UNC
INSTITUTE FOR
THE ENVIRONMENT

THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

CENTER FOR ENVIRONMENTAL
MODELING FOR POLICY DEVELOPMENT

EUROPA CENTER, SUITE 490
100 EUROPA DRIVE
CHAPEL HILL, NC 27517

T 919.966.9922
F 919.966.9920
www.ie.unc.edu/cempd

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FINAL MEMORANDUM

To: Tom Moore, WESTAR
From: Zac Adelman and B.H. Baek, UNC-IE
Subject: Southern New Mexico Ozone Study Base Year Emissions

INTRODUCTION

Doña Ana County in Southern New Mexico experiences some of the highest observed ground-level ozone concentrations in the state. The Sunland Park Ozone Nonattainment Area (NAA) which lies within Doña Ana County was designated as marginal nonattainment for the 1-hour ozone National Ambient Air Quality Standard (NAAQS) on June 12, 1995 (60 FR 30789). With the revocation of the 1-hour ozone NAAQS in 2004, the Sunland Park NAA was designated a maintenance area for 8-hour ozone (NMED, 2007). In March 2008 EPA lowered the 8-hour ozone NAAQS to 0.075 ppm (75 ppb). In October 2015 EPA lowered the 8-hour ozone NAAQS to 0.070 ppm (70 ppb) that based on current ozone levels will likely lead to the Sunland Park NAA receiving a nonattainment designation for 8-hour ozone in October 2017 based on 2014-2016 observed air quality data. In addition, the New Mexico Air Quality Control Act (NMAQCA) requires the New Mexico Environment Department (NMED) to develop a plan for reducing ozone levels in areas that are within 95% of the ozone standard (NMSA 1978, § 74-2-5.3).

The statutory requirements of both the NAAQS and the NMAQCA include the development of a plan to control the emissions of sources pursuant to attainment and maintenance of the NAAQS. In the case of a NAAQS NAA State Implementation Plan (SIP), air quality modeling is required to identify the causes of high pollution and to propose emissions control strategies that will bring the area into attainment. The Southern New Mexico Ozone Study (SNMOS) will study the factors contributing to high ozone in Doña Ana County and investigate future emissions scenarios that will produce NAAQS attainment. The SNMOS is a collaborative project between NMED, the Western Regional Air Partnership (WRAP), the Western Air Resources Council (WESTAR), Ramboll Environ US Corporation (Ramboll Environ), and the University of North Carolina Institute for the Environment (UNC-IE). This Study builds off of the Western Air Quality Study (WAQS), a cooperative project that is intended to facilitate air resource analyses for federal and state agencies in the intermountain western U.S. toward improved information for the public and stakeholders as a part of air quality planning.

This memorandum details the air pollution emissions data and processing approaches used to prepare emissions inputs for the SNMOS air quality model simulations. The SNMOS work plan supplements this memo with details of the meteorology, emissions, and air quality modeling data and applications used for the study (UNC and Ramboll Environ, 2015a). The process for creating model-ready emissions inputs includes defining the scope of the modeling study, collecting the most relevant data for the study, preparing the data for input to air quality modeling software, and performing quality assurance on both the data and preparation procedures. This process was led by UNC-IE and began for SNMOS in August 2015 with the data collection and modeling for a summer season 2011 base case simulation. The project scope included gathering the best available year 2011 criteria pollutant inventory and ancillary emissions data for southern New Mexico and northern Mexico and preparing these for input to the Comprehensive Air Quality Model with Extensions (CAMx)[1] photochemical grid model.

SNMOS 2011 EMISSIONS MODELING PLATFORM

An emissions modeling platform is the collection of emissions data, modeling software, and scripts used to prepare air quality model input emissions data. UNC-IE developed emissions for the SNMOS from the WAQS 2011 version B (2011b) emissions modeling platform available from the Intermountain West Data Warehouse (IWDW)[2]. The data sources for the WAQS 2011b emissions estimates included the U.S. EPA, Ramboll Environ, and the states of Colorado, Utah, and Wyoming. As part of the WAQS, UNC-IE formatted the data for input to the Sparse Matrix Operator Kernel Emissions (SMOKE[3]) system, processed the data into CAMx input files with SMOKE, and performed quality assurance and quality control (QA/QC) on the emissions data and modeling.

UNC-IE used all of the anthropogenic emissions data (e.g. nonroad mobile, nonpoint, electricity generating units) collected and prepared for the WAQS 2011b simulation to generate CAMx-ready emissions for the SNMOS. The significant effort invested in the WAQS in collating and quality assuring these data was inherited by the SNMOS through adaptation of the WAQS 2011b modeling platform. As the modeling domains and meteorology data are different between the studies, adapting the WAQS data involved generating emissions for the SNMOS modeling domains and time period.

The SNMOS used 12-km and 4-km modeling domains focused on Southern New Mexico. The standard continental U.S. (CONUS) Lambert Conformal Conic Projection (LCP) was used in the SNMOS for the domains shown in Figure 1 and described below.

- The SNMOS WESTUS12 CAMx domain encompasses all of New Mexico, extends west to include the metropolitan area of Phoenix, east to include West Texas, and South to include the Carbon II power plant in Coahuila, Mexico. This facility is a large source of NOx emissions and lies in a region that was sometimes upwind of Doña County on high ozone days during 2011. The SNMOS WESTUS12 domain was designed as a tradeoff

[1] http://www.camx.com
[2] http://views.cira.colostate.edu/tsdw
[3] http://www.smoke-model.org

between computational efficiency and the need to model transport from sources likely to influence Doña Ana County at 12 km resolution.

- The SNMOS04 4-km Doña Ana County domain focuses on Southern NM and the major source regions in the immediate vicinity, including Ciudad Juarez, Mexico and El Paso, TX.

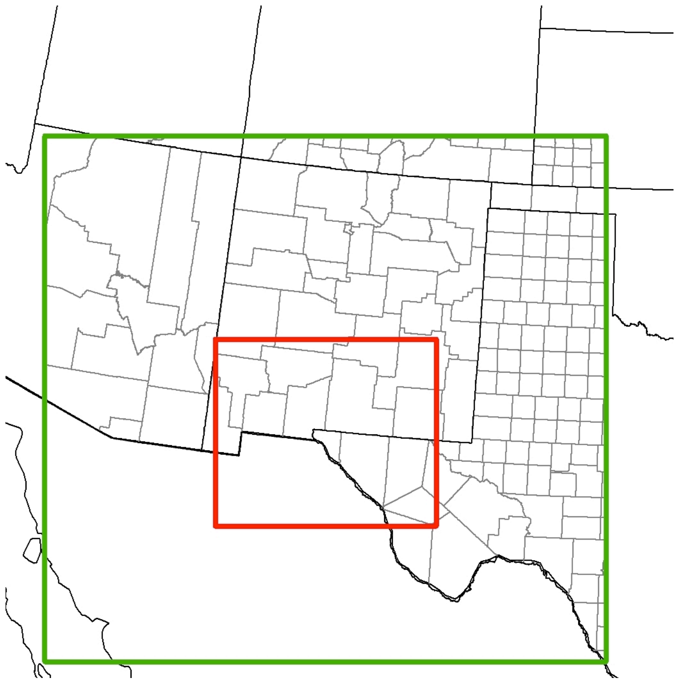


Figure 1. SNMOS 12-km (green) and 4-km (red) nested CAMx modeling domains.

UNC-IE prepared emissions on these domains for April 15 through August 30, 2011. The first 15 days of emissions (April 15-30) were prepared to initialize the CAMx simulation for the air quality analysis period beginning on May 1. The purpose of the two week initialization period is to remove the influence of the model's initial conditions on the CAMx simulation.

Ramboll Environ prepared emissions for fires (wildfire, agricultural burning, prescribed burning), biogenic sources, and lightning NOx on the SNMOS modeling domains and time periods. These gridded data sets were merged with the anthropogenic emissions to create a complete estimate of the ozone precursor emissions for the SNMOS. Additional details of the processing approaches used for the SNMOS are documented in the Three-State Air Quality Study Emissions Modeling Report (Adelman et al., 2015).

Emissions Modeling Software

UNC-IE used SMOKE version 3.7 to prepare emissions for the SNMOS CAMx modeling. The SMOKE modeling system is a set of programs that is used by the U.S. EPA, Regional Planning Organizations, and State environmental agencies to prepare emissions inventory data for input to air quality models (AQMs). SMOKE converts annual, daily, or hourly estimates of emissions at the state or county level to hourly emissions fluxes on a uniform spatial grid that are formatted for input to AQMs. SMOKE integrates county-level emissions inventories with source-based temporal, spatial, and chemical allocation profiles to create hourly emissions fluxes on a predefined model grid. For elevated sources that require allocation of the emissions to the vertical model layers, SMOKE integrates meteorology data to derive dynamic vertical profiles.

