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Quantification Of Emissions From Lawn And Garden Equipment In Central Florida

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QUANTIFICATION OF EMISSIONS FROM LAWN AND GARDEN EQUIPMENT IN CENTRAL FLORIDA

by

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ABSTRACT

The objective of this study was to evaluate the practical limits of EPA's NONROAD 2005 to accurately simulate Central Florida conditions, especially with regard to lawn and garden equipment. In particular we investigated a NONROAD emission inventory using default inputs and then created a locally specific emission inventory. These emission inventories were prepared for Orange, Osceola, and Seminole county and focused only on the VOC and NOx emissions caused by lawn and garden equipment. The model was manipulated to assess its ability to represent this specific category of nonroad equipment for a given airshed first by running a base case scenario using default data and then by developing a locally-specific scenario through administration of a survey.

The primary purpose of the survey was to evaluate local values for equipment population, equipment characteristics, activity estimates, and other relevant information. To develop these local input estimates, data were collected concerning population and usage statistics in the Central Florida area and were combined with emission factors, load factors, allocation factors, and other needed values that have been previously established by the U.S. EPA. The results of the NONROAD model were compared with the resulting emission estimates calculated from locally derived inputs, and as a result of the analysis an accurate emission estimate was calculated. In addition, several possible air quality action steps were further assessed according to feasibility, cost, and predicted emission benefit. These potential management projects were further investigated by assessing the success of other similar projects in other cities in an effort to establish specific costs and emission benefits as they relate to the tri-county area.

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I would like to thank my advisor, Dr. C. David Cooper for his support and advice throughout this effort. I would also like to thank those at MetroPlan Orlando for funding this project, and of course my parents for their unending support. Finally, thank you to Jeremy Nelson for patiently helping me throughout the survey and analysis process.

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INTRODUCTION

Recently local and state policies have begun to consider the effects of air pollution in our communities to a much greater extent than at any other time in our history. As a result of this changing focus, the need to characterize the source of pollution, the quantities produced, and the areas of highest impact has become more significant. Thus, the creation of the emission inventory is quickly becoming a standard practice in local and state governments throughout the country. As such, understanding the mechanics and the critical components of inventory creation has become an indispensable task for communities striving for environmental sustainability.

As part of this study, an emission model was developed for a specific group of sources. This emission model was created by utilizing a widely used emission inventory software, U.S. EPA's NONROAD 2005[1]. This program is accepted as an appropriate means of creating emission inventories because of its ability to model a wide variety of engine types, from motor boats to snowmobiles to lawnmowers, and from two to four-stroke engines and from old to new engines, and because it can be customized to fit specific regions, from state to county level. However, concerns exist regarding the accuracy of county specific estimates, as many program inputs are based on nationally averaged values and are then scaled by an allocation factor.

After the base case model was established, the estimates were compared to the results obtained through explicit investigation in an effort to establish the most accurate emission model. This investigation entailed a detailed survey of local lawn and garden businesses and established accurate activity values, equipment population estimates, and seasonal distribution values. This was done as part of an effort to determine if a custom model is significantly more accurate than that of NONROAD's basic model. Once this entire process was complete, the results were applied by considering specific pollution control strategies and their associated costs as part of local efforts to proactively control ozone precursors in Central Florida.

In this study, only volatile organic compounds (VOCs) and nitrogen oxides (NO_x) were modeled. These two groups of chemicals were selected because of their impact on the formation of ground level ozone. Ozone formation is a photochemical process that begins when NO_2 in ambient air becomes dissociated by ultraviolet radiation from the sun. The atomic oxygen that is formed from this reaction is very reactive and combines with O_2 to form O_3. However, in the presence of NO, ozone will begin to decompose immediately. Because of the reactions of VOCs, an alternative NO-to-NO_2 pathway can be created to enable ozone accumulation. VOCs react with hydroxyl radicals (OH•) to produce peroxy radicals (RO_2•). The peroxy radicals then react rapidly with NO to produce additional NO_2 molecules. These free radicals then react with more VOCs and acid gases to produce the chain propagating and chain terminating steps that make up the ozone formation process[2].

The following figure is a chart of pollutant profiles found in a smog chamber study which simulated urban air masses[3]. Here it can be seen that the formation of ozone begins quickly following the injection of nitrogen oxides and volatile organic compounds. As nitrogen dioxide reacts to form particulate and vapor phase nitrates, the nitric oxide concentration continues to drop and ozone concentration rises. As this process continues the concentration of partial oxidation particles also rises, thus contributing to a dense smog cloud of particulate matter which has many health effects and reduces visibility by scattering light[3].

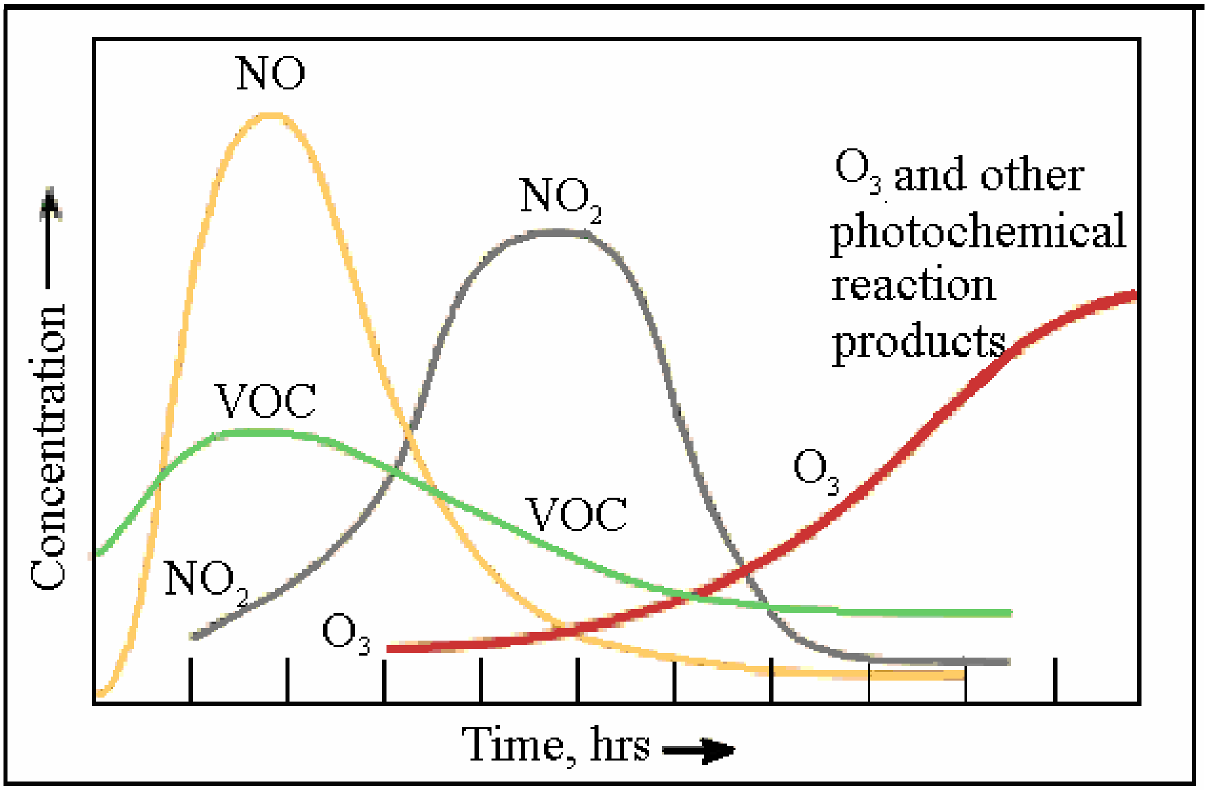

Figure 1: Pollutant Concentration Profiles Due to Photochemical Reactions[3]

Because the initiation of ozone formation requires a high amount of intense sunlight, the formation of ambient levels of ozone is highest in the summer months. May through September is commonly referred to as the ozone season for this reason[3]. However, as can be seen from Figure 2, 8-hour average peaks can occur in Central Florida as early as April and as late as September.

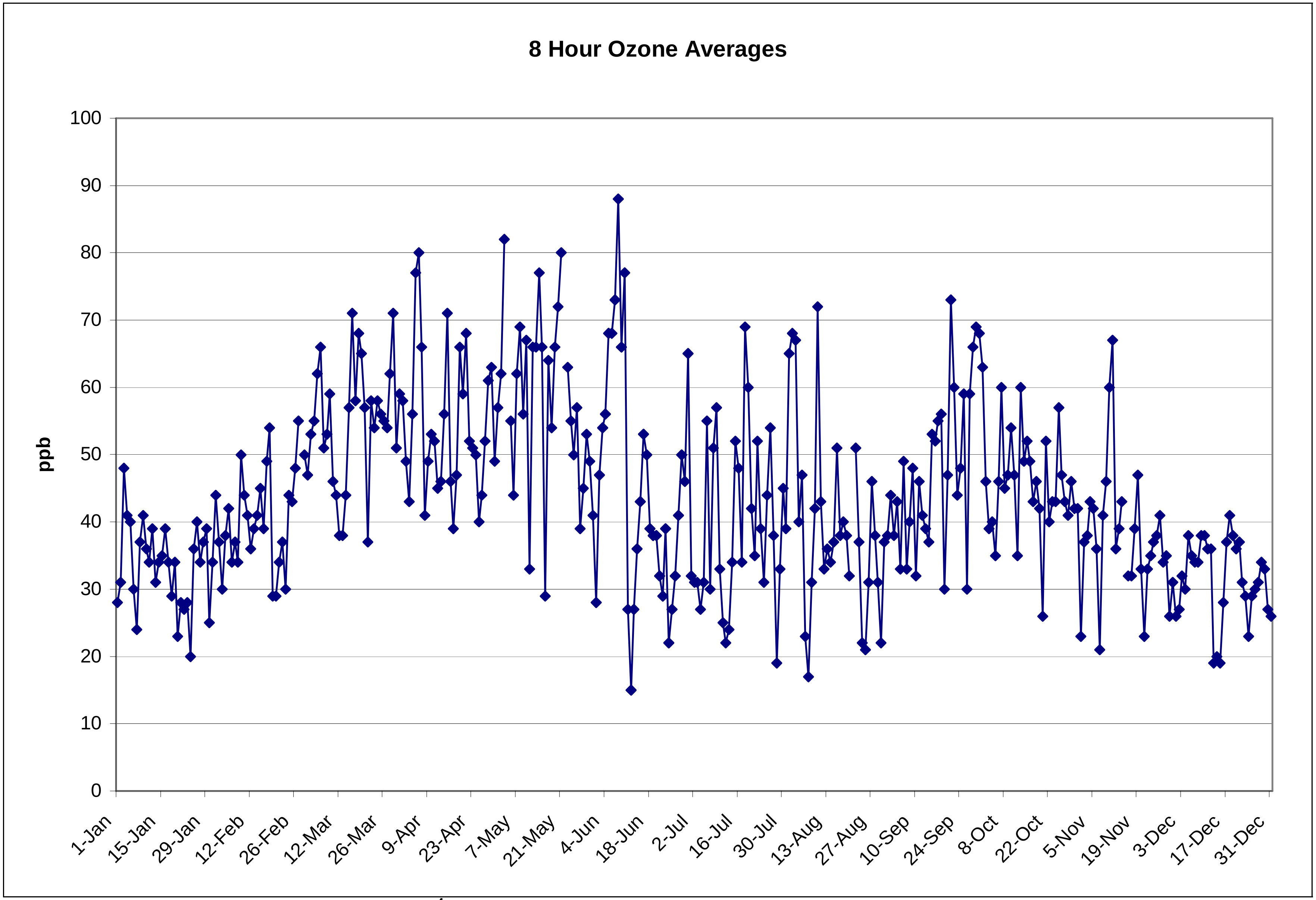

Figure 2: 8 Hour Ozone Averages for 2006[4]

Unlike the protective layer of ozone above the earth, ground level ozone is extremely harmful. Ground level ozone or photochemical smog, can cause a variety of human health problems, can increase deterioration rates in rubbers, textiles, and other materials, and can also cause extensive damage to crops[2]. Consequently, regulations have been established by the EPA to set a limit on the concentration of ozone in the ambient air of any one county without being subjected to sanctions from the national government. According to the National Ambient Air Quality Standards (NAAQS) the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentration as measured at each monitor within an area over each year cannot exceed 0.08 ppm[5]. Because of the way the standard is rounded, 84 ppb would not be a violation whereas 85 ppb would be a violation. The following table summarizes the fourth-highest readings as measured at three different measuring sites in Orlando area over the past four years.

Table 1: Ozone Readings at Lake Isle Estates[4]

	Lake Isle Estates		Winegard Elementary		Seminole Comm. College	
Year	Date	4^{th} Highest 8hr Average, ppb	Date	4^{th} H. 8hr Av, ppb	Date	4^{th} Highest 8hr Av, ppb
2007	03-May	72	03-May	75	20-April	66
2006	21-May	80	05-April	79	03-May	80
2005	16-Sept.	84	10-May	86	26-July	78
2004	06-May	76	05-May	74	07-May	74

Orange, Seminole, and Osceola Counties have been selected as the study area because they comprise the local Standard Metropolitan Statistical Area (SMSA). An SMSA is defined as a core area containing a substantial population nucleus, together with adjacent communities having a high degree of economic and social integration with that core[6]. By specifying this small area, the program's precision will be tested. Also, the area has a subtropical climate that is markedly different from other areas of the country. It is characterized by intense sunlight, a long growing season, and thus different patterns of equipment activity. However, these characteristics may not be accounted for as this area is categorized by NONROAD as being part of the Southeast region which includes Mississippi, Louisiana, South Carolina, Alabama, Georgia, Puerto Rico, and the Virgin Islands. This categorization does not take full account of the differences between areas within this large region.

According to the National Emissions Inventory (NEI) database, three classes of air pollutant sources exist: mobile sources, point sources, and area sources. Mobile sources include any type of vehicle or mobile equipment, while point sources are large stationary sources. Finally, area sources are defined as those small point sources that collectively contribute to a significant amount of emissions[7].

Within the mobile source category, both onroad and nonroad vehicles and equipment exist. Onroad vehicles include cars, trucks, busses, and other automobiles. Nonroad equipment includes mobile sources that are not licensed or certified for highway use such as lawn and garden equipment, construction equipment, recreational vehicles, marine vessels, and other equipment. The focus of this study is lawn and garden equipment, a group which nationally contributes to 6.5% of all VOC emissions and 1.1% of NOx emissions[1].

Lawn and garden equipment is a significant contributor of VOC + NOx emissions due to the largely unregulated nature of the category. Only as of 1997 have small nonroad spark ignition engines been required to meet certain emission standards. In 1997, the Phase I standards put a limit on the HC + NOx emission levels (see Table 2). Further, the Phase II standards incorporate a compliance program to ensure that engines continue to meet standards for the duration of the useful life, which include certification, production line testing, and in-use testing[8]. Table 2 summarizes the regulations set forth by Phase I standards and also the updated requirements that were set forth in April 2007. Some examples of the equipment described by this table include lawn mowers, lawn tractors, generator sets, pumps, air compressors, and commercial turf equipment. It is estimated that when these standards are fully implemented, the result will be a 35% reduction in HC + NOx emissions from new engines' exhaust and a 45% reduction in evaporative emissions.

Table 2: Phase I Emission Standards for New Nonroad Spark Ignition Engines[8]

Class*	Capacity, cc	HC + NOx, g/ kW-hr	Effective Date
I	cc < 225	16.1	2007
II	cc ≥ 225	12.1	2001-2005
I	cc < 225	10.0	2012
II	cc ≥ 225	8.0	2011

*Regardless of the type of equipment, engine class is evaluated according to capacity

LITERATURE REVIEW

EPA's NONROAD 2005

The EPA model, NONROAD 2005, was created as a result of a series of surveys, tests, and investigations that characterized a wide array of offroad engines. To calculate emission estimates several pieces of information must first be gathered. These data include: emission factors for the equipment of concern, the population of equipment in use, the number of hours the equipment is run, useful life, load factors, allocation factors, and some other basic data.

In NONROAD, emission factors were obtained by the EPA by conducting several laboratory tests on a large number of machines ranging in age, power, and size. Collection of equipment populations and activity values, however, involved a much more complex analysis.

Equipment population estimates were primarily obtained through sales estimates submitted to EPA in 1996 as part of a requirement to meet the first set of federal emission standards, or the Phase 1 standards[9]. This was done only for the four groups of equipment with the highest sales volumes (lawn mowers, trimmers, leafblowers, and vacuums). This population was further broken down by fuel type, age, engine type, and application (commercial vs. residential) according to data collected by the California Air Resources Board[9]. For all other equipment types, estimates were derived from a nationally averaged population survey estimate conducted by the Power Systems Research firm (PSR) in 1998[9]. To translate these national population estimates to a local level, the NONROAD software applies an allocation factor obtained from the U.S. Census Bureau which is based on the number of employees working in the industry for a particular area.

Equipment activity values were obtained from data published by the EPA in 1991 as well as from a technical report produced by the California Air Resources Board (CARB) in 1995[10]. The EPA document provided monthly activity allocation fractions obtained from regionally averaged surveys, and the CARB report is the source for monthly activity factors. The program assumes the same total activity values for all areas of the country but differentiates seasonal activity values for six distinct regions (Northeast, Southeast, Great Lakes, Southwest, Northwest, and the West Coast.) While activity for northern areas is concentrated only in the summer, seasonal factors for southern areas are more evenly distributed throughout the year. For example, in the Northeast 16.7% of the total annual activity is allocated to the each of the summer months, whereas in the Southeast 11.3% is allocated to the summer months[1].

While this program serves as a useful tool for interest groups throughout the country, it is based on several estimates that were derived from nationally averaged values. As a result, these values may not adequately represent local conditions. The program does not incorporate local activity patterns and cannot accurately account for variability from county to county or even state to state. The program does however account for differences in equipment populations from county to county by utilizing the allocation factor.

