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Non-Road Emissions Inventory Projections

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Executive Summary

This report summarizes updated non-road mobile activity and emissions inventory projections developed by the Capital Area Council of Governments (CAPCOG) for its 10-county region, which consists of Bastrop, Blanco, Burnet, Caldwell, Fayette, Hays, Lee, Llano, Travis, and Williamson Counties. This project builds on several other research projects completed by CAPCOG in recent years, incorporating new data sources and techniques. Updates include:

- Agricultural equipment in all 10 CAPCOG counties and Milam County, which had previously been included in agricultural equipment emissions inventory research conducted by CAPCOG
- The Lee County mine and quarry diesel construction equipment (DCE) subsector of construction and mining equipment to reflect the planned closure of the Three Oaks coal mine at the end of 2017

CAPCOG has developed population updates to the Texas NONROAD (TexN) model that TCEQ or other agencies can use to update the activity inputs for the CAPCOG region and Milam County in order to incorporate these updates.

The primary benefit of these updates is to provide improvements in the representation of the expected change in nitrogen oxides (NO_X) emissions relative to the emissions estimates currently available through the TexN model, particularly relative to 2012, since this is the base year TCEQ is using for photochemical modeling efforts. Therefore, CAPCOG has focused on accurately representing the relative change in ozone season day (OSD) NO_X emissions for these updates. Due to the constraints of the TexN model that are discussed in this report, however, caution should be exercised in using other model outputs (fuel consumption and emissions estimates of other pollutants) generated for agricultural tractors based on these activity updates. The updates for the Lee County Mine and Quarry Diesel Construction Equipment (DCE) subsector and all other agricultural equipment do not come with that same caveat, although CAPCOG does note that the projections for the other agricultural equipment types simply updates the projections from 2012 but does not update the 2012 estimates or activity data for 2012 or before. The figures below show the changes in 2012, 2017, and 2022 OSD Weekday NO_X estimates for each of these updates.

Figure E-1. Comparison of Agricultural Tractor OSD Weekday NO_X Emissions, 2012 and 2022 (tpd)

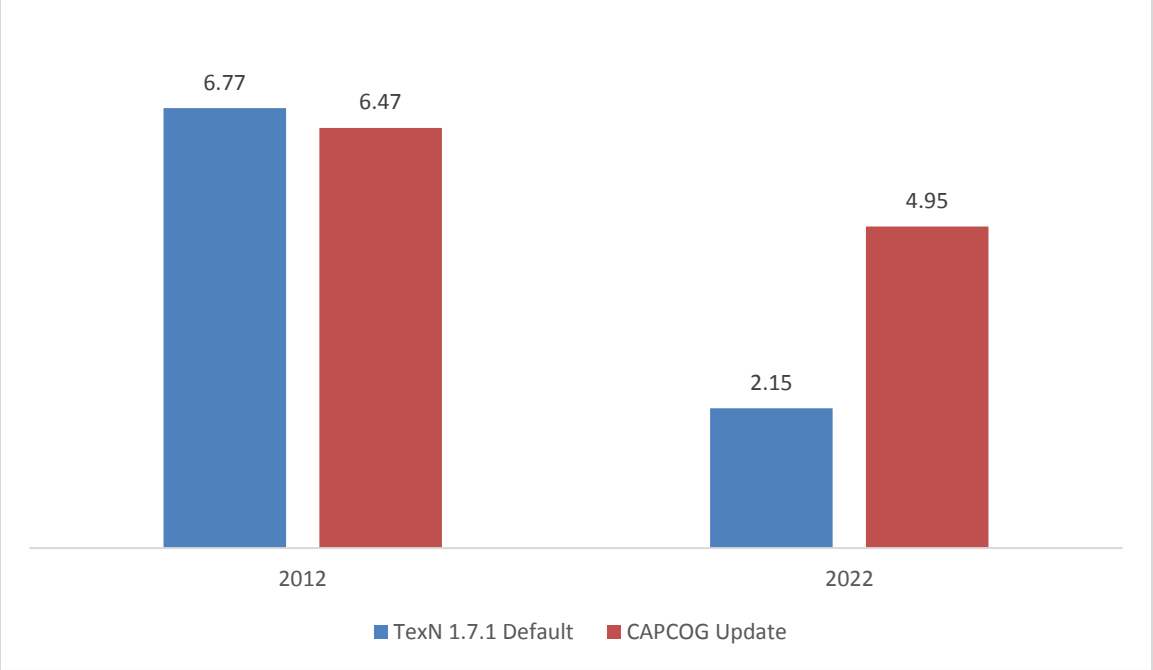


Figure E-2. Comparison of All Other Agricultural Equipment OSD Weekday NO_X Emissions (tpd)

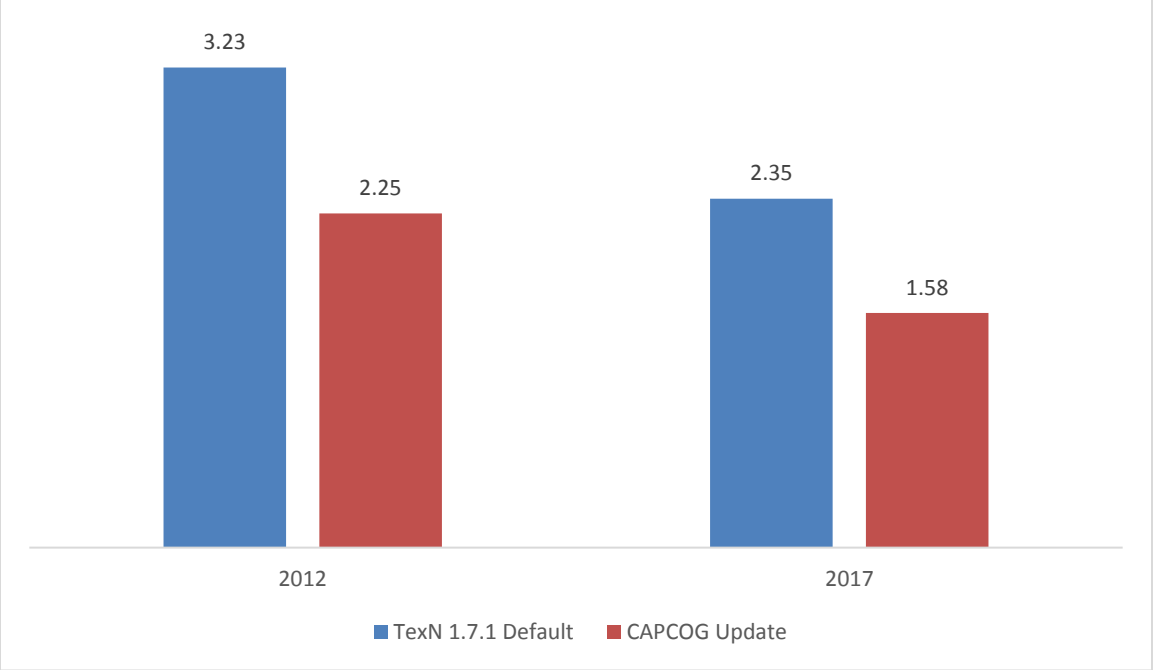
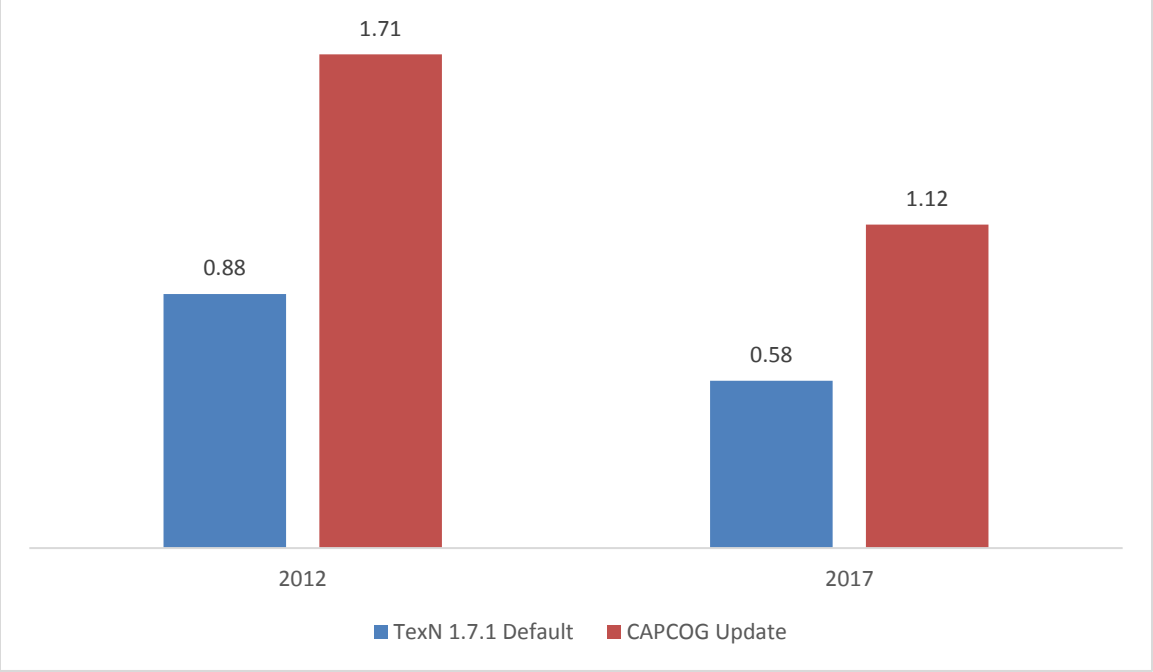


