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# Emissions Inventory Spatial Surrogates Review and Updates

*Prepared by the Capital Area Council of Governments*
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## Executive Summary

This project provides a detailed review of the spatial representation of emissions within the 10-county Capital Area Council of Governments (CAPCOG) region for photochemical modeling. The CAPCOG region includes Bastrop, Blanco, Burnet, Caldwell, Fayette, Hays, Lee, Llano, Travis, and Williamson Counties. CAPCOG reviewed the existing spatial surrogates that the Texas Commission on Environmental Quality (TCEQ) uses for its 2012 modeling platform, including both custom-made surrogates developed by TCEQ and surrogates developed by the U.S. Environmental Protection Agency (EPA) for its 2011v6.2 modeling platform. CAPCOG selected spatial allocation surrogates to analyze based on 2014 National Emissions Inventory (NEI) nitrogen oxides ($NO_X$) emissions estimates associated with each surrogate, focusing on surrogates that impacted at least 250 tons per year (tpy) of $NO_X$ emissions. This included:

- On-road sources:
    - On-network activity
    - Start activity for motorcycles, passenger cars, and passenger trucks
    - Extended idling activity
- Non-road sources:
    - Agricultural equipment
    - Construction and mining equipment
    - Industrial equipment
    - Commercial equipment
    - Rail
    - Airports
- Area sources:
    - Industrial fuel combustion
    - Residential natural gas combustion
    - Commercial and institutional fuel combustion
    - Oil and gas production

This report includes a detailed analysis of the spatial allocation surrogates used for each of these sources, opportunities for improvement to their spatial representation, and technical constraints and considerations for any effort to improve the spatial representation within the region. CAPCOG ultimately provided developed updates to spatial allocation surrogates for all agricultural equipment categories for all 10 CAPCOG counties, and six construction and mining equipment source classification codes (SCCs) in Lee County. The report also provides a detailed justification for TCEQ's consideration of using EPA's surrogates for auxiliary power units (APUs) and extended idling activity.

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# 1 Introduction

The purpose of this report is to document the review and update of spatial allocation surrogates used for emissions modeling within the 10-county Capital Area Council of Governments (CAPCOG) region of Central Texas that includes Bastrop, Blanco, Burnet, Caldwell, Fayette, Hays, Lee, Llano, Travis, and Williamson Counties. Five of these counties make up the Austin-Round Rock Metropolitan Statistical Area (MSA), defined as of 2015: Bastrop, Caldwell, Hays, Travis, and Williamson Counties.[1] Six of CAPCOG's counties constitute the Capital Area Metropolitan Planning Area (MPA) – Bastrop, Burnet, Caldwell, Hays, Travis, and Williamson Counties.

## 1.1 Modeling Domain and Grid System

The modeling domain used by TCEQ includes:

- a 36-kilometer (km) resolution domain the covers the lower 48 states that is compatible with modeling domains used by EPA (referred to as "rpo_36km"),
- a 12-km resolution domain that covers all of Texas, Louisiana, Arkansas, and Oklahoma, and
- a 4-km resolution domain that covers the eastern part of Texas and parts of Arkansas and Louisiana.

TCEQ includes a detailed description of these domains in Appendix A to its December 2016 Houston-Galveston Area 2008 Ozone NAAQS Attainment Demonstration.[2] The following two figures show the CAPCOG region situated within the 4-km E. Texas grid and then a closer-in view of the CAPCOG region with the 4 km grid overlaid on it.

[1] https://www2.census.gov/programs-surveys/metro-micro/geographies/reference-files/2015/delineation-files/list1.xls

[2] https://www.tceq.texas.gov/assets/public/implementation/air/sip/hgb/HGB_2016_AD_RFP/AD_Adoption/HGB_AD_SIP_Appendix_A_Adoption.pdf

**Figure 1-1. CAPCOG Region within TCEQ's 4 km East Texas Grid System**

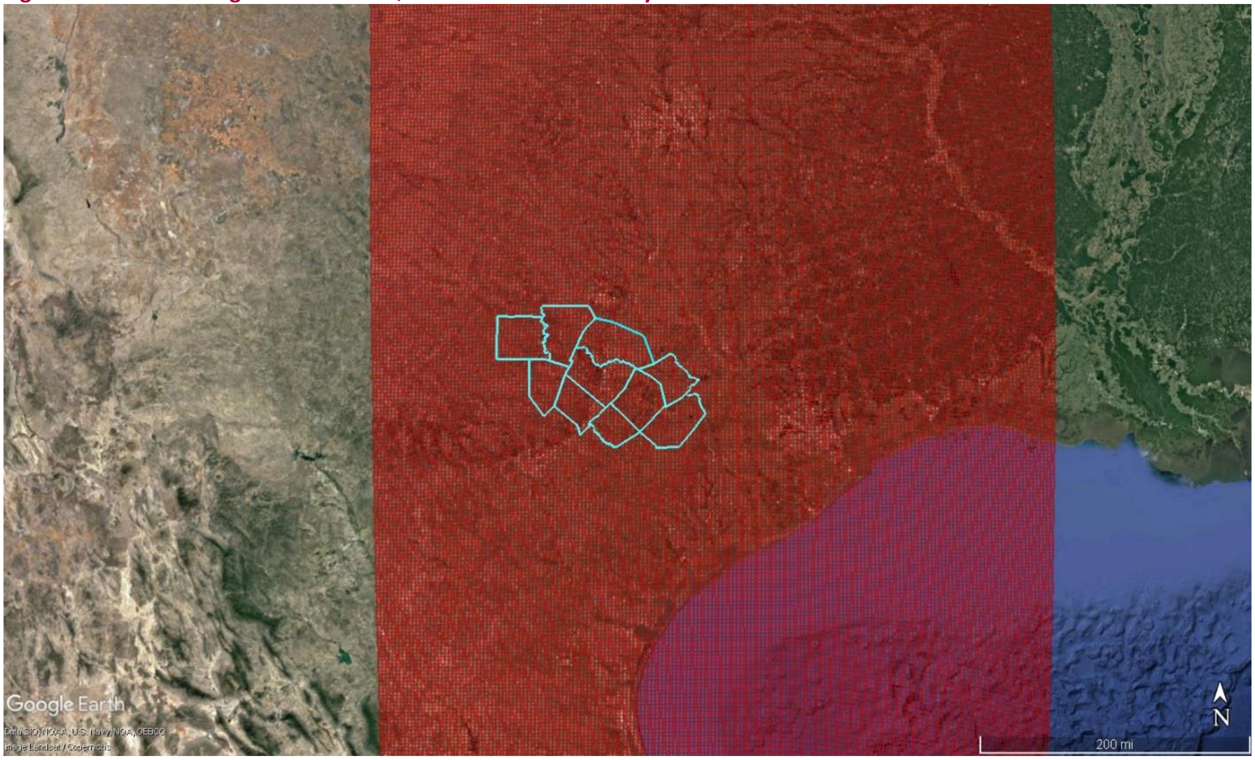
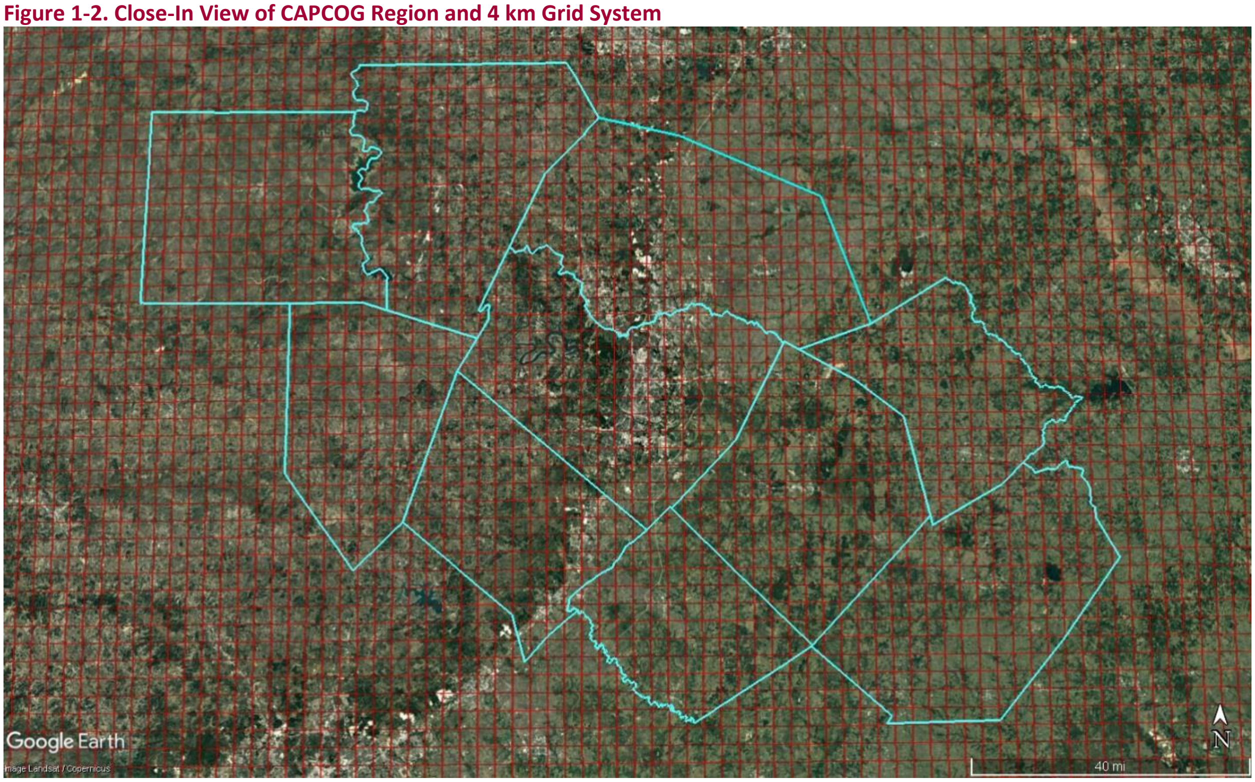



**Figure 1-2. Close-In View of CAPCOG Region and 4 km Grid System**



A total of 1,505 4 km x 4 km grid cells cover all or part of the counties in the CAPCOG region. The following table provides the grid cell counts by county. Since a single grid cell can cover more than one county the sum of these counts will not equal the 1,505 region-wide total.

**Table 1-1. 4 km x 4 km Grid Cell Counts by County**

| County | Only This County | Split with Other CAPCOG County | Total Cell Count |
|---|---|---|---|
| **Bastrop** | 120 | 60 | 180 |
| **Blanco** | 115 | 25 | 140 |
| **Burnet** | 159 | 39 | 198 |
| **Caldwell** | 85 | 28 | 113 |
| **Fayette** | 165 | 21 | 186 |
| **Hays** | 102 | 37 | 139 |
| **Lee** | 101 | 30 | 131 |
| **Llano** | 170 | 19 | 189 |
| **Travis** | 131 | 68 | 199 |
| **Williamson** | 174 | 49 | 223 |

## 1.2 Baseline Surrogates

The main reference point for this project were the 4-km spatial allocation surrogates used by the U.S. Environmental Protection Agency (EPA) for its 2011v6.3 modeling platform[3] and release 2 of TCEQ's 2012 modeling platform. In many cases, TCEQ relies on EPA's surrogates, but for some source categories, TCEQ developed specialized surrogates. For these source categories, CAPCOG only reviewed the TCEQ surrogate. Appendix B of TCEQ's HGB 2008 Ozone NAAQS Attainment Demonstration describes specialized spatial allocation surrogates.[4]

**Table 1-2. EPA or TCEQ Surrogates by Source**

| Source | TCEQ or EPA Surrogate | Description of TCEQ Surrogate |
|---|---|---|
| **On-Road: Hoteling Activity** | TCEQ | Interstate Highways, Other Highways |
| **On-Road: Start** | TCEQ | Various Roadways, Population |
| **On-Road: Running Exhaust** | TCEQ | Roadways |
| **Area: Oil and Gas Production** | TCEQ | RRC O & G Production Data |
| **Area: All Other** | EPA | n/a |
| **Non-Road: Drilling Activity** | TCEQ | RRC Well Drilling Data |
| **Non-Road: Airports** | TCEQ | Areal Extent of Each Airport |
| **Non-Road: Locomotives** | TCEQ | Railway Segments and Switchyards |
| **Non-Road: NONROAD Model Sources** | EPA | n/a |

[3] ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/spatial_surrogates/ These appear to be the same for Texas as the surrogates used in 2011v6.2. The US_SpatialSurrogate_Workbook_v070115.xlsx appears to be the same for both.

[4] https://www.tceq.texas.gov/assets/public/implementation/air/sip/hgb/HGB_2016_AD_RFP/AD_Adoption/HGB_AD_SIP_Appendix_B_Adoption.pdf

## 1.3 Prior CAPCOG Spatial Allocation Work

This project builds on CAPCOG's prior on sub-county-level spatial allocation of emissions:

- *Spatial Allocation Surrogate Updates for Selected Area and Non-Road Sources in the Austin-Round Rock Metropolitan Statistical Area*, August 2013[5]
  - Industrial Fuel Combustion, Commercial Fuel Combustion, Agricultural Equipment
- *2012 and 2018 Emissions Updates for the CAPCOG Region and Milam Counties*, December 2013[6]
  - Area sources: industrial fuel combustion, oil and gas production
  - On-road: start, running, evaporative, and extended idling
  - Non-road: agricultural equipment, mine and quarry DCE subsector, heavy highway DCE subsector, landfill equipment DCE subsector
- *Modeling Truck Idling Emissions in Central Texas*, May 5, 2015: extended and short-term idling locations[7]

This project also leverages prior research that CAPCOG conducted on a number of source categories that helped CAPCOG better understand the underlying activity and how it might be spatially represented.

## 1.4 Screening of Emissions Sources and Spatial Allocation Factors

Given the large number of sources of emissions and spatial allocation factors, CAPCOG decided to screen sources and spatial allocation factors based on the level of annual $NO_X$ emissions associated with a given spatial allocation factor. A recent CAPCOG modeling report showed that anthropogenic $NO_X$ emissions accounted for 98-99% of the ozone impact of anthropogenic emissions on monitors within the CAPCOG region, and that VOC emissions nation-wide accounted for only 0.35 – 1.02 ppb in MDA8 $O_3$ contributions at monitoring locations in Hays, Travis, and Williamson Counties. Therefore, CAPCOG used an initial screening threshold of 250 tpy of $NO_X$ from the 2014 National Emissions Inventory (NEI).

