (Backpack)	4	0:21	16	7:23	1	1:43	2	507	196
Trimmers/ Edgers/ Brushcutters	12	0:13	199	0:11	28	0:15	8	65	121
Chainsaws	3	0:05	6	0:00	0	2:24	1	213	289
* 2 lawn and garden tractor instrumentations yielded less than 5 minutes of on-time - results not used									

To develop these estimates from the daily logger data all readings were grouped by OFFROAD's day of week periods (Monday – Thursday, Friday, and Saturday – Sunday), and on-time values were summed and divided by the number of unit-days of operation during that period. Annual totals were projected from the weekly totals, assuming 52 weeks of operation per year. Since the data were collected in the spring/summer time period, a seasonal activity ratio of 0.80 was applied to the projected 6-month summer hour total to represent the remaining months of the year.[2]

Equipment activity likely varies on a seasonal basis. Although the field data collection period was limited to the April – July timeframe, an attempt was made to identify such variation

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[2] Ratio obtained from OFFROAD's Season.dat file for lawn and garden equipment.

on a monthly basis. Most likely due to the limitations of the instrumentation data set, no obvious trends in seasonal activity were apparent. Instrumentation of more equipment, over additional seasons, may make such trends evident.

Equipment Population Surrogates

ERG identified surrogate data to be used to extrapolate the survey findings to California as a whole. In consultation with ARB, two sets of surrogates were identified for association with the different commercial and institutional categories – GIS data and data from the U.S. Census Bureau's County Business Patterns (CBP). Commercial categories were derived from NAICS codes for this analysis. Institutional categories consisted of a number of different facility/location types maintained by public entities, as identified by both ARB and ERG.

All of the categories having GIS data were calculated using acreage except for public buildings. The public buildings GIS layer gave locations instead of area, so it was calculated like the CBP data (i.e., based on number of locations). Statewide, county, and air basin-level equipment counts were calculated by applying these surrogates to the survey results, by operator category.

Table ES-6 provides a summary of the extrapolated statewide commercial lawn and garden equipment totals, by operator category. The detailed equipment population allocation factors by county and air basin are provided by equipment type in Appendix G.

Table ES-8. Statewide Population Estimates, by Operator Category (2005)

Operator Category	# Units Statewide	Percent
Airport	1,856	0.04%
Cemetery	4,556	0.10%
Construction Rental	1,222	0.03%
Farm	516	0.01%
Fire Stations	357	0.01%
Fisheries	8	0.00%
Forestry	5,652	0.12%
General Rental	1,671	0.04%
Golf	5,285	0.12%
Government	24,758	0.54%
Industry	153,561	3.37%
Landscaping	3,150,356	69.20%
Misc. Business	864,966	19.00%
Prison	5,267	0.12%
Ranch	2,632	0.06%
Real Estate	21,058	0.46%

Operator Category	# Units Statewide	Percent
Religious buildings	53,945	1.18%
School	91,975	2.02%
Utility	160,924	3.53%
Wineries	2,020	0.04%
Total	**4,552,584**	

As seen from the table, over 90% of the lawn and garden equipment population is used in the commercial sector for general landscaping, industrial, or other miscellaneous applications. For this reason it was concluded that none of the institutional categories merited having their equipment emissions calculated and reported separately by the OFFROAD model.

Statewide equipment category totals were also compared to the current default values in the OFFROAD model, as shown in Table ES-7.

Table ES-7. Revised vs. Default OFFROAD Equipment Populations by Type

OFFROAD Categories	Survey	OFFROAD Default
Chainsaws <=5 HP	165,789	118,830
Chainsaws <=5 HP Preempt	Not identified^	61,128
Chippers/Stump Grinders*	19	748
Commercial Turf Equipment	Not identified^	13,888
Front Mowers	Not identified^	10,546
Lawn & Garden Tractors	48,198	6,627
Lawn Mowers	1,920,819	229,820
Leaf Blowers/Vacuums	573,799	102,550
Other Lawn & Garden Equipment	306,695	438,990
Rear Engine Riding Mowers	132,215	3,516
Shredders	9,418	133,834
Snowblower*	0	7,290
Tillers	12,470	44,701
Trimmers/Edgers/Brush Cutters	1,383,135	341,086
Wood Splitters*	27	111,707
Total	**4,552,584**	**1,625,261**

* Sample size too small – OFFROAD defaults used.
^ Categories not explicitly called out in survey – likely included under other categories.

As seen in the table, the revised estimates drastically increase the equipment population totals for the state. Most notably, estimates for lawn mowers and trimmers/edgers/brushcutters both increased by several hundred percent. Of the significant equipment types, only shredders, tillers and other lawn and garden equipment categories were substantially lower in their population estimates than the default values.

Conclusions and Recommendations

The data collected under this study can be used as the basis for updating numerous parameters in the current OFFROAD model for commercial lawn and garden equipment. Key generalizations from the study include:

1)   Overall equipment populations were much higher than OFFROAD defaults;

2)   Mowers, trimmers/edgers/brushcutters, and blowers were by far the most common equipment types reported, as expected;

3)   Equipment is characterized by quick turnover, with the vast majority of units retired within 5 years of use;

4)   Gas-powered equipment dominates the sector, with only lawn and garden tractors being predominantly diesel-powered;

5)   Diesel fuel use is relatively higher for institutional entities compared to commercial companies;

6)   Over 90% of the projected equipment population is operated by commercial entities (general landscaping, misc. businesses, and industry categories);

7)   Commercial equipment use per unit is substantially higher than that for institutional equipment; and,

8)   Climate zone appears to have a substantial impact on overall lawn and garden service activity (although this was not verifiable using logger data).

A number of constraints and difficulties in the data collection and evaluation process limited the utility of certain equipment parameter data, however. Most importantly, the activity data obtained from the loggers was reduced to approximately 25% of the target value, severely limiting the comprehensiveness, representativeness, and overall value of the data. The thinness of the resulting data set had the following implications for the study as a whole:

- Several equipment types did not have any useable logger data to evaluate for activity patterns, including chippers/stump grinders, shredders, snowblowers, tillers, wood splitters, and "other" lawn and garden equipment.

- Lawn and garden tractors did not yield enough usable logger data for analysis.

- For those equipment types with reliable logger data, the activity profiles were relatively thin, yielding just a few observations for certain time periods.

- The thinness of the data set ruled out further stratification by important variables, such as climate zone.

- The instrumentation time frame itself was limited to the four-month period between April and July, so seasonal variation in activity could not be assessed.

Recommendations for use of the current data sets, as well as for improvements to future studies, are provided below.

Recommendations -- Robust survey responses were received for a number of equipment types and characteristics, which may be adjusted if needed, to update OFFROAD model parameters. Table ES-8 summarizes which equipment category/parameter combinations are recommended for update, based on the survey responses and surrogate extrapolations.[3]

Table ES-8. Recommended OFFROAD Model Updates

Equipment Category	Population	Avg. HP	Age Distribution	Fuel Tank Size	Fuel Tank Composition	Growth/Scrap Rates	Fuel Can Use
Chainsaws	√	√	√	√	√		
Chippers/Stump Grinders							
Commercial Turf							
Front Mowers							
Lawn and Garden Tractors	√	√		√	√		
Lawn Mowers	√	√	√	√	√		
Leaf Blowers/Vacuums	√	√	√	√	√		
Other Lawn and Garden	√	√		√	√		
Riding Mowers	√	√	√	√	√		
Shredders	√				√		
Snowblowers							
Tillers	√	√		√	√		
Trimmers/Edgers/Brushcutters	√	√	√	√	√		
Wood Splitters							
ALL CATEGORIES						√	√

As noted above, activity data obtained from data logger instrumentations were significantly limited. As such, we recommend aggregating the activity data in Table ES-5.

In order to address shortcomings in future studies, the following modifications to the data collection methods are recommended:

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[3] In ERG's opinion the fuel type distributions by equipment category seen in the survey response largely validated the OFFROAD model defaults, and do not merit update.

1)   Either increase the number of instrumentation kit mail outs substantially (i.e., by a factor of 4), or institute a much more aggressive logger retrieval policy (e.g., with substantial increases in the incentive payment upon receipt of a logger).

2)   Pre-test all logger batteries before mail out of instrumentation kits. Alternatively, investigate the cost and feasibility of installing longer life batteries in the units.

3)   Extend instrumentation period to include fall and winter time periods.

4)   Develop specific targeting strategies for specialty equipment categories such as snowblowers and wood splitters.

5)   Modify activity strata to include just 2 Climate Zones. Data indicate that climate zones 1 and 2 could be merged, as could zones 3 and 4, with no loss of specificity.

Finally, certain questions of interest were not addressed in this scope of work. Accordingly, future studies could be designed to investigate the following issues:

- Investigate the impact of socio-economic variables on commercial lawn and garden activity.

- Identify additional correlates for growth surrogates. A future evaluation may involve trend analyses correlating equipment activity growth with acreage and census tract population.

- Identify or collect equipment sales data by SIC in order to validate the use of the GIS and CBP surrogates used in this study.

1.0   Objectives and Scope

Lawnmowers, edgers, trimmers, leaf blowers, and chainsaws all fall into the Lawn and Garden equipment category of the Air Resources Board's (ARB) emissions inventory model called OFFROAD. These equipment types primarily use small off-road engines (SORE), which are less than 25 horsepower (hp). In a previous study, ARB surveyed randomly selected California households to estimate the population of residential lawn and garden equipment and their activity. A subset of respondents agreed to allow the instrumentation of their equipment to determine when and how long each piece of equipment was operated. Information obtained from the survey results aided staff in updating the activity and population of residential lawn and garden equipment.

Under this contract, Eastern Research Group and its subcontractor NuStats Partners, conducted a similar study, gathering detailed population and usage information from commercial and institutional gardeners operating in California in 2005. The study was conducted for the purposes of creating a database to update the State's estimate of the contribution of this equipment to the off-road emissions inventory.

The following provides a detailed description of the survey methodology, data logger instrumentation procedure, data analysis, and findings for commercial lawn and garden equipment use across the state.

2.0   Survey Methodology

This section summarizes the technical approach followed in conducting Task 1 of the project: a telephone survey within the California commercial and institutional sectors designed to develop an inventory of lawn and garden equipment within these sectors. This section covers the methodology followed in carrying out this survey (e.g., sample design, questionnaire design, and data collection process) while a summary of the data collection efforts is provided in a subsequent section.

2.1   Sample Design

Developing an inventory of lawn and garden equipment within the commercial and institutional sectors required that two independent samples be drawn from these two domains. For the purpose of this survey, the following definitions were used to identify establishments for each sector:

- The commercial sector is defined as landscaping companies or companies that provide lawn and garden services.

- The Institutional sector is defined as federal, state and local (municipal and county) government agencies, school districts, golf courses, equipment rental facilities, vineyards, orchards, cemeteries, and airports that maintain tended acreage on their properties.

Originally, the sample design called for equal sized samples (N=150) from each domain, totaling 300 completed surveys. However, initial sampling analysis suggested that less than 10 percent of institutions performed their lawn and garden services "in house," making the equal sample size not feasible within the study budget. As a result, this finding led to a recommendation to revise the sample allocation to 238 commercial and 62 institutions and the definition for institutional gardener was expanded to include any commercial entity that performed these services for a surveyed institution.   A pilot test of 30 completed interviews demonstrated that the incidence rate would not be affected as anticipated. Therefore nearly equal sized samples were ultimately obtained.

The universe for the 2005 California ARB Survey was comprised of commercial gardening establishments and institutions, as defined above.   Table 1 summarizes the two sample targets, the entities included in each stratum, the expected eligibility rates for each stratum, the target sample size (N) and the number of sample pieces that were purchased in order to obtain the target sample size. NuStats statisticians had Duns & Bradstreet (D&B), the sample

vendor for this project, identify the sample universe.[4] NuStats then used their previous experience in similar surveys to estimate response rate, calculating eligibility based on that information.

Table 1. Summary of Sample Types

Sample Type	Institutional Types	Expected Eligibility	Initial N	Sample Pieces
Commercial	Landscapers	80%	238	2,479
Institutional	Federal, state and local government; school districts; golf courses; equipment rental facilities; orchards; vineyards; cemeteries; airports; and military bases	60%	62	3,444

Stratification

The sample was stratified by two variables to ensure statewide representation: commercial/institutional status and geography/climate strata. As stated above, independent samples were drawn from the commercial and institutional sectors—using SIC codes within the following SIC Divisions:

- Agriculture, Forestry and Fishing

- Transportation and Public Utilities

- Finance, Insurance and Real Estate

- Service Industries

- Public Administration

With regard to climactic sampling strata, the State was stratified into five distinct climate zones to capture the diversity of lawn/garden equipment usage on tended acreage across zones. This stratification was performed based on the assumption that areas with more rainfall would require more intensive lawn and garden equipment use per unit than areas with less rainfall. The climate zones were constructed using geographic coverage files downloaded from the National

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[4] The sample for the study was derived from D&B's global database, containing more than 80 million D-U-N-S numbered records, as well as their Market Retrieval Database, which contains detailed records educational facilities (including school districts) residing in the United States. D&B's proprietary DUNSRight™ process provides customers with business related information including (but not limited to) business name, address, telephone number, industry, size, and executive names.

Climactic Data Center website.[5]   The climate zones are defined by the mean annual average precipitation ranges contained in Table 2.

Table 2. California Climate Zone Precipitation Ranges

Climate Zone	Mean Annual Average Precipitation (inches)
1	0.00 – 12.00
2	12.01 – 20.00
3	20.01 – 30.00
4	30.01 – 50.00
5	>50.00

Figure 1 depicts the climate zone distribution throughout the State of California, along with the state's major metropolitan statistical areas.

Figure 1. California Climate Zones

<table>
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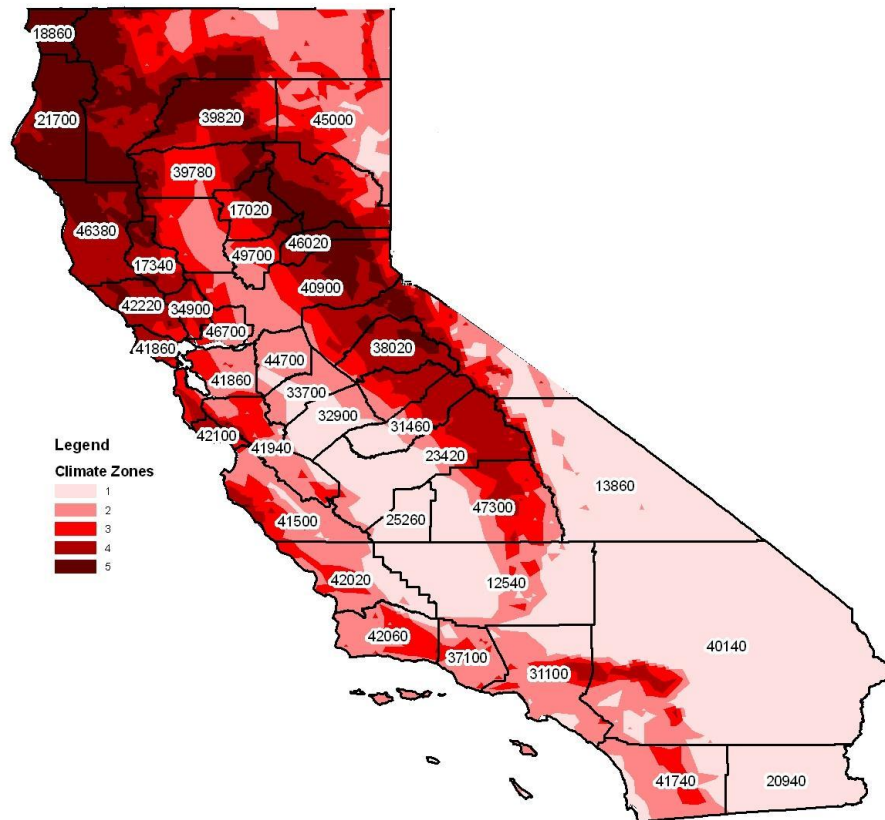
Legend
California Metropolitan Statistical Areas

18860	Crescent City, CA	42220	Santa Rosa-Petaluma, CA	41500	Salinas, CA
21700	Eureka-Arcata-Fortuna, CA	46700	Vallejo-Fairfield, CA	47300	Visalia-Porterville, CA
39820	Redding, CA	38020	Phoenix Lake-Cedar Ridge CA	25260	Hanford-Corcoran, CA
45000	Susanville, CA	41860	San Francisco-Oakland-Fremont, CA	40140	Riverside-San Bernardino-Ontario CA
35260	New Castle, PA	44700	Stockton, CA	12540	Bakersfield, CA
39780	Red Bluff, CA	33700	Modesto, CA	42020	San Luis Obispo-Paso Robles, CA
17020	Chico, CA	31460	Madera, CA	37100	Oxnard-Thousand Oaks-Ventura, CA
46380	Ukiah, CA	32900	Merced, CA	31100	Los Angeles-Long Beach-Santa Ana, CA
49700	Yuba City, CA	23420	Fresno, CA	42060	Santa Barbara-Santa Maria-Goleta, CA
17340	Clearlake, CA	13860	Bishop, CA	41740	San Diego-Carlsbad-San Marcos, CA
46020	Truckee-Grass Valley, CA	42100	Santa Cruz-Watsonville, CA	20940	El Centro, CA
40900	Sacramento--Arden-Arcade--Roseville, CA	41940	San Jose-Sunnyvale-Santa Clara, CA		
34900	Napa, CA				

Using this definition, each California census tract was assigned to a climate zone, and this list was sent to D&B. D&B assigned each commercial and institutional establishment to a climate zone (i.e., stratum), using census tract as a cross walk.

NuStats then used these proportions to order the sample, thus ensuring a sample that was geographically proportional to California climate zones and capturing the full diversity of climactic settings for tended acreage in the state. The sample climate zone distribution is contained in Table 3.

Table 3. Sample Distribution by Climate Zone

Climate Zone	Sample Distribution
1	44%
2	38%
3	9%
4	5%
5	4%

Based on expected dispositions calculated by NuStats using a combination of US Census data and past survey experience, it was conservatively estimated that approximately 5,923 sample records were needed to complete 300 interviews.[6] Once the sample arrived at NuStats, it was prepared using the stratification procedures outlined above and resulted in approximately 4,440 sample items that were then partitioned into replicates of 200 records and sent to DataSource for loading into the CATI system and subsequent dialing. Only individual replicates were released with sample management based upon the advanced mailing process described below). Further sample management rules were in place to ensure that each piece is thoroughly "worked" before it is declared "dead" or unusable.[7]

2.2   Questionnaire

A phone survey mechanism was designed to collect data on equipment by business type, fuel, model, model year, manufacturer, and typical useful life. The instrument was designed to be consistent with the previous lawn and garden equipment survey developed by ARB.

The questionnaire was designed for administration using computer-aided telephone interviewing (CATI) technology. The survey was designed for an interview that might last up to 20 minutes per equipment type (see next section, Data Collection Results for details on interview length).

The objectives of the survey were to collect data on equipment by business type (commercial or institution) and to identify participants for the Task 2 component of this project (instrumentation of equipment). The instrument began with a brief explanation of the project and screened respondents for eligibility. Then, it queried respondents on the types of lawn and garden equipment (e.g., lawn mower, tiller, etc.) it possessed and collected details on the number of equipment pieces for each type (e.g., model, year, fuel type and usage, consistent with OFFROAD model categories). Finally, the instrument was used to recruit participants for Task 2 of the project—data logger instrumentation of their equipment. In this final section, a description of the instrumentation process was provided and respondents were asked regarding their willingness to participate in the instrumentation phase of the study. The survey was conducted in English and Spanish.

Copies of the questionnaires are included in Appendix A.

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[6] Calculation based on a 50% interview response rate and a 30% completion rate for each strata.
[7] A piece of sample is considered "dead" if no interview has been conducted or no contact has been made after 8 attempts.

2.3   Advance Mailing

In order to maximize participation in the survey, an advance letter was sent to each prospective respondent.   The letter briefly described the purpose of the study and explained they may be randomly selected to participate in a telephone interview. The letter also included a toll-free number in case respondents had questions regarding the study or to provide the name of someone else who is more knowledgeable about the establishment's lawn and garden equipment.[8] A copy of the advance letter is provided in Appendix B.

The mailing was conducted in three batches over the course of data collection. As shown in Table 4, telephone interviews did not begin until approximately one week following each mailing.

Table 4. Advance Mail Schedule

Batch No.	Sample Type	Letters Mailed	Date Letters Sent out	Date Calls Began
1	Commercial	400	December 2-7, 2004	Dec 9-10, 2004
1	Institutional	400		
2	Commercial	800	Week of December 27, 2005	Week of January 3, 2005
2	Institutional	1,000		
3	Commercial	816	Week of January 15, 2005	Week of January 21, 2005
3	Institutional	984		
Total		**4,400**		

2.4   Data Collection Schedule

Training of interviewers was conducted on December 9, 2004 (see Appendix C for a copy of the Interviewer Training Manual). The purpose of interviewer training was to provide background on the study to those specialists assigned to the project, review the survey instrument (a question-by-question oral review), and to practice delivery of the interview. Specialists were monitored by Field Supervisors and were permitted to initiate interviews once they demonstrate a comfort-level with the interview and questionnaire.

Data collection began on December 12, 2004 with a Pilot Test of the survey during which approximately 30 interviews were completed. At the completion of the Pilot Test, the data from completed interviews and comments from Interview Specialists on the questionnaire were reviewed.   Minor edits were made to the survey instrument and interviews continued through

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[8] Thirty persons opted to call the toll-free number and did so to provide the name of another person to take the survey for their establishment or to express their desire to "opt-out" of the survey altogether. Reasons for "opting-out" included not having lawn and garden equipment or simply not interested.

January 21, 2005 for Commercial establishments and January 25, 2005 for Institutional establishments.[9]

2.5 Data Processing

Data from the study was processed and delivered in two ACCESS 2000 databases – one each for the Commercial and Institutional data. To ensure data structure integrity, NuStats created a "Data Items Matrix," based on the CATI program, for each dataset. The Data Items matrix identifies variable names, variable descriptions, data types, field widths, code sets, and exact question wording, as it appeared in the questionnaire.

In preparing the datasets, NuStats conducted the following set of quality control and quality assurance checks:

- Checked that the total number of records in the data file equaled the total number of CATI completes. This check was performed to ensure that the correct number of records were being cleaned and delivered.

- Checked that all categorical values were within range and checked for outliers in continuous variables.