Figure E-3. Comparison of Lee County Mine and Quarry NO_X Emissions (tpd)



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1 Introduction

This project provides updated average ozone season weekday emissions from non-road equipment in Bastrop, Blanco, Burnet, Caldwell, Fayette, Hays, Lee, Llano, Milam, Travis, and Williamson Counties for 2012 and 2022.[1] These updates are based on methods that CAPCOG has developed and refined in the past few years and new information that points to substantially different growth projections for agricultural equipment region-wide and construction and mining equipment in Lee County compared to the assumptions used in the Texas NONROAD (TexN) v. 1.7.1 model.

For this project, CAPCOG developed updated emissions estimates for all agricultural equipment (SCC code 22xx0050xx) types included in the U.S. Environmental Protection Agency's (EPA's) NONROAD model and all construction and mining equipment (SCC code 22xx0020xx) in Lee County that are included in the "mining and quarrying" diesel construction equipment (DCE) subsector.

Data developed under this project include estimates for carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_X), particulate matter (PM), sulfur dioxide (SO_2), and volatile organic compounds (VOC). Since the primary purpose for this project is to support air quality planning efforts for ground level ozone, most of the emissions-related analysis in this report focuses on NO_X emissions due to its importance in local ozone photochemistry.

Along with the updated emissions estimates, this project includes a large array of updates to activity data that were used to develop the updated emissions estimates. These included updates to equipment populations estimates for 1970-2050, fuel type distributions, horsepower distributions, average horsepower ratings, age distributions, and annual activity levels. Some of these data were used in off-model or year-specific analysis that CAPCOG then created updated equipment population estimates and corresponding MySQL update scripts in order to enable the TexN model to generate these emissions estimates.

2 Basis for Sources Targeted for Updates

CAPCOG considered a variety of factors in deciding which non-road sources to target for updates under this project. This included:

- The existing estimates of NO_X emissions for individual source classification codes (SCCs) or groups of SCCs that rely on the same underlying activity data
- Knowledge of opportunities to improve the emissions or activity estimates for an individual SCC or groups of SCCs
- The availability of reliable activity data that would produce a substantially different projection from what's currently incorporated into TexN v. 1.7.1
- The expected impact of any updates on NO_X emissions estimates for individual SCCs or groups of SCCs within the region

[1] Milam is not a CAPCOG county, but was previously included in past reports due to its proximity to the Austin-Round Rock MSA.

- The level of effort required to produce updates, including updated activity inputs that could be readily incorporated into the TexN model

In CAPCOG's analysis of the 2014 National Emissions Inventory (NEI), CAPCOG used a screening threshold of ≥ 250 tpy of NO_X emissions in order to identify "significant" sources of NO_X emissions within the region, based on the fact that this level of NO_X emissions would trigger "prevention of significant deterioration" (PSD) permitting requirements for point sources.[2] This provides an initial screening tool that can narrow the sources that could be evaluated for further analysis.

The following table shows the annual NO_X emissions for 2014 for each non-road sector.

Table 2-1. 2014 Annual NO_X Emissions by Non-Road Sector Reported in NEI v. 1

Sector	NO_X (tpy)	%
Agricultural Equipment	1,952	18.99%
Airports	811	7.89%
Commercial Equipment	443	4.31%
Construction and Mining Equipment	4,287	41.70%
Industrial Equipment	582	5.66%
Lawn and Garden Equipment	195	1.90%
Logging Equipment	0	0.00%
Oil and Gas Production	163	1.59%
Pleasure Craft	103	1.00%
Rail	1,660	16.15%
Recreational Equipment	85	0.83%
TOTAL	**10,281**	**100.00%**

Using the 250 tpy NO_X screening threshold eliminates lawn and garden equipment, logging equipment oil and gas production, pleasure craft, and recreational equipment from further consideration.

CAPCOG then analyzed the existing NO_X emissions estimates and basis for these estimates for each of the remaining sectors – construction and mining equipment, agricultural equipment, rail, airports, industrial equipment, and commercial equipment – for further consideration. CAPCOG used a ≥ 1 tpd as an additional screening tool for further evaluation.

CAPCOG's review of these sources resulted in CAPCOG's decision to focus on the following updates:

- The Mine and Quarry Diesel Construction Equipment (DCE) Subsector of Construction and Mining Equipment in Lee County
- Agricultural Tractors
- All Other Agricultural Equipment

[2] http://www.capcog.org/documents/airquality/reports/2016/Deliverable_2.1.3_-_2014_NEI_Report.pdf

CAPCOG believes that ERG's recent trends inventories for airports and rail sources produced for TCEQ are reliable for the Austin area and do not believe that we could make substantial improvements in the projections for those sources beyond what is in those reports at this time.

CAPCOG considered updates for industrial forklifts, which it has previously conducted research on, but determined that the level of effort that would be required outweighed the potential benefits at this stage.

The commercial equipment sector is perhaps the least improved-upon category in TexN, since it used activity data that is the same as the NONROAD model. For the NONROAD model, EPA allocated nation-wide populations to the county level based on the number of wholesale establishments (North American Industrial Classification or NAICS code 42) in each county. [3] In its documentation for the NONROAD model, EPA acknowledged that, "the number of establishments may not be the best possible indicatory of activity, since equipment activity would depend on the average size of establishment and the mix of establishment types, in addition to the absolute number of establishments." It went on to further indicate that alternative sources of activity-related allocation factors such as the dollar value of commercial, wholesale, or industrial output, including their advantages and disadvantages relative to the number of employees and establishments. Given the uncertainty regarding the existing basis for the commercial equipment population, developing improved projected equipment populations would require new research to establish better baseline equipment counts for the region and improved activity surrogates. In light of the resources required, CAPCOG did not feel that updating the growth factors would be a good use of resources at this time.