For non-road and area sources, CAPCOG used the final version of the NEI v. 1 released by EPA in fall 2016 for this screening. CAPCOG used the on-road emissions data developed by TCEQ for the AERR instead of the NEI data because the data is disaggregated by roadway type and process.[8]

## 1.5 Potential Alternative Spatial Allocation Surrogates

CAPCOG has identified a number of potential alternative surrogates for each major source of emissions or spatial surrogate. These are shown below.

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[5] http://www.capcog.org/documents/airquality/reports/2013/Task_3.3_-_Development_of_Updated_Spatial_Surrogates_for_Selected_Area_and_Non-Road_Sources_Final.pdf

[6] http://www.capcog.org/documents/airquality/reports/2013/Task_3.1-2012_and_2018_Emissions_Modeling_for_CAPCOG_Region_and_Milam_Counties_2013-12-02.pdf

[7] http://www.capcog.org/documents/airquality/reports/2015/Modeling_Truck_Idling_Emissions_in_Central_Texas_-_2015-05-05.pdf

[8] ftp://amdaftp.tceq.texas.gov/pub/EI/onroad/aerr/2014/

**Table 1-3. Potential Alternative Spatial Allocation Surrogates and Data Sources**

| Source | Potential Alternative Surrogate | Data Source |
|---|---|---|
| **On-Road, On-Network Activities** | Link-level Activity | CAMPO 2010 Travel Demand Model |
| **On-Road, Off-Network Start Exhaust** | Trip Starts by Travel Analysis Zone | CAMPO 2010 Travel Demand Model |
| **On-Road, Off-Network Idle & APU** | Idling Hours by Location | CAPCOG Idling Report, 2015 |
| **Non-Road: Agricultural Equipment** | Pasture and Crop Land Use | CropScape |
| **Non-Road Construction and Mining Equipment: Mine and Quarry Subsector** | Non-Office Labor Hours by Mine Site | U.S. Mine Health and Safety Administration Data Retrieval System |
| **Non-Road Construction & Mining Equipment: Other Subsectors** | Change in Land Use from Undeveloped to Developed | CropScape |
| **Non-Road Industrial Equipment** | Employees in "Basic" Employment Sectors by Travel Analysis Zones | CAMPO 2010 Travel Demand Model |
| **Non-Road Commercial Equipment** | Employees in "Retail" and "Service" Sectors by Travel Analysis Zones | CAMPO 2010 Travel Demand Model |
| **Non-Road Aircraft** | Flight Paths | Airports |
| **Non-Road Rail** | Ozone Season-Specific Link-Level Activity | Railroad Companies |
| **Area Sources: Residential Natural Gas Fuel Combustion** | 2010-2014 Primary Home Heating Fuel = Natural Gas by Census Block Group | 2010-2014 American Community Survey |
| **Area Sources: Industrial Fuel Combustion** | Employees in "Basic" Sectors | CAMPO 2010 Travel Demand Model |
| **Area Source: Commercial Fuel Combustion** | Employees in "Retail" and "Service" Sectors by Travel Analysis Zone | CAMPO 2010 Travel Demand Model |
| **Area Source: Oil and Gas Production: Pumpjacks** | Oil Wells Located a Significant Distance from an Electrical Power Line | Railroad Commission, Local Utilities |

## 2 On-Road Sources

On-road sources constitute the largest source of $NO_X$ emissions within the CAPCOG region. Six counties within the CAPCOG region make up the Capital Area MPA – Bastrop, Burnet, Caldwell, Hays, Travis, and Williamson Counties. The Capital Area Metropolitan Planning Organization (CAMPO) 2010 Travel Demand Model provides the opportunity for highly detailed, link-level emissions inventories for this portion of the region. The following table shows the total $NO_X$ emissions by roadway type for these six counties.

**Table 2-1. 2014 CAMPO $NO_X$ Emissions by Roadway Type**

| Roadway Type | $NO_X$ |
|---|---|
| **Centroid Connectors** | 968.63 |
| **Interstate** | 3,164.53 |
| **Freeway** | 1,411.52 |
| **Expressway** | 233.15 |
| **Principal Arterial Divided** | 1,441.34 |
| **Principal Arterial CLT** | 1,002.34 |
| **Principal Arterial Undivided** | 1,756.64 |
| **Minor Arterial Divided** | 66.75 |
| **Minor Arterial CLT** | 65.82 |
| **Minor Arterial Undivided** | 1,169.78 |
| **Collector Divided** | 1.95 |
| **Collector CLT** | 2.56 |
| **Collector Undivided** | 216.86 |
| **Local Divided** | 17.00 |
| **Local CLT** | 3.45 |
| **Local Undivided** | 123.64 |
| **Direct Connectors** | 93.01 |
| **Ramp** | 255.34 |
| **Frontage** | 680.34 |
| **HOV Mainlanes** | 0.00 |
| **HOV Ramp** | 0.00 |
| **Toll Facility 1** | 408.30 |
| **Toll Facility 2** | 0.00 |
| **Toll – Ramp** | 30.20 |
| **Toll - Direct Connector** | 32.91 |
| **Local (Intrazonal)** | 16.75 |
| **Off-Network** | 2,891.77 |
| **TOTALS** | **16,054.57** |

The other four counties in the region – Blanco, Fayette, Lee, and Llano Counties – are not within an MPA and are outside of the boundaries of any travel demand model. These inventories are prepared using other methods based on highway performance monitoring system (HPMS) data.

Table 2-2. Non-CAMPO County 2014 $NO_X$ Emissions by Roadway Type

| Roadway Type | $NO_X$ |
|---|---|
| **RUR IH FWY 110** | 707.60 |
| **RUR OTH PRIN ART 130** | 479.06 |
| **RUR MINOR ART 150** | 408.60 |
| **RUR MAJOR COLL 170** | 347.24 |
| **RUR MINOR COLL 190** | 58.49 |
| **RUR LOCAL 210** | 101.49 |
| **SMALL URB IH FWY 230** | 0.00 |
| **SMALL URB FWY 250** | 0.00 |
| **SMALL URB OTH PR ART 270** | 17.10 |
| **SMALL URB MIN ART 290** | 6.43 |
| **SMALL URB MAJ COLL 310** | 2.09 |
| **SMALL URB MIN COLL 310** | 0.00 |
| **SMALL URB LOCAL 330** | 2.56 |
| **URB IH FWY 230** | 0.00 |
| **URB FWY 250** | 0.00 |
| **URB OTH PRIN ART 270** | 0.00 |
| **URB MIN ART 290** | 0.00 |
| **URB MAJ COLL 310** | 0.00 |
| **URB LOCAL 330** | 0.00 |
| **Off-Network** | 219.70 |
| **TOTALS** | **2,350.37** |

## 2.1 On-Network Activity

Based on CAPCOG's review of the DFW and HGB SIPs, it is CAPCOG's understanding that the on-network activity for all 10 counties are allocated based on total road-miles by roadway type. A presentation provided by TCEQ in 2011 details the spatial allocation factors developed by TCEQ.[9]

Table 2-3. On-Network Allocation Factor

| MOVES Roadway Type | HPMS Roadway Categories[10] | Spatial Allocation Factor |
|---|---|---|
| **Rural Restricted Access** | Rural Interstate (110) | Rural Primary Road Miles |
| **Rural Unrestricted Access** | Rural Other Principal Arterial (130), Rural Minor Arterial (150), Rural Major Collector (170), Rural Minor Collector (190), Rural Local (210) | Rural Secondary Road Miles |
| **Urban Restricted Access** | Urban Interstate (230) Urban Other Freeways and Expressways (250) | Urban Primary Road Miles |

[9] https://www.epa.gov/sites/production/files/2016-06/documents/inventory-regional-on-road-emision-moves-2011.pdf

[10] ftp://amdaftp.tceq.texas.gov/pub/EI/EPS3/0ReadMe_EPS3_Files.txt

| MOVES Roadway Type | HPMS Roadway Categories[10] | Spatial Allocation Factor |
|---|---|---|
| **Urban Unrestricted Access** | Urban Other Principal Arterial (270), Urban Minor Arterial (290), Urban Collector (310), Urban Local (330) | Urban Secondary Road Miles |

The main improvement that could be pursued for improving the spatial allocation of on-network activity within the CAPCOG region would be to allocate emissions within the CAMPO region based on link-level activity, similar to the approach TCEQ uses for attainment demonstrations and which CAPCOG used for a photochemical modeling project in 2013.[11]

That project involved development of 2012 and 2018 spatial allocation factors for MOVES2010b-developed link-based emissions inventories. Since these factors were based on different emissions data, and the 2005 travel demand model, it would not necessarily be appropriate to re-use the spatial allocation factors for the current modeling platform, which relies on MOVES2014-based inventories. Also, the spatial allocation work required $15,000, and given CAPCOG's limited resources, CAPCOG ultimately decided not to further pursue this option.

## 2.2 Off-Network Processes

TCEQ's reference files for its spatial allocation surrogates includes the following information:

- Work completed by TCEQ staff in August 2011
- Surrogates for Interstates and Highways are based on 2009 Texas Department of Transportation (TxDOT) data sets
- Surrogates for arterials, collectors, other, and off-road are based on 2010 Geographic Data Technology (GDT) data sets
- Surrogates for population based on 2010 Census data sets
- ART = Arterials (253 counties covered, 1 blank – Kenedy County)
- COL = Collectors (254 counties, 0 blank)
- HWY = Highways (254 counties, 0 blank)
- INT = Interstates (92 counties, 162 blank)
- OTH = Other (249 counties covered, 5 blank – generally not used, but can be backup if "collectors" is weak)
- OFR = Off-Road (199 counties covered, 55 are blank – implies unpaved roads where some activity may occur; not used for on-road allocation and should not be confused with off-network)
- POP = Population (254 counties covered, 0 blank)

[11] http://www.capcog.org/documents/airquality/reports/2013/Task_3.1-2012_and_2018_Emissions_Modeling_for_CAPCOG_Region_and_Milam_Counties_2013-12-02.pdf

**Table 2-4. Maximum TCEQ On-Road, Off-Network Spatial Allocation Factors for a 4 km x 4 km Grid Cell by County**

| County | INT | HWY | ART | COL | POP |
|---|---|---|---|---|---|
| **Bastrop** | 0.0000 | 0.0600 | 0.0452 | 0.0317 | 0.0506 |
| **Blanco** | 0.0000 | 0.1037 | 0.0517 | 0.0288 | 0.1749 |
| **Burnet** | 0.0000 | 0.0633 | 0.0379 | 0.0225 | 0.0850 |
| **Caldwell** | 0.5859 | 0.0828 | 0.0540 | 0.0366 | 0.2137 |
| **Fayette** | 0.1130 | 0.0694 | 0.0322 | 0.0139 | 0.1162 |
| **Hays** | 0.1224 | 0.1792 | 0.0418 | 0.0370 | 0.1405 |
| **Lee** | 0.0000 | 0.0889 | 0.0379 | 0.0432 | 0.2914 |
| **Llano** | 0.0000 | 0.0404 | 0.0423 | 0.0281 | 0.1139 |
| **Travis** | 0.1148 | 0.0691 | 0.0367 | 0.0244 | 0.0399 |
| **Williamson** | 0.0961 | 0.0613 | 0.0345 | 0.0259 | 0.0477 |

The following table lists the primary surrogates for each source use type and off-network process.

**Table 2-5. TCEQ Primary Spatial Allocation Surrogates for On-Road Source, Off-Network Processes**

| Source Use Type | Start | APU | Idle | Evap. Liquid | Evap. Perm. | Evap. Vapor |
|---|---|---|---|---|---|---|
| **Combination Long-Haul Truck** | HWY | INT | INT | n/a | n/a | n/a |
| **Combination Short-Haul Truck** | ART | n/a | n/a | ART | ART | ART |
| **Intercity Bus** | HWY | n/a | n/a | n/a | n/a | n/a |
| **Light Commercial Truck** | ART | n/a | n/a | ART | ART | ART |
| **Motor Home** | POP | n/a | n/a | POP | POP | POP |
| **Motorcycle** | POP | n/a | n/a | POP | POP | POP |
| **Passenger Car** | POP | n/a | n/a | POP | POP | POP |
| **Passenger Truck** | POP | n/a | n/a | POP | POP | POP |
| **Refuse Truck** | ART | n/a | n/a | ART | ART | ART |
| **School Bus** | ART | n/a | n/a | ART | ART | ART |
| **Single Unit Long-Haul Truck** | HWY | n/a | n/a | HWY | HWY | HWY |
| **Single Unit Short-Haul Truck** | ART | n/a | n/a | ART | ART | ART |
| **Transit Bus** | ART | n/a | n/a | ART | ART | ART |

The following table lists the secondary surrogates for each source use type and off-network process.

**Table 2-6. TCEQ Secondary Spatial Allocation Surrogates for On-Road Source, Off-Network Processes**

| Source Use Type | Start | APU | Idle | Evap. Liquid | Evap. Perm. | Evap. Vapor |
|---|---|---|---|---|---|---|
| **Combination Long-Haul Truck** | ART | HWY | HWY | n/a | n/a | n/a |
| **Combination Short-Haul Truck** | COL | n/a | n/a | COL | COL | COL |
| **Intercity Bus** | ART | n/a | n/a | n/a | n/a | n/a |
| **Light Commercial Truck** | COL | n/a | n/a | COL | COL | COL |
| **Motor Home** | COL | n/a | n/a | COL | COL | COL |
| **Motorcycle** | COL | n/a | n/a | COL | COL | COL |
| **Passenger Car** | COL | n/a | n/a | COL | COL | COL |
| **Passenger Truck** | COL | n/a | n/a | COL | COL | COL |

| Source Use Type | Start | APU | Idle | Evap. Liquid | Evap. Perm. | Evap. Vapor |
|---|---|---|---|---|---|---|
| **Refuse Truck** | COL | n/a | n/a | COL | COL | COL |
| **School Bus** | COL | n/a | n/a | COL | COL | COL |
| **Single Unit Long-Haul Truck** | ART | n/a | n/a | ART | ART | ART |
| **Single Unit Short-Haul Truck** | COL | n/a | n/a | COL | COL | COL |
| **Transit Bus** | COL | n/a | n/a | COL | COL | COL |

The following table shows a comparison of the TCEQ and EPA surrogates for each source use type and process.