Orange, Seminole, Osceola County Emission Inventory

In 2003, Arbrandt developed an emission inventory for the Orange, Seminole, and Osceola County area of Central Florida[7]. In this study, VOC and NOx emissions from several categories were considered, and were modeled using the NONROAD program. In the following figures, the portion of emissions produced from a variety of emitter categories is shown. The figure includes all major categories, from all three types of air pollutant sources that contribute significantly to emissions in the Orange, Seminole, and Osceola county region.

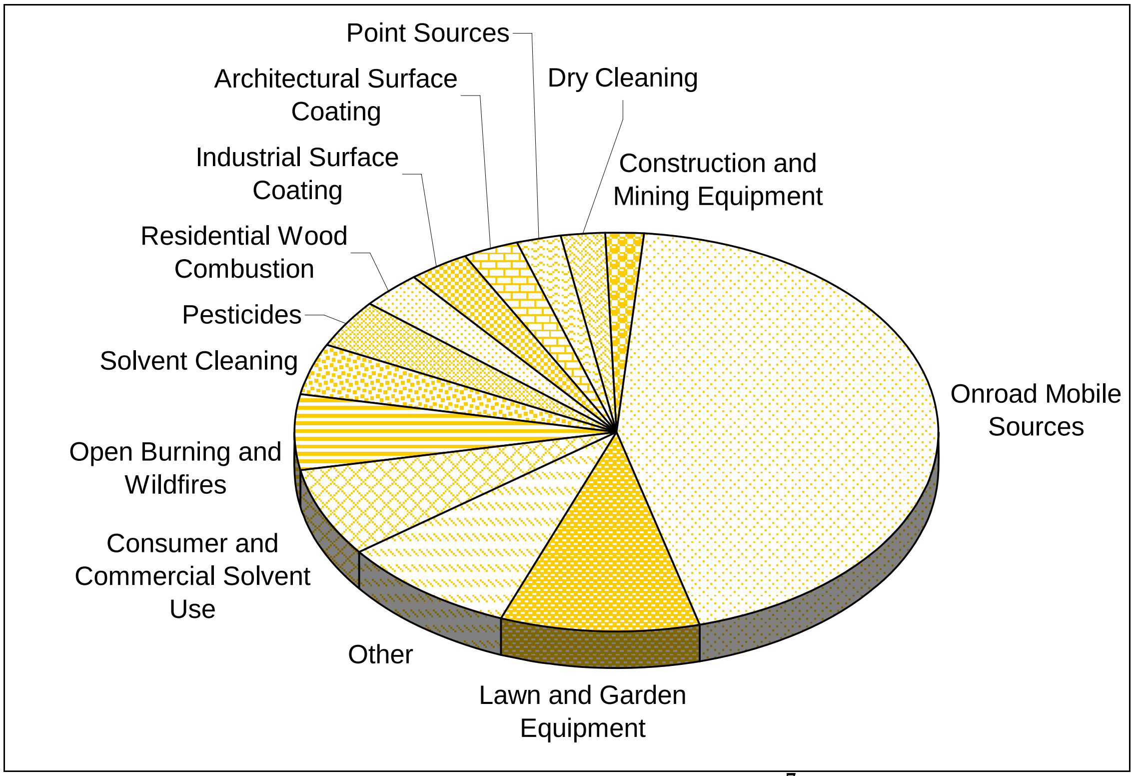

Figure 3: VOC Emissions in Central Florida by Category[7]

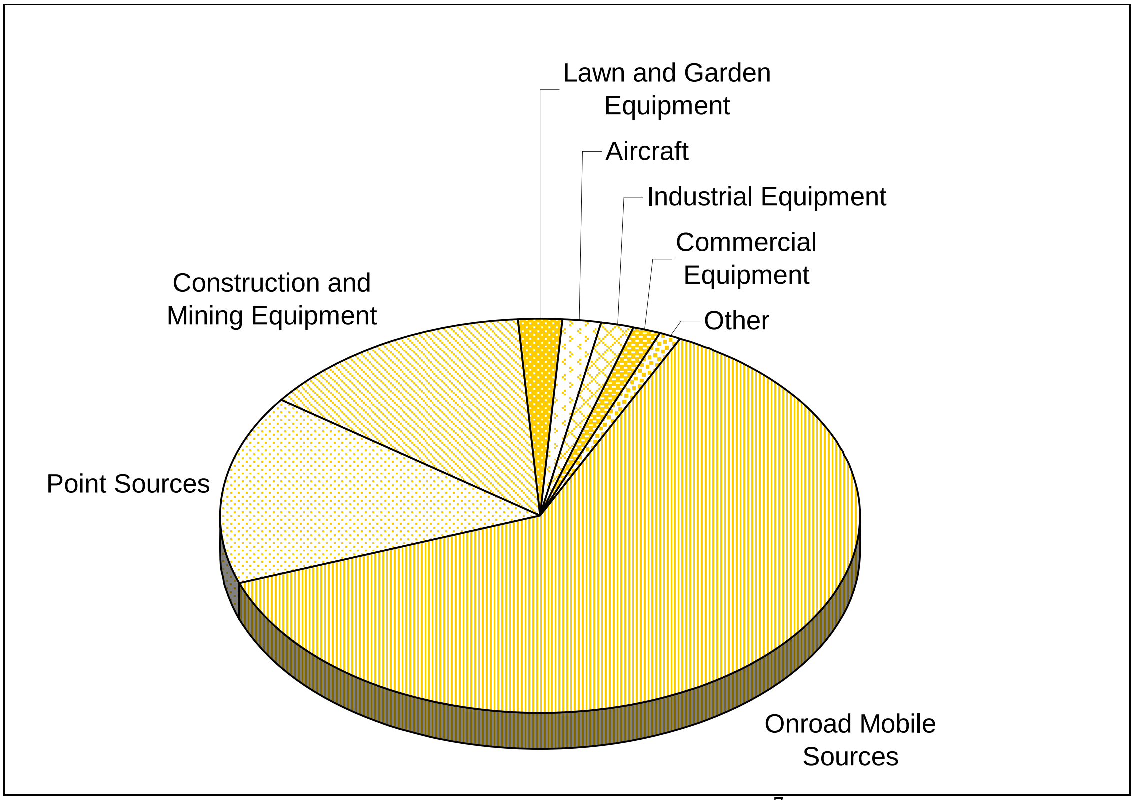

Figure 4: NO_x Emissions in Central Florida by Category[7]

This study is an important building block for the current research as it serves as an initial evaluation of the sources of emissions in the local area. Assessing the results of this study was a key factor for determining the focus of the current study. Observation of Figure 3 and Figure 4 reveals that only two categories contribute significantly to *both* VOC and NO_x emissions, onroad mobile sources and lawn and garden equipment. However, due to the largely unregulated nature of the lawn and garden equipment population, far less information is available concerning air pollution impacts for this type of equipment. Although some studies have been conducted on the matter, very little information exists concerning the nature of lawn and garden equipment use. Consequently, the focus for this study was the lawn and garden equipment category. Lawn and garden equipment contributes to 10% of the 85,000 tons of VOCs and 3% of the 80,000 tons of

NOx emitted annually. Of this, approximately 7,500 tons of VOCs are from commercial lawn and garden businesses and 1,800 tons of NOx are from these businesses.

Arbrandt's emission inventory evaluated all significant emission sources in the Orange, Osceola, and Seminole county region. Modeling for lawn and garden equipment was done using the NONROAD program and by assuming that standard inputs are valid. While this method serves as a valuable initial estimate, no attempt was made to account for unique properties of local activity or populations. Instead all standard assumptions from NONROAD were applied.

California's OFFROAD 2007

California Air Resources Board has created an emission inventory tool that is used to estimate emissions for offroad vehicles, including lawn and garden equipment, in the state of California. This program achieves the same goals for California as does the EPA model for the country. As with the EPA model, emission estimates are calculated as the product of the emission rate, engine population, and activity in annual average use hours.

This program begins with population estimates with a base year of 2000 that was determined in a study by Power Systems Research[11]. Next, values are appropriately scaled according to a growth factor that was determined in a Cal State Fullerton Study in 1994[11]. In this study projection factors were developed based on historical and economic data for both private and commercial equipment. The study recommended using housing units to predict the growth of residential equipment and using construction valuation to assess commercial equipment. While the use of housing units is a common surrogate, the use of construction valuation is unique to this study. This study assumed that increases in construction would result in an increased demand for commercial lawn and garden activity; however this assumption is questionable as the dependence of these two variables is not expressly proven in this study. After growth is determined, the state averaged population is then scaled to county or region according to an allocation factor calculated in the Energy & Environmental Analysis[11]. Other relevant values (useful life, activity, load factor, et cetera) were all assessed in various studies conducted by the Power Systems Research group.

This program is also distinguished from the EPA NONROAD model in that it incorporates changes in emission factors as a result of California's own regulation changes and management tactics. For example, the model recognizes the state-specific regulation changes that were enacted in 2004 and 1998 which were more stringent than those of national regulations.

This is a unique program in that it analyzes assumed input values with a greater degree of accuracy than does the NONROAD program. While it is only applicable to the state of California, it serves as a good example of how locally specific models can be developed. However, if other similar models are created, it may be necessary to further investigate commercial allocation surrogates and assess what factors best relate to commercial equipment populations.

Houston/Galveston and Beaumont/Port Arthur Studies

This study was conducted in 1995 by Systems Applications International (SAI) for the Texas Natural Resource Conservation Commission (TNRCC)[12]. This study focused on assessing activity values for both commercial and residential equipment sectors. Private activity was determined by conducting telephone surveys by random digit dialing. Commercial surveys were administered by mail. Surveys were distributed by selected random businesses from the local business listings.

Some difficulties that arose in the survey include timing and question format. A large flooding event, which may have affected the normal activity, resulted in concerns about the timing of the survey. It was also found that one particular question type consistently resulted in confusion. Specifically, the question asked how long it would take the operator to mow the lawn as opposed to asking how long the mower runs while mowing the lawn.

As a result of this survey, several observations were made concerning the local activity patterns. It was found that Friday has a higher private activity than Saturday. It was also found that 20% of commercial activity occurs over the weekend. Finally, it was found that while private usage is strongly affected by the season, commercial usage remained nearly constant throughout the year[12]. The report for this study did not provide specific population or activity values.

Alamo Area Council of Governments Emission Inventory

This emission inventory assessed a wide variety of emission sources including both residential and commercial lawn and garden equipment[13]. The analysis was performed in 2002 and represented a twelve-county area. The purpose of this study was to provide specifications that would allow for a more complete emission inventory creation at the county level in future years and also to provide a mechanism for determining a representative emission estimate. While this study utilized the NONROAD program for many input variables (emission factors, load factors, average horsepower, et cetera), surveys were created in an effort to acquire more accurate values for equipment populations and activity estimates.

Residential data were obtained through phone call surveys that were selected by random digit dialing. The surveying process was conducted in two separate stages of calls. The first test survey consisted of 889 phone calls. The second test survey was conducted using the same set of questions, and was done in an effort to determine whether habits had changed since the time of the first survey. In total, 1,742 calls were placed with a response rate of 862, or approximately 50%.

Commercial data were obtained through mail surveys that were sent to local businesses selected by way of local business listings. Of the 273 total companies in the local area, 34 companies responded to the survey.

As a result of this survey it was found that most equipment sources had much higher activity rates than the NONROAD defaults, while most population estimates were found to be lower than those estimated by NONROAD. For example, annual activity for lawn mowers was found to be more than 300% greater than the estimate made by NONROAD and the equipment population was found to be only 20% of the NONROAD estimate. The following chart summarizes the results from the top five commercial categories.

Table 3: Results from AACOG Activity Assessment[13]

Equipment Type*	AACOG Survey, hrs/yr	NONROAD Default, hrs/yr
Lawn Mowers	1361	406
Lawn and Garden Tractor	1190	721
Trimmers	1445	137
Chainsaws	1336	303
Tillers	809	472

*Includes Commercial Equipment Only

Table 4: Results from AACOG Population Analysis[13]

Equipment Type*	AACOG Population	NONROAD population
Lawn Mowers	2,019	9,108
Lawn and Garden Tractor	146	2,364
Trimmers	7,875	11,139
Turf Equipment	9	6,013
Tillers	138	3,487

*Includes Commercial Equipment Only

As a result of this study the emission inventory for the AACOG region was greatly improved. It was found that much of the assumed data in the NONROAD program did not adequately represent the actual conditions of the area. Consequently this study serves as a valuable tool to other regions that wish to conduct similar studies. One concern about this survey however, is the fact that the creators of the survey simplified the categories beyond what was defined in NONROAD. For example, one group in NONROAD is trimmers, edgers, and brush cutters. This is a comprehensive group that includes a few similar types of equipment. The creators of this survey, however, simplified the name of this group to trimmers, which could lead to a distortion of the results.

REVIEW OF POTENTIAL CONTROL MEASURES

The goal of this study was not only to create a more accurate emission inventory, but also to assess the cost and emission benefit of possible operating or equipment changes by the lawn and garden industry in response to concerns for the area's air quality. Several air quality management tactics were investigated in this study which include: use of alternative fuels such as ethanol or biodiesel, use of electrical equipment, use of a catalytic converter for certain applications, reduction of two-stroke engine usage, scrap programs, and resident awareness campaigns.

Alternative Fuels

The use of alternative fuels is becoming an increasingly common option in several cities around the world. In fact, the recently passed Energy Policy Act will require up to 7.5 billion gallons of "renewable fuel" to be used by 2012[14]. Two of the most commonly used alternative fuels are ethanol and biodiesel. While both have some advantages over conventional fuels, several factors must be examined before beginning widespread use of either fuel in the lawn and garden industry.

To replace gasoline as a fuel, ethanol, or E85, could be used as an alternative. However, it has been found that with ethanol fuels, decreases in ozone that result from reductions in tail pipe VOC emissions may be offset by increases in ozone caused by enhanced evaporative emissions of VOCs[15]. As such, total emissions from ethanol use may be comparable to that of gasoline. Aside from this, however, is the fact that the engines must be engineered to eliminate certain metals due to the corrosive properties of ethanol[16].

To replace diesel as a fuel, biodiesel, or B20, could be used as an alternative. In one study, it was found that HC emissions would be reduced by 12% relative to petroleum diesel while the changes in NOx ranged from -5.8% to +6.2%[17]. On average, NOx emissions changed by 0.6%[17]. Additionally, no engine modifications are required for the use of biodiesel fuel. Furthermore, biodiesel can contribute to the reduction fossil fuel use and also reduces carbon dioxide emissions.

To implement use of either alternative fuel, fueling stations must be equipped with additional tanks and local residents must be willing to purchase these alternative fuels. A cost analysis revealed that one 15,000-gallon fueling tank would cost approximately $170,000. In 2006, the average price of B20 was $2.82 per gallon with a standard deviation of $0.06. In comparison, the average price of petroleum diesel was $2.93 with a standard deviation of $0.06[18]. In Orange County, from January through June 2007, the prices were within $0.03 of each other. Because of the fluctuations in these prices, it was assumed that there was no difference between these two fuel prices. Thus, the total cost of this project is based solely on the capital cost of the tanks. It was assumed that the project would be annualized over 30 years at a 5% interest rate and that a total of five tanks would be built to satisfy the needs of lawn and garden businesses. The cost of the tanks also includes materials and installation for a canopy, lights, product dispensers, and electrical equipment. The total cost was determined by utilizing the following equation[19]:

$$\text{Total Annual Cost} = \frac{i(1+i)^n}{(1+i)^n - 1} xP = \frac{0.05(1+0.05)^{30}}{(1+0.05)^{30} - 1} \text{ x \$170,000 x 5= \$55,000/yr} \qquad \textbf{(1)}$$

By these approximations, the Orange, Osceola, and Seminole County region could save up to 5 tons of VOCs (12% of 42 tons total diesel emissions) per year and will gain 2 tons of NOx (344 x 0.006) at a cost of approximately $18,300 per ton of VOCs and NOx.

Electric Equipment

Use of electric equipment, such as lawn mowers, trimmers, blowers, et cetera, may also be considered as an option for reducing ozone potential, as they allow for zero exhaust emissions. This, however, is generally considered to be an option primarily targeting residential lawn and garden equipment due to decreases in available power.

Electrical handheld equipment, such as trimmers, tillers, chainsaws, or blowers, compete well with lower-end gasoline handheld models as they have comparable cutting paths and are priced competitively. However, nonhandheld electric equipment, such as lawn mowers, typically have a smaller cutting path and have limited operation time between recharges, thus making the equipment most suited to residential use with smaller sized lots[20]. Additionally, the cost of an electric lawn mower is often much greater than its gasoline counterpart. The following table lists some popular lawn mowers and comparable electric models.

Table 5: Price Comparison of Gasoline and Electric Lawn Mowers[21]

Manufacturer	Cutting Path, in	Type	Price
Yard Machines	21	Gasoline	$199.00
Toro	22	Electric	$399.00
Troy-Bilt	21	Gasoline	$215.00
Troy-Bilt	21	Electric	$379.00

Because of these differences in price, several cities have offered monetary incentives to residents that are willing to purchase electric lawn mowers. Education and awareness are important aspects of successful implementation of these programs. While exchange programs are a feasible option, they are resource intensive which make them difficult to carry out successfully.

For eight consecutive years (1998-2006) the Bay Area Air Quality Management District has conducted the "Lawn Mower Buyback" event in which $100 rebates were offered to local citizens who brought in gasoline powered mowers in exchange for a new electric mower[22]. Television, radio, and flyer advertisements were utilized to educate citizens about the events. Typically, one Home Depot location was chosen in each participating county, and for one Saturday morning in the month of April citizens were invited to bring in their gasoline mowers and purchase a new electric mower at a $100 discount. As a result of this effort, total costs and emission benefits were evaluated for the five years with the most recorded data available. Results are displayed in Table 6 below.