The SMOKE-MOVES processor is an interface for the Motor Vehicle Emissions Simulator (MOVES) on-road mobile emissions model that prepares MOVES results for input to an AQM. SMOKE can additionally be used to calculate future-year mobile emissions estimates, if the user provides data about how the emissions will change in the future.

SMOKE uses C-Shell scripts as user interfaces to set configuration options and call executables. SMOKE is designed with flexible QA capabilities to generate standard and custom reports for checking the emissions modeling process. After modeling all of the emissions source categories individually, SMOKE creates two files per day for input into CAMx: (1) an elevated point source file for large stationary sources, and (2) a merged gridded source file of low-level point, mobile, non-road, and area emissions. The efficient processing of SMOKE makes it an appropriate choice for handling the large processing needs of regional and seasonal emissions processing, as described in more detail by Houyoux et al. (2000).

SMOKE primarily uses two types of input file formats: ASCII files and I/O API netCDF files. Input files are files that are read by at least one core SMOKE program, but are not written by a core program. SMOKE uses strict rules that define the format and content of the input files. These rules are explicitly laid out in the SMOKE User's Manual[4]. All data input to SMOKE must be either formatted to one of the prescribed input file types or converted to an intermediate form, such as a gridded I/O API inventory file, before it can be input to SMOKE.

In general SMOKE requires an emissions inventory, temporal allocation, spatial allocation, and chemical allocation data to prepare emissions estimates for an air quality model. For some source categories, such as on-road mobile and stationary point sources, SMOKE also requires meteorology data to calculate emissions. Upstream software and utilities are used to prepare many of the inputs to SMOKE. The Meteorology Chemistry Interface Processor (MCIP), which is part of the Community Multiscale Air Quality (CMAQ) model[5], is used to prepare WRF meteorology data for input to SMOKE. A Geographic Information System (GIS), such as the open-source Spatial Allocator[6], is needed to create the spatial surrogates that map inventory data to modeling grids. The Speciation Tool[7] is built on top of the SPECIATE[8] database as an interface to create the chemical allocation profiles that convert inventory pollutants to AQM species. Temporal allocation profiles and the assignment files that associate the spatial/chemical/temporal profiles to inventory sources are all available from the EPA Clearinghouse for Inventories and Emissions Factors[9]. Other source-specific inputs, such as land use/land cover data for biogenic emissions and MOVES look up tables and ancillary files, are typically prepared for SMOKE on a project-specific basis

4 http://www.smoke-model.org/
5 http://www.cmaq-model.org/
6 http://www.cmascenter.org/sa-tools/
7 http://www.cmascenter.org/help/model_docs/speciation_tool/3.1/Sptool_UG_V3.1.pdf
8 http://www.epa.gov/ttnchie1/software/speciate/
9 http://www.epa.gov/ttn/chief/index.html

MOVES: The MOtor Vehicle Emission Simulator model (MOVES[10]) is a multi-scale emissions modeling system that generates emission inventories or emission rate lookup tables for on-road mobile sources. MOVES is capable of creating inventories or lookup tables at the national, state, county, or project scales. MOVES was designed by EPA's Office of Transportation and Air Quality (OTAQ) and the current version is MOVES2014 that was released in July 2014. MOVES is principally an emissions modeling system where emissions estimates are simulated from 'first principles' taking into account the effects of fleet age deterioration, ambient temperature and humidity, activity patterns, fuel properties, and inspection and maintenance programs on emissions from all types of motor vehicles. MOVES outputs can be input to emissions processing systems such as SMOKE.

MEGAN: The Model of Emissions of Gases and Aerosols in Nature (MEGAN[11]) is a modeling system for estimating the net emission of gases and aerosols from terrestrial ecosystems into the atmosphere (Guenther et al., 2012). Driving variables include landcover, weather, and atmospheric chemical composition. MEGAN is a global model with a base resolution of ~1 km and so is suitable for regional and global models. A Fortran code is available for generating emission estimates for the CAMx regional air quality model. Global distributions of landcover variables (Emission Factors, Leaf Area Index, and Plant Functional Types) are available for spatial resolutions ranging from ~ 1 to 100 km and in several formats (e.g., ARCGIS, netcdf). WRAP recently sponsored an update to the MEGAN biogenic emissions models using western U.S. data and higher resolution inputs (Sakulyanontvittaya, Yarwood and Guenther, 2012).

SNMOS 2011 Emissions Data

Anthropogenic emissions sources are inventoried as either point or non-point sources. Characteristics of point sources include a state/county code, plant/source/stack identifier, source classification code (SCC), and a latitude-longitude coordinate. Additional details in the point inventories are required if the sources are inventoried with Continuous Emissions Monitors (CEMs) or if they are fire sources. Characteristics of non-point sources include a state/county code and SCC. Non-point sources can further be broken down as either mobile or non-mobile sources, with special characteristics required for mobile sources.

Consistent with the WAQS 2011b emissions modeling platform, all of the non-O&G anthropogenic emission inventories for the SNMOS base year 2011 simulations were taken from the U.S. EPA National Emission Inventory (NEI). EPA publically released the 2011v6 platform in February 2014 and updated it twice, version 6.2 being the most recent. Details of the inventory, sectors, and preparation procedures for these data are available in the NEI2011v6.2 Technical Support Document (EPA, 2015). The exception was the O&G inventories for most of the basins in Northern New Mexico, Colorado, Utah, and Wyoming, which were provided by Ramboll Environ. Ramboll Environ also developed emissions estimates for natural emissions sources for the SNMOS, including fires, and lightning.

In coordination with NMED, UNC-IE and Ramboll Environ determined that the 2008 Mexico National Emission Inventory (MNEI), which is packaged with the NEI2011v6.2, was the most

[10] http://www.epa.gov/otaq/models/moves/index.htm

[11] http://acd.ucar.edu/~guenther/MEGAN/MEGAN.htm

appropriate publically available Mexico inventory to use for the SNMOS (UNC and Ramboll Environ, 2015b).

Ramboll Environ also conducted a review of the available Permian Basin O&G inventories and determined that the inventory and ancillary emissions data that are part of the NEI2011v6.2 are the best available data for these sources (Grant and Kemball-Cook, 2015; UNC and Ramboll Environ, 2015b).

The SNMOS project used MOVES to estimate on-road mobile emissions for U.S. sources. The U.S. EPA provided MOVES input emission-factors for 2011. The SMOKE-ready on-road mobile inventory data are a combination of county-level activity data and emissions factor look-up tables output from MOVES for representative counties. The on-road mobile activity data included county-level vehicle miles traveled (VMT), vehicle population (VPOP), and averaged speed profiles by vehicle type and road class. The look-up tables for representative counties, which are output from MOVES emissions rate mode simulations, contained county-level emissions factors as a function of temperature, relative humidity, and speeds. Land cover data and biogenic emissions factors by land cover type were used to estimate biogenic emissions fluxes. UNC-IE used non-inventory, or ancillary emissions data provided by the U.S. EPA, to convert the inventories into the format required by CAMx.

Part of the preparation process for the inventory data included splitting the inventories into detailed subsectors. UNC-IE split-up many of the U.S. EPA NEI inventories to support the application of source-specific parameterizations of temporal and spatial patterns, to facilitate source-based emissions sensitivities, and to support targeted quality assurance of important inventory sectors. Although anthropogenic inventories can be generally classified as point, non-point, or mobile sources, UNC-IE used over 20 individual anthropogenic inventory sectors in the SNMOS modeling. Table 1 is a listing of the inventory processing sectors used for the SNMOS. The table lists the inventory processing sectors, the source of the inventory data, the type of inventory (i.e. point, nonpoint, or gridded), the inventory year, and brief descriptions of the inventory sources included in the sector.

