2008 EMISSIONS INVENTORY OF CENTRAL FLORIDA

by

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ABSTRACT

An emissions inventory of VOCs, NO_x, and CO_2 was conducted for three central Florida counties – Orange, Seminole, and Osceola (OSO) – for calendar year 2008. The inventory utilized three programs: MOBILE6, NONROAD2005, and EDMS (Emissions and Dispersion Modeling System) to model on-road mobile, non-road mobile, and airport emissions, respectively. Remaining point and area source data was estimated from the Florida Department of Environmental Protection (FDEP) and the U.S. Environmental Protection Agency's (U.S. EPA) 2008 emissions inventory. The previous OSO emissions inventory was done in 2002 and in the six years between inventories, there have been changes in population, commerce, and pollution control technology in central Florida which have affected the region's emissions.

It is important to model VOC and NO_x emissions to determine from where the largest proportions are coming. VOCs and NO_x are ozone precursors, and in the presence of heat and sunlight, they react to form ozone (O_3). Ozone is regulated by the U.S. Environmental Protection Agency through the FDEP. The current standard is 75 parts per billion (ppb) and Orange County's average is 71 ppb. A new standard (which will likely be about 65 ppb) is being developed and is scheduled to be announced by July 2011. If OSO goes into non-attainment, it will need to prepare a contingency plan for how to reduce emissions to submit to the FDEP for approval.

The 2008 inventory determined that approximately 71,300 tons of VOCs and 59,000 tons of NO_x were emitted that year. The majority of VOCs came from on-road mobile sources (33%) and area sources (43%), while the majority of NO_x came from on-road mobile sources (64%) and non-road mobile sources (17%). Other major sources of VOCs included gasoline powered non-road mobile equipment (lawn and garden equipment), consumer solvents, cooking, and gasoline distribution. With the numbers

that could be determined for CO_2 emissions, on-road mobile and point sources were responsible for 93%. Of the point source CO_2 emissions, almost all of it (87%) came from one large coal-fired power plant in Orange County.

I dedicate this to my dad. I worked really, really, really, really hard and I know you would be proud.

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1 INTRODUCTION

This report contains an emissions inventory for the Orange, Seminole, and Osceola (OSO) tri-county area, also called the Orlando Urban Area (OUA). Volatile organic compounds (VOC), nitrogen oxide (NO_x), and carbon dioxide (CO_2) pollutant emissions were tallied for the 2008 calendar year. An emissions inventory is an important tool in managing air quality for any region because it gives managers and decision makers a good tool for focusing their efforts on large sources when trying to reduce emissions of particular types (U.S. Environmental Protection Agency, 2004). The airshed covering central Florida includes Lake County in addition to OSO, however Lake County was not included in the contracted work between UCF and Metroplan.

VOCs and NO_x are "ozone precursors" and in the presence of sunlight can react in the atmosphere to form ground-level ozone (O_3). The EPA's current standard is 75 ppb and a revision is slated to be announced in July 2011. Ground-level ozone is a criteria pollutant that can cause serious health problems. VOCs are emitted as gases from solvents or fuels; liquids that have high vapor pressures and low water solubility. They can exist in many forms, ranging from simple hydrocarbons such as butane or benzene, to oxygenates like formaldehyde or methyl ethyl ketone, to chlorinated solvents such as trichloroethylene. NO_x is emitted from sources where high temperature combustion occurs, including diesel engines in motor vehicles, large steam-electric power generation boilers, and industrial furnaces (U.S. Environmental Protection Agency, 1998). NO_x contributes to acid rain formation and reacts with VOCs to create ground-level ozone. In addition to VOCs and NO_x emissions, CO_2 emissions were estimated as part of this project. That additional information (although not part of the original contracted work) was included because of the current interest in global climate change emissions throughout the region, the state, and the nation.

In this inventory, emissions are categorized into four main source types:

1. On-road mobile – cars, SUVs, trucks, buses, motorcycles
2. Non-road mobile – lawn equipment, pleasure craft (e.g., boats and jet skis), construction and mining equipment, railroad equipment, airport ground service equipment
3. Point – large facilities or industrial sites which require air permits for their emissions and must submit an annual report
4. Area – small emitters that do not emit enough on their own to qualify as a point source, but collectively may be significant. Includes restaurants, dry cleaning facilities, printers, painting operations, wildfires, architectural coating, pesticides, auto body refinishing, gasoline stations, etc.

The United States Environmental Protection Agency (EPA) set minimum emission requirements to define a point source at 25 tons of VOCs and 10 tons of NO_x annually (Florida Department of Environmental Protection, January 2010). Point sources may include power plants, airports, boat manufacturers, hospitals, food production facilities, concrete plants, and large printing firms, among others.

Computer models developed by the EPA and Federal Aviation Authority (FAA) were used to estimate mobile (both on-road and non-road), and airport emissions, respectively. EPA guidelines and journal articles were reviewed and followed to prepare this emissions inventory and provide accurate results. Florida DEP permits were reviewed to obtain estimates of point source emissions in the OUA. For area source emissions, data obtained from the 2008 National Emission Inventory was used ("2008 National emissions inventory data & documentation," 2010).

The last inventory for Metroplan Orlando was prepared in 2002 (Arbrandt, 2003). In the six years between inventories, there have been changes in population, on-road and non-road vehicles (and their emission characteristics), construction and development activity in the region, and the opening and closing of manufacturing facilities. Current data were gathered, and newer EPA models were used (compared with 2002) to produce the 2008 Emissions Inventory. The changes and similarities to the region's previous emission inventory can be seen in the results presented herein.

1.1 Ozone

The EPA's current maximum allowable ozone level was set in 2008 at 75 ppb. Each county's level is determined by a three-year average of the fourth-highest daily maximum 8-hour average readings. There are four monitors in the OSO area:

1. Winegard Elementary School (Winegard Rd., Orlando)
2. Lake Isle Estates (S. Denning Drive, Winter Park)
3. Four Corners Fire Station (US-192, Kissimmee)
4. Seminole State College (Weldon Blvd, Sanford)

When any of the three counties is nonattainment, all three are considered to be nonattainment. OSO is treated as one airshed with any one county's levels affecting the other two. These three counties were selected for emissions monitoring because they were chosen by MetroPlan Orlando in the contracted work with UCF.

Ozone is a byproduct of VOCs and NO_x reacting in the presence of sunlight. The rate at which these reactions occur is related to temperature and intensity of the sunlight. For this reason, the highest ozone levels tend to be in the hottest months of the year.

The health problems caused by ozone are what make it necessary to regulate. Studies have linked ground-level ozone exposure to problems such as airway irritation, aggravation of asthma, wheezing and difficulty breathing during exercise and outdoor activities, and permanent lung damage with repeated exposures. Besides human health, ozone can affect plants and ecosystems. It can increase susceptibility of plants to certain insects, diseases, competing species, harsh weather, and reduce forest growth and crop yields. Figure 1 shows OSO's highest monthly 8-hour ozone readings from the four ozone monitoring stations in the area.

$$\text{VOCs} + NO_x + \text{Heat} + \text{Sunlight} = \text{Ozone}$$

1.2 Nitrogen Oxides

Nitrogen oxides (NO_x) is a group of compounds that includes nitrogen dioxide, nitric acid, and nitrous acid. While all of the compounds influence NO_x levels, NO_2 is of the greatest concern. Formation of NO_x occurs from combustion of any fuel in air at high temperatures. It is released from car and truck engines, non-road mobile equipment, buses, and power plants.

1.3 Volatile Organic Compounds

Volatile organic compounds (VOCs) emissions come from sources such as consumer solvents, on-road vehicles, non-road equipment, industrial processes, dry cleaning facilities, and restaurants. VOCs are carbon containing compounds (not including carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate) which participate in atmospheric photochemical reactions. Adverse health effects from VOCs are similar to those from NO_x. These include headaches, respiratory problems, and nausea.

1.4 Relevance

Emissions inventories must be conducted in order to evaluate contributions from a region's emission source categories. The significance of each category suggests an order for emissions reduction efforts to be focused (i.e. if non-road mobile is the largest contributor of NO_x, then that would be looked at first to reduce NO_x emissions). Airsheds that are ozone nonattainment must create a contingency plan explaining the steps it will take to return to attainment (currently set at 75 ppb). The previously mentioned negative health and environmental effects caused by ground level ozone are the reasons behind the continuous tightening of the ozone standard by EPA. The new standard (to be announced by EPA in July 2011) is expected to be 65 ppb. If this is true, most of Florida will be ozone nonattainment and therefore require contingency plans. This study will serve as a valuable reference for central Florida's emissions reduction efforts.

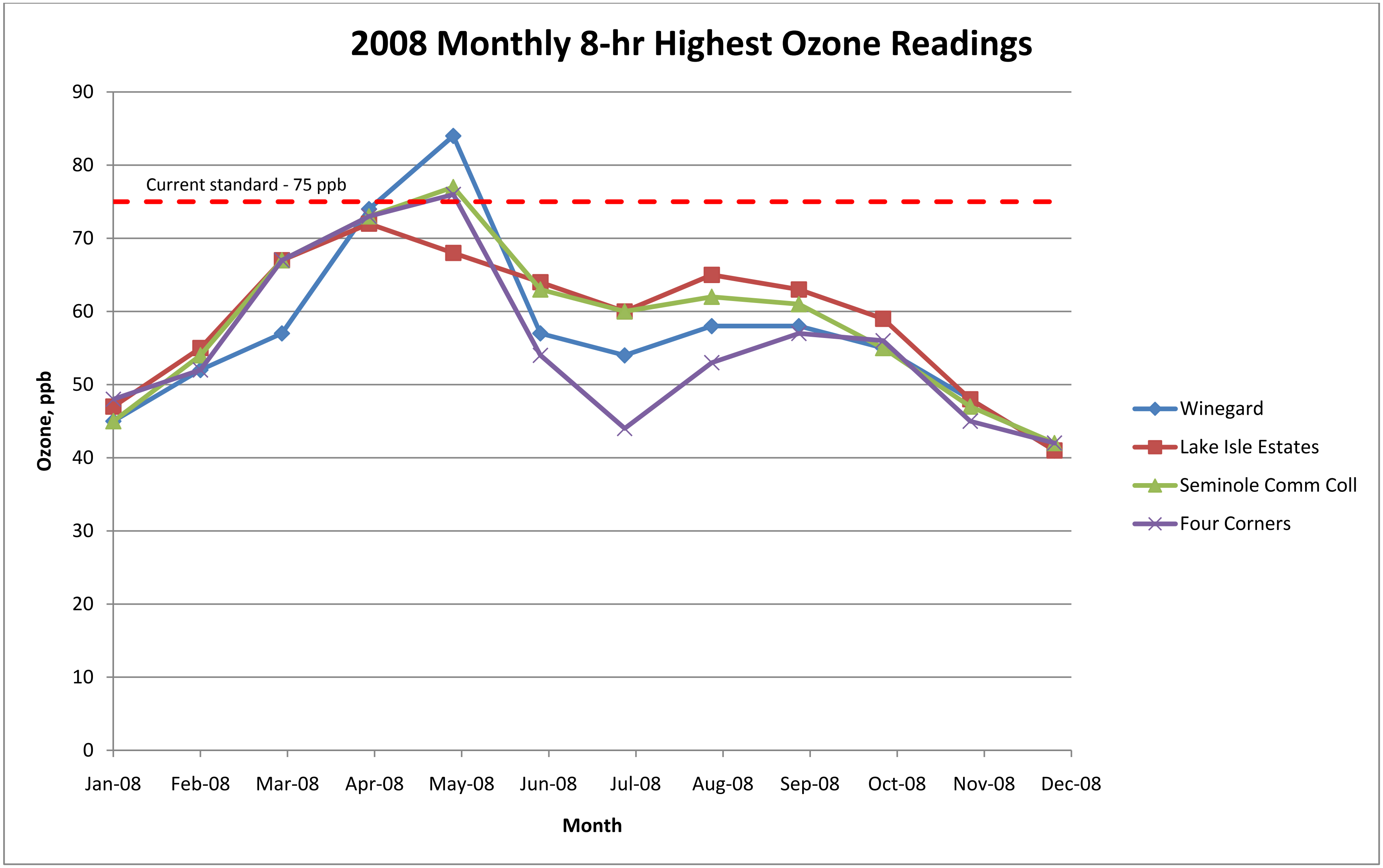

Figure 1 - 2008 Monthly highest 8 hour ozone readings from the four monitors in OSO

2 LITERATURE REVIEW

The US EPA performs a national emissions inventory every three years. It is a comprehensive list that includes VOCs and NO_x, as well as other compounds such as ammonia, methane, sulfur oxides, and more. It is important to quantify these emissions in order to manage emissions to better protect the nation's air quality, and to assess the need for new regulations to preserve and/or improve air quality.

Several methods exist for inventorying emissions. They can be estimated as production-based, consumption-based, or based on a carbon footprint (Larsen and Hertwich, 2009). Production-based inventories are more common and look at the industry within the inventory area's boundaries. Emissions from electricity generation and products manufacturing are attributed to the area. In a consumption-based inventory, emissions are assigned to activities, products, and services, and the more that is consumed in one area, the higher the emissions. The carbon footprint model looks at the life cycle of goods and tracks purchases to estimate emissions. This model incorporates emissions from things such as power generation by finding how much energy was purchased by the municipality. The article by Larsen and Hertwich (2009) makes the argument that consumption-based inventories are the most accurate way to determine emissions. They point out a weakness in the inventorying of industry which can lead to false ideas of progress. Industry activities change over time and if this activity is moved out of a region, emissions will decrease locally, but not due to effective emissions management. For this reason, Larsen and Hertwich argue that consumption-based inventories are the most telling way to determine if emissions have actually been reduced. Production-based inventories are acceptable by the US EPA and are the most common type prepared by municipalities. Due to the availability of data and complex methods which would need to be employed to perform a consumption-based inventory, a production-based inventory was chosen to evaluate OSO emissions.

In a production-based inventory, emissions can be estimated in two ways. One way is called "top-down" modeling, which uses computer models and inputs of the required data so that the model can use standard algorithms to calculate emissions for the specific scenarios. The second way is called "bottom-up" modeling, which makes use of emission factors and multiplies each factor by its appropriate unit of measure. For example, if the factor is given as pounds per capita, it will be multiplied by a county-wide population to give total emissions for that particular county.

The models for the estimation of VOCs, NO_x, and CO_2 for emissions inventories have been explained in professional journal articles discussed in the following sections. Some of these articles used the same estimation methods that were used in this inventory, validating the methods used to produce this emissions inventory.

2.1 EDMS

Theophanides and Anastassopoulou (2009) examined airport emissions from the Athens International Airport (AIA). They used the program that the Environmental Protection Agency (EPA) requires for modeling emissions from airports – the Emissions and Dispersion Modeling System (EDMS) developed by Federal Aviation Authority (FAA). The program incorporates the EPA's NONROAD and MOBILE6 models for contributions from ground support equipment (GSE), buses, and cars. Those authors assumed a reduced number of taxipaths and gates that represented the majority of traffic flow. They found that 75 tonnes of VOCs (a tonne is a metric ton or 1000 kg) and approximately 360 tonnes NO_x per year per 100,000 aircraft movements came from the airport activity. The NO_x results produced from EDMS were within 10% of the values published by AIA (~390 tonnes NO_x per year per 100,000 aircraft movements). These results correlated to those from other studies. There was less information on airport VOC emissions against which to compare the AIA results, so the authors used Dulles International Airport as a reference.

2.2 NONROAD

The inventory performed in 2002 for California non-road equipment compared temporal aspects in generating emissions data using two programs – the National Mobile Inventory Model (NMIM) and NONROAD model. The EPA used the NMIM to generate an inventory for each state besides California. Instead, California submitted its own results. The NMIM accounts for variation in temperature, activity, and fuels. It also takes into account the engine mode when generating emissions data. For the California inventory, the largest of the non-road sources of VOCs was pleasure craft with 2-stroke engines. The second largest contributor was lawn and garden equipment (both 2- and 4-stroke engines). NO_x emissions were highest from construction and mining equipment. The results from the California inventory can be seen in

Table 1. As will be evident later, the results from this 2008 OSO inventory demonstrate similar patterns to those found by Strum et al (2007).

Table 1 - VOC and NO_x emissions based on the NONROAD program for California 2002 (Strum et al, 2007)

SCC	Description	Calif . state total VOC from 2002 NEI, V3 (tons)
2282005000	Pleasure Craft;Gasoline 2-Stroke;Total	37,256
2260004000	Off-highway Vehicle Gasoline, 2-Stroke;Lawn and Garden Equipment;All	29,234
2265004000	Off-highway Vehicle Gasoline, 4-Stroke;Lawn and Garden Equipment;All	19,146
2265001020	Off-highway Vehicle Gasoline, 4-Stroke;Recreational Equipment;Snowmobiles	15,186
2270002000	Off-highway Vehicle Diesel;Construction and Mining Equipment;Total	12,089
2282010000	Pleasure Craft; Gasoline 4-Stroke;Total	6,838
SCC	**Description**	**Calif state total NOX from 2002 NEI, V3 tons)**
2270002000	Off-highway Vehicle Diesel;Construction and Mining Equipment;Total	117,031
2270005000	Off-highway Vehicle Diesel;Agricultural Equipment;Total	48,885

2.3 MOBILE6

A dual method on-road emissions inventory was conducted for the Denver metropolitan area using fuel-based estimation and modeling using MOBILE6 (Pokharel et al, 2002). The fuel-based method used fuel use data from tax records to develop emission factors. MOBILE6 produces emission factors based on vehicle miles traveled (VMT). VMT are estimated using a model based on the registered vehicle fleet. Figure 2 shows the comparison of VMT fraction to vehicle fleet age based on remote sensing data (RSD) that were used in the fuel-based approach and MOBILE6 defaults. These values were highly correlated.

MOBILE6 produced values that were 30-70% higher for CO, 40% lower for HC, and 40-80% higher for NO_x than the fuel-based approach. One of the reasons MOBILE6 produced a lower estimate for total hydrocarbons (THC) could be that it only modeled running exhaust emissions in order to be able to compare the results to the fuel-based results. In the Denver study, the model showed that 32% of THC emissions were from start emissions and 44% are from evaporative emissions. CO start emissions contributed 50% to the total and NO_x start emissions contributed 27%. Regarding mobile source emissions, VOCs are similar in magnitude to THCs, so the general trends from THC estimates can be applied to VOCs. The higher CO and NO_x estimates could indicate the worst case scenario, which can be defined as a certain set of assumptions that yield the highest emissions prediction, leading to better policy formation. In this case, the worst case scenario occurs in cold weather with fuels having high Reid Vapor Pressure values (approximately 10.5-15.2 psi). January is selected for the month and a reasonable temperature is chosen for the minimum to be modeled (i.e. 40°F in Florida, not negative temperatures which may occur in more northern states).

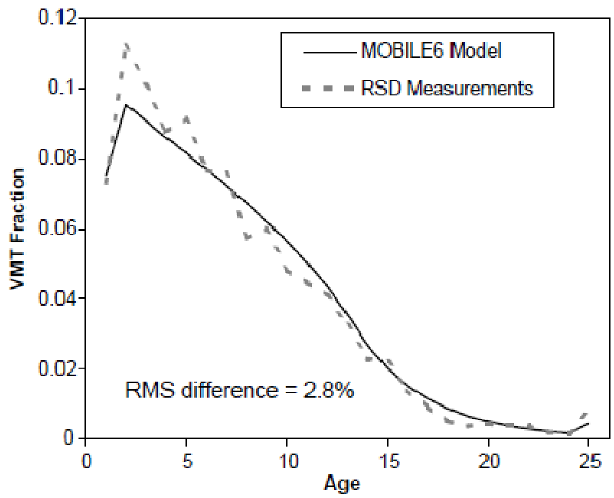

Figure 2 - Correlation of RSD measurements to MOBILE6 default values for the Denver metropolitan area (Pokharel et al, 2002)

3 DESCRIPTION OF INVENTORY SOURCE TYPES

3.1 Mobile Sources

3.1.1 On-road Sources

As the name suggests, on-road mobile sources are comprised of those vehicles which are operated on roadways. These vehicles include cars and light trucks, SUVs, heavy trucks, buses, and motorcycles, and contribute a significant portion of the area's VOC and NO_x emissions. To calculate total emissions, the emission factors produced from the program must be multiplied by vehicle miles traveled (VMT). In this study, VMT data were obtained from the Florida Department of Transportation (FDOT) website and includes rural, small and large urbanized roads, and limited access highways (Florida Department of Transportation, 2009). The emissions were calculated using MOBILE6 – the EPA's approved model for on-road mobile emissions modeling (at the time the modeling was conducted).

3.1.2 Non-road Sources

Non-road mobile sources contribute a large portion of the area's VOC and NO_x emissions. Non-road sources include lawn and garden equipment (leaf blowers, mowers, edgers, chainsaws, etc.), construction and mining equipment (cranes, tractors, forklifts, pavers, etc.), pleasure craft (inboard and outboard motors and personal water craft), recreational equipment (ATVs, golf carts, snowmobiles, etc.), logging equipment, and more. The EPA model NONROAD2005 was used to predict these emissions. The model requires basic inputs such as county names, sulfur content of the fuel, and temperature. It generates total emissions and emission factors for various horsepower values and fuel types. Total emissions values were used in this inventory.

3.2 Point Sources

Point sources are stationary sources that are large enough that they must file a permit with the Florida Department of Environmental Protection (FDEP) documenting their emission levels. The type and size of facility determines which type of permit is required. These permits specify emission testing and monitoring methods for each facility, and that each must report to DEP annually (Florida Department of Environmental Protection, March 2010). Point sources vary by location, but they typically include fossil-fuel fired power plants, manufacturing facilities, hospitals, large printing companies, and airports. The FDEP requires facilities that have the potential to emit more than 10 tons of VOCs or 25 tons of NO_x per year and are located in an ozone nonattainment area or ozone air quality maintenance area to have permits on file with the agency (Florida Department of Environmental Protection, January 2010). To calculate point source contributions, emission reports were obtained from FDEP and EPA. The EDMS model was used for the region's airports. Inputs to EDMS include aircraft and engine types and quantities, runway, gate, and taxiway locations, taxipath configurations for arrival and departures between each gate and runway, and parking facility information. Data for EDMS was obtained from Orlando International Airport's January 2008 operations data.

3.3 Area Sources

Area sources are made up of emitters that do not individually release enough emissions to be considered a point source, but collectively, can emit considerable amounts. They consist of dry cleaners, gasoline stations, restaurants, surface coating and painting operations, paving operations, traffic road striping, auto body shops, degreasing facilities, and even wildfires. The data for area source estimation in this report were obtained from the EPA's 2008 National Emission Inventory ("2008 National emissions inventory data & documentation," 2010).

4 MODELS

Some emissions are impractical to measure and require computer modeling to be able to quantify them. For example, to model on-road mobile emissions, a monitor would need to be placed on the exhaust system of every vehicle on the road. Data including speeds, fuel type, and vehicle year and type would need to be uploaded remotely from each vehicle as well as records for every car added and removed from the road. It is impossible to keep accurate, up to date records on such a scale, thus the need for computer modeling estimations. The results from these models are verified by EPA developed methods for determining emissions. Since EPA is the governing environmental body in the U.S., the models which they approve are assumed to be accurate (provided the inputs to the models come from reputable sources and have been gone over for quality control).

4.1 MOBILE6

For the past 10 years, MOBILE6 was EPA's official on-road emissions modeling program, and has been recently replaced by MOVES. MOBILE6 produces emission factors (grams per vehicle mile traveled) for volatile organic compounds (VOCs), carbon monoxide (CO), nitrogen oxides (NO_x), carbon dioxide (CO_2), particulate matter (PM), toxics, and others (U.S. Environmental Protection Agency, May 2010). The user inputs conditions to simulate different environments and scenarios. Some of these conditions are calendar year, temperature, travel speeds, fuel volatility, and mileage accrual rates (U.S. Environmental Protection Agency, 2003). MOBILE6 is widely used by the air pollution control community to evaluate on-road mobile source emissions and develop control strategies (U.S. Environmental Protection Agency, 2003). Table 2 shows the parameters input into MOBILE6 for this particular inventory.

Table 3 shows the VMT data on which the results are based.

Table 2 - MOBILE6 Inputs

Parameter	Value
Pollutants	HC, NO_x, CO_2, CO
Year	2008
Reid Vapor Pressure (RVP)	7.8
Min/Max Temperature	50°F, 90°F
Roadway Type	Freeway
Month	January
Altitude	Low
Absolute Humidity	75 grains/lb
Fuel Sulfur Content	300 ppm

Table 3 - VMT by road type and county

By Road Type	Annual VMT		By County	Annual VMT
Interstate	2,560,893,578		Orange	13,545,117,964
Turnpike/Freeway	3,017,185,973		Seminole	3,881,803,302
Principal Arterials	5,335,451,948		Osceola	3,435,849,156
Minor Arterials	3,825,722,089			
Urban Collectors	2,496,076,039			
Locals	3,627,440,795			
Total	**20,862,770,422**			**20,862,770,422**

Source: Florida Department of Transportation, Reports of Highway Mileage and Travel (DVMT)

4.2 NONROAD2005

NONROAD is the EPA model for non-road emission estimation. The program can produce national estimates at the broadest use and county level estimates at the most specific use (U.S. Environmental Protection Agency, 2005). The program was set up to specify Orange, Seminole, and Osceola counties and the results were tabulated in Microsoft Access, then imported to Microsoft Excel. Inputs to the program include calendar year, temperatures, fuel properties, county name, and others. NONROAD uses embedded algorithms to generate emissions estimates. The algorithms combine user inputs as well as default values contained in the program to provide these calculations. NONROAD calculates emissions from 92 different pieces of equipment and four fuel types.

4.3 EDMS

EDMS is the FAA's required model for airport air quality. Inputs which determine airport air quality are number of landings and takeoffs (LTOs), type and number of aircraft, engine model, airport configuration, taxipaths, parking facilities, auxiliary power units, ground service equipment, incinerators, shuttles, etc. The model also requires the average time spent in each mode of an LTO. An LTO is split into six phases: approach, taxi in, start up, taxi out, takeoff, and climb out. Climb out is the phase that occurs after the landing gear is retracted until the aircraft reaches 3000 feet. The program is also capable of dispersion modeling; however that was not used for this study. Several options are available for the level of detail which the program requires. The application level allows the user to create data for aircraft, ground service equipment, and auxiliary power units. This data is then available for any study which chooses to utilize it. The study level allows the user to make changes to the entire study as opposed to changing details specific to an aircraft or scenario. The scenario level allows the user to change details to evaluate their sensitivity without changing the entire study. Creating many scenarios presents many modeling options which can then be compared. The airport level permits the user to define weather, gates, taxiways, taxipaths, runways, runway configurations, and select the emissions sources to be included. In the most detailed level – the year level – the user can define operational data such as number of take offs and landings.

5 RESULTS

5.1 Mobile Sources

5.1.1 On-road

Of the eight (8) vehicle types used in the fleet in MOBILE6, light duty gas vehicles (LDGV – cars) and light duty gas trucks and SUVs (LDGT) accounted for about 90% of VOC emissions and about 45% of NO_x emissions. The distinctions for light duty truck types within MOBILE6 are based on weight, and range from micro-pick-up trucks and small SUVs to large pick-ups and large SUVs. These light duty vehicle types make up about 90% of the vehicle miles traveled (VMT) in the region, so it was expected that they would be responsible for the largest portion of VOCs. Vehicles using gasoline (instead of diesel) are more numerous than diesel vehicles. However, diesel fuel burns at a higher temperature and therefore diesel vehicles emit considerably more NO_x but less VOCs per VMT than gasoline vehicles. Because of this, heavy duty diesel vehicles (HDDV) contributed a very large portion of the region's NO_x (47.2%) despite accounting for less than 10% of the VMT. Table 4 shows the outputs of EFs and percentage of VMT from each vehicle class calculated by MOBILE6.