**Table 2-7. Comparison of On-Road, Off-Network TCEQ Surrogates to EPA Surrogates**

| Source & Process | TCEQ Surrogate | EPA Surrogate | 2014 $NO_X$ Emissions (tpy) |
|---|---|---|---|
| **Combination Long-Haul APU & Extended Idling** | Interstate Highways (primary) Highways (secondary) | 205 – Extended Idle Locations (2014 Idling Database) | 279.27 |
| **Motorcycle, Passenger Car, Passenger Truck, All** | Population | 535 - Residential + Commercial + Institutional + Government Sq. Ft. (FEMA) | 2,667.27 |
| **Light Commercial Truck, All** | Arterials | 510 - Commercial + Industrial Sq. Ft. (FEMA) | 288.27 |
| **Intercity Buses – All** | Highways | 258 - Intercity Bus Terminals | 0.07 |
| **Transit Buses – All** | Arterials | 259 - Transit Bus Terminals | 0.00 |
| **School Buses – All** | Arterials | 506 - Education Sq. Ft. (FEMA) | 0.21 |
| **Refuse Trucks – All** | Arterials | 875 - Landfills | 2.36 |
| **Short Haul Trucks – All** | Arterials | 256 - Off-Network Short-Haul Trucks (FEMA Industrial + Commercial Sq. Ft. except theaters and parking garages) | 51.70 |
| **Long-Haul Trucks – Start, Evaporative** | Highways | 257 - Off-Network Long-Haul Trucks (FEMA Industrial and Wholesale Trade Sq. Ft.) | 3.45 |
| **Motor Homes – All** | Population | 526 - Residential Non-Institutional (FEMA) | 0.44 |
| **TOTAL** | **n/a** | **n/a** | **3,293.04** |

The off-network activities that have large enough $NO_X$ emissions to meet the 250 tpy threshold are the following:

- Motorcycle, Passenger Car, and Passenger Vehicle start $NO_X$ emissions
- Light Commercial Truck start $NO_X$ emissions
- Combination Long-Haul Truck idling and APU $NO_X$ emissions

The remaining off-network activities only account for 58.23 tpy of $NO_X$ emissions in 2014.

### 2.2.1 Motorcycle, Passenger Car, and Passenger Truck Start Emissions

TCEQ's spatial allocation factors for motorcycle, passenger car, and passenger truck start emissions are based on 2010 Census population data, while EPA's spatial allocation factor is based on FEMA's 2006 estimate of square footage of residential, commercial, institutional, and government square footage, which is included in its 2011 HAZUS 2.0 MH model.

**Table 2-8. Comparison of Alternatives to the Use of Population for Vehicle Starts**

| Parameter | TCEQ | Alt. 1: EPA | Alt. 2: ACS Vehicles Available | Alt. 3: CAMPO |
|---|---|---|---|---|
| **Basis for Surrogate** | Population | Square feet of residential, commercial, institutional, and government buildings | Number of vehicles available by household | Trip origin and destinations |
| **Representation Year(s)** | 2010 | 2006 | 2010-2014, 2011-2015, 2012-2016 | 2010, 2020, 2030, 2040 |
| **Geographic Resolution** | 2010 Census Blocks | 2002 Census Blocks | 2010 Block Groups | 2010 Travel Analysis Zones |
| **Counties** | All | All | All | Bastrop, Burnet, Caldwell, Hays, Travis, and Williamson |
| **Bastrop Resolution (avg. km$^2$)** | 1.0 | 1.0 | 59.0 | 16.7 |
| **Blanco Resolution (avg. km$^2$)** | 4.5 | 4.5 | 262.4 | n/a |
| **Burnet Resolution (avg. km$^2$)** | 1.6 | 1.6 | 95.4 | 25.96 |
| **Caldwell Resolution (avg. km$^2$)** | 1.0 | 1.0 | 56.5 | 14.03 |
| **Fayette Resolution (avg. km$^2$)** | 1.3 | 1.3 | 73.0 | n/a |
| **Hays Resolution (avg. km$^2$)** | 0.4 | 0.4 | 21.9 | 5.9 |
| **Lee Resolution (avg. km$^2$)** | 2.2 | 2.2 | 125.3 | n/a |
| **Llano Resolution (avg. km$^2$)** | 2.3 | 2.3 | 134.4 | n/a |
| **Travis Resolution (avg. km$^2$)** | 0.1 | 0.1 | 4.4 | 2.66 |
| **Williamson Resolution (avg. km$^2$)** | 0.2 | 0.2 | 11.9 | 6.30 |
| **CAPCOG Resolution (avg. km$^2$)** | 0.3 | 0.3 | 20.1 | n/a |

| Parameter | TCEQ | Alt. 1: EPA | Alt. 2: ACS Vehicles Available | Alt. 3: CAMPO |
|---|---|---|---|---|
| **ARR MSA Resolution (avg. km$^2$)** | 0.2 | 0.2 | 11.3 | 5.6 |

The following table shows the number of 2010 Census Block groups in each county, the total land area in square miles, and the average land area of each block group.

**Table 2-9. CAPCOG Region 2010 Census Block Group Land Area Data**

| County | Block Groups | Land Area (km$^2$) | Avg. Land Area per Block Group (km$^2$) |
|---|---|---|---|
| **Bastrop** | 39 | 2,300.30 | 58.98 |
| **Blanco** | 7 | 1,836.95 | 262.42 |
| **Burnet** | 27 | 2,575.12 | 95.37 |
| **Caldwell** | 25 | 1,412.22 | 56.49 |
| **Fayette** | 25 | 1,825.40 | 73.02 |
| **Hays** | 80 | 1,755.96 | 21.95 |
| **Lee** | 13 | 1,629.16 | 125.32 |
| **Llano** | 18 | 2,419.13 | 134.40 |
| **Travis** | 580 | 2,564.61 | 4.42 |
| **Williamson** | 243 | 2,896.39 | 11.92 |
| **TOTAL** | **1,057** | **21,215.23** | **20.07** |

CAMPO's travel demand model uses data from 2010 to simulate trip origins and destinations for a variety of trip types within 2,102 travel analysis zones (TAZs) that cover Bastrop, Burnet, Caldwell, Hays, Travis, and Williamson Counties. Since this data more directly represents actual vehicle starts, it has the potential for being an improvement over TCEQ's surrogate. The travel demand model simulates the following trip types:

1. Home-Based Work (HBW) (a trip from home to work)
2. Home-Based Non-Work – Retail (HBNW-R) (a trip from home to a retail location)
3. Home-Based Non-Work – Other (HBNW-O) (a trip from home to another location)
4. Non-Home-Based Work (NHBW) (a trip from a location other than home to work)
5. Non-Home-Based Other (NHBO) (a trip between two locations other than home and work)
6. Primary Education (ED1)
7. Secondary Education (ED2)
8. University of Texas (UT)
9. Airport (AIR)
10. Truck/Taxi (TR_TX)
11. Non-Home Based External (NHB-EX)
12. External-Local Auto (EXLO_A)
13. External-Local Truck (EXLO_T)

Factors that influence trip generation include:

- Households
- Population
- Median Income/Average Household Income
- Average Household Size
- Area Type
- Total Employment
- Employment by Type

There are also a number of “special generators,” including the following:

- Seton Northwest Hospital
- St. David’s Medical Center
- Zilker Park
- St. Edward’s University
- St. David’s South Austin Hospital
- Central Texas Medical Center

The following table shows the total number of trips generated per weekday by trip type.

**Table 2-10. CAMPO 2010 Travel Demand Model Data on Number of Trip Productions by Trip Type**

| Trip Type | Trip Productions | % of Trip Productions |
|---|---|---|
| **HBW** | 1,196,963 | 16.93% |
| **HBNW-R** | 577,156 | 8.16% |
| **HBNW-O** | 1,038,357 | 14.69% |
| **NHBW** | 1,119,144 | 15.83% |
| **NHBO** | 896,624 | 12.68% |
| **ED1** | 943,913 | 13.35% |
| **ED2** | 138,866 | 1.96% |
| **UT** | 138,866 | 1.96% |
| **AIR** | 21,542 | 0.30% |
| **TR_TX** | 348,778 | 4.93% |
| **NHB-EX** | 346,999 | 4.91% |
| **EXLO_A** | 262,288 | 3.71% |
| **EXLO_T** | 39,751 | 0.56% |
| **TOTAL** | **7,069,247** | **100.00%** |

The table above shows that home-based trips account for 39.78% of all trip productions. Since the spatial allocation factor used by TCEQ is focused on allocating start emissions to population/homes, it is presumably missing the trips generated from other locations.

**Table 2-11. CAMPO TAZ Info**

| County | TAZs | # of TAZs Masked | % of "Basic" Employees in Masked TAZs | % of "Retail" Employees in Masked TAZs | % of "Service" Employees in Masked TAZs |
|---|---|---|---|---|---|
| **Bastrop** | 139 | 16 | 2.03% | 0.26% | 4.69% |
| **Burnet** | 102 | 11 | 0.63% | 0.39% | 0.21% |
| **Caldwell** | 101 | 11 | 2.90% | 0.12% | 0.76% |
| **Hays** | 296 | 31 | 0.95% | 1.11% | 2.19% |
| **Travis** | 998 | 32 | 0.15% | 0.05% | 0.23% |
| **Williamson** | 466 | 41 | 0.56% | 0.11% | 0.38% |
| **TOTAL** | **2,102** | **142** | **0.37%** | **0.17%** | **0.40%** |

Given that a 4 km x 4 km grid cell covers 16 $km^2$, these data suggest that there may not be a great advantage to moving from the block group level of resolution to the block level of resolution in Hays, Travis, and Williamson Counties, but there would be significant improvements in resolution for the other 7 counties in the region. Statewide, there is an average of 57.8 census blocks per census block group.

### 2.2.2 Extended Idle Locations

EPA's surrogates for extended idle locations includes 7 different classes of parking locations:

1. State DOT visitor centers
2. DOT welcome centers
3. DOT rest areas
4. DOT weigh stations
5. DOT parking areas
6. Private truck stops
7. Private retail locations, including Walmart and McDonald's

The shapefile EPA uses includes the latitude and longitude coordinates of the parking location, and includes attributes indicating the number of parking spots at each location to use for weighting a spatial surrogate. The database pulls information from multiple sources, and UNC performed a number of checks, gap-filling procedures, and processing activities to produce the surrogates.

The gap-filling for the number of parking spots was completed as follows:

- If number of spots was listed as <20, set to 20
- If number of spots listed as 20-69, set to 45
- If number of spots listed as >70, set to 70
- If retail locations listed number of spots as "unknown," set to 2
- Weigh stations and parking areas all listed number of spots set as "unknown," set to 2
- For rest areas with missing truck parking spots, calculated 1st quartile, median, and 3rd quartile from all known DOT rest area data and used these as low, medium, and high attributes for the number of spots: results: low = 14, median = 18, high = 31

- For truck stops with missing truck parking spots, calculated 1st quartile, median, and 3rd quartile from all known truck stop data and used these as low, medium, and high attributes for the number of spots; results: low= 80, median = 123, high = 188

These data are from 2014 and represent a much more precise and accurate representation of the spatial distribution of idling and APU emissions than TCEQ's existing surrogates, which simply allocate these emissions to all grid cells with highways equally. This would tend to over-represent this activity in high-density urban areas like downtown Austin, where it is very unlikely to find extended idling activity by combination long-haul trucks. Since this database is newer and potentially more comprehensive than CAPCOG's own truck stop inventory, which was developed based on 2011 data, it may also represent an improvement over CAPCOG's own detailed regional truck stop inventory. CAPCOG recommends that TCEQ adopt this surrogate for the counties in the CAPCOG region, but also strongly recommends revising the emissions for this category statewide to be consistent with this dataset, as it clearly is a better representation of idling locations in 2012 than the 13-year old ERG study that current county-level estimates are based on.[12]

### 2.2.3 Summary of Off-Network Process Recommendations

CAPCOG believes that EPA's off-network surrogates are likely to provide a more accurate spatial representation of off-network activity than TCEQ's surrogates for the CAPCOG area in general.

- EPA's surrogates tie each source use type to a spatial surrogate, based on that specific use and factors likely to be more strongly associated with vehicle starts and parking hours, than TCEQ's surrogates
- EPA's surrogates for extended idling, APU emissions, and off-network activity for motorcycles, passenger cars, and passenger trucks appear to represent better the spatial distribution of what collectively are a significant source of $NO_X$ emissions

Among these options, the use of EPA's surrogates for APU emissions and extended idling emissions appears to be the most obvious improvement over the existing spatial allocation surrogates. While CAPCOG believes that there may be a substantial benefit to TCEQ using EPA's surrogate for motorcycle, passenger car, and passenger vehicle starts instead of population, CAPCOG is also cognizant of the limitations of the modeling process in representing changes in the spatial distribution by hour of the day. Since emissions in the morning tend to have a much more significant impact on peak 8-hour ozone concentrations than emissions late in the afternoon and emissions per start tend to be higher in the morning too due to larger temperature differentials, it is more important to accurately represent the spatial distribution of start emissions in the morning than in the afternoon. This tends to suggest that spatial allocation factors that more heavily weight residential areas will better represent the spatial distribution of the highest-impact start activities on ozone formation than allocation factors that both origins for a round-trip home-to-work or home-to-non-work location would.

[12] ftp://amdaftp.tceq.texas.gov/pub/EI/onroad/aerr/2014/reports/mvs14_aerr_2014.tex_214co_final.pdf, ftp://amdaftp.tceq.texas.gov/pub/EI/onroad/aerr/2014/reports/mvs14_aerr_2014.aus_6co_final.pdf, see references to 2004 ERG study.

# 3 Non-Road Sources

The following table summarizes the EPA surrogates for non-road sources along with the impacted sources and 2014 $NO_X$ emissions.