Table 1. SNMOS emissions processing sectors

Sector	Source	Type	Inventory Period and Year	Description
Locomotive/ marine	NEI 2011v6.2	Point and Nonpoint	Annual 2011 and 2025	The locomotive/marine sector is a subset of the non-point/area sector. It includes county-level emissions for line haul locomotives (nonpoint), train yards (point), and class 1 and 2 in- and near-shore commercial marine
Off-road mobile	NEI 2011v6.2	Nonpoint	Monthly 2011 and 2025	NMIM county-level inventories for recreational vehicles, logging equipment, agricultural equipment, construction equipment, industrial equipment, lawn and garden equipment, leaf and snow blowers, and recreational marine. The CA and TX NONROAD estimates were normalized to emissions values provided by these states.
On-road	NEI	MOVES	Annual and	EPA ran MOVES2014 for 2011 in emissions

Sector	Source	Type	Inventory Period and Year	Description
mobile (US)	2011v6.2		Daily 2011 and 2025	factor mode. The MOVES lookup tables include on-network (RPD), on-network for CA (RPD_CA), off-network starts/stops (RPV), off-network starts/stops for CA (RPV_CA), off-network vapor venting (RPP), off-network vapor venting sources for CA (RPP_CAT, off-network hotelling (RPH). These data include the reference county and reference fuel month assignments that EPA used for the MOVES simulations. The CA MOVES estimates were normalized to emissions values provided by these states.
Non-point/ Area	NEI 2011v6.2	Nonpoint	Annual 2011 and 2025	County-level emissions for sources that individually are too small in magnitude or too numerous to inventory as individual point sources. Includes small industrial, residential, and commercial sources; broken out into nonpoint, residential wood combustion, livestock, and fertilizer processor sectors
Refueling	NEI 2011v6.2	Nonpoint	Annual 2011 and 2025	Nonpoint, gasoline stage 2 refueling
Area Oil & Gas	WAQS 2011 and NEI 2011v6.2	Nonpoint	Annual 2011 and 2020	Non-point oil and gas sources are survey-based and typically unpermitted sources of emissions from up-stream oil and gas exploration, development, and operations. The non-point O&G sector consists of the WAQS Phase II and the NEI 2011v6.2 inventory for all basins outside of the WAQS inventory coverage area.
Point Oil & Gas	WAQS 2011 and NEI 2011v6.2	Point	Annual 2011 and 2020	Point oil and gas sources are permitted sources of emission from up-stream oil and gas exploration, development, and operations. The point O&G sector consists of the WAQS Phase II and the NEI 2011v6.2 inventory for all areas outside of the WAQS inventory coverage area
CEM Point	2011v6.2 and CAMD	Point	Hourly 2011 and 2025	2011 Clean Air Markets Division (CAMD) hourly Continuous Emissions Monitor (CEM) data and Integrated Planning Model (IPM) projections to 2025
non-CEM Point	2011v6.2	Point	Annual 2011 and 2025	Elevated and low-level combustion and industrial sources, airports, and offshore drilling platforms.
Offshore Shipping	2011v6.2	Point	Annual 2011 and 2025	Elevated point C3 commercial marine sources in offshore commercial shipping lanes
Fires	PMDETAIL	Point	Daily 2011	PMDETAIL version 2 wildfire, prescribed burns and agricultural burning open land fires
Canada Sources	NPRI 2010	Nonpoint and Point	Annual 2010	Canadian 2010 National Pollutant Release Inventory; there are no future year projections from the 2010 NPRI
Mexico Sources	MNEI 2012	Nonpoint and Point	Annual 2008 and	Mexican NEI 2008 and projections to 2025

Sector	Source	Type	Inventory Period and Year	Description
			2025	
Biogenic	MEGAN v2.10	Gridded	Hourly 2011	MEGANv2.10 estimated with 2011 meteorology
Lightning	Ramboll Environ	Gridded	Daily 2011	Lightning NOx emissions estimated with 2011 meteorology

Several gridded emissions datasets were used for either directly estimating air emissions or as ancillary data for processing/adjusting the emissions data. The following datasets are key gridded data used in the SNMOS. We included neither sea salt nor windblown dust emissions in the SNMOS because of the study emphasis on O_3.

Biogenic Emissions Model Inputs

The major components of biogenic emissions models include:

- Leaf Area Index (LAI)
- Plant Functional Type (PFT)
- Plant specific species composition data and averaging
- Emissions factors, including the effects of temperature and photosynthetically active radiation (PAR)

The gridded data for input to the MEGANv2.10 biogenic model that were used to estimate 2011 biogenic emissions for the SNMOS include the following:

- Leaf Area Index (LAI): A gridded dataset of 46 8-day files for North America were generated for 2011 at 1-km resolution
- Plant Functional Type (PFT): A gridded dataset of 9 PFTs were developed at both 1-km and 56-m resolutions across the modeling domains.
- Photosynthetically Active Radiation (PAR): WRF solar radiation fields scaled by a factor of 0.45
- Additional details on the development and evaluation of the gridded data to be used for this Study are available in the final report on the WRAP Biogenic Emissions Study (Sakulyanontvittaya, Yarwood and Guenther, 2012).
- SNMOS 2011 WRF meteorology

Fire Emissions

Open biomass burning makes up an important part of the total global emissions of greenhouse gases, reactive trace gases, and particulate matter. Although episodic in nature and highly variable, open biomass burning emissions can contribute to local, regional, and global air quality problems and climate forcings. The SNMOS will use fire emissions for 2011 that were generated by the Particulate Matter Deterministic and Empirical Tagging and Assessment of Impacts on Levels (PMDETAIL[12]) study. PMDETAIL developed 2011 fire emission using satellite data and ground detect and burn scar, in addition to other data, with a slight modification (Mavko, 2014)

[12] https://pmdetail.wraptools.org/index.php

to the methodology used in the Deterministic and Empirical Assessment of Smoke's Contribution to Ozone Project (DEASCO3[13]) study for the 2008 modeling year (DEASCO3, 2013). We will use a similar plume rise approach as PMDETAIL/DEASCO3 where plume rise depends on fire size and type (Mavko and Morris, 2013). The PMDETAIL 2011 fire inventory was selected over the 2011 Fire INventory from NCAR (FINN) and Smartfire 2011 inventory because it uses a more complete satellite and surface fire dataset.

Lightning

The modified lightning NOx emissions model of Koo et al. (2010) used in the WAQS was used to estimate lightning NOx emissions for the SNMOS. Additional details on the development and evaluation of the lightning emissions processor used for the SNMOS are available in the WestJumpAQMS Sea Salt and Lightning memo (Morris, Emery, Johnson and Adelman, 2012).

Fugitive Dust Transport Factors

Transport factors are applied to the primary dust emissions estimates to adjust the emissions for vegetative scavenging. The dust models and emissions factors are based on soil characteristics and do not account for the presence of vegetation, which has a mitigating effect on both winds and dust emissions. An ad-hoc approach of adjusting dust emissions estimates has been developed that uses gridded land cover data to simulate the impacts of vegetation cover on dust.

For the SNMOS 2011 modeling we used dust transport factors collected for the WAQS, which were derived from the Biogenic Emission Landuse Database version 3 (BELD3; Vukovich and Pierce, 2002). Following the approach of Pouliot et al. (2010) we adjusted the fugitive and road dust emissions as a post-processing step after the emissions data are output from SMOKE. We used the transport factors gridded to each of the SNMOS modeling domains to reduce the dust emissions.

Ancillary Emissions Data

In addition to the inventory and gridded emissions data, ancillary datasets provide temporal, chemical, and spatial allocation specifications to the emissions. The ancillary data for SNMOS were taken directly from the WAQS 2011b modeling, which was derived primarily from the EPA 2011v6.2 modeling platform. Ancillary emissions data refer to the non-inventory data used to prepare emissions for input to an AQM, including:

- ***Spatial data.*** All anthropogenic non-point inventory data, including on-road and non-road mobile sources, are estimated at the county level. Data files called spatial surrogates are used to map the county-level emission inventories to the model grid cells. Spatial surrogates are generated from GIS Shapefiles using software that calculates the fractions of county-level different geospatial attributes in a model grid cell.

[13] https://deasco3.wraptools.org/

- ***Spatial Surrogates.*** Spatial surrogates require cross-referencing data that assign a spatial surrogate to specific categories of inventory sources. Spatial cross-reference files assign surrogates to inventory sources using FIPS and SCCs.

- ***Temporal data.*** Air quality modeling systems, such CAMx, require hourly emissions input data. With the exception of a few source types (e.g. Continuous Emissions Monitoring data, biogenic emissions and some fire inventories), most inventory data include annual or daily emission estimates. Temporal profiles are used to compute hourly emissions from the annual or daily inventory estimates. The SMOKE model uses three types of temporal profiles:
    - Monthly profiles: Convert annual inventory to monthly emissions accounting for seasonal and other effects.
    - Daily profiles: Convert monthly emissions to daily emissions accounting for day-of-week and other effects.
    - Hourly profiles: Convert daily emissions to hourly emissions accounting for the diurnal variation in emissions (e.g., work schedules and commute times).

  Temporal profiles are assigned to inventory sources using EPA cross-referencing data that match the profiles and inventory sources using country/state/county FIPS codes and SCCs.