Table 4 - Outputs from MOBILE6

Vehicle Type	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
GVWR		< 6000	> 6000	(All)						
VMT distribution	0.3803	0.3662	0.1249		0.0357	0.0004	0.0019	0.0852	0.0055	1.0000
Fuel economy (mpg)	24.1	18.6	14.3	17.3	9.6	32.2	17.2	7.2	50	16.7
Composite Emission Factors (g/mi)										
VOC	0.936	0.977	1.662	1.151	1.394	0.292	0.567	0.461	2.52	1.025
NO_x	0.697	0.868	1.291	0.975	3.183	0.712	0.994	9.08	1.25	1.64
CO_2	368.4	476.8	619.5	513.1	920	316.4	592.8	1421.5	177.4	548.21

LDGV = Light Duty Gasoline Vehicle
LDGT12 = Light Duty Gasoline Truck 1 and 2 (less than 8,500 lbs)
LDGT34 = Light Duty Gasoline Truck 3 and 4 (greater than 8,500 lbs)
HDGV = Heavy Duty Gasoline Vehicle
LDDV = Light Duty Diesel Vehicle
LDDT = Light Duty Diesel Truck
HDDV = Heavy Duty Diesel Vehicle
MC = Motorcycle

The Florida Department of Transportation keeps records of annual vehicle miles traveled on their website by city, county, and road type. The mileage used for this report is the cumulative total of VMT on interstates, turnpikes & freeways, principal arterials, minor arterials, urban/major collector, and rural minor collector roads for Orange, Seminole, and Osceola counties. To calculate emissions, the emission factor produced by MOBILE6 was multiplied by VMT for each category. These results were then converted from grams to tons per year. The formula for this calculation is shown in Equation 1:

Equation 1

$$\boldsymbol{Emission\ Factor\ \left(\frac{grams}{mile}\right) \times VMT \left(\frac{miles}{year}\right) \times \frac{1\ kg}{1000\ g} \times \frac{2.2\ lb}{1\ kg} \times \frac{1\ ton}{2000\ lb} = tons\ of\ pollutant/year}$$

Diesel fuel has a higher carbon content than gasoline, which is why diesel vehicles contributed more than 20% of the CO_2. Table 5 shows the emissions of each vehicle type in both tons per year and its percentage of the total. Figure 3, Figure 4, and Figure 5 show the same results graphically for VOCs, NO_x, and CO_2 respectively. On-road emissions by county can be seen in Table 6.

Table 5 - 2008 On-road mobile source emission totals for OSO by vehicle type

Vehicle Type	Annual VMT	VOCs		NO_x		CO_2	
		tons/year	**percent**	**tons/year**	**percent**	**tons/year**	**percent**
LDGV	7,934,111,592	8,186	34.7%	6,096	16.2%	3,221,975	25.6%
LDGT12	7,639,946,529	8,228	34.9%	7,310	19.4%	4,015,419	31.8%
LDGT34	2,605,760,026	4,774	20.2%	3,708	9.8%	1,779,426	14.1%
HDGV	744,800,904	1,144	4.9%	2,613	6.9%	755,322	6.0%
LDDV	8,345,108	3	0.0%	7	0.0%	2,911	0.02%
LDDT	39,639,264	25	0.1%	43	0.1%	25,902	0.21%
HDDV	1,777,508,040	903	3.8%	17,791	47.2%	2,785,240	22.1%
MC	114,745,237	319	1.4%	158	0.4%	22,438	0.2%
TOTALS	**20,864,856,699**	**23,582**	**100%**	**37,726**	**100%**	**12,608,634**	**100%**

Table 6 - Total on-road emissions by county

	VMT	VOC (tons/yr)	NO_x (tons/yr)	CO_2 (tons/yr)
Orange	13,545,117,964	15,304	24,487	8,185,289
Seminole	3,881,803,302	4,386	7,017	2,345,766
Osceola	3,435,849,156	3,882	6,211	2,076,277
TOTAL	**20,862,770,422**	**23,572**	**37,716**	**12,607,322**

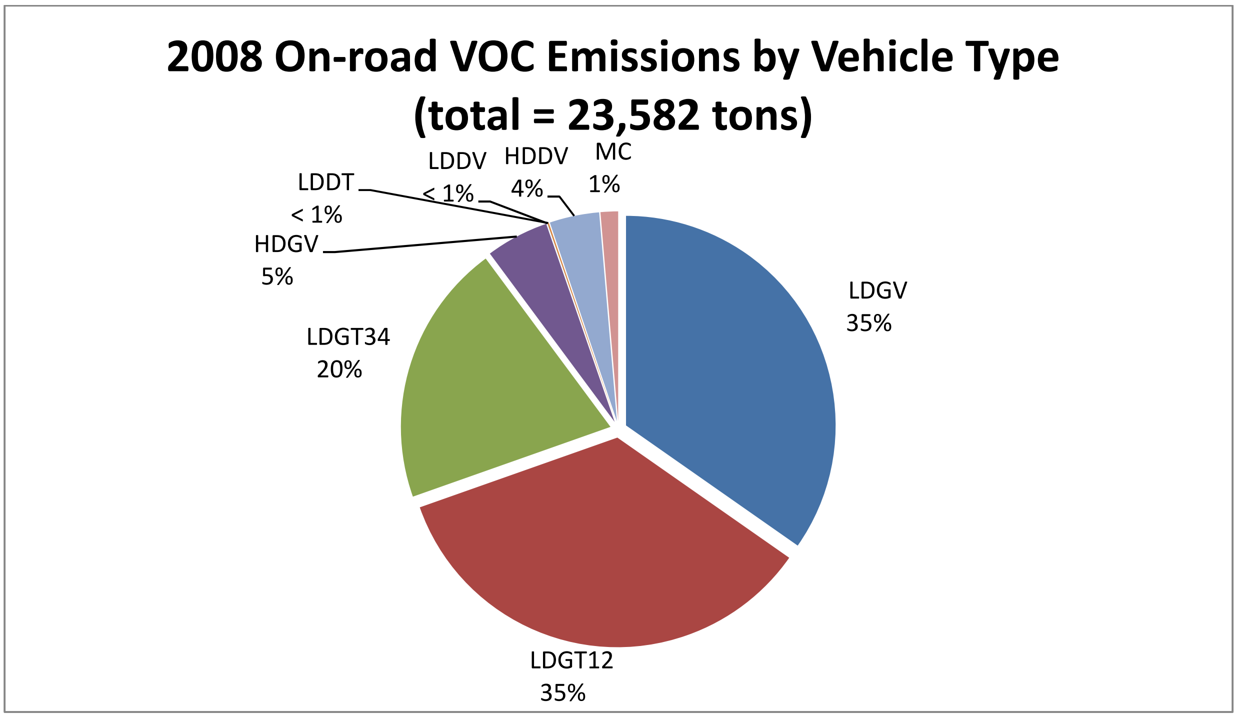

Figure 3 - 2008 On-road VOC contributions by vehicle type for the OSO area

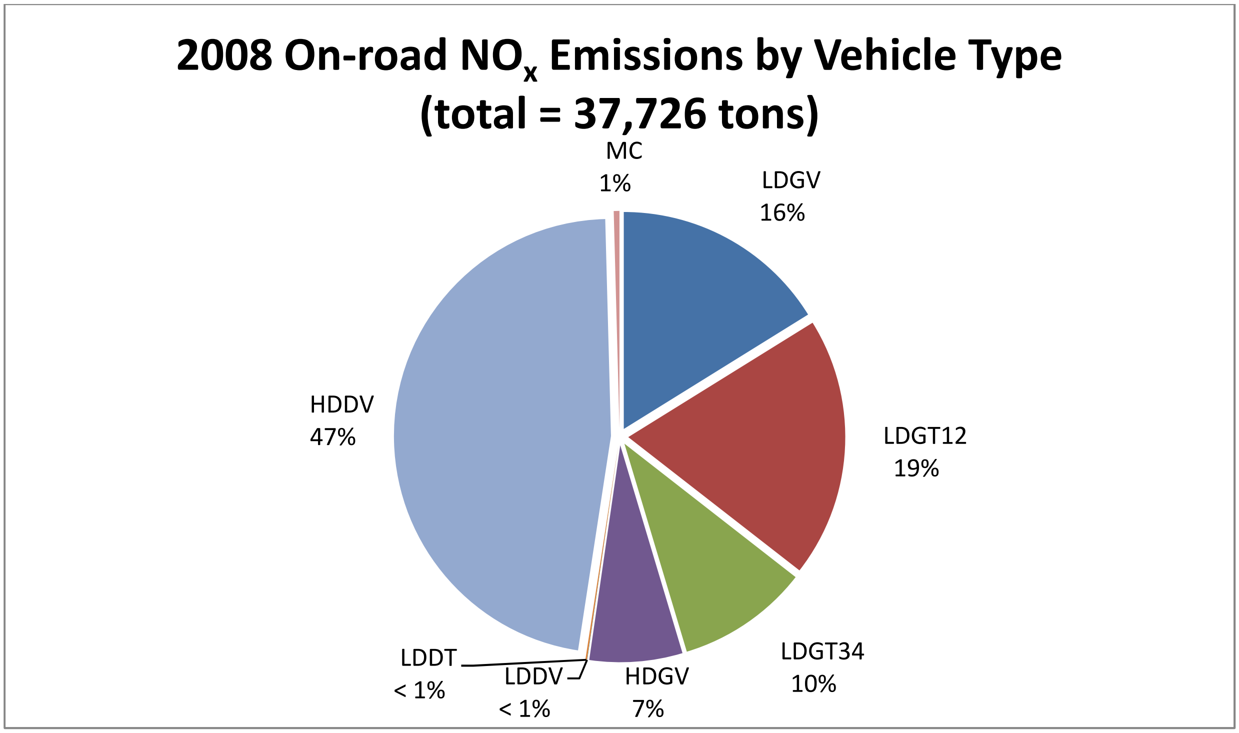

Figure 4 - 2008 On-road NO_x contributions by vehicle type for the OSO area

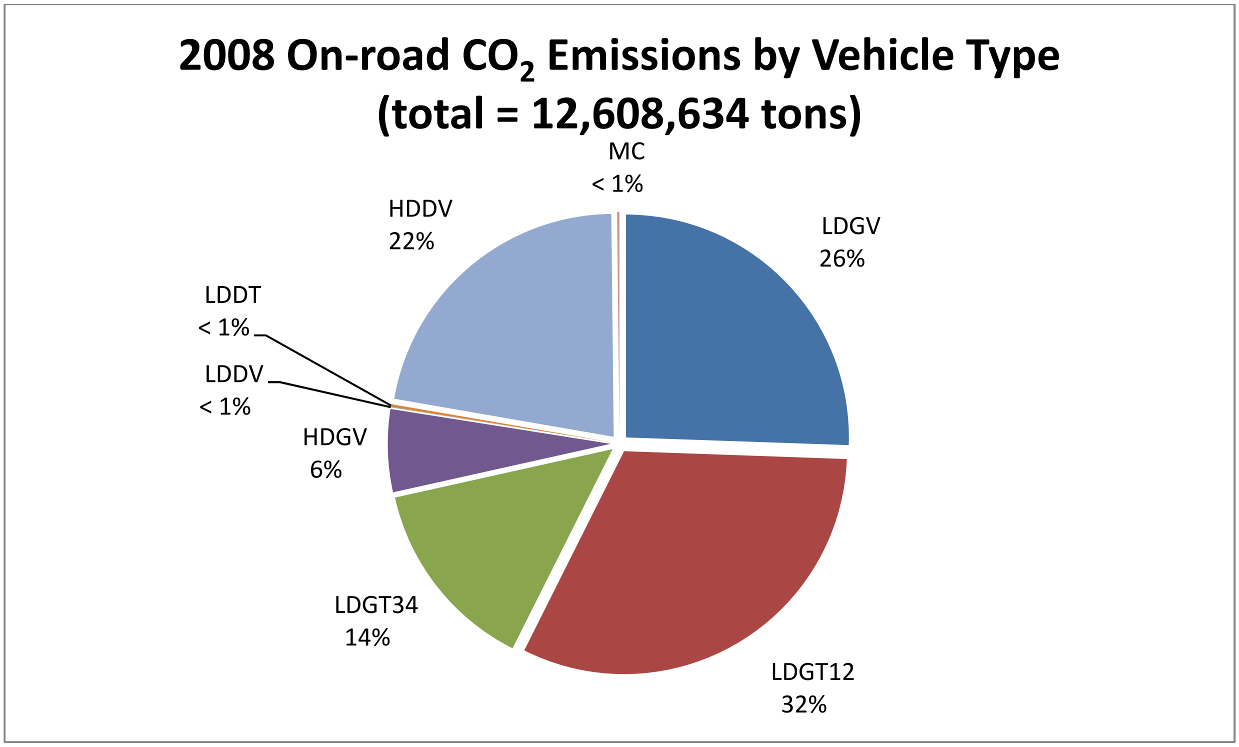

Figure 5 - 2008 On-road CO_2 contributions by vehicle type for the OSO area

5.1.2 Non-road

According to the NONROAD model, pleasure craft (motor boats and jet skis) are the largest source of VOC emissions in the OSO region, comprising 42% of the total, followed closely by lawn and garden equipment (mowers, edgers, trimmers, chain saws, blowers, etc) with 35% of the total. Construction and mining equipment is the largest source of NO_x emissions. This class accounts for 67% of the total. This type of equipment is also responsible for the largest portion of CO_2 emissions, making up 56% of the total non-road category. VOC, NO_x, and CO_2 emissions from the NONROAD program are tabulated by county in Table 7, Table 8, and Table 9, and the totals are shown in Table 10. Figure 6, Figure 7, and Figure 8 show the break-down of VOC, NO_x, and CO_2 emissions in the OSO area by source, respectively.

Table 7 - Orange County NONROAD equipment emissions

Classification	VOC (tons/yr)	NO_x (tons/yr)	CO_2 (tons/yr)
Agricultural Equipment	2.9	26.2	2488.5
Airport Equipment	16.4	174.6	19477.8
Commercial Equipment	777.9	502.1	76696.1
Construction and Mining Equipment	579.6	3889.5	432602.8
Industrial Equipment	129.0	617.7	65261.1
Lawn and Garden Equipment (Com)	2481.7	528.7	132795.3
Lawn and Garden Equipment (Res)	1056.0	69.6	25898.1
Logging Equipment	0.5	0.9	125.5
Pleasure Craft	1925.5	151.9	29864.0
Railroad Equipment	0.1	0.3	25.4
Recreational Equipment	474.6	15.7	7068.6
TOTAL	**7,444**	**5,977**	**792,303**

Table 8 - Seminole County NONROAD equipment emissions

Classification	VOC (tons/yr)	NO_x (tons/yr)	CO_2 (tons/yr)
Agricultural Equipment	0.5	4.0	377.4
Airport Equipment	0.8	8.3	921.7
Commercial Equipment	357.5	230.7	35242.2
Construction and Mining Equipment	204.2	1370.3	152412.6
Industrial Equipment	55.5	263.4	27793.3
Lawn and Garden Equipment (Com)	836.3	178.1	44749.0
Lawn and Garden Equipment (Res)	430.4	28.4	10554.3
Logging Equipment	0.4	0.7	104.4
Pleasure Craft	731.7	57.7	11348.3
Railroad Equipment	0.05	0.2	19.6
Recreational Equipment	161.8	6.0	2659.6
TOTAL	**2,779**	**2,148**	**286,182**

Table 9 - Osceola County NONROAD equipment emissions

Classification	VOC (tons/yr)	NO_x (tons/yr)	CO_2 (tons/yr)
Agricultural Equipment	5.3	42.6	4040.7
Airport Equipment	0.0	0.1	7.4
Commercial Equipment	59.1	38.2	5831.4
Construction and Mining Equipment	229.0	1536.8	170924.5
Industrial Equipment	8.8	53.2	5860.2
Lawn and Garden Equipment (Com)	256.9	54.7	13749.2
Lawn and Garden Equipment (Res)	227.7	15.0	5584.9
Logging Equipment	1.2	2.1	296.0
Pleasure Craft	3681.5	290.4	57100.0
Railroad Equipment	0.03	0.1	13.6
Recreational Equipment	497.6	13.3	6264.9
TOTAL	**4,967**	**2,047**	**269,673**

In the years from 2005-2008, prior to the extreme slow-down in economic activity that occurred in the latter half of 2008, there had been enormous land development activity in the OSO area. This equated to a large number of various types of construction equipment being used (graders, pavers, dozers, excavators, off-highway trucks, scrapers, backhoes, etc). This equipment is diesel engine driven (higher NO_x emissions), and typically moves under high load for short distances or sits idling, waiting to be used numerous times throughout the day. The stop-and-go movements are an inefficient use of fuel and according to the modeling results, construction vehicles produce a majority of the non-road NO_x emissions in this region.

Table 10 - 2008 NONROAD Emission totals for OSO

Classification	VOC (tons/yr)	NO_x (tons/yr)	CO_2 (tons/yr)
Agricultural Equipment	9	73	6,907
Airport Equipment	17	183	20,407
Commercial Equipment	1,195	771	117,770
Construction and Mining Equipment	1,013	6,796	755,940
Industrial Equipment	193	934	98,915
Lawn and Garden Equipment (Com)	3,575	762	191,294
Lawn and Garden Equipment (Res)	1,714	113	42,037
Logging Equipment	2	4	526
Pleasure Craft	6,339	500	98,312
Railroad Equipment	0	1	59
Recreational Equipment	1,133	35	15,993
TOTAL	**15,190**	**10,172**	**1,348,158**

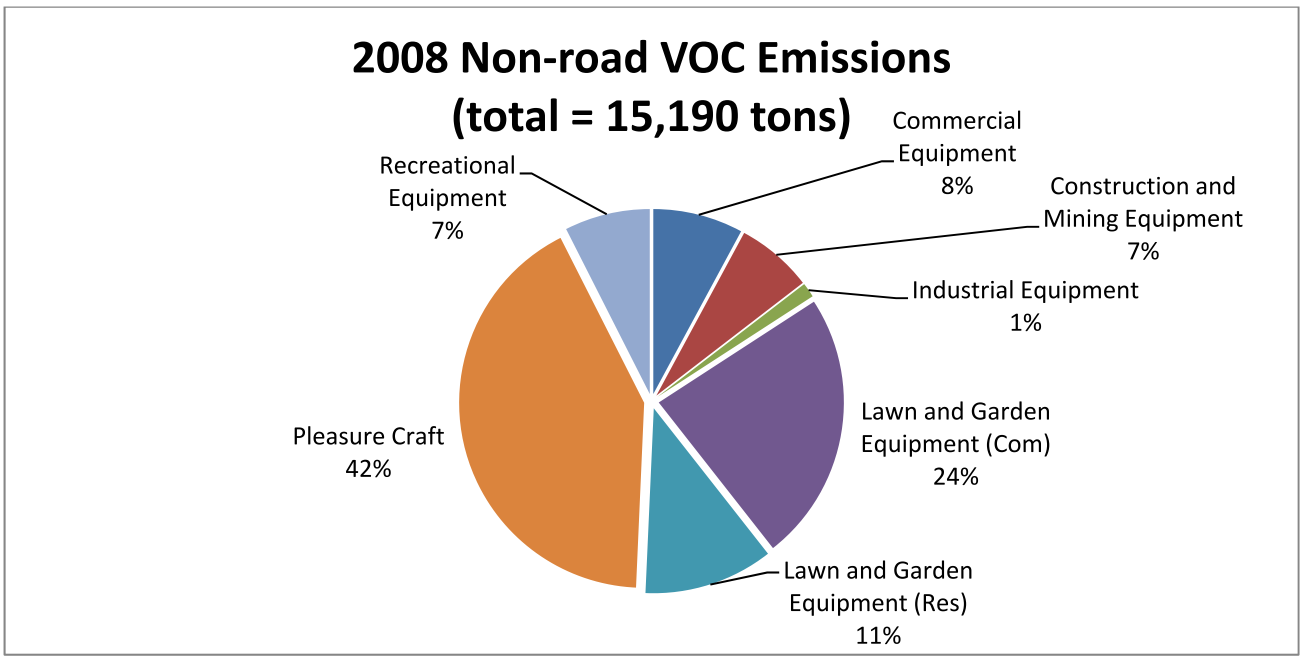

Figure 6 - 2008 Non-road VOC contributions by source for the OSO area*

* Does not include agricultural equipment, airport equipment, logging equipment, and railroad equipment. The total from these sources combined was less than 0.25%.

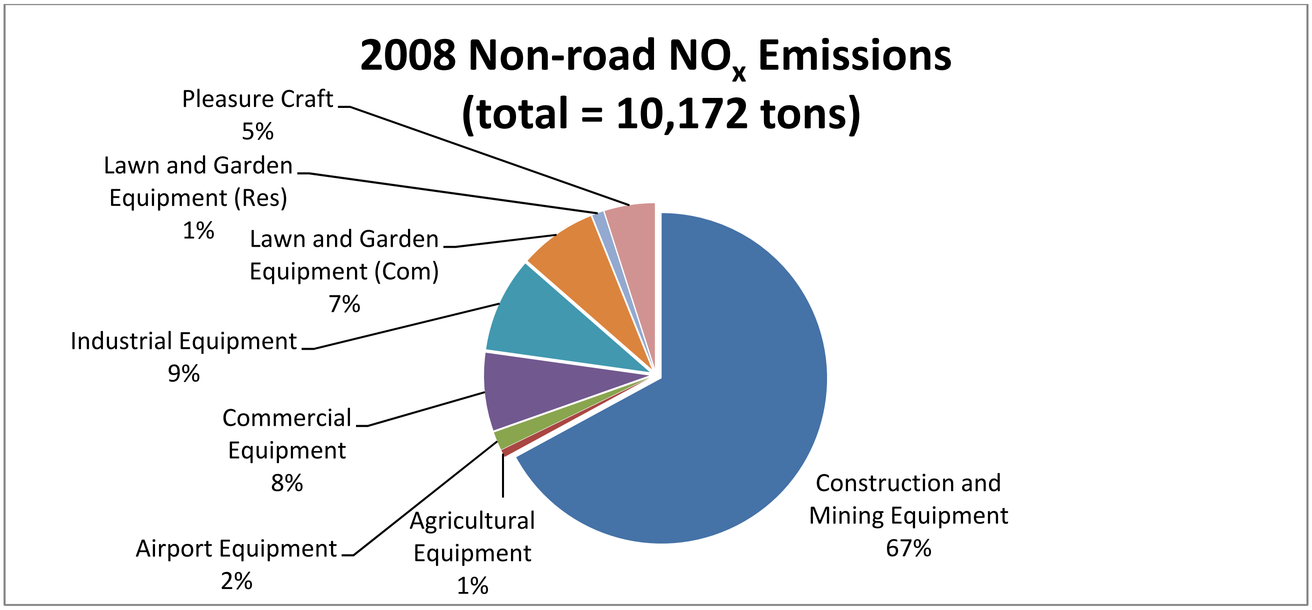

Figure 7 - 2008 Non-road NO_x contributions by source for the OSO area*

* Does not include logging equipment, railroad equipment, and recreational equipment. The total from these sources combined was less than 0.50%.

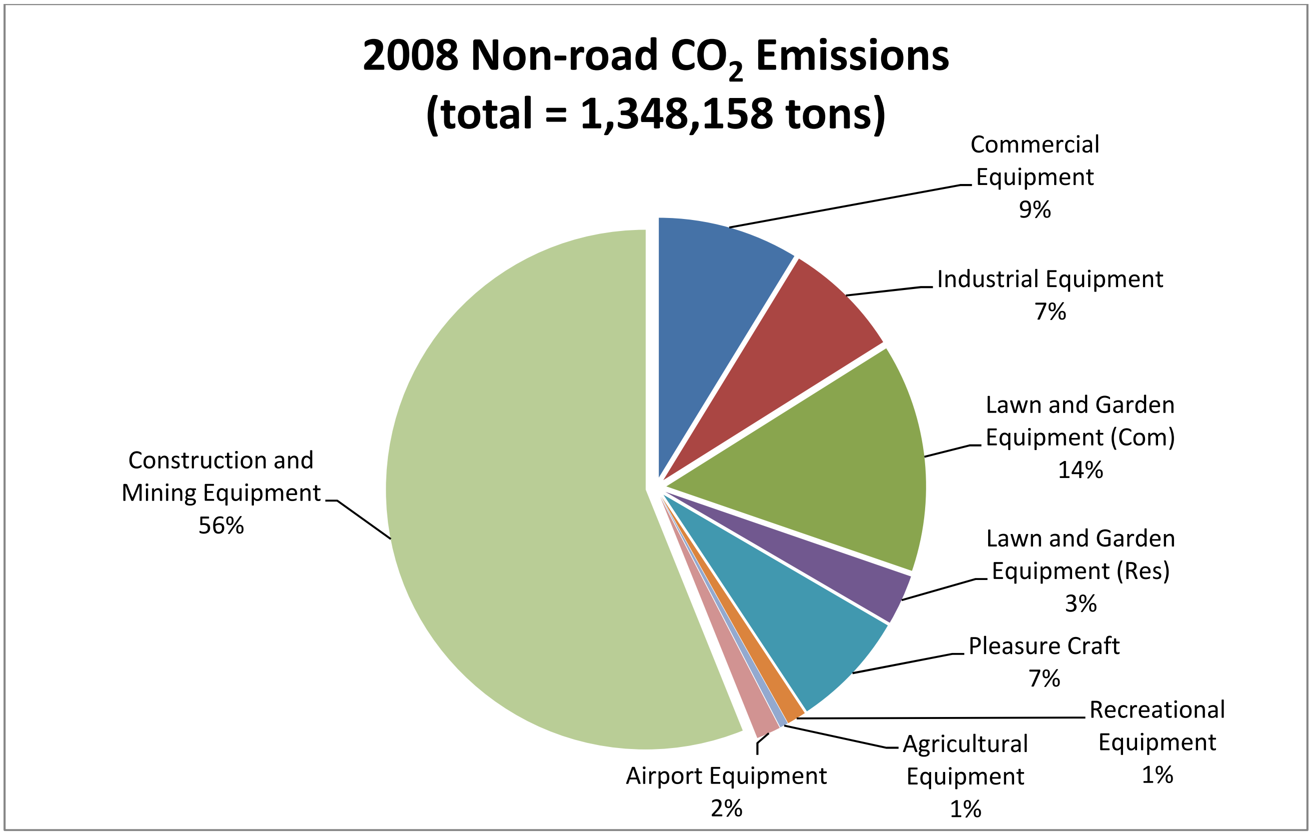

Figure 8 - 2008 Non-road CO_2 contributions by source for the OSO area*

* Does not include logging equipment and railroad equipment. The total from these sources combined was less than 0.05%.

5.2 Point Sources

Point sources were identified from the US EPA Facility Emissions List and the central Florida office of the FDEP (U.S. Environmental Protection Agency, Clean Air Markets Division, 2010 and Michael Young, personal communication, December 4, 2009). Point source facilities included large power plants (such as the OUC Stanton Plant), large facilities (such as Disney World, Lockheed Martin, large graphic arts shops, and large asphalt plants), and major airports (such as Orlando International). Each individual facility must submit annual emission records to the FDEP to show they are operating within their permitted limits.