**Table 3-1. EPA Non-Road Surrogates Not Updated by TCEQ**

| Surrogate | Desc. | Sources Impacted | Source Desc. | $NO_X$ |
|---|---|---|---|---|
| **100** | 2010 Population | 22xx003060 | Refrigeration Trucks | 150.89 |
| **140** | 50% Population, 50% Housing Change | 22xx0020xx | Construction & Mining Equipment | 4,287.11 |
| **261** | NTAD Total Roadway Density | 228500x015 | Railway Maintenance | 8.80 |
| **271** | NTAD Class 1, 2, and 3 Railroad Density | 2285002006 | Class I Locomotives | 1,414.25 |
| **280** | Class 2 and 3 Railroad Miles | 2285002007 | Class II/III Locomotives | 226.76 |
| **300** | Low-Intensity Residential Land | 22xx004015<br>22xx004020<br>22xx004025<br>22xx004030<br>22xx004035<br>22xx004040<br>22xx004055<br>22xx004075 | Residential Lawn and Garden Equipment | 104.65 |
| **310** | Agricultural Land | 22xx0050xx | Agricultural Equipment | 1,952.30 |
| **350** | Water | 2282005010<br>2282005015<br>2282010005<br>2282020005<br>2282020010 | Recreational Marine | 102.60 |
| **400** | Rural Land Area | 22xx001010<br>22xx001030 | ATVs & Off-Road Motorcycles | 60.08 |
| **505** | Industrial Land | 22xx003010<br>22xx003020<br>22xx003040<br>22xx003050<br>22xx003070 | Industrial Equipment Except for Refrigeration Units and Sweepers/Scrubbers | 403.89 |
| **510** | Commercial Plus Industrial | 22xx003030<br>22xx0060xx | Sweepers/Scrubbers and Commercial Equipment | 470.03 |
| **520** | Commercial Plus Industrial Plus Institutional | 22xx001060<br>22xx004016<br>22xx004031<br>22xx004046<br>22xx004066<br>22xx004071 | Specialty Vehicles, Lawn and Garden Equipment | 108.31 |
| **850** | Golf Courses | 22xx001050 | Golf Cart | 7.26 |
| **TOTAL** | **n/a** | **n/a** | **n/a** | **9,296.93** |

ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/spatial_surrogates/US_SpatialSurrogate_Workbook_v072115.xlsx

## 3.1 Agricultural Equipment

EPA's "Agricultural Land" surrogate is used to spatially allocate emissions from non-road agricultural equipment, which accounts for 1,952.30 tpy of $NO_X$ emissions. Agricultural equipment includes 10 equipment types:

- 22xx005010: 2-Wheel Tractors,
- 22xx005015: Agricultural Tractors,
- 22xx005020: Combines,
- 22xx005025: Balers
- 22xx005030: Agricultural Mowers,
- 22xx005035: Sprayers,
- 22xx005040: Tillers >6 HP,
- 22xx005045: Swathers,
- 22xx005055: Other Agricultural Equipment, and
- 22xx005060: Irrigation Sets.

The total $NO_X$ emissions for each of these equipment types in the 2014 NEI v. 1 is shown below.

**Table 3-2. 2014 Non-Road Agricultural Equipment $NO_X$ Emissions by Equipment Type**

| Equipment Type | $NO_X$ (tpy) | % |
|---|---|---|
| **2-Wheel Tractors** | 10.91 | 0.56% |
| **Agricultural Tractors** | 1,398.30 | 71.62% |
| **Combines** | 82.35 | 4.22% |
| **Balers** | 46.57 | 2.39% |
| **Agricultural Mowers** | 63.59 | 3.26% |
| **Sprayers** | 110.81 | 5.68% |
| **Tillers >6 HP** | 38.27 | 1.96% |
| **Swathers** | 18.78 | 0.96% |
| **Other Agricultural Equipment** | 62.63 | 3.21% |
| **Irrigation Sets** | 120.09 | 6.15% |
| **TOTAL** | **1,952.30** | **100.00%** |

As the data above shows, agricultural tractors are the dominant source of $NO_X$ emissions among the agricultural equipment category and is the only individual equipment type that meets the 250 tpy on its own. However, the other 9 equipment categories collectively account for 554.00 tpy as well.

According to EPA's surrogate documentation, the "Agricultural Land" surrogate used for all 10 of these equipment types was based on areas identified as 2006 National Land Cover Database (NLCD) as "Pasture/Hay" and "Row Crops." Information on this database is available online at https://www.mrlc.gov/nlcd2006.php. The classification system used by the 2006 NLCD includes the following categories:

**Table 3-3. 2006 NLCD Land Cover Classifications**

| Code | Category | Description |
|---|---|---|
| **11** | Water | Open Water – Areas of open water, generally with less than 25% cover of vegetation or soil |
| **12** | Water | Perennial Ice/Snow – areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover |
| **21** | Developed | Developed, Open Space – areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes |
| **22** | Developed | Developed, Low-Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units. |
| **23** | Developed | Developed, Medium Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units. |
| **24** | Developed | Developed High Intensity -highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover. |
| **31** | Barren | Barren Land (Rock/Sand/Clay) - areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover. |
| **41** | Forest | Deciduous Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change. |
| **42** | Forest | Evergreen Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage. |
| **43** | Forest | Mixed Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover. |
| **44** | Shrubland | Dwarf Scrub - Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation. |
| **45** | Shrubland | Shrub/Scrub - areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions. |

| Code | Category | Description |
|---|---|---|
| **46** | Herbaeceous | Grassland/Herbaceous - areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing. |
| **72** | Herbaceous | Sedge/Herbaceous - Alaska only areas dominated by sedges and forbs, generally greater than 80% of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra. |
| **73** | Herbaceous | Lichens - Alaska only areas dominated by fruticose or foliose lichens generally greater than 80% of total vegetation. |
| **74** | Herbaceous | Moss - Alaska only areas dominated by mosses, generally greater than 80% of total vegetation. |
| **81** | Planted/Cultivated | Pasture/Hay - areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation. |
| **82** | Planted/Cultivated | Cultivated Crops - areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled. |
| **90** | Wetlands | Woody Wetlands - areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water. |
| **91** | Wetlands | Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water. |

The “agricultural land” surrogate is based on the “Pasture/Hay” (81) and “Cultivated Crops” (82) land use codes. The total land area of the U.S. is 3.797 million square miles, and the NLCD statistics indicate that “agriculture” accounted for 22.24% of the total land cover.[13] This translates to 0.844 million square miles, or 540 million acres. Land used for cultivated crops accounts for 377 million acres, while pasture/hay accounts for the remaining 163 million acres.

The estimate for total cropland is relatively close to the reported total cropland nation-wide in the 2007 Census of Agriculture (406 million acres), but the estimate for pasture/hay is well below the 409 million acres of permanent pasture and rangeland reported in the 2007 Census.[14] Based on the descriptions above, it is reasonable to conclude that a significant share of the missing land is categorized in the “grassland/herbaceous” category, which specifies that this type of land is not used for more intensive agricultural activities but could be used for grazing.

[13] https://www.mrlc.gov/nlcd06_stat.php
[14] https://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_US/st99_1_008_008.pdf

The spatial resolution of this dataset is highly granular – just 30 meters – making it a high-quality product for identifying local land use. An accuracy assessment of this database found that overall "level 1" (i.e., "category") accuracy for the 2006 NLCD was 84%.[15]

The most obvious update that could be made to the spatial allocation factors would be the use of the more recent 2011 NLCD, which was released in 2015.[16] However, a more detailed product focused on representing agricultural land is available through the U.S. Department of Agriculture's (USDA's) CropLand Data Layer (CDL) and its CropScape application.[17] The CDL provides year-specific data on agricultural activity at the 30 m resolution level. An accuracy assessment for the 2012 CDL for Texas showed an 81.3% overall accuracy level for all land use types, an 88.1% accuracy level for corn, a 92.2% accuracy level for cotton, a 90.9% accuracy level for winter wheat, and an 80.9% accuracy level for sorghum, the main cultivated crops within the state. The accuracy level for grassland/pasture was 72.6%. This category includes "pasture/grass," "grassland herbaceous," and "pasture/hay."

CAPCOG used the 2012 CropScape data to develop updated spatial allocation factors for the county-level emissions estimates. In order to do so, CAPCOG used ArcGIS to spatially join the land use data with the TCEQ's four kilometer modeling grid domain. This allowed each 30 meter CropScape data cell to be assigned to the 4 kilometer grid cell that it falls within. CAPCOG then matched land use types to equipment types based on the description for each SCC in the NONROAD user's guide.

Agricultural tractors and irrigation sets, which are the first and second largest sources of $NO_X$ emissions in this class of non-road equipment in the region, were assigned equally to all agricultural land use types. For other land use types, two-wheel tractors and tillers >6 HP were assigned to high-intensity crop production such as vegetables, fruits, and other tree crops. Combines were assigned to oilseed and grain crop types. Balers, agricultural mowers, and swathers were assigned to the pasture/hay category. The "other agricultural equipment" category, which includes various types of specialized harvesting equipment, was assigned exclusively to the cotton land use type due to the more energy-intensive nature of cotton harvesting and prior research suggesting that cotton harvesters made up most of this equipment. The following table shows the land use types that were assigned to each equipment type, listed as column headings. The numbers represent the last four digits of the source classification codes:

- 5010 = 2-wheeled tractors,
- 5015 = agricultural tractors,
- 5020 = combines,
- 5025 = balers,
- 5030 = agricultural mowers,
- 5035 = sprayers,
- 5040 = tillers >6 HP,
- 5045 = swathers,
- 5055 = other agricultural equipment (inc. forage harvesters and cotton pickers/strippers), and

[15] http://www.sciencedirect.com/science/article/pii/S0034425712004579?via%3Dihub
[16] https://www.mrlc.gov/nlcd2011.php
[17] https://www.nass.usda.gov/Research_and_Science/Cropland/sarsfaqs2.php

- 5060 = irrigation sets.

**Table 3-4. Assignment of Equipment to CropScape Land Use Types**

| Land Use Category | 5010 | 5015 | 5020 | 5025 | 5030 | 5035 | 5040 | 5045 | 5055 | 5060 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Corn** | | X | X | | | X | | | | X |
| **Cotton** | | X | X | | | X | | | X | X |
| **Rice** | | X | X | | | X | | | | X |
| **Sorghum** | | X | X | | | X | | | | X |
| **Soybeans** | | X | X | | | X | | | | X |
| **Sunflower** | | X | X | | | X | | | | X |
| **Peanuts** | | X | X | | | X | | | | X |
| **Barley** | | X | X | | | X | | | | X |
| **Spring Wheat** | | X | X | | | X | | | | X |
| **Winter Wheat** | | X | X | | | X | | | | X |
| **Dbl Crop WinWht/Soybeans** | | X | X | | | X | | | | X |
| **Rye** | | X | X | | | X | | | | X |
| **Oats** | | X | X | | | X | | | | X |
| **Millet** | | X | X | | | X | | | | X |
| **Alfalfa** | | X | | X | X | X | | X | | X |
| **Other Crops** | X | X | | | | X | X | | | X |
| **Misc Vegs & Fruits** | X | X | | | | X | X | | | X |
| **Onions** | X | X | | | | X | X | | | X |
| **Peas** | X | X | | | | X | X | | | X |
| **Other Tree Crops** | X | X | | | | X | X | | | X |
| **Pasture/Hay** | | X | | X | X | X | | X | | X |

CAPCOG spatially allocated the emissions at the county level. The following table shows statistical analyses of all cells' updated allocation values by county. The following tables shows statistics for all cells in each county for each equipment type using these updated surrogates relative to the 2006 Agricultural Land surrogate used by EPA and TCEQ.

**Table 3-5. Bastrop County Changes in Ag Allocations**

| Equipment Type | Max Increase | Max Decrease | Avg. Deviation | St. Deviation |
|---|---|---|---|---|
| **5010** | 0.127 | -0.016 | 0.007 | 0.015 |
| **5015** | 0.014 | -0.013 | 0.003 | 0.004 |
| **5020** | 0.024 | -0.011 | 0.004 | 0.006 |
| **5025** | 0.011 | -0.014 | 0.003 | 0.004 |
| **5030** | 0.011 | -0.014 | 0.003 | 0.004 |
| **5035** | 0.014 | -0.013 | 0.003 | 0.004 |
| **5040** | 0.127 | -0.016 | 0.007 | 0.015 |
| **5045** | 0.011 | -0.014 | 0.003 | 0.004 |
| **5055** | 0.066 | -0.014 | 0.006 | 0.010 |
| **5060** | 0.014 | -0.013 | 0.003 | 0.004 |

**Table 3-6. Blanco County Changes in Ag Allocations**

| Equipment Type | Max Increase | Max Decrease | Avg. Deviation | St. Deviation |
|---|---|---|---|---|
| **5010** | 0.121 | -0.073 | 0.009 | 0.020 |
| **5015** | 0.015 | -0.069 | 0.009 | 0.014 |
| **5020** | 0.031 | -0.070 | 0.007 | 0.012 |
| **5025** | 0.016 | -0.069 | 0.009 | 0.014 |
| **5030** | 0.016 | -0.069 | 0.009 | 0.014 |
| **5035** | 0.015 | -0.069 | 0.009 | 0.014 |
| **5040** | 0.121 | -0.073 | 0.009 | 0.020 |
| **5045** | 0.016 | -0.069 | 0.009 | 0.014 |
| **5055** | 0.130 | -0.079 | 0.010 | 0.023 |
| **5060** | 0.015 | -0.069 | 0.009 | 0.014 |

**Table 3-7. Burnet County Changes in Ag Allocations**

| Equipment Type | Max Increase | Max Decrease | Avg. Deviation | St. Deviation |
|---|---|---|---|---|
| **5010** | 0.080 | -0.060 | 0.007 | 0.015 |
| **5015** | 0.012 | -0.080 | 0.007 | 0.012 |
| **5020** | 0.046 | -0.071 | 0.006 | 0.011 |
| **5025** | 0.013 | -0.080 | 0.007 | 0.012 |
| **5030** | 0.013 | -0.080 | 0.007 | 0.012 |
| **5035** | 0.012 | -0.080 | 0.007 | 0.012 |
| **5040** | 0.080 | -0.060 | 0.007 | 0.015 |
| **5045** | 0.013 | -0.080 | 0.007 | 0.012 |
| **5055** | 0.235 | -0.086 | 0.009 | 0.025 |
| **5060** | 0.012 | -0.080 | 0.007 | 0.012 |