- ***Chemical speciation data.*** Emissions inventories have limited chemical composition information. The emissions inventories for the WAQS included six criteria pollutants: carbon monoxide (CO), nitrogen oxides (NO_X), volatile organic compounds (VOC), ammonia (NH_3), sulfur dioxide (SO_2), coarse particulate matter with a mean diameter < 10 micrometers (PM_{10}), and fine particulate matter with a mean diameter < 2.5 micrometers ($PM_{2.5}$). Chemical speciation profiles are used to describe the chemical compositions of the effluent from particular emissions sources. The exact specification of the source-specific emissions species is determined by the chemistry mechanism selected for the AQM simulation. Speciation profiles convert the inventory pollutants to more detailed source-specific species in terms required by the AQM chemistry mechanism. For example, there is a speciation profile that converts the inventory pollutant NO_X to the AQM input species NO, NO_2, and HONO. Speciation profiles are required to convert inventory NO_X, VOC, SO_2, and $PM_{2.5}$ into AQM species. The VOC and $PM_{2.5}$ emissions are speciated using source specific speciation profiles developed using the SPECIATE 4.3 database.[14]

  We speciated the VOC emissions for the SNMOS 2011 modeling platforms in terms of the Carbon Bond 6 revision 2 (CB6r2) photochemical mechanism. We assigned the chemical speciation profiles to inventory sources using EPA cross-referencing data that match the profiles and inventory sources using FIPS and SCCs.

[14] http://www.epa.gov/ttnchie1/software/speciate/

SNMOS 2011 EMISSIONS SUMMARY

This section presents the results and analysis of the inventory data that UNC-IE collected and processed for the SNMOS. The plots in this section illustrate the contribution of the different inventory sectors to the annual 2011 total criteria pollutant emissions at the state-level and county-level for all New Mexico counties and 5 Mexico border states. As the MNEI does not contain the same level of inventory sector detail as the U.S. NEI, the plots in this section that include MNEI data use aggregate inventory sectors (area, mobile, point, biogenic, fire) relative to the New Mexico plots. The fire emissions totals in these plots are annual totals and include the contribution of fire events outside of the SNMOS modeling period. The biogenic emissions totals in these plots are annualized daily averages developed from emissions estimates for the SNMOS modeling episode. As the SNMOS modeling period (April 15 – August 31, 2011) occurs during the peak biogenic emissions season, the annual biogenic emissions values presented in this section overstate the annual total for this sector.

Figure 2 through Figure 5 show the New Mexico county and Mexico border municipality annual total emissions for the areas immediately surrounding Doña Ana County. These plots illustrate the major source regions for anthropogenic and natural emissions of CO, NOx, VOC, and $PM_{2.5}$.

Figure 6 through Figure 11 show the 2011 annual total emissions of CO, NOx, VOC, NH_3, SO_2, and $PM_{2.5}$ for all New Mexico counties. Table 2 through Table 7 are supplements to these figures and include tabulated annual total emissions shown in the figures.

Figure 12 through Figure 17 show the 2008 annual total emissions of CO, NOx, VOC, NH_3, SO_2, and $PM_{2.5}$ for the six Mexico border states. These plots include tabulated summaries of the Mexico state total emissions.

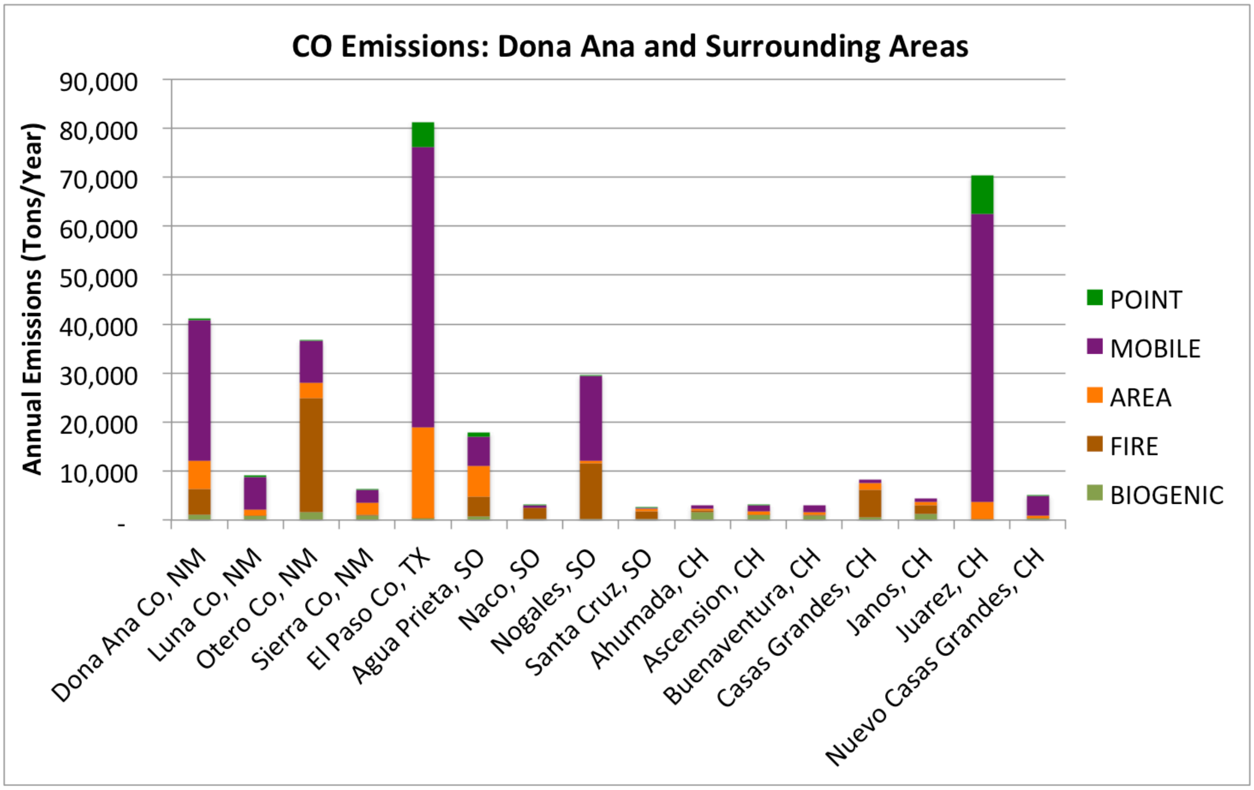


Figure 2. Doña Ana and surrounding areas 2011 carbon monoxide (CO) emissions.

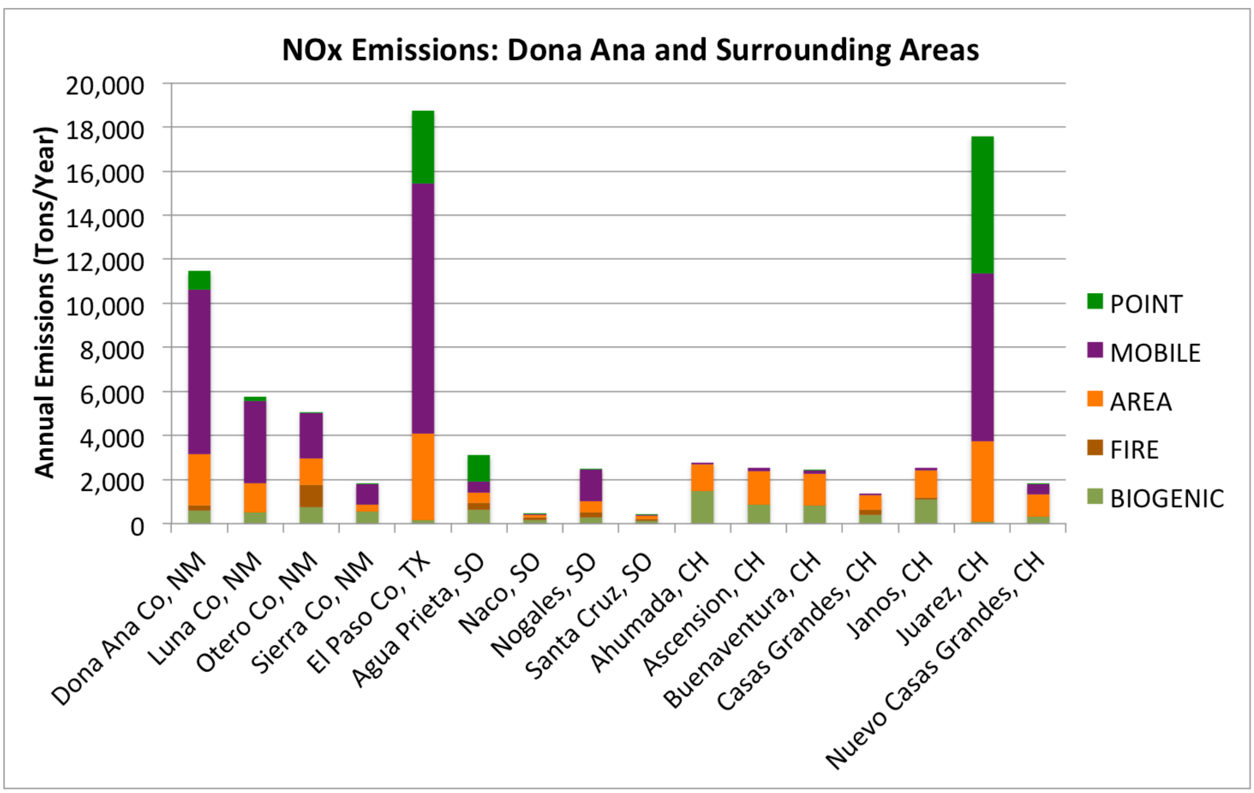


Figure 3. Doña Ana and surrounding areas 2011 nitrogen oxide (NOx) emissions.