Table 14 shows the categories in which facilities may be classified. The "Airports" and "Other" categories had the highest level of VOC emissions. The "Airport" category includes aircraft emissions, but does not include ground service equipment (GSE) emissions. GSE was included in the non-road source section. Some of the companies included in the "Other" category were Cellofoam North America Inc., Sonoco Products Company, Walt Disney World Co., and Lockheed Martin Missiles & Fire Control. Emissions by point source by county can be seen in Table 11, Table 12, and Table 13.

Table 11 - Orange County point source emissions by company

AIRS ID	Owner/Company	VOC (tons/yr)	NO_x (tons/yr)
950006	The Coca Cola Company	55.7	0.1
950014	Florida Power Corporation D/B/A Progress	0.0	1.1
950031	Orlando Paving Company	3.3	8.3
950044	Sonoco Products Company	46.8	
950046	Lockheed Martin Missiles & Fire Control	14.7	1.7
950048	Ranger Construction Industries Inc	3.5	6.1
950052	Nina Plastic Bags, Inc.	23.9	
950055	Industrial Container Services - Fl, Llc	39.0	2.7
950063	Florida Hospital	3.1	40.2
950067	Orlando Regional Medical Center	0.8	17.5
950069	Kinder Morgan Energy Partners Lp	80.4	8.7
950078	Frito-Lay	0.8	13.5
950088	Kerry'S Nursery, Inc.	0.1	1.9
950090	Brenntag Mid-South, Inc.	1.5	
950095	John Bean Technologies Corp.	14.6	6.3
950111	Walt Disney World Co.	23.9	186.5
950112	Florida Hospital	0.1	1.2
950113	Orange County Utilities Solid Waste Div	6.8	11.8
950114	Walt Disney World Co.	1.8	
950120	Lockheed Martin Sts	0.2	
950123	Crown Cork And Seal	47.1	0.4
950125	Spiralkote Flexible Packaging, Inc.	85.4	
950136	Trailer Conditioners, Inc.	0.8	
950137	Orlando Utilities Commission	90.4	8104.1

AIRS ID	Owner/Company	VOC (tons/yr)	NO_X (tons/yr)
950145	Central Florida Press, Llc	18.7	0.9
950156	Orlando Paving Company	3.0	8.9
950159	Cubic Simulation Systems, Inc.	1.7	
950169	Stericycle Inc	0.5	31.6
950172	Orlando Sentinel Communications	17.5	
950184	Greater Orlando Aviation Authority	1.0	12.2
950185	Orlando Drum Company	18.9	0.4
950190	Florida Gas Transmission Company	17.6	474.5
950203	Orlando Cogen Limited, L.P.	8.6	131.1
950212	Regal Marine Industries	88.6	
950213	Sea World Of Florida, Inc.	0.5	9.1
950214	Manheim Auctions, Inc.	7.2	0.2
950271	Gale Industries	0.3	
950277	Manheim Auctions, Inc.	4.4	0.1
950278	Fiber Unlimited	4.4	
950279	Modern Welding Company Of Florida	11.2	
950332	Marriott Hotel Properties Limited Partnp	0.9	5.0
950356	Smp Electronics	2.0	
950364	Interstate Brands Corporation	66.8	0.5
950368	Univar Usa, Inc.	8.2	
950369	Marine Muffler Corporation	7.8	
951185	Schuff Steel - Atlantic, Inc.	3.8	
951198	Quality Cabinets - Masco Builder Cabinet	2.0	
951219	Orlando Paving Company	1.6	4.7
951222	Manheim Auctions, Inc.	6.2	0.0

AIRS ID	Owner/Company	VOC (tons/yr)	NO_x (tons/yr)
951223	Manheim Auctions, Inc.	7.9	0.2
951231	Mid Gulf Bakeries Llc	64.0	13.9
951247	Collins Industries, Inc.	44.3	0.2
951249	Cellofoam North America Inc	81.9	
951254	Baker Manufacturing Co	2.7	
951259	Middlesex Asphalt Llc	6.9	12.4
951272	Correct Craft, Inc	89.6	
951273	Universal City Development Partners Ltd	14.2	11.4
951282	Toufayan Bakeries Of Florida, Inc.	58.7	1.6
951284	Cook Composites And Polymers Co.	2.0	
951290	Loews Hotel	0.2	2.6
951296	Gencor Industries Inc	5.0	
951298	Color Wheel Paints & Coatings	10.1	
951300	Custom Fab Inc	12.6	
951311	Lanco & Harris Corp.	6.2	
951315	Florida Hospital	0.5	8.1
	TOTAL	**1,255**	**9,141**

Table 12 - Seminole County point source emissions by company

AIRS ID	Owner/Company	VOC (tons/yr)	NO_X (tons/yr)
1170019	Apac-Southeast Inc Central Fla Division	3.1	7.8
1170027	Florida Extruders International Inc	0.0	0.9
1170030	Orlando Paving Company	4.2	8.8
1170040	Flexstar Packaging, Inc.	6.8	
1170084	Seminole Co Board Of Co Commissioners	9.6	11.6
1170362	Florida Hospital	0.3	4.4
1170379	Transflo Terminal Services, Inc.	0.2	
1170385	Orlando Sanford Int'l Airport	0.3	0.3
1170390	Progressive Communications International	3.8	
1170395	Leisure Bay Manufacturing Inc	7.5	0.1
1170396	Featherlite Coaches, Inc.	11.2	
1170400	Florida Container Services Inc	0.9	
	TOTAL	**48**	**34**

Table 13 - Osceola County point source emissions by company

AIRS ID	Owner/Company	VOC (tons/yr)	NO_x (tons/yr)
970001	Kissimmee Utility Authority	0.1	7.3
970010	Comtech Antenna Systems, Inc.	3.0	
970014	Florida Power Corporation D/B/A Progress	9.5	351.1
970030	Apac-Southeast Inc Central Fla Division	5.0	9.2
970037	East Balt. Bakery Of Florida, Inc.	50.8	1.5
970042	Windsor Metal Specialties, Inc.	30.8	0.8
970043	Kissimmee Utility Authority	2.7	79.9
970054	Phoenix Marble Inc	0.3	
970059	Jeld-Wen, Inc.	2.5	
970068	Florida Hospital	0.3	5.5
970071	Reliant Energy Florida, Llc	0.3	35.6
970077	Florida Gas Transmission Company	0.8	0.6
970079	Omni Waste Of Osceola County, Llc	20.3	0.3
	TOTAL	**126**	**492**

The airports in OSO are Orlando International Airport (OIA), Orlando Sanford International Airport, Orlando Executive Airport, and Kissimmee Gateway. Orlando International (by far the busiest) handled approximately 360,000 flights during the 2008 calendar year. The OIA emissions were estimated based on a detailed model of flight activity (data gathered directly from OIA) and using the EDMS model. The other three airports have significantly less air traffic, so the emissions from those were calculated as a simple factor (percentage) of OIA emissions. Airport emissions can be seen in Table 16.

Power plants emitted significant amounts of NO_x in OSO, accounting for three-fourths of all the point source emissions, and about 14% of the total regional emissions of NO_x from all sources. Most of that came from the two (2) coal fired units at the Orlando Utilities Commission (OUC) Stanton Energy Center. OUC, Kissimmee Utility Authority (KUA), and the Southern Company have ownership in one or more of the power plants in OSO. The NO_x and CO_2 emissions from each power plant can be seen in Table 15. It was assumed that CO_2 emissions from facilities besides airports and power plants would be insignificant in comparison (based on the presence of combustion at the facilities) and were not included in this inventory.

Figure 9 and Figure 10 show the totals for VOC and NO_x emissions, respectively, from point sources in OSO.

Table 14 - 2008 Point source emission totals for OSO

Category	Total		
	VOC (tons/yr)	NO_x (tons/yr)	CO_2 (tons/yr)
Airports*	**473**	**1,469**	**492,645**
Asphalt Plant	**31**	**66**	**-**
Chemical Plant	**2**	**0**	**-**
Electric Production	**0**	**36**	**-**
Fiberglass Products Mfg.	**103**	**0**	**-**
Food Production	**297**	**31**	**-**
Graphic Arts/Printing	**146**	**1**	**-**
Hospitals/Health Care	**5**	**77**	**-**
Misc Wood Products Mfg.	**2**	**0**	**-**
MSW Landfill	**37**	**24**	**-**
Other Incineration	**1**	**32**	**-**
Petroleum Storage/Transfer	**80**	**9**	**-**
Power Plants	**111**	**8,525**	**8,134,554**
Secondary Metal Production	**0**	**1**	**-**
Surface Coating Operations	**249**	**8**	**-**
All Other	**364**	**708**	**-**
TOTAL	**1,901**	**10,987**	**8,627,199**

*Airports in this table represent aircraft emissions (landings and take-offs and taxiing) but do not include ground service equipment (GSE). This is included in the non-road inventory.

Table 15 - 2008 Annual NO_x and CO_2 emissions of OSO power plants

Facility Name	NO_x (tons/yr)	CO_2 (tons/yr)
Curtis H. Stanton Energy Center	8,137	5,953,729
Orlando CoGen	144	328,439
RRI Energy Osceola	35	142,176
Reedy Creek	1	1,910
Stanton A	126	1,099,367
Cane Island	82	608,933
TOTAL	**8,525**	**8,134,554**

Table 16 - 2008 EDMS airport (aircraft) emission results

Airport	VOC (tons/yr)	NO_x (tons/yr)	CO_2 (tons/yr)
Orlando International	322	1,353	453,743
Orlando Executive	40	3	1,006
Orlando-Sanford International	66	110	36,890
Kissimmee Gateway	45	3	1,006
TOTAL	**473**	**1,469**	**492,645**

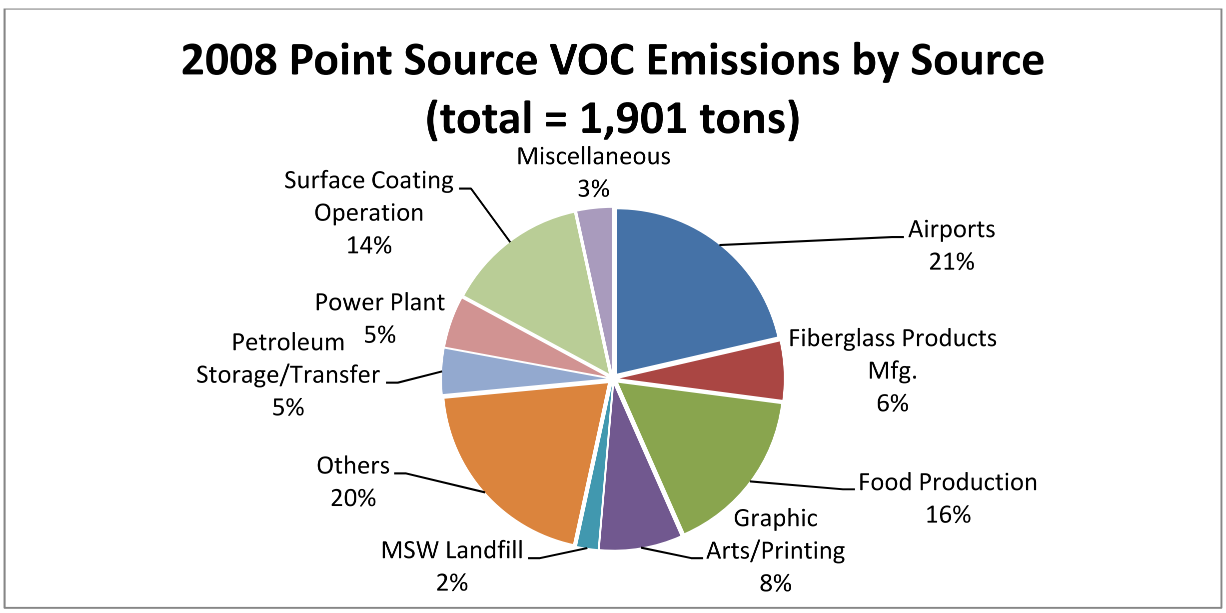

Figure 9 - 2008 Point source VOC contributions by source for the OSO area*

* The "Miscellaneous" source category includes chemical plants, hospitals/healthcare facilities, miscellaneous wood products manufacturing, other incineration, and asphalt plants

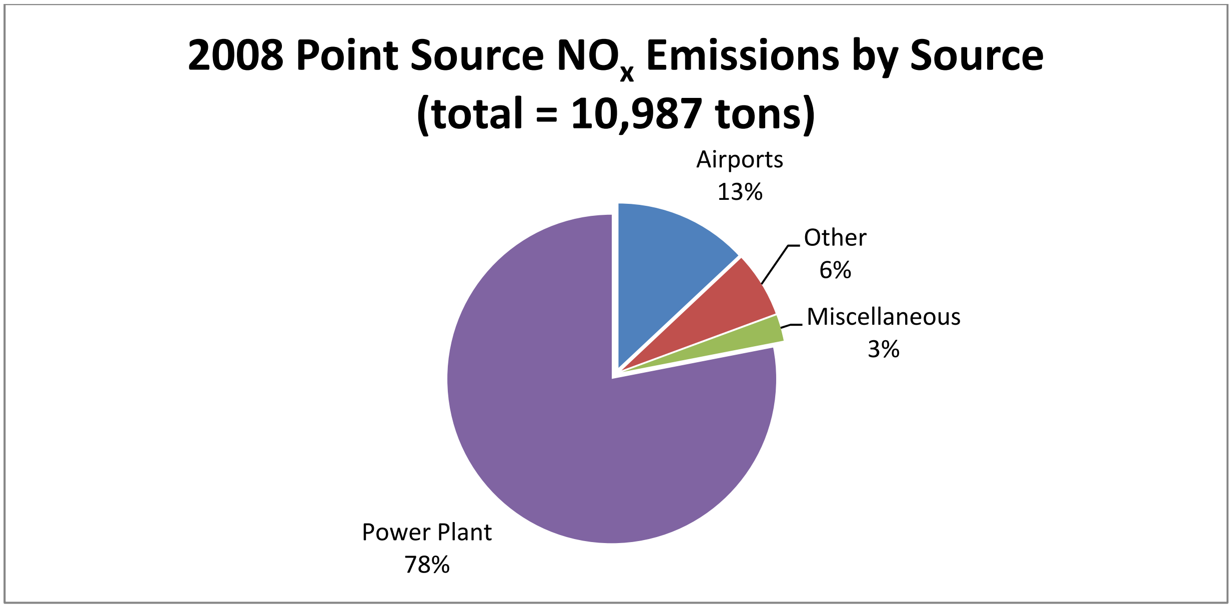

Figure 10 - 2008 Point source NO_x contributions by source for the OSO area*

* The "Miscellaneous" source category includes graphic arts/printing, petroleum storage/transfer, secondary metal production, surface coating operation, MSW landfill, asphalt plant, electric production, food production, hospitals/healthcare facilities, and other incineration

5.3 Area Sources

Area source emissions data came from the US EPA 2008 National Emissions Inventory ("2008 National emissions inventory data & documentation," 2010). The EPA has county-level data for the sub-categories listed in Table 17. The totals for the area source emissions in the OSO region can be seen in Table 18. It was assumed that source categories which did not show measurable NO_x emissions would have negligible contributions to CO_2 emissions. Therefore, burning, land clearing, and residential heating categories were the only ones for which CO_2 emissions were significant, but for two of those sub-categories, the CO_2 emissions are typically assumed to be part of the natural cycle. CO_2 contributions from residential heating can be seen in Table 19. The largest contributor of VOCs amongst the area sources was the chemicals and paint category, which comprised 48% of the area source total. The chemical solvent sub-category accounted for approximately half of that source with VOC emissions of 7,365 tons per year. The majority of NO_x emissions came from residential heating. There are approximately 53,000 homes in central Florida that use coal, natural gas, liquefied petroleum gasoline (LPG), kerosene, or distillate fuel for heating. They account for 79% of NO_x emitted from area sources. Emission totals for area sources (by category) can be seen graphically in Figure 11 and Figure 12.

Table 17 - List of categories included in area sources

Area Source Category	Sub-categories
Coatings	Architectural coatings Industrial maintenance coatings Other special purpose coatings Surface coatings
Chemicals and Paints	Consumer solvents Degreasing Dry cleaning Graphic arts (smaller print shops) Pesticide application Traffic paints
Gasoline and Fuels	Aviation gasoline distribution stages 1 and 2 Gasoline distribution – stage 1 Portable fuel containers Residential heating Stage 2 gasoline refueling
Cooking	Commercial cooking
Asphalt	Cutback asphalt (small operations) Emulsified asphalt (small operations)
Land Clearing	Land clearing
Burning	Household waste burning Open burning – yard waste

Table 18 - 2008 Area Source Emission Totals for OSO

Sub-category	VOC (tons/yr)	NO_x (tons/yr)	CO_2 (tons/yr)
Asphalt	67	0	-
Burning	51	33	**Assumed to be part of the natural carbon cycle*** **
Chemicals and Paints	14,519	0	-
Coatings	5,229	0	-
Cooking	63	0	-
Gasoline and Fuels	10,719	125	147,153*
Land Clearing	<1	<1	**Assumed to be part of the natural carbon cycle*** **
TOTALS	**30,648**	**158**	**147,153**

* The CO_2 data for “Gasoline and Fuels” comes from residential heating and not the entire list of sub-categories

**As per EPA guidelines, CO_2 from fuels other than fossil fuels is not tallied.

Table 19 - CO_2 from residential heating

Fuel Type	Emission Factor (EF)	EF Unit	County	Number of Homes Using Fuel	Fuel Use	Fuel Unit	CO_2 (tons/yr)	CO_2 from Fuel (tons)
Bituminous coal (assumed 70% carbon)	72.6	lb CO_2/ton coal	Orange	10	1.07	tons of coal	0.027	0.052
			Seminole	9	0.96		0.024	
			Osceola	0	0		0.000	
Anthracite coal	5,680	lb CO_2/ton coal	Orange	10	0.24	tons of coal	0.682	1.306
			Seminole	9	0.22		0.625	
			Osceola	0	0		0.000	
Natural gas	120,000	lb $CO_2/10^6$ scf	Orange	21,350	885,064,000	cubic feet	53,104	83,601
			Seminole	9,683	401,409,000		24,085	
			Osceola	2,578	106,871,000		6,412	
LPG	14,300	lb CO_2/1000 gal	Orange	5,557	98,441	barrels	29,327	55,799
			Seminole	2,431	43,064		12,829	
			Osceola	2,585	45,793		13,642	
Kerosene	21,500	lb CO_2/1000 gal	Orange	6,047	4,624	barrels	2,071	2,963
			Seminole	2,233	1,710		766	
			Osceola	365	280		125	
Distillate fuel	22,300	lb CO_2/1000 gal	Orange	6,047	7,211	barrels	3,350	4,789
			Seminole	2,233	2,663		1,237	
			Osceola	365	435		202	
						TOTAL		**147,153**

Source: U.S. Environmental Protection Agency 2008 Emissions Inventory, Non-point residential heating

Sample calculation for residential heating CO_2: $LPG\ (Orange) = \left(\frac{14{,}300\ lb\ CO_2}{1000\ gal\ LPG}\right) \times (98{,}441\ bbl) \times \left(\frac{1\ gal}{0.024\ oil\ bbl}\right) \times \left(\frac{1\ ton}{2000\ lb}\right) = 29{,}237\ tons\ CO_2$

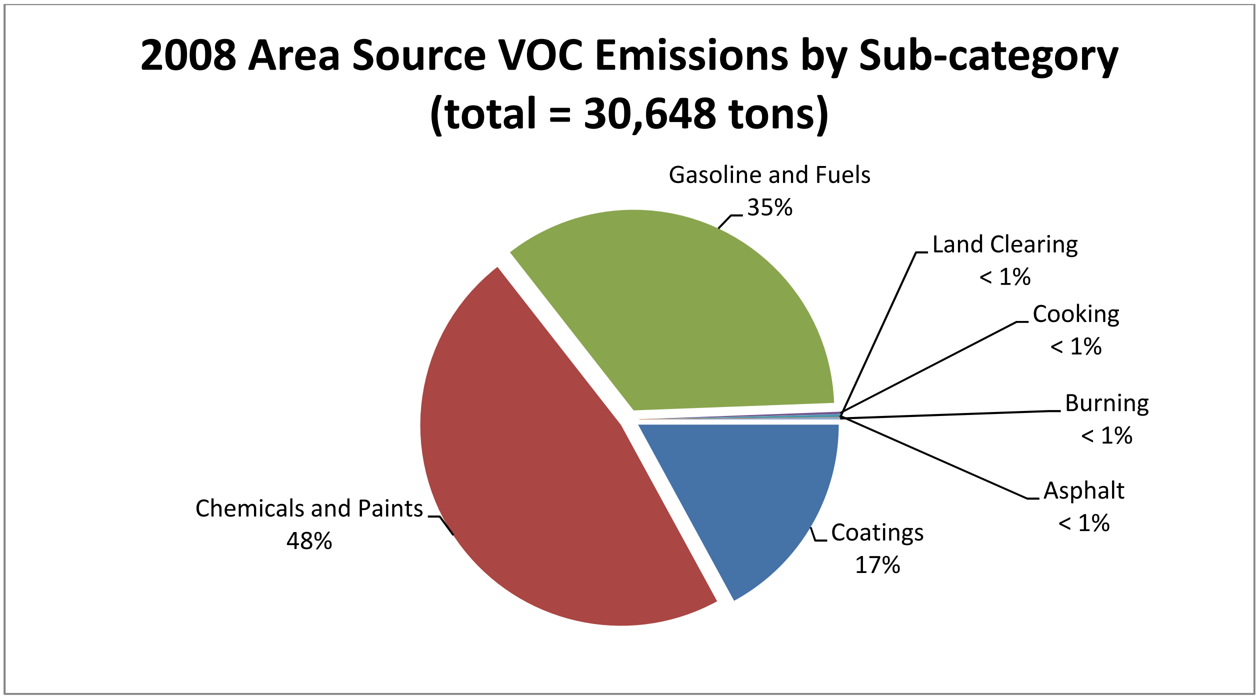

Figure 11 - 2008 Area source VOC contributions by source for the OSO area

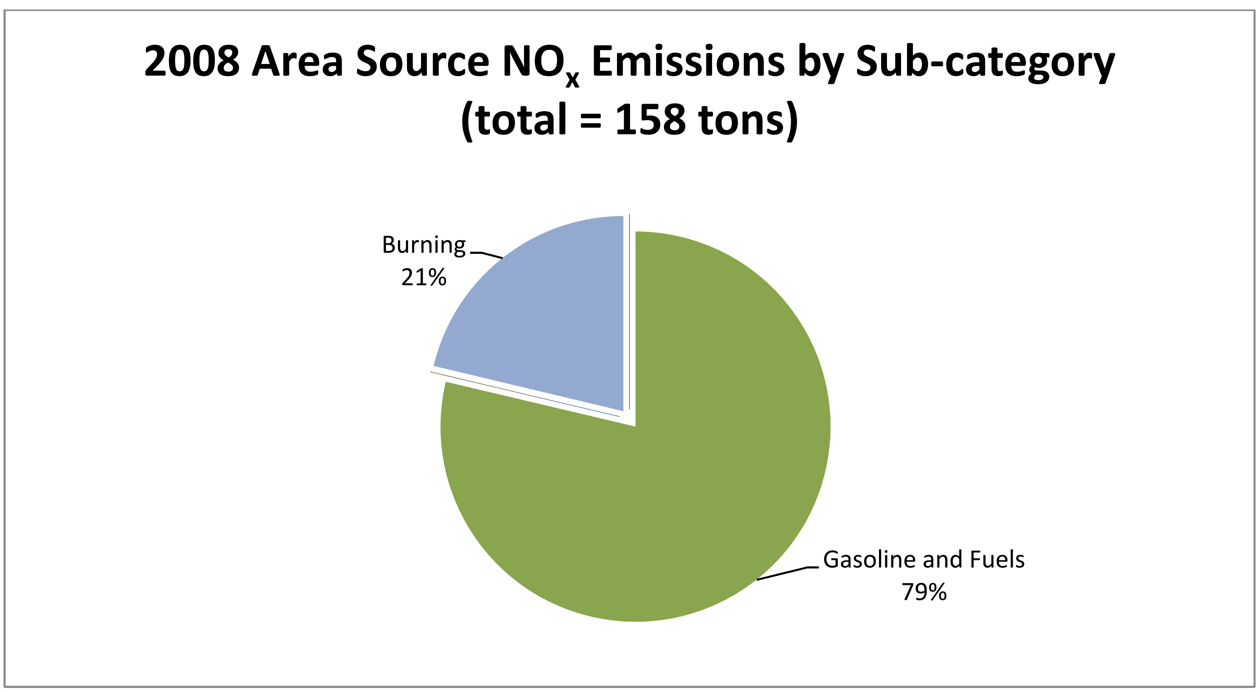

Figure 12 - 2008 Area source NO_x contributions by source for the OSO area

6 2008 RESULTS VERSUS 2002 RESULTS

Table 20 shows a summary of the results from the 2008 inventory compared with the 2002 inventory. The largest decrease in emissions came from on-road mobile sources, despite an increase in the VMT. This decrease can be attributed to the change in the vehicle fleet over six (6) years. Through normal free market trading, older model, higher-emitting vehicles are continually being removed and replaced with newer model, lower-emitting ones. Non-road VOCs stayed about the same while NO_x showed a decrease of 36%. This decrease likely is due to improvements in the non-road vehicles and engines over that period. Point sources remained relatively consistent with a slight drop in NO_x emissions. Area source VOCs increased in keeping with the population increase. NO_x emissions from area sources remained as a small percentage of the total (0.27% in 2008). The sub-categories that were listed in the 2002 inventory differ from those in the 2008 inventory, so the quantities cannot be compared directly. Overall, total emissions in the region decreased – VOCs by 15% and NO_x by 25% - mostly due to decreases in mobile source emissions. These decreases were the result of the natural replacement of older vehicles with newer vehicles (which are cleaner and more efficient).

Table 20 - 2002 and 2008 OSO emission totals for VOC and NO_x

Source	2002		2008	
	VOC (tons/yr)	NO_x (tons/yr)	VOC (tons/yr)	NO_x (tons/yr)
On-road	37,511	49,872	23,582	37,726
Non-road	13,389	15,889	15,190	10,172
Point	1,711	12,596	1,901	10,987
Area	31,198	103	30,648	158
TOTAL	**83,809**	**78,460**	**71,321**	**59,043**

7 POSSIBLE ACTION STEPS

7.1 On-road Action Steps

OSO is in danger of becoming ozone non-attainment. The current EPA ozone standard is 75 ppb and it is expected that it will be announced in July 2011 that the standard will be lowered to 65 ppb. If this happens, OSO will need to create a contingency plan to submit to the EPA explaining how the region will meet the new standard. In the following sections are estimates of VOC and NO_x reductions and their annual and per ton costs.