- Checked text variables associated with the "Other" equipment type category and recoded text responses that belong to one of the categories in the response list/code set.

- Corrected text response spelling and typographical errors.

- Reviewed the data for logical consistency of responses. If there were any errors, then they were verified and corrected.

- Checked for duplicates and corrected and / or removed duplicates.

- Prepared multiple-response variables by splitting them into the variables specified in the Matrix.

- Checked if the number of equipment types had "YES," then verified that it matched the number of equipment types in the rows of data within the roster.

- Verified roster data whenever a respondent indicated "YES" for a certain equipment type.

- Verified if a respondent indicated "NO" to having a specific equipment type, data did not exist for that equipment.

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[9] Data collection was halted during the December holiday—from December 17, 2004 through January 2, 2005

Appendix D provides a detailed listing of all of the QA checks performed for both Commercial and Institutional respondents.

2.6   Data Collection Results

As shown in Table 5, a total of 305 interviews were completed.

Table 5. Completed Questionnaires by Sample Type

Sample Type	Total Collected	Percent
Commercial	157	51%
Institutions	148	49%
Total	**305**	**100%**

The breakdown of participants by SIC Division is contained in Table 6.

Table 6. Survey Participants by SIC Division

SIC Division	Number of Participants	Percentage of Participants
Agriculture, Forestry, and Fishing*	180	59%
Transportation and Public Utilities	6	2%
Finance, Insurance and Real Estate	26	9%
Services	41	13%
Public Administration	52	17%
Total	**305**	**100%**

*Includes general landscaping services

The average survey length was 18.46 minutes. The interview length was dependent upon the amount of equipment types and pieces of equipment per type of each establishment. The shortest interview lasted 9 minutes with the longest lasting 69 minutes. The following Table illustrates the range in survey length by sample type.

Table 7. Survey Length

Sample Type	Average Survey Length (minutes)	Shortest Interview (Min)	Longest Interview (min)
Commercial	19.54	9	58
Institutions	17.39	9	69
Average (All)	18.46	9	63.5

Overall, the response rate was 13% and 12% for Commercial and Institutional establishments respectively.

Equipment Inventory

One of the primary purposes of the survey was to create an inventory of lawn and garden equipment. In total, the survey collected data on 1,395 pieces of equipment within fifteen types (including a miscellaneous "Other" category). As shown in Table 8, as expected, more pieces of equipment were collected from Commercial entities than from Institutions.

Table 8. Number of Equipment Pieces by Establishment

EQUIPMENT TYPE	COMMERCIAL ENTITIES	INSTITUTIONS	ALL
Leaf Blower (Backpack)	132	69	201
Leaf Blower (Handheld)	48	39	87
Chain Saw	118	69	187
Brush cutter	39	17	56
Lawn Edger	68	53	121
Lawn Mower	148	118	266
Riding Lawn Mower	51	88	139
Lawn & Garden Tractor	18	35	53
Shredder Chipper	8	10	18
Wood Splitter	3	2	5
Stump Grinder	1	1	2
Snow Blower	2	0	2
String Trimmer	98	93	191
Tiller	28	10	38
Other	12	17	29
Total	**774**	**621**	**1,395**

The distribution of the total number of equipment pieces across the climate/geographic zones are illustrated in Table 9.

Table 9. Number of Equipment Pieces by Climatic/Geographic Zone

Zone	Commercial		Institutional		All	
	Entities	Equipment Pieces	Entities	Equipment Pieces	Entities	Equipment Pieces
1	77 / 49%	379 / 50%	62 / 42%	224 / 36%	139 / 46%	603 / 43%
2	65 / 41%	303 / 39%	49 / 33%	234 / 38%	114 / 37%	537 / 38%
3	12 / 8%	81 / 10%	22 / 15%	98 / 16%	34 / 11%	179 / 13%
4	3 / 2%	11 / 1%	10 / 7%	49 / 8%	13 / 4%	60 / 4%
5	0 / 0%	0 / 0%	5 / 3%	16 / 2%	5 / 2%	16 / 2%
Total	**157 / 100%**	**774 / 100%**	**148 / 100%**	**621 / 100%**	**305 / 100%**	**1,395 / 100%**

A much more detailed discussion of survey results is provided in the Data Analysis section of this report.

3.0   Equipment Instrumentation

This task involved the recruitment of survey respondents to participate in the instrumentation of their lawn and garden equipment. The recruitment was conducted during the survey interviews. The data loggers used for instrumentation collected equipment on-time, as well as time stamp, allowing for the development of activity estimates and temporal allocation profiles for different equipment types.

3.1   Recruitment Plan

ERG and NuStats developed a sampling plan to yield successful instrumentations of ARB's data logger. Sample was drawn from those participants in the survey who indicated willingness to participate in the study. Prior to the survey, a goal of 30 recruits each from the commercial and institutional strata were identified as sample targets. It was estimated that this number of recruits could yield sufficient instrumentation data to produce statistically reliable modeling results. Upon completion of the survey, 51 commercial entities (170% of the recruitment goal) and 28 institutional entities (93% of the recruitment goal) agreed to participate in the instrumentation phase of the project.

The 51 commercial entities reported operating 294 different pieces of equipment from 13 various equipment types, while the 28 institutional entities reported operating 172 different pieces of equipment from 14 various equipment types. Table 10 below provides some descriptive statistics regarding each of the commercial and institutional entities that agreed to participate in the instrumentation phase.

Table 10. Commercial Equipment Types by Number of Pieces and Climate Zone

Zone	Back Pack Leaf Blower	Hand Held Leaf Blower	Chain Saw	Brush Cutter	Lawn Edger	Lawn Mower	Riding Lawn Mower	Lawn and Garden Tractor	Shredder/ Chipper	Wood Splitter	Stump Grinder	Snow Blower	String Trimmer	Tiller	Other	Total
1	18	10	19	9	12	22	6	3	0	1	0	0	15	2	3	120
2	21	6	22	6	8	22	5	3	2	1	0	0	20	7	2	125
3	8	3	10	3	3	4	5	2	1	1	0	0	2	3	2	47
4	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	2
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	47	19	51	18	23	48	16	9	3	3	0	0	37	13	7	294

Table 11. Institutional Equipment Type by Number of Pieces and Climate Zone

Zone	Back Pack Leaf Blower	Hand Held Leaf Blower	Chain Saw	Brush Cutter	Lawn Edger	Lawn Mower	Riding Lawn Mower	Lawn and Garden Tractor	Shredder/ Chipper	Wood Splitter	Stump Grinder	Snow Blower	String Trimmer	Tiller	Other	Total
1	5	3	9	2	4	8	6	2	2	0	0	0	11	1	5	58
2	10	2	6	0	13	11	7	5	2	0	1	0	15	2	2	76
3	3	2	4	0	0	5	2	1	1	1	0	0	3	1	1	24
4	1	1	3	0	1	2	2	0	0	0	0	0	2	0	0	12
5	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	2
Total	**19**	**8**	**22**	**2**	**18**	**26**	**18**	**8**	**5**	**1**	**1**	**0**	**32**	**4**	**8**	**172**

Selection of Recruits for Instrumentation

Stratified sampling can result in a more accurate overall sample than that provided by a probability sample, as it allows for the explicit analysis of each stratum. However, in order for this to be an affective method of selection, each strata, or cell, must have a sufficient number of observations to provide a useful analysis. For this reason, selection of valid stratification variables is paramount.

Prior to analyzing the recruitment data, discussions between NuStats and ERG identified the following potential stratification variables: climate zone, equipment type, business type, equipment horsepower, fuel type, etc. Upon completion of the survey, the recruitment data was processed and analyzed to reveal that while the number of commercial recruits far exceeded the goal, the number of institutional recruits fell short of the goal by 2. Furthermore, many of the variables identified as potential stratification variables were characterized by high levels of non-response, thus making them ineffective for this purpose. For example, of all reported equipment pieces, 59% had unknown horsepower ratings.

In order to obtain a more accurate picture of the most effective sampling method to employ, an equipment matrix was created. This matrix, presented as Table 12, lists, by sample number, each recruited entity and the number of reported equipment pieces by equipment type (the equipment key is presented as Table 13). As suggested by Table 12, some entities operate as few as one piece of equipment, while others operate as many as 28 pieces in multiple type categories.

Table 12. Instrumentation Potential by Individual Recruits
(Number of Pieces by Equipment Type)

Recruit #:	Equipment Type															Total Pieces Held
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
5006958	2				9	2	2	3					9		1	28
5007608	1	1	1		1	3	1		1				3		2	14
5001295	2	1	2			2	1		1	1			1	1	1	13
5000238	1		2	1	1	2	1	2					1	1		12
5006853	1		1		2	1	2	1	1		1		1	1		12
5008192	2	1	1	1	1	1							3	1	1	12
5000337	4		4				2								1	11
5000390	2	1	1			1	1		1				1	1	1	10
5001921	1	1	2	1	1	1		1					1	1		10
5006879	3	1				2		1					2		1	10
5000297	1	1	1	1	1	1		1					1	1		9
5000343	1	1	1	1	1	1							1	1	1	9
5001946		1	2		1	1	1	1		1				1		9
5007089	1	1	1			1	1	1	1	1			1			9
5000152	1		1	1	1	1	1	1					1			8
5000371	1	1	2	1	1	1							1			8
5000383	3		1		1	1		1					1			8
5001066		1	2		1	1							1		2	8
5001592		1	2	1	1	3										8
5008915	1		2		1		2						2			8
5000067	1		3		1	1							1			7
5000487	1	1	1	1		1	1						1			7
5000530	1	1	1		1	1							2			7
5000969	1		1	1	1	1							1	1		7
5001088	1		1	1	1					1			1	1		7
5001391		1	1		1	3							1			7
5001670	1		2			1	1						1		1	7
5000062	2		1				1						1	1		6
5000405	1		1	2		1							1			6
5000407	1		1		1	1							2			6
5000729		1	1			2							2			6
5001145	1	1	1	1		1							1			6
5001779		1	1		1	2							1			6
5001932	1		1		1	1		1					1			6
5007373		1	1		1	1		1					1			6
5007676	1		2			1	1						1			6
5007791	2		2			1							1			6
5007896			1				1	1					2		1	6
5007934	1		1			1	2							1		6
5000160	1		1	1			1	1								5

3-3

| | Equipment Type | | | | | | | | | | | | | | | Total Pieces Held |
Recruit #:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
5000381	1		1	1	1	1										5
5000577	1		1	1	1	1										5
5001035	1		1	1			1							1		5
5001643		1	1	1	1	1										5
5006978	1			1	1	1		1								5
5008767		1	1			1							1	1		5
5008849	1		1			1							1	1		5
5000045	1		1			1	1									4
5000891	1		1		1								1			4
5000950	2					1							1			4
5001123	1		1			1							1			4
5001612		1			1	1							1			4
5008480			1			1	2									4
5008751		1	1			2										4
5008774		1	2						1							4
5000368	1		1										1			3
5000781	1		1			1										3
5000888	1					1	1									3
5000975	1					1							1			3
5001022		1				1							1			3
5007188			1		1		1									3
5007722			1			1							1			3
5007989	1					1							1			3
5008092			1		1		1									3
5000065								1						1		2
5000578							1						1			2
5000586	1												1			2
5000637			1										1			2
5000821	1					1										2
5001192	1					1										2
5001243	1					1										2
5001275	1					1										2
5001847		1					1									2
5006787	1					1										2
5006975						1									1	2
5007286							1						1			2
5008719							1						1			2
5006977						1										1
5007852						1										1
Total	66	27	73	20	41	73	34	19	6	4	1	0	69	17	14	464
%	14%	6%	16%	4%	9%	16%	7%	4%	1%	1%	0%	0%	15%	4%	3%	100%

Table 13. Equipment Type Key

Equipment Number	Equipment ID
1	LEAF BLOWER (BACK-PACK)
2	LEAF BLOWER (HAND-HELD)
3	CHAIN SAW
4	BRUSHCUTTER
5	LAWN EDGER
6	LAWN MOWER
7	RIDING LAWN MOWER
8	LAWN & GARDEN TRACTOR
9	SHREDDER/CHIPPER
10	WOOD SPLITTER
11	STUMP GRINDER
12	SNOW BLOWER
13	STRING TRIMMER
14	TILLER
15	OTHER

Some of the entities originally agreeing to the instrumentation were expected to decline. As such, we recommended approaching all 79 commercial and institutional recruits for instrumentation.

A method to logically determine which equipment pieces would be selected for instrumentation was implemented as follows. The equipment available for instrumentation appears in Table 12. This table tabulates the reported number of pieces held by each survey participant that agreed to participate in the instrumentation phase, by equipment type. Table 12 shows that just under half of the recruits (39 of the 79 entities or 49%) reported more than five types of equipment. The bottom row of Table 12 presents the equipment totals and the percentage distribution of equipment pieces across equipment types for the collection of recruits.

The goal for the instrumentation task was to capture the diversity of equipment usage across all commercial and institutional entities. Thus, care was taken when selecting equipment type, lest the rare pieces go un-represented or under-represented in the instrumentation. Moreover, only five instruments were to be deployed per entity.

To achieve the goal of maximizing the diversity of equipment measured, an "importance" index was created.[10] This index gave priority to equipment types reported in smaller quantities (e.g., stump grinders), relative to common equipment types (lawn mowers) and was used to

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[10] To maximize the diversity of equipment data captured, only one piece of equipment per equipment type was instrumented per entity.

select five equipment types from those entities reporting more than five equipment types. The result of this exercise is presented in Table 14. This table presents the equipment types that could undergo instrumentation for each survey recruit. Note that a maximum of 5 pieces were selected per entity (Col. C). As an example, Recruit 5000238 (the first row of data entries) originally reported operating 12 pieces of equipment of 10 different equipment types. According to our instrumentation selection plan, this entity was asked to instrument 5 different types of equipment – one each from equipment types 4, 5, 7, 8, and 14 (See Col. B).

Table 14. Recommended Selection of Pieces by Equipment Type

| A | B | | | | | | | | | | | | | | | C | D | E |
| Recruit # | Equipment Type* | | | | | | | | | | | | | | | Sample Pieces | Comm./Inst. | Original # Equip. Types |
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
5000238				1	1		1	1						1		5	C	10
5006853							1	1	1		1			1		5	I	10
5006958					1		1	1					1		1	5	I	10
5007896			1				1	1					1		1	5	I	10
5000062	1		1				1						1	1		5	C	9
5000067	1		1		1	1							1			5	C	9
5000160	1		1	1			1	1								5	C	9
5000297		1		1	1			1						1		5	C	9
5000343		1		1	1									1	1	5	C	9
5000381	1		1	1	1	1										5	C	9
5000383	1		1		1			1					1			5	C	9
5000390		1					1		1					1	1	5	C	9
5000405	1		1	1		1							1			5	C	9
5000407	1		1		1	1							1			5	C	9
5000577	1		1	1	1	1										5	C	9
5000969	1			1	1								1	1		5	C	9
5001035	1		1	1			1							1		5	C	9
5001066		1	1		1								1		1	5	C	9
5001088	1			1	1					1				1		5	C	9
5001295		1							1	1				1	1	5	C	9
5001391		1	1		1	1							1			5	C	9
5001592		1	1	1	1	1										5	C	9
5001643		1	1	1	1	1										5	C	9
5001670	1		1				1						1		1	5	C	9
5001779		1	1		1	1							1			5	C	9
5001921		1		1	1			1						1		5	C	9
5001932	1		1		1			1					1			5	C	9

A	B															C	D	E
	Equipment Type*																	
Recruit #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Sample Pieces	Comm./Inst.	Original # Equip. Types
5001946		1					1	1		1				1		5	C	9
5006978	1			1	1	1		1								5	I	9
5007089		1					1	1	1	1						5	I	9
5007373		1	1		1			1					1			5	I	9
5007608		1			1		1		1						1	5	I	9
5007676	1		1			1	1						1			5	I	9
5007934	1		1				1	1						1		5	I	9
5008192		1		1	1									1	1	5	I	9
5008767		1	1			1							1	1		5	I	9
5008849	1		1			1							1	1		5	I	9
5008915	1		1		1		1						1			5	I	9
5000371	1	1		1	1								1			5	C	8
5000487	1	1		1			1						1			5	C	8
5000530	1	1	1		1								1			5	C	8
5001145	1	1	1	1									1			5	C	8
5006879	1	1						1					1		1	5	I	8
5000152				1	1		1	1								4	C	8
5000045	1		1			1	1									4	C	7
5000337	1		1				1								1	4	C	7
5000729		1	1			1							1			4	C	7
5000891	1		1		1								1			4	C	7
5001123	1		1			1							1			4	C	7
5001612		1			1		1						1			4	C	7
5007791	1		1			1							1			4	I	7
5007188		1			1		1									3	I	6
5007722		1				1							1			3	I	6
5008092		1			1		1									3	I	6
5008480		1				1	1									3	I	6
5000368	1		1										1			3	C	5
5000781	1		1			1										3	C	5
5000888	1					1	1									3	C	5
5000950	1					1							1			3	C	5
5000975	1					1							1			3	C	5
5001022		1				1							1			3	C	5
5007989	1					1							1			3	I	5
5008751		1	1			1										3	I	5
5008774		1	1						1							3	I	5
5000065								1						1		2	C	4
5000578							1						1			2	C	4

A	B															C	D	E
	Equipment Type*																	
Recruit #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**Sample Pieces**	**Comm./Inst.**	**Original # Equip. Types**
5000637			1										1			2	C	4
5006975						1									1	2	I	4
5007286							1						1			2	I	4
5008719							1						1			2	I	4
5000586	1												1			2	C	3
5000821	1					1										2	C	3
5001192	1					1										2	C	3
5001243	1					1										2	C	3
5001275	1					1										2	C	3
5001847		1					1									2	C	3
5006787	1					1										2	I	3
5006977						1										1	I	2
5007852						1										1	I	2
Total	40	27	40	19	30	36	27	16	6	4	1	0	39	17	12	314		
Sample %	13%	9%	13%	6%	10%	11%	9%	5%	2%	1%	0.3%	0%	12%	5%	4%	100%		
Phase I %	14%	6%	16%	4%	9%	16%	7%	4%	1%	1%	0%	0%	15%	4%	3%	100%		

(Cell Entries in Col. B; 1=select for instrumentation),
 Number of Pieces to Select (Col. C), Organization Type (Col. D), and
Total Number of Equipment Pieces (Col. E)

Note the comparison of sample and total recruit percentages at the bottom of Table 14. This demonstrates that the proposed selection plan amply reflected the diversity of equipment available from the survey recruits. Under this plan, a total of 314 pieces of equipment (from the pool of 464) were targeted for instrumentation.

Table 15 below provides a brief description of the number of pieces of commercial and institutional equipment targeted for instrumentation by climate zone under the proposed sampling pan. The mean number of instrumented equipment pieces for the commercial strata was 4.1, while the mean number of instrumented equipment pieces for the institutional strata was 3.75.

Table 15. Commercial and Institutional Instrumentation Pieces by Climate Zone

Strata	Climate Zone					Total
	1	2	3	4	5	
Commercial	96	83	28	2	0	209
Institutional	39	37	19	8	2	105
Total	135	120	47	10	2	314

Compensating for Multiple Pieces of Equipment within Equipment Types

Approximately 40% of all recruited entities reported operating multiple pieces of equipment within a given equipment type (e.g., a single entity operating two edgers or two lawn mowers). As only one piece of equipment within each type was to be instrumented, for this 40% there existed some potential for ambiguity regarding what data came from what equipment. For this reason the instruction packet provided to the equipment operators contained instructions prompting the participant to provide the make, model, horsepower and/or other equipment-specific information that would help identify the link between data and equipment.

Expected Response Rates

Table 16 presents the expected outcome from the proposed instrumentation plan. Based on ARB's experience using the data loggers in the previous residential lawn and garden study, it was estimated that approximately 65% of all recruited entities targeted for instrumentation would actually properly install the equipment and submit usable data. It was assumed that the remaining 35% would not install the loggers properly, would record their data incorrectly, or would simply choose not to participate even though they agreed to do so during the survey.

Therefore a total of 51 entities were expected to participate, providing instrumentation on just over 200 pieces of equipment. Of the 51 commercial recruits, it was estimated that 33 would successfully install the equipment and provide data on some 135 pieces of equipment. Likewise, of the 28 institutional recruits it was estimated that 18 would successfully install the equipment and provide data on some 68 pieces of equipment.

Table 16. Expected Instrumentation Outcome

	Recruits	Equipment Targeted for Instrumentation	Expected Successful Recruits	Expected Successfully Instrumented Equipment
Commercial	51	209	33	135
Institutional	28	105	18	68
Total	79	314	51	203

3.2 Recruitment and Instrumentation

An overview of the seven-steps comprising the recruitment and logger installation process is presented in Figure 2. NuStats prepared the materials to be included in the instrumentation packet mailed to participants. The packet contained a letter thanking them for their participation along with general instructions, and an information sheet on how to install the instrumentation. Materials were similar to those previously developed by ARB for their residential study, and were prepared in English and Spanish.

NuStats supplied ARB with sufficient copies of these materials and mailing labels for returning instrumentation. Preparation of mailing labels and return packaging required the use of ARB's bulk mail permit to cover postage costs. All mailout materials were submitted to ARB in advance for approval.

The following items related to the instrumentation process are provided in Appendix E:

- Recruitment script

- Mail out letter

- Instrumentation log (provided to ARB as a pdf file)

- Recording unit instrumentation instructions (provided to ARB as a pdf file)

Mail out items maintained consistency with ARB's request that they not be readily identified as a study sponsor.

To assist ARB with the mail out, NuStats provided BRM Reply Mail Labels and prepared electronic versions of mail out materials (letter, instrumentation log, and mail out label). To facilitate linking the data logger with the right instrumentation log, NuStats generated a label to apply to the recording device, which would correspond to the instrumentation log, thereby reducing the chance for participant-derived error. ARB ensured that the labeled recording devices and instrumentation logs sent to each participant matched.

During the course of the recruitment phase, a hotline was established and maintained to answer participant questions. Bilingual staff monitored the hotline.

Table 17 provides a summary of the data loggers that were mailed out by ARB between March and July of 2005, indicating the type of equipment targeted for instrumentation.

Figure 2. Instrumentation Process

Step 1
DataSource Recruits
Participant

Step 2
For each participant, NuStats prepares word versions of: (1) mail merged letter, (2) outgoing mailing label, (3) instrumentation log(s) and recording device label with equipment to be instrumented indicated.

Step 3
NuStats provides ARB with participant specifications (number of instrumentations) and materials prepared in Step 2.