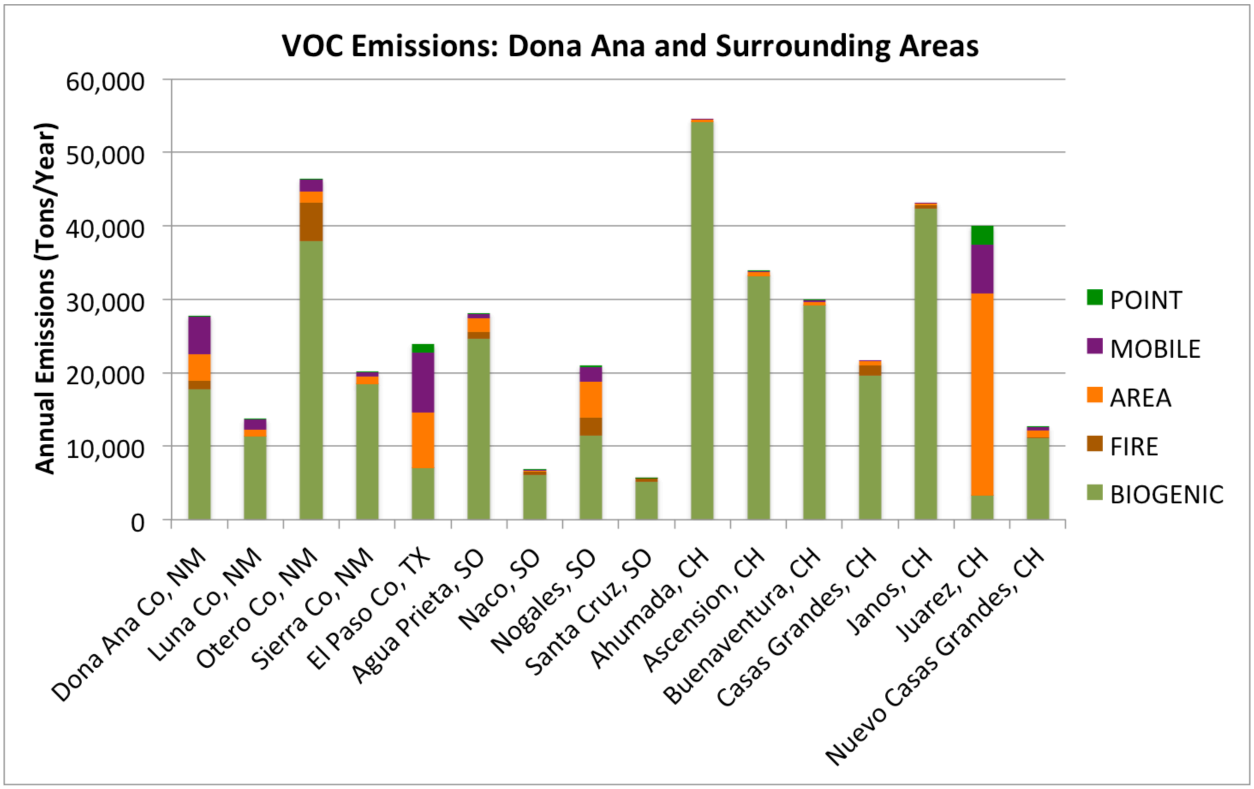


Figure 4. Doña Ana and surrounding areas 2011 volatile organic compound (VOC) emissions.

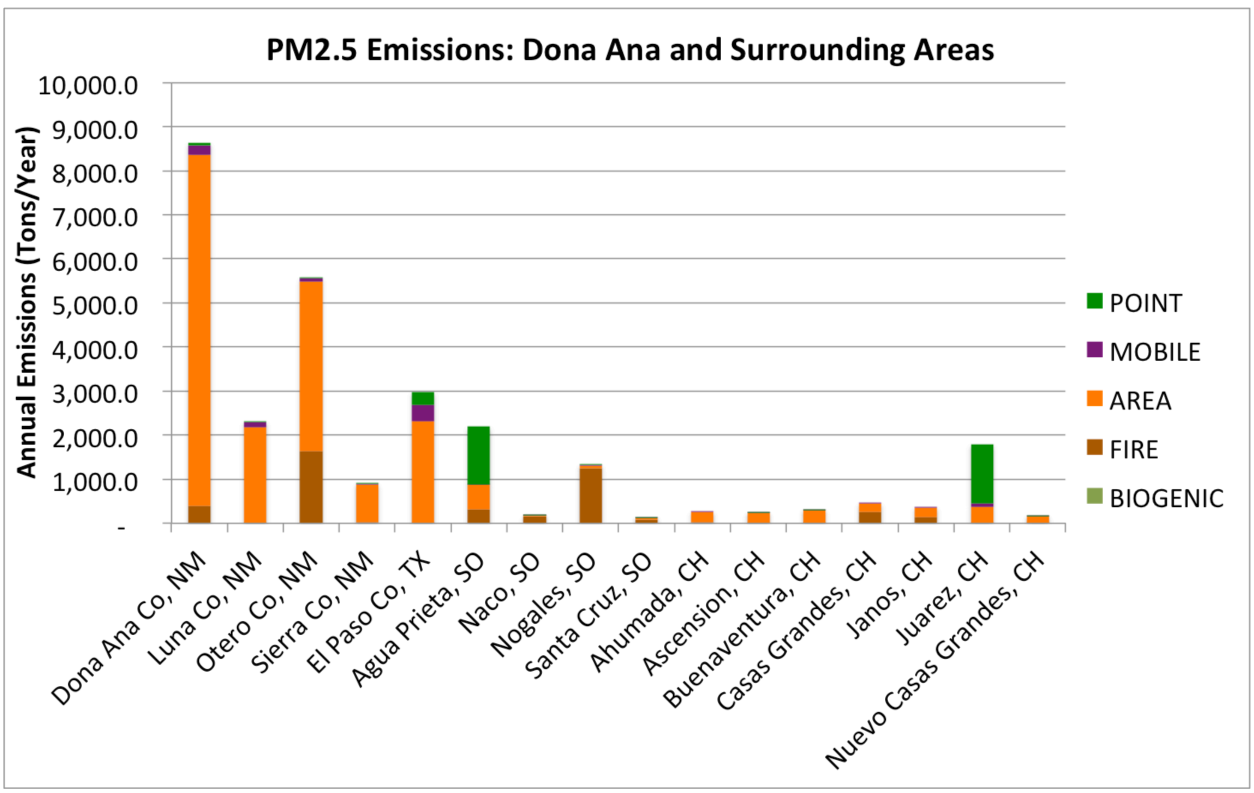


Figure 5. Doña Ana and surrounding areas 2011 fine particulate matter ($PM_{2.5}$) emissions.