7.1.1 Decrease School Bus Idling Time

This action step has the potential to reduce VOC emissions by 1.1 tons/year and NO_x emissions by 11 tons/year. Central Florida has a hot, humid climate which tends to make sitting in a vehicle without the air conditioner running uncomfortable. One reason school buses are left running is to keep them cool to maximize passenger (and driver) comfort. There is a policy in place in Orange County that prohibits drivers from idling their buses for the purpose of cooling them down, except in the case of a "medically fragile" student (grade school). A "medically fragile" student is one who is sensitive to high temperatures and may experience adverse effects on a bus that is too hot. If one of those students is going to ride a bus, the driver is permitted to cool the bus down for 5 minutes prior to the student's arrival (Wheeler, 2011). Drivers also leave buses idling before they start their route in the mornings and as they wait in line during after-school pick-ups. This step is difficult to regulate because it relies on the word of the driver that they will turn off the bus while not in use. There is no penalty for not turning it off. Seminole County already has a policy against idling. The savings calculated (based on fuel savings) amounted to $13,700 per ton of VOCs and NO_x reduced and $166,000 annually. These savings are split between the three counties with Orange County seeing the largest return since its fleet is larger than the other two. Calculations for these figures are shown in Equation 2 using the idle emission factors shown in Table 21:

Table 21 - Idling emission factors for various diesel fuels

Fuel Type	Total Hydrocarbons (g/min)	NO_x (g/min)
CD	0.088	0.832
ULSD	0.088	0.832
B20	0.077	0.837

Equation 2

$$\frac{\mathbf{0.088\ g\ HC}}{\mathbf{min}} \times \frac{\mathbf{15\ min}}{\mathbf{day}} \times \frac{\mathbf{200\ school\ days}}{\mathbf{year}} \times \frac{\mathbf{1\ lb}}{\mathbf{454\ g}} \times \frac{\mathbf{1\ ton}}{\mathbf{2000\ lb}}$$

7.1.2 Switch School Bus Fleet from ULSD to B20

The school bus fleet currently uses ultra low sulfur diesel (ULSD) and emits approximately 28 tons/year of VOCs and 380 tons/year of NO_x. These emissions can be cut by 3.4 tons/year of VOCs. B20 – a blend of 80% diesel and 20% biodiesel – may cause an increase in NO_x, but the data are inconclusive ("Transit Bus Life Cycle Cost and Year 2007 Emissions Estimation", 2007 and "Effects of Biodiesel Blends on Vehicle Emissions", 2006). To be conservative, an increase was estimated at approximately 2.3 tons. Biodiesel costs approximately $0.15/gal more than petroleum diesel (U.S. Department of Energy, 2009). The cost of switching to B20 is approximately $2,280,000 per ton of emissions reduced depending on the price of B20 over ULSD. This expense would be distributed among the three counties.

7.1.3 Implement More Aggressive Carpooling Programs

Orlando's major carpooling service is currently provided by LYNX. It is a computer-based voluntary program, and LYNX's involvement is solely to match the participants. They do not keep track of interested parties after they have been put in contact with one another, so the reductions estimated in this report are based on estimated ridership. There were 3,868 participants who contacted LYNX in the 2007/2008 fiscal year (Metroplan, 2009). Estimating that 20% of interested parties actually followed through and began carpooling, 440 automobiles were removed from the roads because of carpooling. This resulted in a reduction of 2.79 tons of VOCs and 1.95 tons of NO_x annually. The cost of the program is attributed to having one full time employee, a website, and web maintenance. This was estimated to be $81,000 annually and equates to $16,800/ton averted. However, from the participants' point of view, they saved on gasoline consumption as well as wear and tear on their vehicles. Thus, it is estimated that this action step saved them about $550,000/year (for a net savings of $470,000/year in OSO). A more aggressive program might well result in a substantial increase in carpoolers.

FDOT began a program to promote ride sharing in central Florida called "ReThink Your Commute." It utilizes Google Maps to verify that the origin and destination are correct, as well as provides the safest biking and walking routes. This program was started on July 12, 2010 and its success has not yet been measured. There are currently over 600 people registered with the program. Registered users were to be contacted in December, 2010, to determine the success of the program. A potential incentive is being considered which would be similar to that offered by the "Clear Air Campaign" in Georgia (currently $3 per day, up to $100 over a 90 day period) (Clear Air Campaign, 2010).

UCF began a "Zimride" carpooling program in summer 2010. Zimride is a national service with universities and businesses as its subscribers (Zimride, 2010). There were 543 active rides posted on December 1, 2010 for the UCF program. There is not a method for ridership participation to allow us to determine Zimride's success, and thus to estimate the emissions reduction achieved. The goal is to connect UCF students, faculty, and staff with rides to and from campus as well as throughout the area.

7.1.4 LYNX VanPlan Program

The LYNX VanPlan program is another service which LYNX provides to aid in the carpooling effort of the region. LYNX provides the commuter group with a van, insurance, and vehicle maintenance. Each van can accommodate between seven and fifteen passengers. The IRS offers up to $230/month in tax-free salary to assist in the cost of the vanpool. In the 2007/2008 fiscal year, the LYNX VanPlan program provided 180,065 rides using 71 vans (Champion, 2010). This effort averted 3.6 tons of VOCs and 2.5 tons of NO_x in 2008. The program costs LYNX an estimated $300,000/year, which equates to $49,100/ton averted (Champion, 2010).

7.1.5 Inspection/Maintenance Programs

Inspection and maintenance (I/M) programs require people to drive their vehicles to an inspection station periodically for evaluation of their emissions control system. The programs range from basic tailpipe emissions tests to a more detailed “Enhanced I/M” program developed by the EPA, which includes visual inspection and evaluation of evaporative emissions. Visual inspection determines if the system has been tampered with. Evaporative emissions can occur even when the vehicle is not in operation.

Vehicles must pass these tests before their registration can be renewed. Costs for these tests are either paid at the time of inspection, or included in vehicle registration fees. The maximum cost for an inspection in the U.S. is $50 in Anchorage, Alaska (St. Denis and Lindner, 2005). The lowest cost (aside from free inspection) was $8 in Memphis, Tennessee. There is also a maximum cost to the owner for the mandatory repairs on the vehicles. This varies by program, but the literature showed that it was generally less than $1000. Assuming an average cost of the programs that test for VOCs and NO_x to be $25, the cost of an I/M program to central Floridians would be approximately $38.7 million per year.

This estimate does not include the cost of lost time. The types and numbers of vehicles registered per county can be seen in Table 22.

Table 22 - Vehicles registered in OSO

	Orange	Osceola	Seminole	Renewal period (years)	Revenue	Annual
Passenger cars (pass cars 0-3500+ lb; not including antique pass cars)	618,389	152,030	269,642	2	$52,003,050	$26,001,525
Antique passenger cars	6,988	1,875	3,955	0		
Lease vehicles (semi-annual and short term lease, pass car for hire)	39,254	4,081	12,904	0.5	$702,988	$1,405,975
Buses, ambulances, hearses	2,061	221	243	1	$63,125	$63,125
Trucks (except tractors; 0-3001+ lb)	88,075	24,130	44,063	2	$7,813,400	$3,906,700
Antique trucks	1,285	401	707	0		
Mobile homes and park trailers (mobile homes (inc. military), park trailers, 5th wheel)	16,650	9,232	5,807	2	$1,584,450	$792,225
Trailers (private, trailer for hire, semi - flat and permanent)						
- Private	51,607	18,647	35,600	2	$5,292,700	$2,646,350
- For hire	167	13	64	1	$6,100	$6,100
- Semis	1,616	284	396	2	$114,800	$57,400
Motorcycles (motorcycle, moped)	30,633	9,091	16,160	2	$2,794,200	$1,397,100
Antique motorcycles	868	249	597	0		
Demonstrators (dealer plates, boat trailer (dealer))	5,625	522	2,344	1	$212,275	$212,275
Truck tractors (truck tractor forestry, GVW truck/tractor, tractor crane)	44,315	10,350	22,325	1	$1,924,750	$1,924,750
Other vehicles (goat, x-series exempt, permanent (all gov't))	1,733	274	519	1	$63,150	$63,150
Miscellaneous (non-resident military, transporter, trucks (agri use), all other tax bases)	960	407	483	2	$92,500	$46,250
Recreational (auto - motorcoach, camp trailer)	3,243	1,217	2,221	2	$334,050	$167,025
TOTAL	**904,328**	**230,499**	**412,771**			**$38,689,950**

I/M programs were effective in the 1980s and 1990s, when there was a substantial fraction of older vehicles in the fleet. EPA models still show a reduction in VOCs and NO_x with a properly operated, high compliance program. However, other studies show that actual reductions are much less than those indicated by the models. This is especially true for a modern fleet, which typically has a very low percentage of vehicles out of compliance.

According to an EPA document ("Clean Cars for Clean Air: Inspection and Maintenance Programs", 1994), I/M programs can reduce VOC and NO_x emissions substantially (5 to 15% for VOCs and 0-10% for NO_x). That EPA study was based on data from the late 1980s and early 1990s – a time when the vehicle fleet had a high percentage of older, higher emitting vehicles than exists today. Using conservative reduction estimates to reflect the 2010 fleet, it was estimated that OSO on-road VOC emissions could be reduced by 708 tons/year and NO_x by 377 tons/year (3% and 1% reductions, respectively). This step would cost $34,839 per ton of VOCs and NO_x averted. The use of such conservative reduction estimates was made due to the older timeframe of the data from the EPA article. The cars that make up the majority of today's fleet are running on engines that are regulated by computers, and have more modern exhaust emissions reduction technology. It is the opinion of the author that I/M programs are not worth the expense.

An article evaluating vehicle I/M programs in Arizona and California found that the EPA overestimated the effectiveness of such programs (Harrington, 2000). The difficulty in regulating I/M programs lies in the large fleet population being managed. It tries to regulate the behavior of millions of small sources rather than one large source. In addition to being less effective than anticipated, the programs also cost more. Harrington also attributes emissions reduction to improved vehicle technology more than to repairs on failed vehicles.

7.1.6 Parking Cash Out in Downtown Orlando

Parking cash out programs offer employees an incentive to carpool by giving a cash subsidy to participants. This subsidy is generally representative of the cost of the parking space that is no longer needed and is paid by the employer. Estimates suggest that single passenger car use can be reduced by approximately 20% for any given company that implements this program (Champion, 2010). If this program were to be implemented in Orlando, emissions could be decreased by 3.7 tons of VOCs and 2.5 tons of NO_x per year. The projected cost of this program is $22,600/year and $3,620/ton averted. The annual cost is the net difference between the cost to the employers of paying for the parking spaces less the cost for them to pay the employees not to use the parking spaces.

7.1.7 Shuttle Service for UCF Students

UCF offers a free shuttle service to students, visitors, faculty, and staff from off-campus student apartments and park-and-ride lots in Research Park. During the 2008-2009 academic year, the shuttle service provided an average of 8,255 one-way rides per day (Champion, 2010). This kept approximately 3,100 vehicles off campus each day. The car traffic (which uses gasoline) was replaced with bus traffic (which uses diesel) causing an increase in NO_x emissions of 3.42 tons per year. VOC emissions decreased by 5.15 tons per year. The shuttle service cost UCF's Student Government Association $4.9 million during the 2009-2010 academic year (Keena, 2010). The cost per ton of pollutant averted is $2.83 million. However, there is also a savings that is distributed among the riders (gasoline costs, vehicle wear and tear, and parking permit savings). This was estimated to be $1,430,000 per year. The net cost is approximately $3.5 million.

7.1.8 "Free" Transit for UCF Students

This action step would allow UCF students to use public transportation (Lynx buses) throughout the metro area along with the UCF shuttles free of charge. This "free" charge is actually only free to the student. The university pays a negotiated annual lump sum to the transit agency based on projected ridership estimates, that money most likely from increased student fees. This program has been successful at many other college and university locations. Once implemented, none of the schools have discontinued the "Unlimited Access" program (Champion, 2010). Students are only required to show a valid student ID to board the bus. According to a survey of 35 universities who offer this type of program, ridership increased between 71 and 200 percent during the first year (Champion, 2010). Because of increased use, the public transit system service also improved. This would then benefit the LYNX service area because there's a guaranteed amount of funding that could potentially expand the service to lesser populated areas making it even more accessible. At an estimated $30 per student per year and approximately 56,000 students at UCF, LYNX could expect about $1,680,000 of additional funding per year. The survey of 35 universities showed that the average number of rides provided by the programs annually to students at universities of comparable size was 2,221,000 (Brown, 2001).

Assuming a round trip distance to UCF of approximately 5 miles, this program could decrease VOC emissions by 18.5 tons and NO_x by 11.7 tons per year. This equates to $55,700 per ton averted. An estimated 4,830 cars would be removed from the road each day (approximately 8.5% student participation) and the savings passed on to the students who utilize this feature is $797,000 annually.

7.1.9 Increase Transit Use (LYNX) in the OUA

Increasing transit use by all persons in the OUA on existing buses will reduce VMT and fuel consumption. This will result in decreases in CO_2, VOCs, and NO_x. Emissions reductions are evaluated for this situation in two ways:

1. Increasing passengers on existing buses
2. Adding new buses

LYNX currently operates 268 buses on 65 fixed routes (LYNX Fast Facts, 2010). Adding an average of three people to each of these buses would decrease OUA emissions of VOCs by 4.4 tons and NO_x by 3.1 tons per year. This would generate additional revenues for LYNX and would also likely save money for the 804 new passengers. This estimate was based on the assumption that the new passengers would replace their car use by the bus for their work commute (but still use their cars for leisure driving).

Based on the MOBILE6 model's emission factors for urban buses and light duty gasoline vehicles, it was determined that the NO_x emissions from one diesel bus are equal to that of 18 cars. Additional buses are recommended if ridership is expected to be 18 or greater to yield both emissions and traffic reduction. Fewer passengers would result in an increase in NO_x emissions, while any number greater than 18 results in emissions reductions. For VOCs, the "breakeven" passenger load is about 3.

Another option is to add smaller buses to the fleet. Smaller buses use less fuel, emit less pollution, and may be more attractive to operate on routes where ridership is light. As ridership increases on the routes using the smaller buses, larger buses may be substituted and the smaller buses can be used to expand LYNX service to other low ridership areas.

7.1.10 Replace Existing Buses with CNG or Diesel/Electric Hybrid Buses

A report from the National Renewable Energy Laboratory (NREL) found that CNG buses can reduce NO_x emissions by as much as 53% ("Evaluating the Emission Reduction Benefits of WMATA Natural Gas Buses", 2003). The diesel emission factor from that study is higher than that of the one used for data calculations in this report, so that percentage reduction would not be realized. However, using the numbers from the MOBILE6 model, NO_x emissions would decrease by 38%. By replacing 20% of the LYNX fleet (approximately 54 buses) with CNG buses, NO_x emissions could be reduced by 30.3 tons per year (or 7.6% of bus NO_x emissions).

Another study of the New York area's buses on emissions from diesel/electric hybrid buses found that NO_x emissions decreased between 36% and 44% (Chandler, Walkowicz, and Eudy, 2002). There was not a clear pattern for VOC emissions as two of the routes saw decreases of 28% and 43%, while the third route saw an increase of 88%. Substituting 20% of the LYNX fleet with diesel/electric hybrid buses could decrease NO_x by 32 tons per year (or 8% of bus NO_x emissions).

CNG and diesel/electric hybrid buses result in approximately the same reduction in NO_x. The advantage of diesel/electric hybrid buses is that they have the potential to reduce VOCs depending on the speed at which they travel.

According to a report by the U.S. Department of Transportation, the capital cost of a CNG bus is $371,000 ("Transit Bus Life Cycle Cost and Year 2007 Emissions Estimation", 2007). The capital cost of a diesel/electric hybrid bus is $533,000[1]. These costs include emissions equipment, depot modification, a refueling station, and the vehicle cost. The annual operating cost (fuel, labor, maintenance) of a CNG bus is $350,200/year and a diesel/electric hybrid it is $375,200/year. Annualizing the capital cost of each bus over 10 years, the total annual operating cost for a CNG bus is $387,300/year, while that of a diesel/electric hybrid bus is $428,500/year. These costs are undoubtedly higher than ultra low sulfur diesel buses (capital cost = $321,000; operating cost = $356,000), but this step is something that should be reviewed in detail if the OUA should go into non-attainment.

7.1.11 Reduce HDDV Speeds on I-4

Heavy duty diesel vehicles (HDDV) are responsible for the majority of NO_x emissions from on-road mobile sources in central Florida. They produce 47% of NO_x from on-road mobile sources and 4% of VOCs. Interstate NO_x emissions amount to 4,630 tons/year of which it was estimated that

[1] The cost of installing a refueling station for the new buses is $2,000 per bus (already included in the capital cost). The cost may change depending on the cost of the station divided by the number of buses ordered.

approximately 80% come from HDDVs (despite the fact that they make up only 8.5% of total VMT). Based on computer modeling runs using MOBILE6, the approximate highway speed at which they produce the least grams per mile of NO_x is 45 miles per hour. At this speed, the emissions factor is 8.966 grams per mile. At an average speed of 65 miles per hour, the emissions factor is 15.165 grams per mile. By lowering this speed to 60 miles per hour, NO_x emissions can be reduced from 1195 tons per year to 993 tons per year – an improvement of 202 tons. Peak hours (morning and evening rush hours) for weekdays were not included in the emissions calculations because at those times traffic on the interstate is already travelling well below 65 miles per hour. This would not have an effect on VOC emissions. Table 23 shows the NO_x emissions factors for speeds between 45 and 65 miles per hour.

Table 23 - NO_x emission factors for HDDV at common highway speeds

Speed (mph)	Emission Factor (g/mi)
45	8.966
50	9.733
55	10.907
60	12.639
65	15.165

Source: MOBILE6

The costs associated with HDDV speed reduction involve additional signage and enforcement. These costs are highly variable depending on the required signage per mile, size of signs, and number and types of patrols. There likely is a cost to the trucking company for “lost time,” but reducing the speed from 65 mph to 60 mph on the portion of I-4 which runs through OSO will only add approximately three (3) minutes. Therefore, the cost for this action step was not quantified.

7.1.12 Restrict HDDVs to the Right Lanes

HDDVs often drive slower than other vehicle types, causing slow downs on the road. This can frustrate drivers which pushes some to exercise less efficient driving practices and increase emissions. By restricting HDDVs from using the left lane or lanes, other cars can move along faster and decrease the occurrence of traffic congestion due to slower moving semi-trucks. This also has the desirable effect of slowing down the HDDVs. Using the VisSim program, this restriction would also lower truck speeds from the current estimate of 69 mph to 65 mph (in the non-rush hour times). It was estimated that 147 tons of NO_x per year could be averted by restricting semi-truck access from only the left-most lane. This step is also one of few that has the potential for reducing large quantities of NO_x. Figure 13 shows how speed affects NO_x emissions from HDDVs in OSO. As with the HDDV speed reduction step on I-4, the costs for this step were not quantified for the same reasons (variability of signage, size of signs, number and type of patrol).

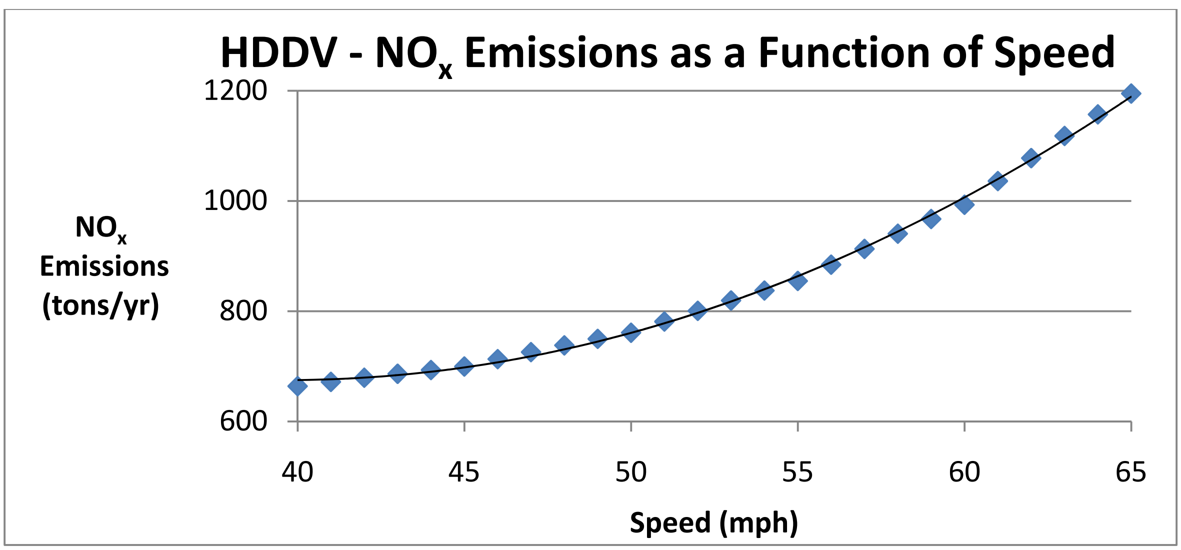

Figure 13 - HDDV NOx emissions in OSO as a function of speed

7.1.13 Change Signal Timing on Major Arterials

Assuming a 10% reduction in idling emissions could be achieved, a methodology was developed to estimate the potential emissions reductions from changing signal timing on major arterial roads in OSO. If the signal timing can be computerized to reduce the delay times for the vehicles on the major arterials, it will result in a reduction of idling time at the signals. Assuming that such a signal optimization program can accomplish a 10% reduction in idling emissions throughout the region, VOCs would decrease by up to 111.6 tons and NO_x by 9.9 tons per year. The estimation method used to produce these values can be found in the Appendix along with tables detailing the routes chosen to calculate them. Calculating the monetary costs of changing the signal timing is outside the scope of this study, as is proving that a 10% idling reduction can be achieved.

7.1.14 Stage II Vapor Recovery

Stage II vapor recovery (S2VR) systems are used at gas stations to recover VOCs that usually escape vehicle gas tanks during refueling. A cup-like device is attached to the nozzle and fits over the tank opening. When gas is pumped into the tank, the vapors are pushed out through a concentric hose, and back into the underground storage tank. These systems are useful at recovering a large portion of the VOCs, but in recent years, this system has become less effective thanks to onboard refueling vapor recovery (ORVR) technology in newer vehicles (see Figure 14). The cars now recover the gasoline vapors themselves and pass the vapors along to an activated carbon packed canister (which adsorbs the vapor). The vapors are used as fuel when they are drawn into the engine intake manifold while the engine is in operation. However, the carbon canisters have a life of approximately 10 years (Koch, 1997). Unless the canister is replaced, after 10 years VOCs will stop being recovered by the car and will be released to the atmosphere.

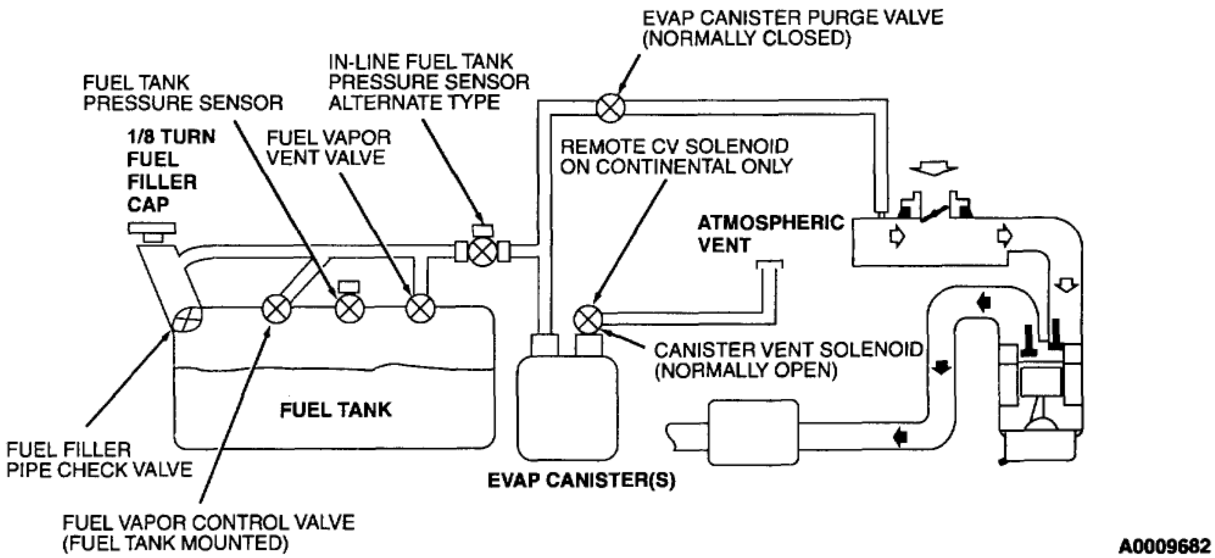

Figure 14 - Diagram of ORVR system ("My beloved Sable--help me save her", 2009)

Because of ORVR, there is a rate of diminishing returns occurring with S2VR. The systems were effective in the 1990s, and may still help today, but lose effectiveness each year as the older vehicles in the fleet continue to be replaced by newer vehicles. As the vehicle fleet is updated, more cars from 2000 and later will be on the road (catching their own vapors), and fewer vapors will be available to recover with S2VR. The equipment still costs the same to install but achieves decreasing emission reduction rates, making the cost per ton averted much higher.

To estimate the cost for upgrading a conventional fueling station to S2VR capabilities, a "model" station was created on which to base the calculations. This station was estimated (based on the average number of pumps per station in Orange, Seminole, and Osceola counties) to have eight pumps. MOBILE6 predicted that with a 3 year phase-in period beginning in 2012, 2,608 tons of VOCs could be averted through 2015. Reductions for the first two years are approximately 260 and 460 tons of VOCs, then when fully implemented, reductions average around 630 tons per year. For equipment alone (no labor or demolition to upgrade a station), the estimated cost is $11,100. Labor and construction costs were estimated at $100,000 per station. For all stations in all three counties, this cost is approximately $73,659,000, or $283,000 per ton of VOC averted in the first year ($54,560[2] per ton of VOC averted after phased in).

7.1.15 Create HOV and HOT Lanes

Central Florida has previously attempted to use HOV lanes (in the 1980s) without much success. The largest hindrance was the lack of planning for these lanes when the roads are upgraded. Enforcing the multi-passenger requirement was problematic for police because it was difficult and dangerous to pull into traffic and pull cars over onto the small shoulder of I-4. The lanes wound up being used as just another lane on the highway. HOV lanes will need to be designed and constructed rather than simply designated on the existing roads. Dallas, Texas, and Los Angeles County, California, have experienced success with HOV lanes. A study in 1999 of the Dallas HOV lanes showed a 79% increase in carpools on eastbound I-635 and a 296% increase on I-35E North (Skowronek, P.E., Ranft, and Slack, 1999). This study also found that the lanes saved motorists an average of at least five minutes over the other non-HOV lanes on incident-free days. A similar study conducted in Los Angeles County, California, found that emissions from carpool lanes (per person per mile) are approximately half of those emitted from other lanes (HOV Performance Program, 2002). A cost estimate for this step was not done because HOV lanes are already in the plan for the I-4 expansion and funds for this have already been budgeted.

[2] $54,560 = total cost divided by the cumulative emissions reduced up to the time of full implementation.

7.2 On-road Mobile Summary

Table 24 shows the on-road mobile emissions reduction steps discussed previously. If all of these proposed steps were to be put into action, OSO could reduce on-road mobile emissions by 785 tons of VOCs and 822 tons of NO_x annually.

The steps which resulted in the biggest reductions for VOCs were changing the signal timing to reduce idling emissions by 10% and offering "free" transit to UCF students. Stage 2 vapor recovery would also decrease emissions by 260 tons in its first year of the phase in period, ultimately saving 630 tons annually when fully phased in. The cost for refiguring the signal timing was not estimated because quantifying the time to change it for the whole city and manpower required was outside the scope of the study. Furthermore, it has not been proven that a full 10% idling reduction can be accomplished. The "free" UCF transit would cost $1,680,000, but would be paid for by UCF and not the counties. Upgrades to stage 2 vapor recovery would cost approximately $73.7 million, but that cost would be spread to gas station owners and could perhaps be offset by an emissions reduction tax credit. Again, the expense for stage 2 vapor recovery systems is for the estimated equipment, labor, and construction costs to update from conventional refueling to vapor recovery. It does not include downstream VOC recovery costs.