Step 4
ARB sends mail out package (8x8x8 box or large envelope) containing:
Mail merged letter
Recording Unit Installation Instructions
Recording Unit* (one per piece of equipment)
Recording Unit label (one per piece of equipment)
Installation Log (one per piece of equipment)
Return Mail Label

Step 5
ARB informs NuStats of packet mailed out date.

Step 6
NuStats tracks receipt of packet by participant and return of data loggers; provides incentives to participants who completed their obligations.

Step 7
NuStats delivers data logger to ERG for downloading.
ERG returns data logger to ARB

Table 17. Instrumentation Kit Mailouts by Equipment Type

Equipment Type	Count
BRUSHCUTTER	15
CHAIN SAW	35
LAWN & GARDEN TRACTOR	13
LAWN EDGER	22
LAWN MOWER	57
LEAF BLOWER (BACK-PACK)	45
LEAF BLOWER (HAND-HELD)	20
OTHER	17
RIDING LAWN MOWER	28
SHREDDER/CHIPPER	3
SNOW BLOWER	1
STRING TRIMMER	44
TILLER	10
WOOD SPLITTER	2
Totals	**312**

4.0　Data Analysis

In this task ERG evaluated the data collected during the phone surveys and equipment instrumentation to establish populations, age distributions, and activity profiles by equipment and horsepower categories. An evaluation of major polluting source categories was made, and surrogates were developed for extrapolation across the different geographic and temporal resolutions required of the OFFROAD model.

4.1　Data Processing and Quality Assurance

Survey Responses

NuStats provided ERG with all survey data received on a monthly basis for processing and evaluation. Survey data were provided in Access 2000 format. All data from NuStats were logged into an ERG masterfile upon receipt.

ERG modified the Access database for storage and manipulation of all survey data collected during the surveys. Data checks for internal and external consistency were instituted before loading information into the database. These checks were performed in addition to the standard NuStats QA protocol, listed in detail in Appendix D. ERG's QA checks included range checks, review for outliers (e.g., reported hp or hrs/yr), and uniformity checks (e.g., for manufacturer and equipment type spelling). (Relative populations across equipment categories were also compared with existing values in the OFFROAD model, as discussed in Section 4.2 below.)

ERG first identified several equipment type categorization problems. The following summarizes the problems and the resulting actions taken.

3) Certain equipment pieces were obviously not lawn and garden equipment as defined, including a tamper, conveyor, trencher, and bobcat (construction equipment). A tractor was also described as using a pull-behind mower, and therefore most likely an agricultural tractor. As such, these equipment were not assigned to a standard lawn and garden equipment category for this analysis.

4) Hedge trimmers and power pruners were assigned to the "Other" equipment category.

5) A "yard vacuum" was reported with 8 hp. Given the relatively high hp ERG assumed this was not a backpack model. Therefore this unit was assigned to the "handheld leaf blower" category.

6)   A fairway mower (35 hp Toro) was assigned to the "Riding Lawn Mower" category.

7)   One "blade type" weed eater was assigned to the string trimmer category.

8)   One aerator was placed under the "Other" category.

9)   One piece of equipment was described as a "Dingo". A web search found no definitive equipment type associated with this description. Therefore this unit was not assigned to a standard lawn and garden equipment category.

Apparent discrepancies involving the reported hours of use were also identified and resolved, as summarized below, with adjustments shown in italics for each problematic respondent ID and response.

Institutional Survey – Reported Activity Discrepancies

- If TIMEB is '1'; TIMEA must be ≤ 24 hours – 5008452, 5008046, 5007501 (40 hours); 5009093 (50 hours). *Recommend treating this as a per WEEK response, instead of a per day response*.

- If TIMEB is '2'; TIMEA must be ≤ 168 hours – 5007477, 5006916 (200 hrs) *Per Month*; 5008192 (216 hrs) *Per Month*; 5006953 (280 hrs) *Per Month*; 5007961 (400 hrs) *Per Month*; 5007089, 5007633 (500 hrs) *Per Month*; 5007692 (600 hrs) *Per Month*; 5007639 (800 hrs) *Per Year*; 5008091 (840 hrs) *Per Year*; 5007053 (1040 hrs) *Per Year*; 5007608 (1080 hrs) *Per Year*; 5007474 (1500 hrs) *Per Year*.

- If TIMEB is '3'; TIMEA must be ≤ 744 hours (*assumes the month has 31 days) – 5007315 (1500 hrs) *Per Year*; 5007983 (2700 hrs) *Per Year*.

Commercial Survey – Reported Activity Discrepancies

- If TIMEB is '1'; TIMEA must be ≤ 24 hours – 5000738 (32) *Recommend treating this as a per WEEK response, instead of a per day response*; 5001241 (40) *Recommend treating this as a per WEEK response, instead of a per day response;* 5000062 (40) *Recommend treating this as a per WEEK response, instead of a per day response;* 5000582 (152) *Per Month*; 5001295 (560) *Per Month*; 5000022 (1500) *Per Year*

- If TIMEB is '2'; TIMEA must be ≤ 168 hours – 5001833, 5000530, 5000603, 5001053 (200) *Per Month*; 5001685 (240) *Per Month*; 5000065, 5000067 (280) *Per Month*; 5000719, 5001147, 5001921 (400) *Per Month*; 5000914 (600) *Per Month*; 5001051 (900) *Per Year*; 5001131 (1000) *Per Year*; 50019746 (2400) *Per Year*

- If TIMEB is '3'; TIMEA must be ≤ 744 hours (*assumes the month has 31 days) – 5002000 (800) *Per Year*

In addition to the discrepancies in reported activity, there were 505 survey responses that did not have a reported horsepower (hp) value. Of these only 43 had both the model name and make of the equipment. ERG located hp information for 33 of these 43 records through a search of manufacturers' websites. The remaining 10 records were for either very old equipment (e.g. pre-1980) or included unidentifiable model/make information.

Responses without hp values and with no model name (~ 450) were gap-filled using average hp values from the OFFROAD model.

In addition, a small number of units had reported hp values that were likely out of range:

- 4 chainsaws were reported to have values between 12 and 22 hp. The highest hp rating identified on vendor websites was 11;

- 2 edgers had reported hp values of 398 and 675;

- One lawn and garden tractor was reported with 270 hp;

- 2 riding lawn mowers were reported with 147 hp.

In these cases average hp values were used from the OFFROAD model.

Finally, certain equipment types were identified so infrequently (or not at all), that extrapolation of the survey findings would not yield reliable population and activity estimates. These include chippers and stump grinders, snowblowers, woodsplitters. In addition, the survey did not explicitly differentiate front mowers and commercial turf equipment. Therefore OFFROAD defaults can be used for these categories.

Instrumentation Data

As ERG received the data loggers from NuStats, ERG downloaded the data collected by the loggers using the EL-100 software, along with a 3-foot serial to 3.5 mm cable used to connect the logger to the PC, provided by ARB. The procedure used to download the data from the loggers is summarized below:

1) Installed EL-100 software

2) Executed EL-100 program

3) Connected cable between PC & Datalogger

4)   Selected "File" ---> "Download" ----> "Serial" (the program looks for the serial port and initials the download)

5)   Once completed, several dialog boxes appeared showing "start" and "stop" intervals

6)   Selected "File" ---> "Save" to copy the data to the hard drive

Of the 312 instrumentation kits mailed out, ERG received 122 data loggers back for download, even after multiple attempts were made to contact recruits retaining loggers by phone. Of these 122 data loggers, only 53 were included in the final activity analysis for commercial lawn and garden equipment. The remaining 69 data loggers were excluded from analysis for a number of reasons, most often failure to download due to software/hardware problems. Many data loggers reported having a low battery, which made them unable to record the dates and times of usage. The data from these data loggers were sent to ARB project staff for review. ARB project staff applied an algorithm to the dates, based on the dates reported on the paperwork that accompanied the data loggers, to convert the incorrect dates to dates that reflected the appropriate time period. Appendix F provides a complete log of the downloads.

For each piece of instrumented equipment, ERG calculated the total duration the equipment was in use, the total number of "in use" events, and the average duration per event. In order to examine the data for reasonableness, ERG reviewed the average duration per event to identify any obvious breaks in trends that needed further investigation. This review found some equipment types had questionable (i.e., very short) average durations per event. After consulting with ARB project staff, any events less than thirty seconds were eliminated from the analysis. To review the average duration per event trends, refer to Table 18 below.

Table 18. Average On-Time Duration by Equipment Type

Equipment Type	ID	Duration	Event Count	Average Duration Per Event
Trimmers/Edgers/Brushcutters	5006879 Blade Type Weed Eater	0:00:07	4	0:00:02
	5000487 Brushcutter	0:00:05	2	0:00:02
	5000487 String Trimmer	0:00:05	2	0:00:02
	5007373 String Trimmer	0:03:46	13	0:00:17
	5008915 String Trimmer	0:32:02	100	0:00:19
	5006879 String Trimmer	9:26:23	822	0:00:41
	5001391 Lawn Edger	0:23:53	9	0:02:39
	5001145 Brushcutter	2:07:49	47	0:02:43

Equipment Type	ID	Duration	Event Count	Average Duration Per Event
	5001066 Lawn Edger	1:07:22	24	0:02:48
	5001670 String Trimmer	1:11:05	25	0:02:51
	5001391 String Trimmer	5:42:15	102	0:03:21
	5007896 String Trimmer	16:40:23	262	0:03:49
	5001946 Weedeater	8:04:10	123	0:03:56
	5000888 Hedge Trimmer	2:14:42	19	0:07:05
	5000888 String Trimmer	5:10:36	42	0:07:24
Hand-held Blowers	5001066 Leaf Blower (Hand Held)	3:00:47	60	0:03:01
	5001391 Leaf Blower (Hand Held)	7:25:17	120	0:03:43
	5006879 Leaf Blower (Hand Held)	0:07:38	2	0:03:49
	5007608 Leaf Blower (Hand Held)	5:44:48	80	0:04:19
	5001946 Leaf Blower (Hand Held)	0:26:21	3	0:08:47
Backpack Blowers	5001670 Leaf Blower (Back Pack)	0:39:01	29	0:01:21
	5000487 Leaf Blower (Back Pack)	0:11:50	5	0:02:22
	5000062 Leaf Blower (Back Pack)	9:15:11	87	0:06:23
	5000888 Leaf Blower (Back Pack)	6:40:10	42	0:09:32
Mowers	5000487 Lawn Mower	0:00:03	2	0:00:02
	5007852 Lawn Mower	0:00:05	2	0:00:02
	5006879 Lawn Mower	1:05:18	292	0:00:13
	5008849 Lawn Mower	0:31:44	15	0:02:07
	5007373 Lawn Mower	0:07:13	3	0:02:24
	5001670 Lawn Mower	1:12:39	24	0:03:02
	5001391 Lawn Mower	16:29:47	237	0:04:11
	5001035 Lawn Mower	9:18:14	131	0:04:16
	5001946 Lawn Mower	0:54:37	12	0:04:33
	5006977 Lawn Mower	1:20:33	11	0:07:19
	5001066 Lawn Mower	10:20:18	73	0:08:30
	5007608 Lawn Mower	6:19:42	34	0:11:10
	5000888 Lawn Mower	9:32:00	33	0:17:20
Riding Mowers				
	5000487 Riding Lawn Mower	0:00:06	2	0:00:03
	5008751 Riding Lawn Mower	2:14:16	194	0:00:42
	5008915 Riding Lawn Mower	0:00:49	1	0:00:49
	5001946 Riding Lawn Mower	0:30:38	10	0:03:04
	5001670 Riding Lawn Mower	1:26:40	19	0:04:34
	5000062 Riding Lawn Mower	2:56:03	25	0:07:03
	5007896 Riding Lawn Mower	20:31:23	158	0:07:48
	5000888 Riding Lawn Mower	5:03:58	19	0:16:00

Equipment Type	ID	Duration	Event Count	Average Duration Per Event
Chainsaws				
	5000487 Chain Saw	0:00:02	1	0:00:02
	5000637 Chain Saw	0:19:55	19	0:01:03
	5001145 Chain Saw	0:11:49	7	0:01:41
	5008849 Chain Saw	2:24:20	25	0:05:46
Garden Tractors				
	5007896 Lawn & Garden Tractor	0:20:50	328	0:00:04
	5006879 Lawn & Garden Tractor	0:00:48	1	0:00:48

4.2 Data Analysis

Operator Profiles

Institutional and commercial survey respondents were asked about their tended properties and their overall equipment use patterns. Survey results found that of the 148 institutional respondents, 139 indicated they did not contract out their services, while an additional 7 did so only intermittently for specialty services. Given that only 2 institutional respondents (<2%) contracted services out, the institutional and commercial survey responses were assumed to contain essentially no overlap, and were treated as a complete data set for the purposes of developing equipment population and activity profiles.

The vast majority of institutional respondents (125) indicated that their equipment use was restricted to a single location, while only 12 indicated their equipment was used at 5 or more locations. As expected, commercial equipment users tended a far greater number of locations, with a mean of 38 properties per company. Commercial property numbers ranged from a single location to 400, indicating a very broad range in the size of the companies surveyed.

Commercial and institutional respondents also exhibited very different equipment use patterns, in terms of acres tended, hours of use, fuel use, and even geographic location, as summarized in Tables 19-23. Figures 3-8 present data distributions for acres tended, hours of services, and fuel use graphically. The distributions are clearly skewed, with a numerous smaller entities and a handful of large service providers. Figures 7 and 8 also indicate that the majority of respondents do not use diesel fuel in their operations.

Table 19. Acres Tended/Week

	Institutional	Commercial
Average	86	276
Total	10,455	11,866
Min	1	1
Max	1,200	7,000

Table 20. Hours Servicing Properties/Week

	Institutional	Commercial
Average	25	43
Total	3,427	6,336
Min	0	0
Max	160	160

Table 21. Gasoline Use/Month (gallons - all equipment)

	Institutional	Commercial
Average	49	74
Total	5,183	8,351
Min	0	0
Max	600	900

Table 22. Diesel Use/Month (gallons - all equipment)

	Institutional	Commercial
Average	30	5
Total	3,971	785
Min	0	0
Max	800	160

Table 23. Acres Tended by Climate Zone

Zone	Institutional		Commercial	
	Acres	Percent	Acres	Percent
1	2,663	25.5%	9,287	78.3%
2	2,975	28.5%	1,335	11.3%
3	3,645	34.9%	1,222	10.3%
4	1,165	11.1%	22	0.2%
5	7	0.1%	0	0.0%

Figure 3. Institutional Acres Tended
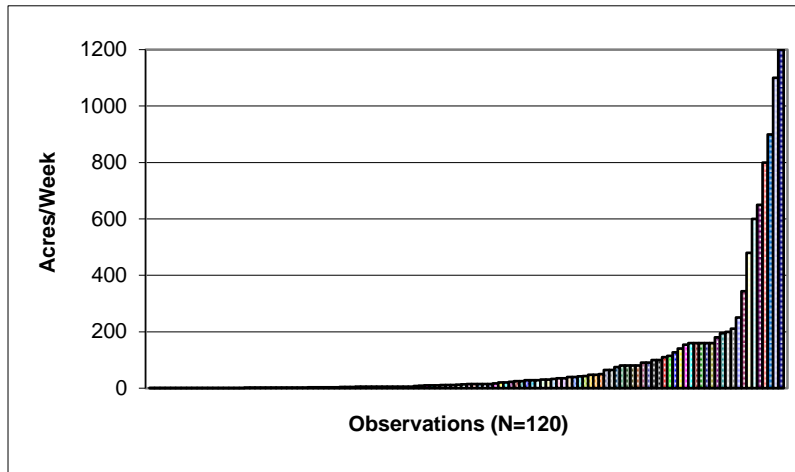
Figure 4. Commercial Acres Tended

* 4 observations of 1000, 1100, 2000, and 7000 omitted due to scale
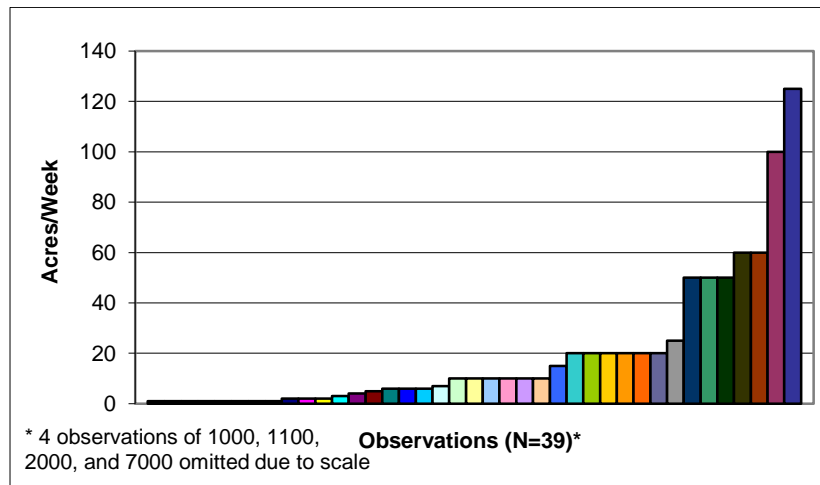
Figure 5. Gasoline Use – Institutional Entities
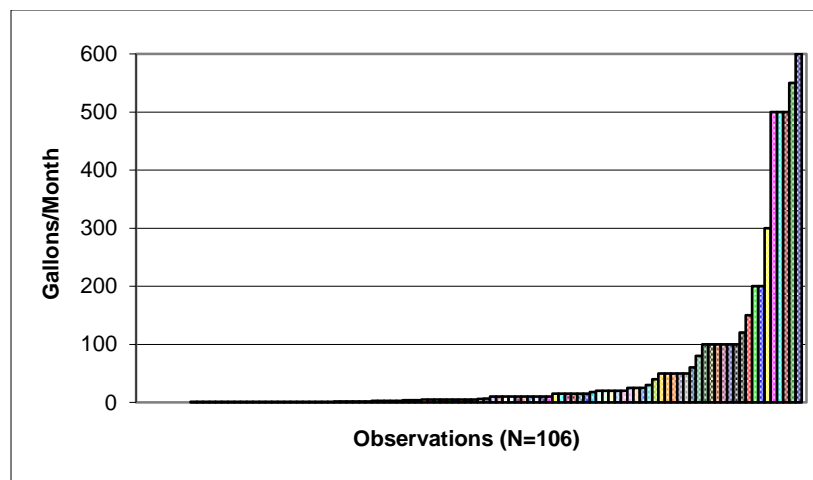
Figure 6. Gasoline Use – Commercial Entities
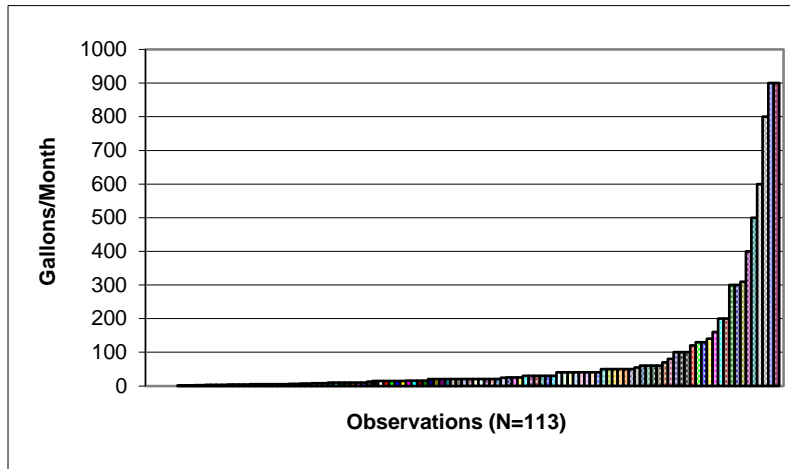
Figure 7. Diesel Use – Institutional Entities
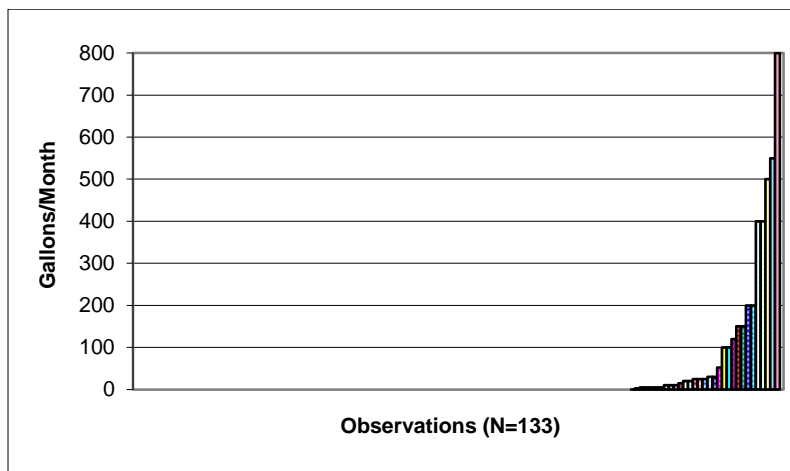
Figure 8. Diesel Use – Commercial Entities
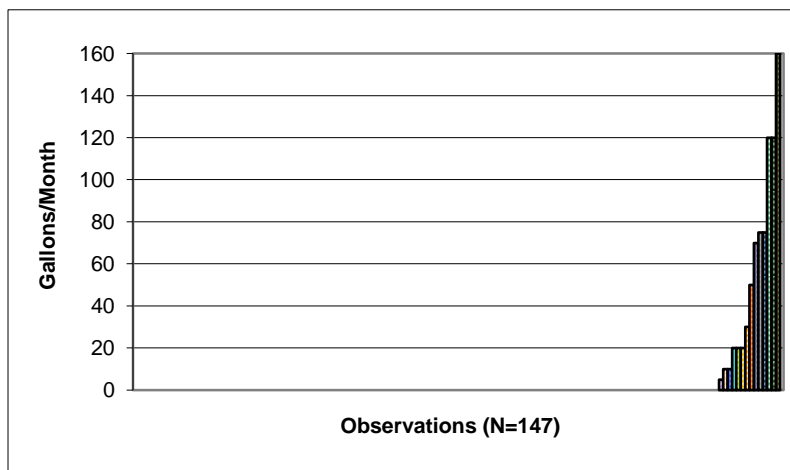
Tables 24 thru 26 show equipment activity per unit for a number of common equipment types assumed to be used in most commercial services, thereby providing a reference point and reasonableness check for the values in Tables 19-22.