3 Construction and Mining Equipment Sector

The construction and mining equipment sector is by far the largest source of NO_X emissions in the region among the various non-road sectors, accounting for more than double the 2014 NO_X emissions estimate of the next-largest sector. However, this sector is also already one of the most extensively studied and updated non-road sectors, and the TexN model is specially structured in order to account for the activity and emissions this sector in 24 diesel construction equipment sub-sectors. CAPCOG's interim report on the 2014 NEI included a detailed, county-by-county analysis of the NO_X emissions by subsector for the construction and mining equipment based on a 2014 OSD run of TexN v. 1.7.1. This most recent update includes updates for the CAPCOG region and Milam Counties for the heavy-highway, commercial construction, residential construction, utility construction, city and county road construction, TxDOT-owned equipment, and cranes. The following table provides a summary of the region-wide NO_X emissions estimates for each subsector, as well as the smallest and largest NO_X emissions estimate for any single county. This table is derived from CAPCOG's interim report on the 2014 NEI, based on the data TCEQ submitted to EPA in early 2016.[4]

[3] https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1004LDX.pdf

[4] http://www.capcog.org/documents/airquality/reports/2016/Deliverable_2.1.2_CAPCOG_2014_NEI_Review_Interim_Report_final.pdf

Table 3-1. 2014 OSD Non-Road Construction and Mining Equipment NO_X Emissions by Subsector

DCE Subsector	2014 NO_X (tpy)	%
Agricultural Activities	0.1890	1.81%
Boring/Drilling Equipment	0.0595	0.57%
Brick and Stone Operations	0.0416	0.40%
City and County Road Construction	0.0333	0.32%
Commercial Construction	0.3932	3.77%
Concrete Operations	0.0525	0.50%
County-Owned Construction Equipment	0.0424	0.41%
Cranes	0.3762	3.61%
Heavy Highway Construction	0.3424	3.28%
Landfill Operations	0.1275	1.22%
Landscaping Activities	0.1287	1.23%
Manufacturing Operations	0.0891	0.85%
Municipal-Owned Construction Equipment	0.1383	1.33%
Transportation/Sales/Services	0.5735	5.50%
Residential Construction	0.7498	7.19%
Rough Terrain Forklifts	1.0974	10.53%
Scrap/Recycling Operations	0.0378	0.36%
Skid Steer Loaders	0.9930	9.53%
Special Trades Contractors	0.0142	0.14%
Trenchers	0.6948	6.66%
TxDOT Equipment	0.0443	0.42%
Utility Construction	0.0704	0.68%
Mining and Quarry Operations	3.6205	34.73%
Off-Road Tractors, Misc. Equipment, and all Equipment <25 hp	0.5153	4.94%
TOTAL	**10.4247**	**100.00%**

The only two subsectors with ≥ 1 tpd of NO_X emissions region-wide were the mine and quarry equipment and rough terrain forklift subsectors. Based on ERG's report on the 2014 AERR and trends inventories,[5] the estimates for these two subsectors within the CAPCOG region are based on ERG's "Update of Diesel Construction Equipment Emissions Estimates for the State of Texas," prepared for TCEQ in August 2009, including projections.[6] ERG's report indicates that growth surrogates are based on 2007 county-level Economy.com projections:

- Mine and Quarry equipment surrogate: county-level economic output for mining activity, excluding oil and gas production, using 2007 base

[5] ftp://amdaftp.tceq.texas.gov/pub/EI/nonroad/TexN/Nonroad_2014_AERR_and_Trend_Inventory_Final_Report.pdf

[6] https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/20090731-ergi-DCE_EI_Update.pdf

- Rough Terrain Forklift equipment surrogate: statewide economic output for all construction sectors, using 2007 base

CAPCOG has experience updating mine and quarry equipment activity and emissions inventory data, but does not have any experience with updating rough terrain forklift data. Since the RTF data are based on statewide data and CAPCOG does not have any local RTF data that it believes are better than what is already available in the TexN model, CAPCOG decided not to further consider updates to the RTF projections for the region.

For the mine and quarry sector, one of the primary sources of surrogate data used by ERG and CAPCOG to develop mine and quarry activity and emissions estimates is data on coal production and non-office labor-hours at mines within the region obtained from the U.S. Mine Health and Safety Administration's (MHSA's) data retrieval system.[7] One relatively straightforward approach to updating the Mine and Quarry subsector's projections for the region would be to simply bring these data forward from its current base of 2007 to 2016 using the data available in the data retrieval system and then applying the existing growth assumptions to these data. A more involved version of this would include updated Economy.com county-level projections for each county with a mine or a quarry. And an even more involved version would include updated county-specific mine and quarry data based on prior research conducted by CAPCOG. CAPCOG decided to rule these out based on resource constraints and the fact the constraints imposed on county-level and year-specific activity updates in the TexN model. For example, the TexN model's databases are not currently structured to accommodate distinct county-level activity profiles for the CAPCOG region and changes in the seasonal distribution of activity within each year (since the US MHSA data is available quarterly). Therefore, despite the significance of this subsector as a source of NO_X emissions and the prospects for improvements in the projections, CAPCOG initially chose not to pursue updates to this sector.

However, on October 13, 2017, Luminant Power announced the closure of the Three Oaks mine in Lee County. A recent report by the Austin Business Journal indicated that the closure will be effective January 13.[8] Since this mine is the only mine or quarry in Lee County and constitutes a major source of NO_X emissions on its own, at 1.5655 tpd NO_X in 2014, CAPCOG decided that a targeted update of the mine and quarry population data in Lee County would be a good use of resources.

First, CAPCOG reviewed the coal production data the quarterly coal production data at the Three Oaks mine from 2007-2017. Since the data for 2017 is only through Q3, and the main use of these updates is improving OSD emissions estimates, CAPCOG calculated growth factors based on both annual coal production and April 1 – September 30 coal production. The following table shows these data.

[7] https://arlweb.msha.gov/drs/drshome.htm
[8] https://www.bizjournals.com/austin/news/2017/11/21/coal-plant-operator-luminant-sets-hundreds-of.html

Table 3-2. Three Oaks Mine Lignite Coal Production by Quarter, 2007-2017 (tons)

Year	Q1	Q2	Q3	Q4	Total for Year	OSD Growth Factor Variance from Annual
2007	1,119,432	1,019,397	976,792	1,004,998	4,120,619	0.00%
2008	1,116,980	816,861	849,891	970,280	3,754,012	-8.35%
2009	1,175,370	1,291,276	1,082,328	1,338,791	4,887,765	0.24%
2010	1,381,660	1,204,838	1,468,502	1,309,236	5,364,236	2.87%
2011	1,823,302	1,815,217	1,955,235	1,598,650	7,192,404	8.21%
2012	1,646,294	1,876,481	2,107,700	2,129,826	7,760,301	5.98%
2013	1,551,532	1,427,063	2,191,730	2,018,853	7,189,178	3.91%
2014	2,021,352	1,421,772	2,007,554	2,076,680	7,527,358	-5.96%
2015	1,922,304	1,276,342	1,758,866	1,524,640	6,482,152	-3.34%
2016	1,828,254	1,497,668	1,795,673	1,861,752	6,983,347	-2.65%
2017	1,960,766	1,844,224	1,690,596	n/a	n/a	n/a

The average variance from 2008-2016 between using the annual total and the OSD total is only 3.37%, with a range of -8.35% to +8.21%. Based on the relatively small variance and lack of systematic seasonal differences over this time frame and the availability of the quarterly data for Q2 and Q3 in 2017, CAPCOG decided to calculate the growth factors for 2008-2017 based on the Q2 and Q3 production totals, and to then set the factor to 0 for 2018 and beyond. Since this coal mine is used exclusively to supply lignite to the Sandow power plant, which has been approved for closure by ERCOT, it would not be reasonable to assume that this mine will be operational again at any point beyond January 13, 2018, unless that plant re-opens at some point in the future. The following table identifies the growth factors CAPCOG applied to the mine and quarry DCE subsector equipment populations for 2008-2050 in Lee County in order to reflect these data.