Table 6: Analysis for BAAQMD Lawn Mower Buy Back Program[22]

Year	Number Exchanged	HC + NOx Annual Emission Reduction	$/ton HC + NOx
2000	1340	6.74	$19,900
2001	1244	6.26	$19,900
2002	850	4.28	$19,900
2003	1100	5.54	$22,600
2004	1588	7.99	$16,900
AVERAGE:		6.16	$19,840

Engine Modifications

While the U.S. EPA has set certain standards for lawn and garden equipment emission rates[8], states do have the option of limiting the type of equipment sold. For example, California has imposed a rule to require manufacturers to increase fuel efficiency by improving carburetor systems[23]. The rich air-to-fuel mixtures of two-stroke engines have also been considered unfavorable as they result in high emissions as compared to their four-stroke counterparts. Use of equipment with an overhead valve system may be a positive option as VOC emissions tend to be much lower for this engine type[24].

Another option for reducing emissions may be to utilize a catalytic converter on some machines. Catalytic converters have proven a valuable part of emission control for cars and trucks. Total HC and CO emissions were reduced by about 70%, while NOx emissions were reduced by about 50%[25]. California was recently allowed by the EPA to sell small engine equipment with catalytic converters despite previous arguments that catalytic converters could cause fires with such small engines, which was actually disproved in a study by the EPA[26]. As a result the EPA has passed a revision of Phase I regulations that lowers emission factors for certain classes of lawn and garden equipment to a level that will only be possible to achieve by improving engine combustion and adding catalysts[27]. Regulations go into effect in 2012 and are expected to reduce VOC emissions by 630,000 tons and NOx emissions by 98,000 tons nationally. To estimate an average price for a lawn mower catalytic converter, typical prices for automobile catalytic converters were determined and extrapolated for a small engine[28]. The cost was estimated at \$230. Details of this extrapolation are given in Appendix A. This average cost was then multiplied by the total population of Class I and II engines (lawn mowers, tractors, commercial turf equipment) as determined by NONROAD. This cost was annualized over 4 years at an interest rate of 5% according to the following equation[19]:

$$\text{Total Annual Cost} = \frac{i(1+i)^n}{(1+i)^n - 1} xP = \frac{0.05(1+0.05)^4}{(1+0.05)^4 - 1} \text{ x \$230 x 319,896= \$20.7M/yr} \qquad \textbf{(2)}$$

To find the cost per ton of pollutant reduced, this value was divided by 70% of the total VOC emissions from lawn mowers, commercial turf equipment and tractors (2,900 tons x .7) and 50% of NOx emissions from this group of engines (600 x .5). This translates to about 2,000 tons of

VOCs and 215 tons of NOx reduced in Orange, Osceola, and Seminole County at a cost of $9,000 per ton of VOC + NOx.

Scrap Programs

Another tactic for reducing emissions may be implementation of a scrap program. By hosting scrap programs, the turn-over rate of older, less efficient machines could be increased. It may also be difficult to adequately implement, considering the fact that there is no way to verify the actual age of machines since lawn and garden equipment does not require registration. However, this would be an effective tool to use when new regulations go into effect. By encouraging locals to retire old equipment, the newer, less polluting equipment will become part of the equipment population in larger numbers and at a faster rate. A comparable program was conducted in California, and it was estimated that for a similar sized area as the Orange, Osceola, and Seminole county region, a program such as this would result in an emission benefit of 2-4 tons VOC + NOx and would cost approximately $18,000/ton[20]. However, considering the fact that regulations will be at a new low by the year 2012, this emission benefit could rise even more should a scrap program be conducted at that time.

Education Campaigns

Education is an essential tool that can be effectively used to help residents understand how their habits and actions impact air quality. Education campaigns can range in topics from the effects of biodiesel, to the properties of ozone, to specific actions people can take to improve the air quality. The Bay Area Air Quality Management District (BAAQMD) hosts education campaigns to encourage residents to avoid certain activities that may contribute to air pollution on certain high risk days. Surveys showed that about 8% of residents subsequently reduced their use of gasoline powered lawn equipment on those days[20]. Education campaigns can be used in a variety of ways and are essential to changing resident behavior. As a result of the BAAQMD education campaign, 2 tons of HC + NOx were saved and from year to year the project cost $20,000- 36,000/ton[20].

METHODOLOGY

For purposes of this study, two runs were made using the NONROAD program. For the first run, standard assumptions were made. This run represented default values determined by investigation and surveys conducted through EPA studies. This represents a "top-down" survey method in which broad estimates are scaled down according to an allocation factor.

In contrast, an alternate model was created using a "bottoms-up" survey method[12]. It was assumed that the EPA determined values for emission factors adequately represent the equipment used in central Florida. Equipment populations and activity values were obtained by administering and subsequently analyzing surveys of local lawn and garden businesses. All other assumptions and values applied by NONROAD were assumed to adequately represent local situations.

Model Initialization

The initial lawn and garden emission model for central Florida was calibrated by conducting simulations in EPA's NONROAD 2005. Selections from four main screens are required to run this program. First, the option file requires information such as run name, information about the fuel, and environmental conditions. The base case run was estimated for the year 2006. The following table summarizes the basic parameters that were associated with this run.

Table 7: Option File Parameters

Parameter	Value
Fuel RVP for gas	8.0
Oxygen weight %	0.0
Gas Sulfur %	0.003
Diesel Sulfur %	0.050
CNG/LPG Sulfur %	0.003
Minimum Annual Average Temperature (F)	60
Maximum Annual Average Temperature (F)	84
Annual Average Temperature (F)	75
Stage II Control %	0.0

Next, the region of interest was selected from the Region screen as seen in Figure 5. For this run, county level emissions were required. Specifically, the run was made for Orange, Osceola, and Seminole Counties in Florida. All three counties were run simultaneously.

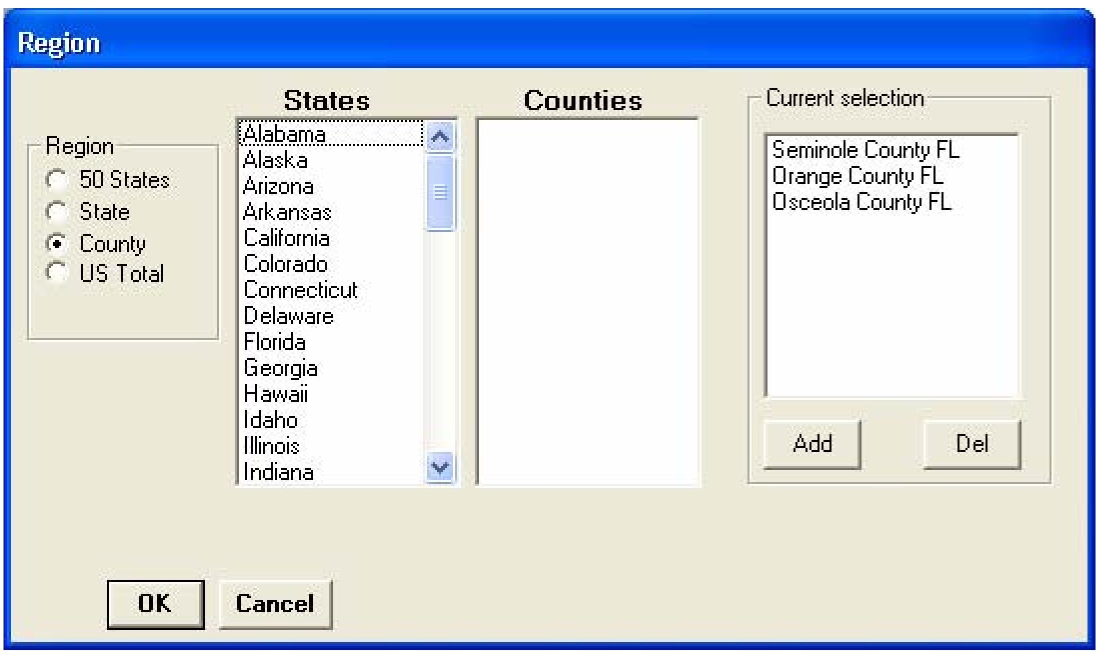

Figure 5: Region Screen of NONROAD

Following this step, equipment types were selected from the Sources screen as seen in Figure 6. In addition to selecting the type of equipment to be analyzed, the desired fuel types were also specified at this time. For this run “All Fuels” was selected and the complete segment for “Lawn & Garden” was selected.

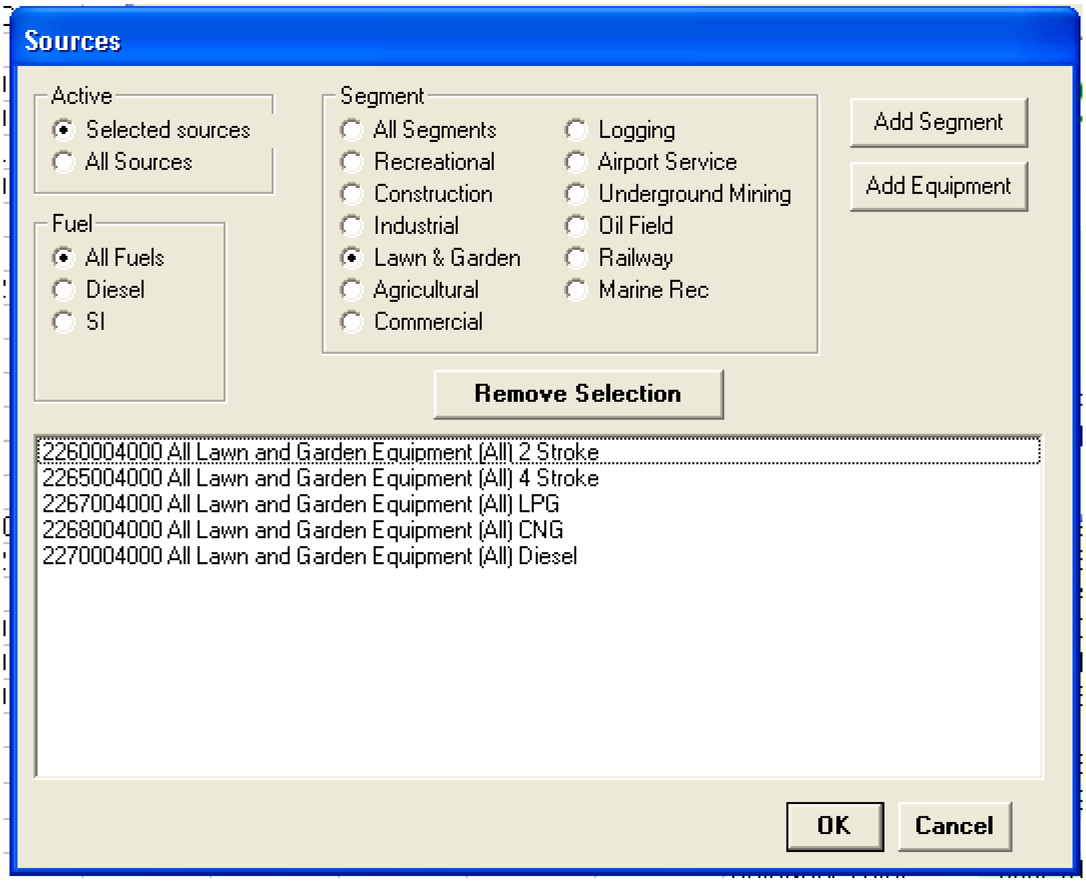

Figure 6: Sources Screen of NONROAD

The final selection screen is Period as seen in Figure 7. In this menu the episode year 2006 was chosen. Next, the period option provides for the user to select annual emissions, monthly, or seasonal. The base case scenario was run five separate times, once for annual emissions and four times for seasonal emissions. If the seasonal period is selected, the user must also specify which season will be run, as data for winter, spring, summer, and fall vary slightly. Additionally, this menu requires the user to specify what type of day is being modeled. In other words, the program can either model all days inclusively or it can be customized to include only weekday or weekends.

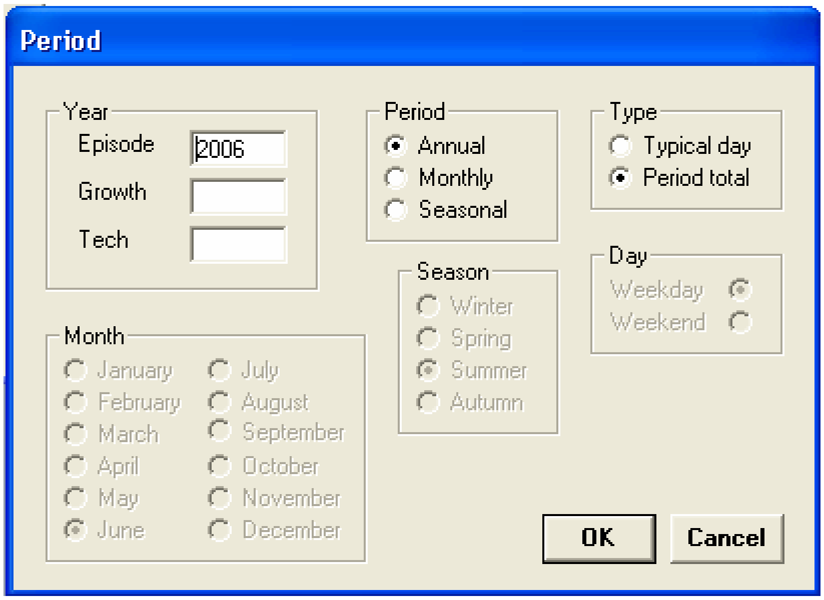

Figure 7: Period Screen of NONROAD

Once all parameters were specified, the model was run. Files were then viewed using Microsoft Access. From Access a variety of outputs can be derived from the results of the run. For example, the program calculated estimates for emission totals, equipment populations, fuel consumption, and emission factors. These results were further broken down according to equipment type, source category, horsepower, location, et cetera. Finally, once the appropriate analysis was selected, results were displayed and were exported to Excel to create figures for the data.

From the results of this run the equipment categories of largest impact were evaluated. It was found that the following five commercial groups were the top contributors of emissions:

- lawn mowers
- trimmers, edgers, and brush cutters
- leafblowers and vacuums
- chainsaws
- turf equipment

By determining which groups contribute most significantly, appropriate questions for the survey were designed. By observing the results of this run any categories that were found to be significantly larger than the other groups of equipment were further investigated in an effort to improve the accuracy of the estimate.

Survey Analysis

In an effort to increase the accuracy of annual emission estimates produced by NONROAD, specific input values were obtained through surveys and were then compared to the NONROAD results obtained with default inputs. The primary objective of the survey was to accurately assess the equipment population and activity levels for the five largest commercial lawn and garden equipment groups in the Central Florida area. Additionally, the survey included introductory questions that focused on user preferences concerning alternative fuels and electrical equipment usage. The following is a list of the hypotheses that were tested in this survey as they pertain to the Orange, Osceola, and Seminole County region.

1. If the tri-county area were to implement use of either biodiesel *or* ethanol, which fuel would most benefit the lawn and garden industry?

2. If the tri-county area were to acquire funds for new alternative fueling stations would commercial lawn and garden businesses use this new source for their fleet?

3. If the tri-county area were to build alternative fueling stations should a significant amount of money be spent on marketing campaigns to educate business owners about the effects of ethanol/biodiesel?

4. What percent of commercial lawn and garden companies have utilized electrical equipment for their work?

5. When commercial businesses purchase electrical equipment, are they generally satisfied with their selection?

6. Is the most frequently used lawn mower type accurately predicted by NONROAD?

7. Does NONROAD accurately predict the most frequently used engine power for lawn mowers?

8. Does NONROAD accurately predict the amount of springtime activity for the top five emission categories?

9. Does NONROAD accurately predict the amount of summertime activity for the top emission categories?

10. Does NONROAD accurately predict the amount of wintertime activity for the top emission categories?

11. How many individual pieces of equipment are owned by commercial lawn and garden businesses in the tri-county area of the top emission categories?

The survey was created to target commercial lawn and garden equipment in the Orange, Osceola, and Seminole county region as they were identified as a significantly larger emission category than that of residential equipment[7]. A print copy of the survey was created and sent by mail. To obtain addresses, the local tax collectors' offices were contacted. Through the tax collectors office a comprehensive list of all lawn and garden businesses that had filed taxes in that year was obtained[29, 30, 31]. This list of businesses included large companies as well as individuals that performed lawn and garden business on their own. To avoid bias the sample surveyed was chosen by random selection. The list of businesses was organized in Excel and assigned a random five digit number. The businesses were then rearranged according to their randomly assigned number and the top 600 businesses were selected to receive the survey. By doing this no preference was given to the type of company or the size of the company.

In an effort to increase participation and the response rate of the surveys, a cover letter with an introduction and the UCF emblem was sent out to the companies explaining the purpose of the survey and asked for the help of the business owner, as suggested by Czaja[32]. The survey itself contained questions concerning various usage and application topics, the number of machines each company owned, characteristics of the equipment such as power levels, age, and engine type, and finally it inquired about the amount of time each equipment type is typically used per week. Once the survey was created, it was reviewed for errors and unclear wording by three students not involved in the commercial lawn and garden business and finally by two persons that were involved in the lawn and garden business. Survey pre-testing is a commonly used step in the survey creation process[32] that serves to ensure that all questions can be clearly understood and are applicable to those that will be taking the survey.

As a result of the base case run, the top five emission source categories were determined. The majority of the questions included in the survey focused on these groups. These categories include:

- lawn mowers
- trimmers, edgers, and brush cutters
- leafblowers and vacuums
- chainsaws
- turf equipment

Print copies of the survey were sent out first (See Appendix B for a copy of the complete survey). Within eight weeks 31 responses were received. Later an online version of the survey was created to allow those who had misplaced their survey to easily access the survey again. Reminder postcards were sent out which included a link to the online version of the survey. Four additional surveys were received within the three weeks after the reminder postcards were sent. In terms of the total number of employees, this represents 8% of the lawn and garden commercial industry in the Central Florida area. In terms of the total amount of lawn and garden companies, these 35 surveys represented a 6% response rate for the industry in the Central Florida Area. While typical survey standards may consider this response rate to be somewhat low[32], this sample was assumed to satisfy the needs of this study. Survey data were difficult to obtain from this population because of language barriers and because of the high level of mobility of these businesses.