**Table 3-8. Caldwell County Changes in Ag Allocations**

| Equipment Type | Max Increase | Max Decrease | Avg. Deviation | St. Deviation |
|---|---|---|---|---|
| **5010** | 0.204 | -0.028 | 0.014 | 0.027 |
| **5015** | 0.015 | -0.020 | 0.004 | 0.006 |
| **5020** | 0.032 | -0.021 | 0.006 | 0.008 |
| **5025** | 0.011 | -0.019 | 0.005 | 0.006 |
| **5030** | 0.011 | -0.019 | 0.005 | 0.006 |
| **5035** | 0.015 | -0.020 | 0.004 | 0.006 |
| **5040** | 0.204 | -0.028 | 0.014 | 0.027 |
| **5045** | 0.011 | -0.019 | 0.005 | 0.006 |
| **5055** | 0.058 | -0.025 | 0.009 | 0.014 |
| **5060** | 0.015 | -0.020 | 0.004 | 0.006 |

**Table 3-9. Fayette County Changes in Ag Allocations**

| Equipment Type | Max Increase | Max Decrease | Avg. Deviation | St. Deviation |
|---|---|---|---|---|
| **5010** | 0.187 | -0.015 | 0.008 | 0.021 |
| **5015** | 0.009 | -0.012 | 0.003 | 0.004 |
| **5020** | 0.039 | -0.011 | 0.004 | 0.006 |

| Equipment Type | Max Increase | Max Decrease | Avg. Deviation | St. Deviation |
|---|---|---|---|---|
| **5025** | 0.010 | -0.012 | 0.004 | 0.005 |
| **5030** | 0.010 | -0.012 | 0.004 | 0.005 |
| **5035** | 0.009 | -0.012 | 0.003 | 0.004 |
| **5040** | 0.187 | -0.015 | 0.008 | 0.021 |
| **5045** | 0.010 | -0.012 | 0.004 | 0.005 |
| **5055** | 0.066 | -0.015 | 0.005 | 0.009 |
| **5060** | 0.009 | -0.012 | 0.003 | 0.004 |

**Table 3-10. Hays County Changes in Ag Allocations**

| Equipment Type | Max Increase | Max Decrease | Avg. Deviation | St. Deviation |
|---|---|---|---|---|
| **5010** | 0.074 | -0.046 | 0.009 | 0.016 |
| **5015** | 0.012 | -0.038 | 0.007 | 0.010 |
| **5020** | 0.038 | -0.022 | 0.003 | 0.006 |
| **5025** | 0.013 | -0.042 | 0.008 | 0.012 |
| **5030** | 0.013 | -0.042 | 0.008 | 0.012 |
| **5035** | 0.012 | -0.038 | 0.007 | 0.010 |
| **5040** | 0.074 | -0.046 | 0.009 | 0.016 |
| **5045** | 0.013 | -0.042 | 0.008 | 0.012 |
| **5055** | 0.064 | -0.025 | 0.004 | 0.009 |
| **5060** | 0.012 | -0.038 | 0.007 | 0.010 |

**Table 3-11. Lee County Changes in Ag Allocations**

| Equipment Type | Max Increase | Max Decrease | Avg. Deviation | St. Deviation |
|---|---|---|---|---|
| **5010** | 0.145 | -0.023 | 0.012 | 0.022 |
| **5015** | 0.024 | -0.011 | 0.003 | 0.005 |
| **5020** | 0.054 | -0.014 | 0.005 | 0.008 |
| **5025** | 0.018 | -0.016 | 0.004 | 0.005 |
| **5030** | 0.018 | -0.016 | 0.004 | 0.005 |
| **5035** | 0.024 | -0.011 | 0.003 | 0.005 |
| **5040** | 0.145 | -0.023 | 0.012 | 0.022 |
| **5045** | 0.018 | -0.016 | 0.004 | 0.005 |
| **5055** | 0.117 | -0.023 | 0.008 | 0.015 |
| **5060** | 0.024 | -0.011 | 0.003 | 0.005 |

**Table 3-12. Llano County Changes in Ag Allocations**

| Equipment Type | Max Increase | Max Decrease | Avg. Deviation | St. Deviation |
|---|---|---|---|---|
| **5010** | 0.087 | -0.109 | 0.008 | 0.019 |
| **5015** | 0.011 | -0.157 | 0.009 | 0.018 |
| **5020** | 0.050 | -0.135 | 0.009 | 0.018 |
| **5025** | 0.011 | -0.158 | 0.009 | 0.018 |
| **5030** | 0.011 | -0.158 | 0.009 | 0.018 |
| **5035** | 0.011 | -0.157 | 0.009 | 0.018 |
| **5040** | 0.087 | -0.109 | 0.008 | 0.019 |

| Equipment Type | Max Increase | Max Decrease | Avg. Deviation | St. Deviation |
|---|---|---|---|---|
| **5045** | 0.011 | -0.158 | 0.009 | 0.018 |
| **5055** | 0.152 | -0.097 | 0.008 | 0.022 |
| **5060** | 0.011 | -0.157 | 0.009 | 0.018 |

**Table 3-13. Travis County Changes in Ag Allocations**

| Equipment Type | Max Increase | Max Decrease | Avg. Deviation | St. Deviation |
|---|---|---|---|---|
| **5010** | 0.326 | -0.030 | 0.008 | 0.026 |
| **5015** | 0.012 | -0.019 | 0.004 | 0.005 |
| **5020** | 0.014 | -0.018 | 0.002 | 0.004 |
| **5025** | 0.015 | -0.025 | 0.005 | 0.007 |
| **5030** | 0.015 | -0.025 | 0.005 | 0.007 |
| **5035** | 0.012 | -0.019 | 0.004 | 0.005 |
| **5040** | 0.326 | -0.030 | 0.008 | 0.026 |
| **5045** | 0.015 | -0.025 | 0.005 | 0.007 |
| **5055** | 0.018 | -0.018 | 0.003 | 0.005 |
| **5060** | 0.012 | -0.019 | 0.004 | 0.005 |

**Table 3-14. Williamson County Changes in Ag Allocations**

| Equipment Type | Max Increase | Max Decrease | Avg. Deviation | St. Deviation |
|---|---|---|---|---|
| **5010** | 0.101 | -0.016 | 0.006 | 0.012 |
| **5015** | 0.006 | -0.011 | 0.003 | 0.004 |
| **5020** | 0.008 | -0.010 | 0.002 | 0.003 |
| **5025** | 0.012 | -0.014 | 0.004 | 0.006 |
| **5030** | 0.012 | -0.014 | 0.004 | 0.006 |
| **5035** | 0.006 | -0.011 | 0.003 | 0.004 |
| **5040** | 0.101 | -0.016 | 0.006 | 0.012 |
| **5045** | 0.012 | -0.014 | 0.004 | 0.006 |
| **5055** | 0.020 | -0.011 | 0.003 | 0.004 |
| **5060** | 0.006 | -0.011 | 0.003 | 0.004 |

These allocation surrogates provide a significantly improved spatial representation of emissions from agricultural equipment compared to the TCEQ allocation surrogates. They provide highly resolved spatial data that account for differences in the types of agricultural equipment likely to be used on different types of farmland and provides a much more up-to-date representation of the geographic allocation of agricultural activity.

## 3.2 Construction and Mining Equipment

EPA's spatial surrogate for construction and mining equipment relies 50% on population and 50% on change in housing between 2000 and 2010. TexN models the construction and mining equipment class of non-road equipment using 24 diesel construction equipment (DCE) subsectors, each of which has different equipment profiles and equipment population, with each modeling run's outputs aggregated back up to the SCC level. The following table shows the DCE subsectors with the largest estimates of $NO_X$

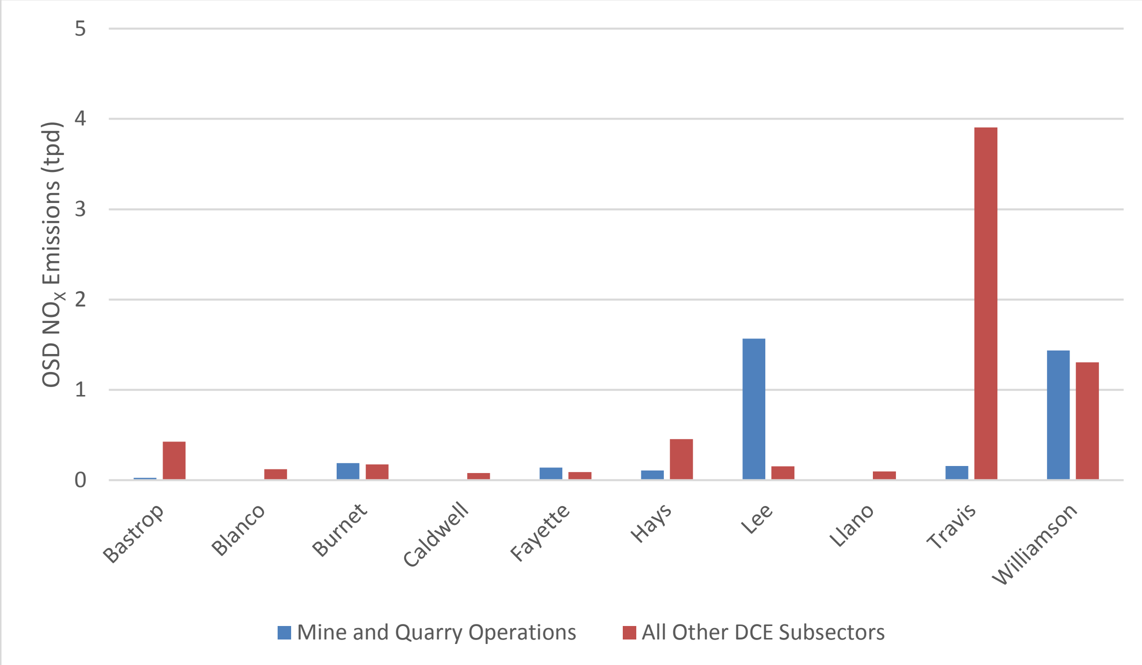
emissions for the region, based on a default 2014 ozone season weekday TexN run for CAPCOG's 10-county region.

**Table 3-15. 2014 TexN Source Ozone Season Day $NO_X$ Emissions by DCE Subsectors (tpd)**

| DCE Subsector | $NO_X$ (tpd) | % |
|---|---|---|
| **Mining and Quarry Equipment** | 3.6205 | 34.73% |
| **Rough Terrain Forklifts** | 1.0974 | 10.53% |
| **Skid Steer Loaders** | 0.9930 | 9.53% |
| **Residential Construction** | 0.7498 | 7.19% |
| **Trenchers** | 0.6948 | 6.66% |
| **Transportation/Sales/Services** | 0.5735 | 5.50% |
| **Off-Road, Tractors, Misc. Equipment, and all Equipment <25 HP** | 0.5153 | 4.94% |
| **Commercial Construction** | 0.3932 | 3.77% |
| **Cranes** | 0.3762 | 3.61% |
| **Heavy Highway Construction** | 0.3424 | 3.28% |
| **OTHER 14 DCE SUBSECTOR** | 1.0686 | 10.25% |
| **TOTAL DCE** | **10.4247** | **100.00%** |

Each of the 24 DCE subsectors represents a distinct set of activity data, very few of which would be expected to be highly correlated to 2010 population or 2000-2010 population change. TexN separately generates each of the 24 DCE subsector emissions, then aggregates these distinct run files into an aggregate output file that includes totals for each SCC by horsepower range. EPA's modeling protocol involves allocating county-level emissions for each SCC, but does not differentiate the emissions for a given SCC code by DCE subsector This poses a problem for developing and implementing a separate modeling-preparation protocol if CAPCOG wanted to strictly allocate each DCE subsector to spatial allocation surrogates separate, or a complicated, county-specific weighted surrogate accounting or each SCC code in the construction and mining equipment class. So while there are data that exist that could provide significant improvements to the allocation of construction and mining equipment, particularly in representing the quarry and mine subsector, CAPCOG initially decided not to pursue updates for the construction and mining sector. However, upon the announcement that the Three Oaks Mine in Bastrop County and Lee County was going to close in early 2018, CAPCOG decided to evaluate whether simply substituting spatial allocation factors based on mine and quarry activity for the existing surrogate in some counties might be appropriate. The following figure shows the $NO_X$ emissions for quarry and non-quarry DCE subsectors by county.