Table 3-3. Updated Lee County Mine and Quarry Growth Factors

Year	Existing Factor	Updated Factor	Change from Existing
2007	1.000	1.000	0.000%
2008	0.744	0.835	12.233%
2009	0.827	1.189	43.833%
2010	0.796	1.339	68.157%
2011	0.962	1.889	96.278%
2012	0.926	1.996	115.522%
2013	1.676	1.813	8.167%
2014	2.049	1.718	-16.172%
2015	1.878	1.521	-19.045%
2016	1.695	1.650	-2.659%
2017	1.567	1.771	12.988%
2018	1.458	0.000	-100.000%
2019	1.362	0.000	-100.000%
2020	1.278	0.000	-100.000%
2021	1.208	0.000	-100.000%
2022	1.148	0.000	-100.000%

Year	Existing Factor	Updated Factor	Change from Existing
2023	1.097	0.000	-100.000%
2024	1.048	0.000	-100.000%
2025	1.001	0.000	-100.000%
2026	0.954	0.000	-100.000%
2027	0.910	0.000	-100.000%
2028	0.874	0.000	-100.000%
2029	0.841	0.000	-100.000%
2030	0.808	0.000	-100.000%
2031	0.781	0.000	-100.000%
2032	0.750	0.000	-100.000%
2033	0.722	0.000	-100.000%
2034	0.697	0.000	-100.000%
2035	0.676	0.000	-100.000%
2036	0.655	0.000	-100.000%
2037	0.636	0.000	-100.000%
2038	0.621	0.000	-100.000%
2039	0.607	0.000	-100.000%
2040	0.596	0.000	-100.000%
2041	0.581	0.000	-100.000%
2042	0.566	0.000	-100.000%
2043	0.551	0.000	-100.000%
2044	0.551	0.000	-100.000%
2045	0.551	0.000	-100.000%
2046	0.551	0.000	-100.000%
2047	0.551	0.000	-100.000%
2048	0.551	0.000	-100.000%
2049	0.551	0.000	-100.000%
2050	0.551	0.000	-100.000%

The following figure shows the 2012 and 2017 OSD weekday mine and quarry construction and mining equipment emissions inventories for Lee County using the updated growth factors.

Table 3-4. 2012 and 2017 Lee County Mine and Quarry Ozone Season Weekday EI Using Updated Inputs

Pollutant (tpd)	2012	2017
CO	0.71	0.43
NO_X	1.71	1.12
CO_2	302.46	342.71
SO_2	0.00	0.00
PM	0.11	0.05
VOC	0.13	0.12

4 Agricultural Equipment

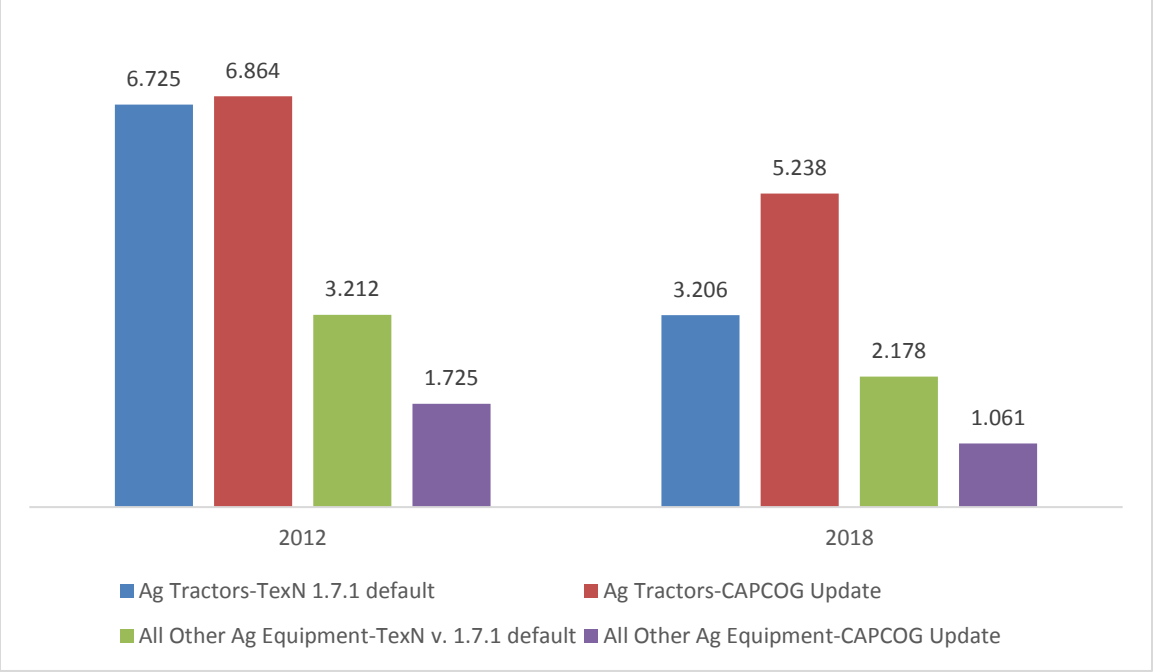
CAPCOG has made agricultural tractor activity and emissions estimates a major part of its emissions inventory improvement efforts in recent years. Reports documenting these efforts include:

- CAPCOG. "Agricultural Tractor 2006 Ozone Season Weekday Emission Inventory for the CAPCOG Program Area." August 2013. Available online at: http://www.capcog.org/documents/airquality/reports/2013/CAPCOG_Agricultural_Tractor_Emissions_2006_Merged.pdf
- CAPCOG. "2012 and 2018 Emissions Updates for the CAPCOG Region and Milam Counties." December 2013. Available online at: 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
- Hoekzema, A.; Daubert, L., and Baker, R. "Modeling Non-Road Agricultural Tractor Emissions in Central Texas." April 12, 2015. Presented at EPA's 2015 International Emissions Inventory Conference, San Diego, California. Available online at: http://www.capcog.org/documents/airquality/reports/2015/Modeling_Non-Road_Agricultural_Tractor_Emissions_in_Central_Texas_2015-04-12.pdf
- CAPCOG. "Non-Road Agricultural Equipment Emissions Inventory Updates for Selected Counties in Central Texas." August 19, 2015. Available online at: http://www.capcog.org/documents/airquality/reports/2015/CAPCOG_Non-Road_Ag_Equipment_EI_Updates_2015-08-19.pdf

CAPCOG's most recent work on this sector included comprehensive updates to all 10 equipment types in the agricultural equipment sector for 2012 and 2018.

Agricultural tractors are the single largest non-road source of NO_X emissions for all SCCs within the region. Collectively, the NO_X emissions estimates for the other 9 agricultural equipment types constitute a "significant" source of NO_X emissions in that they account for more than 1 tpd of NO_X emissions region-wide. However, no individual equipment type accounts for more than 0.595 tpd in CAPCOG's 2012 estimates or 0.706 tpd in the default TexN v. 1.7.1 estimates. The following figure shows the differences between these estimates and default runs of the TexN model for all 10 CAPCOG counties and Milam County.

Figure 4-1. Comparison of 2015 Report's Agricultural Equipment OSD NO_X for CAPCOG and Milam Counties (tpd)



Updating the profiles and associated TexN inputs for each of these equipment types would constitute an entirely separate effort, so CAPCOG chose to only do comprehensive updates to the base year inputs and projections for agricultural tractors and to make adjustments only to the equipment population growth for 2013-2015 relative to 2012 for the other nine equipment types.