To analyze the data, the survey was coded and entered into the statistical program, SPSS 11.0 for Windows[33]. While all questions were initially analyzed using frequency distributions and descriptive statistics, different questions were further assessed. For example, while several introductory questions required a straightforward frequency analysis, other questions were directed at obtaining population estimates required further calculations.

First, a summation of the survey sample equipment population was obtained. Next, that value was divided by the total number of employees represented by the sample and multiplied by the total number of employees working in the tri-county area (as measured by the U.S. Census Bureau). To account for additional industries with commercial lawn and garden equipment that are not explicitly listed in the industry for tax purposes, an additional factor was included in the population estimate. While some theme parks were surveyed, available budget was limited thus making it difficult to obtain information from sources such as golf courses, cemeteries, and state parks. A 10% factor was included in the population estimate to account for this discrepancy. This value was selected because it allowed the survey population to closely correlate with NONROAD default populations. Consequently, this study focuses less on determining exact population data and more on determining the proportions of different types of equipment.

To obtain activity data, questions were designed to target the number of hours that each equipment type is used. To account for seasonal variation, separate questions addressed activity in spring, fall, summer, and winter. The resulting values were then normalized on a per equipment basis and the sample mean was calculated to represent both seasonal and annual activity levels.

In NONROAD one input file lists the number of hours per year that each type of equipment is used and another file with the fraction of hours allotted to each month of the year is used to determine seasonal activity. To determine the appropriate fraction to use for this input file, seasonal activity values were first normalized to find the most appropriate value for each equipment type. The seasonal input file then lists only two separate categories for lawn and garden equipment: lawn and garden equipment excluding chainsaws and lawn and garden chainsaws. Thus, to determine an appropriate fraction for lawn and garden equipment excluding chainsaws, values were averaged to find one representative value.

Once all input information was calculated, NONROAD input files were edited to reflect the survey data. This was done for three files: Population, Activity, and Season. Next, the NONROAD program was initialized and the Advanced Options menu was selected. Each of the three new input files was specified for use. The run was then completed in the same manner as was previously described in the last section.

This survey represents the habits and equipment inventories of lawn and garden businesses in Orange, Seminole, and Osceola County. A regression analysis was used to determine the relationship between the number of employees represented and the equipment population. Values of the coefficient of determination (R^2) indicate the magnitude, in percent, of correlation and explained variance between the variables included within the equation. This value is calculated by the following equation:

$$R^2 = \frac{SS_{yy} - SSE}{SS_{yy}} \quad \textbf{(3)}$$

where SS is the total sample variation of the observations around the mean and SSE is the remaining unexplained sample variability[34].

Next a t-statistic was used to test the significance of the estimate. To find t, the following equation was used:

$$t = \frac{\bar{x} - \mu}{s / \sqrt{n}} \tag{4}$$

where $\bar{x}$ is the sample mean, μ is the normally distributed mean, s is the sample standard deviation and n is the sample size. Then, to test at the 95% confidence level the significance of the value will have to be less than 0.05 (allowing for up to 5% error) to ensure that there is a correlation between employee number and equipment populations[35]. This is further discussed in the following sections for each equipment type.

To evaluate independent variables, such as activity, a chi-square distribution was utilized to verify the statistical significance of the findings. This statistic is used to assess normally distributed samples with (n-1) degrees of freedom, where n is the sample size. The shape of the distribution curve is dependent on the number of degrees of freedom. Significance values test the upper and lower tails of this curve. Chi-square is found according to the following equation:

$$\chi^2 = \frac{(n-1)s^2}{\sigma^2} \tag{5}$$

where X represents the chi-square value, n is the sample size, s is the sample standard deviation, and σ is the sample variance. The results of these statistical analyses will be presented and discussed in the Results section of this report.

RESULTS AND DISCUSSION

Model Initialization

As a result of the initial base case runs, a chart was created to display the VOC and NOx emissions from a variety of lawn and garden categories. The following figure displays the results of the simulation. From this chart, the levels of VOC and NO_x emissions can be comprehensively understood for a number of specific equipment types. Emission levels are listed for the top ten equipment categories. It is also important to note that all categories are represented as either commercial or residential equipment, with residential equipment distinguished by use of an asterisk. From this chart of lawn and garden emissions, it can be seen that of the top ten categories only two are residential equipment. Careful consideration of this classification distinction is essential as it recognizes the major differences associated with the two types of usage patterns. Generally, commercial use is characterized as more intensive, while residential use occurs less frequently and for shorter periods of time. As a result of this run, it was found that the top five commercial emission categories are:

- lawn mowers
- trimmers, edgers, and brush cutters
- leafblowers and vacuums
- chainsaws
- turf equipment

Consequently, these five groups were the focus of the survey study.

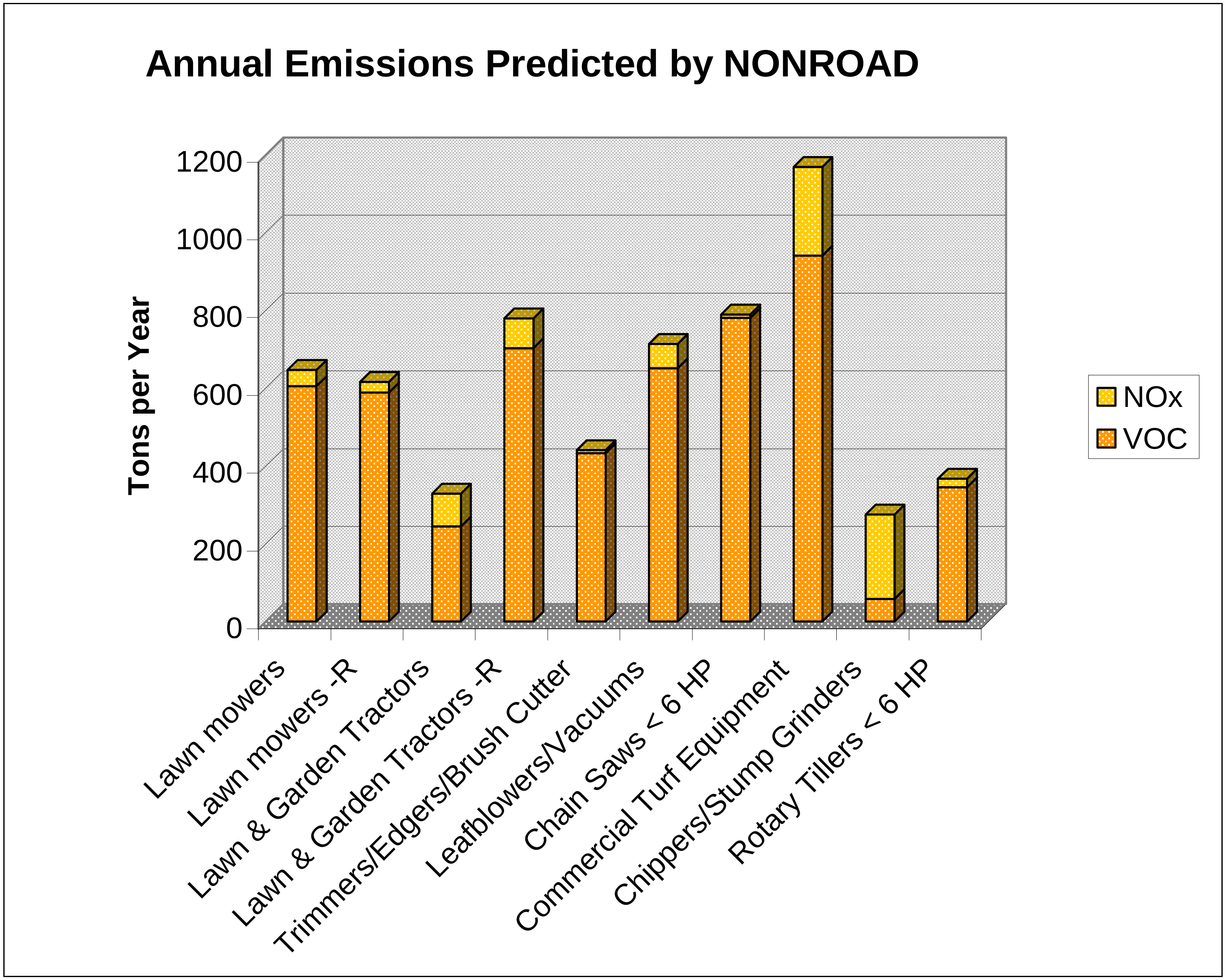

Figure 8: Lawn and Garden Emission Levels in Central Florida
Note: 'R' Denotes Residential Equipment

Survey Analysis

Survey questions were primarily divided among the top five commercial equipment categories but also included a section for miscellaneous questions. Questions for each of the five equipment categories referred to activity levels, seasonal changes, equipment populations, equipment types, and engine horsepower. Table 8, Table 9, and Table 10 display data that was used as an input to the NONROAD program. Table 9 displays seasonal fractions that are applied to the annual activity values to obtain the number of hours spent on each activity per month. Summer months refer to June, July, and August. Winter months are December, January, and February, while spring and fall include the remaining months between seasons.

Generally it was found that activity values calculated from survey information were higher than those assumed by NONROAD, with a few exceptions. Also, it was found that commercial activity is affected by the seasons to a lesser extent than was previously estimated by NONROAD. The population analysis reveals that the distribution of certain types of equipment is different from what was assumed by NONROAD. Specifically, the ratio of two-stroke to four-stroke engines is quite different, with NONROAD assuming a much higher proportion of 2-stroke engines. In Figure 9 and Figure 10 the emission results of this analysis are displayed side-by-side with the associated results from the base case NONROAD run. Figure 11 and Figure 12 display final emission estimates for all lawn and garden equipment. Results are discussed in further detail in the following sections. Appendix C lists the outputs of all frequency analyses, Appendix D lists the results of the Chi-Square analyses, and Appendix E lists the emission estimates for all equipment assessed by the survey.

Table 8: Comparison of Annual Activity Values

	NONROAD Activity Hrs/yr	Survey Activity Hrs/yr
Lawn mowers	406	900
Rear Engine Riding Mowers	569	924
Lawn & Garden Tractors	721	852
Trimmers/Edgers/Brush Cutters	137	294
Leafblowers/Vacuums	282	476
Chainsaws	303	168
Commercial Turf Equipment	682	571

Table 9: Comparison of Monthly Fractions by Season

	Monthly Fract. in Summer	Fraction in Winter	Fraction in Spring/Fall
Lawn/Garden Excluding Chainsaws (NONROAD)	0.113	0.02	0.1
Lawn/Garden Excluding Chainsaws (Survey)	0.108	0.057	0.084
Lawn and Garden Chainsaws (NONROAD)	0.083	0.083	0.083
Lawn and Garden Chainsaws (Survey)	0.1	0.075	0.083

Table 10: Comparison of Equipment Populations

	NONROAD Population	Survey Population
2 Stroke Trimmers/Edgers/Brush Cutters	23,495	16,800
4 Stroke Trimmers/Edgers/Brush Cutters	452	5,400
Total Trimmers/Edgers/Brush Cutters	23,947	22,200
Leafblowers/Vacuums	13,615	10,400
Chainsaws < 3 hp	2,079	4,200
Chainsaws > 3 hp	7,315	3,800
Commercial Turf Equipment	12,076	4,900