**Figure 3-1. 2014 Non-Road Construction Equipment $NO_X$ Emissions Quarry and Non-Quarry $NO_X$ Emissions (tpd)**

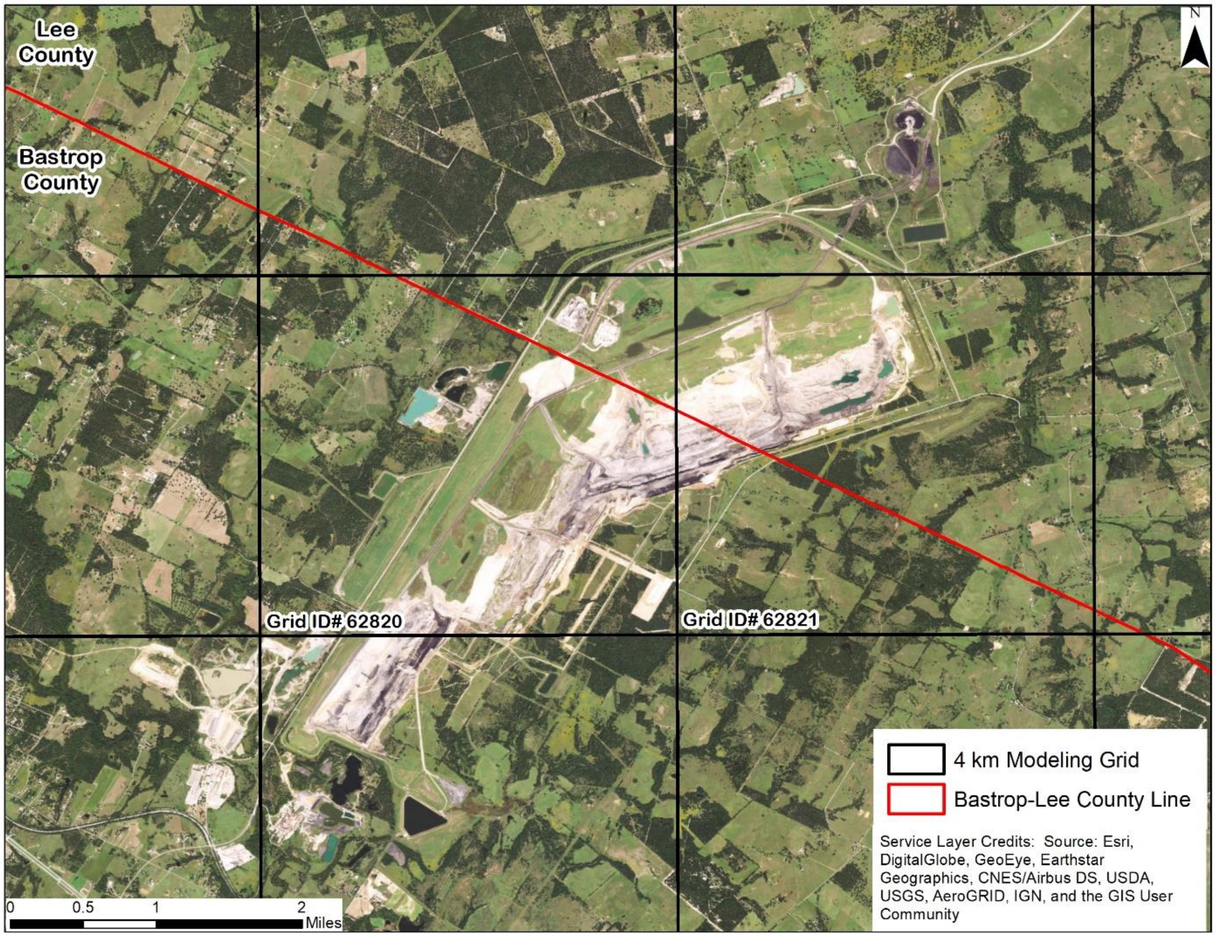



The mine and quarry subsector makes up 0% of the emissions for three counties: Blanco, Caldwell, and Llano, but it makes up more than 50% of the construction and mining equipment in Burnet (52.18%), Fayette (60.85%), Lee (91.14%), and Williamson (52.43%) Counties. Since updates to the spatial allocation factors for any of these counties would constitute a distinct data-collection effort, CAPCOG focused on Lee and Williamson Counties. CAPCOG looked up data on the quarries and mines in Lee and Williamson Counties, since total $NO_X$ emissions for each county in this subsector exceeded 1 tpd.

CAPCOG then reviewed the number of mines and quarries in each county in order to evaluate the level of effort that would be required to update the construction and mining surrogate for that county. Lee County had one mine or quarry – the Three Oaks Mine that is scheduled to close, while Williamson County had 35 active quarries as of 11/10/2017, and 42 abandoned quarries. Due to the relative simplicity of updating the Lee County data, CAPCOG chose to focus on updating this county's construction and mining equipment spatial allocation surrogates to better capture the location of the county's single mine.

The Three Oaks Coal Mine is listed as being located in Lee County in the Mine Health and Safety Administration's Data Retrieval System, but, as the map below shows, it actually is located in both Lee County and Bastrop County and in fact, most of the spatial extent of the mining activity appears to occur within Bastrop County. In TexN though, the activity and emissions are only accounted for as being in Lee County. As the figure below shows, the mine appears to include some activity in four grid cells – two split between Bastrop and Lee Counties, one exclusively in Bastrop County and one exclusively in Lee County.

**Figure 3-2. Three Oaks Mine**




Since the vast majority of the spatial extent of the mine is within two grid cells covered by Bastrop and Lee Counties and the photochemical model merges emissions from each county into each grid cell during emissions processing, the fact that the emissions are only accounted for in Lee County's inventory does not pose a significant problem. Only a small portion of the mine is exclusively in Bastrop County immediately to the south of grid ID 62820. There also appears to be a coal pile directly to the north of grid ID 62821 that is exclusively in Lee County, but this is not likely to account for nearly as much activity as the areas of the mine where coal is actually being extracted from the ground.

As a result, CAPCOG decided to modify the spatial allocation surrogate for the SCC codes included in the mine and quarry subsector in Lee County to allocate 50% of their emissions to grid ID 62820 and 50% to grid ID 62821. These SCCs included:

- 2270002018: Scrapers,
- 2270002036: Excavators,
- 2270002048: Graders,
- 2270002051: Trucks,
- 2270002060: Loaders, and

- 2270002069: Dozers.

CAPCOG decided that, given the fact that mine and quarry equipment account for more than 90% of the county's construction and mining equipment $NO_X$ emissions, this approach was reasonable, particularly since it retains the existing spatial allocation surrogate for all remaining DCE subsectors. CAPCOG also felt that this was a better choice than trying to develop some kind of weighted allocation factor due to CAPCOG's concerns regarding the reliability of the existing surrogate for representing other types of construction activity as well.

Since the mine is scheduled to close in January 2018 and, consistent with a separate project CAPCOG completed under Task 2.2 to update the DCE subsector activity data in the TexN database to reflect this development, CAPCOG recommends only using this spatial allocation factor for analysis years up through (and including) 2017, but to revert to using the default EPA allocation factor for Lee County for 2018 and beyond.

## 3.3 Industrial Equipment

EPA's surrogate for 5 of the 7 industrial equipment (excluding sweeper/scrubbers and refrigeration units) is based on 2006 square footage of "industrial" buildings. This includes the sum of the following classifications:

- IND1 – Heavy
- IND2 – Light
- IND3 – Food/Drugs/Chemicals
- IND4 – Metals/Minerals/Processing
- IND5 – High Technology
- IND6 – Construction

This spatial allocation surrogate includes the equipment types listed below, along with the associated 2014 $NO_X$ emissions.

**Table 3-16. Industrial equipment categories allocated by industrial land (2014)**

| Equipment | $NO_X$ | % |
|---|---|---|
| **Aerial Lifts** | 13.21 | 3.27% |
| **Forklifts** | 331.22 | 82.01% |
| **Other General Industrial Equipment** | 32.58 | 8.07% |
| **Other Material Handling Equipment** | 2.12 | 0.53% |
| **Terminal Tractors** | 24.76 | 6.13% |
| **TOTAL** | **403.89** | **100.00%** |

Given the importance of forklifts in this group, focusing on whether or not this surrogate is appropriate for forklifts if the most important part of the analysis for this spatial allocation factor. Prior research conducted by TCEQ and CAPCOG on industrial forklifts has shown that a wide variety of establishments aside from manufacturing establishments, including retail, wholesale trade, and warehouses, also use forklifts. The table below shows the number of forklift sales within the region by SIC code from CAPCOG's 2013 study.

**Table 3-17. CAPCOG Region Forklift UCC Records by SIC Code**

| SIC Code Group | Description | Forklift Sales |
|---|---|---|
| **01-09** | Agricultural, Forestry, and Finishing | 7 |
| **10-14** | Mining | 5 |
| **15-17** | Construction | 49 |
| **20-39** | Manufacturing | 209 |
| **40-49** | Transportation, Communications, Electric, Gas, and Sanitary Services | 122 |
| **50-51** | Wholesale Trade | 120 |
| **52-59** | Retail Trade | 125 |
| **60-67** | Finance, Insurance, and Real Estate | 1 |
| **70-89** | Services | 30 |
| **91-99** | Public Administration | 26 |
| **TOTAL** | **TOTAL** | **694** |

Given that only 30% of the forklifts in this record were purchased in the manufacturing sector, it seems that a broader spatial allocation surrogate for forklifts that includes some other building types other than "industrial" would be appropriate. From CAPCOG's review of the building classifications and these sales data, CAPCOG believes that it would be appropriate to add the following building types:

- COM1 – Retail Trade
- COM2 – Wholesale Trade

However, given the level of effort required, CAPCOG has decided not to further pursue this project.

## 3.4 Commercial Equipment and Sweepers/Scrubbers

The existing surrogate that EPA is using to allocate sweepers/scrubbers (22xx003030) and all commercial equipment (22xx0060xx) is 2006 building square footage in the following categories:

- COM1: Retail Trade
- COM2: Wholesale Trade
- COM3: Personal and Repair Services
- COM4: Professional/Technical Services
- COM5: Banks
- COM6: Hospital
- COM7: Medical Office/Clinic
- COM8: Entertainment & Recreation
- COM9: Theaters
- IND1: Heavy
- IND2: Light
- IND3: Food/Drugs/Chemicals
- IND4: Metals/Minerals Processing

- IND5: High Technology
- IND6: Construction

The equipment types impacted by this surrogate and their 2014 $NO_X$ emissions are shown below.

**Table 3-18. Non-Road Equipment Types Allocated Under Surrogate Code 510: Commercial and Industrial**

| Equipment Type | $NO_X$ (tpy) | % |
|---|---|---|
| **Sweepers/Scrubbers** | 27.22 | 5.79% |
| **Generator Sets** | 224.77 | 47.82% |
| **Pumps** | 49.92 | 10.62% |
| **Air Compressors** | 76.92 | 16.36% |
| **Gas Compressors** | 3.21 | 0.68% |
| **Welders** | 58.56 | 12.46% |
| **Pressure Washers** | 25.51 | 5.43% |
| **Hydro Power Units** | 3.93 | 0.84% |
| **TOTAL** | **470.03** | **100.00%** |

Given the diversity of these equipment types, CAPCOG thinks that a different EPA surrogate that includes governmental, institutional, and education buildings would likely be a better representation of the spatial distribution of these equipment types. Since Austin also has many special events throughout ozone season, and these activities typically require significant amounts of portable generators, it would be reasonable to also allocate some share of the generator emissions to locations like Zilker Park, Auditorium Shores, Fiesta Gardens, Circuit of the Americas, and the University of Texas campus could help reflect this activity. However, since generators by themselves do not meet the 250 tpy threshold and improvements to the spatial allocation for this one equipment type would require significant resources, CAPCOG did not feel like this was a worthwhile project to pursue. In general, commercial equipment is one of the least-studied of the non-road categories. CAPCOG has some data on sweepers/scrubbers as part of its industrial equipment emissions inventory update project several years ago, and ERG's off-road inventory for California[18] did include information on each equipment type:

- Air Compressors (247)
- Compressor (1)
- Generator Sets (2)
- Hydro-Pumps (1)
- Pressure Washers (1)
- Pumps (1)
- Welders (13)

However, no Texas-specific data on these equipment types are available in any existing literature that CAPCOG has been able to identify and the existing TexN emissions inventories simply rely on the default

[18] https://www.arb.ca.gov/research/apr/past/04-315.pdf

NONROAD activity inputs. Therefore, there is not much information to go on to work towards improving the spatial allocation of emissions from this category.

## 3.5 Rail and Airports

TCEQ's spatial allocation factors for rail and airport emissions are both spatially allocated based on custom-made TCEQ surrogates. Original data collection efforts could provide additional levels of detail to these sources. For example, CAPCOG could survey rail operators to obtain episode-specific data on rail usage within the region or attempt to spatially allocate ABIA's emissions three-dimensionally based on flight data, similar to a project AACOG completed several years ago[19]. CAPCOG has concluded that the existing surrogates for these categories are high-quality enough that it is not likely that the type of significant data collection efforts that would be required to achieve these improvements would substantially improve modeling results.

## 3.6 Summary of Non-Road Review

Several different non-road source categories and associated spatial allocation factors accounted for significant sources of $NO_X$ emissions within the region, including:

- Agricultural equipment
- Construction and mining equipment
- Industrial equipment (minus refrigerator units and sweepers/scrubbers)
- Commercial equipment and sweepers/scrubbers
- Rail equipment
- Airports/aircraft

Of these categories, CAPCOG decided to develop wholesale updates for the spatial allocation factors for all 10 equipment types under the agricultural equipment category based on similar prior methods developed in 2013 and using USDA's CropScape application. CAPCOG also prepared a targeted update to the spatial surrogate for six construction and mining equipment SCC codes within Lee County in order to better represent the extent to which the Three Oaks Mine accounts for Lee County's construction and mining equipment $NO_X$ emissions. These updates should provide important improvements in the spatial representation of non-road $NO_X$ emissions within the region.

CAPCOG also analyzed the existing surrogates for the other equipment types and determined for various reasons not to pursue updates, but did provide some fairly specific suggestions for improvements that could be made by TCEQ or EPA on a more wholesale basis across the state next time they perform photochemical modeling and develop the required spatial allocation files.

# 4 Area Sources

The following table provides a summary of each of the EPA 2011v6.2 spatial allocation surrogates used for area sources that were not updated by EPA (i.e., all sources other than oil and gas production). The

[19] https://pdfs.semanticscholar.org/7fa3/29b26eaae7ff26da52d6a64517089ccf429a.pdf

table includes the EPA surrogate code, a description of the surrogate, the SCCs affected, the SCC description, and the 2014 $NO_X$ emissions region-wide associated with that spatial allocation surrogate.