4.1 Updates to Agricultural Tractors

CAPCOG has a very high degree of confidence in the agricultural tractors emissions estimates generated in 2015 for 2012, as they were based on high-quality survey and equipment sales data. This methodology relies on a combination of county-level tractor population data from the USDA's Census of Agriculture, ERG's 2012 agricultural tractor user phone survey, and tractor sales data from within the region. These estimates and the methodology used for them were presented to EPA's 2015 International Emissions Inventory Conference in San Diego and were accepted by TCEQ under CAPCOG's 2014-2015 Rider 7 grant. As CAPCOG's 2015 report documents, however, a lot of off-model work needed to be completed in order to produce these estimates due to the constraints of the TexN model. Some of the more notable constraints were:

- The lack of differentiation in activity level by horsepower range or county
- The fact that the age distribution is simulated based on a variety of other model inputs (unlike the MOVES model, where it is a direct model input) and direct age distribution data for equipment has to be manually post-processed
- The lack of an LPG tractor SCC or certain fuel type/horsepower range combinations for diesel-powered and gasoline-powered tractors

For these reasons, CAPCOG did not attempt in 2015 to provide updates to TexN model, since there was no package of updates that would accommodate the various data that CAPCOG had developed and produce the same model outputs. For any projections, there is an added constraint from the fact that the only data that varies by year is the equipment population.

Despite these constraints, updates to the TexN model could still be made to produce outputs that were as close as possible to the outputs produced by CAPCOG using the "long way" of generating these estimates.

4.1.1 Updated Baseline Inputs

CAPCOG's first step involved updating the 2012 base year inputs for the TexN model. Since the age distribution in any given year is partially a function of the equipment population in prior years, CAPCOG updated all years from 1970 – 2012 using the same tractor population counts developed for the 2015 report for each county.

CAPCOG then undertook an iterative process of updating the 2012 equipment populations in order to produce NO_X emissions estimates for the region that were as close as possible to the estimates produced in CAPCOG's 2015 report. This involved applying an adjustment factor ("AF") to the 2012 equipment populations for SCCs 2270005015 and 2265005015 (diesel and gasoline agricultural tractors) calculated based on the region-wide ratio of the NO_X estimates produced by CAPCOG in 2015 using the "long way" relative to the most recent model output. The generalized form for the way this adjustment factor is shown below.

$$AF_{Fuel\ Type,County,2012} = \frac{2015\ Report\ NO_X\ for\ 2012}{NO_X\ Output\ from\ Most\ Recent\ 2012\ Model\ Run}$$

CAPCOG multiplied the adjustment factor to the 2012 diesel and gas tractor equipment populations, as shown in the formula below.

$$AF_{Fuel\ Type,County,2012} \times\ Updated\ Baseline\ Engine\ Pop._{Fuel\ Type,County,2012} = Adjusted\ \ Pop._{Fuel\ Type,County,2012}$$

CAPCOG updated the TexN database with the adjusted 2012 populations and re-ran TexN for a 2012 OSD weekday. CAPCOG repeated the process until the region-wide NO_X from the model output to the 2012 estimate was within ±5% of the 6.86 tpd NO_X reported in CAPCOG's 2015 report. The table below summarizes these adjustment calculations.

Table 4-1. Agricultural Tractor 2012 Population Adjustment Factors Calculation Methodology

TexN Run	Population Calculation
Updated 2012 Baseline (v0)	2015 Report 2012 Engine Population
Adjusted 2012 Population Version 1 (v1)	$AF_{v0,Fuel\ Type,County,2012} \times Updated\ Baseline\ Engine\ Pop._{v0,Fuel\ Type,County,2012}$
Adjusted 2012 Population Version 2 (v2)	$AF_{v0,Fuel\ Type,County,2012} \times AF_{v1,Fuel\ Type,County,2012} \times Updated\ Baseline\ Engine\ Pop._{v0,Fuel\ Type,County,2012}$
Adjusted 2012 Population Version 2 (v3)	$AF_{v0,Fuel\ Type,County,2012} \times AF_{v1,Fuel\ Type,County,2012} \times AF_{v2,Fuel\ Type,County,2012} \times Updated\ Baseline\ Engine\ Pop._{v0,Fuel\ Type,County,2012}$

These adjustment factors were calculated on the county level, and for version 3, equaled 1.00 for all counties except for Bastrop County. The difference in the Bastrop County inventories is notable given its percent difference. However, CAPCOG investigated the issue and it appears that the combination of the activity level used in the model and the assumptions regarding the trends in the county's equipment population from 2002-2012 make it difficult to use this adjustment method in order to bring the modeling results in line with the more detailed 2012 modeling results described elsewhere. Since version 3 was within 5% of the existing 2012 NO_X estimate CAPCOG produced in its 2015 report for all 10 other counties and the Bastrop County factor had stabilized, CAPCOG used the "version 3" equipment populations as the new baseline inputs for 2012.

These adjustments were performed for both diesel and gasoline tractors for each county. They provide an accurate picture of county-to-county variations in NO_X emissions. The following tables provide the adjustment factors by county for each fuel type.

Table 4-2. Diesel Agricultural Tractor 2012 OSD Weekday NO_X Emissions and Population Adjustment Factors

County	2015 Report NO_X (tpd)	NO_{Xv0} (tpd)	AF_{v0}	NO_{Xv1} (tpd)	AF_{v1}	NO_{Xv2} (tpd)	AF_{v2}	NO_{Xv3} (tpd)	AF_{v3}
Bastrop	0.66	1.36	0.48	1.36	0.48	1.36	0.483	1.36	0.48
Blanco	0.18	0.39	0.45	0.18	1.00	0.18	1.000	0.18	1.00
Burnet	0.33	0.75	0.43	0.75	0.44	0.14	2.295	0.33	1.00
Caldwell	0.47	1.00	0.46	1.00	0.47	0.22	2.147	0.47	1.00
Fayette	1.07	2.17	0.50	2.16	0.50	0.53	2.014	1.07	1.00
Hays	0.28	0.61	0.46	0.28	1.00	0.28	1.000	0.28	1.00
Lee	0.63	1.26	0.50	1.26	0.50	0.32	1.995	0.63	1.00
Llano	0.13	0.32	0.42	0.31	0.42	0.06	2.365	0.13	1.00
Milam	0.88	1.62	0.54	1.61	0.55	0.48	1.833	0.88	1.00
Travis	0.44	0.80	0.55	0.80	0.55	0.24	1.820	0.44	1.00
Williamson	1.19	2.11	0.56	2.11	0.56	0.67	1.778	1.19	1.00

Table 4-3. Gasoline Agricultural Tractor 2012 NO_X Emissions and Population Adjustment Factors

County	2015 NO_X (tpd)	NO_{Xv0} (tpd)	AF_{v0}	NO_{Xv1} (tpd)	AF_{v1}	NO_{Xv2} (tpd)	AF_{v2}	NO_{Xv3} (tpd)	AF_{v3}
Bastrop	0.06	0.03	1.97	0.03	1.97	0.03	1.97	0.03	1.97
Blanco	0.02	0.01	1.92	0.02	1.00	0.02	1.00	0.02	1.00
Burnet	0.04	0.02	1.87	0.02	1.87	0.07	0.53	0.04	1.00
Caldwell	0.04	0.02	1.88	0.02	1.88	0.08	0.53	0.04	1.00
Fayette	0.11	0.05	2.07	0.05	2.07	0.22	0.48	0.11	1.00
Hays	0.03	0.02	1.86	0.03	1.00	0.03	1.00	0.03	1.00
Lee	0.06	0.03	2.08	0.03	2.08	0.13	0.48	0.06	1.00
Llano	0.02	0.01	1.87	0.01	1.87	0.03	0.53	0.02	1.00
Milam	0.06	0.03	2.04	0.03	2.04	0.12	0.49	0.06	1.00
Travis	0.03	0.02	1.88	0.02	1.88	0.06	0.53	0.03	1.00
Williamson	0.07	0.04	1.99	0.04	1.99	0.14	0.50	0.07	1.00

The following table shows the comparison of the emissions between the more detailed version produced in 2015 and the version produced using the updated TexN inputs.