Table 24. Acres Tended/Week/Unit

Equipment Type	Institutional	Commercial
Mowers	32	72
Blowers	58	123
Trimmers/Edgers/Brushcutters	28	136

Table 25. Hours/Week/Unit

Equipment Type	Institutional	Commercial
Mowers	11	18
Blowers	15	20
Trimmers/Edgers/Brushcutters	11	15

Table 26. Fuel Consumption (Gallons/Month/Unit - all equipment types)*

Fuel	Institutional	Commercial
Gasoline	4.4	8.1
Diesel	2.6	0.6

*Fuel consumption only reported at the aggregate level for entire inventory.

These tables clearly show that commercial entities are much more intensive users of lawn and garden equipment than institutional users, with one exception – diesel fuel use is substantially more common among institutional entities than among commercial entities.

(The values in Tables 24 and 25 appear to imply high equipment utilization rates, especially for commercial entities. However, the survey questions did not determine the fraction of total acres tended that required some/all of these equipment types, nor did they determine the fraction of time these types of equipment actually operated during an entity's working hours. Therefore these tables assume complete utilization of all of these equipment types, for all acres tended and hours of operation. Since some fraction of acres tended and operation time will not involve these equipment types, the utilization values in these tables are necessarily overestimated, though the degree of overestimation is uncertain.)

Acres tended are more evenly distributed among institutions than commercial entities, with commercial activity much more heavily centered in the more populated regions of the state (e.g., the drier climate zones of Southern California). In addition, the average hours required to

tend an acre of land varied substantially by climate zone, with the wetter regions requiring the most labor and equipment use, as expected (see Table 27).

Table 27. Hours per Acre per Year (all establishments)

Zone	Avg. Hr/Acre/Yr	Acres in Survey
1	7.5	11,617
2	6.7	14,300
3	17.0	3,667
4	19.7	1,187
5	609.1*	7*

*Suspected outlier – only based on 4 valid survey responses.

Population Characteristics

Survey responses were evaluated for a number of equipment characteristics, including fuel type and age distributions, average horsepower, fuel tank volume and type, refueling method, throttle position, and replacement frequency. Depending on the robustness of the responses, these results will allow for updating the OFFROAD supporting files at the equipment and/or fuel type level.

Fuel Type Distribution

Table 28 summarizes the distribution of fuel type by equipment category, for gasoline, diesel and electric units. Wood splitters, grinders, and snowblowers are excluded from reporting due to their very low observation frequency in the data. The table also indicates the percentage of gasoline units assumed in the current OFFROAD model. Note that OFFROAD equipment population data does not currently include electric units.

Table 28. Fuel Type Distribution by Equipment Category

Equipment Type	Gas	Diesel	Electric	OFFROAD Gas %
Leaf Blower (backpack)	0.979	0.012	0.010	100%
Leaf Blower (handheld)	0.918	0.000	0.082	100%
Chain saw	0.984	0.008	0.008	100%
Brushcutter	0.989	0.011	0.000	100%
Edger	0.980	0.012	0.008	100%
Lawn Mower	0.987	0.011	0.003	100%
Riding Mower	0.713	0.287	0.000	100%
L&G Tractor	0.328	0.672	0.000	16%
Shredder/chipper	0.947	0.053	0.000	100%
String Trimmer	0.993	0.000	0.007	100%
Tiller	1.000	0.000	0.000	100%
Other	0.316	0.032	0.652	100%

In most instances the observed gas-to-diesel ratio corresponds very closely to the default OFFROAD values. One exception is found in the Riding Mower category, which had a non-trivial amount of diesel units reported, where none are assumed in OFFROAD. (Riding mowers have higher hp ratings than other lawn and garden equipment, with engine designs favoring diesel.) Based on past experience we suspect that many respondents incorrectly categorized lawn and garden tractors (which are dominated by diesel) as riding mowers. Given this common problem it may be warranted to merge these categories in future updates to OFFROAD.

The "Other" equipment category also has a relatively low fraction of gasoline units, although removing the electric component and renormalizing results in a 91% gasoline fraction, roughly comparable to the default OFFROAD value.

Average Horsepower

Equipment data were grouped by OFFROAD hp bin and average hp was calculated for 2-stroke and 4-stroke/diesel engines for each bin. Table 29 provides these results for each OFFROAD equipment category for which there were adequate survey responses (i.e., wood splitters, grinders, and snowblowers were excluded, as well as shredders/chippers, which did not have hp reported for any of the 16 responses). Dashes indicate hp bins without a corresponding equipment population

Table 29. Average HP by Equipment Type and HP Bin

HP Range	Fuel Type	Leaf Blowers/ Vacuums	Chain saw	Lawn Mower	Riding Mower	L&G Tractor	Trimmers/ Edgers/ Brushcutters	Tiller	Other
0-5	4-strk/dsl	2.46	-	4.49	-	-	2.89	4.06	2.91
5-15	4-strk/dsl	-	-	7.12	7.56	9.33	-	7.82	13.00
15-25	4-strk/dsl	-	-	-	20.30	19.33	-	-	-
25-50	4-strk/dsl	-	-	-	31.80	34.50	-	-	35.00
0-2	2-strk	1.82	1.83	-	-	-	1.85	-	-
2-15	2-strk	-	4.48	-	-	-	-	-	-

These values can be used to update the average hp value in the OFFROAD population data files.

Equipment Age

The survey requested respondents provide an estimate of "average" age for each of their equipment types, rather than a specific age for each piece of equipment, in order to improve the efficiency and response rate of the survey. An "average age" distribution was then developed for each equipment type based on the reported values. Only five equipment categories were observed with great enough frequency to confidently develop by-year age distributions, as shown in Table 30.

Table 30. Observed Age Distributions for Selected Equipment Categories

	Blower/ Vacuum		Chain Saw		Trimmers/ Edgers/ Brushcutters		Lawn Mower		Riding Mower	
# Obs	701		362		913		766		290	
Age	#	%	#	%	#	%	#	%	#	%
0	149	21.3%	40	11.0%	80	8.8%	83	10.8%	20	6.9%
1	133	19.0%	50	13.8%	113	12.4%	94	12.3%	29	10.0%
2	225	32.1%	95	26.2%	257	28.1%	157	20.5%	28	9.7%
3	78	11.1%	60	16.6%	203	22.2%	156	20.4%	66	22.8%
4	40	5.7%	14	3.9%	34	3.7%	52	6.8%	37	12.8%
5	48	6.8%	26	7.2%	113	12.4%	152	19.8%	35	12.1%
6	2	0.3%	18	5.0%	58	6.4%	28	3.7%	3	1.0%
7	1	0.1%	1	0.3%	9	1.0%	2	0.3%	16	5.5%
8	6	0.9%	6	1.7%	19	2.1%	5	0.7%	16	5.5%
9	0	0.0%	1	0.3%	0	0.0%	3	0.4%	2	0.7%
10	16	2.3%	11	3.0%	16	1.8%	18	2.3%	33	11.4%
11	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
12	1	0.1%	1	0.3%	0	0.0%	1	0.1%	3	1.0%
13	0	0.0%	31	8.6%	0	0.0%	0	0.0%	0	0.0%
14	1	0.1%	0	0.0%	0	0.0%	4	0.5%	0	0.0%
15	1	0.1%	3	0.8%	4	0.4%	4	0.5%	2	0.7%
16+	0	0.0%	5	1.4%	7	0.8%	7	0.9%	0	0.0%

The data clearly show that the vast majority of lawn and garden equipment are retired within four to five years of use. These data may be used to update the age distribution for these equipment types in the OFFROAD model. However, given the "granular" nature of the age data some type of curve-fitting or smoothing function would be recommended before inclusion in the model.

Fuel Tank Characteristics

The survey collected data on the size and composition of fuel tanks by equipment type. Average fuel tank size is presented below in Table 31. Table 32 summarizes the reported tank

composition by equipment type. As above, equipment categories with minimal observations are not presented, and default values from OFFROAD were assumed.

Table 31. Fuel Tank Size Distribution (gal)

HP Range	Fuel Type	Leaf Blowers/ Vacuums	Chain saw	Lawn Mower	Riding Mower	L&G Tractor	Trimmers/ Edgers/ Brushcutters	Tiller	Other
0-5	4-strk/dsl	0.89	-	0.76	-	-	0.41	0.58	1.00
5-15	4-strk/dsl	-	-	0.83	2.02	4.38	-	0.95	2.67
15-25	4-strk/dsl	-	-	1.33	5.72	6.63	-	-	-
25-50	4-strk/dsl	-	-	-	7.80	22.83	-	-	2.50
0-2	2-strk	0.71	0.52	-	-	-	0.28	-	-
2-15	2-strk	-	0.31	-	-	-	0.41	-	-

Table 32. Fuel Tank Composition

Equipment Type	Plastic	%	Metal	%
LEAF BLOWER (BACK-PACK)	170	90.4%	18	9.6%
LEAF BLOWER (HAND-HELD)	67	94.4%	4	5.6%
CHAIN SAW	133	70.4%	56	29.6%
BRUSHCUTTER	44	78.6%	12	21.4%
LAWN EDGER	62	39.2%	96	60.8%
LAWN MOWER	186	62.0%	114	38.0%
RIDING LAWN MOWER	80	52.6%	72	47.4%
LAWN & GARDEN TRACTOR	22	30.6%	50	69.4%
SHREDDER/CHIPPER	219	74.7%	74	25.3%
STRING TRIMMER	167	96.5%	6	3.5%
TILLER	15	27.3%	40	72.7%
OTHER	21	77.8%	6	22.2%

Typical Throttle Position

The survey asked respondents for the throttle position most used when operating their equipment. Possible responses were restricted to "high/medium/low". Table 33 presents the fraction of operation at each throttle position, weighted by the number of units and the reported number of uses per year. Equipment categories with minimal observations are not presented, for which default values from OFFROAD can be assumed (shredders, wood splitters, stump grinders, and snowblowers).

Table 33. Reported Throttle Position Distribution

Equipment Type	Low	Medium	High
Leaf Blower (backpack)	0.05	0.37	0.58
Leaf Blower (handheld)	0.01	0.24	0.75
Chain Saw	0.05	0.33	0.62
Brushcutter	0.48	0.30	0.22
Edger	0.05	0.78	0.18
Lawn Mower	0.11	0.45	0.44
Riding Mower	0.04	0.45	0.51
L&G Tractor	0.01	0.53	0.46
String Trimmer	0.02	0.11	0.87
Tiller	0.02	0.50	0.48
Other	0.00	0.71	0.29

Although there were a substantial number of responses to this set of questions, it remains unclear how to translate these qualitative responses into the quantitative load factor values used in the OFFROAD model.

Equipment Scrappage and Growth

The survey asked respondents if they planned on replacing existing, or buying additional, lawn and garden equipment in the subsequent 12 months. 25% of the 277 respondents answering this question indicated they had such plans. The survey differentiated between replacements and new additions to their inventories, allowing for an estimation of scrappage and growth rates. In order to improve the data sample size, responses were pooled across all equipment categories. Accordingly, for all commercial lawn and garden equipment categories the survey results indicate a 3.9% scrappage/replacement rate, with an additional 2.0% growth rate.

Refueling Practices

Respondents were asked how they refueled their equipment. To improve the data sample size, responses were pooled across all equipment categories. Table 34 summarizes the frequency of portable fuel can use versus refueling at a pump, for gasoline and diesel equipment.

Table 34. Equipment Refueling Practices

	Gasoline		Diesel	
Total Responses	204	%	43	%
Portable Cans	163	79.9%	20	46.5%
Pumps	41	20.1%	23	53.5%

The findings indicate that equipment refueling via portable cans is significantly more common for gasoline equipment compared to diesel. This information may be used to update the refueling can emissions data in the OFFROAD model.

Activity Profiles

Instrumentation data was used to characterize equipment activity in terms of annual hours of use, as well as temporal distributions for weekday versus weekend operation.[11] Each equipment type with downloaded data was analyzed separately to obtain the temporal allocation for equipment activity. Summaries of the analyses for each equipment type are presented in Table 35, along with annual hours of use defaults from the OFFROAD model.

Table 35. Instrumentation Activity Summary

Equipment Category*	# Units logged	24-hr average hrs:mins/day						Hr/Yr – Logger	Hr/Yr - OFFROAD
		M-Th		Fri		S-Su			
		Duration	Unit-days	Duration	Unit-days	Duration	Unit-days		
Riding Mowers	7	1:34	18	0:01	1	1:03	6	345	271
Lawn Mowers	11	1:15	42	1:26	3	0:26	10	302	229
Blowers (Handheld)	5	0:19	33	0:33	10	0:07	5	85	196
Blowers (Backpack)	4	0:21	16	7:23	1	1:43	2	507	196
Trimmers/ Edgers/ Brushcutters	12	0:13	199	0:11	28	0:15	8	65	121
Chainsaws	3	0:05	6	0:00	0	2:24	1	213	289
* 2 lawn and garden tractor instrumentations yielded less than 5 minutes of on-time - results not used									

To develop these estimates from the daily logger data ERG grouped all readings by OFFROAD's day of week periods (Monday – Thursday, Friday, and Saturday – Sunday), summed the on-time values, and divided by the number of unit-days of operation during that period. Annual totals were projected from the weekly totals, assuming 52 weeks of operation per year. Since the data were collected in the spring/summer time period, a seasonal activity ratio of 0.80 was applied to the 6-month summer hour total to represent the 6 remaining months of the year.[12]

Equipment activity likely varies on a seasonal basis. Although the field data collection period was limited to the April – July timeframe, an attempt was made to identify such variation

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[11] Given the challenges faced with assigning dates to data loggers with low batteries, and the improbability that commercial lawn and garden entities frequently operated at every hour of the day, ERG feels strongly that the hour-of-day data was incorrectly recorded by the data loggers and should not be used to adjust the hourly distribution of activity for commercial lawn and garden equipment in the OFFROAD Model.

[12] Ratio obtained from OFFROAD's Season.dat file for lawn and garden equipment.

on a monthly basis. Table 36 below summarizes the average duration of use per day for the different equipment types with significant amounts of logger data retrieved.

Table 36. Average Use per Unit per Day, by Month (hrs:mins)

Equipment Type	April	May	June	July
Riding Mowers	2:25	0:30	NA*	0:43
Lawn Mowers	0:49	0:41	2:06	1:06
Hand-held Blowers	1:21	0:26	0:08	0:18
Backpack Blowers	0:06	NA*	0:55	1:16
Trimmers/Edgers/Brushcutters	0:17	0:28	0:10	0:08
Chainsaws	0:10	2:24	0:03	NA*
* No logger data available for month/equipment type combination				

Most likely due to the limitations of the instrumentation data set, no obvious trends in seasonal activity are apparent in this table. Instrumentation of more equipment, over additional seasons, may make such trends evident.

The number of successful logger downloads that passed QA screening was relatively small (42), ultimately limiting the accuracy and reliability of the resulting activity projections. As seen in Table 35, the number of unit-days of operation was limited, particularly for Friday measurements. Therefore ARB may consider aggregating certain equipment categories, such as hand-held and backpack blowers, or riding and other mowers, in order to improve the robustness of the activity projections.

Equipment categories lacking adequate logger data can utilize default activity values from OFFROAD. These categories include lawn and garden tractors, shredder/chippers, tillers, wood splitters, stump grinders, snowblowers, and "other" equipment.

Equipment Population Surrogates

ERG identified surrogate data to be used to extrapolate the survey findings to California as a whole. In consultation with ARB, two sets of surrogates were identified for association with the different commercial and institutional categories – GIS data and data from the U.S. Census Bureau's County Business Patterns (CBP). Commercial categories were derived from NAICS codes for this analysis. Institutional categories consisted of a number of different facility/location types maintained by public entities, as identified by both ARB and ERG. Table 37 shows which categories were extrapolated using GIS data (and the layer name) and which were extrapolated using the CBP data.

Table 37. Surrogate Selection by Equipment Operator Category

Subcategory	Data Source	NAICS code	NAICS description
Airport	GIS-Landmarks (acres)	--	Airport
Cemetery	GIS-Landmarks (acres)	--	Cemetery
Construction Rental	CBP	53241	Construction, Mining, and Forestry Machinery and Equipment Rental and Leasing
Farm	CBP	115116	Support Activities for Crop Production
Fire Stations	GIS - Public Buildings (locations)	--	Fire Stations
Fisheries	US FWS - locations	--	National Fish Hatcheries
Forestry	CBP	1133	Logging
General Rental	CBP	5323	General Rental Centers
Golf Courses	GIS-Landmarks (acres)	--	Golf Courses
Government	GIS - Public Buildings (locations)	--	Government
Industry	CBP	311-339	All Manufacturing
Landscaping	CBP	56173	Landscaping Services
Misc. Business	CBP	Many	Many*
Prison	GIS-Landmarks (acres)		Prison
Ranch	CBP	1152	Cattle Ranching and Farming
Real Estate	CBP	5313	Activities Related to Real Estate
Religious buildings	CBP	8131	Religious Organizations
Schools	GIS-Landmarks (acres)		Schools
Utility	GIS-Roads & Utilities (acres)		Utility
Wineries	CBP	312130	Wineries

* Includes wholesale and retail trade, information services, finance and insurance, and professional/scientific/technical services

For those categories associated with the CBP data, the table also shows what NAICS code was used to represent that category. All of those categories having GIS data were calculated using acreage except for public buildings. The public buildings GIS layer gave locations instead of area, so it was calculated like the CBP data (i.e., based on number of locations).

Statewide, county, and airbasin level equipment counts were calculated by applying these surrogates to the survey results, by operator category, as indicated below:

GIS data - Acres
Equipment count = (Avg. equipment count/avg acres) * sum of area (acres) per region

CBP Surrogates (and public buildings) - Facility Count
Equipment count = Avg. equipment count * count of facilities per region

Table 38 provides a summary of the extrapolated statewide commercial lawn and garden equipment totals, by operator category. The detailed equipment population allocation factors by county and air basin are provided by equipment type in Appendix G.

Table 38. Statewide Population Estimates, by Operator Category (2005)

Operator Category	# Units Statewide	Percent
Airport	1,856	0.04%
Cemetery	4,556	0.10%
Construction Rental	1,222	0.03%
Farm	516	0.01%
Fire Stations	357	0.01%
Fisheries	8	0.00%
Forestry	5,652	0.12%
General Rental	1,671	0.04%
Golf	5,285	0.12%
Government	24,758	0.54%
Industry	153,561	3.37%
Landscaping	3,150,356	69.20%
Misc. Business	864,966	19.00%
Prison	5,267	0.12%
Ranch	2,632	0.06%
Real Estate	21,058	0.46%
Religious buildings	53,945	1.18%
School	91,975	2.02%
Utility	160,924	3.53%
Wineries	2,020	0.04%
Total	**4,552,584**	

As seen from the table, over 90% of the lawn and garden equipment population is used in the commercial sector for general landscaping, industrial, or other miscellaneous applications. For this reason it was concluded that none of the institutional categories merited having their equipment emissions calculated and reported separately by the OFFROAD model.

Statewide equipment category totals were also compared to the current default values in the OFFROAD model, as shown in Table 39.

Table 39. Revised vs. Default OFFROAD Equipment Populations by Type

OFFROAD Categories	Survey	OFFROAD Default
Chainsaws <=5 HP	165,789	118,830
Chainsaws <=5 HP Preempt	Not identified^	61,128
Chippers/Stump Grinders*	19	748
Commercial Turf Equipment	Not identified^	13,888
Front Mowers	Not identified^	10,546
Lawn & Garden Tractors	48,198	6,627
Lawn Mowers	1,920,819	229,820
Leaf Blowers/Vacuums	573,799	102,550
Other Lawn & Garden Equipment	306,695	438,990
Rear Engine Riding Mowers	132,215	3,516
Shredders	9,418	133,834
Snowblower*	0	7,290
Tillers	12,470	44,701
Trimmers/Edgers/Brush Cutters	1,383,135	341,086
Wood Splitters*	27	111,707
Total	**4,552,584**	**1,625,261**

* Sample size too small – OFFROAD defaults used.

^ Categories not explicitly called out in survey – likely included under other categories.

As seen in the table, the revised estimates drastically increase the equipment population totals for the state. Most notably, estimates for lawn mowers and trimmers/edgers/brushcutters both increased by several hundred percent. Of the significant equipment types, only shredders, tillers and other lawn and garden equipment categories were substantially lower in their population estimates than the default values.

5.0　Conclusions and Recommendations

Key Findings

The data collected under this study can be used as the basis for updating numerous parameters in the current OFFROAD model for commercial lawn and garden equipment. Key generalizations from the study include:

1) Overall, equipment populations were substantially higher than OFFROAD default values;

2) Mowers, trimmers/edgers/brushcutters, and blowers were by far the most common equipment types reported, as expected;

3) Equipment is characterized by quick turnover, with the vast majority of units retired within 5 years of use;

4) Gas-powered equipment dominates the sector, with only lawn and garden tractors being predominantly diesel-powered;

5) Diesel fuel use is relatively higher for institutional entities compared to commercial companies;

6) Over 90% of the projected equipment population is operated by commercial entities (general landscaping, miscellaneous businesses, and industry categories);

7) Commercial equipment use per unit is substantially higher than that for institutional equipment; and,

8) Climate zone appears to have a substantial impact on overall lawn and garden service activity (although this was not verifiable using logger data).

Study Limitations

A number of constraints and difficulties in the data collection and evaluation process limited the utility of certain equipment parameter data. Most importantly, the activity data obtained from the loggers was reduced to approximately 25% of the target value, severely limiting the comprehensiveness, representativeness, and overall value of the data. The thinness of the resulting data set had the following implications for the study as a whole:

- Several equipment types did not have any useable logger data to evaluate for activity patterns, including chippers/stump grinders, shredders, snowblowers, tillers, wood splitters, and "other" lawn and garden equipment. Although equipment populations for these categories are expected to be small (based on

OFFROAD and EPA NONROAD defaults), nothing can be inferred regarding hours of activity or temporal profiles for these specialized equipment categories.

- Another equipment type, lawn and garden tractors, did not yield enough usable logger data for activity analysis.

- For those equipment types with reliable logger data, the activity profiles were relatively thin, yielding just a few observations for shorter time periods. For example, the Friday time period had only one logger download for riding mowers. Similarly, there was only one logger download available for chainsaws during the Saturday-Sunday time period. Accordingly, disaggregated activity projections for these time periods may yield unrepresentative results, depending on the equipment category.

- The thinness of the data set also ruled out further stratification by important variables, such as climate zone. (As shown in Table 27 above, climate zone appears to have a substantial impact on overall lawn and garden service activity).

- The instrumentation time frame itself was limited to the four-month period between April and July. Therefore seasonal variation in activity could not be assessed.