**Table 4-1. EPA 2011v6.2 Area Source Surrogates**

| EPA 2011v6.2 Surrogate Code | Description | SCCs Affected | SCC Description | Impacted $NO_X$ Emissions, 2014 |
|---|---|---|---|---|
| **140** | 50% Housing Change, 50% Population | 2610000500 | Open Burning | 143.64 |
| **150** | 2005-2010 5-year ACS housing units using NG heat normalized to 2010 total housing | 2104006000 | Residential Natural Fuel Combustion | 664.28 |
| **165** | 50% Residential Heating – Wood Plus 50% Low-Intensity Residential Housing | 2104008100<br>2104008210<br>2104008220<br>2104008230<br>2104008310<br>2104008330<br>2104008400<br>2104008510<br>2104008610<br>2104008700<br>2104009000 | Residential Wood Combustion | 47.52 |
| **170** | 2005-2010 5-year ACS housing units using distillate oil heat normalized to 2010 total housing | 2104004000<br>2104011000 | Residential Distillate Oil Fuel Combustion, Residual Kerosene Fuel Combustion | 0.09 |
| **190** | 2005-2010 5-year ACS housing units using LP gas heat normalized to 2010 total housing | 2104007000 | Residual LP Gas Fuel Combustion | 103.68 |
| **300** | Low-Intensity Residential Land Use | 2610000100<br>2610000400<br>2610030000<br>2810025000 | Open Burning | 76.96 |
| **310** | Total Agriculture (Pasture/Hay and Crops) | 2801500000<br>2810500150<br>2801500170<br>2801500262 | Ag. Field Burning | 3.43 |

| EPA 2011v6.2 Surrogate Code | Description | SCCs Affected | SCC Description | Impacted $NO_X$ Emissions, 2014 |
|---|---|---|---|---|
| **505** | 2006 Industrial Square Feet (FEMA) | 2012001000<br>2012002000<br>2012004000<br>2012005000<br>2012006000<br>2012007000<br>2012008000<br>2012011000 | Industrial Fuel Combustion. | 689.02 |
| **515** | 2006 Commercial Plus Institutional Square Feet (FEMA) | 2013001000<br>2013002000<br>2013004000<br>2013004001<br>2013004002<br>2013005000<br>2013006000<br>2013007000<br>2013008000<br>2013011000 | Commercial & Institutional Fuel Combustion | 503.42 |

The allocation factors with associated 2014 $NO_X$ emissions exceeding 250 tpy included:

- Industrial Fuel Combustion
- Residential Natural Gas Combustion
- Commercial and Institutional Fuel Combustion

For both the industrial fuel combustion and commercial and institutional fuel combustion categories, natural gas fuel combustion accounts for most of the $NO_X$ emissions, and accounts separately for 250 tpy as well, while the other fuels do not.

## 4.1 Industrial Fuel Combustion

Emissions estimates for industrial fuel combustion are based on state-wide fuel consumption data for the "industrial" obtained from the EIA. The EIA defines the industrial sector as follows:

*"An energy-consuming sector that consists of all facilities and equipment used for producing, processing, or assembling goods. The industrial sector encompasses the following types of activity manufacturing (NAICS codes 31-33); agriculture, forestry, fishing and hunting (NAICS code 11); mining, including oil and gas extraction (NAICS code 21); and construction (NAICS code 23). Overall energy use in this sector is largely for process heat and cooling and powering machinery, with lesser amounts used for facility heating, air conditioning, and lighting. Fossil fuels are also used as raw material inputs to manufactured products. Note: This sector includes generators that produce electricity and/or useful thermal output*

*primarily to support the above-mentioned industrial activities. Various EIA programs differ in sectoral coverage."*[20]

EPA's spatial allocation factor for industrial fuel combustion relies on FEMA's estimate of the square feet of "industrial" buildings in 2006. This included:

- IND1: Heavy
- IND2: Light
- IND3: Food/Drugs/Chemicals
- IND4: Metals/Minerals Processing
- IND5: High Technology
- IND6: Construction

Since the "industrial" sector includes agricultural use of fuels, "AGR1: Agriculture" should also be included in this category. However, since the emissions estimates for this category rely on allocating state-level fuel consumption to the county level using employment in NAICS codes 31-33, maintaining the existing approach would maintain some geographic consistency with the county-level emissions estimate. Additionally, given the coarse nature of these county-level estimates and the high levels of uncertainty, it is not clear that this change would be a good use of resources.

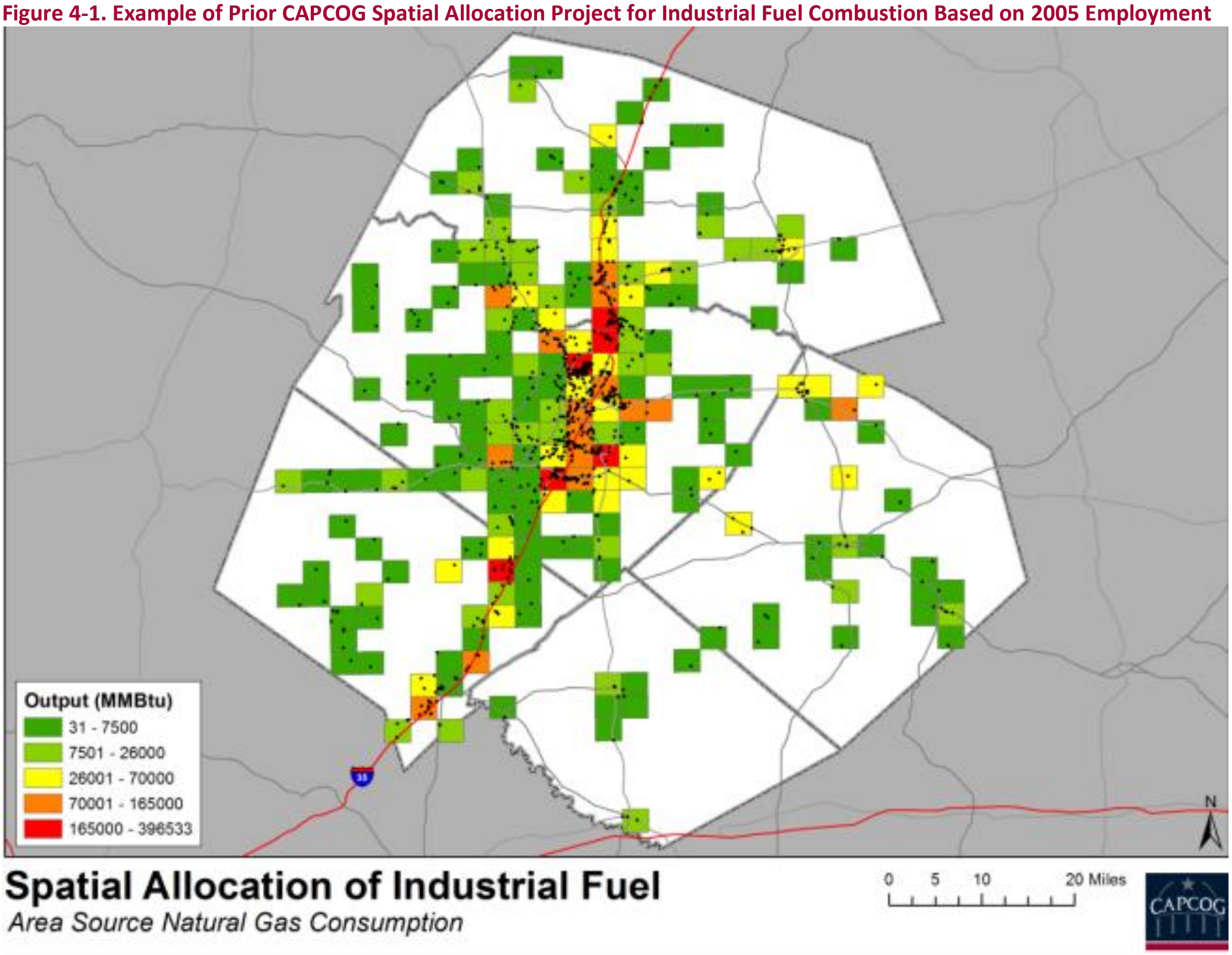
Other options CAPCOG explored were using the Texas Department of Licensing and Registration's (TDLR's) boiler inspection data and using employment data from CAMPO's Travel Demand Model as the basis for allocating the industrial fuel combustion emissions.

TDLR's boiler database contains information on boiler inspections for each boiler registered across the state.[21] The data can be queried by county, and includes information on the year the boiler was built, the fuel type, the location, and the maximum heat input, among other information. This has the benefit of providing precise organization names, locations and boiler sizes for actual fuel-consuming equipment that would be generating $NO_X$ emissions. The problem, however, is that boilers are not the only use of these fuels – process heaters and other pieces of equipment also use fuel. So while it might be possible to allocate just boiler emissions this way, it is not clear that it would necessarily improve the overall representation of industrial fuel combustion since it is only relevant to a single type of combustion device. Looking up and categorizing businesses is also a very labor-intensive process.

The use of employment data from CAMPO's Travel Demand Model would be an alternative way to allocate industrial fuel combustion. This was the approach CAPCOG took in 2013, when we obtained and used CAMPO's 2005 employment data inputs to its travel demand model in order to generate updated spatial allocation factors for industrial fuel combustion. The following figure shows the results of this project for industrial natural gas.

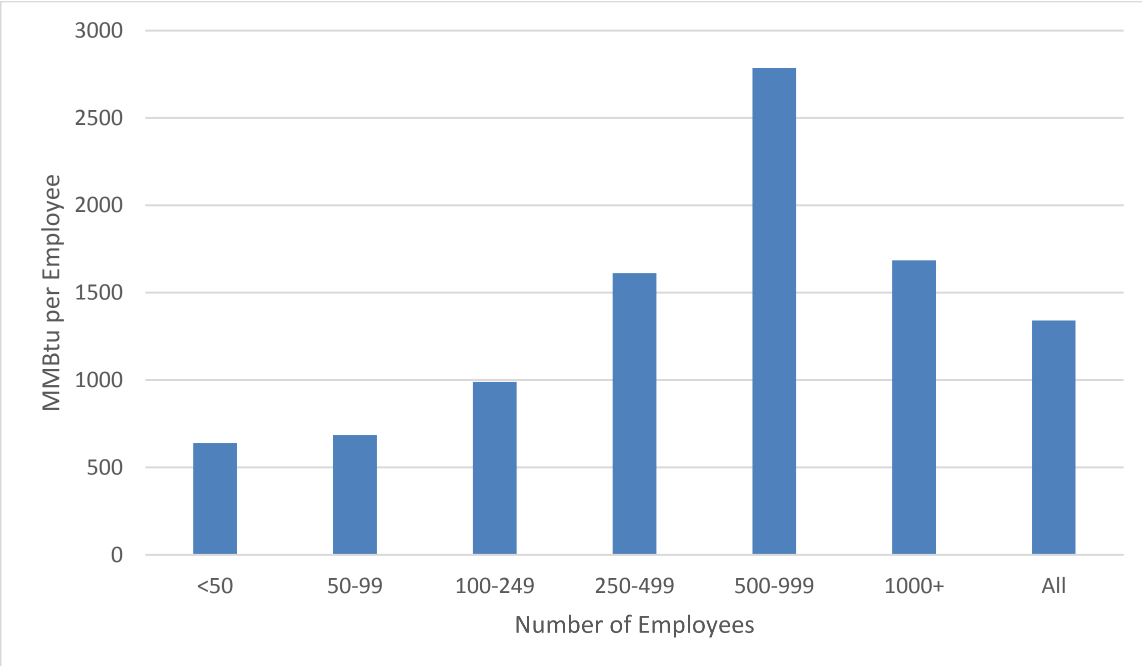
[20] https://www.eia.gov/tools/glossary/index.php?id=I
[21] https://www.tdlr.texas.gov/Boilerdata/

**Figure 4-1. Example of Prior CAPCOG Spatial Allocation Project for Industrial Fuel Combustion Based on 2005 Employment**




While CAPCOG did receive data from CAMPO's latest travel demand model more recently, we were not able to obtain the establishment-level detail that would have been needed to do this again. What is available is the data on "basic" employment, but that category includes a mix of NAICS codes that are both in the "Industrial" and "Commercial" sectors. For example, warehouses and wholesale trade establishments get categorized under "basic" employment, but are considered by EIA to be part of the "Commercial" sector. It's also not obvious that employment is a better surrogate for industrial fuel combustion activity than building square footage. The most recent Manufacturing Energy Consumption Survey (MECS) shows that the energy consumption per-employee ratio is not consistent across industry or in terms of firm size. The following figure shows the per-employee ratios for all manufacturing nation-wide.

**Figure 4-2. MECS Data on Fuel Consumption Per Employee in Manufacturing Sector[22]**




There's also the issue of several of the TAZs having their employment levels masked. This introduces additional uncertainty into the allocation of the data and would require some procedure to compensate for this issue, such as using the county-level residual employment and allocating it evenly across these "masked" TAZs. Also, the data that is available is only available for the six CAMPO counties.

As a result of this analysis, CAPCOG concluded that it was not clear that the adjustments that were possible truly constituted an improvement over the existing allocation factor or that they required more effort that the likely benefit in improved accuracy would achieve.

## 4.2 Residential Natural Gas Combustion

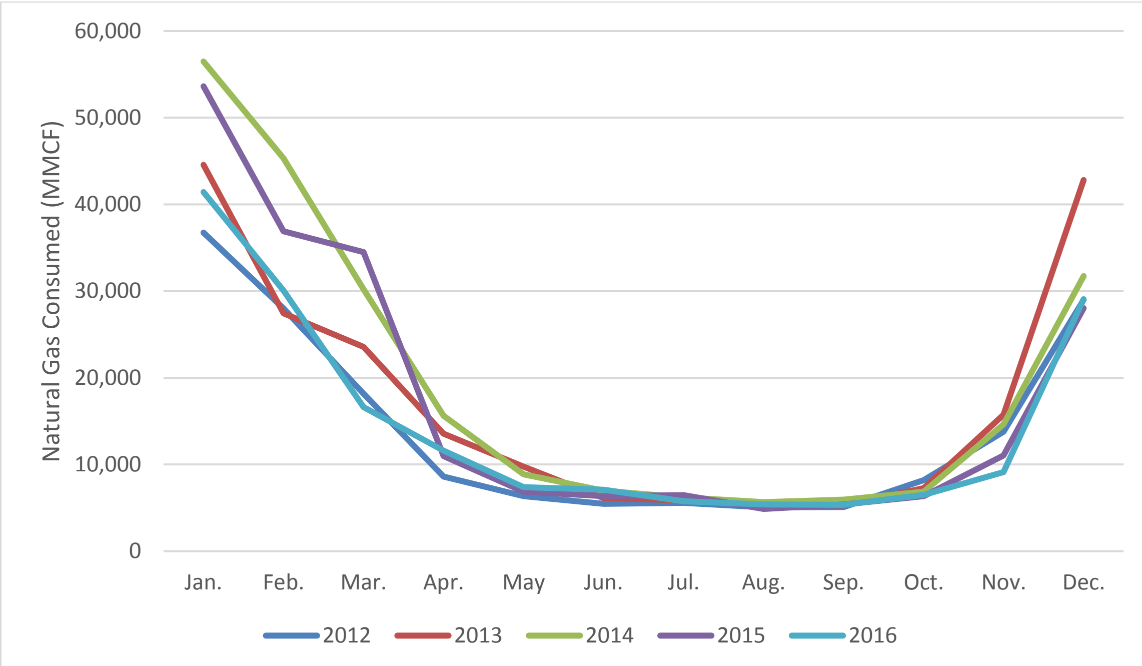
EPA's spatial allocation factor for residential natural gas relies on American Community Survey (ACS) data for 2006-2010 at the census block group level based on the number of households that reported that natural gas was their primary home heating fuel. These counts were then normalized to 2010 housing totals. A relatively straightforward update would involve simply using a more recent analysis year. Since the census block-group level of data is only available in the 5-year surveys, the 2010-2014 data would be the most appropriate data to use for the 2012 baseline year, since 2012 is the middle year in that period. Using the more recent 2012-2016 data for years beyond 2012 would help better capture changes in housing and fuel use within the region since 2012.