Table 4-4. Comparison of Agricultural Tractor Emissions OSD Weekday Outputs Using Updated 2012 TexN Inputs

Model Output	2015 Report (tpd)	Updated Model Output (tpd)	Difference (tpd)	% Difference
CO	15.10	22.41	7.31	48.40%
NO_X	6.86	6.47	-0.39	-5.75%
CO_2	645.81	1255.32	609.51	94.38%
SO_2	0.00	0.0	0.00	0.00%
PM	1.12	0.62	-0.50	-44.42%
VOC	1.56	0.95	-0.61	-39.18%

The following table shows a county-level comparison of the NO_X emissions for agricultural tractors between the more detailed version produced in 2015 and the version produced using the updated TexN inputs as described above.

Table 4-5. County Agricultural Tractor Comparison for 2012 OSD Weekay (tpd)

County	2015 Report NO_X (tpd)	Updated TexN Inputs NO_X (tpd)	Difference (tpd)	% Difference
Bastrop	0.73	0.40	-0.33	-45.77%
Blanco	0.20	0.20	0.00	0.00%
Burnet	0.37	0.36	-0.01	-1.95%
Caldwell	0.52	0.51	-0.01	-1.83%
Fayette	1.19	1.18	-0.01	-0.96%
Hays	0.31	0.31	0.00	0.24%
Lee	0.70	0.69	-0.01	-0.97%
Llano	0.15	0.15	0.00	0.00%
Milam	0.95	0.94	-0.01	-1.25%
Travis	0.48	0.47	-0.01	-1.64%
Williamson	1.27	1.26	-0.01	-0.89%
TOTAL	**6.86**	**6.47**	**-0.39**	**-5.75%**

4.1.2 Updated Population Projections

CAPCOG's 2012 equipment populations are based on the USDA's 2012 Census of Agriculture, which includes county-level tractor counts. This survey is conducted every five years, so CAPCOG needed to rely on other agricultural data in order to evaluate what types of adjustments are needed for the projections. In CAPCOG's 2015 report, CAPCOG projected equipment populations to 2018 based on county-level trends in the 2002, 2007, and 2012 Census of Agriculture data. This resulted in declines in equipment populations and fuel consumption across the region, although the rate of change differed by horsepower range.

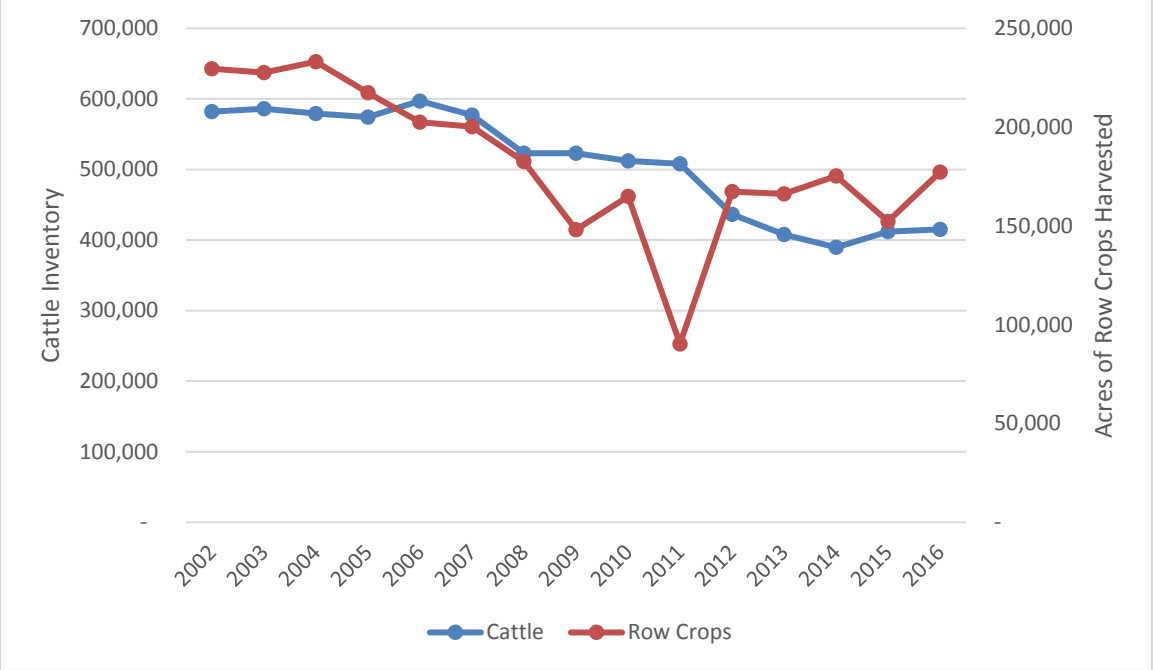
In order to evaluate whether or not the region's agricultural production data since 2012 matched this assumption, CAPCOG analyzed the USDA's National Agricultural Statistics Service (NASS) "Quick Stats" data[9] on cattle inventory and row crops harvested from 2002-2016. The analysis focused on the total annual change of the total number of cattle, including calves, and the total acres of row crops harvested.

- For cattle, the January 1, 2012, numbers reflect the herd sell-off from 2011 drought. As a result, the cattle inventory has not recovered to its pre-2012 levels. From 2013-2016, the number of cattle has remained level.
- For row crops, there was a long-term decline between 2002 and 2010. As a result of the 2011 drought, there was a sharp 1-year decrease in 2011. However, there was a rebound in 2012 that recovered the crops lost in 2011. Since 2012, the number of row crops harvested have remained fairly constant for 2013-2016.

Figure 5-2 shows the trend over time for cattle inventory and row crops harvested. The cattle data reflect the number on the 1st of January of each year, while the crop data reflect the number on the 31st of December of each year.

[9] https://quickstats.nass.usda.gov/

Figure 4-2. Trends in Regional Cattle Inventories and Row Crop Acreage Harvested, 2002-2016



These data show that the total number of cattle and acreage of row crops harvested from 2012-2016 has remained fairly constant. A trend line analysis shows that the 2012-2016 trend is equivalent to a decrease of less than 1% of the 2012 cattle inventory per year, and an increase in the baseline row crop harvesting of less than 1% of the 2012 acreage per year, with both trend lines having very low R^2 values (0.13 and 0.01, respectively). This lack of a discernable trend over this five-year period led CAPCOG to decide to assume that agricultural activity levels in the region will remain constant at 2012 levels for modeling purposes.

4.1.3 Updated 2013-2022 Population Inputs

Due to the need to perform adjustments to population data in order to get TexN to produce NO_X results similar to the more detailed emissions inventory estimates, calculating future year population inputs requires first performing the more detailed emissions estimates using the methodology CAPCOG used in its 2015 report. Theoretically, this should be performed for every future year sequentially in order to provide the correct adjustment factors for each year that is going to be used for modeling purposes. However, this is a quite labor-intensive process, and not all analysis years are equally valuable for "calibrating" the TexN model. CAPCOG selected 2022 as the future year to calibrate the model's population updates to, since this year is 10 years beyond the 2012 base year and 5 years from now.

Since this process is divided into two phases and is time consuming, it is known as the "long way." This process involves separating the emissions modeling into two basic steps:

1. Initial model runs for 2022 using updated equipment and activity data using the same methods that CAPCOG used for the 2018 projection in its 2015 report, including adjustments to the equipment population files for 1970-2022, a modification to the scrappage curve, and a

sequence of TexN runs designed to account for differences in activity levels by HP range and certain fuel type/horsepower tractor combinations

2. Post-processing of the TexN outputs in order to force the age distribution to match the Census of Agriculture age distribution data for tractors within the region

This "long way" produced detailed emissions estimates consistent with CAPCOG's 2015 report and updated projection assumptions. The region-wide total NO_X emissions was 5.11 tpd.