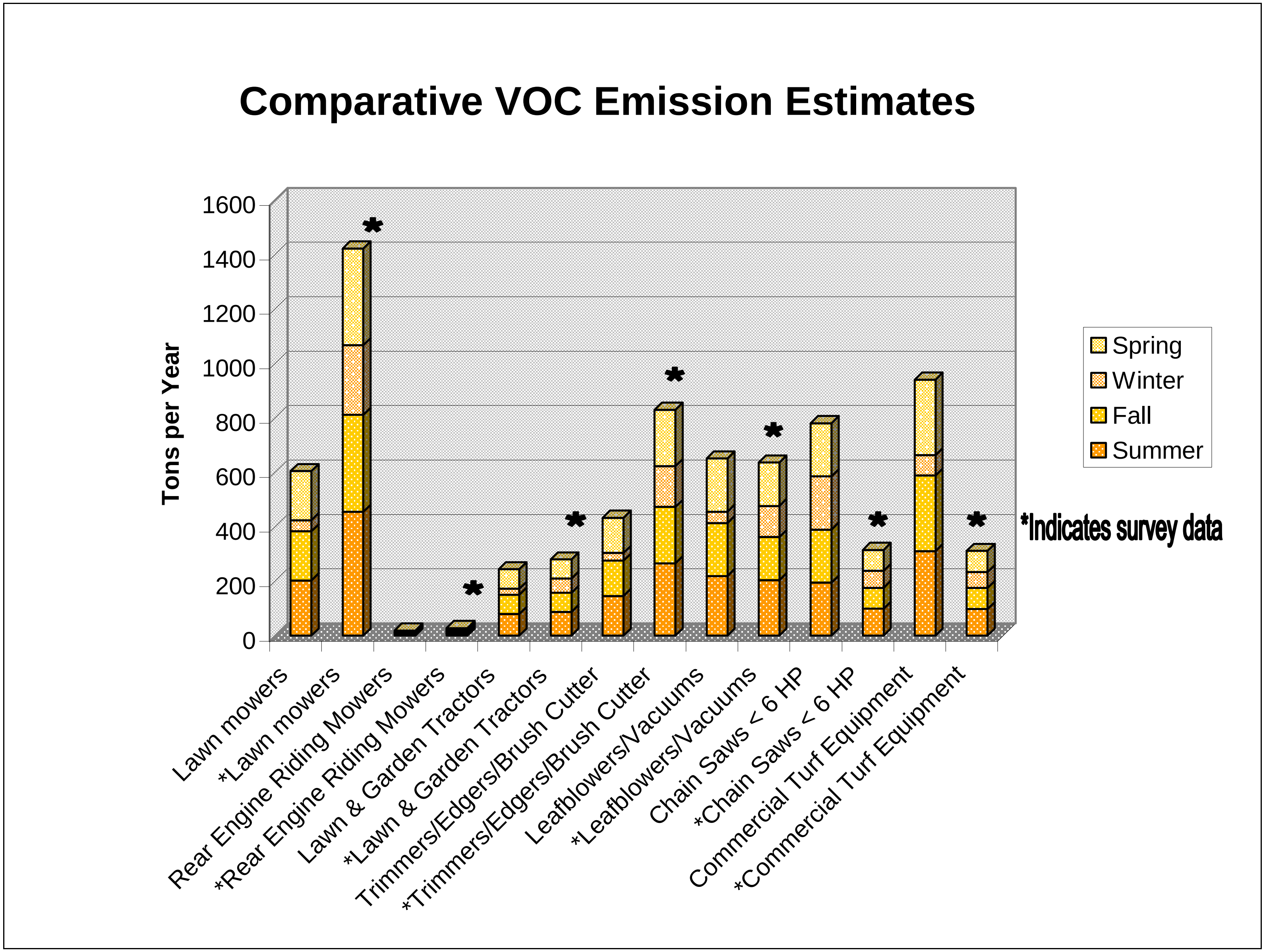

Figure 9: VOC Emission Comparison

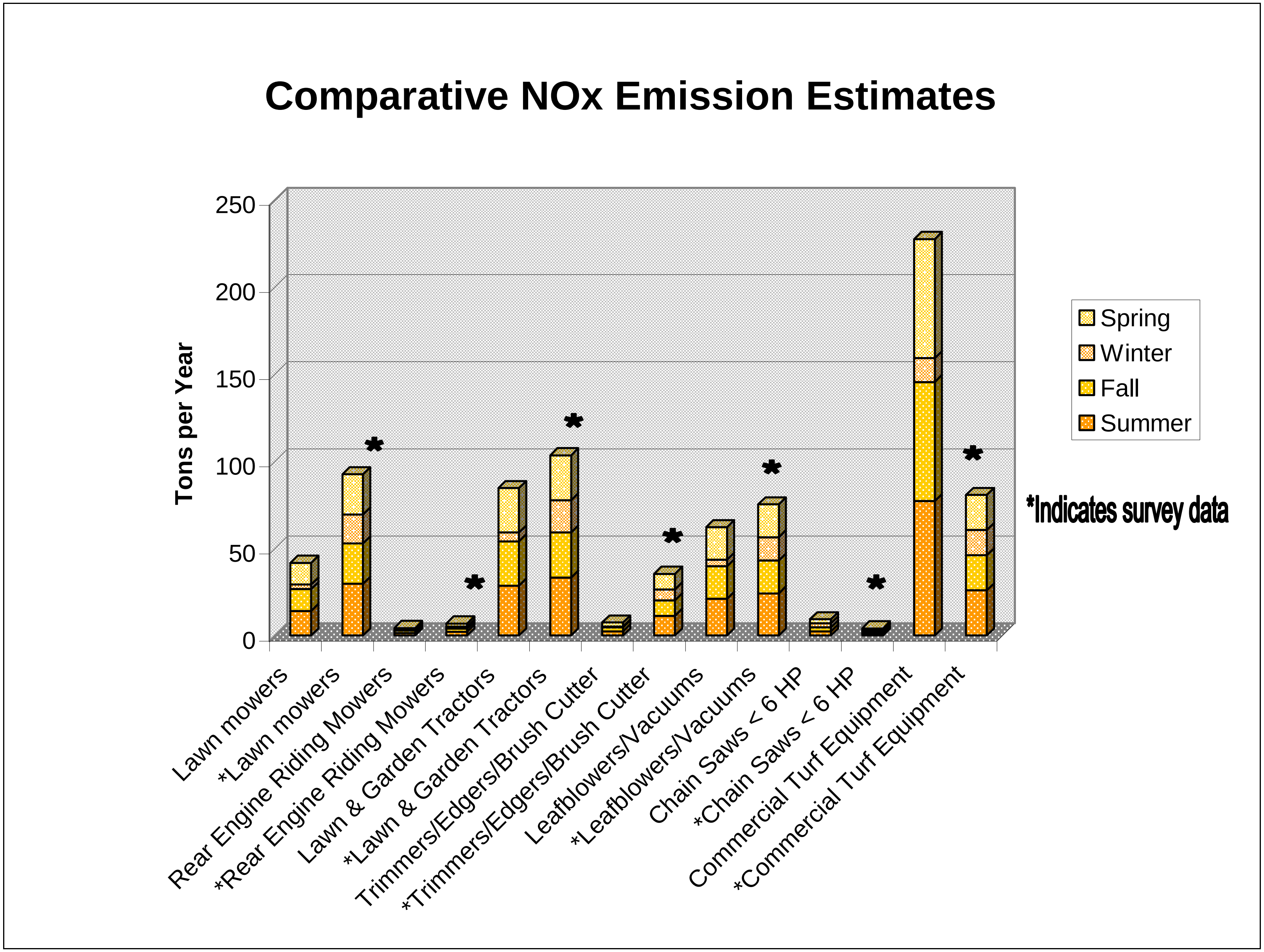

Figure 10: NOx Emission Comparison

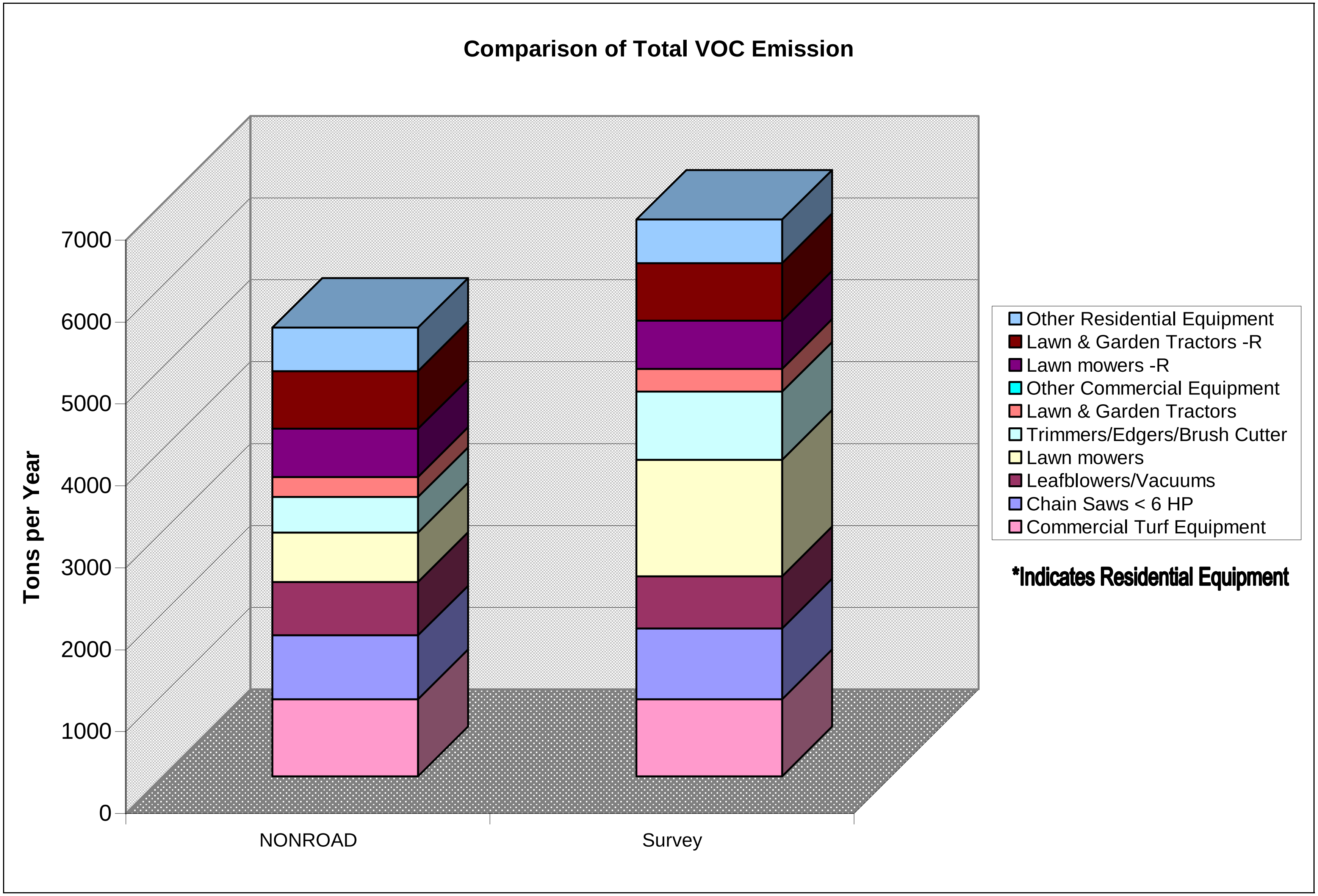

Figure 11: Comparison of Total VOC Emissions

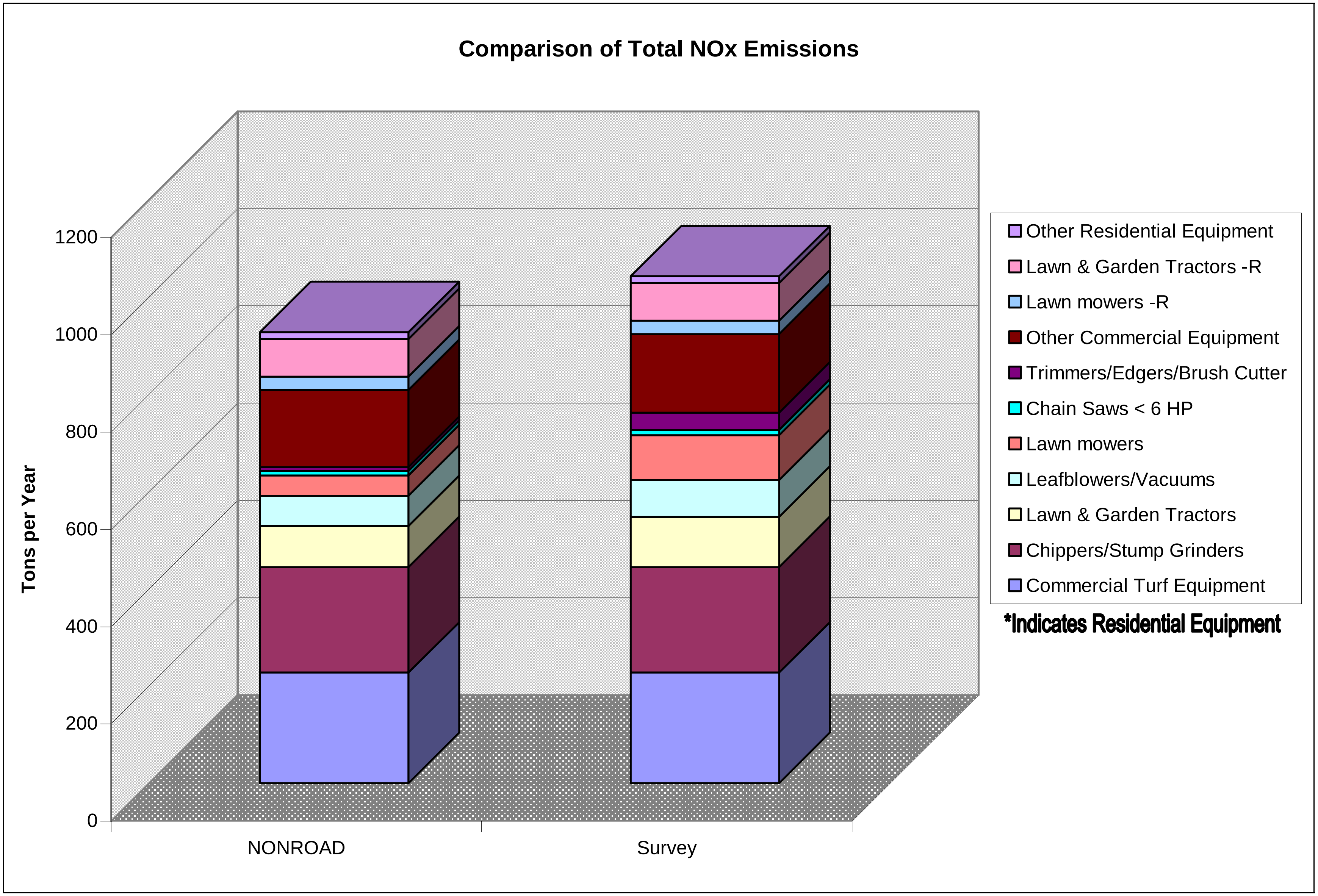

Figure 12: Comparison of Total NOx Emissions

Table 11: Summary of Final Emission Estimates, tons/year

Commercial Handheld Equipment	**VOCs**	**NOx**
Trimmers/Edgers/Brush Cutter	829.984	35.43951
Leafblowers/Vacuums	635.7618	75.36614
Chain Saws < 6 HP	865.9806	10.91838
Rotary Tillers < 6 HP	345.1464	21.99713
Shredders < 6 HP	35.73	2.47
TOTAL:	2856.324	146.1911
Commercial Nonhandheld Eqp.		
Lawn mowers	1422.208	92.6
Lawn & Garden Tractors	279.87	103.52
Rear Engine Riding Mowers	28.11	6.9
Commercial Turf Equipment	940.6987	227.65
Front Mowers	58.76	122.67
Other Lawn & Garden Eqp.	77.53118	7.01
TOTAL:	3034.826	560.35
Residential Handheld Equipment		
Trimmers/Edgers/Brush Cutter	156.59	1.27
Leafblowers/Vacuums	111.97	1
Chain Saws < 6 HP	107.06	0.79
Rotary Tillers < 6 HP	59.46	2.37
TOTAL:	435.08	5.43
Commercial Nonhandheld Eqp.		
Lawn mowers	589	27.33
Lawn & Garden Tractors	702.16	77.55
Rear Engine Riding Mowers	64.36	5.71
Other Lawn & Garden Eqp.	31.63	2.67
TOTAL:	1387.15	113.26

Lawn Mowers

Commercial lawn mowers, as originally calculated by NONROAD, are the fourth largest commercial emitter of VOCs and NOx within the lawn and garden division. However, as a result of the information revealed through the survey, this may be the largest contributing group in the Central Florida area. This group's characteristics have a horsepower range from 1-40 hp on a variety of machine types including front mowers, rear engine riding mowers and lawn & garden tractors. The focus of questions for this category aimed to characterize the typical horsepower ranges for each type of lawnmower and then to compare the sample data to predictions obtained through NONROAD. It was found that 24% of mowers were found to have a horsepower range between 11 and 16 hp and 58% of mowers were found to have a horsepower range between 16 and 25 hp. Horsepower ranges determined by the survey were highly significant (at the 0.05 level). Significance was tested by utilizing the Chi-square statistic which tests values at a 95% confidence interval. The details of the chi-square analysis are listed in Appendix D. The NONROAD model estimates a smaller number of machines with large engines, while estimating a larger amount of small engine lawn mowers relative to this survey's data. The underestimation of engines with a greater horsepower would result in a low emission estimate due to the fact that emission factors increase with engine size. The following charts (Figure 13 and Figure 14) were created to illustrate discrepancies between the NONROAD model and survey data.

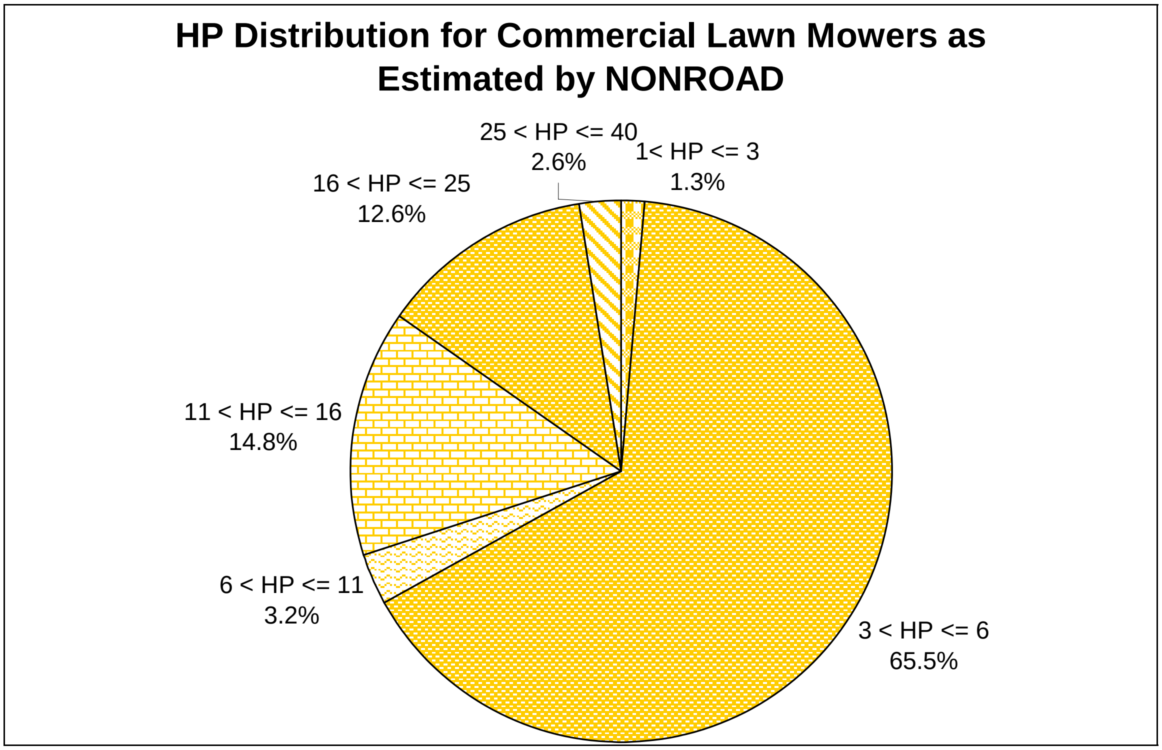

Figure 13: Power distribution predicted by NONROAD

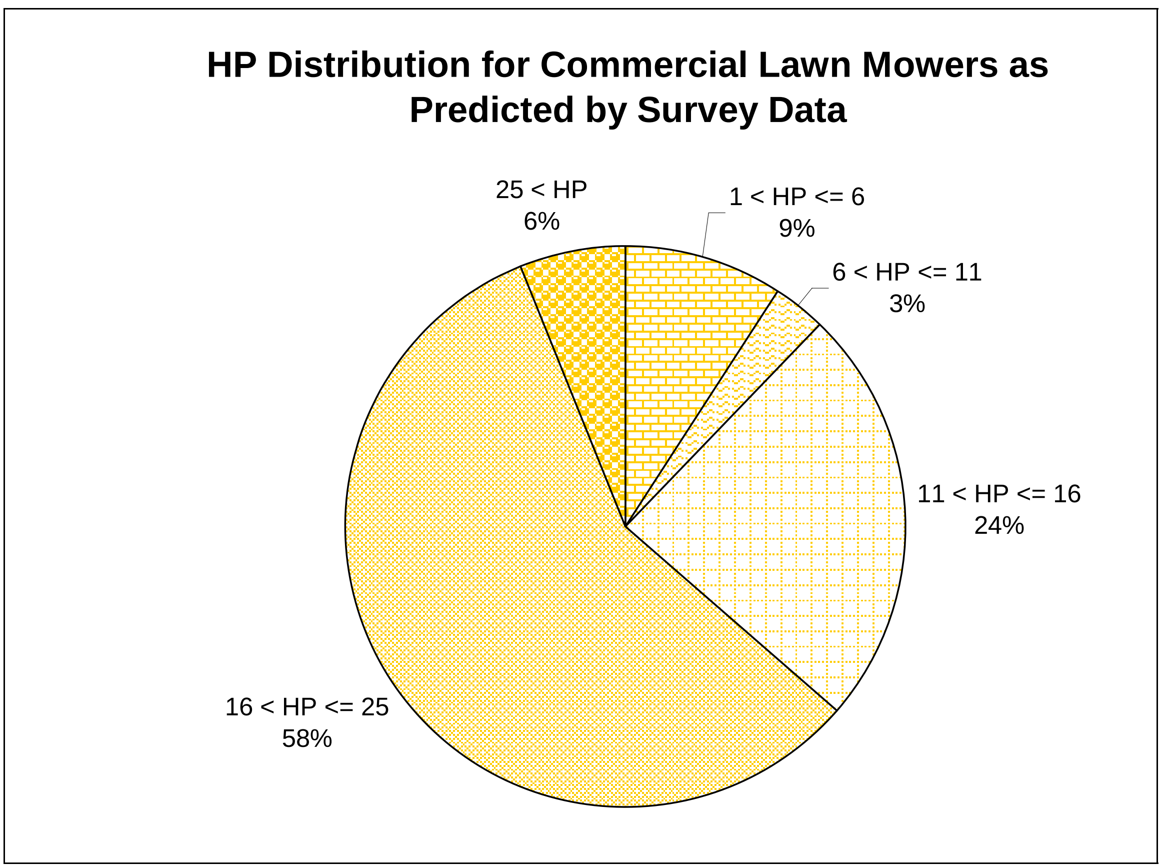

Figure 14: Power distribution predicted by Survey Data

Once basic characteristics of these machines were established, average annual and seasonal activity values were calculated. Table 8 details the annual activity values found through the survey alongside the assumed values from the NONROAD program. Activity values were found to have a chi-square significance valid for a 90% confidence interval. From this table it can be seen that the NONROAD program dramatically underestimates the number of hours spent by the lawn mower groups (lawn mowers, rear engine riding mowers, lawn and garden tractors), also resulting in an under-estimated emission level. This finding could be related to the differences in growing season for the local area as compared to the national average. Because the local growing season is much longer than that of the rest of the country, the number of hours spent mowing tends to be significantly higher. Also, Table 9 shows that the distribution of activity throughout the seasons was found to be slightly less varied than that estimated through NONROAD, thus giving more weight to the winter months. Table 10 is not relevant to this section as equipment populations were not obtained for lawn mower engines.