Although less significant, the survey data was also limited in a few regards:

- The survey did not include explicit equipment categories for commercial turf equipment or front mowers. We anticipate that many of these units may have been reported in the "Other" equipment category, and in the case of front mowers, in the "riding mower" category. Overall populations of this equipment are expected to be relatively low, however.

- The survey did not differentiate between preempted and non-preempted chainsaws. (Survey estimates may be split between these categories using default population ratios from OFFROAD.)

- Qualitative responses regarding typical throttle position are difficult to translate to quantitative load factors without additional correlative data (e.g., rpm).

Recommendations for use of the current data sets, as well as for improvements to future studies, are provided below, considering the strengths and weaknesses of the available information.

Recommendations

Robust survey responses were received for a number of equipment types and characteristics, which may be adjusted if needed, to update OFFROAD model parameters.[13] Table 40 summarizes which equipment category/parameter combinations are recommended for update (indicated by check marks), based on the survey responses and surrogate extrapolations.[14]

Table 40. Recommended OFFROAD Model Updates – Equipment Characteristics

Equipment Category	Population	Avg. HP	Age Distribution	Fuel Tank Size	Fuel Tank Composition	Growth/Scrap Rates	Fuel Can Use
Chainsaws	√	√	√	√	√		
Chippers/Stump Grinders							
Commercial Turf							
Front Mowers							
Lawn and Garden Tractors	√	√		√	√		
Lawn Mowers	√	√	√	√	√		
Leaf Blowers/Vacuums	√	√	√	√	√		
Other Lawn and Garden	√	√		√	√		
Riding Mowers	√	√	√	√	√		
Shredders	√				√		
Snowblowers							
Tillers	√	√		√	√		
Trimmers/Edgers/Brushcutters	√	√	√	√	√		
Wood Splitters							
ALL CATEGORIES						√	√

As noted above, activity data obtained from data logger instrumentations were significantly limited. As such, we recommend aggregating the activity data in Table 35 in the following fashion:

- For Riding Mowers and Lawn Mowers, combine Monday-Thursday and Friday time periods;

- Combine hand-held and backpack blowers into one equipment category. This should provide adequate detail to retain the Monday-Thursday/Friday/Saturday-Sunday time periods in the OFFROAD model;

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[13] We recommend adjusting the equipment age distributions by applying a smoothing function to the current data before inclusion in OFFROAD, as discussed in Section 4.

[14] In ERG's opinion the fuel type distributions by equipment category seen in the survey response largely validated the OFFROAD model defaults, and do not merit update.

- For chainsaws, combine all readings into a single 7-day week period.

In order to address shortcomings in future studies, we recommend the following modifications to the data collection methods:

1) Either increase the number of instrumentation kit mail outs substantially (i.e., by a factor of 4), or institute a much more aggressive logger retrieval policy (e.g., with substantial increases in the incentive payment upon receipt of a logger). Roughly half of the loggers sent out to study recruits were not returned.

2) Pre-test all logger batteries before mail out of instrumentation kits. Alternatively, investigate the cost and feasibility of installing longer life batteries in the units. Approximately half of the logger download failures in this study were a result of low battery levels.

3) Extend instrumentation period to include fall and winter time periods.

4) Develop specific targeting strategies for specialty equipment categories such as snowblowers and wood splitters.

5) Modify activity strata to include just 2 Climate Zones. Table 27 indicates that climate zones 1 and 2 could be merged, as could zones 3 and 4, without loss of activity specificity.[15]

Finally, certain questions of interest were not addressed in this scope of work. Accordingly, future studies could be designed to investigate the following issues:

- Investigate the impact of socio-economic variables on commercial lawn and garden activity. Survey sample frames could be weighted to account for such variables using available census tract information.

- Identify additional correlates for growth surrogates. A future evaluation may involve trend analyses correlating equipment activity growth with acreage and census tract population, as well as with reported values (like those collected in this study).

- Identify or collect equipment sales data by SIC in order to validate the use of the GIS and CBP surrogates used in this study.

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[15] Climate Zone 5 had too few responses (4) to generalize in this regard.

Appendix A – Commercial and Institutional Questionnaires

PROGRAMMER NOTES:

A) **SAMPLE IMPORT SPECS: We may add more fields after we have received the sample.**
   i)   **SAMPN – (Sample Number); Number ; Field width = 7**
   ii)   **REP – (Replicate); Number; Field width = 3**
   iii) **LISTD – (Listed or Unlisted); Number; Field width = 1; 1=Listed, 2=Unlisted**
   iv)   **STYPE – (Sample Type); Number; Field width = 1; 1=Commercial, 2=Institution**
   v)   **PHONE – (Phone number with dashes);Text; Field width = 12**
   vi)   **BNAME - (Business Name); Text; Field width = 50**
   vii) **CTFIP – (County Fipscode); Text; Field width = 5**

INTRODUCTORY TEXT
INTRO1   IF COMMERCIAL

Hi, my name is _____ and I'm calling on behalf of NuStats. We are not selling anything. We are conducting a study on the use of lawn and garden equipment by businesses and would like to include your organization's input. Your answers are for research purposes only and will be held strictly confidential.

May I speak with [someone responsible for the lawn and garden services your organization provides]?

[REPEAT INTRO PARAGRAPH 1 WITH APPROPRIATE PERSON ON PHONE].

Essential info:
ID selves (and whom we're calling for if pressed, State of California)
Not selling anything
Purpose of call—"conducting a study on the use of lawn and garden equipment by businesses"
Strictly confidential
Appropriate screening (asking for someone "responsible for the lawn and garden services" provided by the organization)

INTRO2   IF INSTITUTION

Hi, my name is _____ and I'm calling on behalf of NuStats. We are not selling anything. We are conducting a study on the use of lawn and garden equipment by institutions and would like to include your organization's input. Your answers are for research purposes only and will be held strictly confidential.

May I speak with [someone responsible for lawn and garden maintenance in your organization]?

IF NEEDED: May I speak with the person responsible for contracting out this service?

[REPEAT INTRO PARAGRAPH 1 WITH APPROPRIATE PERSON ON PHONE].

Essential info:
ID selves (and whom we're calling for if pressed, State of California)
Not selling anything
Purpose of call—"conducting a study on the use of lawn and garden equipment by institutions"
Strictly confidential
Appropriate screening (asking for someone "responsible for the lawn and garden maintenance"
of the organization; if contracted out, asking for someone "responsible for contracting out this
service")

INTRO3

Hi, my name is _____ and I'm calling on behalf of NuStats. We are not selling anything. We are conducting a study on the use of lawn and garden equipment by institutions and would like to include your organization's input. I was referred to you by [NAME OF PERSON] in your company because you are knowledgeable about your organization's equipment use and inventory. Your answers are for research purposes only and will be held strictly confidential.

PROGRAMMER NOTE:

- *THIS INTRO IS ASKED IF SQ7 AND SQ8 IS NO.*
- *SQ QUESTIONS WITH A RESPONSE OF DK/RF SHOULD BE ASKED BEFORE PROCEEDING TO Q1.*

INTRO 4

Hi, my name is _____ and I'm calling on behalf of NuStats. We are not selling anything. We are conducting a study on the use of lawn and garden equipment by institutions. I was referred to you by [NAME OF PERSON AND INSTITUTION] because your company services their property(s). Your answers are for research purposes only and will be held strictly confidential.

IF NEEDED: May I speak with the person responsible for providing this service to this company?

[REPEAT INTRO PARAGRAPH 1 WITH APPROPRIATE PERSON ON PHONE].

[**PROGRAMMER NOTE for CATI Institution program only**: Display "Institution Referral: <BNAME>" throughout the program for records that are Institution Referrals. "BNAME" is the name of the Institution that referred us]

Commercial Screening Questions

SQC1. Which of the following services does your business provide? MULTIPLE RESPONSE.

Residential property lawn and garden maintenance	1	SKIP TO SQC3
Landscaping contractor	2	SKIP TO SQC3
Commercial property lawn and garden maintenance	3	
Tree Service	4	SKIP TO SQC3
Other [SPECIFY:_____]	7	SKIP TO SQC3

SQC2.Which of the following commercial properties does this include? MULTIPLE RESPONSE.

Businesses	1
Schools, colleges, universities	2

Golf courses 3

Industrial facilities 4

Parks 5

Airports 6

Transportation/Utility Department 7

Military Base 8

Cemeteries 9

Other government properties 10

Other [SPECIFY:_____] 97

SQC3. How many properties does your business usually service each week? An estimate is okay.

OPEN RESPONSE [RANGE 1-97]

DK 98

RF 99

SQC4. What is the total acreage that your business services per week? An estimate is okay. *NOTE TO INTERVIEWER: SMALL LOT OF LESS THAN 1 ACRE = 1]*

OPEN RESPONSE [RANGE 1-9,997]

DK 9998

RF 9999

SQC5.How many hours do you usually spend in servicing all your clients? An estimate is okay.

A. SPECIFY NUMBER OF HOURS [RANGE 1-9997]
DK   9998

RF   9999

B. SPECIFY UNIT [(1)PER WEEKDAY, (2)PER WEEK, (3)PER MONTH]
       DK/RF   9

SQC6. I would like to know how many gallons of fuel your business uses each month to refuel your lawn and garden equipment.

A1. On average, how many gallons of gasoline does your business use each month to refuel your lawn and garden equipment? An estimate is okay.

OPEN RESPONSE [RANGE 0-997]

NONE/DON'T USE GAS   000   SKIP TO SQC6B1

DK   998   SKIP TO SQC6B1

RF   999   SKIP TO SQC6B1

A2. How do you refuel your gasoline equipment? Is it by portable can or pump?

Portable Can   1

Pump   2

DK   8

RF   9

B1. On average, how many gallons of diesel does your business use each month to refuel your lawn and garden equipment? An estimate is okay.

OPEN RESPONSE [RANGE 0-997]

NONE/DON'T USE DIESEL   000   SKIP TO SQC7

DK   998   SKIP TO SQC7

RF   999   SKIP TO SQC7

B2. How do you refuel your diesel equipment? Is it by portable can or pump?

Portable Can   1

Pump   2

DK   8

RF   9

NOTE TO PROGRAMMER: IF SCQ4 – SCQ6B = DK AND/OR RF, SKIP TO SQC8]

SQC7. The next series of questions are very specifically related to your inventory of lawn and garden equipment. Would you be the person in your company who is most knowledgeable to answer these questions?

YES   1   SKIP TO Q1.

NO   2

SQC8. May I speak to someone who is more familiar with your company's lawn and garden services and equipment?

YES [GET NAME/TRANSFER;RESTART INTRO 3]   1

NOT IN OFFICE   2

   [THANK AND CONCLUDE; GET NAME; ASSIGN AS CALL BACK]

DK/RF   9   THANK AND
CONCLUDE

Institution Screening Questions

SQI1.Which of the following best describes your organization? MULTIPLE RESPONSE

School, college, university 1

Golf course 2

Industrial facility 3

Park 4

Airports 5

Transportation/Utility Department 6

Military Base 7

Cemetery 8

Commercial business 9   THANK AND CONCLUDE

Other [SPECIFY:_____] 97

SQI2. How many campuses or individual properties do you manage in California?

One 1

Two 2

Three 3

Four 4

Five or more 5

SQI3. Is the lawn and garden maintenance of these properties in California conducted by an in-house staff or is this service contracted out?

In-house staff	1
Contracted out	2 SKIP TO SQI9
Mixed	3

SQI4. [IF RESPONDENT IS A FLAGGED INSTITUTION REFERRAL: The next series of questions only apply to the Institution that referred us to you.]

What is the total acreage of these properties in California serviced by your in-house staff ?An estimate is okay. [IF RESPONDENT IS A FLAGGED INSTITUTION REFERRAL: … acreage of this property in California serviced by your company?]

OPEN RESPONSE [RANGE 1-9,997]

DK   9998

RF   9999

SQI5. How many hours does your organization usually spend in servicing your property(s) [this property—IF RESPONDENT IS A FLAGGED INSTITUTION REFERRAL?] in California? An estimate is okay.

A. SPECIFY NUMBER OF HOURS [RANGE 1-9997]
DK   9998

RF   9999

B. SPECIFY UNIT [(1)PER WEEKDAY, (2)PER WEEK, (3)PER MONTH]

DK/RF   9

SQI6. I would like to know how many gallons of fuel your organization uses each month to refuel your lawn and garden equipment. [NOTE TO INTERVIEWER, IF FLAGGED INSTITUTION REFERRAL: This applies to only the institution that referred us to you.]

A1.   On average, how many gallons of gasoline does your business use each month to refuel your lawn and garden equipment? An estimate is okay.

OPEN RESPONSE [RANGE 0-997]

NONE/DON'T USE GAS   000   SKIP TO SQI6B1

DK   998 SKIP TO SQI6B1

RF   999 SKIP TO SQI6B1

A2. How do you refuel your gasoline equipment? Is it by portable can or pump?

Portable Can   1

Pump   2

DK   8

RF   9

B1. On average, how many gallons of diesel does your business use each month to refuel your lawn and garden equipment? An estimate is okay.

OPEN RESPONSE [RANGE 0-997]

NONE/DON'T USE DIESEL   000   SKIP TO SQI7

DK   998   SKIP TO SQI7

RF   999   SKIP TO SQI7

B2. How do you refuel your diesel equipment? Is it by portable can or pump?

Portable Can   1

Pump   2

DK   8

RF   9

[NOTE TO PROGRAMMER: IF SQI4 – SQI6B = DK OR RF, SKIP TO SQI8]

SQI7. The next series of questions are very specifically related to your organization's inventory of lawn and garden equipment. [IF FLAGGED INSTITUTION REFERRAL: …and

garden equipment used to service the institution that referred us.] Would you be the person who is most knowledgeable to answer these questions?

YES   1   SKIP TO Q1.

NO   2

SQI8. May I speak to someone who is more familiar with your organization's lawn and garden equipment?

YES [RESTART INTRO 3]   1

NOT IN OFFICE   2

 [THANK AND CONCLUDE; GET NAME; ASSIGN AS CALL BACK; RESTART INTRO 3]

DK/RF   9   THANK AND CONCLUDE

SQI9. *[PROGRAMMER: ASK ONLY IF SQI3=2; THIS ITEM TO BE FLAGGED AS AN "INSTITUTION REFERRAL FLAG"]* The next series of questions are related to the equipment that is used to service your organization's property. Could you provide the name and phone number of the business that services your property?

YES   1

 [GET NAME AND CONTACT INFORMATION; ASSIGN AS CALL BACK; RESTART WITH INTRO 4]

NO   2   THANK AND TERMINATE

DK/RF   9   THANK AND TERMINATE

EQUIPMENT AND USAGE

The next series of questions will focus only on lawn and garden equipment contained in your organization's inventory of owned equipment. [IF FLAGGED INSTITUTION

REFERRAL: The next series of questions will focus only on lawn and garden equipment contained in your organization's inventory used to service <BNAME>.]

[PROGRAMMER NOTE: "BNAME" is the name of the Institution that referred us]

Q1.   I am going to read a list of lawn and garden equipment. Please indicate whether it is included in your organization's inventory. [NOTE TO INTERVIEWER: REFER TO PHOTOS TO CLARIFY EQUIPMENT TYPES, IF ASKED.]

[IF NEEDED: This refers only to power equipment, either fuel or electric. It does not include equipment operated manually.]

[IF FLAGGED INSTITUTION REFERRAL: …your organization's inventory used to service the institution that referred us.]

[IF FLAGGED INSTITUTION REFERRAL: Again, this only refers to that equipment you use to service <BNAME.]

	YES	NO	DK/RF
a. Leaf Blower (Back-pack)	1	2	9
b. Leaf Blower (Hand-held)	1	2	9
c. Chain Saw	1	2	9
d. Brush cutter	1	2	9
e. Lawn Edger	1	2	9
f. Lawn Mower (walk behind)	1	2	9
g. Riding Lawn Mower	1	2	9
h. Lawn & Garden Tractor	1	2	9
i. Shredder/Chipper	1	2	9
j. Wood Splitter	1	2	9
k. Stump Grinder	1	2	9
l. Snow Blower	1	2	9
m. String trimmer	1	2	9

n. Tiller	1	2	9
o. Other: (specify)	1	2	9

PROGRAMMER NOTES:

- ***ROSTER ITEMS AS [EQUIPMENT TYPE] IN Q1 = 1 for Questions 2 –5 (HORIZONTAL ROSTER)***
- ***FOR PRETEST—ADD COMMENT THAT IF MORE THAN ONE OTHER, SPECIFY EQUIPMENT TYPE.***

Now I am going to ask you a series of questions about each type of equipment contained in your organization's inventory.

PROGRAMMER NOTE: WORDING IF "INSTITUTION REFERRAL" NOW I AM GOING TO ASK YOU A SERIES OF QUESTIONS ABOUT EACH TYPE OF EQUIPMENT USED TO SERVICE [NAME OF COMPANY PROPERTY].

Q2.   Regarding [EQUIPMENT TYPE], how many are contained in your inventory that are …….?

A. … gasoline fueled
      OPEN RESPONSE [RANGE 0-97]

      DK   98

      RF   99

B. ….Diesel fueled
      OPEN RESPONSE [RANGE 0-97]

      DK   98

      RF   99

C. …..Electric

OPEN RESPONSE [RANGE 0-97]

DK   98

RF   99

Q3.   On Average, how MANY TIMES DO YOU USE [EQUIPMENT TYPE]? An estimate is
       okay.

       A. SPECIFY NUMBER [RANGE 0-97]
           DK   98

           RF   99

       B. SPECIFY UNIT [(1)PER WEEKDAY, (2)PER WEEK, (3)PER MONTH, (4)PER
           YEAR]
           DK/RF   9

Q4.   [PROGRAMMER NOTE: IF Q2 A OR Q2B> 0, ASK THIS QUESTION] What would
       you say is the most used throttle setting on [EQUIPMENT TYPE]? Would that be Light,
       Medium or Full?

       Light   1

       Medium   2

       Full   3

       DK   8

Q5.   On average how often do you refuel [EQUIPMENT TYPE]?

       A. SPECIFY NUMBER [RANGE 0-97]
           DK   98

                           RF   99

B. SPECIFY UNIT [(1)PER WEEKDAY, (2)PER WEEK, (3)PER MONTH, (4)PER YEAR]
   DK/RF   9

[NOTE TO PROGRAMMER: VERTICAL ROSTER FOR Q6-Q7D. THERE ARE 15 ROSTERS, ONE FOR EACH EQUIPMENT TYPE INCLUDING THE "OTHER".]

Q6.   A. What is the make of [EQUIPMENT TYPE] in your inventory that you use the (next) most often? NOTE TO INTERVIEWER: DO NO READ. IF NEEDED: THIS INCLUDES ONLY THOSE FUEL OR ELECTRIC-POWERED.

OPEN RESPONSE

[NOTE TO PROGRAMMER: CREATE A PULL DOWN LIST USING THE FOLLOWING MAKES.]

Ariens
Briggs & Stratton
Bandit
BCS
Clarke
Craftsman
Echo
Ex Mark
Great Dane
Hitachi
Husky
Husqvarna
Honda
John Deere (JD, Kid II)
Kubota
McClane
Murray (briggs)
Poulan
Red Max
Ryan
Shindawa
Skag
Snapper
Steel Mags
Snapper

Stihl
Tanaka
TMC
Toro
Trucut
Vermer
Walker

OTHER [SPECIFY]	*97*
DK	*98*
RF	*99*

B. And what is the model name or number?
       OPEN RESPONSE

DK	8
RF	9

[NOTE TO PROGRAMMER: IF MORE THAN ONE MAKE/MODEL, ROSTER QUESTIONS Q7A,B, and C TO CORRESPOND TO EACH] MULTIPLE RESPONSE]

C. How many [EQUIPMENT TYPE] do you have?
       OPEN RESPONSE [RANGE 1-97]

DK	*98*
RF	*99*

Q7.   Of your [MAKE/MODEL EQUIPMENT TYPE]

A. What is the horsepower or displacement?
       OPEN RESPONSE [RANGE 1-997]

DK	998
RF	999

UNIT [CC OR HP]

HORESPOWER   HP

DISPLACEMENT   CC

DK   98

RF   99

B. How about the average age?
        OPEN RESPONSE [RANGE 0-97 YEARS WHERE 0=BRAND NEW OR LESS
THAN 1 YR]

UNIT [YEAR]

NEW, LESS THAN 1 YR OLD   00

DK   98

RF   99

C. What is the size of the fuel tank?
        OPEN RESPONSE [RANGE 0-97]

NOTE: IF NO FUEL TANK, ENTER 0.

DK   98

RF   99

UNIT [(1)PINTS, (2)QUARTS,(3)(GALLONS),(4)(LITERS)]

DK   8

RF   9

D. What is the composition of the fuel tank?
        Plastic   1

Metal   2

Other [Specify]	7
DK	8
RF	9

Q8. Do you plan on replacing or buying any additional lawn and garden equipment during the next 12 months?

[IF FLAGGED INSTITUTION REFERRAL: Again, this only refers to equipment you will use to service <BNAME>.]

YES	1
NO	2 SKIP TO Q 11
DK/RF	9 SKIP TO Q 11

Q9. What equipment types would that be.

LIST ALL.

[NOTE TO PROGRAMMER: MAY USE A POP UP SCREEN WITH A LIST OF ALL EQUIPMENT TYPES DRAWN FROM Q1. HORIZONTAL ROSTER ALL TYPES FOR Q10A - 10C]

Q10. For [EQUIPMENT TYPE FROM Q9]

A. How many are you replacing?
OPEN RESPONSE [RANGE 0-97]

| DK | 98 |
| RF | 99 |

B. How many are you adding to your inventory?
OPEN RESPONSE [RANGE 0-97]

| DK | 98 |

C. Will you buy the equipment new or used?

New   1

Used   2

New and Used   3

DK   8

RF   9

Instrumentation—Willingness to Participate Questions

Thank you. That's all the questions I have for you today.

We are also conducting a follow up study during which participants will be asked to attach a small recording devise on up to five pieces of lawn and garden equipment for two weeks. These easy-to-attach devices can automatically record equipment usage. Afterwards, participants return the devices using pre-addressed, postage-paid envelopes. This portion of the study will be conducted now through next Spring.

Q11. Are you interested in participating in this follow up study?

YES   1   CONFIRM NAME/PHONE

NO   2

Q12. If you are able to help us with this important study, we will provide you with $20 per piece of equipment for your time. Would you be willing to participate in the follow up study?