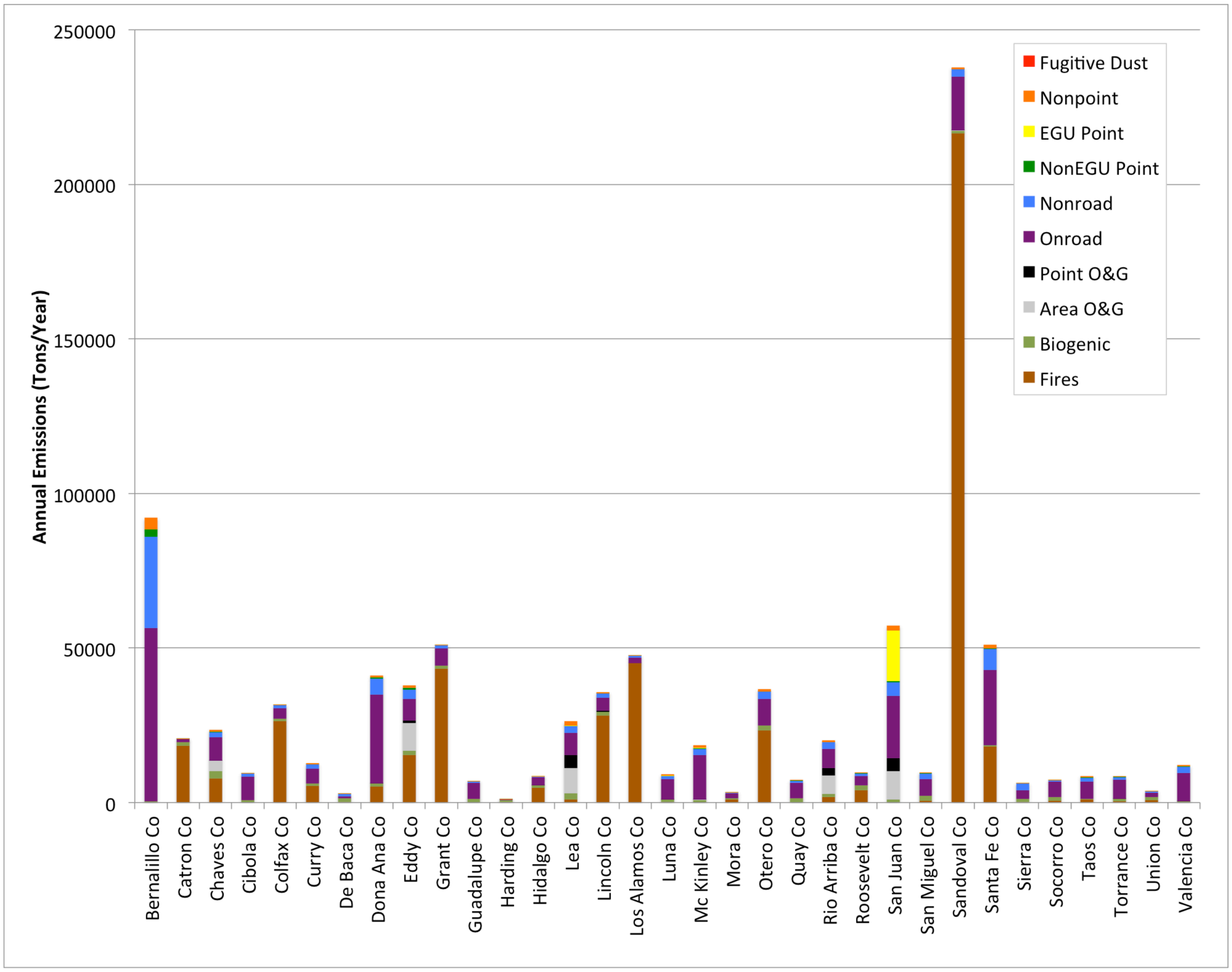


Figure 6. 2011 New Mexico county carbon monoxide (CO) emissions

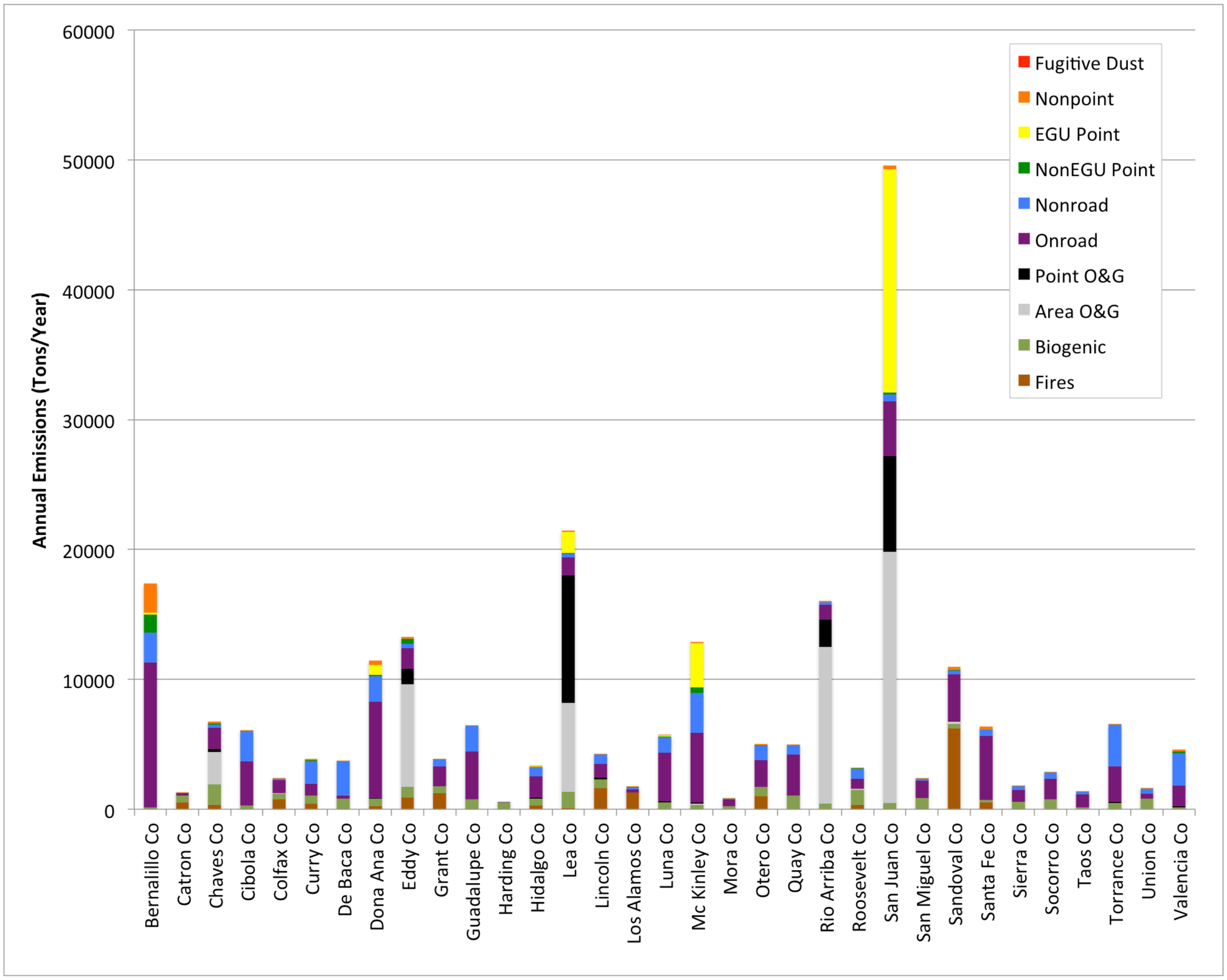


Figure 7. 2011 New Mexico county nitrogen oxide (NOx) emissions

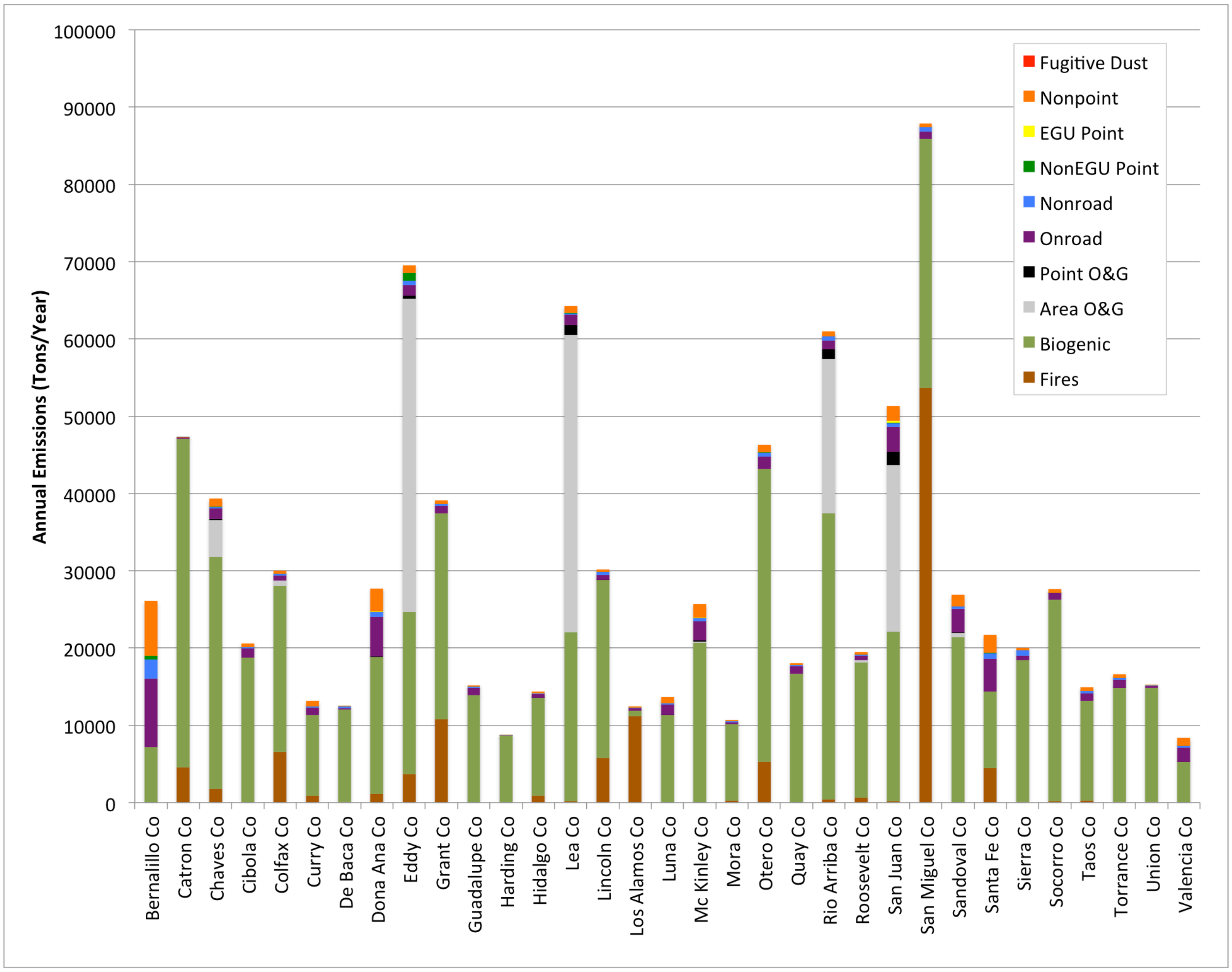


Figure 8. 2011 New Mexico county volatile organic compound (VOC) emissions

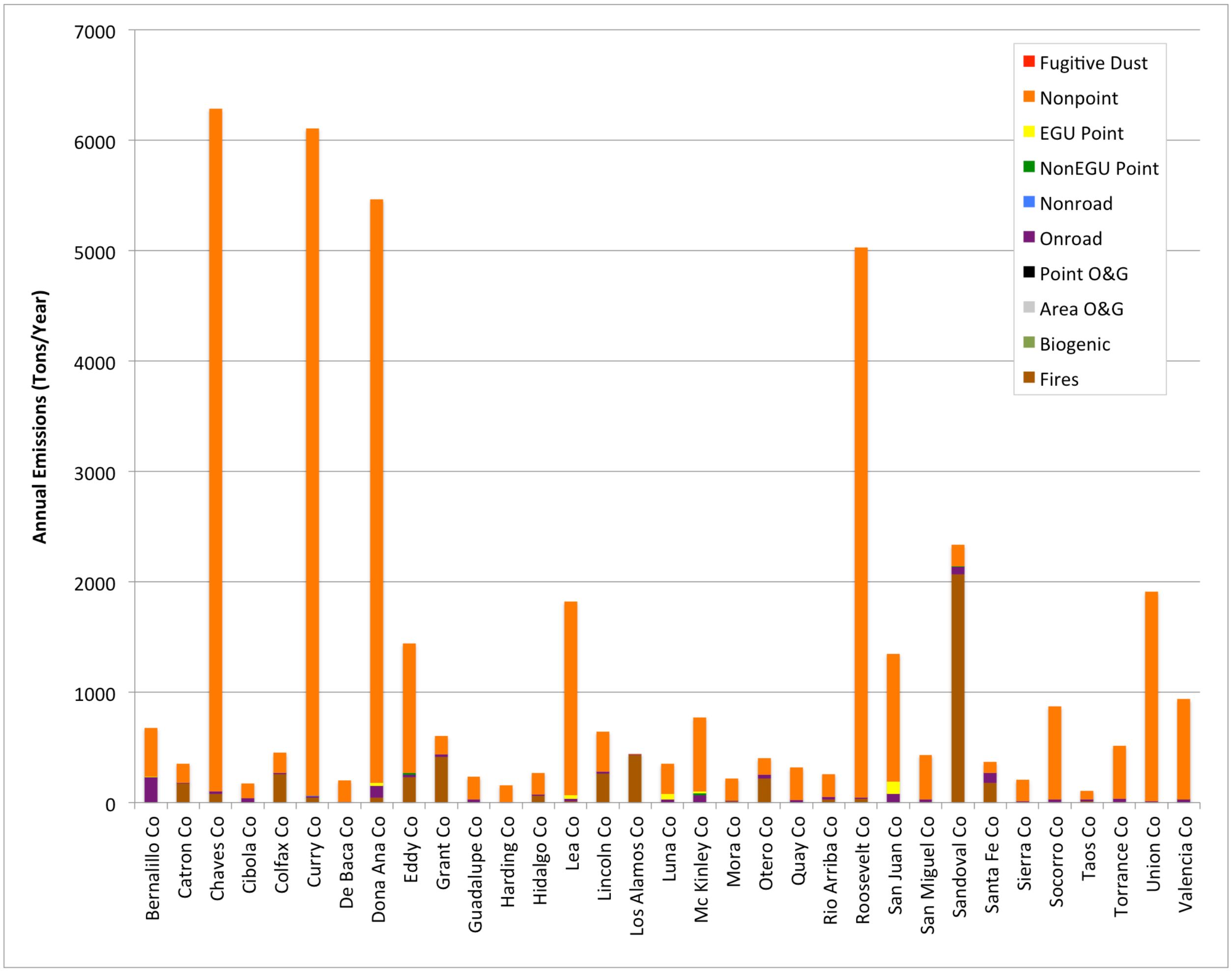


Figure 9. 2011 New Mexico county ammonia (NH_3) emissions

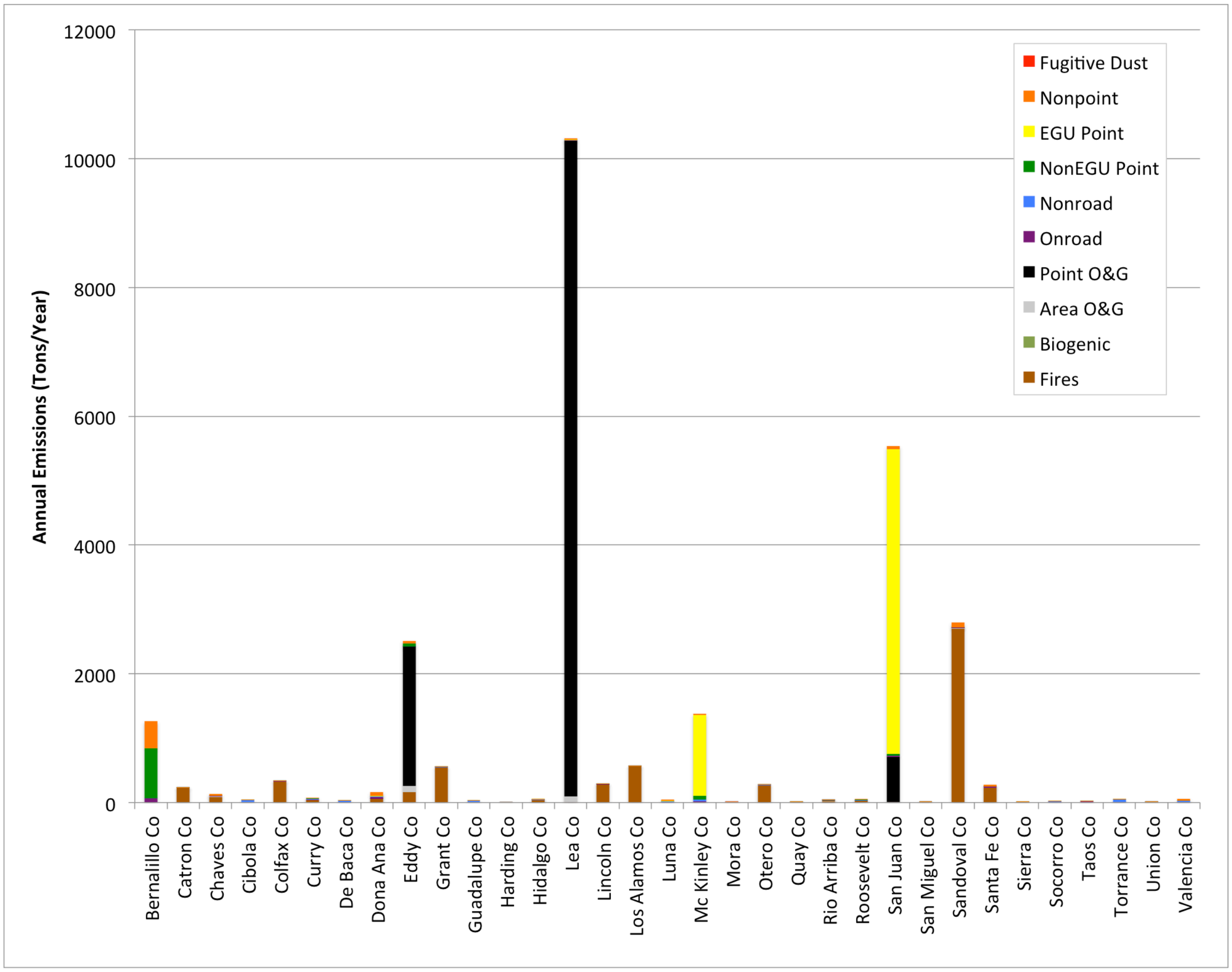


Figure 10. 2011 New Mexico county sulfur dioxide (SO_2) emissions

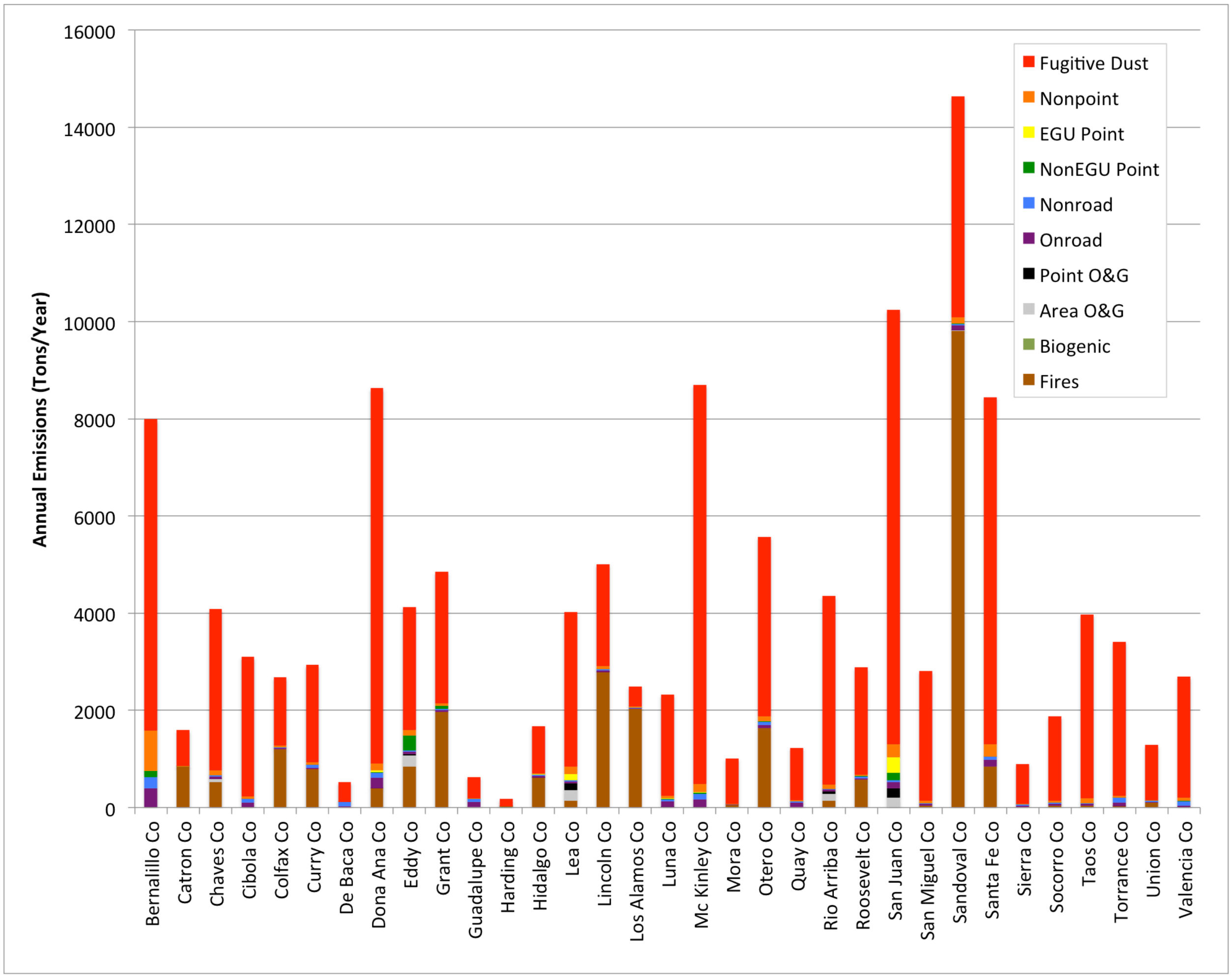


Figure 11. 2011 New Mexico county fine particulate matter ($PM_{2.5}$) emissions

Table 2. New Mexico county 2011 annual total carbon monoxide emissions (tons/year)

County	Fugitive Dust	Nonpoint	EGU Point	NonEGU Point	Nonroad	Onroad	Point O&G	Area O&G	Fires	Biogenic
Bernalillo Co	–	3,732	9	2,455	29,474	56,115			86	261
Catron Co	–	40		3	109	957			18,392	1,124
Chaves Co	–	554		188	1,662	7,519	117	3,317	7,815	2,408
Cibola Co	–	210		25	963	7,748			77	636
Colfax Co	–	148		35	1,008	3,347		48	26,309	737