The steps which achieved the largest NO_x reductions were reducing HDDV speeds on I-4 and restricting their access from the left lane (allowing them in the middle and right lanes). These two steps accounted for the majority of NO_x reductions in OSO with 754 of the estimated 822 potential tons of NO_x which could be reduced. The costs associated with these steps were unable to be quantified due to the uncertainty of signage required and additional patrol to enforce them. Unlike the VOC reduction steps, these two NO_x reduction steps would be a cost to the counties. However, they are highly recommended due to the relative ease of enacting them and significance to NO_x reduction.

Table 24 - Reduction steps for on-road mobile sources

Reduction Step	Pollutant reductions (tons/yr) VOC	Pollutant reductions (tons/yr) NO_x	Cost ($/yr)	Cost, $/(ton of VOC + NO_x reduced)
Decrease school bus idling time 15 minutes/day	1.1	11	-$166,000	-$13,719
Switch from ULSD to B20 (80% ULSD + 20% biodiesel) school bus fleet	3.4	-2.3	$2,280,000	$2,072,727
Implement carpooling programs	2.8	2	$80,640	$16,800
Lynx VanPlan program	3.6	2.5	$300,000	$49,100
Inspection/Maintenance Program	N/A	N/A	$37,800,000	N/A
Parking cash out in downtown Orlando	3.7	2.5	$22,600	$3,620
Shuttle service for UCF students or at large employment centers	5.2	-3.42	$709,090	$410,000
"Free" transit for UCF students	18.5	11.7	$1,680,000	$55,629
Increase transit use (adding passengers to existing buses)	4.4	3.1	No additional cost	No additional cost
Replace existing buses with CNG or diesel/electric hybrid buses	not quantified	31	No additional cost	No additional cost
Reduce HDDV speeds on I-4 and other limited access highways in OSO	negligible	607	not quantified	not quantified
Restrict HDDVs on I-4 and other limited access highways to the right two lanes only	negligible	147	not quantified	not quantified
Changing the signal timing on major arterials	112	10	not quantified	not quantified
Stage 2 vapor recovery	630	0	$73,659,000[+]	$54,562
Create HOV and HOT lanes	not quantified	not quantified	not quantified	not quantified
TOTAL EMISSION REDUCTION POTENTIAL	**785**	**822**		

[+] Cost to upgrade all stations; these are one-time costs, not annual operating costs

7.3 Non-road Action Steps

7.3.1 Use Biodiesel in Diesel Powered Lawn and Garden Equipment

Results from a survey conducted for determining emissions from lawn and garden equipment showed that over half of commercial lawn care companies use gasoline-powered equipment (for at least 90% of their equipment) (Radford, 2009). Only 20% of those who responded reported using more diesel-fueled equipment than gasoline. Ethanol is a potential replacement for gasoline, but changing to ethanol in gasoline-powered equipment may require changes to their fuel and engine systems. Because VOC emissions are approximately the same from ethanol as they are from gasoline, biodiesel is the only other option suggested for use in lawn and garden equipment.

Switching from diesel to biodiesel in all applicable lawn and garden equipment could save 5 tons of VOC emissions per year. These savings would be realized by consumption of an estimated 2.8 million gallons annually of B20. There is debate over B20 NO_x emissions and whether or not they are greater than petroleum diesel NO_x emissions. Assuming NO_x emissions would increase by 1% after switching to B20, NO_x emissions would increase by less than 0.5 tons per year. The net reduction of VOCs and NO_x would be 4.5 tons per year. The monetary cost for this reduction is $445,000/year and $98,900/ton. Based on the literature, it was assumed that B20 costs approximately $0.15 more per gallon than regular diesel (U.S. Department of Energy, 2009).

7.3.2 Use PuriNOx™ in 20% of Diesel Construction Equipment

PuriNOx™ is a water emulsified fuel (i.e. watered down diesel) that consists of approximately 15% water. The addition of water greatly reduces NO_x emissions but also increases VOC emissions. NO_x emissions can be reduced by about 14.5% while VOC emissions increase by 75%. Nonroad diesel equipment emissions totaled 884 tons of VOCs and 8,439 tons of NO_x in 2008. Converting 20% of the nonroad diesel construction equipment fleet to PuriNOx™ would yield a 245 ton reduction in NO_x, but an increase of 133 tons of VOCs. The cost per gallon of PuriNOx™ is about the same as that of petroleum diesel, however due to the lower energy content, 15-20% more fuel is required. The total estimated cost in OSO for converting to 20% use of PuriNOx™ would be $7.2 million/year and $64,200/ton averted.

7.3.3 Catalytic Converters on all Gasoline Lawn and Garden Engines

Newly manufactured lawn and garden equipment will require catalytic converters by 2012 (EPA in "Lawn and Garden (Small Gasoline) Equipment", 2010). These changes will be phased in between 2010-2012 depending on the equipment type. In 2011, Class II engines (those above 225 cc) will require catalytic converters, and in 2012, Class I engines (those less than 225 cc). For now, they freely pollute (although, improvements in engine design have significantly reduced emissions from previous years). The catalytic converters will reduce VOC and NO_x emissions further by approximately 35%. This is about 1850 tons of VOCs and 306 tons of NO_x per year. A monetary cost for adding retrofit catalytic converters to lawn and garden engines was not calculated. However, since regulations have already been passed, and since the useful life of most lawn and garden equipment is less than five years, it is recommended to wait for the regulations to take effect.

7.3.4 Require Oxygen Catalysts or Diesel Selective Catalytic Reduction Units for Construction Equipment

Oxidation catalytic converters are not required for construction equipment exhaust systems at this time. They have the potential to reduce 70-90% of VOCs, but do not reduce NO_x. The way this technology works is by oxidizing hydrocarbons (which include VOCs) to water and carbon dioxide, and carbon monoxide to carbon dioxide. An estimate for VOC reduction of 50% was used for the emission reduction and cost calculations (Radford, 2009). By installing catalytic converters on 20% of the diesel construction vehicle fleet in OSO, 70 tons of VOCs could be averted. The cost for updating 20% of the fleet is \$5,700,000 capital cost. If the life of the oxygen catalyst is assumed to be 5 years, this is approximately \$1,100,000 per year, or \$16,000 per ton of VOCs averted.

Diesel selective catalytic reducers (SCRs) are highly effective at reducing NO_x emissions. They have the potential to reduce 90% of NO_x in exhaust gases ("The EPA non-road diesel Tier 4 final rule: an overview", 2010). This level of reduction occurs at temperatures between about 400-550°C. If 20% of the fleet were also fitted with SCRs, this would avert approximately 1,223 tons of NO_x per year. Assuming the cost of an SCR to be \$4,000 per unit, applied to 20% of the construction/mining equipment fleet population of 22,733 pieces of diesel equipment, the cost associated with this step is \$242 million. This equates to \$198,000 per ton of NO_x averted. This cost is a lump sum which assumes that the equipment would be installed and emissions savings would begin to occur at once. These costs are borne by equipment owners, but ultimately will be passed on to their clients. Also incorporated into the cost estimate are the prices of diesel fuel and urea (a chemical needed to make the SCR units work).

7.3.5 Reduce Lawn Care Equipment Use by 25%

An easy, inexpensive way to reduce non-road emissions is to cut down on the frequency by which central Floridians manicure their lawns. By stretching the time between mowing, trimming, and edging, a reduction of 1,322 tons of VOCs and 219 tons of NO_x could be realized. This would not really affect lawn care companies as most are paid per month rather than per mow, assuming they would not have to lower their fees. They would actually save money because they would spend less on fuel, as would those citizens who do their own yard work. The savings cannot be quantified because there is no data estimating the amount of fuel used in all commercial and residential lawn care equipment. The only cost would be for a campaign to make the public aware of the effect frequent lawn maintenance has on the environment, particularly on high-level ozone days. This step is very amenable to partial implementation. That is, in those months when ozone formation potential is highest (March – June), reducing the use of lawn care equipment, may have the best "bang for the buck."

7.3.6 Reduce Idling in 20% of Diesel Tractors

There are perhaps several hours of the workday when construction tractors are left idling. This may be due to lunch breaks, waiting for deliveries, or waiting for another piece of machinery to move or clear things away. The NONROAD model estimated 14,339 tractors in OSO in 2008. Emissions reduction calculations were based on the assumption that equipment idling could be reduced by 1 hour per day, 5 days per week, for 49 work weeks during the year. If this idling reduction can be achieved, it would prevent 599 tons of NO_x (a 5.9% reduction in nonroad NO_x emissions) from being released to the atmosphere. It was assumed that the equipment uses about 1 gallon of fuel per hour of idling. This would save construction companies $2,200,000/year, and thus there would be a net savings of $3,700/ton averted.

7.3.7 Scrap Programs

A scrap program would encourage citizens in OSO to get rid of their older, less efficient lawn care equipment. This has the benefit of speeding up the rate for new, cleaner machines to become part of the equipment population. A scrap program in California was used as the basis for our estimates, and their results were adjusted for the size of the OSO area. A similar program in OSO was estimated to produce a 2-4 ton reduction in VOCs and NO_x, at a cost of approximately $18,000 per ton averted. The costs were due to subsidies and advertising to convince people to scrap their older equipment. However, modern equipment engines are at their lowest emission rates ever, and new, even stricter EPA regulations are currently being phased in. The benefits depend on when the scrap program is implemented, and because lawn care equipment typically has a short life, it may be better to simply wait until after the new regulations are in full effect.

7.3.8 Public Education Campaigns

Public education campaigns have large variability in how to get across their messages. These methods can include television commercials, print mailings, radio spots, and encouraging public awareness by holding events/having a booth at an event. The basis for our estimates for public education costs was the "ReThink Your Commute" program set up by FDOT. The original contract is for five years and costs $1.9 million. Included in that cost are website maintenance, marketing, staffing, and rideshare incentives. Annualized, this is $380,000 per year. Since the program began about six months ago and still has much growth potential to be realized, emissions reduction from participants cannot yet be estimated, and the costs/ton averted are not available.

Another campaign by the Bay Area Air Quality Management District (BAAQMD) in California urged residents to abstain from certain activities on high-risk ozone days. A survey showed that about 8% of residents reduced their use of gasoline powered lawn equipment on those days ("Report to the Board on the Potential Electrification Programs for Small Off-Road Engines", 2004). This campaign was estimated to have averted 2 tons of VOCs and NO_x and cost between $20,000 and $36,000 per ton.

7.3.9 Commercial and Residential Ban on Leafblowers/Vacuums

Leafblowers and street vacuums serve the purpose of "clean up." The intention is to blow the grass clippings and leaves back into the lawn so that they can decompose naturally. Often they are used improperly, and they just blow the dirt and grass clippings off the sidewalks and into the street so that they end up in the gutters. The rain washes the dirt and clippings away and they eventually find their way to our lakes and streams. Blowers are also noisy and heavy polluters. Leafblowers and vacuums accounted for 599 tons of VOCs (3.9% of total nonroad VOC emissions) and 59 tons of NO_x (0.6% of total nonroad NO_x emissions) in 2008. A ban would be one method for the counties to reduce emissions. However, businesses would lose money and many citizens likely would oppose a ban. In some communities where bans have been passed, some people are highly in favor and in others they are highly opposed (Crum, 2007). Central Floridians who subscribe to lawn care services expect a pristine yard. To achieve the same effect, lawn care companies would have to hire more employees to sweep the debris or use electric leafblowers. Both of these measures cost the companies more money. It was estimated that such a ban would cost OSO approximately $2,607,000 or $3,960/ton VOC and NO_x averted.

7.3.10 Voluntary Electric-for-Gasoline Mower Exchange

The mower exchange program would be targeted at residential users. It would work by offering the participant a rebate on an electric mower in exchange for turning in their old gasoline one. Adjusting a California program's success to the OSO area's size, it was estimated that 5-10 tons of VOCs and NO_x could be averted. The cost associated with such a program is about $20,300 per ton. The costs include administration of the program, advertising, and rebates.

7.3.11 Voluntary Electric-for-Gasoline Handheld Exchange

This program would also be targeted at residential users. The participant would be offered a rebate to buy hand-held electric equipment (leaf blowers, chain saws, trimmers, etc) in exchange for their old gasoline powered piece. Participation is expected to be higher for a handheld exchange than a mower exchange because electric powered equipment is more amenable to smaller devices. Because of this, a higher savings was estimated – 10-15 tons of VOCs and NO_x per year – at a lower cost – $15,200 per ton of VOCs and NO_x averted.

7.3.12 Reduction of Boating Emissions

The year 2010 was the first model year where boat manufacturers were required to produce engines which will eventually reduce pleasure craft emissions substantially. It is estimated that nationally, boating emissions will be reduced by 70% by 2030, or about 600,000 tons of VOC emissions and 130,000 tons of NO_x emissions nationwide (U.S. Environmental Protection Agency, 2008). Using these EPA estimates, we calculated that this step eventually could reduce OSO's portion of these emissions by 2,516 tons of VOCs and 545 tons of NO_x over the next 20 years. For this estimate, it was assumed that the annual reduction was linear. VOCs would be reduced by 126 tons per year and NO_x by 27 tons. EPA estimates the net cost for this standard is $236 million (for the entire nation). Purchasers of watercraft in OSO can expect to bear $990,000 of this national cost through 2030. That is $49,500 per year or $324 per ton averted.

7.4 Non-road Mobile Summary

Table 25 shows the non-road mobile emissions reduction steps discussed above. If all of these proposed steps were to be put into action, OSO could reduce non-road mobile emissions by 3,737 tons of VOCs and 2,651 tons of NO_x annually. The largest contributors are lawn and garden equipment and construction/mining equipment. Some of the most effective reduction measures involve using these types of equipment less and result in a cost savings.

The largest reduction of VOCs comes from adding catalytic converters to gasoline powered lawn and garden equipment. Since the EPA has already passed legislation which requires the addition of catalytic converters by 2012, OSO should take no action and wait for the regulations to take effect. The second largest VOC reducing step is reducing overall use of lawn and garden equipment by 25%. This is an effective measure, however it would be extremely difficult to accomplish because it would require cooperation of almost all the residents in OSO. Also, the EPA requirement of catalytic converters on new equipment will accomplish significant reductions. The costs for these steps were not quantified because the associated costs for catalytic converters will be applied to new equipment, and older equipment will soon be replaced.

NO_x reduction was best achieved by the addition of diesel selective catalytic reducers to 20% of all diesel construction equipment. However, the cost for this step is prohibitively high. The next largest reduction step is to reduce tractor idling in 20% of all diesel and construction equipment by one hour each day. There is no net cost associated with this – only a savings to the construction companies.

Table 25 - Reduction steps for non-road mobile sources

Reduction Step	Pollutant reductions (tons/yr) VOC	Pollutant reductions (tons/yr) NO_x	Cost ($/yr)	Cost, $/(ton of VOC + NO_x reduced)
Use biodiesel in diesel-powered lawn and garden equipment	5	-0.5	$444,750	$98,833
PuriNOx™ water emulsion fuel for 20% of available diesel construction equipment	-133	245	$9,744,000	$87,000
Catalytic converters on all gasoline lawn & garden engines	1,850	306	Not quantified	Not quantified
"Oxygen catalysts" installed on 20% of all diesel construction equipment	70	negligible	$1,100,000	$15,700
Diesel selective catalytic reducers installed on 20% of all tractors	negligible	1223	$242,120,000+	$197,972
Reduce lawn care equipment use by 25%	1,322	219	Not quantified	Not quantified
Reduce idling by 60 min/day for 20% of construction equipment	negligible	599	-$2,200,000	-$3,673
Scrap programs	3		Not quantified	$18,000
Public education campaigns	2		Not quantified	$25,000
Leafblower/Vacuum ban (com/res)	599	59	$2,607,000	$3,962
Electric-for-gasoline mower exchange (voluntary)	7		Not quantified	$20,300
Electric-for-gasoline handheld exchange (voluntary)	12		Not quantified	$15,200
Boating emissions mandated reductions	126	27	$49,500	$324
TOTAL EMISSION REDUCTION POTENTIAL	**3,737**	**2,651**		

+ Cost to purchase SCRs; these are one-time costs, not annual operating costs.

8 CONCLUSIONS AND RECOMMENDATIONS

Emissions in the OSO area are on the decline. Improvements to emissions control systems in the on-road vehicle fleet and improvements in the design of new non-road engines are the two main reasons for this reduction. The largest contributors to VOCs are area sources, on-road vehicles, and non-road engines (see Figure 15); the largest NO_x emitters are on-road vehicles, construction equipment and point sources (mainly power plants) (see Figure 16). Figure 17 shows that the majority of CO_2 is emitted from on-road sources as well as point sources. Point source CO_2 comes largely from the area's power plants. The totals for each pollutant by source category are shown in Table 26. On-road mobile sources produce the most carbon dioxide emissions, but point sources also make up a large portion of the total.

Despite population growth in the three counties, total emissions of VOCs and NO_x decreased over the six (6) years between inventories. This indicates that policies in place and advances in technology are still achieving lower emissions.

The implementation of EPA's MOVES will result in different on-road mobile emissions. It is recommended to run MOVES for 2008 to compare the VOC, NO_x, and CO_2 emissions to the results produced by MOBILE6. In addition to this, steps for reducing area source emissions should be developed, as they are the largest source of VOCs in OSO. Area sources are the most difficult to regulate, but have shown (in the 2002 and 2008 inventories) to be significant and worth investigation.

Table 26 - 2008 OSO Emission totals

Source	VOC (tons/yr)	NO_x (tons/yr)	CO_2 (tons/yr)
On-road	23,582	37,726	12,608,634
Non-road	15,190	10,172	1,348,158
Point	1,901	10,987	8,627,199
Area	30,648	158	147,158
TOTALS	**71,321**	**59,043**	**22,731,149**

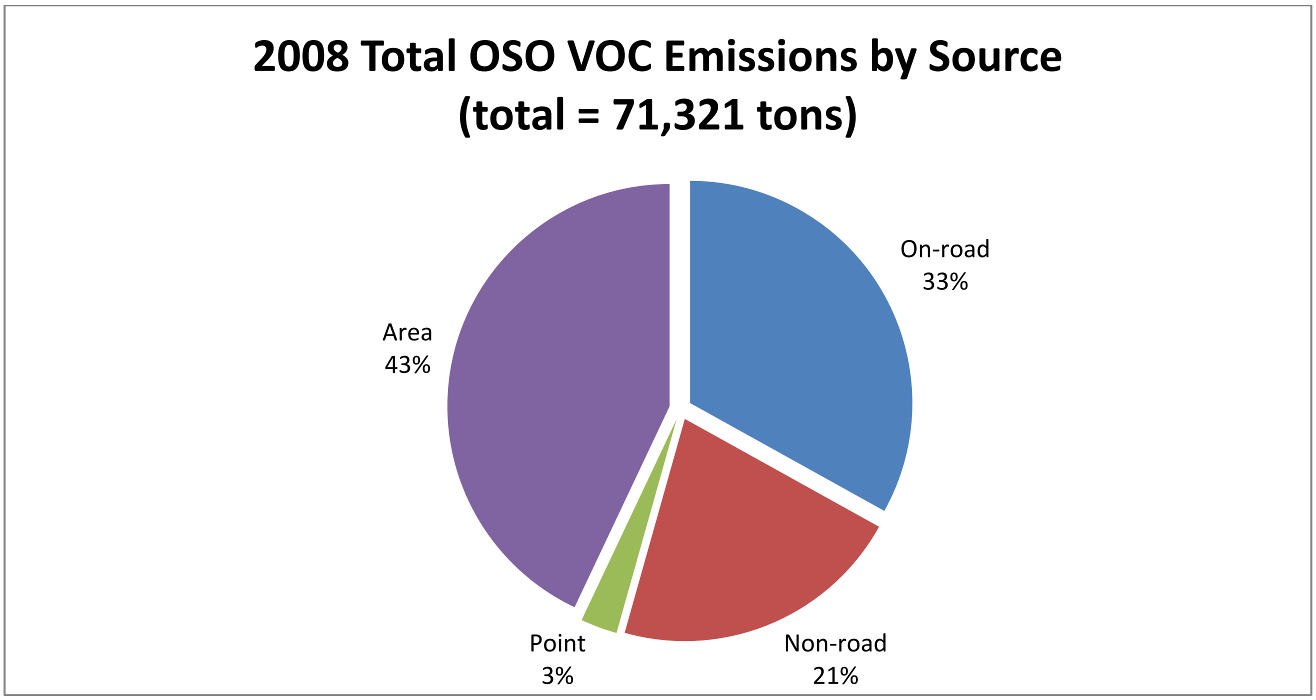

Figure 15 - 2008 Total VOC emissions for the OSO area

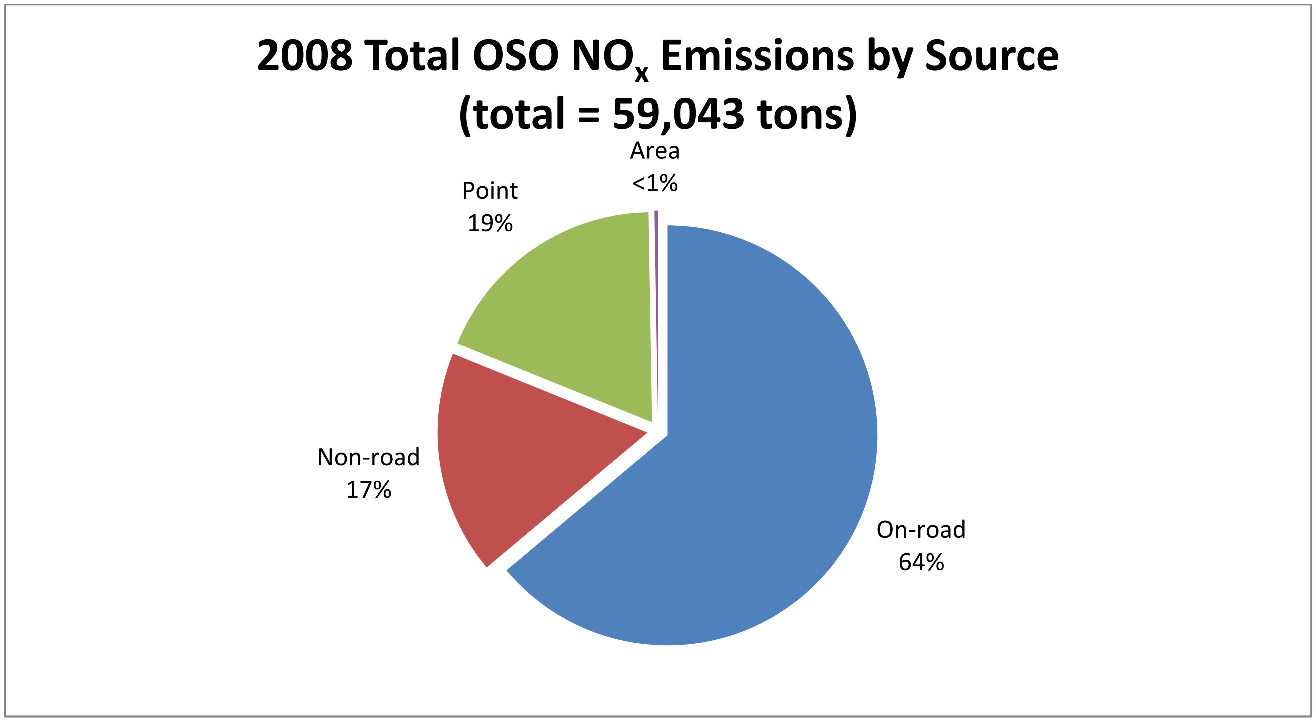

Figure 16 - 2008 Total NO_x emissions for the OSO area

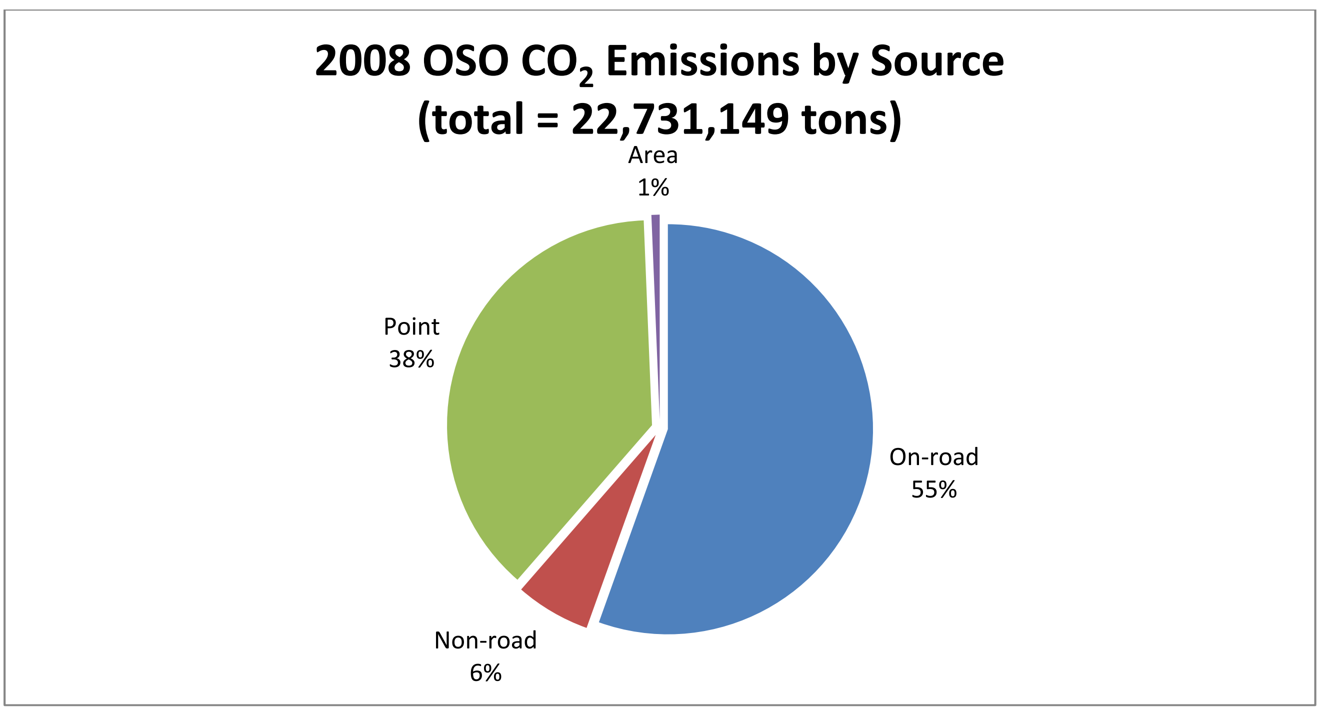

Figure 17 - 2008 Total CO_2 emissions for the OSO area

9 APPENDIX

This section contains information about source category emissions by county. Then, total emissions for each county are broken down by source category. The graphs serve as a visual aid to show the emissions by major sub-categories.