Once the input data were calculated, NONROAD input files were altered to reflect the new information. Referring to Figure 9, it can be seen that the changes made in this new run have effectively made the lawn mower equipment category the largest contributor of VOC emissions of all surveyed groups. Lawn mowers are also a large contributor of NOx emissions as can be seen in Figure 10. The localized data for this group of equipment was characterized by a greater number of large engines and a level of annual activity that was nearly double that of the default scenario, thus there was a significant rise in estimated emission levels. The default NONROAD amounts were 203 tons per year VOCs and 14 tons per year NOx. In contrast, the amounts determined through survey data were 455 tons per year VOCs and 30 tons per year NOx.

Trimmers, Edgers, & Brush Cutters

Trimmers, edgers, and brush cutters originally comprised the fifth largest commercial group. However, as can be seen from Figure 9 and Figure 10, after adjustments were made, this group appears to be more significant. To analyze this group, questions were designed to obtain an area equipment population, to establish typical engine types, and to find annual and seasonal activity values. Table 8, Table 9, and Table 10 summarize the findings for this category. Again, NONROAD default values were found to be lower than the total activity values estimated by the survey. Additionally, the population data for this category was divided into two stroke and four stroke engines and in Table 10 it can be seen that the NONROAD program greatly underestimated the number of four stroke engines existing in the population, while the total population for this category remained nearly equal to NONROAD's estimate. This is an important observation as four stroke engines typically utilize fuel in a much more efficient manner than two stroke engines[21].

In Figure 9 and Figure 10 the results of the NONROAD default and survey data runs for this category can be seen. Although the population of both runs is nearly equal, the change in annual activity greatly increases the emission estimate. This emission estimate was accepted for the final model because the population for this group was found to highly correlate with the number of lawn and garden employees represented by the sample. An R^2 value of 0.59 was found for this segment and a t value of 6.9 was found with a probability far less than 0.05. Thus, it was concluded that the number of employees at the establishment is highly related to the number of trimmers, edgers, and brush cutters in the inventory.

Leafblowers and Vacuums

Questions for the leafblower and vacuum category covered equipment population, annual activity, and seasonal activity. It was found that according to survey data, the equipment population calculated by NONROAD was only narrowly overestimated. The emission estimate for this group was accepted for the final model because the equipment population for this group was found to highly correlate to the number of lawn and garden employees represented by the sample. An R^2 value of 0.89 was found for this segment and a t-value of 15.8 was found with a probability of error less than 0.05. Thus, it was concluded that the number of employees at the establishment is highly related to the number of leafblowers and vacuums in the inventory.

The number of hours per year spent on this equipment was found to be underestimated by NONROAD as compared to survey data. This finding was significant at the 95% confidence interval for both handheld and nonhandheld equipment, with chi-sqaure values of 10.333 and 12.895 respectively.

The differences between populations and activity values were found to offset each other (as seen in Table 8 and Table 10) thus leading to emission estimates for leafblowers and vacuums that were very similar for both the base case run and final survey run.

Chainsaws

Questions concerning chainsaws divided the population between common groups of horsepower ranges, and also looked into annual and seasonal activity values. By dividing the population data into separate horsepower groups, information could be found concerning the specific types of equipment that are most commonly used. Survey data indicated that the total chainsaw population was much greater than that which was assumed by NONROAD (Table 10). Within the group of chainsaw equipment, it was found that the small engine population was much greater, while the large engines were much lower. It was also found that local businesses use each piece of equipment less frequently than was estimated by NONROAD.

The emission estimate for this group was not accepted for the final model because the equipment population for this group was found to have a low regression value. An R^2 value of 0.26 was found for this segment which led to the rejection of this estimate. This finding may be explained by the distribution of business types that were surveyed, as it may not be fully representative of the businesses that do tree service or large scale projects involving chainsaws. Some of the organizations that use chainsaws frequently may not be in this market segment. There are likely other significant variables that affect chainsaw use and thus identifying these additional factors and quantifying chainsaw use more accurately will prove to be a difficult task. Information provided by the U.S. Census Bureau does not enumerate the size distribution of businesses, and chainsaw use is more prevalent in larger businesses, such as with Aspludndh Tree Expert and Davey Tree and Lawn Care. For analysis of this category, it was assumed that too few data from large businesses were collected. As a result, the default assumptions made by NONROAD were not altered for the final emission estimate.

Commercial Turf Equipment

Finally, commercial turf equipment was investigated as a significant contributor to emissions from lawn and garden equipment. It was found that NONROAD slightly overestimated the number of hours spent with this equipment type. The activity value was estimated with a probability of error of 0.416, thus indicating that the finding was statistically insignificant.

The difference in the two population estimates was found to be very large. The emission estimate for this group was not accepted for the final model because the equipment population for this group was not found to correlate closely with employees at the business. An R^2 value of 0.27 was found for this segment. Consequently, it was concluded that the number of commercial turf equipment in the area cannot be predicted adequately by the data. Little data were collected from companies that conducted any turf maintenance at all and as a result it may be assumed that not enough surveys were returned from the appropriate businesses. Some large businesses that perform this type of work includes Duda Sod, Winter Garden Grassing Inc., and Winrock Grass Farm. The information gathered from the U.S. Census Bureau concerning business characteristics and population is very general and limited, therefore it is difficult to judge if a particular business type is adequately represented by the survey.

Potential Control Measures

In addition to assessing different aspects concerning the top emission categories, one goal of this study was to assess the financial costs and emission benefits that are associated with the implementation of a variety of emission control measures. Several air quality management tactics were reviewed as part of this study's Literature Review. In addition to this, however, some questions were included in the survey that addressed the reactions of lawn and garden business owners to some management methods. Specifically, questions addressed the use of alternative fuels and electrification of equipment.

Alternative Fuels

As the number of cities using alternative fuels increase, more and more people are faced with the decision to use conventional fuels or alternative fuels. While governments can install more and more tanks for alternative fuels, the demand for the fuel ultimately depends on the acceptance of locals as they relate to consumer habits, compatibility, engine performance, price and availability. Consequently, this survey aimed to assess both how local lawn and garden businesses are using fuel and also how they would react to alternative fuels if they were to become available.

As part of the survey conducted for this study, it was found that half of all business owners utilize more than 90% gasoline in their fuel mix, while only 20% of those surveyed reported using a greater portion of diesel than gasoline. This leads to the conclusion that ethanol would be a more viable option to the lawn and garden industry. However, as was previously discussed in the section titled "Review of Potential Control Measures," it has been found that with ethanol fuels, reductions in tail pipe VOC emissions may be offset by increases in ozone precursors caused by enhanced evaporative emissions of VOCs[15]. As such, emissions from ethanol use may be comparable to that of gasoline. Additionally, applications may prove to be more challenging for ethanol use in lawn and garden equipment as engine modifications are required to account for the increase corrosivity[16]. The development of ethanol compatible lawn and garden equipment is required before this option becomes viable.

Although only a small portion of business owners utilize a larger portion of diesel in their fuel mix, biodiesel may still be an option to consider. While HC emissions are reduced by 12% relative to petroleum diesel, NOx emission changes ranged from -5.8% to +6.2%. On average, NOx emissions changed by 0.6%[17]. Additionally, no engine modifications are required for the use of biodiesel fuel, thus leading to the conclusion that this would be a viable option. Furthermore, biodiesel use has the benefit of reducing the use of fossil fuels and also reduces net "new" carbon dioxide emissions.

If fueling stations are constructed in the Central Florida area, sale of the alternative fuels will depend on the acceptance of locals. For lawn and garden small business owners, however, willingness to purchase these fuels may not come easy. While a majority of those surveyed reported that they would consider using biodiesel, one fifth of the people were undecided and approximately one third said they would not consider using biodiesel fuel. The most commonly cited issue among those surveyed was concern about compatibility with the equipment. This may indicate that an education campaign would be a valuable tool to precede implementation of new fueling stations. As a result the previously estimated cost of $18,300 per ton should rise to account for additional costs that include marketing and advertising. If a total campaign cost of $10,000 is budgeted, the total cost will rise to $20,300 per ton.

Electrical Equipment

Use of zero exhaust electrical equipment may also serve as a valuable tool for reducing ozone potential. While this is commonly considered an option that targets residential lawn and garden equipment, several Orlando area business owners have reported using some type of electrically powered handheld equipment. Handheld equipment includes small equipment such as trimmers, tillers, blowers, and other equipment that is held by the user. Of those that have utilized electrical equipment, 70% said that they would continue using electrical equipment to some degree. Additionally, one of the largest companies that participated in this survey reported using electrical equipment with a high degree of satisfaction. Thus, despite some of the drawbacks of electrical equipment use, this may be a viable option for many lawn and garden businesses.

One possible scenario for controlling emissions would be to replace all handheld equipment with electrical equipment. Based on estimates from NONROAD, approximately 430 tons of VOCs and 5 tons of NOx could be saved by replacing all residential equipment. Based on the final estimations resulting from the survey, by replacing all commercial equipment, approximately 2,900 tons of VOCs and 150 tons of NOx could be saved annually. These emissions would be partially offset, however, by the emissions generated by the power plant to produce energy for the electrical equipment. If 1000 tons per year of NOx are emitted by the Stanton Energy Plant and 633 MW of energy are produced, an emission factor of 0.00036 lb NOx/kwh results. Handheld equipment utilizes 6.5M gallons of gasoline per year. Assuming a conversion rate of 36.9 kwh/gallon of gasoline and a conversion loss of 50%, then the total emissions will be offset by 87 tons per year. This results in a total emission reduction of 3,400 tons per year.

This could be done with minimal costs, as prices are fairly comparable for handheld equipment. It is acknowledged, however that this is an idealized scenario because a limited selection of electrical equipment exists, thus making it difficult to replace all handheld equipment. Additionally, it is possible that not all people would be willing to make the change.

Table 12 lists some prices of handheld equipment. Although prices are comparable, to encourage people to switch to electric some type of incentive may still be an option to consider such as a small rebate or coupon. Additionally, marketing and advertising would be required to make such a project successful. Because this is a hypothetical situation that has not been previously implemented in any other areas, total project costs were not determined. Costs would mainly be derived from marketing, advertising, and administration as well as optional rebates. Costs for similar voluntary programs can cost up to $20,000 per ton as discussed previously, however if a substantially larger amount of emissions is saved, such as would be the case with a mandatory exchange program, cost per ton would be much lower because the same capital would be spent on marketing and advertising.

Table 12: Price Comparison of Gasoline and Electric Handheld Equipment[21]

Manufacturer	Equipment	Type	Price
Versatool	Trimmer	Gasoline	$99.00
Remington	Trimmer	Electric	$99.00
Homelite	Blower	Gasoline	$69.00
Toro	Blower	Electric	$69.97
Task Force	Edger	Gasoline	$69.98
Black & Decker	Edger	Electric	$89.97
Black & Decker	Edger	Electric	$49.97

CONCLUSIONS AND RECOMMENDATIONS

Figure 11 and Figure 12 show the final estimations for each category of interest in the survey. It is important to note that because of the changes made as a result of the survey, lawn mowers are now the largest emitting category, which indicates that if control measures need to be taken, a greater focus should be on the lawn mowing equipment. Figure 11 and Figure 12 also show that the data for chainsaws and turf equipment was assumed to be represented by the default values of the NONROAD program. As a result of this study, the total VOC emission estimates for lawn and garden equipment increased by 1,300 tons per year, and the NOx estimate increased by 110 tons per year as compared to the default case. This results in a total survey estimation of 7,400 tons of VOCs and 1,040 tons of NOx emitted in comparison to the NONROAD estimate which showed 6,100 tons of VOCs and 930 tons of NOx emitted. Thus, this category of equipment may be contributing to ozone emissions to a greater extent than was previously predicted. By comparing this data to Arbrandt's data for the base year 2003, it was found that the portion of VOC emissions from lawn and garden equipment would rise from the originally estimated 10% to 12%, with onroad mobile sources as the only group with a greater contribution to emissions. NOx emissions would rise from 2.8% to 2.9% of the total emissions for the Orange, Seminole, and Osceola region, with onroad mobile sources, point sources, and construction equipment as the only categories with greater emission levels.

Table 13 summarizes some of the management options possible for improving emissions for this category of equipment. While some options may be more cost effective than others, there are several things to consider before adopting any one program. For the Electrical

Exchange, Scrap Program, and Education Campaign emission benefits and costs were estimated based on the effectiveness of other similar programs conducted in cities around the country as discussed in the Literature Review.

Further suggested research includes focusing on larger businesses, like Davey and Duda. Also, surveys could be conducted to target equipment use outside of the commercial lawn and garden industry including residential and specialized commercial applications such as golf courses, schools, and parks. The use of surveys as a method to improving emission inventories is a valuable tool and may be necessary for communities to reach a greater understanding of emission contributions. Surveys are a cost-effective tool that may provide useful information for communities that are interested in developing or implementing emission management strategies and need to know the most effective methods of regulating those emissions.

Concerning the suggested action steps for the lawn and garden industry, some programs could be effectively utilized now while others may be more useful in the future. It is recommended that biodiesel use begin as soon as an Education Campaign is begun. Biodiesel use is a highly feasible option but should be coupled with an education campaign that explains how biodiesel interacts with engines and how it can benefit our community. A scrap program is recommended as the next step as it will help to turn over the fleet of older more polluting engines. An Electric Mower Exchange is recommended as the next step to reducing emissions. Electric exchange programs are also highly feasible and can be used as a tool to communicate with residents the importance of saving emissions. If ozone continues to be problematic, an Education Campaign can then be used to lower emissions on the days of greatest concern. Application of catalytic converters eventually will be phased in by the EPA and thus does not serve as a viable option for local action. However, once newer more efficient lawn mowers are on the market in 2012, scrap programs will again be a highly valuable tool for turning over the fleet and thus retiring older engines at a faster rate.

Table 13: Potential Control Measures for Lawn and Garden Industry

Potential Control Measure	Emission Benefit, tons/yr HC + NOx	Cost Effectiveness $/ton HC + NOx	Comments
Biodiesel Use	5	$20,300	Capital costs for a 15,000 gallon tank are estimated at $170,000. There is no statistically significant difference in fuel prices[16]. Emission benefit is low because few lawn and garden engines run on diesel.
Scrap Program	2-6	$18,000	Will be a useful tool when new, lower emitting equipment is available. Effectiveness of this type of program is limited as there is no way to verify the age of a particular engine.
Electric Mower Exchange	5-10	$20,000	This voluntary program can be combined with an Education Campaign and a Scrap Program. Effective method for communicating with residents. More effective with residential than commercial.
Education Campaign	1-3	$20,000-36,000	Program requires advertising and marketing to get a simple message across about what people can do to benefit the community.
Catalytic Converters	2,300	$9,000	EPA legislation will require use of catalytic converters on new equipment in 2012.
Handheld Electric Exchange	3,400	N/A	Costs are not estimated because of lack of available information; however costs would cover marketing, advertising, administration, and an optional rebate. This is a hypothetical mandatory exchange program.

APPENDIX A: CATALYTIC CONVERTER COST ANALYSIS

Table 14: Catalytic Converter Prices

Model	Capacity, cc	Price
Avalon	3000	$380
Camry	2400	$387
Corolla	1800	$324
Paseo	1800	$297
Previa	1500	$247
RAV 4	2400	$302
Tarcel	2000	$241
Sienna	1500	$250
Echo	1500	$416
Solara	2200	$304
Matrix	1800	$297
Tahoe	4800	$460
Yukon	5300	$460
Suburban	4300	$460
Blazer	4300	$425
Dodge Ram	5900	$483

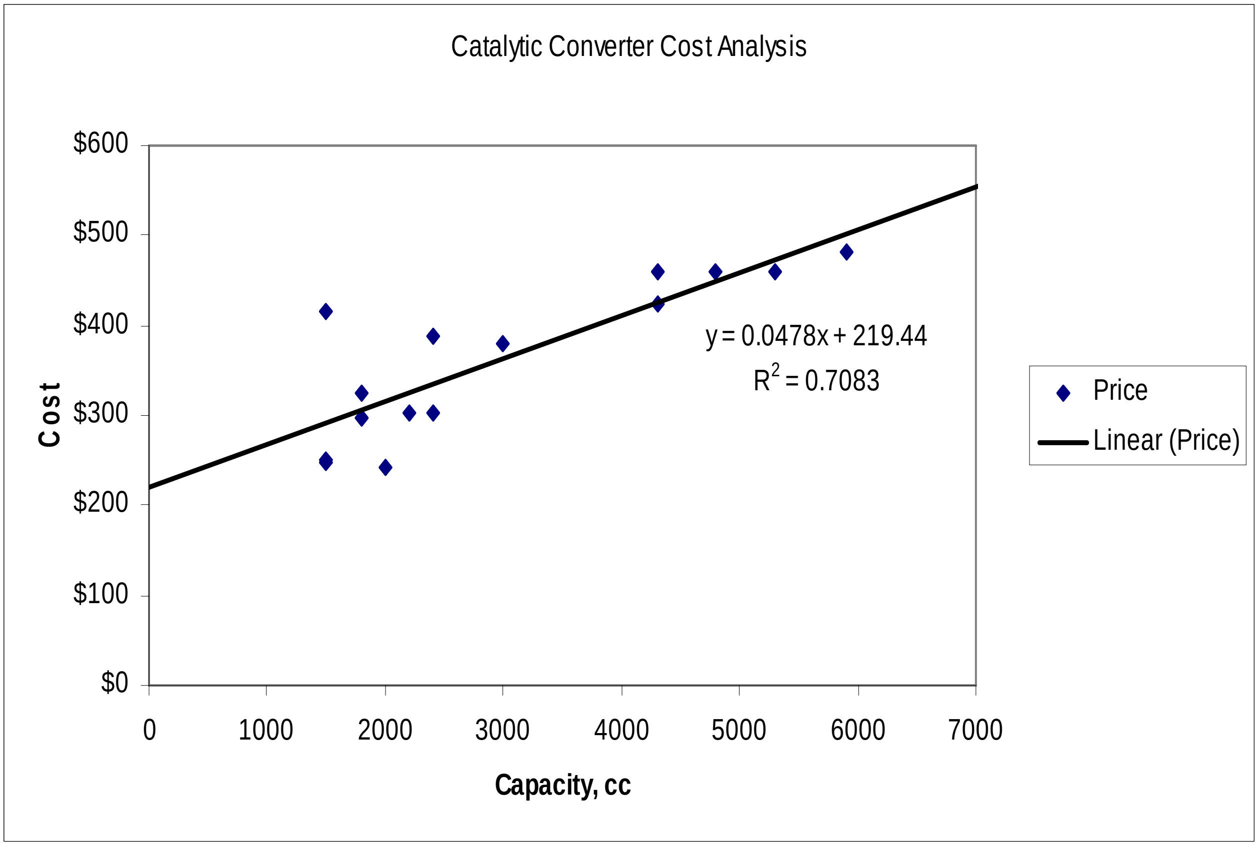

Figure 15: Catalytic Converter Cost Analysis

APPENDIX B: COVER LETTER AND SURVEY

Civil and Environmental Engineering
211 Engineering Building II #431
Orlando, FL 32816

March 6, 2007

Dear Lawn and Garden Professional,

We need your participation! As part of a new study conducted by the University of Central Florida for Metroplan Orlando (a metropolitan planning organization for Orange, Osceola, and Seminole Counties), I would like to invite you to help us by sharing information about your activities as a lawn and garden professional in the Central Florida area. With your cooperation we will be better able to understand how changes in Orlando's infrastructure, local regulations, and changes in technology could affect our air quality and your industry. The results of this survey will be used to evaluate how we can protect the air quality of our community without compromising the goals of local businesses.