Curry Co	–	220		115	1,373	4,692			5,398	878
De Baca Co	–	15		1	700	757			186	1,113
Dona Ana Co	–	527	112	263	5,328	28,605	1		5,099	1,148
Eddy Co	–	792		572	3,010	7,095	674	9,109	15,336	1,374
Grant Co	–	173		32	1,031	5,552			43,355	936
Guadalupe Co	–	45		6	512	5,211		2	50	1,071
Harding Co	–	7		2	72	160		0	176	657
Hidalgo Co	–	36	13	16	320	2,499	14		4,780	795
Lea Co	–	1,254	187	111	2,249	7,022	4,306	8,154	1,070	1,915
Lincoln Co	–	296		30	1,418	4,281	331		28,215	1,127
Los Alamos Co	–	106		55	486	1,904			45,000	17
Luna Co	–	302	194	124	881	6,646	38		90	841
Mc Kinley Co	–	731	246	136	2,160	14,280	79	56	53	795
Mora Co	–	62		1	388	1,585			960	342
Otero Co	–	652		105	2,426	8,583			23,310	1,561
Quay Co	–	70		76	638	4,954		0	74	1,401
Rio Arriba Co	–	566		6	2,073	6,229	2,475	5,920	1,813	965
Roosevelt Co	–	134		89	815	3,000		115	3,890	1,593
San Juan Co	–	1,631	16,375	273	4,554	20,102	4,118	9,169	55	991
San Miguel Co	–	262		37	1,871	5,444			672	1,480
Sandoval Co	–	613		24	2,327	17,432	45	156	216,572	695
Santa Fe Co	–	1,241		234	6,861	24,262			18,220	356