YES   1 CONFIRM NAME/PHONE
NO   2 THANK & CONCLUDE

Appendix B – Advance Notification Letter

<<Date>>
«COMP_NAME»
«ADDRESS»
«CITY», «STATE» «ZIP»
Dear «DEAR_TEXT»:

Your organization has been selected to participate in the **California Statewide Lawn and Garden Equipment Usage Survey**, sponsored by the State of California. The survey goal is to create an inventory of lawn and garden equipment used in commercial and institutional landscaping and maintenance activities throughout the state. The information you provide will be used to estimate the impact of lawn and garden equipment on air quality. Your participation will improve state and local planners' ability to make fair and equitable decisions regarding air quality improvements in California.

Within the next two weeks, we will initiate a phone interview with you (or a designated representative) about your organization's inventory and usage of lawn and garden equipment. Your organization was randomly selected based on your geographic location and type of business. Participation in the survey is voluntary; however, your participation ensures the scientific representation we need for your geographic location. The data collected is confidential and will only be used to create an inventory of statewide lawn and garden equipment. This inventory will not contain any information on you (or the designated representative) or your organization.

If you are not the appropriate person to contact for this survey, please contact Sandra Rodriguez at 1-800-447-8287 x2231 and forward this letter to that person. Also if you have any questions about this important study, contact Sandra or me directly at 1-800-447-8287 x 2224.
In advance, thank you for taking time to help with this worthwhile project.
Sincerely,

Mia Zmud
Research Director

Appendix C – Interviewer Training Manual

ARB Lawn and Garden Equipment Commercial and Institution Surveys

Introduction
The California Air Resources Board (ARB) gathers air quality data and sets air quality standards for the state of California. Presently, the ARB is conducting a study of emissions from small, "off-road" engines, such as lawnmowers, edgers, trimmers, leaf blowers, and chainsaws. We will be surveying lawn and garden service companies in California about their use of this type of equipment. We also will be surveying large institutions, such as universities or large businesses, about their use of this equipment for their own lawn and garden maintenance. We will also recruit a few organizations to attach a small recording device to some of their equipment to determine when and for how long the equipment is used.

Project Scope
We will be completing surveys with a total of 300 California organizations. Of these, we will complete up to 240 surveys with companies which provide lawn and garden services to other organizations or to residential properties. We will complete at least 60 surveys with either institutions which do their own lawn and garden maintenance, or with the companies these institutions contract to do it for them.

For our pilot, which runs until December 16, we will be completing 20 "commercial" surveys and 20 "institutional" surveys. The commercial surveys will be conducted with lawn and garden service companies in the pilot program ARBC1. The institutional surveys, whether conducted with an institution doing their own lawn and garden maintenance or with the company they've contracted to do it, will be conducted in the pilot program ARBI1.

We will use the data from the pilot to assess the effectiveness of the survey, its flow, and its length, as well as the effectiveness of our means of gaining cooperation. However, the pilot is more than a learning exercise, because if possible, the completes from the pilot will count toward our overall goal for the survey.

Commercial and Institutional Sample
Our sample has been divided into two types, "Commercial" and "Institutional". The commercial sample loaded into ARBC1 consists of companies which provide lawn and garden services. The institutional sample loaded into ARBI1 consists of organizations which are reasonably likely to do their own lawn and garden maintenance. However, it is also likely that many organizations in ARBI1 actually contract out for these services. In these cases, we will attempt to obtain the contact information of the company which provides these services to our institutions, and conduct the survey with them. This sample, though, will remain in ARBI1 and will count as an "Institutional" complete. We refer to such cases as "Institution Referrals", since we are actually conducting the surveys with the companies contracted by, or referred to us by, the Institutions. Please note that with an Institution Referral in ARBI1, we will actually be surveying a company more like the commercial lawn and garden surveys in ARBC1. However, with an Institution Referral, our questions will focus not on that company's overall lawn and garden inventory, but instead on the inventory used by that company for the Institution which referred us.

Inventory

The focus on the survey is on inventory—specifically, lawn and garden service equipment powered either by fuel or by electricity. We will not be surveying companies about equipment they operate only manually.

The following are the types of equipment we'll be asking about:

- Leaf Blower (Back-pack)
- Leaf Blower (Hand-held)
- Chain Saw
- Brush cutter
- Lawn Edger
- Lawn Mower (walk behind)
- Riding Lawn Mower
- Lawn & Garden Tractor
- Shredder/Chipper
- Wood Splitter
- Stump Grinder
- Snow Blower
- String trimmer
- Tiller
- Other: (specify)

Please note that if an organization uses a type of power equipment we haven't listed, we'll capture it with "Other/specify".

For each type of equipment in the company's inventory, we'll ask about the frequency of its use; its age; the type of power, whether gasoline, fuel or electric; how, and how often they re-fuel the equipment. For each make and model, we'll ask about the quantity, the average age, the horsepower or displacement, and the size and composition of the fuel tank, if any.

We'll also be asking about whether the organization plans to replace or add power equipment to their inventory, and whether the equipment will be purchased new or used.

Screening Respondents

It will be important to conduct the survey with a knowledgeable Respondent. We will initially ask a few questions to a person responsible for the lawn and garden services provided by the company (if Commercial in ARBC1), to a person responsible for the lawn and garden maintenance in their organization (if Institution in ARBI1), or to a person responsible for providing lawn and garden maintenance to a particular institution (if Institution Referral in ARBI1). These initial screening questions provide an overview of that Commercial company's services or that Institution's needs.

With Commercial sample in ARBC1, we'll ask about the type of services they provide, the type of organization provided to, how many properties they service each week, the total acreage of these properties, the total number of hours spent in servicing all their clients, and how much fuel they use. Most of our Respondents are not expecting our call, and will not have exact figures. Estimates are okay. However, if the Respondent doesn't know the answer to any of these questions, we will set the case up for a call-back with a more knowledgeable Respondent. With Institution sample and Institution Referrals in ARBI1, we will ask the same sets of questions, only they will apply only to the particular Institution we are interested in. Thus, an Institution Referral may service a total of 40 acres to all of their clients, but we are only interested in how many acres they service for the Institution which referred us.

After these initial screening questions in both programs, we will ask to speak to the person responsible for the inventory of the lawn and garden equipment. Often, but not always, it will be the same person we have just screened. If it is not, we will ask to speak to the appropriate person and set the case up for a call-back if that person isn't immediately available.

Survey Intros
We will generally identify ourselves as calling on behalf of NuStats. At training, we will discuss other permissible identification, such as calling on behalf of the State of California. However, we will not volunteer that we are calling on behalf of the ARB or the California Air Resources Board. The ARB regulates many of the companies we are calling, and we do not want them to feel threatened or intimidated, nor do we want to bias their responses. If pressed by the Respondent, however, we will acknowledge that we are calling on behalf of ARB.

If you read the Introduction verbatim, you will not "go wrong". However, it is permissible to use your judgment and stray from verbatim in the Introduction. In all cases, however, it is important to communicate the following essential information:

- ID selves (and whom we're calling for if pressed, State of California or ARB)
- Not selling anything
- Purpose of call—"conducting a study on the use of lawn and garden equipment by businesses"
- Strictly confidential
- Appropriate screening (asking for someone "responsible for the lawn and garden services" provided by the organization)

Recruitment/ Incentives
At the end of the survey, we will ask Respondents if they are interested in participating in a follow-up study where they attach a small recording device to up to 5 pieces of equipment in their inventory. We are building a sample pool of interested Respondents, whom we will actually recruit in a separate phase of the project this spring. (To facilitate sample management, this phase of the project will likely be conducted at the DataSource San Marcos.) However, simply because a Respondent says that they are willing to participate in the follow-up survey does not mean they will be selected.

For those Respondents who initially state that they are not interested in the follow-up survey, we will ask them if they would be interested if we offered them a $20 incentive for each piece of equipment. However, this still does not guarantee that this particular Respondent will be selected. The actual selection process will be done this January and will be designed to ensure we have representatives from appropriate geographic areas and climates. Respondents not selected will receive no incentive.

Please do not mention the incentive unless directed by the program. In most cases, the program will refer to an incentive only if the Respondent initially states they are not interested in the follow-up.

Survey Management Team
If you have any questions during your tenure on this project, please feel free to contact member of the survey management team:

UTEP Leader:	Lucy Peden, 915-747-6134
NuStats Project Managers:	Mia Zmud, 512-306-9065, Ext. 2224
	Sandra Rodriguez, 512-306-9064, Ext. 2231
DataSource Project Coordinator:	David Gibson, 512-805-6000, Ext. 6024
DataSource Research Manager:	Jon Wivagg, 512-805-6000, Ext. 6010

If a Respondent has questions, please refer them to Mia, Sandra, or David. If necessary, we will refer their questions to the client, as appropriate.

Welcome to the team! Thank you in advance for your assistance with this important project.

Appendix D – Survey Response Quality Assurance Checks

COMMERCIAL SURVEY QUALITY ASSURANCE

1. If TIMEB is '1'; TIMEA must be ≤ 24 hours – 5000738 (32); 5001241 (40); 5000062 (40); 5000582 (152); 5001295 (560); 5000022 (1500)
2. If TIMEB is '2'; TIMEA must be ≤ 168 hours – 5001833, 5000530, 5000603, 5001053 (200); 5001685 (240); 5000065, 5000067 (280); 5000719, 5001147, 5001921 (400); 5000914 (600); 5001051 (900); 5001131 (1000); 50019746 (2400)
3. If TIMEB is '3'; TIMEA must be ≤ 744 hours (*assumes the month has 31 days) – 5002000 (800)
4. If TIMEA ≠ '9998' or '9999'; TIMEB cannot = '9'- CHECKED AND VALID
5. If TOTGS = 000; HOWGS cannot = '1' or '2' – HOWGS = IS NULL
6. If TOTDS = 000; HOWDS cannot = '1' or '2' – HOWGS = IS NULL
7. If LB2A = '98','99', or blank(null); LB2B cannot = '1','2','3',or '4' – LB2B= IS NULL
8. If LB2A ≠ '98','99', or blank(null); LB2B cannot = '98', '99', or 'blank' – CAN HAVE LB2B= "9" IF <> 98 OR <> 99. LB2B CANNOT = "BLANK" IF LB2A <> BLANK.
9. If LB4A = '98','99', or blank(null); LB4B cannot = '1','2','3',or '4'- SAME AS ABOVE.
10. If LB4A ≠ '98','99', or blank(null); LB4B cannot = '98', '99', or 'blank' - SAME AS ABOVE.
11. If HL2A = '98','99', or blank(null); HL2B cannot = '1','2','3',or '4'- SAME AS ABOVE.
12. If HL2A ≠ '98','99', or blank(null); HL2B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
13. If HL4A = '98','99', or blank(null); HL4B cannot = '1','2','3',or '4'- SAME AS ABOVE.
14. If HL4A ≠ '98','99', or blank(null); HL4B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
15. If CS2A = '98','99', or blank(null); CS2B cannot = '1','2','3',or '4'- SAME AS ABOVE.
16. If CS2A ≠ '98','99', or blank(null); CS2B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
17. If CS4A = '98','99', or blank(null); CS4B cannot = '1','2','3',or '4'- SAME AS ABOVE.
18. If CS4A ≠ '98','99', or blank(null); CS4B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
19. If BC2A = '98','99', or blank(null); BC2B cannot = '1','2','3',or '4'- SAME AS ABOVE.
20. If BC2A ≠ '98','99', or blank(null); BC2B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
21. If BC4A = '98','99', or blank(null); BC4B cannot = '1','2','3',or '4'- SAME AS ABOVE.
22. If BC4A ≠ '98','99', or blank(null); BC4B cannot = '98', '99', or 'blank'- SAME AS ABOVE.

23. If LE2A = '98','99', or blank(null); LE2B cannot = '1','2','3',or '4'- SAME AS ABOVE.
24. If LE2A ≠ '98','99', or blank(null); LE2B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
25. If LE4A = '98','99', or blank(null); LE4B cannot = '1','2','3',or '4'- SAME AS ABOVE.
26. If LE4A ≠ '98','99', or blank(null); LE4B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
27. If LM2A = '98','99', or blank(null); LM2B cannot = '1','2','3',or '4'- SAME AS ABOVE.
28. If LM2A ≠ '98','99', or blank(null); LM2B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
29. If LM4A = '98','99', or blank(null); LM4B cannot = '1','2','3',or '4'- SAME AS ABOVE.
30. If LM4A ≠ '98','99', or blank(null); LM4B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
31. If RM2A = '98','99', or blank(null); RM2B cannot = '1','2','3',or '4'- SAME AS ABOVE.
32. If RM2A ≠ '98','99', or blank(null); RM2B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
33. If RM4A = '98','99', or blank(null); RM4B cannot = '1','2','3',or '4'- SAME AS ABOVE.
34. If RM4A ≠ '98','99', or blank(null); RM4B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
35. If GT2A = '98','99', or blank(null); GT2B cannot = '1','2','3',or '4'- SAME AS ABOVE.
36. If GT2A ≠ '98','99', or blank(null); GT2B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
37. If GT4A = '98','99', or blank(null); GT4B cannot = '1','2','3',or '4'- SAME AS ABOVE.
38. If GT4A ≠ '98','99', or blank(null); GT4B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
39. If SC2A = '98','99', or blank(null); SC2B cannot = '1','2','3',or '4'- SAME AS ABOVE.
40. If SC2A ≠ '98','99', or blank(null); SC2B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
41. If SC4A = '98','99', or blank(null); SC4B cannot = '1','2','3',or '4'- SAME AS ABOVE.
42. If SC4A ≠ '98','99', or blank(null); SC4B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
43. If WS2A = '98','99', or blank(null); WS2B cannot = '1','2','3',or '4'- SAME AS ABOVE.
44. If WS2A ≠ '98','99', or blank(null); WS2B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
45. If WS4A = '98','99', or blank(null); WS4B cannot = '1','2','3',or '4'- SAME AS ABOVE.

46. If WS4A ≠ '98','99', or blank(null); WS4B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
47. If SG2A = '98','99', or blank(null); SG2B cannot = '1','2','3',or '4'- SAME AS ABOVE.
48. If SG2A ≠ '98','99', or blank(null); SG2B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
49. If SG4A = '98','99', or blank(null); SG4B cannot = '1','2','3',or '4'- SAME AS ABOVE.
50. If SG4A ≠ '98','99', or blank(null); SG4B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
51. If SB2A = '98','99', or blank(null); SB2B cannot = '1','2','3',or '4'
52. If SB2A ≠ '98','99', or blank(null); SB2B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
53. If SB4A = '98','99', or blank(null); SF4B cannot = '1','2','3',or '4'- SAME AS ABOVE.
54. If SB4A ≠ '98','99', or blank(null); SF4B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
55. If ST2A = '98','99', or blank(null); ST2B cannot = '1','2','3',or '4'- SAME AS ABOVE.
56. If ST2A ≠ '98','99', or blank(null); ST2B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
57. If ST4A = '98','99', or blank(null); ST4B cannot = '1','2','3',or '4'- SAME AS ABOVE.
58. If ST4A ≠ '98','99', or blank(null); ST4B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
59. If TL2A = '98','99', or blank(null); TL2B cannot = '1','2','3',or '4'- SAME AS ABOVE.
60. If TL2A ≠ '98','99', or blank(null); TL2B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
61. If TL4A = '98','99', or blank(null); TL4B cannot = '1','2','3',or '4'- SAME AS ABOVE.
62. If TL4A ≠ '98','99', or blank(null); TL4B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
63. If OT2A = '98','99', or blank(null); OT2B cannot = '1','2','3',or '4'- SAME AS ABOVE.
64. If OT2A ≠ '98','99', or blank(null); OT2B cannot = '98', '99', or 'blank'- SAME AS ABOVE.
65. If OT4A = '98','99', or blank(null); OT4B cannot = '1','2','3',or '4'- SAME AS ABOVE.
66. If OT4A ≠ '98','99', or blank(null); OT4B cannot = '98', '99', or 'blank' – SAME AS ABOVE
67. If PLANB = '1';
    BLBBP,BLBHH,BCS,BBC,BLE,BLMWB,BRLM,BLGT,BSC,BWS,BSG,BSB,BST,BTL, and BOTH cannot = '2' ; THIS IS CORRECT.

68. If PLANB = '2';
BLBBP,BLBHH,BCS,BBC,BLE,BLMWB,BRLM,BLGT,BSC,BWS,BSG,BSB,BST,BT
L, or BOTH cannot = '1' ; THIS IS CORRECT. THEY ARE "NULL".
69. If BLBBP = '1'; LBB1 or LBB2 cannot = 'null' and LBB3 cannot = 'null'; THIS IS
CORRECT.
70. If BLBHH = '1'; HLB1 or HLB2 cannot = 'null' and HLB3 cannot = 'null'; THIS IS
CORRECT.
71. If BCS = '1'; CSB1 or CSB2 cannot = 'null' and CSB3 cannot = 'null'; THIS IS
CORRECT.
72. If BBC = '1'; BCB1 or BCB2 cannot = 'null' and BCB3 cannot = 'null' THIS IS
CORRECT.
73. If BLE = '1'; LEB1 or LEB2 cannot = 'null' and LEB3 cannot = 'null' THIS IS
CORRECT.
74. If BLMWB = '1'; LMB1 or LMB2 cannot = 'null' and LMB3 cannot = 'null' THIS IS
CORRECT.
75. If BRLM = '1'; RMB1 or RMB2 cannot = 'null' and RMB3 cannot = 'null' THIS IS
CORRECT.
76. If BLGT = '1'; GTB1 or GTB2 cannot = 'null' and GTB3 cannot = 'null' THIS IS
CORRECT.
77. If BSC = '1'; SCB1 or SCB2 cannot = 'null' and SCB3 cannot = 'null' THIS IS
CORRECT.
78. If BWS = '1'; WSB1 or WSB2 cannot = 'null' and WSB3 cannot = 'null' THIS IS
CORRECT.
79. If BSG = '1'; SGB1 or SGB2 cannot = 'null' and SGB3 cannot = 'null' THIS IS
CORRECT.
80. If BSB = '1'; SBB1 or SBB2 cannot = 'null' and SBB3 cannot = 'null' THIS IS
CORRECT.
81. If BST = '1'; STB1 or STB2 cannot = 'null' and STB3 cannot = 'null' THIS IS
CORRECT.
82. If BTL = '1'; TLB1 or TLB2 cannot = 'null' and TLB3 cannot = 'null' THIS IS
CORRECT.
83. If BOTH = '1'; OTB1 or OTB2 cannot = 'null' and OTB3 cannot = 'null'; THIS IS
CORRECT.
84. SERV1, SERV2, SERV3, SERV4, and SERV5 should not be 'null' – THIS IS A
MULTIPLE RESPONSE QUESTION. IT DOES HAVE DATA FOR AT LEAST
SERV1, BUT NOT NECESSARILY FOR SERV2-SERV5.
85. CROP1, CROP2, CROP3, CROP4, CROP5, CROP6, CROP7, CROP8, CROP9, and
CROP10 should not be 'null'; THIS IS A MULTIPLE RESPONSE QUESTION. IT
MAY HAVE DATA FOR CROP1, BUT NOT NECESSARILY FOR CROP2-CROP10.
86. PRCNT should not be 'null'; THIS IS CORRECT.
87. If LBLWB = '1'; LBTOT should not be 'null'; THIS IS CORRECT.
88. If LBLWH = '1'; HLTOT should not be 'null' THIS IS CORRECT.
89. If CHAIN = '1'; CSTOT should not be 'null' THIS IS CORRECT.
90. If BRUSH = '1'; BCTOT should not be 'null' THIS IS CORRECT.
91. If EDGER = '1'; LETOT should not be 'null' THIS IS CORRECT.
92. If LMOW = '1'; LMTOT should not be 'null' THIS IS CORRECT.

93. If RLMOW = '1'; RMTOT should not be 'null' THIS IS CORRECT.
94. If TRACT = '1'; GTTOT should not be 'null' THIS IS CORRECT.
95. If SHRED = '1'; SCTOT should not be 'null' THIS IS CORRECT.
96. If SPLIT = '1'; WSTOT should not be 'null' THIS IS CORRECT.
97. If GRIND = '1'; SGTOT should not be 'null' THIS IS CORRECT.
98. If SBLOW = '1'; SBTOT should not be 'null' THIS IS CORRECT.
99. If STRIM = '1'; STTOT should not be 'null' THIS IS CORRECT.
100. If TILLR = '1'; TLTOT should not be 'null' THIS IS CORRECT.
101. If OTHER = '1'; OTTOT should not be 'null'; THIS IS CORRECT.
102. If EQUIPTYPE = '1' and LB1A ≠ '98','99', or 'null'; HPOWER should be between 0 and 175 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID
103. If EQUIPTYPE = '1' and LB1B ≠ '98','99', or 'null'; HPOWER should be between 3 and 175 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID
104. If EQUIPTYPE = '2' and HL1A ≠ '98','99', or 'null'; HPOWER should be between 0 and 175 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID
105. If EQUIPTYPE = '2' and HL1B ≠ '98','99', or 'null'; HPOWER should be between 3 and 175 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID
106. If EQUIPTYPE = '3' and CS1A ≠ '98','99', or 'null'; HPOWER should be between 1 and 11 hp (based off of default NONROAD equipment populations for California)- 5000337 (12 hp); 5001592 (14 HP); 5000895 (16&22 HP)
107. If EQUIPTYPE = '4' and BC1A ≠ '98','99', or 'null'; HPOWER should be between 0 and 25 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID
108. If EQUIPTYPE = '5' and LE1A ≠ '98','99', or 'null'; HPOWER should be between 0 and 25 hp (based off of default NONROAD equipment populations for California)- 5000740 (398 HP); 5001088 (675 HP)
109. If EQUIPTYPE = '6' and LM1A ≠ '98','99', or 'null'; HPOWER should be between 0 and 11 hp (based off of default NONROAD equipment populations for California)- 5001779, 5000615, 5000639 (12 HP); 5001670 (13 HP); 5001194, 5000238 (15 HP); 5000343, 5001243 (16 HP); 5000680 (18 HP); 5000895 (21 HP)
110. If EQUIPTYPE = '7' and RM1A ≠ '98','99', or 'null'; HPOWER should be between 3 and 40 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID
111. If EQUIPTYPE = '7' and RM1B ≠ '98','99', or 'null'; HPOWER should be between 3 and 100 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID
112. If EQUIPTYPE = '8' and GT1A ≠ '98','99', or 'null'; HPOWER should be between 3 and 25 hp (based off of default NONROAD equipment populations for California)- 5001932 (270 HP)
113. If EQUIPTYPE = '8' and GT1B ≠ '98','99', or 'null'; HPOWER should be between 6 and 100 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID

114. If EQUIPTYPE = '9' and SC1A ≠ '98','99', or 'null'; HPOWER should be between 3 and 175 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID

115. If EQUIPTYPE = '9' and SC1B ≠ '98','99', or 'null'; HPOWER should be between 16 and 1200 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID

116. If EQUIPTYPE = '11' and SG1A ≠ '98','99', or 'null'; HPOWER should be between 3 and 175 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID (NONE REPORTED HP VALUES)

117. If EQUIPTYPE = '11' and SG1B ≠ '98','99', or 'null'; HPOWER should be between 16 and 1200 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID (NONE REPORTED HP VALUES)

118. If EQUIPTYPE = '12' and SB1A ≠ '98','99', or 'null'; HPOWER should be between 1 and 16 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID (NONE REPORTED HP VALUES)

119. If EQUIPTYPE = '12' and SB1B ≠ '98','99', or 'null'; HPOWER should be between 100 and 600 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID (NONE REPORTED HP VALUES)

120. If EQUIPTYPE = '13' and ST1A ≠ '98','99', or 'null'; HPOWER should be between 0 and 25 hp (based off of default NONROAD equipment populations for California) – CHECKED and VALID

121. If EQUIPTYPE = '14' and TL1A ≠ '98','99', or 'null'; HPOWER should be between 0 and 16 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID

122. If EQUIPTYPE = '14' and TL1B ≠ '98','99', or 'null'; HPOWER should be between 3 and 600 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID.