Your company has been selected to be a part of this survey as a representative member of the lawn and garden commercial service industry in the Orange, Seminole, and Osceola County region. The questions included in this survey will ask about the fuels and equipment your company uses, how the equipment is used, and other various questions. It is suggested that whoever has the most knowledge about your company's operations complete this survey. While some questions you will be able to answer quickly and easily, other questions may require you to consult your current inventory of equipment or other records. Please answer all questions to the best of your knowledge and with as much accuracy as possible. All information provided is fully confidential and will be used solely for research and statistical purposes.

To make this study effective, we need your participation! Please complete and return this survey by March 20, 2007. For your convenience a pre-labeled envelope is included in this packet. If you have any questions about the survey or need further clarifications please feel free to call me, Megan Crum, at (407) 823-4554.

Sincerely,

Megan L. Crum, E.I.
Graduate Research Assistant
Office: (407) 823-4554
Fax: (407) 823-3315
Email: LawnAndGarden@mail.ucf.edu

Introduction

Questions 1-6 cover introductory questions about your lawn and garden equipment and fuel needs. Please answer all applicable questions by selecting the appropriate response.

1. Considering total gasoline and diesel fuel usage for equipment used directly on lawn and garden services, what percent of gasoline does your company CURRENTLY use?

- ☐ 90-100%
- ☐ 70-90%
- ☐ 50-70%
- ☐ 25-50%
- ☐ 0-25%

2. If biodiesel fuel were to become locally available for the same price as conventional diesel fuel, would your company consider using this fuel as an alternative to conventional diesel?

- ☐ Yes, without reservation.
- ☐ Yes, but with reservation.
- ☐ Maybe yes, maybe no.
- ☐ No, probably not.
- ☐ No, definitely not.

3. If you were to consider biodiesel as a fueling option for your company's operations, what aspect would be your primary concern preventing you from using biodiesel? (Choose one only)

- ☐ Comparative cost
- ☐ Supply or availability
- ☐ Effects on engine performance
- ☐ Compatibility with equipment
- ☐ No major concerns
- ☐ Other

4. At what engine age does most of your non-handheld equipment get replaced by newer equipment?

- ☐ 6+ years
- ☐ 5-6 years
- ☐ 4-5 years
- ☐ 3-4 years
- ☐ Less than 3 years

5. At what engine age does most of your handheld equipment get replaced by newer equipment?

- ☐ 3+ years
- ☐ 2-3 years
- ☐ 18-24 months
- ☐ 12-18 months
- ☐ Less than 12 months

6. Has your lawn and garden department ever used electrically powered lawn and garden equipment?

- ☐ Yes. (Go to Question 6a and 6b)
- ☐ No. (Go to Next Section)

6a. Please indicate the total number of electrically powered machines that your organization CURRENTLY uses according to the following categories:

- ☐ Chain Saws: ________
- ☐ Leafblowers\Vacuums: ________
- ☐ Trimmers/Edgers/Brush Cutters: ________
- ☐ Other handheld devices: ________

6b. Will your organization continue to purchase electrical equipment in the future?

- ☐ Yes, and we plan to increase the number of electrical equipment.
- ☐ Yes, and we plan to maintain the same numbers.
- ☐ We may or may not use electrical equipment in the future.
- ☐ Yes, but we plan to reduce the number of electrical equipment we use.
- ☐ No; we will no longer purchase electrical equipment.

Lawn Mowers

When answering questions 7-14, please select the appropriate answer related only to your company's use of lawn mowers. Please answer each question as accurately as possible.

7. What category best describes the lawn mowers which are used most frequently for your organization's purposes?

☐ Front Mowers (With engine attached on front of vehicle)
☐ Rear Engine Riding
☐ Lawn & Garden Tractors (Small tractors used for mowing but able to perform tasks other than mowing)

8. How many lawn mowers that are currently in use at your organization can be described by the category that you selected in Question 7?

☐ All lawn mowers
☐ Nearly all lawn mowers
☐ Most lawn mowers
☐ Nearly even with one or more categories
☐ None of the above

9. What horsepower range best describes the lawn mowers that are used most frequently for your organization's purposes?

☐ Less than 6 hp
☐ 6-11 hp
☐ 11-16 hp
☐ 16-25 hp
☐ Other: ________________________________

10. Considering operations for a typical spring week, how many hours per week would a single machine from the group described in Questions 7-9 be used?

☐ More than 24 hours
☐ 20-24 hours
☐ 16-20 hours
☐ 12-16 hours
☐ 8-12 hours
☐ Less than 8 hours

11. Considering the peak period of activity (summer season), how many hours per week will you use this same piece of equipment?

☐ More than 24 hours
☐ 20-24 hours
☐ 16-20 hours
☐ 12-16 hours
☐ 8-12 hours
☐ Less than 8 hours

12. Considering the slowest period of activity (winter season), how many hours per week would you use this equipment?

☐ More than 20 hours
☐ 16-20 hours
☐ 12-16 hours
☐ 8-12 hours
☐ 4-8 hours
☐ Less than 4 hours

13. How many lawn mowers are currently in use at your organization that have more horsepower than the group described in Question 9?

____

14. How many lawn mowers have less horsepower than the group described in Question 9?

____

Trimmers, Edgers, & Brush Cutters

When answering questions 15-19, please select the appropriate answer related only to your organization's use of trimmers, edgers, and brush cutters. If your company does not own machines of this type, enter "0" for Question 15 and skip to the next section.

15. What is the total number of equipment from this category currently in use at your business?

____

16. From the group of equipment mentioned in Question 15, how many of these have 2 stroke engines?

____

17. How many hours per week would a typical piece of equipment from this category usually used?

- ☐ More than 6 hours
- ☐ 5-6 hours
- ☐ 4-5 hours
- ☐ 3-4 hours
- ☐ 2-3 hours
- ☐ Less than 2 hours

18. Considering the peak period of activity (summer season), how many hours per week will you use this equipment?

- ☐ More than 6 hours
- ☐ 5-6 hours
- ☐ 4-5 hours
- ☐ 3-4 hours
- ☐ 2-3 hours
- ☐ Less than 2 hours

19. Considering the slowest period of activity (winter season), how many hours per week would you use this equipment?

- ☐ More than 6 hours
- ☐ 5-6 hours
- ☐ 4-5 hours
- ☐ 3-4 hours
- ☐ 2-3 hours
- ☐ Less than 2 hours

Leafblowers & Vacuums

When answering questions 20-24, please select the appropriate answer related only to your company's use of leafblowers and vacuums. If your company does not own any leafblowers or vacuums, enter "0" for Question 20 and 23 and skip to the next section.

20. How many handheld leafblowers or vacuums are currently in use at your business?

____

21. How many of your handheld leafblowers or vacuums have 2 stroke engines?

____

22. Considering operations for a typical spring week, how many hours per week would a handheld leafblower or vacuum usually used?

- ☐ More than 10 hours
- ☐ 8-10 hours
- ☐ 7-8 hours
- ☐ 5-7 hours
- ☐ Less than 5 hours

23. How many non-handheld leafblowers or vacuums are currently in use at your business?

____

24. Considering operations for a typical spring week, how many hours per week would a non-handheld leafblower or vacuum usually be turned on and used?

- ☐ More than 10 hours
- ☐ 8-10 hours
- ☐ 7-8 hours
- ☐ 5-7 hours
- ☐ Less than 5 hours

Chainsaws

When answering questions 25-29, please select the appropriate answer related only to your company's use of chainsaws. If your company does not own any chainsaws, enter "0" for Question 25 and 26 and skip to the next section.

25. How many chainsaws with engines less than 3 hp are currently in use at your business?

____

26. How many chainsaws with engines greater than or equal to 3 hp are currently in use at your business?

____

27. Considering operations for a typical spring week, how many hours per week would a chainsaw usually be used?

- ☐ More than 8 hours
- ☐ 7-8 hours
- ☐ 6-7 hours
- ☐ 5-6 hours
- ☐ Less than 4 hours

28. Considering the peak period of activity (summer season), how many hours per week do you expect to use this equipment?

- ☐ More than 8 hours
- ☐ 7-8 hours
- ☐ 6-7 hours
- ☐ 5-6 hours
- ☐ Less than 4 hours

29. Considering the slowest period of activity (winter season), how many hours per week do you expect to use this equipment?

- ☐ More than 8 hours
- ☐ 7-8 hours
- ☐ 6-7 hours
- ☐ 5-6 hours
- ☐ Less than 4 hours

Turf Equipment

For questions 30-34, select the appropriate answer turf equipment such as *aerators, dethatchers, sod cutters, hydroseeders, turf utility vehicles, chemical application equipment (motorized spreaders and sprayers), etc*. Enter “0” for Question 30 and skip to the next section if this section is not applicable to your business.

30. What is the total number of handheld equipment from this category currently in use at your business?

____

31. What percent have four-stroke engines?

- ☐ 90-100%
- ☐ 70-90%
- ☐ 50-70%
- ☐ 25-50%
- ☐ 0-25%

32. On average, how many hours per week would one piece of equipment from this category be used for a typical spring week?

- ☐ More than 24 hours
- ☐ 20-24 hours
- ☐ 16-20 hours
- ☐ 12-16 hours
- ☐ Less than 12 hours

33. What is the total number of non-handheld equipment from this category currently in use at your business?

____

34. On average, how many hours per week would one piece of equipment from this category be turned on and used for a typical spring week?

- ☐ More than 24 hours
- ☐ 20-24 hours
- ☐ 16-20 hours
- ☐ 12-16 hours
- ☐ Less than 12 hours

Background

Questions 35 through 37 are biographical questions that will help to identify differences in operations for a variety of companies. Please answer each question to the best of your knowledge.

35. In what county do you conduct the majority of your business? (Select all that significantly contribute to your work load.)

- ☐ Orange County
- ☐ Seminole County
- ☐ Osceola County
- ☐ Other

36. How many employees are currently working in your lawn and garden service department?

____

37. What category describes the primary function of your lawn and garden service work?

- ☐ To provide lawn and garden/landscaping services for outside clients
- ☐ To provide maintenance services as a part of a larger establishment
- ☐ To rent lawn and garden equipment for others to use
- ☐ Other: ______________________________

____

APPENDIX C: SPSS FREQUENCY ANALYSES

What percent of gasoline does your company currently use?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	90-100%	15	44.1	46.9	46.9
	70-90%	4	11.8	12.5	59.4
	50-70%	6	17.6	18.8	78.1
	25-50%	2	5.9	6.3	84.4
	0-25%	5	14.7	15.6	100.0
	Total	32	94.1	100.0	
Missing	9.00	2	5.9		
Total		34	100.0		

Would your company consider using this fuel as an alternative?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes without reservation	14	41.2	42.4	42.4
	Yes but with reservation	4	11.8	12.1	54.5
	Maybe yes, maybe no	6	17.6	18.2	72.7
	No, probably not	3	8.8	9.1	81.8
	No, definitely not	6	17.6	18.2	100.0
	Total	33	97.1	100.0	
Missing	9.00	1	2.9		
Total		34	100.0		

What would be your primary concern preventing you from using biodiesel?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Comparative Cost	6	17.6	18.2	18.2
	Supply or availability	2	5.9	6.1	24.2
	Effects on engine performance	7	20.6	21.2	45.5
	Compatibility with equipment	15	44.1	45.5	90.9
	No major concerns	3	8.8	9.1	100.0
	Total	33	97.1	100.0	
Missing	9.00	1	2.9		
Total		34	100.0		

At what engine age does nonhandheld equipment get replaced?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	6+ years	10	29.4	29.4	29.4
	5-6 years	5	14.7	14.7	44.1
	4-5 years	6	17.6	17.6	61.8
	3-4 years	10	29.4	29.4	91.2
	Less than 3 years	3	8.8	8.8	100.0
	Total	34	100.0	100.0	

At what engine age does handheld equipment get replaced?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3+ years	9	26.5	26.5	26.5
	2-3 years	14	41.2	41.2	67.6
	18-24 months	5	14.7	14.7	82.4
	12-18 months	5	14.7	14.7	97.1
	Less than 12 months	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

Ever used electrically powered lawn and garden equipment?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	6	17.6	17.6	17.6
	No	28	82.4	82.4	100.0
	Total	34	100.0	100.0	

Total number of electrically powered machines?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	5	14.7	14.7	14.7
	1	1	2.9	2.9	17.6
	9	28	82.4	82.4	100.0
	Total	34	100.0	100.0	

Total number of electrically powered machines?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	5	14.7	14.7	14.7
	1	1	2.9	2.9	17.6
	9	28	82.4	82.4	100.0
	Total	34	100.0	100.0	

Total number of electrically powered machines?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	3	8.8	8.8	8.8
	1	3	8.8	8.8	17.6
	9	28	82.4	82.4	100.0
	Total	34	100.0	100.0	

Total number of electrically powered machines?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	3	8.8	8.8	8.8
	1	3	8.8	8.8	17.6
	9	28	82.4	82.4	100.0
	Total	34	100.0	100.0	

Continue to purchase electrical equipment in the future?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes, maintain numbers	2	5.9	28.6	28.6
	Yes, reduce numbers	3	8.8	42.9	71.4
	No	2	5.9	28.6	100.0
	Total	7	20.6	100.0	
Missing	9.00	27	79.4		
Total		34	100.0		

Lawn mowers used most frequently?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Front mowers	12	35.3	37.5	37.5
	Rear Engine Riding	17	50.0	53.1	90.6
	Lawn & Garden Tractors	3	8.8	9.4	100.0
	Total	32	94.1	100.0	
Missing	9.00	2	5.9		
Total		34	100.0		

Lawn mowers used most frequently?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Front Mowers	1	2.9	25.0	25.0
	Rear Engine Riding	1	2.9	25.0	50.0
	4.00	2	5.9	50.0	100.0
	Total	4	11.8	100.0	
Missing	9.00	30	88.2		
Total		34	100.0		

How many lawn mowers described by question 7?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	All lawn mowers	14	41.2	42.4	42.4
	Nearly all lawn mowers	9	26.5	27.3	69.7
	Most lawn mowers	6	17.6	18.2	87.9
	Even w. other category	3	8.8	9.1	97.0
	Other	1	2.9	3.0	100.0
	Total	33	97.1	100.0	
Missing	9.00	1	2.9		
Total		34	100.0		

What horsepower range is your lawn mowers?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 6 hp	3	8.8	9.1	9.1
	6-11 hp	1	2.9	3.0	12.1
	11-16 hp	8	23.5	24.2	36.4
	16-25 hp	19	55.9	57.6	93.9
	Other	2	5.9	6.1	100.0
	Total	33	97.1	100.0	
Missing	9.00	1	2.9		
Total		34	100.0		

How many hours of use for these lawn mowers?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	More than 24 hours	12	35.3	36.4	36.4
	20-24 hours	10	29.4	30.3	66.7
	16-20 hours	5	14.7	15.2	81.8
	12-16 hours	3	8.8	9.1	90.9
	8-12 hours	3	8.8	9.1	100.0
	Total	33	97.1	100.0	
Missing	9.00	1	2.9		
Total		34	100.0		

How many hours of use in summer season?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	1	2.9	3.0	3.0
	More than 24 hours	22	64.7	66.7	69.7
	20-24 hours	5	14.7	15.2	84.8
	16-20 hours	2	5.9	6.1	90.9
	12-16 hours	1	2.9	3.0	93.9
	8-12 hours	1	2.9	3.0	97.0
	Less than 8 hours	1	2.9	3.0	100.0
	Total	33	97.1	100.0	
Missing	9.00	1	2.9		
Total		34	100.0		

How many hours of use in winter season?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	1	2.9	3.0	3.0
	More than 20 hours	4	11.8	12.1	15.2
	16-20 hours	8	23.5	24.2	39.4
	12-16 hours	9	26.5	27.3	66.7
	8-12 hours	5	14.7	15.2	81.8
	4-8 hours	5	14.7	15.2	97.0
	Less than 4 hours	1	2.9	3.0	100.0
	Total	33	97.1	100.0	
Missing	9.00	1	2.9		
Total		34	100.0		