At 664.28 tpy of $NO_X$ emissions in 2014, residential natural gas averages 1.82 tpd of $NO_X$ emissions region-wide, which would make it a rather significant source of ozone-forming pollutants if there was no seasonal variation in its use. However, the vast majority of this activity occurs outside of ozone season

[22] https://www.eia.gov/consumption/manufacturing/data/2014/pdf/table6_4.pdf

since it is primarily used for heating. The figure below shows the average monthly statewide consumption of natural gas by residential customers.

**Figure 4-3. Texas Residential Natural Gas Consumption by Month[23]**




One issue with the use of these data is that they represent the use of the fuel for home heating, which is not relevant for summer ozone season usage. It is possible that there is a different spatial distribution of residential natural gas usage during summer months compared to winter months. However, if a home has a natural gas connection and is using natural gas for heating during winter months, it is likely that this spatial distribution is similar for other uses during summer months.

The more important issue is that while this source category accounted for more than 250 tpy $NO_X$ emissions in 2014 region-wide, the vast majority of these emissions occurred outside of ozone season. When TCEQ estimates summertime emissions for residential natural gas combustion, it applies an adjustment factor of 0.3 to the simple daily average. For 2014, this would mean that summertime $NO_X$ emissions from this source are only 0.55 tpd across the region. While residential natural gas $NO_X$ emissions exceed 250 tpy region-wide and therefore met the general screening threshold for this analysis, the average ozone season usage is more consistent with an annualized amount of only 199 tpy. Therefore, due to this source being a significantly smaller source of ozone-season $NO_X$ emissions than the annual number would suggest, CAPCOG decided that further work on this source was not a good use of resources.

[23] https://www.eia.gov/dnav/ng/hist/n3010tx2m.htm

## 4.3 Commercial and Institutional Fuel Combustion

Commercial and institutional fuel combustion emissions estimates are based on state-wide EIA fuel consumption data for the "commercial" sector. The EIA defines the "commercial sector" as follows:

*"An energy-consuming sector that consists of service-providing facilities and equipment of businesses; Federal, State, and local governments; and other private and public organizations, such as religious, social, or fraternal groups. The commercial sector includes institutional living quarters. It also includes sewage treatment facilities. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking, and running a wide variety of other equipment. Note: This sector includes generators that produce electricity and/or useful thermal output primarily to support the activities of the above-mentioned commercial establishments."*[24]

EPA's spatial allocation factor for commercial and institutional fuel combustion relies on the 2006 estimated building square footage for the following categories:

- COM1: Retail Trade[25]
- COM2: Wholesale Trade
- COM3: Personal and Repair Services
- COM4: Professional/Technical Services
- COM5: Banks
- COM6: Hospital
- COM7: Medical Office/Clinic
- COM8: Entertainment & Recreation
- COM9: Theaters
- RES5: Institutional Dormitory
- RES6: Nursing Home
- EDU1: Grade Schools
- EDU2: Colleges/Universities
- REL1: Churches and Other Non-Profit Organizations

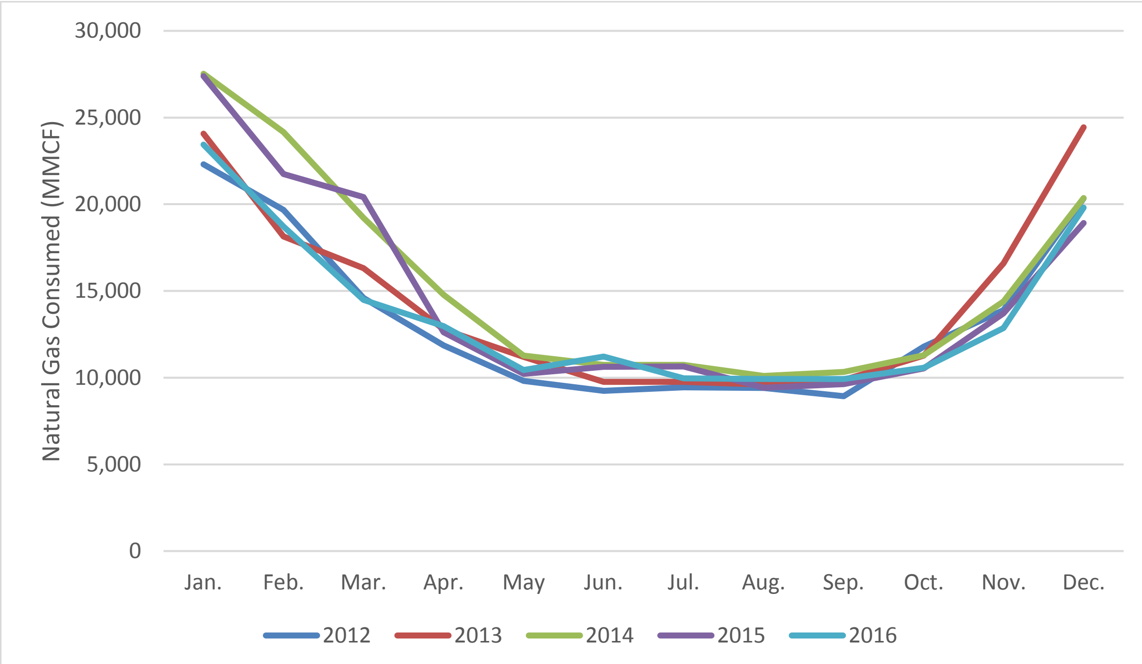
Given the fact that the "commercial/institutional" fuel use estimates include fuel use from government entities, it seems that this spatial allocation factor should also include GOV1: General Services and GOV2: Emergency Response. It may also be appropriate to put RES4: Temporary Housing in this category to the extent that this represents commercial hotels and motels, which would report energy consumption under the "commercial" energy sector.

CAPCOG also explored the use of the TDLR's boiler database and employment data as alternative allocation factors. But, for the same reasons described above in the section regarding industrial fuel combustion, CAPCOG determined that these were not unambiguously better options.

[24] https://www.eia.gov/tools/glossary/index.php?id=C
[25] https://www.fema.gov/media-library-data/20130726-1819-25045-8574/hzmh2_1_cdms_data_dictionary.pdf

Based on the annual total of 503.41 tpy $NO_X$ emissions in 2014, average $NO_X$ emissions was 1.38 tpd. However, as was the case with residential fuel combustion, commercial fuel combustion is seasonal, with significantly higher usage in winter months, although the seasonal effect is not nearly as much as it is for residential fuel consumption.

**Figure 4-4. Texas Commercial Natural Gas Consumption by Month**[26]




Based on this seasonality, the average ozone season day $NO_X$ emissions for commercial fuel combustion would wind up at 0.57 tpd. Therefore, even though this source meets the threshold for further analysis due to its annual $NO_X$ emissions, the seasonality of the underlying activity makes this source also much less significant for ozone formation. This ultimately led CAPCOG to decide not to pursue further work.

## 4.4 Summary for Area Sources Using EPA Surrogates

There are clear and obvious improvements that can be made to the EPA surrogates identified above:

- The industrial fuel combustion spatial allocation factor can more comprehensively cover all of the fuel consumption included in this emissions source category by adding AGR1.
- The residential natural gas combustion spatial allocation factor can be updated to 2010-2014 for the 2012 base case and to 2012-2016 for future years.
- The commercial and institutional spatial allocation factor can more comprehensively cover all of the fuel consumption included in this emissions source category by adding GOV1, GOV2, and RES4 to the surrogate. This could be especially important for Travis County since it includes extensive state and federal government and hotel properties in the City of Austin.

[26] https://www.eia.gov/dnav/ng/hist/n3010tx2m.htm

Ultimately, CAPCOG concluded that the expected benefits of improvements to the spatial representation of these sources did not warrant the level of effort that would be required to complete these updates. Since the FEMA data is based on 2006 building information, it's not necessarily the most reliable information any longer, for instance. Alternative approaches could include:

- Using the heat input capacity of boilers listed in the Texas Department of Licensing and Registration's boiler safety inspection database to allocate industrial and commercial/institutional fuel combustion data
- Using employment in the "basic" sector by travel analysis zone to allocate industrial fuel combustion
- Using employment in the "retail" and "service" sectors by travel analysis zone to allocate commercial/institutional fuel combustion
- Working with local gas providers to provide the number of residential gas connections within each grid cell

While there are additional benefits that could be achieved by pursuing these updates, CAPCOG again felt that the level of effort that would be required would not match the expected improvements, or that it generated higher uncertainty than the current approach entailed.

CAPCOG is not recommending any updates to these default EPA surrogates.

## 4.5 Review of Oil and Gas Surrogates

Oil and gas emissions constitute a significant source of $NO_X$ emissions within the CAPCOG region. TCEQ's estimates for the region are that it accounted for 1,871.38 tpy $NO_X$ emissions and 5.01 tpd. CAPCOG has reviewed TCEQ's documentation for its oil and gas allocation factors for the HGB SIP. These allocation factors are not likely to be able to be improved upon for the CAPCOG region without significant outlay of resources and no guarantee of significantly more reliable data. CAPCOG's 2013 study on oil and gas emissions strongly suggests that there is a high degree of likelihood that there are many more electric-powered pumpjacks in the region than current inventories account for, and that proximity to a power line is a major factor in that pattern. Therefore, it is likely that spatial allocation factors that treat production or the presence of a well near a power line as equally as likely to have pumpjack emissions as one far away is missing this pattern. However, since grid cells cover areas of 16 square kilometers, and obtaining better data that would enable that differentiation would require more success than CAPCOG has in its 2013 survey, CAPCOG does not believe that any such project would be a good use of resources.

Therefore, CAPCOG is not recommending any updates to these default TCEQ surrogates.

# 5 Conclusion and Recommendations

This report includes a detailed analysis of surrogates used to spatially allocate emissions from on-road, on-road, and area source emissions within the CAPCOG region onto TCEQ's 4 km x 4 km grid system for photochemical modeling. The table below summarizes CAPCOG's recommendations.

**Table 5-1. CAPCOG Recommendations for Spatial Allocation Surrogates for Major $NO_X$ Sources in the Region**

| Source | Recommendation |
|---|---|
| **On-Road, On-Network Activities** | Keep using TCEQ factors |
| **On-Road, Off-Network Start Exhaust: Motorcycles, Passenger Cars, Passenger Trucks** | Keep using TCEQ factor |
| **On-Road, Off-Network Idle & APU** | Use EPA factor instead of TCEQ factor |
| **Non-Road: Agricultural Equipment** | Use CAPCOG-generated 2012 factors based on CropScape data |
| **Non-Road Construction and Mining Equipment** | Use CAPCOG-generated factors for Lee County up through 2017 based on mine activity, keep current TCEQ factors for all others |
| **Non-Road Industrial Equipment** | Keep using EPA factor |
| **Non-Road Commercial Equipment** | Keep using EPA factor |
| **Non-Road Aircraft** | Keep using TCEQ factor |
| **Non-Road Rail** | Keep using TCEQ factor |
| **Area Sources: Residential Natural Gas Fuel Combustion** | Keep using EPA factor |
| **Area Sources: Industrial Fuel Combustion** | Keep using EPA factor |
| **Area Source: Commercial Fuel Combustion** | Keep using EPA factor |
| **Area Source: Oil and Gas Production: Pumpjacks** | Keep using TCEQ factor |

While in each case, CAPCOG identified at least one potential alternative surrogate, it decided only to develop new spatial allocation data for agricultural equipment and selected construction and mining equipment SCC codes in Lee County. CAPCOG hopes that TCEQ will update its spatial allocation factor files for non-road equipment in order to incorporate these updates, particularly since CAPCOG has also developed updated TexN inputs for these same sources. Combined, these two improvements will substantially improve the modeling of non-road emissions within the CAPCOG region and should improve the accuracy of modeled ozone concentrations, particularly in the eastern part of the region where the Three Oaks Mine is located and the highest concentration of agricultural activity within the region is located.

CAPCOG has also included a recommendation that TCEQ consider using EPA's high-quality database of idling locations as the basis both for any future county-wide extended idling and APU emissions and the spatial allocation factors consistent with those data. Current county-wide emissions estimates are based on a statewide database developed in 2004, and county-level activity is highly sensitive to the location of large-scale truck stops and rest areas. The distribution of these locations within the state has changed significantly since 2004, but the county-level emissions data do not reflect these changes. Within each county, prior research by CAPCOG showed that significant idling activity occurs in locations other than interstates or other highways, and there are large areas of interstates and highways that do not have any extended idling. Using EPA's data for this activity would likely significantly improve the representation of this activity statewide. This would have a particularly significant impact within the CAPCOG region, given the fact that idling activity substantially shifted from Hays County to Williamson County after 2006, when a large truck stop and rest areas in Hays County closed, and a large truck stop opened in Williamson County. Since this is also a category that can be controlled through state and local actions, improving the spatial distribution of this source category would likely also have some direct benefits for attainment modeling.

Finally, CAPCOG's analysis above provides a solid basis for future broad-scale improvements to spatial allocation surrogates for numerous source categories. CAPCOG believes that these analyses can be helpful to TCEQ, EPA, and other agencies considering ways to improve the spatial representation of these source categories for photochemical modeling.