9.1 Mobile Sources

9.1.1 On-road

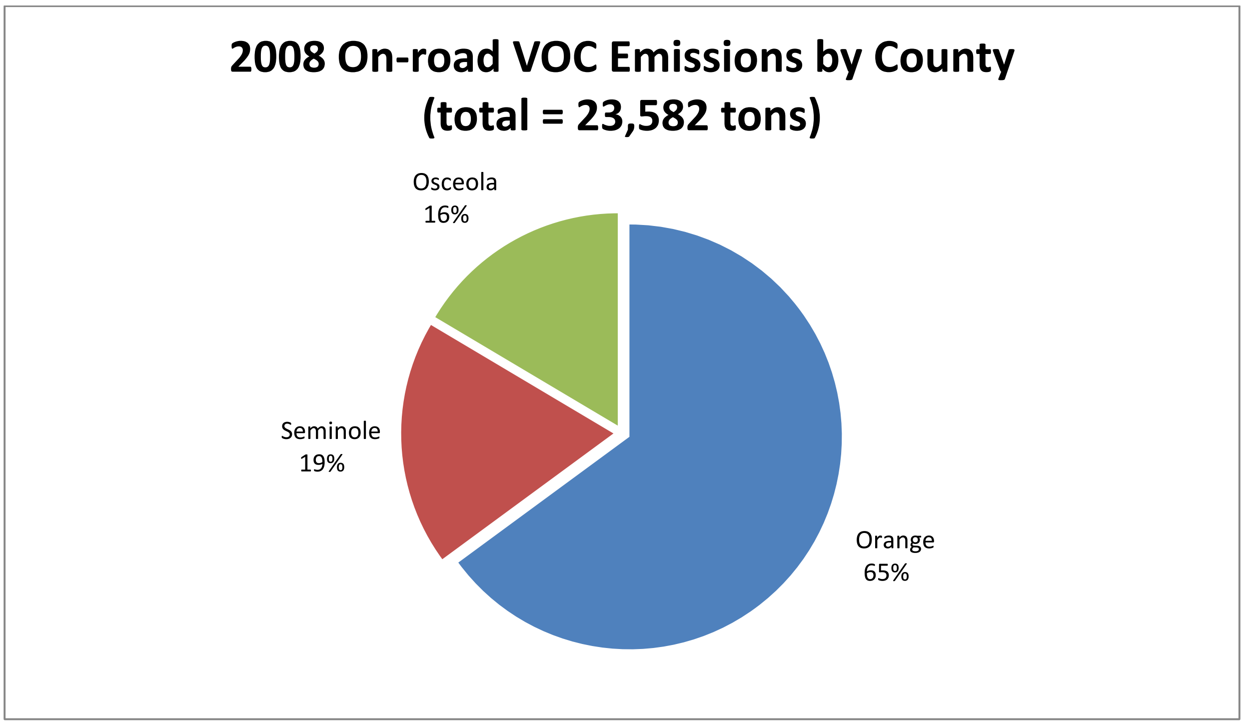

Figure 18 - 2008 On-road VOC Contributions for OSO

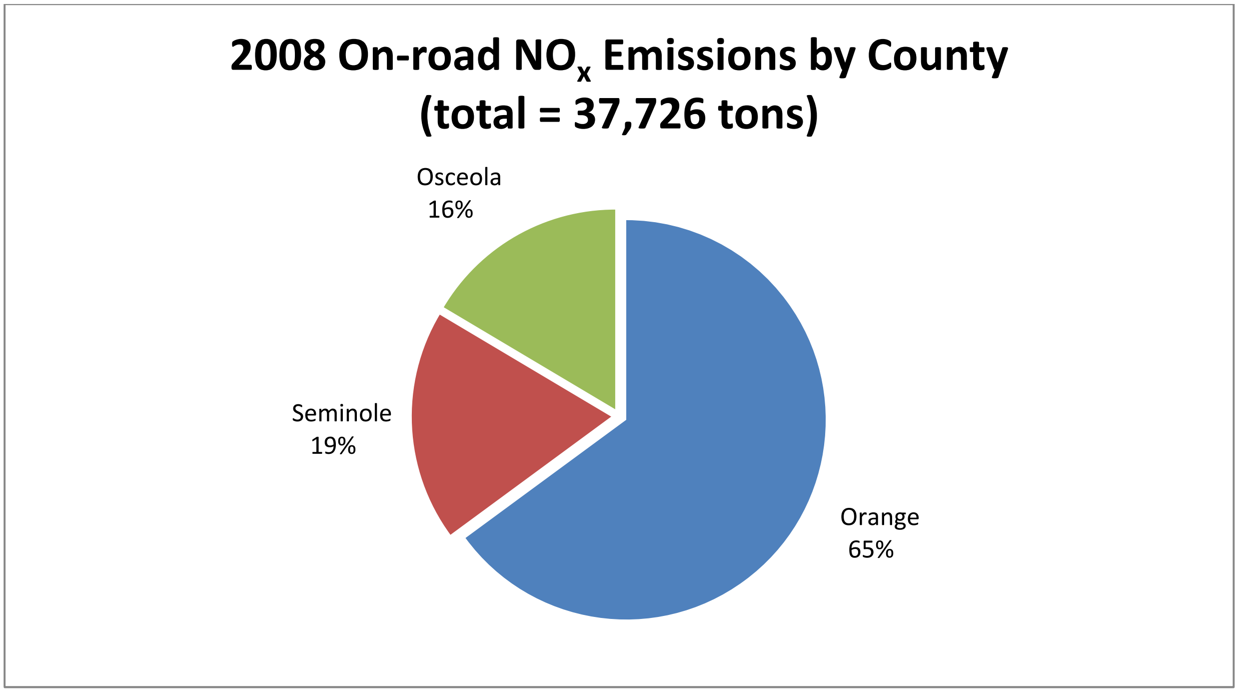

Figure 19 - 2008 On-road NO_x Contributions for OSO

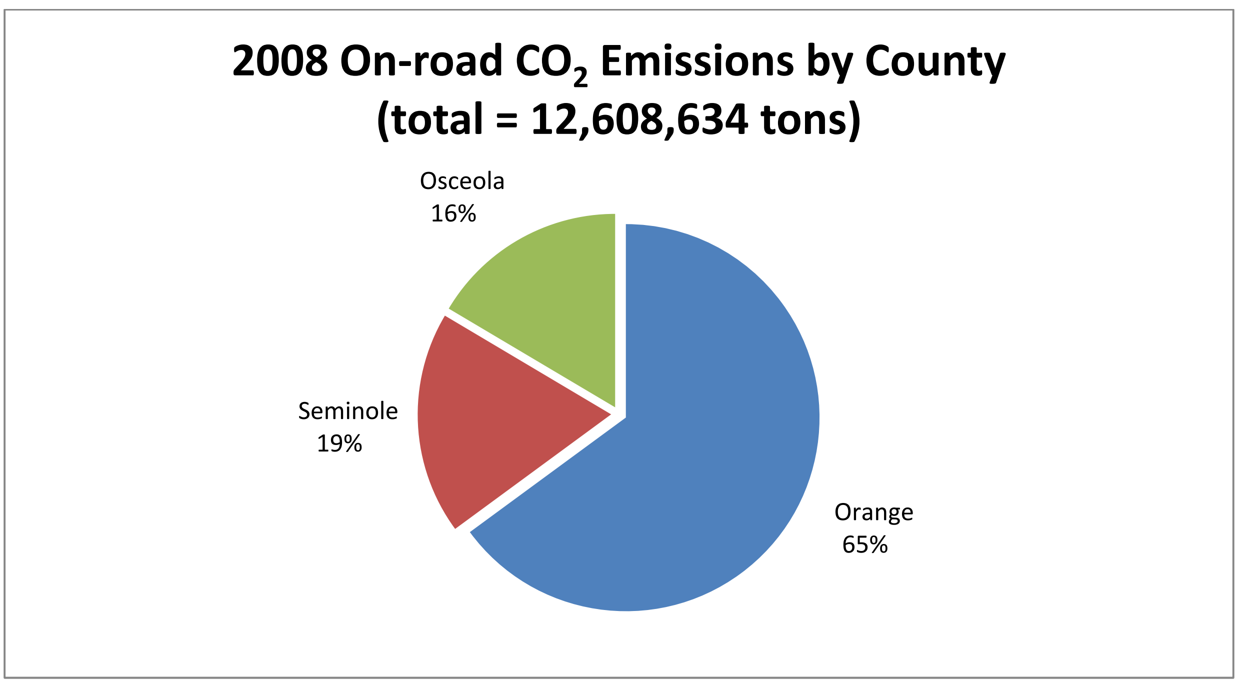

Figure 20 - 2008 On-road CO_2 Contributions for OSO

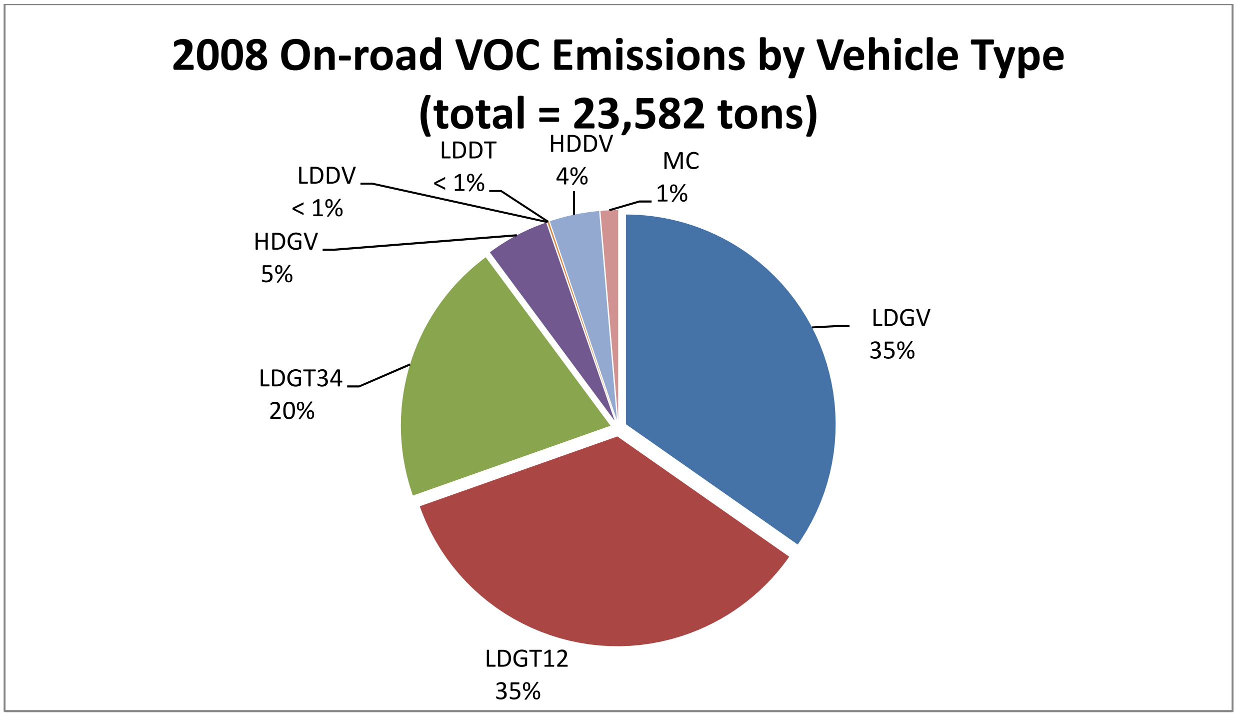

Figure 21 - 2008 On-road VOC contributions by vehicle type for the OSO area

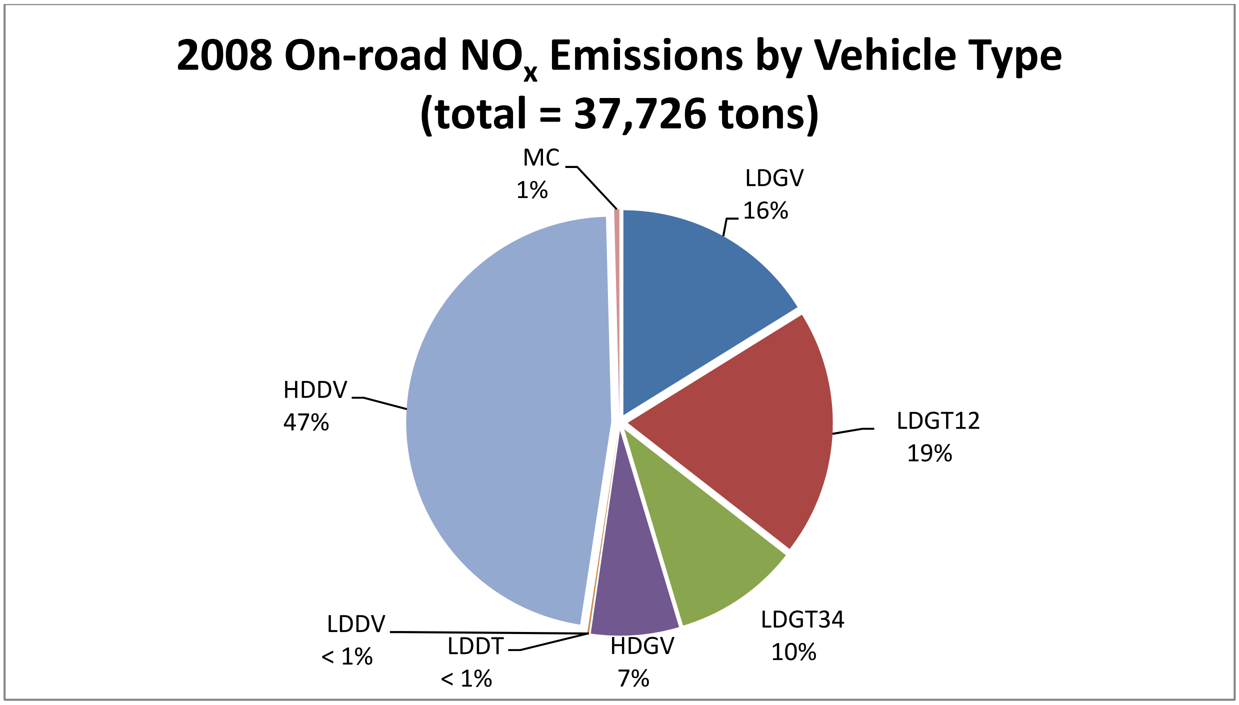

Figure 22 - 2008 On-road NO_x contributions by vehicle type for the OSO area

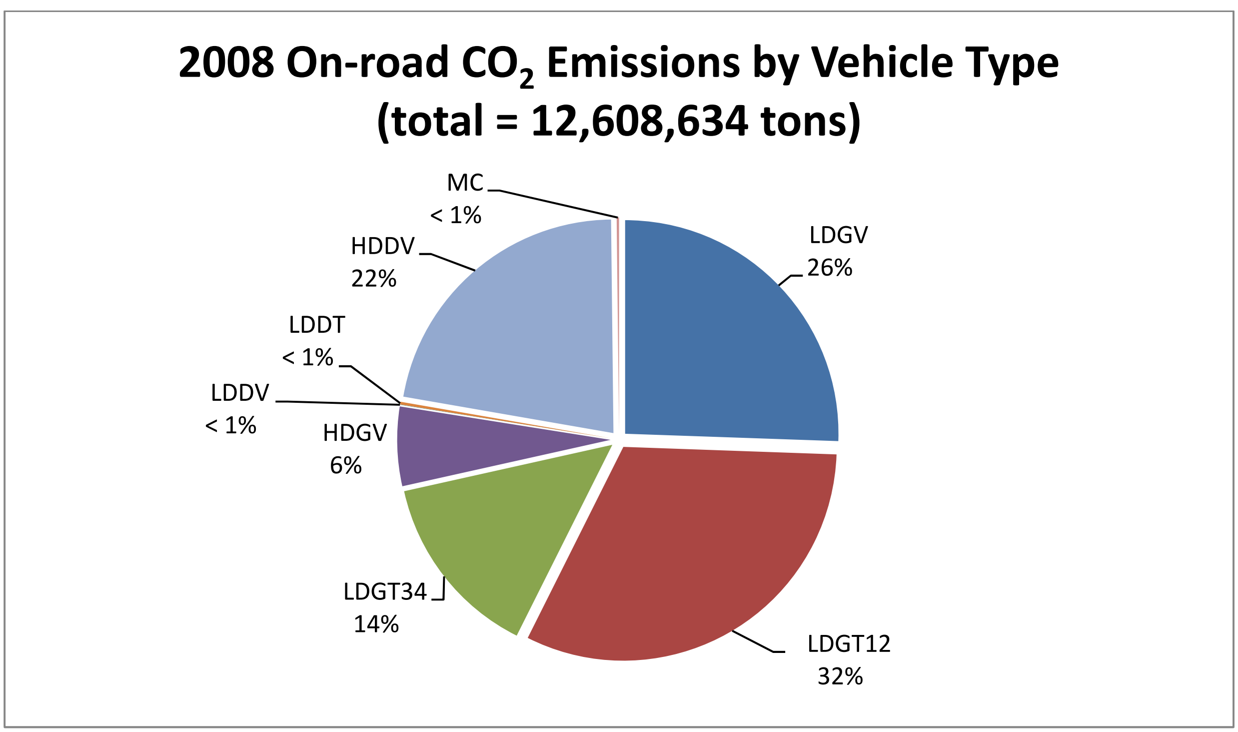

Figure 23 - 2008 On-road CO_2 contributions by vehicle type for the OSO area

9.1.2 Non-road

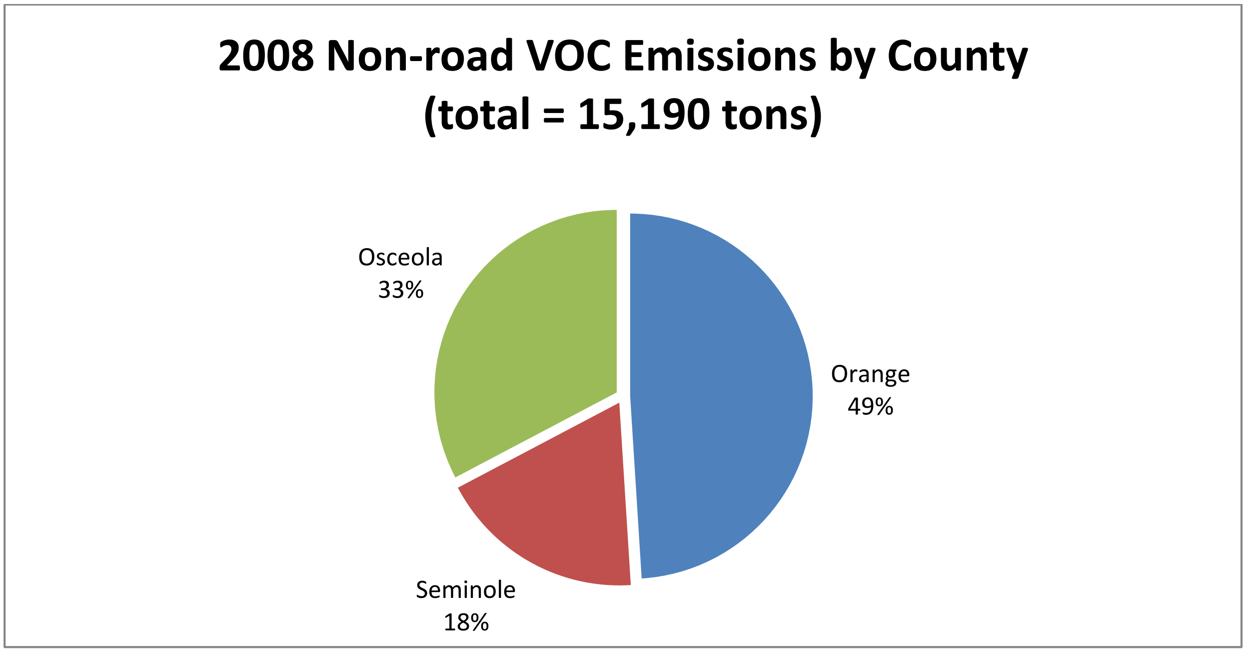

Figure 24 - 2008 Non-road VOC Contributions for OSO

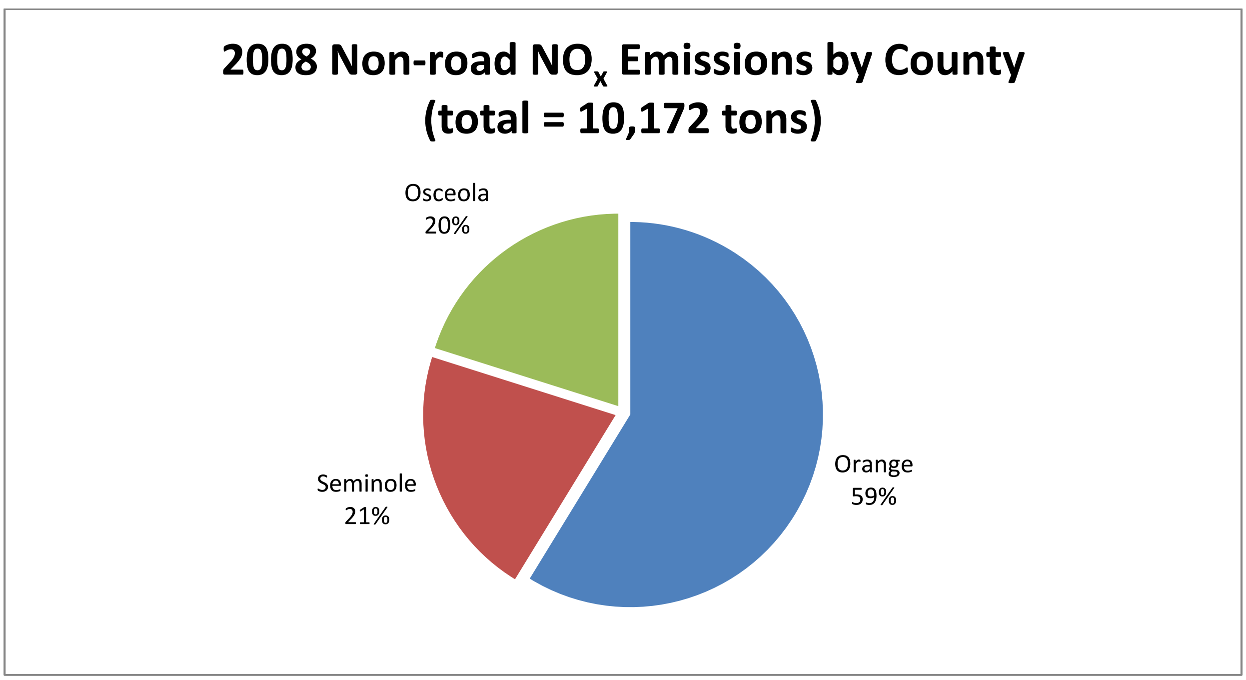

Figure 25 - 2008 Non-road NO_x Contributions for OSO

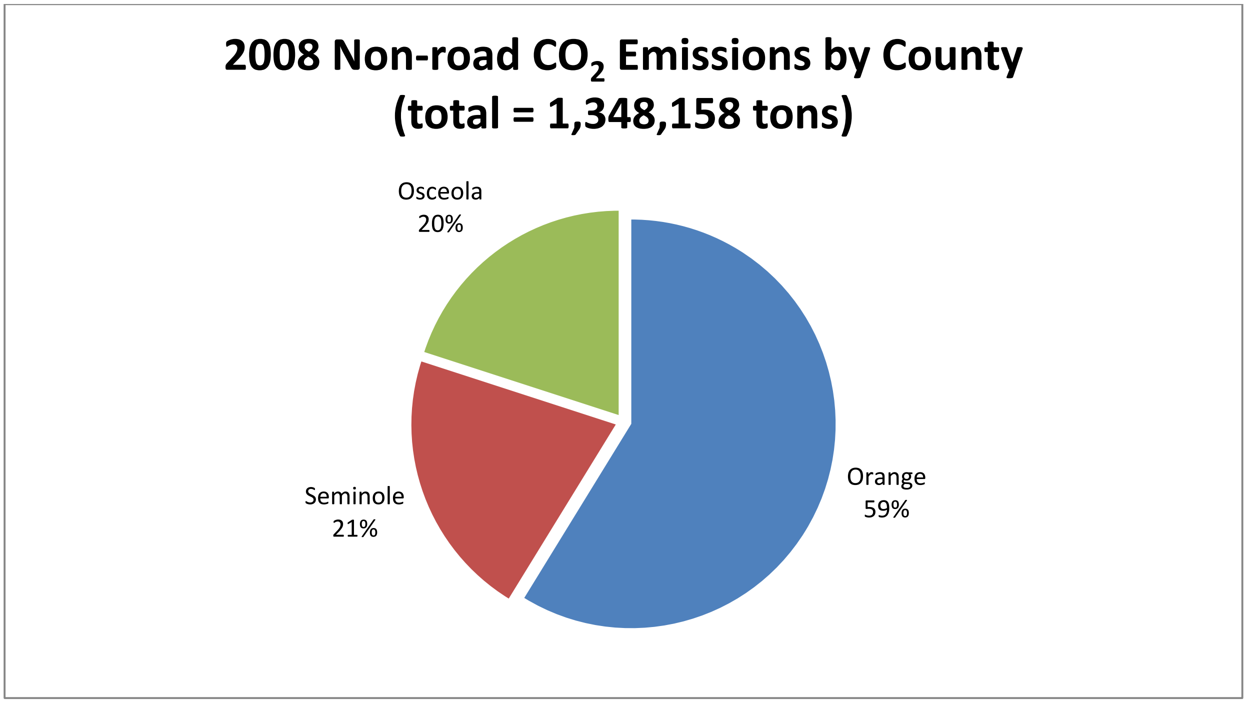

Figure 26 - 2008 Non-road CO_2 Contributions for OSO

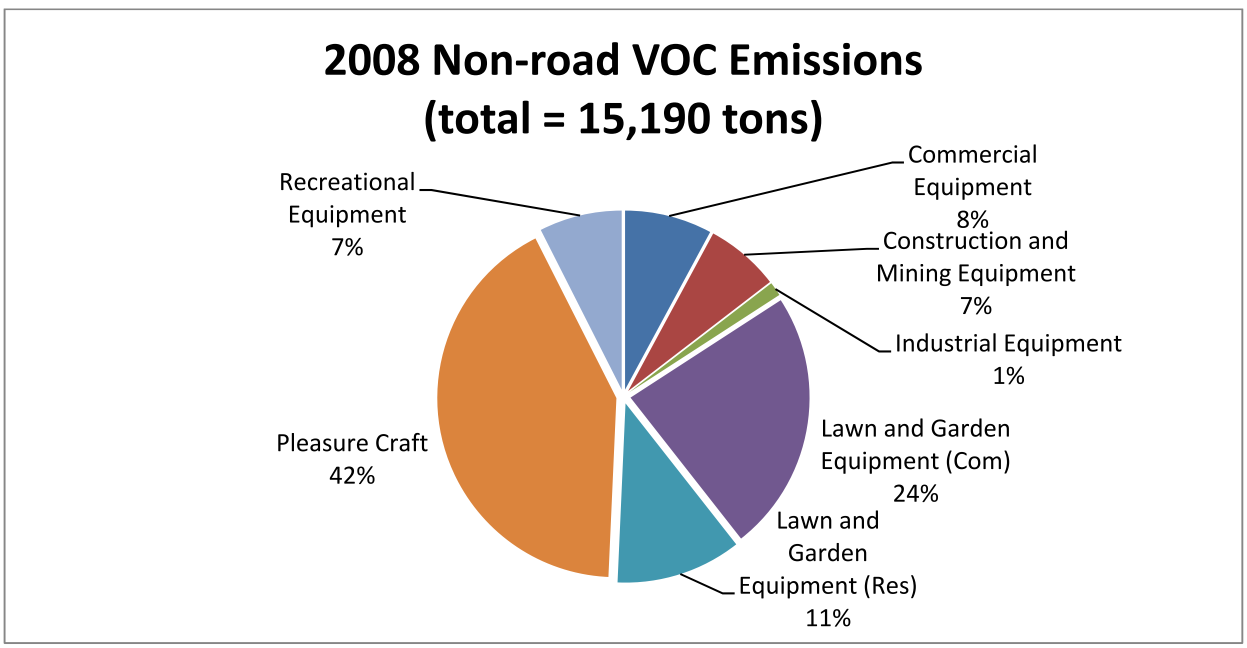

Figure 27 - 2008 Non-road VOC contributions by source for the OSO area*

* Does not include agricultural equipment, airport equipment, logging equipment, and railroad equipment. The total from these sources combined was less than 0.25%.