How many lawnmowers greater than hp in Q9?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	21	61.8	61.8	61.8
	1	6	17.6	17.6	79.4
	2	3	8.8	8.8	88.2
	3	1	2.9	2.9	91.2
	4	1	2.9	2.9	94.1
	9	1	2.9	2.9	97.1
	60.00	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

How many lawnmowers less than hp in Q9?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	18	52.9	52.9	52.9
	1	8	23.5	23.5	76.5
	2	5	14.7	14.7	91.2
	4	1	2.9	2.9	94.1
	6	1	2.9	2.9	97.1
	9	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

Total number of trimmers, edgers, brush cutters?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	6	17.6	17.6	17.6
	4	6	17.6	17.6	35.3
	5	5	14.7	14.7	50.0
	6	6	17.6	17.6	67.6
	7	1	2.9	2.9	70.6
	8	2	5.9	5.9	76.5
	10	2	5.9	5.9	82.4
	12	2	5.9	5.9	88.2
	25	1	2.9	2.9	91.2
	40	2	5.9	5.9	97.1
	165.00	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

How many have 2 stroke engines?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	2.9	2.9	2.9
	2	2	5.9	5.9	8.8
	3	7	20.6	20.6	29.4
	4	5	14.7	14.7	44.1
	5	4	11.8	11.8	55.9
	6	4	11.8	11.8	67.6
	7	1	2.9	2.9	70.6
	8	3	8.8	8.8	79.4
	9	1	2.9	2.9	82.4
	10	1	2.9	2.9	85.3
	12	2	5.9	5.9	91.2
	25.00	1	2.9	2.9	94.1
	40.00	1	2.9	2.9	97.1
	165.00	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

How many have 4 stroke engines?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	24	70.6	70.6	70.6
	1	3	8.8	8.8	79.4
	2	2	5.9	5.9	85.3
	3	4	11.8	11.8	97.1
	28.00	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

How many hours per week would this equipment be used?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	More than 6 hours	20	58.8	58.8	58.8
	5-6 hours	7	20.6	20.6	79.4
	4-5 hours	1	2.9	2.9	82.4
	3-4 hours	2	5.9	5.9	88.2
	2-3 hours	4	11.8	11.8	100.0
	Total	34	100.0	100.0	

How many hours of use in summer season?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	More than 6 hours	27	79.4	79.4	79.4
	5-6 hours	1	2.9	2.9	82.4
	4-5 hours	1	2.9	2.9	85.3
	3-4 hours	4	11.8	11.8	97.1
	2-3 hours	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

How many hours of use in winter season?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	More than 6 hours	11	32.4	32.4	32.4
	5-6 hours	8	23.5	23.5	55.9
	4-5 hours	4	11.8	11.8	67.6
	3-4 hours	3	8.8	8.8	76.5
	2-3 hours	5	14.7	14.7	91.2
	Less than 2 hours	3	8.8	8.8	100.0
	Total	34	100.0	100.0	

How many HH leafblowers/vacuums?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	5	14.7	14.7	14.7
	1	11	32.4	32.4	47.1
	2	9	26.5	26.5	73.5
	3	3	8.8	8.8	82.4
	6	2	5.9	5.9	88.2
	16.00	1	2.9	2.9	91.2
	20.00	1	2.9	2.9	94.1
	25.00	1	2.9	2.9	97.1
	60.00	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

How many HH have 2 stroke engines?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	9	26.5	26.5	26.5
	1	11	32.4	32.4	58.8
	2	8	23.5	23.5	82.4
	3	3	8.8	8.8	91.2
	6	1	2.9	2.9	94.1
	15.00	1	2.9	2.9	97.1
	25.00	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

How many HH have 4 stroke engines?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	27	79.4	79.4	79.4
	1	3	8.8	8.8	88.2
	2	1	2.9	2.9	91.2
	4	1	2.9	2.9	94.1
	20.00	1	2.9	2.9	97.1
	60.00	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

How many hours per week used?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	More than 10 hours	11	32.4	35.5	35.5
	8-10 hours	8	23.5	25.8	61.3
	7-8 hours	2	5.9	6.5	67.7
	5-7 hours	3	8.8	9.7	77.4
	Less than 5 hours	7	20.6	22.6	100.0
	Total	31	91.2	100.0	
Missing	9.00	3	8.8		
Total		34	100.0		

How many NH leafblowers/vacuums?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	18	52.9	52.9	52.9
	1	9	26.5	26.5	79.4
	2	1	2.9	2.9	82.4
	3	2	5.9	5.9	88.2
	4	1	2.9	2.9	91.2
	5	1	2.9	2.9	94.1
	6	1	2.9	2.9	97.1
	24.00	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

How many total leafblowers/vacuums?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	9	26.5	26.5	26.5
	2	10	29.4	29.4	55.9
	3	2	5.9	5.9	61.8
	4	4	11.8	11.8	73.5
	5	1	2.9	2.9	76.5
	6	4	11.8	11.8	88.2
	17.00	1	2.9	2.9	91.2
	20.00	1	2.9	2.9	94.1
	26.00	1	2.9	2.9	97.1
	84.00	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

How many hours per week NH used?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	1	2.9	5.0	5.0
	More than 10 hours	1	2.9	5.0	10.0
	8-10 Hours	4	11.8	20.0	30.0
	7-8 hours	2	5.9	10.0	40.0
	5-7 hours	3	8.8	15.0	55.0
	Less than 5 hours	9	26.5	45.0	100.0
	Total	20	58.8	100.0	
Missing	9.00	14	41.2		
Total		34	100.0		

How many chainsaws less than 3 hp?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	6	17.6	17.6	17.6
	1	14	41.2	41.2	58.8
	2	8	23.5	23.5	82.4
	3	1	2.9	2.9	85.3
	4	1	2.9	2.9	88.2
	5	1	2.9	2.9	91.2
	6	1	2.9	2.9	94.1
	9	1	2.9	2.9	97.1
	40.00	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

How many chainsaws greater than 3 hp?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	19	55.9	55.9	55.9
	1	6	17.6	17.6	73.5
	2	1	2.9	2.9	76.5
	3	3	8.8	8.8	85.3
	4	1	2.9	2.9	88.2
	6	1	2.9	2.9	91.2
	9	3	8.8	8.8	100.0
	Total	34	100.0	100.0	

How many hours per week in spring are chainsaws used?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	7-8 hours	2	5.9	6.7	6.7
	5-6 hours	2	5.9	6.7	13.3
	Less than 4 hours	26	76.5	86.7	100.0
	Total	30	88.2	100.0	
Missing	9.00	4	11.8		
Total		34	100.0		

How many hours in summer are chainsaws used?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	More than 8 hours	1	2.9	3.2	3.2
	7-8 hours	2	5.9	6.5	9.7
	6-7 hours	2	5.9	6.5	16.1
	5-6 hours	5	14.7	16.1	32.3
	Less than 4 hours	21	61.8	67.7	100.0
	Total	31	91.2	100.0	
Missing	9.00	3	8.8		
Total		34	100.0		

How many hours in winter are chainsaws used?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	6-7 hours	1	2.9	3.2	3.2
	5-6 hours	2	5.9	6.5	9.7
	Less than 4 hours	28	82.4	90.3	100.0
	Total	31	91.2	100.0	
Missing	9.00	3	8.8		
Total		34	100.0		

How many HH turf equipment?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	23	67.6	67.6	67.6
	1	2	5.9	5.9	73.5
	2	1	2.9	2.9	76.5
	4	3	8.8	8.8	85.3
	5	2	5.9	5.9	91.2
	9	1	2.9	2.9	94.1
	12.00	1	2.9	2.9	97.1
	25.00	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

What percent have four stroke engines?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	1	2.9	7.7	7.7
	90-100%	2	5.9	15.4	23.1
	70-90%	1	2.9	7.7	30.8
	50-70%	1	2.9	7.7	38.5
	0-25%	8	23.5	61.5	100.0
	Total	13	38.2	100.0	
Missing	9.00	21	61.8		
Total		34	100.0		

How many hours per week in spring is turf equipment?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	1	2.9	7.7	7.7
	More than 24 hours	1	2.9	7.7	15.4
	20-24 hours	1	2.9	7.7	23.1
	16-20 hours	2	5.9	15.4	38.5
	12-16 hours	2	5.9	15.4	53.8
	Less than 12 hours	6	17.6	46.2	100.0
	Total	13	38.2	100.0	
Missing	9.00	21	61.8		
Total		34	100.0		

How many NH turf equipment?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	7	20.6	20.6	20.6
	1	2	5.9	5.9	26.5
	2	2	5.9	5.9	32.4
	4	2	5.9	5.9	38.2
	5	1	2.9	2.9	41.2
	9	19	55.9	55.9	97.1
	30.00	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

How many hours per week turf equipment used?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	1	2.9	8.3	8.3
	More than 24 hours	2	5.9	16.7	25.0
	12-16 hours	1	2.9	8.3	33.3
	Less than 12 hours	8	23.5	66.7	100.0
	Total	12	35.3	100.0	
Missing	9.00	22	64.7		
Total		34	100.0		

In what county do you conduct most business?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Orange County	26	76.5	76.5	76.5
	Seminole County	4	11.8	11.8	88.2
	Osceola County	4	11.8	11.8	100.0
	Total	34	100.0	100.0	

In what county do you conduct most business?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Seminole County	3	8.8	60.0	60.0
	Osceola County	2	5.9	40.0	100.0
	Total	5	14.7	100.0	
Missing	9.00	29	85.3		
Total		34	100.0		

How many employees are working in your business?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	19	55.9	55.9	55.9
	2	8	23.5	23.5	79.4
	4	1	2.9	2.9	82.4
	6	1	2.9	2.9	85.3
	9	1	2.9	2.9	88.2
	10	2	5.9	5.9	94.1
	16	1	2.9	2.9	97.1
	50.00	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

What is the primary function of your business?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	To provide lawn and garden services for outside clients	29	85.3	85.3	85.3
	To provide maintenance services for large establishment	5	14.7	14.7	100.0
	Total	34	100.0	100.0	

APPENDIX D: CHI SQUARE OUTPUTS

Test Statistics

	What horsepower range is your lawn mowers?	How many hours of use for these lawn mowers?	How many hours of use in summer season?	How many hours of use in winter season?	How many hours per week would this equipment be used?	How many hours of use in summer season?
Chi-Square[a,b]	24.500	9.250	71.688	11.750	32.303	72.303
df	3	4	6	6	4	4
Asymp. Sig.	.000	.055	.000	.068	.000	.000

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 8.0.

b. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 6.4.

c. 7 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 4.6.

d. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 6.6.

Test Statistics

	How many hours of use in winter season?	How many hours per week used?	How many hours per week NH used?	How many hours per week in spring are chainsaws used?	How many hours in summer are chainsaws used?	How many hours in winter are chainsaws used?
Chi-Square[a,b]	10.091	10.333	12.895	41.448	48.667	60.933
df	5	4	5	2	4	3
Asymp. Sig.	.073	.035	.024	.000	.000	.000

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 5.5.

b. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 6.0.

c. 6 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 3.2.

d. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 9.7.

e. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 7.5.

Test Statistics

	How many hours per week in spring is turf equipment?	How many hours per week turf equipment used?
Chi-Square[a,b]	5.000	6.091
df	5	3
Asymp. Sig.	.416	.107

a. 6 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 2.2.

b. 4 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 2.8.

APPENDIX E: COMPARATIVE EMISSION TOTALS

*Indicates Survey Data

Equipment Type	Season	VOC	NOx
Lawn mowers	Summer	203.06	14.17
*Lawn mowers	Summer	455.48	29.76
Rear Engine Riding Mowers	Summer	6.08	1.50
*Rear Engine Riding Mowers	Summer	8.80	2.23
Lawn & Garden Tractors	Summer	79.47	28.72
*Lawn & Garden Tractors	Summer	87.27	33.27
Trimmers/Edgers/Brush Cutter	Summer	146.16	2.55
*Trimmers/Edgers/Brush Cutter	Summer	265.73	11.39
Leafblowers/Vacuums	Summer	219.23	21.12
*Leafblowers/Vacuums	Summer	203.41	24.22
Chain Saws < 6 HP	Summer	195.07	2.35
*Chain Saws < 6 HP	Summer	98.83	1.30
Commercial Turf Equipment	Summer	310.63	77.25
*Commercial Turf Equipment	Summer	97.55	25.94
Lawn mowers	Fall	180.39	12.54
*Lawn mowers	Fall	355.60	23.15
Rear Engine Riding Mowers	Fall	5.48	1.32
*Rear Engine Riding Mowers	Fall	7.04	1.74
Lawn & Garden Tractors	Fall	71.45	25.42
*Lawn & Garden Tractors	Fall	70.05	25.88
Trimmers/Edgers/Brush Cutter	Fall	129.63	2.25
*Trimmers/Edgers/Brush Cutter	Fall	207.53	8.86
Leafblowers/Vacuums	Fall	194.54	18.69
*Leafblowers/Vacuums	Fall	158.97	18.84
Chain Saws < 6 HP	Fall	195.07	2.35
*Chain Saws < 6 HP	Fall	77.01	1.01
Commercial Turf Equipment	Fall	277.75	68.36
*Commercial Turf Equipment	Fall	78.01	20.18
Lawn mowers	Winter	40.76	2.51
*Lawn mowers	Winter	255.59	16.54
Rear Engine Riding Mowers	Winter	1.76	0.26
*Rear Engine Riding Mowers	Winter	5.25	1.24
Lawn & Garden Tractors	Winter	21.89	5.08
*Lawn & Garden Tractors	Winter	52.61	18.49
Trimmers/Edgers/Brush Cutter	Winter	27.83	0.45
*Trimmers/Edgers/Brush Cutter	Winter	149.24	6.33
Leafblowers/Vacuums	Winter	42.46	3.74
*Leafblowers/Vacuums	Winter	114.45	13.46
Chain Saws < 6 HP	Winter	195.05	2.35
*Chain Saws < 6 HP	Winter	62.45	0.82
Commercial Turf Equipment	Winter	74.85	13.67
*Commercial Turf Equipment	Winter	58.26	14.41
Lawn mowers	Spring	180.39	12.54
*Lawn mowers	Spring	355.60	23.15
Rear Engine Riding Mowers	Spring	5.48	1.32

Equipment Type	Season	VOC	NOx
*Rear Engine Riding Mowers	Spring	7.04	1.74
Lawn & Garden Tractors	Spring	71.45	25.42
*Lawn & Garden Tractors	Spring	70.05	25.88
Trimmers/Edgers/Brush Cutter	Spring	129.63	2.25
*Trimmers/Edgers/Brush Cutter	Spring	207.53	8.86
Leafblowers/Vacuums	Spring	194.54	18.69
*Leafblowers/Vacuums	Spring	158.97	18.84
Chain Saws < 6 HP	Spring	195.07	2.35
*Chain Saws < 6 HP	Spring	77.01	1.01
Commercial Turf Equipment	Spring	277.75	68.36
*Commercial Turf Equipment	Spring	78.01	20.18
Lawn mowers	Annual	604.61	41.77
*Lawn mowers	Annual	1422.27	92.60
Rear Engine Riding Mowers	Annual	18.79	4.41
*Rear Engine Riding Mowers	Annual	28.12	6.94
Lawn & Garden Tractors	Annual	244.26	84.64
*Lawn & Garden Tractors	Annual	279.97	103.52
Trimmers/Edgers/Brush Cutter	Annual	433.24	7.51
*Trimmers/Edgers/Brush Cutter	Annual	830.03	35.44
Leafblowers/Vacuums	Annual	650.77	62.23
*Leafblowers/Vacuums	Annual	635.80	75.37
Chain Saws < 6 HP	Annual	780.25	9.38
*Chain Saws < 6 HP	Annual	315.30	4.14
Commercial Turf Equipment	Annual	940.97	227.65
*Commercial Turf Equipment	Annual	311.8222793	80.71042962

Equipment Type	Season	VOC	NOx	VOC + NOx
*Rear Engine Riding Mowers	Spring	4.70	1.10	5.81
Lawn & Garden Tractors	Spring	71.45	25.42	96.87
*Lawn & Garden Tractors	Spring	61.12	21.16	82.28
Trimmers/Edgers/Brush Cutter	Spring	129.63	2.25	131.88
*Trimmers/Edgers/Brush Cutter	Spring	109.44	4.11	113.55
Leafblowers/Vacuums	Spring	194.54	18.69	213.23
*Leafblowers/Vacuums	Spring	107.18	12.00	119.18
Chain Saws < 6 HP	Spring	195.07	2.35	197.41
*Chain Saws < 6 HP	Spring	84.67	1.02	85.68
Commercial Turf Equipment	Spring	277.75	68.36	346.11
*Commercial Turf Equipment	Spring	91.52	24.66	116.18
Lawn mowers	TOTAL	604.61	41.77	646.38
*Lawn mowers	TOTAL	604.61	41.77	646.38
Rear Engine Riding Mowers	TOTAL	18.79	4.41	23.21
*Rear Engine Riding Mowers	TOTAL	18.79	4.41	23.21
Lawn & Garden Tractors	TOTAL	244.26	84.64	328.90
*Lawn & Garden Tractors	TOTAL	244.26	84.64	328.90
Trimmers/Edgers/Brush Cutter	TOTAL	433.24	7.51	440.75
*Trimmers/Edgers/Brush Cutter	TOTAL	437.68	16.46	454.14
Leafblowers/Vacuums	TOTAL	650.77	62.23	713.01
*Leafblowers/Vacuums	TOTAL	428.66	47.99	476.64
Chain Saws < 6 HP	TOTAL	780.25	9.38	789.63
*Chain Saws < 6 HP	TOTAL	346.69	4.17	350.86
Commercial Turf Equipment	TOTAL	940.97	227.65	1168.62
*Commercial Turf Equipment	TOTAL	365.89	98.63	464.52

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