Since CAPCOG needed to ultimately produce updates to the TexN model, CAPCOG needed to follow a similar procedure for 2022 that it followed for calculating updated 2012 baseline TexN inputs. CAPCOG used the "version 3" population inputs for the 2012 baseline and updated the 2013-2022 population records to match those values. CAPCOG then performed a 2022 OSD weekday run using these inputs, which produced a region-wide total of 2.96 tpd of NO_X.

$$AF_{\,Fuel\,Type,\frac{Long}{Short}} = \frac{2022\ Long\ Way\ NOX_{Fuel\,Type,County}}{2022\ Short\ Way\ NOX_{\,Fuel\,Type,County}}$$

Table 4-6. Summary of 2022 Modeling Population Sources and OSD Weekday NO_x Emissions

TexN Run	2012 Population Source	NO_X (tpd)
2022 Long Way	2015 Report	5.11
2022 Short Way	Adjusted 2012 Population Version 3	2.96

The tables below summarize the results of the long and short way of modeling the emissions from agricultural tractors in 2022 by county and fuel type.

Table 4-7. Diesel Agricultural Tractor 2022 Long and Short Way NO_X Emissions (tpd) and Population Adjustment Factors

County	2022 Long NO_X (tpd)	2022 Short NO_X (tpd)	AF
Bastrop	0.60	0.56	1.07
Blanco	0.14	0.08	1.74
Burnet	0.21	0.15	1.43
Caldwell	0.26	0.19	1.33
Fayette	0.65	0.45	1.45
Hays	0.14	0.12	1.13
Lee	0.38	0.26	1.45
Llano	0.13	0.06	2.20
Milam	0.57	0.31	1.83
Travis	0.24	0.17	1.46
Williamson	0.76	0.41	1.84

Table 4-8. Gasoline Agricultural Tractor 2022 Long and Short Way NO_X Emissions (tpd) and Population Adjustment Factors

County	2022 Long NO_X (tpd)	2022 Short NO_X (tpd)	AF
Bastrop	0.05	0.01	4.50
Blanco	0.04	0.01	5.07
Burnet	0.07	0.01	5.15
Caldwell	0.09	0.02	5.38
Fayette	0.22	0.04	5.68
Hays	0.06	0.01	4.72
Lee	0.13	0.02	5.95
Llano	0.03	0.01	4.91
Milam	0.13	0.02	6.05
Travis	0.06	0.01	4.67
Williamson	0.15	0.03	5.52

4.1.4 2012-2022 Modeling

CAPCOG combined the results from the 2012 and 2022 modeling, described previously. With this combination, CAPCOG developed unique agricultural tractor population updates for 2012-2022.

Using the values calculated for 2012 from the Updated 2012 Population Version 3, CAPCOG calculated the 2013-2022 populations through a series of runs. First, CAPCOG calculated the 2022 value by multiplying the 2012 value, from Updated 2012 Population Version 3, by the adjustment factor of the 2022 Long Way to Short Way runs, shown in Tables 5-7 and 5-8.

$$AF_{\,Fuel\ Type,\frac{Long}{Short}} \times Updated\ 2022\ Engine\ Pop._{Fuel\ Type,County} = Adjusted\ 2022\ Pop._{Fuel\ Type,County}$$

With 2012 and 2022 populations calculated, CAPCOG then extrapolated the 2013-2021 populations through the change over time. With the updated populations, CAPCOG modeled the 2022 OSD tractor emissions. CAPCOG then calculated the adjustment factor of the 2022 Long Way NO_X emissions to the 2022 emissions modeled with the adjusted 2013-2021 populations.

$$AF_{Fuel\ Type,2022} = \frac{2022\ Long\ Way\ NOX_{Fuel\ Type,County}}{Adjusted\ 2022\ NOX_{\,Fuel\ Type,County}}$$

The table below summarizes the adjusted population factor calculations.

Table 4-9. Summary of 2012-2022 Adjusted Population Calculations

TexN Run	Adjusted Population Calculation
2022 Long Way	$Adjusted\ 2012\ Pop._{v3}$
Adjusted 2022 Population Version 1 (v_1)	$AF_{\ Fuel\ Type,\frac{Long}{Short}} \times Adjusted\ 2012\ Pop._{v3}$

Since the ratios were within ±5% of the values CAPCOG obtained using the "long way," for every county except Bastrop County after the 1st adjustment factor was applied, CAPCOG used the "version 1" updated population factor. The tables below show the resulting NO_X emissions and the calculated factors.

Table 4-10. Diesel Agricultural Tractor 2022 OSD Weekday NO_X Emissions and Population Adjustment Factors

County	2022 Long NO_X	2022 Short NO_X	$AF_{Long/Short}$	Adjusted 2022 Population Version 1 NO_X (v_1)	AF_{v1}
Bastrop	0.60	0.56	1.07	0.23	2.61
Blanco	0.14	0.08	1.74	0.14	1.00
Burnet	0.21	0.15	1.43	0.21	1.00
Caldwell	0.26	0.19	1.33	0.26	1.00
Fayette	0.65	0.45	1.45	0.65	1.00
Hays	0.14	0.12	1.13	0.14	1.00
Lee	0.38	0.26	1.45	0.38	1.00
Llano	0.13	0.06	2.20	0.13	1.00
Milam	0.57	0.31	1.83	0.57	1.00
Travis	0.24	0.17	1.46	0.24	1.00
Williamson	0.76	0.41	1.84	0.76	1.00

Table 4-11. Gasoline Agricultural Tractor 2022 OSD Weekday NO_X Emissions and Population Adjustment Factors

County	2022 Long NO_X	2022 Short NO_X	$AF_{Long/Short}$	Adjusted 2022 Population Version 1 NO_X (v_1)	AF_{v1}
Bastrop	0.05	0.01	4.50	0.12	0.46
Blanco	0.04	0.01	5.07	0.04	1.00
Burnet	0.07	0.01	5.15	0.07	1.00
Caldwell	0.09	0.02	5.38	0.09	1.00
Fayette	0.22	0.04	5.68	0.22	1.00
Hays	0.06	0.01	4.72	0.06	1.00
Lee	0.13	0.02	5.95	0.13	1.00
Llano	0.03	0.01	4.91	0.03	1.00
Milam	0.13	0.02	6.05	0.13	1.00
Travis	0.06	0.01	4.67	0.06	1.00
Williamson	0.15	0.03	5.52	0.15	1.00

4.1.5 Emissions Inventory Summary

Table 5-11 and Table 5-12 provide summaries of the total estimated emissions from all agricultural tractor equipment for each county in 2012 and 2022.