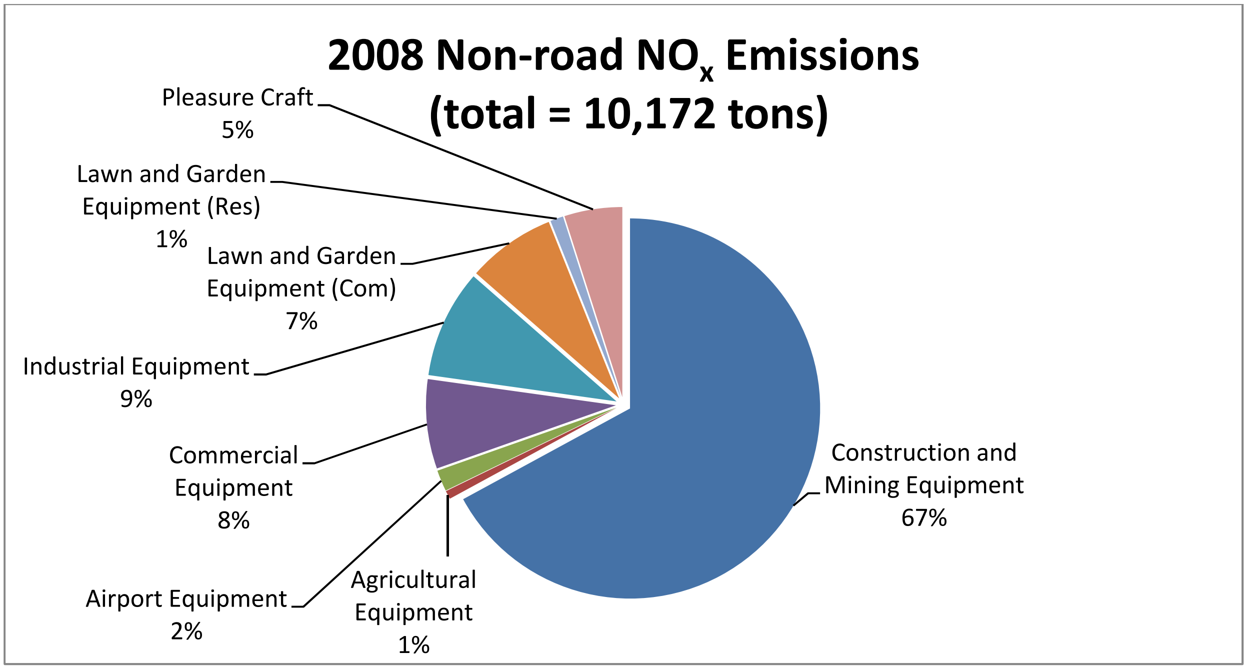

Figure 28 - 2008 Non-road NO_x contributions by source for the OSO area*

* Does not include logging equipment, railroad equipment, and recreational equipment. The total from these sources combined was less than 0.50%.

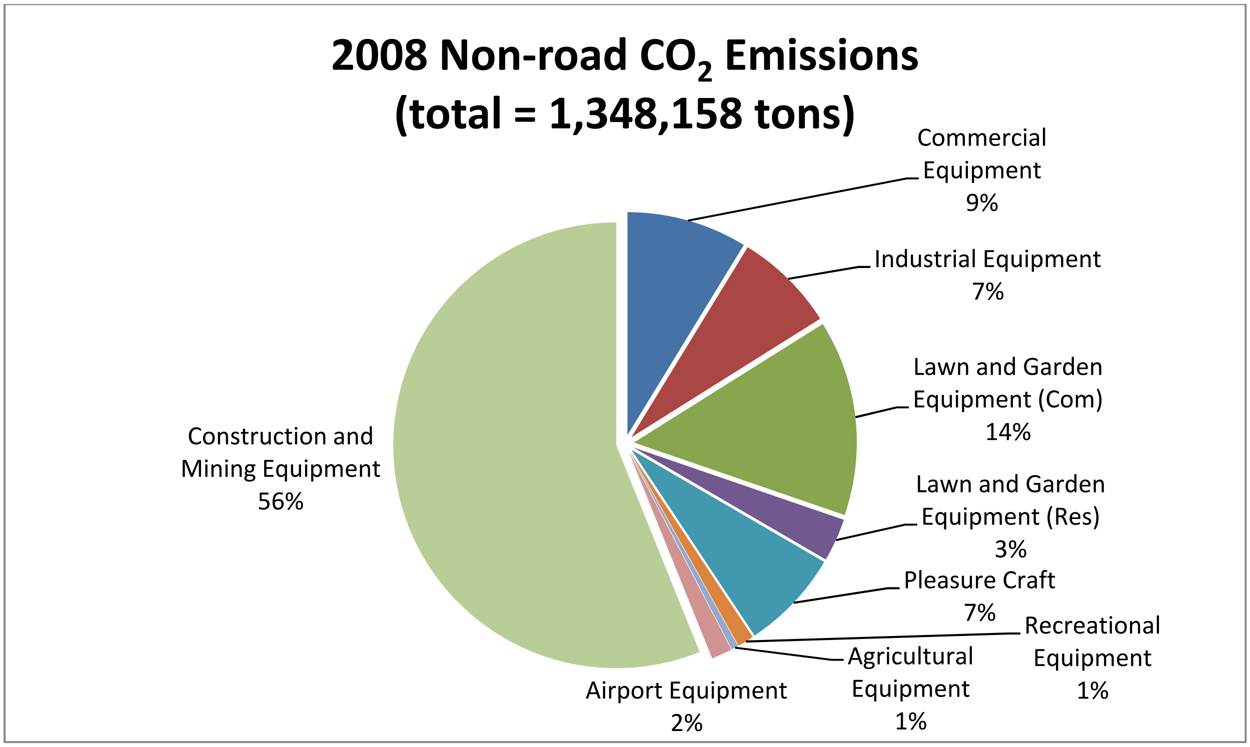

Figure 29 - 2008 Non-road CO_2 contributions by source for the OSO area*

* Does not include logging equipment and railroad equipment. The total from these sources combined was less than 0.05%.

Table 27 - OSO total NONROAD outputs by equipment type

Classification	Equipment	VOC Total	NO_x exhaust	CO_2 exhaust
Agricultural Equipment	2-Wheel Tractors	0.0224	0.0065	2.1128
Agricultural Equipment	Agricultural Mowers	0.0248	0.0109	2.2774
Agricultural Equipment	Agricultural Tractors	6.3794	62.6301	5972.9667
Agricultural Equipment	Balers	0.0789	0.0776	8.493
Agricultural Equipment	Combines	0.5709	6.5202	535.5284
Agricultural Equipment	Irrigation Sets	0.1671	0.9411	100.6039
Agricultural Equipment	Other Agricultural Equipment	0.2867	1.4089	129.2389
Agricultural Equipment	Sprayers	0.518	0.5744	64.4338
Agricultural Equipment	Swathers	0.154	0.5464	50.7338
Agricultural Equipment	Tillers > 6 HP	0.8577	0.0947	40.1784
Agricultural Equipment Totals		**9.1**	**72.8**	**6906.6**
Airport Equipment	Airport Ground Support Equipment	17.183	182.9794	20406.8763
Airport Equipment Totals		**17.2**	**183**	**20406.9**
Commercial Equipment	Air Compressors	59.5255	154.9413	18471.0809
Commercial Equipment	Gas Compressors	0.0438	4.3506	2029.2449
Commercial Equipment	Generator Sets	580.8446	371.126	53720.4592
Commercial Equipment	Hydro Power Units	8.4198	7.2811	1194.0376
Commercial Equipment	Pressure Washers	251.176	39.1048	12752.2309
Commercial Equipment	Pumps	177.861	86.324	13444.4832
Commercial Equipment	Welders	116.6337	107.9103	16158.1281
Commercial Equipment Totals		**1194.5**	**771**	**117769.7**

Classification	Equipment	VOC Total	NO_x exhaust	CO_2 exhaust
Construction and Mining Equipment	Bore/Drill Rigs	22.0815	134.7344	11128.7482
Construction and Mining Equipment	Cement & Mortar Mixers	29.2297	8.4541	1599.5252
Construction and Mining Equipment	Concrete/Industrial Saws	122.8605	17.1343	4607.4547
Construction and Mining Equipment	Cranes	17.2053	235.4331	24370.83
Construction and Mining Equipment	Crawler Tractor/Dozers	63.8159	923.8744	105539.1843
Construction and Mining Equipment	Crushing/Proc. Equipment	5.5393	43.2599	4449.4046
Construction and Mining Equipment	Dumpers/Tenders	4.6627	2.1176	333.9949
Construction and Mining Equipment	Excavators	62.5924	831.5958	105961.1572
Construction and Mining Equipment	Graders	15.6643	209.0425	26369.9302
Construction and Mining Equipment	Off-Highway Tractors	8.098	117.9775	11348.4627
Construction and Mining Equipment	Off-highway Trucks	45.638	812.2706	90617.5881
Construction and Mining Equipment	Other Construction Equipment	10.0587	116.2719	11136.9683
Construction and Mining Equipment	Other Underground Mining Equipment	0	0	0
Construction and Mining Equipment	Pavers	11.3431	89.273	10895.1421
Construction and Mining Equipment	Paving Equipment	26.3298	18.0098	2930.2671
Construction and Mining Equipment	Plate Compactors	17.9381	4.8057	976.7748
Construction and Mining Equipment	Rollers	26.4733	226.2931	26929.1633
Construction and Mining Equipment	Rough Terrain Forklifts	31.7704	302.8663	34201.1858
Construction and Mining Equipment	Rubber Tire Loaders	81.5247	1084.8701	116043.3645
Construction and Mining Equipment	Scrapers	14.3084	246.477	28437.9297
Construction and Mining Equipment	Signal Boards/Light Plants	4.5168	28.0453	2913.345
Construction and Mining Equipment	Skid Steer Loaders	149.2982	493.7487	48704.1779
Construction and Mining Equipment	Surfacing Equipment	8.0202	11.6201	1527.0891
Construction and Mining Equipment	Tampers/Rammers	45.205	0.8157	473.4523

Classification	Equipment	VOC Total	NO_x exhaust	CO_2 exhaust
Construction and Mining Equipment	Tractors/Loaders/Backhoes	162.7729	719.7136	70670.8973
Construction and Mining Equipment	Trenchers	25.8195	117.9509	13773.8469
Construction and Mining Equipment Totals		**1012.8**	**6796.7**	**755939.9**

Industrial Equipment	AC\Refrigeration	19.7629	209.6312	24727.964
Industrial Equipment	Aerial Lifts	7.6908	16.6516	1522.7117
Industrial Equipment	Forklifts	142.9174	567.4658	55310.1128
Industrial Equipment	Other General Industrial Eqp	10.4509	44.3778	4977.2701
Industrial Equipment	Other General Industrial Equipm	0.2595	0.9165	95.1029
Industrial Equipment	Other General Industrial Equipment	0.0004	0.0223	1.6832
Industrial Equipment	Other Material Handling Eqp	0.6589	2.324	198.8551
Industrial Equipment	Other Material Handling Equipment	0.0937	0.339	25.0644
Industrial Equipment	Other Oil Field Equipment	0.7747	2.7162	335.3733
Industrial Equipment	Sweepers/Scrubbers	6.1521	41.6466	5021.3405
Industrial Equipment	Terminal Tractors	4.502	48.2193	6699.1814
Industrial Equipment Totals		**193.3**	**934.3**	**98914.7**

Lawn and Garden Equipment (Com)	Chain Saws < 6 HP	602.3938	7.8411	5880.8747
Lawn and Garden Equipment (Com)	Chippers/Stump Grinders	53.4187	210.1238	21906.61
Lawn and Garden Equipment (Com)	Commercial Turf Equipment	873.9812	204.7143	73369.155
Lawn and Garden Equipment (Com)	Front Mowers	55.8854	124.2926	14203.9926
Lawn and Garden Equipment (Com)	Lawn & Garden Tractors	241.7508	83.9457	25024.6442
Lawn and Garden Equipment (Com)	Lawn mowers	467.917	31.8571	13620.5653
Lawn and Garden Equipment (Com)	Leafblowers/Vacuums	511.5555	57.7308	19335.8677

Classification	Equipment	VOC Total	NO_x exhaust	CO_2 exhaust
Lawn and Garden Equipment (Com)	Other Lawn & Garden Eqp.	75.4982	6.8178	2272.092
Lawn and Garden Equipment (Com)	Rear Engine Riding Mowers	18.7257	4.4048	1654.7041
Lawn and Garden Equipment (Com)	Rotary Tillers < 6 HP	305.2809	19.7984	7718.1812
Lawn and Garden Equipment (Com)	Shredders < 6 HP	34.0335	2.2397	831.453
Lawn and Garden Equipment (Com)	Snowblowers	0	0	0
Lawn and Garden Equipment (Com)	Trimmers/Edgers/Brush Cutter	334.4302	7.7721	5475.4799
Lawn and Garden Equipment (Com) Totals		**3574.9**	**761.5**	**191293.6**
Lawn and Garden Equipment (Res)	Chain Saws < 6 HP	78.0226	0.9696	769.2462
Lawn and Garden Equipment (Res)	Lawn & Garden Tractors	701.4488	73.9624	26409.7906
Lawn and Garden Equipment (Res)	Lawn mowers	579.1723	25.1904	9238.2273
Lawn and Garden Equipment (Res)	Leafblowers/Vacuums	87.3154	1.129	784.4797
Lawn and Garden Equipment (Res)	Other Lawn & Garden Eqp.	30.7729	2.5945	919.2083
Lawn and Garden Equipment (Res)	Rear Engine Riding Mowers	65.0007	5.4791	1964.3308
Lawn and Garden Equipment (Res)	Rotary Tillers < 6 HP	56.2042	2.1925	835.2033
Lawn and Garden Equipment (Res)	Snowblowers	0	0	0
Lawn and Garden Equipment (Res)	Trimmers/Edgers/Brush Cutter	116.1396	1.4992	1116.7987
Lawn and Garden Equipment (Res) Totals		**1714.1**	**113**	**42037.3**
Logging Equipment	Chain Saws > 6 HP	1.3111	0.0171	12.8851
Logging Equipment	Forest Eqp - Feller/Bunch/Skidder	0.2747	3.5997	482.4788
Logging Equipment	Shredders > 6 HP	0.5606	0.0892	30.4738
Logging Equipment Totals		**2.1**	**3.7**	**525.8**

Classification	Equipment	VOC Total	NO_x exhaust	CO_2 exhaust
Pleasure Craft	Inboard/Sterndrive	394.1414	321.9648	33820.4804
Pleasure Craft	Outboard	4722.3617	133.7391	46339.1698
Pleasure Craft	Outboards	0.1845	0.9438	94.1016
Pleasure Craft	Personal Water Craft	1222.0423	43.4301	18058.5177
Pleasure Craft Totals		**6338.7**	**500.1**	**98312.3**
Railroad Equipment	Railway Maintenance	0.1494	0.6396	58.504
Railroad Equipment Totals		**0.1**	**0.6**	**58.5**
Recreational Equipment	ATVs	671.3669	13.3375	8688.7057
Recreational Equipment	Golf Carts	39.2629	8.8027	3309.6249
Recreational Equipment	Motorcycles: Off-Road	394.7005	2.4188	2081.2716
Recreational Equipment	Snowmobiles	0	0	0
Recreational Equipment	Speciality Vehicle Carts	1.9091	6.829	632.8163
Recreational Equipment	Specialty Vehicle Carts	0.1554	0.5668	36.78
Recreational Equipment	Specialty Vehicles/Carts	26.6712	3.0985	1243.9501
Recreational Equipment Totals		**1134.1**	**35.1**	**15993.1**
TOTAL		**15,191**	**10,172**	**1,348,158**

9.2 Point Sources

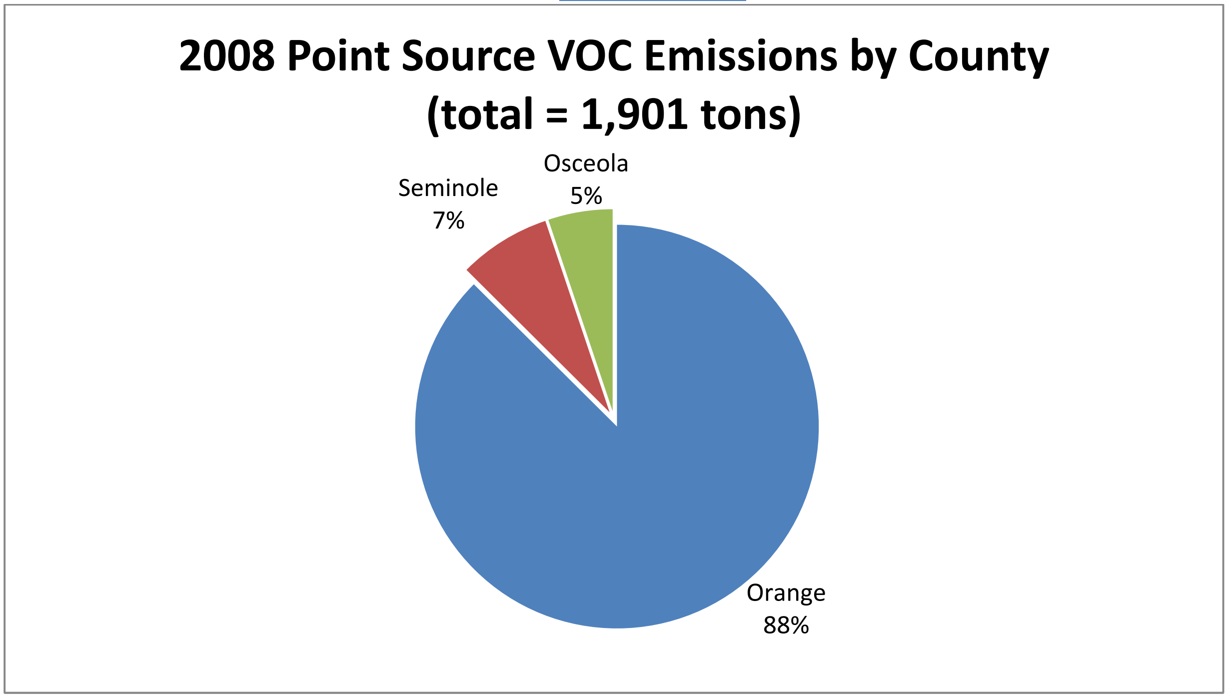

Figure 30 - 2008 Point Source VOC Contributions for OSO

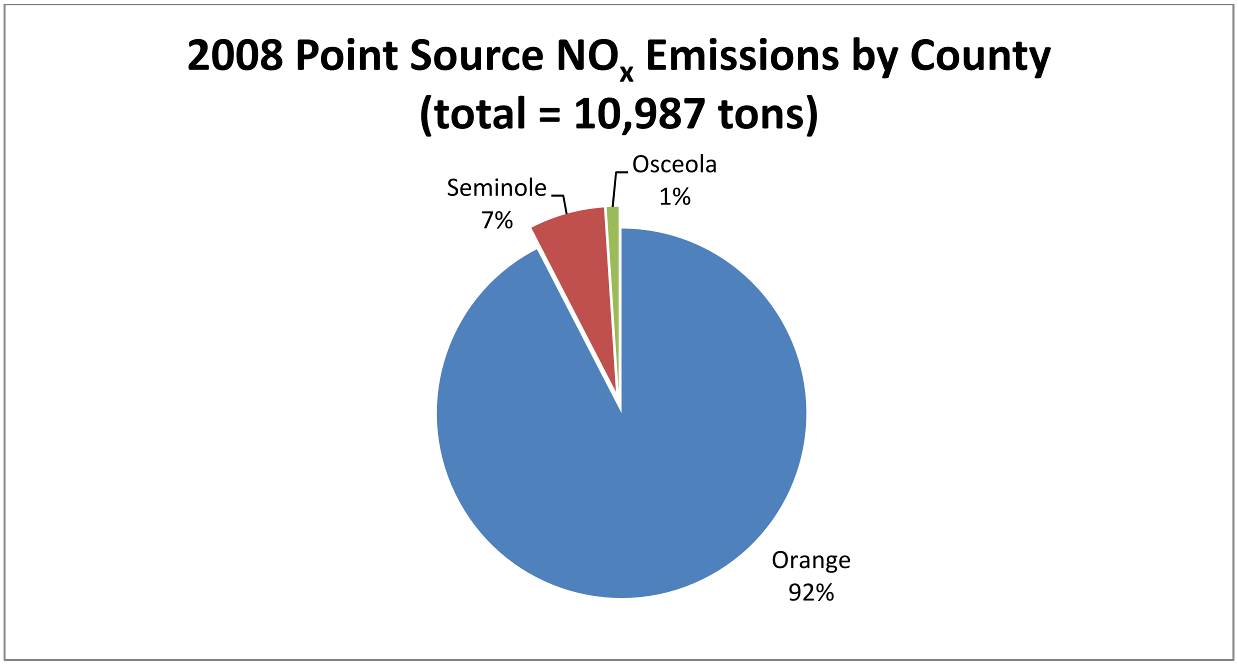

Figure 31 - 2008 Point Source NO_x Contributions for OSO

9.3 Area Sources

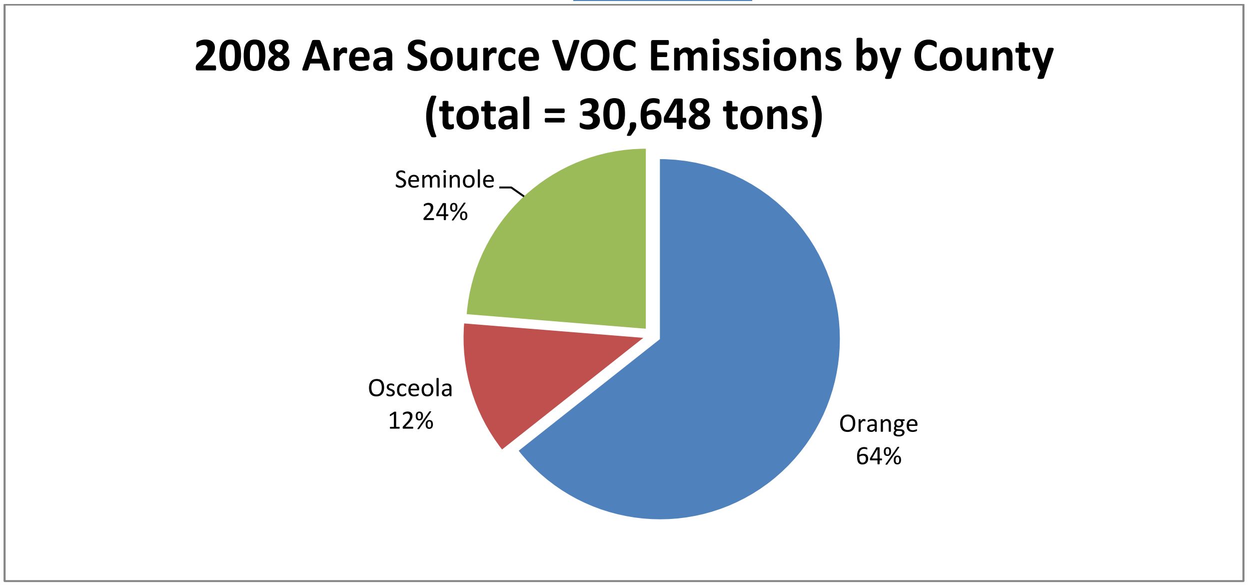

Figure 32 - 2008 Area Source VOC Contributions for OSO

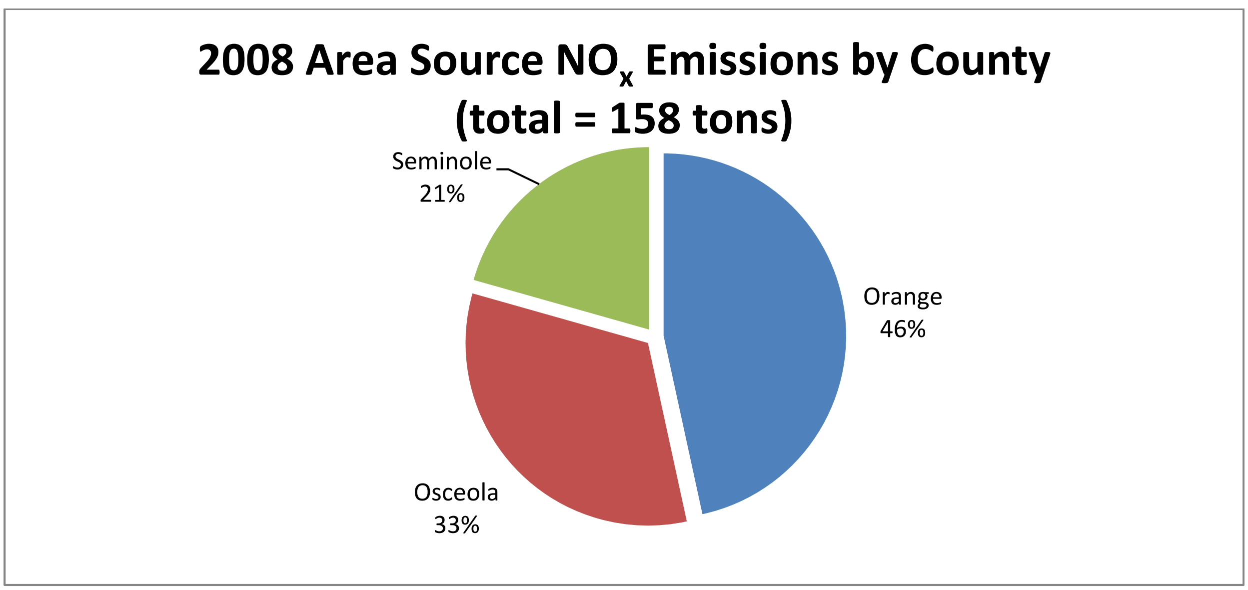

Figure 33 - 2008 Area Source NO_x Contributions for OSO

Table 28 - Area source emissions by county

	EF			Orange - 12095		Osceola - 12097		Seminole - 12117	
	VOC	NO_x	Unit	VOC (tons/yr)	NO_x (tons/yr)	VOC (tons/yr)	NO_x (tons/yr)	VOC (tons/yr)	NO_x (tons/yr)
Architectural Coating	3.09	0.0	lb/person	1657.48	0.00	407.38	0.00	634.77	0.00
Aviation Gasoline Distribution - Stage 1	0.006156	0.0	lb/gal	39.41	0.00	34.15	0.00	34.41	0.00
Aviation Gasoline Distribution - Stage 2	0.0136	0.0	lb/gal	2.04	0.00	1.77	0.00	1.79	0.00
Commercial Cooking									
- Conveyorized Charbroiling	0.01206	0.0	lb/broiler	6.47	0.00	1.59	0.00	2.48	0.00
- Under-fired Charbroiling	0.04148	0.0	lb/broiler	22.25	0.00	5.47	0.00	8.52	0.00
- Deep Fat Frying	0.01261	0.0	lb/fryer	6.76	0.00	1.66	0.00	2.59	0.00
- Flat Griddle Frying	0.00594	0.0	lb/fryer	3.19	0.00	0.78	0.00	1.22	0.00
- Clamshell Griddle Frying	0.00023	0.0	lb/fryer	0.12	0.00	0.03	0.00	0.05	0.00
Consumer Solvents									
- Adhesives and Sealants	0.57	0.0	lb/person	305.75	0.00	75.15	0.00	117.09	0.00
- Automotive Aftermarket	1.36	0.0	lb/person	729.50	0.00	179.30	0.00	279.38	0.00
- Coatings and Related Products	0.95	0.0	lb/person	509.58	0.00	125.25	0.00	195.16	0.00
- FIFRA Regulated Products	1.78	0.0	lb/person	954.79	0.00	234.67	0.00	365.66	0.00
- Household Cleaning Products	1.8	0.0	lb/person	965.52	0.00	237.31	0.00	369.77	0.00
- Miscellaneous Products	0.07	0.0	lb/person	37.55	0.00	9.23	0.00	14.38	0.00
- Personal Care Products	1.9	0.0	lb/person	1019.16	0.00	250.49	0.00	390.31	0.00
Cutback Asphalt	88.0	0.0	lb/barrel	12.64	0.00	1.14	0.00	5.37	0.00
Degreasing	30.5	0.0	lb each	636.13	0.00	41.62	0.00	184.57	0.00
Dry Cleaning	467.0	0.0	lb/facility	742.06	0.00	10.64	0.00	55.05	0.00