123.   If TIMEB is '1'; TIMEA must be ≤ 24 hours– 5008452, 5008046, 5007501 (40 hours); 5009093 (50 hours).

124.   If TIMEB is '2'; TIMEA must be ≤ 168 hours – 5007477, 5006916 (200 hrs); 5008192 (216 hrs); 5006953 (280 hrs); 5007961 (400 hrs); 5007089, 5007633 (500 hrs); 5007692 (600 hrs); 5007639 (800 hrs); 5008091 (840 hrs); 5007053 (1040 hrs); 5007608 (1080 hrs); 5007474 (1500 hrs).

125.   If TIMEB is '3'; TIMEA must be ≤ 744 hours (*assumes the month has 31 days) – 5007315 (1500 hrs); 5007983 (2700 hrs).

126.   If TIMEA ≠ '9998' or '9999'; TIMEB cannot = '9'– CHECKED and VALID.

127.   If TOTGS = 000; HOWGS cannot = '1' or '2' HOWGS = IS NULL

128.   If TOTDS = 000; HOWDS cannot = '1' or '2' HOWGS = IS NULL

129.   If LB2A = '98','99', or blank(null); LB2B cannot = '1','2','3',or '4' – LB2B= IS NULL

130.   If LB2A ≠ '98','99', or blank(null); LB2B cannot = '98', '99', or 'blank' – CAN HAVE LB2B= "9" IF <> 98 OR <> 99. LB2B CANNOT = "BLANK" IF LB2A <> BLANK.

131.   If LB4A = '98','99', or blank(null); LB4B cannot = '1','2','3',or '4'- SAME AS ABOVE.

132.   If LB4A ≠ '98','99', or blank(null); LB4B cannot = '98', '99', or 'blank' - SAME AS ABOVE.

133.   If HL2A = '98','99', or blank(null); HL2B cannot = '1','2','3',or '4' SAME AS ABOVE.

134.   If HL2A ≠ '98','99', or blank(null); HL2B cannot = '98', '99', or 'blank' SAME AS ABOVE.

135.   If HL4A = '98','99', or blank(null); HL4B cannot = '1','2','3',or '4' SAME AS ABOVE.

136.   If HL4A ≠ '98','99', or blank(null); HL4B cannot = '98', '99', or 'blank' SAME AS ABOVE.

137.   If CS2A = '98','99', or blank(null); CS2B cannot = '1','2','3',or '4' SAME AS ABOVE.

138.   If CS2A ≠ '98','99', or blank(null); CS2B cannot = '98', '99', or 'blank' SAME AS ABOVE.

139.   If CS4A = '98','99', or blank(null); CS4B cannot = '1','2','3',or '4' SAME AS ABOVE.

140.   If CS4A ≠ '98','99', or blank(null); CS4B cannot = '98', '99', or 'blank' SAME AS ABOVE.

141.   If BC2A = '98','99', or blank(null); BC2B cannot = '1','2','3',or '4' SAME AS ABOVE.

142.   If BC2A ≠ '98','99', or blank(null); BC2B cannot = '98', '99', or 'blank' SAME AS ABOVE.

143.   If BC4A = '98','99', or blank(null); BC4B cannot = '1','2','3',or '4' SAME AS ABOVE.

144.   If BC4A ≠ '98','99', or blank(null); BC4B cannot = '98', '99', or 'blank' SAME AS ABOVE.

145. If LE2A = '98','99', or blank(null); LE2B cannot = '1','2','3',or '4' SAME AS ABOVE.
146. If LE2A ≠ '98','99', or blank(null); LE2B cannot = '98', '99', or 'blank' SAME AS ABOVE.
147. If LE4A = '98','99', or blank(null); LE4B cannot = '1','2','3',or '4' SAME AS ABOVE.
148. If LE4A ≠ '98','99', or blank(null); LE4B cannot = '98', '99', or 'blank' SAME AS ABOVE.
149. If LM2A = '98','99', or blank(null); LM2B cannot = '1','2','3',or '4' SAME AS ABOVE.
150. If LM2A ≠ '98','99', or blank(null); LM2B cannot = '98', '99', or 'blank' SAME AS ABOVE.
151. If LM4A = '98','99', or blank(null); LM4B cannot = '1','2','3',or '4' SAME AS ABOVE.
152. If LM4A ≠ '98','99', or blank(null); LM4B cannot = '98', '99', or 'blank' SAME AS ABOVE.
153. If RM2A = '98','99', or blank(null); RM2B cannot = '1','2','3',or '4' SAME AS ABOVE.
154. If RM2A ≠ '98','99', or blank(null); RM2B cannot = '98', '99', or 'blank' SAME AS ABOVE.
155. If RM4A = '98','99', or blank(null); RM4B cannot = '1','2','3',or '4 SAME AS ABOVE.'
156. If RM4A ≠ '98','99', or blank(null); RM4B cannot = '98', '99', or 'blank' SAME AS ABOVE.
157. If GT2A = '98','99', or blank(null); GT2B cannot = '1','2','3',or '4' SAME AS ABOVE.
158. If GT2A ≠ '98','99', or blank(null); GT2B cannot = '98', '99', or 'blank' SAME AS ABOVE.
159. If GT4A = '98','99', or blank(null); GT4B cannot = '1','2','3',or '4' SAME AS ABOVE.
160. If GT4A ≠ '98','99', or blank(null); GT4B cannot = '98', '99', or 'blank' SAME AS ABOVE.
161. If SC2A = '98','99', or blank(null); SC2B cannot = '1','2','3',or '4' SAME AS ABOVE.
162. If SC2A ≠ '98','99', or blank(null); SC2B cannot = '98', '99', or 'blank' SAME AS ABOVE.
163. If SC4A = '98','99', or blank(null); SC4B cannot = '1','2','3',or '4' SAME AS ABOVE.
164. If SC4A ≠ '98','99', or blank(null); SC4B cannot = '98', '99', or 'blank' SAME AS ABOVE.
165. If WS2A = '98','99', or blank(null); WS2B cannot = '1','2','3',or '4' SAME AS ABOVE.
166. If WS2A ≠ '98','99', or blank(null); WS2B cannot = '98', '99', or 'blank' SAME AS ABOVE.
167. If WS4A = '98','99', or blank(null); WS4B cannot = '1','2','3',or '4' SAME AS ABOVE.

168. If WS4A ≠ '98','99', or blank(null); WS4B cannot = '98', '99', or 'blank' SAME AS ABOVE.
169. If SG2A = '98','99', or blank(null); SG2B cannot = '1','2','3',or '4' SAME AS ABOVE.
170. If SG2A ≠ '98','99', or blank(null); SG2B cannot = '98', '99', or 'blank' SAME AS ABOVE.
171. If SG4A = '98','99', or blank(null); SG4B cannot = '1','2','3',or '4' SAME AS ABOVE.
172. If SG4A ≠ '98','99', or blank(null); SG4B cannot = '98', '99', or 'blank' SAME AS ABOVE.
173. If SB2A = '98','99', or blank(null); SB2B cannot = '1','2','3',or '4' SAME AS ABOVE.
174. If SB2A ≠ '98','99', or blank(null); SB2B cannot = '98', '99', or 'blank' SAME AS ABOVE.
175. If SB4A = '98','99', or blank(null); SF4B cannot = '1','2','3',or '4' SAME AS ABOVE.
176. If SB4A ≠ '98','99', or blank(null); SF4B cannot = '98', '99', or 'blank' SAME AS ABOVE.
177. If ST2A = '98','99', or blank(null); ST2B cannot = '1','2','3',or '4' SAME AS ABOVE.
178. If ST2A ≠ '98','99', or blank(null); ST2B cannot = '98', '99', or 'blank' SAME AS ABOVE.
179. If ST4A = '98','99', or blank(null); ST4B cannot = '1','2','3',or '4' SAME AS ABOVE.
180. If ST4A ≠ '98','99', or blank(null); ST4B cannot = '98', '99', or 'blank' SAME AS ABOVE.
181. If TL2A = '98','99', or blank(null); TL2B cannot = '1','2','3',or '4' SAME AS ABOVE.
182. If TL2A ≠ '98','99', or blank(null); TL2B cannot = '98', '99', or 'blank' SAME AS ABOVE.
183. If TL4A = '98','99', or blank(null); TL4B cannot = '1','2','3',or '4' SAME AS ABOVE.
184. If TL4A ≠ '98','99', or blank(null); TL4B cannot = '98', '99', or 'blank' SAME AS ABOVE.
185. If OT2A = '98','99', or blank(null); OT2B cannot = '1','2','3',or '4' SAME AS ABOVE.
186. If OT2A ≠ '98','99', or blank(null); OT2B cannot = '98', '99', or 'blank' SAME AS ABOVE.
187. If OT4A = '98','99', or blank(null); OT4B cannot = '1','2','3',or '4' SAME AS ABOVE.
188. If OT4A ≠ '98','99', or blank(null); OT4B cannot = '98', '99', or 'blank' SAME AS ABOVE.
189. If PLANB = '1';
BLBBP,BLBHH,BCS,BBC,BLE,BLMWB,BRLM,BLGT,BSC,BWS,BSG,BSB,BST,BTL, and BOTH cannot = '2' THIS IS CORRECT.

190. If PLANB = '2'; BLBBP,BLBHH,BCS,BBC,BLE,BLMWB,BRLM,BLGT,BSC,BWS,BSG,BSB,BST,BTL, or BOTH cannot = '1' THIS IS CORRECT. THEY ARE "NULL".

191. If BLBBP = '1'; LBB1 or LBB2 cannot = 'null' and LBB3 cannot = 'null' THIS IS CORRECT.

192. If BLBHH = '1'; HLB1 or HLB2 cannot = 'null' and HLB3 cannot = 'null' THIS IS CORRECT.

193. If BCS = '1'; CSB1 or CSB2 cannot = 'null' and CSB3 cannot = 'null' THIS IS CORRECT.

194. If BBC = '1'; BCB1 or BCB2 cannot = 'null' and BCB3 cannot = 'null' THIS IS CORRECT.

195. If BLE = '1'; LEB1 or LEB2 cannot = 'null' and LEB3 cannot = 'null' THIS IS CORRECT.

196. If BLMWB = '1'; LMB1 or LMB2 cannot = 'null' and LMB3 cannot = 'null' THIS IS CORRECT.

197. If BRLM = '1'; RMB1 or RMB2 cannot = 'null' and RMB3 cannot = 'null' THIS IS CORRECT.

198. If BLGT = '1'; GTB1 or GTB2 cannot = 'null' and GTB3 cannot = 'null' THIS IS CORRECT.

199. If BSC = '1'; SCB1 or SCB2 cannot = 'null' and SCB3 cannot = 'null' THIS IS CORRECT.

200. If BWS = '1'; WSB1 or WSB2 cannot = 'null' and WSB3 cannot = 'null' THIS IS CORRECT.

201. If BSG = '1'; SGB1 or SGB2 cannot = 'null' and SGB3 cannot = 'null' THIS IS CORRECT.

202. If BSB = '1'; SBB1 or SBB2 cannot = 'null' and SBB3 cannot = 'null' THIS IS CORRECT.

203. If BST = '1'; STB1 or STB2 cannot = 'null' and STB3 cannot = 'null' THIS IS CORRECT.

204. If BTL = '1'; TLB1 or TLB2 cannot = 'null' and TLB3 cannot = 'null' THIS IS CORRECT.

205. If BOTH = '1'; OTB1 or OTB2 cannot = 'null' and OTB3 cannot = 'null' THIS IS CORRECT.

206. SERV1, SERV2, SERV3, SERV4, and SERV5 should not be 'null' THIS IS A MULTIPLE RESPONSE QUESTION. IT DOES HAVE DATA FOR AT LEAST SERV1, BUT NOT NECESSARILY FOR SERV2-SERV5.

207. PRCNT should not be 'null' THIS IS CORRECT.

208. HOUSE should not be 'null' THIS IS CORRECT.

209. If LBLWB = '1'; LBTOT should not be 'null' THIS IS CORRECT.

210. If LBLWH = '1'; HLTOT should not be 'null' THIS IS CORRECT.

211. If CHAIN = '1'; CSTOT should not be 'null' THIS IS CORRECT.

212. If BRUSH = '1'; BCTOT should not be 'null' THIS IS CORRECT.

213. If EDGER = '1'; LETOT should not be 'null' THIS IS CORRECT.

214. If LMOW = '1'; LMTOT should not be 'null' THIS IS CORRECT.

215. If RLMOW = '1'; RMTOT should not be 'null' THIS IS CORRECT.

216. If TRACT = '1'; GTTOT should not be 'null' THIS IS CORRECT.

217.   If SHRED = '1'; SCTOT should not be 'null' THIS IS CORRECT.
218.   If SPLIT = '1'; WSTOT should not be 'null' THIS IS CORRECT.
219.   If GRIND = '1'; SGTOT should not be 'null' THIS IS CORRECT.
220.   If SBLOW = '1'; SBTOT should not be 'null' THIS IS CORRECT.
221.   If STRIM = '1'; STTOT should not be 'null' THIS IS CORRECT.
222. If TILLR = '1'; TLTOT should not be 'null' THIS IS CORRECT.
223. If OTHER = '1'; OTTOT should not be 'null' THIS IS CORRECT.
224. If EQUIPTYPE = '1' and LB1A ≠ '98','99', or 'null'; HPOWER should be between 0 and 175 hp (based off of default NONROAD equipment populations for California)- CHECKED and VALID.
225. If EQUIPTYPE = '1' and LB1B ≠ '98','99', or 'null'; HPOWER should be between 3 and 175 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID.
226. If EQUIPTYPE = '2' and HL1A ≠ '98','99', or 'null'; HPOWER should be between 0 and 175 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID.
227. If EQUIPTYPE = '2' and HL1B ≠ '98','99', or 'null'; HPOWER should be between 3 and 175 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID.
228. If EQUIPTYPE = '3' and CS1A ≠ '98','99', or 'null'; HPOWER should be between 1 and 11 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID.
229. If EQUIPTYPE = '4' and BC1A ≠ '98','99', or 'null'; HPOWER should be between 0 and 25 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID.
230. If EQUIPTYPE = '5' and LE1A ≠ '98','99', or 'null'; HPOWER should be between 0 and 25 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID.
231. If EQUIPTYPE = '6' and LM1A ≠ '98','99', or 'null'; HPOWER should be between 0 and 11 hp (based off of default NONROAD equipment populations for California)- 5007075 (LM1A =1; 15 HP); 5007639 (LM1A = 4, 18 HP).
232. If EQUIPTYPE = '7' and RM1A ≠ '98','99', or 'null'; HPOWER should be between 3 and 40 hp (based off of default NONROAD equipment populations for California)- 5008120 (RM1A = 1, 147 HP); 5008004 (RM1A = 4, **725 CC**).
233. If EQUIPTYPE = '7' and RM1B ≠ '98','99', or 'null'; HPOWER should be between 3 and 100 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID.
234. If EQUIPTYPE = '8' and GT1A ≠ '98','99', or 'null'; HPOWER should be between 3 and 25 hp (based off of default NONROAD equipment populations for California)- 5007305 (GT1A = 1, 150 HP).
235. If EQUIPTYPE = '8' and GT1B ≠ '98','99', or 'null'; HPOWER should be between 6 and 100 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID.
236. If EQUIPTYPE = '9' and SC1A ≠ '98','99', or 'null'; HPOWER should be between 3 and 175 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID.

237. If EQUIPTYPE = '9' and SC1B ≠ '98','99', or 'null'; HPOWER should be between 16 and 1200 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID (No SC1B reported).
238. If EQUIPTYPE = '11' and SG1A ≠ '98','99', or 'null'; HPOWER should be between 3 and 175 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID (No HP Reported).
239. If EQUIPTYPE = '11' and SG1B ≠ '98','99', or 'null'; HPOWER should be between 16 and 1200 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID. (No SG1B reported).
240. If EQUIPTYPE = '12' and SB1A ≠ '98','99', or 'null'; HPOWER should be between 1 and 16 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID (No snow blowers reported).
241. If EQUIPTYPE = '12' and SB1B ≠ '98','99', or 'null'; HPOWER should be between 100 and 600 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID (no snow blowers reported).
242. If EQUIPTYPE = '13' and ST1A ≠ '98','99', or 'null'; HPOWER should be between 0 and 25 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID.
243. If EQUIPTYPE = '14' and TL1A ≠ '98','99', or 'null'; HPOWER should be between 0 and 16 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID.
244. If EQUIPTYPE = '14' and TL1B ≠ '98','99', or 'null'; HPOWER should be between 3 and 600 hp (based off of default NONROAD equipment populations for California) - CHECKED and VALID (no TL1B reported).

Appendix E – Instrumentation Recruitment Materials

Recruitment Script

Hi, my name is _____ and I'm calling on behalf of NuStats. May I speak with [**FIRST NAME**LAST NAME]? [If new person, reintroduce, if same person, continue]. This winter, you participated in a study on the use of lawn and garden equipment and you indicated interest in participating in our follow up study. Thank you for agreeing to participate in this next phase of our study.

For this research, we are asking you to attach a small device on up to five pieces of lawn and garden equipment contained in your organization's inventory for a period of two weeks. These easy-to-attach devices automatically record equipment usage. After two weeks of recording you will return the devices using pre-addressed, postage-paid envelopes. This study is for scientific test purposes so all information about your organization and your equipment will be kept confidential.

PROGRAMMER NOTE: IF FLAGGED AS REQUIRING AN INCENTIVE, ADD: For each piece of equipment that you install the recording device, we will provide a monetary thank you for your efforts of $20. You will receive that once the device has been returned.

1)	We are interested in testing the following equipment types in [**INSERT MONTH**]. For each, please confirm that the equipment will likely be used during this time.

Is it likely a **EQUIPMENT TYPE**, **HORSEPOWER** **FUEL TYPE** will be in use during this month?

PROGRAMMER NOTE: CONTINUE THROUGH ALL EQUIPMENT TYPES INDICATED FOR THIS PARTICIPANT.

2)	So that I can send you a packet with the recording device and instructions, I need to confirm/obtain your address:

	ADDRESS, CITY, STATE, ZIP
3)	Do you have an email address that you regularly check, where I can contact you to confirm you received the packet and send you a reminder to complete the installation process?

You can expect to receive your study packet in [**INSERT MONTH**]. In it, there will be detailed instructions on how to install the device on the equipment and we also provide a toll-free number in case you have questions or need help. Thank you so much for your help and participation in this very important study!

Mail Out Letter

Date

Dear [NAME]:

Thank you for agreeing to participate in a study on the use of lawn and garden equipment in California.   The information gathered in this study is important for understanding air pollution in the state. Because lawn and garden equipment contributes to smog, your help in this important study will ensure that California's air quality continues to improve in the future.

**Before proceeding with the installation, please call the
Lawn and Garden Equipment Study Hotline, toll free, at 1-866-830-2279
to confirm your participation.**

Please read through this letter and the installation materials carefully, including the Frequently Asked Questions.

Your installation packet contains the following:

1. This letter
2. Recording Unit Installation Instructions
3. Recording Unit (one per piece of equipment)
4. Installation Log (one per piece of equipment)
5. Return Mail label
6. Box or envelope that came with the unit(s) – be sure to keep the box or envelope to mail unit(s) and log sheet(s) back to us

For each piece of equipment you agreed to test, you will need to install a Recording Unit for two weeks. The Recording Unit captures data on the equipment while it's running. You'll also need to complete an Instrument Log Sheet for each piece of equipment. ***Be sure to send back the Units and Log Sheets for all equipment tested.***

To thank you for your participation, we will send you $20 for each piece of equipment tested during the two-week study period – provided you return the unit(s) in working condition, along with the log sheets for all equipment.

If you have questions about the study, how to install equipment, or any other issue, call the Lawn and Garden Equipment Study, toll free, at 1-866-830-2279.