Table 4-12. Summary of Estimated Agricultural Tractor OSD Weekday Emissions, 2012 (tpd)

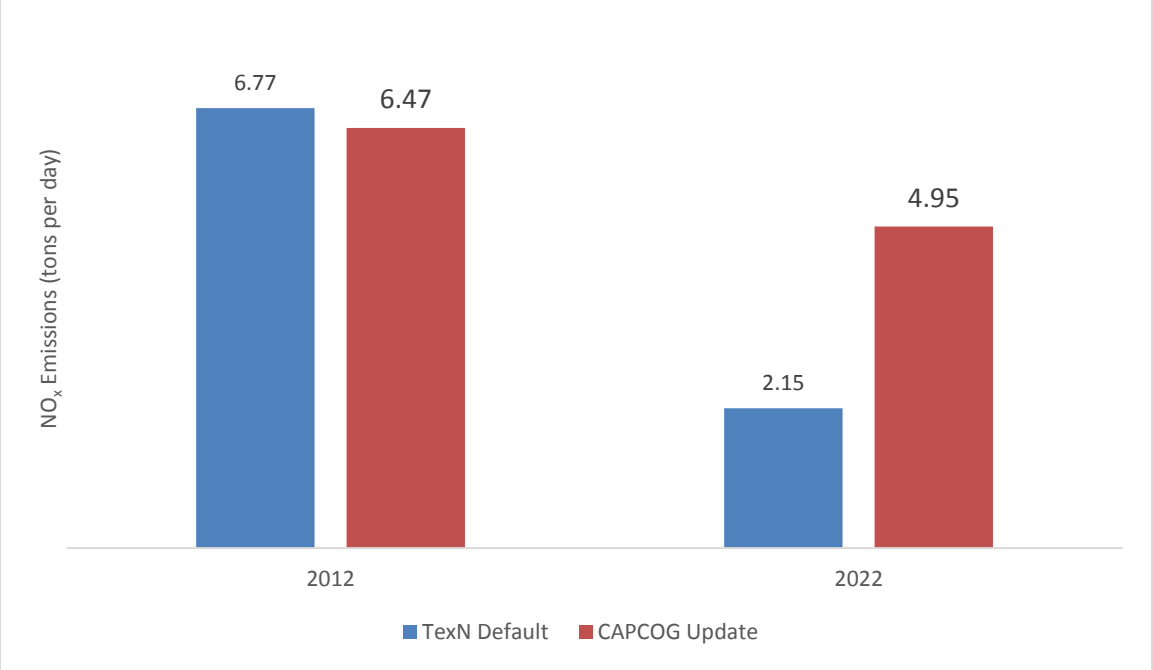
County	CO	NO_X	CO_2	SO_2	PM	VOC
Bastrop	6.4045	0.3959	88.4516	0.0016	0.0222	0.1606
Blanco	0.6603	0.1959	36.5931	0.0002	0.0188	0.0279
Burnet	1.2049	0.3628	67.3949	0.0004	0.0348	0.0512
Caldwell	1.4971	0.5105	98.1928	0.0006	0.0507	0.0694
Fayette	3.4190	1.1786	226.3917	0.0010	0.1182	0.1600
Hays	1.0218	0.3108	58.2063	0.0004	0.0294	0.0436
Lee	1.9471	0.6932	133.0212	0.0008	0.0699	0.0929
Llano	0.5234	0.1488	27.8602	0.0002	0.0142	0.0216
Milam	2.0067	0.9381	180.8467	0.0008	0.0931	0.1124
Travis	1.1621	0.4721	91.7246	0.0005	0.0461	0.0597
Williamso	2.5619	1.2587	246.6386	0.0012	0.1251	0.1494
Total	**22.4088**	**6.4654**	**1,255.3218**	**0.0076**	**0.6225**	**0.9488**

Table 4-13. Summary of Estimated Agricultural Tractor OSD Weekday Emissions, 2022 (tpd)

County	CO	NO_X	CO_2	SO_2	PM	VOC
Bastrop	17.8760	0.4884	291.8041	0.0067	0.0281	0.3256
Blanco	1.7727	0.1787	79.7541	0.0008	0.0059	0.0451
Burnet	3.2256	0.2839	129.0822	0.0014	0.0098	0.0780
Caldwell	3.9771	0.3505	173.6777	0.0018	0.0124	0.0997
Fayette	9.1279	0.8696	429.0940	0.0029	0.0298	0.2364
Hays	2.6271	0.1968	92.9081	0.0011	0.0072	0.0605
Lee	5.3052	0.5099	252.9440	0.0025	0.0175	0.1383
Llano	1.3978	0.1646	71.8869	0.0006	0.0053	0.0379
Milam	5.1478	0.6975	384.7439	0.0022	0.0231	0.1695
Travis	2.7945	0.3028	159.2347	0.0013	0.0106	0.0798
Williamso	6.2973	0.9044	512.7328	0.0034	0.0302	0.2185
Total	**59.5490**	**4.9471**	**2,577.8627**	**0.0246**	**0.1800**	**1.4892**

CAPCOG's updates resulted in 2012 NO_X emissions for the 11-county region to be close to the estimate generated using default TexN inputs, but much higher NO_X estimates for 2022, due primarily to the much slower fleet turnover modeled in CAPCOG's updates. Figure 4-3 below shows the comparison for each year.

Figure 4-3. Comparison of Total Estimated OSD Weekday NO_X Emissions Estimates for 2012 and 2022



While the aggregate NO_X emissions estimate for the 11-county region in 2012 is surprisingly close to the TexN estimate, a county-by-county comparison shows that CAPCOG's updates produced more substantial changes at the county level, with notably higher emissions estimates for Bastrop, Burnet, Fayette, and Lee Counties, and notably lower estimates for Milam and Williamson Counties.

4.2 All Other Agricultural Equipment

CAPCOG decided not to update the 2012 baseline TexN inputs for any other agricultural equipment aside from tractors due to the resource-intensive process that would take. However, CAPCOG did update the 2013-2050 equipment populations for all 10 counties and Milam County for the other nine agricultural equipment types in order to match the 2012 populations, consistent with the 2012-2016 agricultural production trends described above. This allows for consistency in the growth projections and relative change in emissions for all agricultural equipment within the region. The following table summarizes the emissions data for 2012 and 2017 using these inputs.

Table 4-14. 2012 and 2017 OSD Weekday Other Agricultural Equipment Emissions from Updated Inputs

Pollutant	2012 (tpd)	2017 (tpd)
CO	2.27	1.73
NO_X	2.25	1.58
CO_2	312.92	317.38
SO_2	0.00	0.00
PM	0.25	0.16
VOC	0.27	0.20

5 Conclusion and Recommendations

This report documents three distinct non-road emissions inventory projection projects completed by CAPCOG:

1. Updates to the Mine and Quarry DCE subsector for Lee County to account for 2008-2017 coal production data and the forthcoming closure of the Three Oaks mine in early 2018
2. Updates to the Agricultural Tractor TexN inputs in order to produce NO_X emissions inventories for 2012-2022 and beyond that more closely match the NO_X estimates produced by CAPCOG's more detailed method of modeling this source and an updated assumption about flat growth in agricultural tractor activity after 2012
3. Updates to equipment populations for all other Agricultural Equipment categories for 2013-2050 to reflect the updated assumption of flat growth relative to 2012

CAPCOG is also providing TexN update scripts that TCEQ or other users can update their TexN v. 1.7.1 databases with in order to take advantage of these updates.

The limitations of the TexN model pose some significant challenges to taking advantage of some key data that can produce improved emission inventories for many non-road sources. CAPCOG's research for this project leads CAPCOG to believe that future modeling efforts would benefit from a model that is better able to incorporate county-level and year-by-year variations in activity levels, and that statewide inputs for the agricultural equipment sector would benefit greatly from the inclusion of data from the Census of Agriculture, including tractor, combine, cotton picker, and forage harvester counts and fuel expense data. Given the magnitude of the NO_X emissions from the mine and quarry sector within the construction and mining sector, CAPCOG also recommends a set of state-wide updates to the 2008-2017 equipment populations using the US MHSA data and updating mining economic projections. CAPCOG also believes that statewide research into the industrial and commercial equipment categories and updates to the TexN inputs for those categories would be valuable in order to establish a better statewide baseline of estimates for these equipment types. These categories account for a significant amount of NO_X emissions but the only updates to the NONROAD defaults for these categories are some selected industrial equipment categories in the Dallas-Fort Worth and Houston-Galveston-Brazoria areas. These would help build a stronger foundation upon which local efforts to refine those estimates and projections could be based on.