	EF			Orange - 12095		Osceola - 12097		Seminole - 12117	
	VOC	**NO_x**	**Unit**	**VOC (tons/yr)**	**NO_x (tons/yr)**	**VOC (tons/yr)**	**NO_x (tons/yr)**	**VOC (tons/yr)**	**NO_x (tons/yr)**
Emulsified Asphalt	9.2	0.0	lb/barrel	31.78	0.00	2.86	0.00	13.51	0.00
Gasoline Distribution - Stage 1									
- Bulk Plants	8.62	0.0	lb/1000 gal	74.05	0.00	36.62	0.00	0.00	0.00
- Bulk Terminals	8.62	0.0	lb/1000 gal	168.47	0.00	83.32	0.00	0.00	0.00
- Pipelines	8.62	0.0	lb/1000 gal	182.04	0.00	90.03	0.00	0.00	0.00
- Service Station Unloading	8.62	0.0	lb/1000 gal	3914.65	0.00	383.58	0.00	1690.00	0.00
- Tank Trucks in Transit	8.62	0.0	lb/1000 gal	17.49	0.00	1.71	0.00	7.55	0.00
- Underground Storage Tanks	8.62	0.0	lb/1000 gal	267.50	0.00	26.21	0.00	115.48	0.00
Graphic Arts	4.4	0.0	lb/person	2360.16	0.00	580.09	0.00	903.88	0.00
Household Waste Burning	8.56	6.0	lb/ton waste	0.00	0.00	46.15	32.34	0.00	0.00
Industrial Maintenance Coatings	0.59	0.0	lb/person	590.04	0.00	145.02	0.00	225.97	0.00
Land Clearing	11.6	5.0	lb/ton	0.00	0.00	0.14	0.06	0.00	0.00
Open Burning - Yard Waste	19/28/19	5/6.2/6.2	lb/ton	0.00	0.00	5.50	1.31	0.00	0.00
Other Special Purpose Coatings	0.007	0.0	lb/person	3.75	0.00	0.92	0.00	1.44	0.00
Pesticide Application	1.78	0.0	lb each	954.79	0.00	234.67	0.00	365.66	0.00
Portable Fuel Containers				1359.85	0.00	198.35	0.00	538.39	0.00
Residential Heating									
- Anthracite coal	10	3	lb/ton coal	0.00	0.00	0.00	0.00	0.00	0.00
- Bituminous coal	10	9.1	lb/ton coal	0.01	0.00	0.00	0.00	0.00	0.00
- Distillate Fuel	0.7	18.0	lb/gal	0.11	2.73	0.01	0.16	0.04	1.01
- Kerosene	28.35	729.0	lb/barrel	0.07	1.69	0.00	0.10	0.02	0.62
- LPG	21.91	562.8	lb/barrel	1.08	27.70	0.50	12.89	0.47	12.12

	EF			Orange - 12095		Osceola - 12097		Seminole - 12117	
	VOC	**NO_x**	**Unit**	**VOC (tons/yr)**	**NO_x (tons/yr)**	**VOC (tons/yr)**	**NO_x (tons/yr)**	**VOC (tons/yr)**	**NO_x (tons/yr)**
- Natural Gas	5.5	94.0	lb/ft^3	2.43	41.60	0.29	5.02	1.10	18.87
Stage 2 Gasoline Refueling	8.62	0.0	lb/1000 gal	949.08	0.00	82.56	0.00	411.02	0.00
Surface Coating									
- Aircraft	15.0	0.0	lb/employee	0.50	0.00	0.07	0.00	0.07	0.00
- Auto Refinishing	89.0	0.0	lb/employee	303.00	0.00	47.08	0.00	125.62	0.00
- Electronic and Other Electric Coatings	24.7	0.0	lb/employee	1.25	0.00	0.00	0.00	0.17	0.00
- Factory Finished Wood - SIC 2426 through 242	43.0	0.0	lb/employee	10.41	0.00	6.11	0.00	7.80	0.00
- Large Appliances - SIC 363	249.0	0.0	lb/employee	0.00	0.00	0.00	0.00	0.76	0.00
- Machinery and Equipment - SIC 35	109.0	0.0	lb/employee	134.29	0.00	3.53	0.00	7.46	0.00
- Marine	198.0	0.0	lb/employee	131.47	0.00	0.00	0.00	1.45	0.00
- Metal Can Coating	2326.0	0.0	lb/employee	194.96	0.00	0.00	0.00	0.00	0.00
- Metal Furniture - SIC 25	772.0	0.0	lb/employee	17.92	0.00	1.57	0.00	8.10	0.00
- Miscellaneous Manufacturing	136.0	0.0	lb/employee	85.33	0.00	2.45	0.00	49.76	0.00
- Motor Vehicles	164.0	0.0	lb/employee	66.03	0.00	18.07	0.00	62.81	0.00
- Paper, Foil, and Film	735.0	0.0	lb/employee	1.70	0.00	0.00	0.00	0.00	0.00
- Railroad	222.0	0.0	lb/employee	0.00	0.00	0.00	0.00	0.00	0.00
- Sheet, Strip, and Coil	2877.0	0.0	lb/employee	133.83	0.00	11.04	0.00	17.04	0.00
- Wood Furniture	244.0	0.0	lb/employee	71.43	0.00	7.52	0.00	31.61	0.00
Traffic Paints	22.1	0.0	lb/lane mile	50.28	0.00	16.44	0.00	17.94	0.00
TOTAL				**19,730**	**74**	**3,650**	**52**	**7,268**	**33**

9.4 Total Emissions per County by Source Category

9.4.1 Orange County

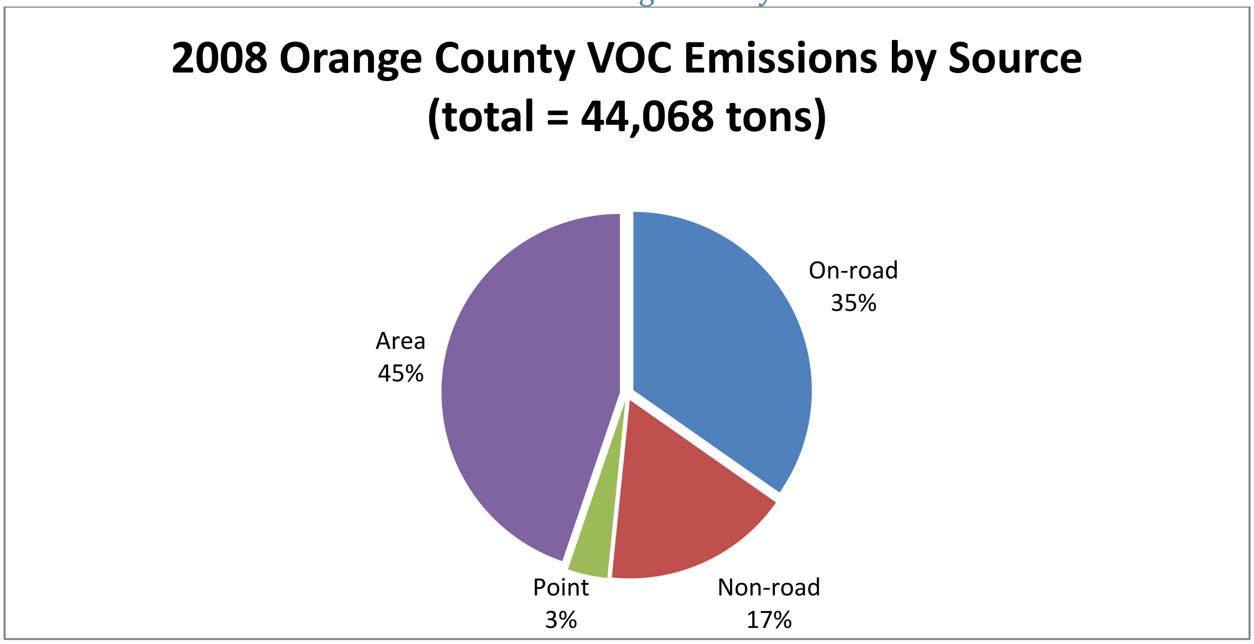

Figure 34 - 2008 Orange county VOC emissions by source

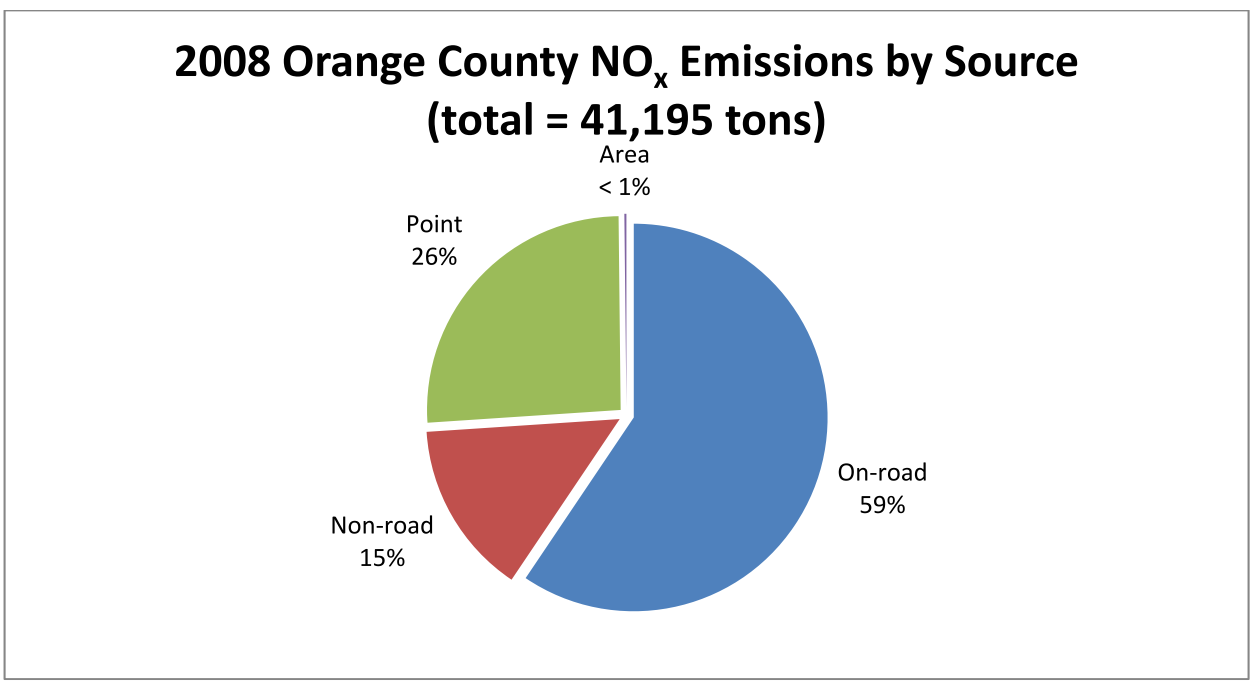

Figure 35 - 2008 Orange county NO_x emissions by source

9.4.2 Seminole County

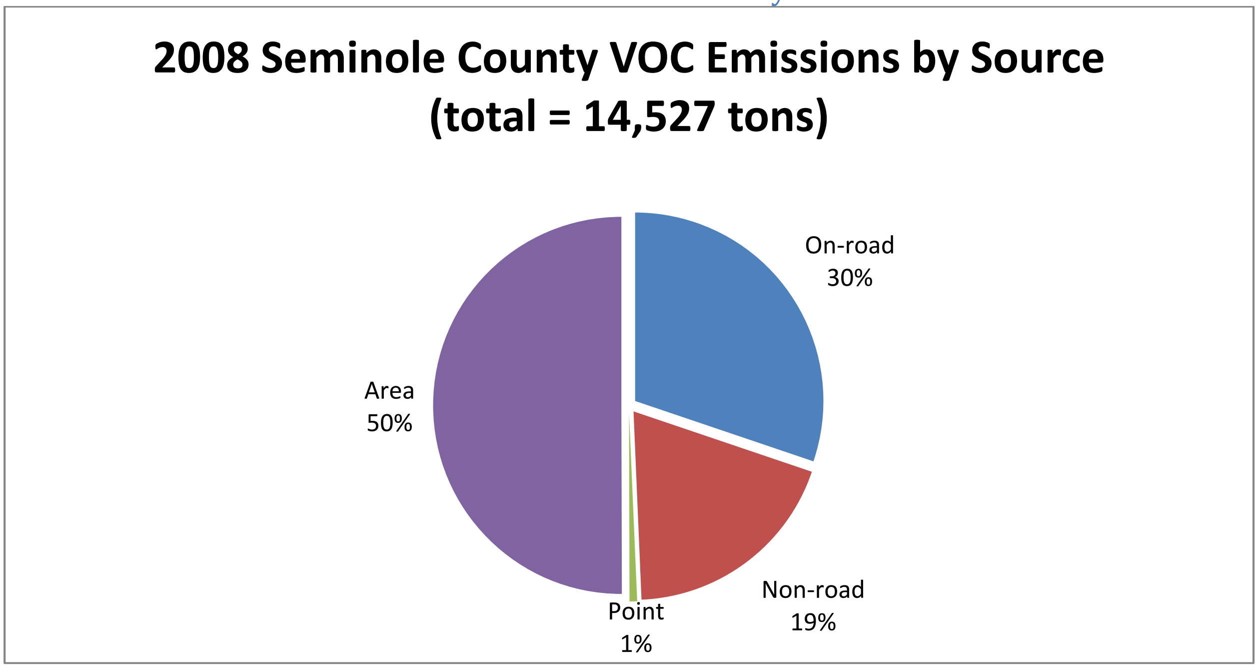

Figure 36 - 2008 Seminole county VOC emissions by source

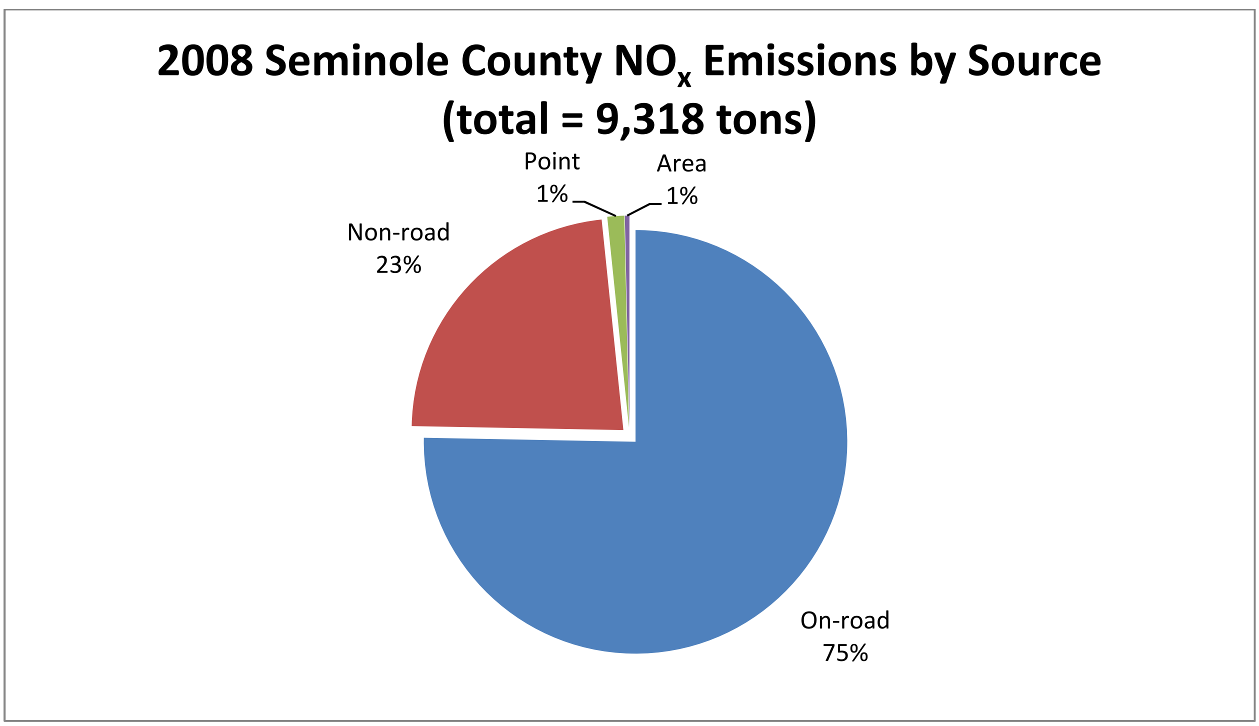

Figure 37 - 2008 Seminole county NO_x emissions by source

9.4.3 Osceola County

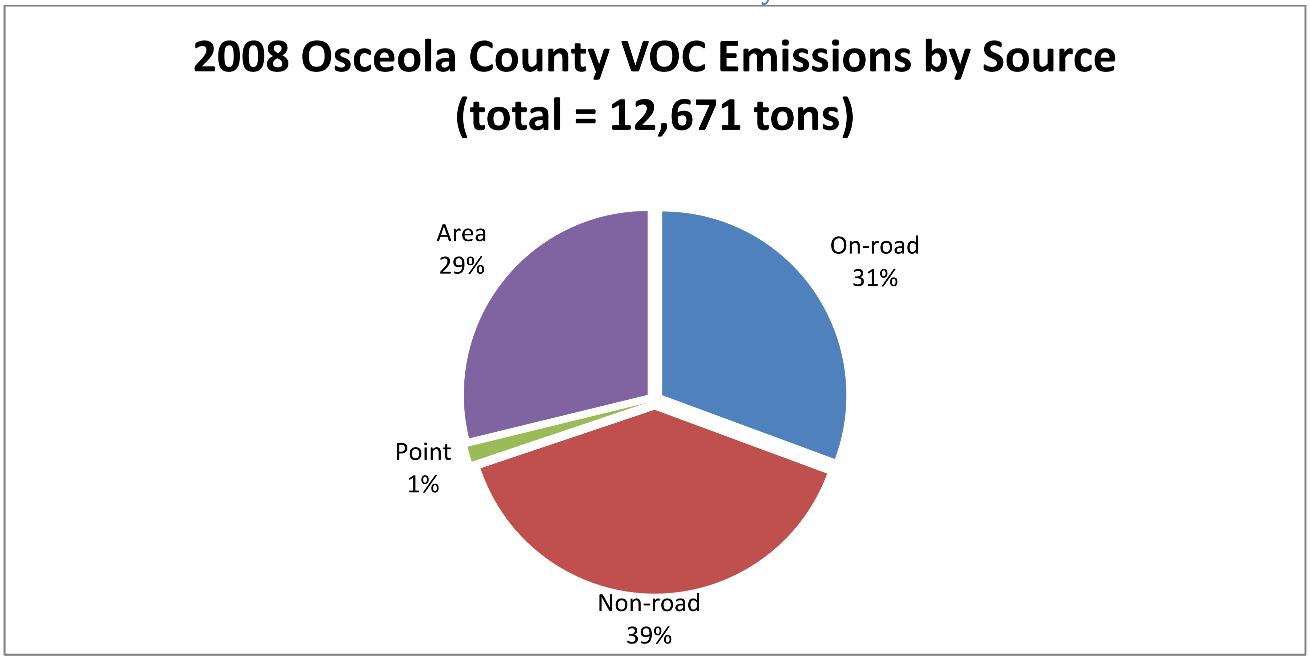

Figure 38 - 2008 Osceola county VOC emissions by source

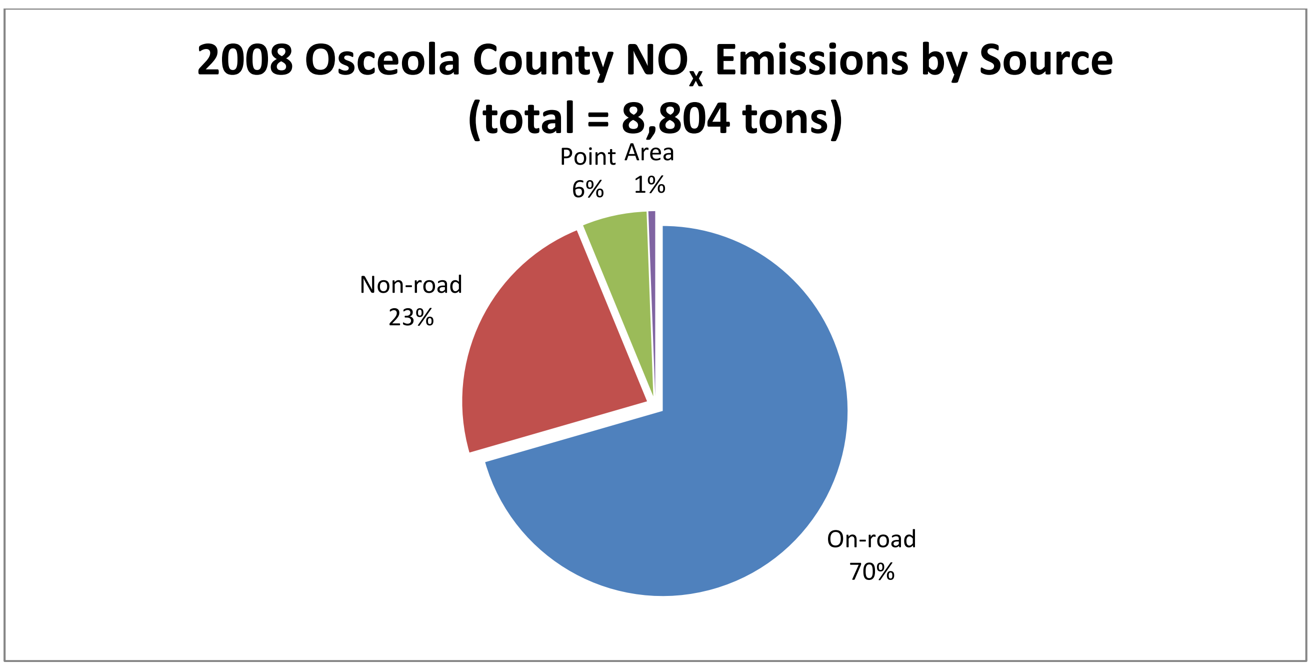

Figure 39 - 2008 Osceola county NO_x emissions by source

This section contains details of the methodology used for estimating the emissions reduction achieved by an assumed 10% reduction in idling delay time at all the traffic signals along all major arterials in the OSO area. It shows the calculations and assumptions necessary to make these estimates.

Figure 40 - Map used to estimate idle emissions reduction based on adjusted signal timing

Figure 40 shows the selected routes for idle emissions reduction estimation. The routes extend from two selected points central to high traffic areas – the southwest point being Downtown Disney and the northeast being the LYNX Central Station in downtown Orlando. Routes extended from these points to the outer limits of the city. In Table 29, the details of these routes are listed such as how many lights are on each, average speed, and distance. The idea is that more idling occurs around these selected points. For example, given a one mile radius around the Downtown Disney point, there will be a higher concentration of emissions as opposed to a ten mile radius which has fewer lights per length of road at which to stop traffic to contribute to idle emissions.

Table 29 - Idle emissions reduction routes

Cycle Length (sec)	90	Idle Time per Light (sec)	13.07
Idle Emission VOC Rate (g/hr)	10	Idle Emission NO_x Rate (g/hr)	5.34

Trip	Origin	Destination	Miles	Time (hrs)	mph	Lights	Idle Time (min)	Idle (min/mile)	Idle Emission VOC Rate (g/mile)	Idle Emission NO_x Rate (g/mile)
1	Lynx Garland Avenue Station, 455 North Garland Avenue, Orlando, FL 32801	Gemini Springs Park, 37 Dirksen Dr., Debary, FL 32713	27.6	0.68	40.39	64	13.94	0.50	0.09	0.01
2	Lynx Garland Avenue Station, 455 North Garland Avenue, Orlando, FL 32801	Orlando Sanford Airport, 1200 Red Cleveland Blvd., Sanford, FL 32773	21.0	0.55	38.18	56	12.20	0.58	0.10	0.01
3	Lynx Garland Avenue Station, 455 North Garland Avenue, Orlando, FL 32801	Geneva Elementary School, Geneva, FL 32732	30.4	0.73	41.45	65	14.16	0.47	0.08	0.01
4	Lynx Garland Avenue Station, 455 North Garland Avenue, Orlando, FL 32801	University of Central Florida, 4000 Central Florida Blvd, Orlando, FL 32816	15.0	0.50	30.00	42	9.15	0.61	0.10	0.01
5	Lynx Garland Avenue Station, 455 North Garland Avenue, Orlando, FL 32801	House of Blues, 1490 East Buena Vista Dr., Lake Buena Vista, FL 32830	19.7	0.63	31.11	50	10.89	0.55	0.09	0.01

Trip	Origin	Destination	Miles	Time (hrs)	mph	Lights	Idle Time (min)	Idle (min/mile)	Idle Emission VOC Rate (g/mile)	Idle Emission NO_x Rate (g/mile)
6	House of Blues, 1490 East Buena Vista Dr., Lake Buena Vista, FL 32830	Poinciana High School, 2300 S. Poinciana Blvd., Kissimmee, FL 34744	12.9	0.42	30.96	14	3.05	0.24	0.04	0.00
7	House of Blues, 1490 East Buena Vista Dr., Lake Buena Vista, FL 32830	Reunion Resort, 7593 Gathering Dr., Reunion, FL 34747	12.7	0.42	30.48	12	2.61	0.21	0.04	0.00
8	House of Blues, 1490 East Buena Vista Dr., Lake Buena Vista, FL 32830	Apopka High School, 555 Martin St., Apopka, FL 32712	14.4	0.40	36.00	21	4.57	0.32	0.05	0.00
9	House of Blues, 1490 East Buena Vista Dr., Lake Buena Vista, FL 32830	Ocoee High School, 1925 Ocoee Crown Point Pkwy, Ocoee, FL 34761	20.0	0.70	28.57	38	8.28	0.41	0.07	0.01
10	House of Blues, 1490 East Buena Vista Dr., Lake Buena Vista, FL 32830	Saint Cloud High School, 2000 Bulldog Lane, Saint Cloud, Florida 34769	21.4	0.60	35.67	39	8.49	0.40	0.07	0.01
Average								**0.4284**	**0.0730**	**0.0065**

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