Sincerely,

Mia Zmud
Research Director

Appendix F. Instrumentation Download Log

Total Count of Data Loggers Received	Considered in Analysis 2006	Mod DL (dates translated by ARB)	Mod DL -PI (incomplete data/ documentation)	Unused (various reasons)	Datalogger ID	Messages/Comments
1			1	0	5000045 Lawn Mower	No paperwork
1				1	5000045 Leaf Blower (Back Pack)	Run-time Error "55" File already open
1			1	0	5000045 Riding Lawn Mower	No paperwork
1	1	1		0	5000062 Leaf Blower (Back Pack)	Low Battery*
1	1	1		0	5000062 Riding Lawn Mower	Ok
1				1	5000062 String Trimmer	Run time error 9 - subscript out of range
1				1	5000069 Leaf Blower (Back Pack)	No data to download
1				1	5000381 Brushcutter	No data to download
1			1	0	5000381 Chain Saw	No date shown
1			1	0	5000381 Lawn Edger	Low Battery* / No date shown
1				1	5000381 Lawn Mower	No data to download
1				1	5000381 Leaf Blower (Back Pack)	No data to download
1			1	0	5000381 String Trimmer	Low Battery* / No date shown
1	1	1		0	5000487 Brushcutter	Low Battery*
1	1	1		0	5000487 Chain Saw	Low Battery*
1	1	1		0	5000487 Lawn Mower	Low Battery*
1	1	1		0	5000487 Leaf Blower (Back Pack)	Low Battery*
1	1	1		0	5000487 Riding Lawn Mower	Low Battery* / Two start dates
1	1	1		0	5000487 String Trimmer	Low Battery*
1				1	5000498 Leaf Blower (Back Pack)	Would not connect
1				1	5000498 String Trimmer	Would not connect

Total Count of Data Loggers Received	Considered in Analysis 2006	Mod DL (dates translated by ARB)	Mod DL -PI (incomplete data/ documentation)	Unused (various reasons)	Datalogger ID	Messages/Comments
1				1	5000581 Lawn Edger	No data to download
1				1	5000581 Lawn Mower	No data to download
1				1	5000581 Leaf Blower (Back Pack)	No data to download
1	1	1		0	5000637 Chain Saw	Ok
1				1	5000637 String Trimmer	Low Battery / download unsuccessful
1				1	5000781 Chain Saw	Paperwork but unit not labeled
1				1	5000781 Lawn Mower	Paperwork but unit not labeled
1				1	5000781 Leaf Blower (Back Pack)	Run time error 9 - subscript out of range
1	1	1		0	5000888 Hedge Trimmer	Low Battery*
1	1	1		0	5000888 Lawn Mower	Low Battery*
1	1	1		0	5000888 Leaf Blower (Back Pack)	Low Battery*
1	1	1		0	5000888 Riding Lawn Mower	Low Battery*
1	1	1		0	5000888 String Trimmer	Low Battery*
1				1	5000945 Leaf Blower (Back Pack)	Runtime Error '9' Script out of range / low battery
1				1	5001035 Brushcutter	No label or unit
1				1	5001035 Chain Saw	No label or unit
1	1	1		0	5001035 Lawn Mower	Low Battery*
1				1	5001035 Leaf Blower (Back Pack)	Never connected to software
1			1	0	5001035 Riding Lawn Mower	Low Battery*
1				1	5001066 Hedge Trimmer	Did not connect
1	1	1		0	5001066 Lawn Edger	Low Battery*
1	1	1		0	5001066 Lawn Mower	Low Battery*

Total Count of Data Loggers Received	Considered in Analysis 2006	Mod DL (dates translated by ARB)	Mod DL -PI (incomplete data/ documentation)	Unused (various reasons)	Datalogger ID	Messages/Comments
1	1	1		0	5001066 Leaf Blower (Hand Held)	Low Battery*
1				1	5001066 String Trimmer	Did not connect
1	1	1		0	5001145 Brushcutter	Low Battery*
1	1	1		0	5001145 Chain Saw	Low Battery*
1				1	5001145 Lawn Mower	No data to download / Run time error 6 overflow
1				1	5001145 Leaf Blower (Back Pack)	Did not connect
1				1	5001145 Leaf Blower (Hand Held)	Did not connect
1				1	5001145 String Trimmer	Did not connect
1				1	5001295 Lawn Mower	Low Battery*
1				1	5001295 Tiller	Low Battery*
1				1	5001295 Trencher	Event logger memory full - available data processed
1				1	5001295 Wood Splitter	Run time error '55' - file already open
1	1	1		0	5001391 Lawn Edger	Low Battery*
1	1	1		0	5001391 Lawn Mower	Ok
1	1	1		0	5001391 Leaf Blower (Hand Held)	Ok
1	1	1		0	5001391 String Trimmer	Low Battery*
1			1	0	5001462 Chain Saw	No date shown
1				1	5001462 Lawn Mower	No data to download
1				1	5001462 Leaf Blower (Hand Held)	No data to download
1				1	5001462 String Trimmer	No data to download
1	1	1		0	5001670 Lawn Mower	Two dates shown
1	1	1		0	5001670 Leaf Blower (Back Pack)	Two dates shown

Total Count of Data Loggers Received	Considered in Analysis 2006	Mod DL (dates translated by ARB)	Mod DL -PI (incomplete data/ documentation)	Unused (various reasons)	Datalogger ID	Messages/Comments
1			1	0	5001670 Other	No date shown
1	1	1		0	5001670 Riding Lawn Mower	Two dates shown
1	1	1		0	5001670 String Trimmer	Two dates shown
1			1	0	5001921 Chain Saw	Low Battery* / No date shown
1			1	0	5001921 Lawn & Garden	Low Battery* / No date shown
1			1	0	5001921 Lawn Mower	Low Battery* / No date shown
1			1	0	5001921 Leaf Blower (Back Pack)	Low Battery* / No date shown
1			1	0	5001921 Leaf Blower (Hand Held)	Low Battery* / No date shown
1			1	0	5001921 Tiller	Low Battery* / No date shown
1		1		0	5001946 Bobcat	Diesel Construction Equipment - exclude from L&G
1	1	1		0	5001946 Lawn Mower	Low Battery*
1	1	1		0	5001946 Leaf Blower (Hand Held)	Ok
1	1	1		0	5001946 Riding Lawn Mower	Low Battery*
1	1	1		0	5001946 Weedeater	Low Battery*
1	1	1		0	5006879 Blade Type Weed Eater	Ok
1	1	1		0	5006879 Lawn & Garden Tractor	Ok
1	1	1		0	5006879 Lawn Mower	Low Battery*
1	1	1		0	5006879 Leaf Blower (Hand Held)	Ok
1	1	1		0	5006879 String Trimmer	Low Battery*
1				1	5006958 (2 units)	No label - No paperwork
1			1	0	5006958 Lawn Edger	No paperwork
1			1	0	5006958 Lawn Mower	No paperwork

Total Count of Data Loggers Received	Considered in Analysis 2006	Mod DL (dates translated by ARB)	Mod DL -PI (incomplete data/ documentation)	Unused (various reasons)	Datalogger ID	Messages/Comments
1			1	0	5006958 Vacuum	No paperwork
1	1	1		0	5006977 Lawn Mower	Low Battery*
1			1	0	5006977 Shredder/Chipper	Low Battery* / No date shown
1			1	0	5006977 Tiller	Low Battery* / No date shown
1			1	0	5007373 Lawn & Garden Tractor	Low Battery*
1	1	1		0	5007373 Lawn Mower	Low Battery*
1			1	0	5007373 Leaf Blower (Back Pack)	Low Battery* / No date shown
1	1	1		0	5007373 String Trimmer	Low Battery*
1				1	5007608 Fairway Mower	1 of 3 unlabeled units in this batch
1	1	1		0	5007608 Lawn Mower	Low Battery*
1				1	5007608 Leaf Blower (Back Pack)	1 of 3 unlabeled units in this batch
1	1	1		0	5007608 Leaf Blower (Hand Held)	Ok
1				1	5007608 Riding Lawn Mower	1 of 3 unlabeled units in this batch
1				1	5007676 Chain Saw	Low Battery*
1				1	5007676 Greens Mower	Low Battery*
1				1	5007676 Lawn Mower	Low Battery*
1				1	5007676 Leaf Blower (Back Pack)	Low Battery*
1				1	5007676 Riding Lawn Mower	No Data logger to match paperwork
1				1	5007676 String Trimmer	Low Battery*
1	1	1		0	5007852 Lawn Mower	Low Battery*
1	1	1		0	5007896 Lawn & Garden Tractor	Ok
1	1	1		0	5007896 Riding Lawn Mower	Low Battery*

Total Count of Data Loggers Received	Considered in Analysis 2006	Mod DL (dates translated by ARB)	Mod DL -PI (incomplete data/ documentation)	Unused (various reasons)	Datalogger ID	Messages/Comments
1	1	1		0	5007896 String Trimmer	Ok
1	1	1		0	5007896 Tamper	Ok
1	1	1		0	5008751 John Deer	Low Battery*
1				1	5008751 Lawn Edger	Low Battery* / download unsuccessful
1				1	5008751 Lawn Mower	Low Battery* / download unsuccessful
1	1	1		0	5008751 Riding Lawn Mower	Low Battery*
1	1	1		0	5008849 Chain Saw	Ok
1	1	1		0	5008849 Lawn Mower	Low Battery*
1				1	5008849 String Trimmer	Never connected to software
1				1	5008915 Chain Saw	Unable to retrieve data
1				1	5008915 Leaf Blower (Back Pack)	Unable to retrieve data runtime error '9'
1	1	1		0	5008915 Riding Lawn Mower	Only one entry
1	1	1		0	5008915 String Trimmer	Low Battery*
122	53	54	21	47		

*The low battery message read: "A low battery condition has occurred with the EL-100. Unable to calculate start of monitoring time. Please provide correct time and date."

Appendix G – Geographic Allocation Factors by Equipment Type (ASC)

County	ASC Code	4010	4015	4020	4021	4025	4030	4035	4040	4045	4050	4055	4060	4065	4070	4075
Alameda		0.002805	0.003702	0.015224	0.015224	0.004169	0.007925	0.000000	0.011605	0.011605	0.033322	0.008495	0.044679	0.044679	0.008495	0.002345
Alpine		0.000006	0.000066	0.000052	0.000052	0.000012	0.000031	0.026000	0.000088	0.000088	0.000010	0.000036	0.000065	0.000065	0.000036	0.000010
Amador		0.000092	0.000451	0.002382	0.002382	0.000393	0.000594	0.031000	0.000922	0.000922	0.000710	0.000372	0.000651	0.000651	0.000372	0.000089
Butte		0.000757	0.010764	0.012703	0.012703	0.003404	0.006371	0.047000	0.010083	0.010083	0.006834	0.009982	0.006110	0.006110	0.009982	0.002143
Calaveras		0.000098	0.000232	0.002696	0.002696	0.000382	0.000533	0.010000	0.000818	0.000818	0.000607	0.000178	0.001049	0.001049	0.000178	0.000047
Colusa		0.000122	0.000038	0.004025	0.004025	0.000581	0.000638	0.000000	0.000900	0.000900	0.000371	0.000088	0.000324	0.000324	0.000088	0.000016
Contra Costa		0.004923	0.003968	0.008825	0.008825	0.005595	0.006274	0.000000	0.007838	0.007838	0.010869	0.004965	0.030457	0.030457	0.004965	0.004689
Del Norte		0.000160	0.002046	0.003205	0.003205	0.000708	0.001233	0.000000	0.001946	0.001946	0.000856	0.001828	0.000206	0.000206	0.001828	0.000394
El Dorado		0.000062	0.000220	0.001346	0.001346	0.000205	0.000335	0.022200	0.000561	0.000561	0.000742	0.000271	0.001254	0.001254	0.000271	0.000057
El Dorado		0.000162	0.000578	0.003541	0.003541	0.000540	0.000882	0.055800	0.001477	0.001477	0.001953	0.000714	0.003300	0.003300	0.000714	0.000150
Fresno		0.007126	0.050360	0.046996	0.046996	0.016779	0.028840	0.042000	0.043978	0.043978	0.026002	0.045576	0.018926	0.018926	0.045576	0.012855
Glenn		0.000103	0.000112	0.003179	0.003179	0.000476	0.000563	0.005000	0.000790	0.000790	0.000433	0.000121	0.000516	0.000516	0.000121	0.000025
Humboldt		0.000956	0.015835	0.014867	0.014867	0.004096	0.008199	0.000000	0.013305	0.013305	0.007351	0.014088	0.005275	0.005275	0.014088	0.003065
Imperial		0.001258	0.006703	0.013561	0.013561	0.003420	0.004943	0.000000	0.007261	0.007261	0.003073	0.006038	0.002525	0.002525	0.006038	0.001861
Inyo		0.12985	0.19664	0.09820	0.09820	0.13769	0.14297	0.005000	0.14626	0.14626	0.06536	0.17319	0.00049	0.00049	0.17319	0.14608

	7	8	4	4	2	2	0	8	8	0	7	5	5	7	7
Kern	0.014994	0.005767	0.007399	0.007399	0.013250	0.009880	0.003008	0.005524	0.005524	0.002978	0.005214	0.002620	0.002620	0.005214	0.013899
Kern	0.064761	0.024909	0.031956	0.031956	0.057230	0.042673	0.012992	0.023860	0.023860	0.012864	0.022521	0.011316	0.011316	0.022521	0.060030
Kings	0.004764	0.000214	0.005265	0.005265	0.004450	0.003085	0.000000	0.001429	0.001429	0.001049	0.000258	0.002144	0.002144	0.000258	0.004161
Lake	0.000102	0.000553	0.002598	0.002598	0.000486	0.000713	0.000000	0.001010	0.001010	0.000732	0.000544	0.001572	0.001572	0.000544	0.000117
Lassen	0.020163	0.000057	0.002274	0.002274	0.016239	0.009406	0.114000	0.000474	0.000474	0.000126	0.000047	0.000563	0.000563	0.000047	0.017987
Los Angeles	0.000643	0.001442	0.002008	0.002008	0.000750	0.001387	0.000000	0.002167	0.002167	0.004596	0.002067	0.004387	0.004387	0.002067	0.000589
Los Angeles	0.036844	0.082681	0.115112	0.115112	0.042988	0.079512	0.000000	0.124278	0.124278	0.263530	0.118521	0.251554	0.251554	0.118521	0.033760
Madera	0.000193	0.000230	0.005424	0.005424	0.000861	0.001107	0.021000	0.001536	0.001536	0.001407	0.000375	0.001659	0.001659	0.000375	0.000079
Marin	0.000674	0.009679	0.006968	0.006968	0.002493	0.005267	0.000000	0.009331	0.009331	0.007220	0.009098	0.011879	0.011879	0.009098	0.001938
Mariposa	0.000060	0.000098	0.001762	0.001762	0.000263	0.000330	0.005000	0.000501	0.000501	0.000258	0.000076	0.000422	0.000422	0.000076	0.000020
Mendicino	0.000344	0.001498	0.008963	0.008963	0.001345	0.001930	0.000000	0.003027	0.003027	0.002385	0.001588	0.001807	0.001807	0.001588	0.000339
Merced	0.000316	0.001112	0.008623	0.008623	0.001456	0.001966	0.000000	0.002817	0.002817	0.001898	0.001133	0.003846	0.003846	0.001133	0.000242
Modoc	0.000107	0.000016	0.003603	0.003603	0.000497	0.000516	0.000000	0.000762	0.000762	0.000040	0.000014	0.000243	0.000243	0.000014	0.000002
Mono	0.000158	0.000454	0.004659	0.004659	0.000665	0.000833	0.067000	0.001409	0.001409	0.000121	0.000141	0.000546	0.000546	0.000141	0.000059
Monterey	0.069677	0.001089	0.008339	0.008339	0.056516	0.033459	0.000000	0.003514	0.003514	0.004504	0.001696	0.008471	0.008471	0.001696	0.062343
Napa	0.000189	0.000981	0.004378	0.004378	0.000765	0.001095	0.000000	0.003549	0.003549	0.003010	0.001129	0.004269	0.004269	0.001129	0.000242
Nevada	0.000235	0.001293	0.005068	0.005068	0.000871	0.001434	0.052000	0.002221	0.002221	0.002874	0.001514	0.001861	0.001861	0.001514	0.000313
Orange	0.01131	0.01346	0.02958	0.02958	0.00943	0.01862	0.00000	0.03268	0.03268	0.08293	0.02690	0.13332	0.13332	0.02690	0.00687

	9	7	9	9	0	0	0	0	0	8	4	5	5	4	9
Placer	0.000021	0.000019	0.000438	0.000438	0.000079	0.000119	0.004200	0.000187	0.000187	0.000308	0.000066	0.000541	0.000541	0.000066	0.000012
Placer	0.000032	0.000028	0.000656	0.000656	0.000118	0.000178	0.006000	0.000280	0.000280	0.000460	0.000098	0.000810	0.000810	0.000098	0.000018
Placer	0.000244	0.000215	0.005034	0.005034	0.000904	0.001369	0.046800	0.002145	0.002145	0.003531	0.000753	0.006212	0.006212	0.000753	0.000136
Plumas	0.000125	0.000508	0.003424	0.003424	0.000488	0.000673	0.166000	0.001026	0.001026	0.000600	0.000492	0.000615	0.000615	0.000492	0.000106
Riverside	0.000134	0.001096	0.000846	0.000846	0.000294	0.000586	0.000000	0.000989	0.000989	0.000744	0.001033	0.000714	0.000714	0.001033	0.000227
Riverside	0.000018	0.000149	0.000115	0.000115	0.000040	0.000080	0.000000	0.000134	0.000134	0.000101	0.000140	0.000097	0.000097	0.000140	0.000031
Riverside	0.006653	0.054394	0.042027	0.042027	0.014587	0.029073	0.000000	0.049120	0.049120	0.036954	0.051287	0.035450	0.035450	0.051287	0.011269
Riverside	0.001648	0.013478	0.010414	0.010414	0.003614	0.007204	0.000000	0.012171	0.012171	0.009157	0.012708	0.008784	0.008784	0.012708	0.002792
Sacramento	0.001204	0.003353	0.009445	0.009445	0.002684	0.005169	0.000000	0.008022	0.008022	0.014589	0.005114	0.035900	0.035900	0.005114	0.000938
San Benito	0.000194	0.001791	0.004323	0.004323	0.000858	0.001395	0.000000	0.002245	0.002245	0.001523	0.001640	0.000639	0.000639	0.001640	0.000359
San Bernardino	0.096781	0.015265	0.014045	0.014045	0.079825	0.051545	0.000000	0.013695	0.013695	0.010956	0.014736	0.008526	0.008526	0.014736	0.088062
San Bernardino	0.400815	0.063221	0.058165	0.058165	0.330599	0.213469	0.016000	0.056718	0.056718	0.045374	0.061027	0.035310	0.035310	0.061027	0.364705
San Diego	0.054815	0.104062	0.075456	0.075456	0.060104	0.074991	0.000000	0.097698	0.097698	0.084107	0.101336	0.093760	0.093760	0.101336	0.058905
San Francisco	0.000827	0.001627	0.004812	0.004812	0.001409	0.003123	0.000000	0.006564	0.006564	0.013435	0.003321	0.021352	0.021352	0.003321	0.000779
San Joaquin	0.001748	0.000758	0.010616	0.010616	0.002868	0.003518	0.000000	0.004305	0.004305	0.008448	0.001938	0.013383	0.013383	0.001938	0.001428
San Luis Obispo	0.000449	0.001599	0.010578	0.010578	0.001924	0.002806	0.000000	0.004450	0.004450	0.005416	0.002301	0.010139	0.010139	0.002301	0.000453
San Mateo	0.000676	0.003343	0.006640	0.006640	0.001641	0.003565	0.000000	0.006752	0.006752	0.013326	0.004918	0.021281	0.021281	0.004918	0.000956
Santa Barbara	0.02731	0.04670	0.02819	0.02819	0.02971	0.03335	0.000000	0.03783	0.03783	0.02284	0.04235	0.01196	0.01196	0.04235	0.03041

	4	2	6	6	5	5	0	7	7	5	4	6	6	4	1
Santa Clara	0.002319	0.010066	0.020537	0.020537	0.005001	0.010988	0.000000	0.018819	0.018819	0.043679	0.015595	0.049377	0.049377	0.015595	0.003099
Santa Cruz	0.000354	0.003630	0.004938	0.004938	0.001367	0.002736	0.000000	0.004440	0.004440	0.006406	0.004202	0.007650	0.007650	0.004202	0.000852
Shasta	0.001707	0.028319	0.028104	0.028104	0.007863	0.014942	0.031000	0.024224	0.024224	0.011929	0.025347	0.004072	0.004072	0.025347	0.005485
Sierra	0.000053	0.000018	0.001723	0.001723	0.000209	0.000227	0.026000	0.000340	0.000340	0.000061	0.000016	0.000111	0.000111	0.000016	0.000004
Siskiyou	0.000493	0.005074	0.011169	0.011169	0.002134	0.003477	0.093000	0.005502	0.005502	0.002221	0.004410	0.001111	0.001111	0.004410	0.000966
Solano	0.000533	0.000619	0.004383	0.004383	0.001050	0.001502	0.000000	0.001946	0.001946	0.003335	0.001048	0.005775	0.005775	0.001048	0.000357
Solano	0.000209	0.000243	0.001721	0.001721	0.000412	0.000590	0.000000	0.000764	0.000764	0.001309	0.000411	0.002267	0.002267	0.000411	0.000140
Sonoma	0.000123	0.000572	0.001887	0.001887	0.000364	0.000646	0.000000	0.001260	0.001260	0.001829	0.000723	0.002254	0.002254	0.000723	0.000150
Sonoma	0.000636	0.002960	0.009769	0.009769	0.001883	0.003343	0.000000	0.006521	0.006521	0.009467	0.003745	0.011668	0.011668	0.003745	0.000776
Stanislaus	0.000536	0.003269	0.010861	0.010861	0.002280	0.003807	0.000000	0.005505	0.005505	0.007404	0.003892	0.009164	0.009164	0.003892	0.000800
Sutter	0.000157	0.000089	0.004581	0.004581	0.000694	0.000850	0.000000	0.001231	0.001231	0.001077	0.000233	0.001746	0.001746	0.000233	0.000044
Tehama	0.000233	0.000106	0.007377	0.007377	0.001030	0.001177	0.005000	0.001666	0.001666	0.000782	0.000183	0.001089	0.001089	0.000183	0.000038
Trinity	0.000412	0.006392	0.007525	0.007525	0.001879	0.003441	0.005000	0.005607	0.005607	0.002217	0.005590	0.000389	0.000389	0.005590	0.001220
Tulare	0.002114	0.042780	0.027049	0.027049	0.010027	0.020731	0.021000	0.033644	0.033644	0.017947	0.038084	0.006990	0.006990	0.038084	0.008274
Tuolumne	0.003499	0.077880	0.040841	0.040841	0.016628	0.035313	0.057000	0.058417	0.058417	0.026882	0.068671	0.001302	0.001302	0.068671	0.014919
Ventura	0.010626	0.068232	0.039354	0.039354	0.019782	0.035538	0.000000	0.054868	0.054868	0.037424	0.062869	0.026162	0.026162	0.062869	0.018238
Yolo	0.001423	0.000779	0.004340	0.004340	0.000761	0.001246	0.000000	0.002028	0.002028	0.002547	0.000774	0.003904	0.003904	0.000774	0.000177
Yuba	0.00684	0.00011	0.00381	0.00381	0.00587	0.00368	0.00400	0.00094	0.00094	0.00062	0.00015	0.00116	0.00116	0.00015	0.00604

		8	4	6	6	9	7	0	7	7	8	6	9	9	6	4