Sierra Co	–	94		51	2,212	2,737			195	960
Socorro Co	–	164		24	388	4,908			571	1,286
Taos Co	–	472		40	1,308	5,504			954	299
Torrance Co	–	159		85	939	6,185	32		336	759
Union Co	–	44		11	433	1,350			704	1,075
Valencia Co	–	336		126	1,977	9,314	13		13	289
State Total	**–**	**15,687**	**17,136**	**5,349**	**81,965**	**285,977**	**12,243**	**36,047**	**469,828**	**31,886**

Table 3. New Mexico county 2011 annual total nitrogen oxide emissions (tons/year)

County	Fugitive Dust	Nonpoint	EGU Point	NonEGU Point	Nonroad	Onroad	Point O&G	Area O&G	Fires	Biogenic
Bernalillo Co	–	2,272	113	1,420	2,296	11,163			3	118
Catron Co	–	6		0	13	213			533	502
Chaves Co	–	147		76	265	1,640	208	2,481	337	1,598
Cibola Co	–	45		0	2,349	3,389			3	288
Colfax Co	–	35		0	116	992		47	782	411
Curry Co	–	83		111	1,729	881			440	634
De Baca Co	–	5		0	2,652	266			10	781
Dona Ana Co	–	357	743	102	1,988	7,433	8		236	592
Eddy Co	–	165		353	341	1,575	1,195	7,930	906	809
Grant Co	–	58		7	512	1,552			1,250	498
Guadalupe Co	–	10		0	1,917	3,731		2	4	738
Harding Co	–	2		0	35	30		0	14	452
Hidalgo Co	–	13	25	0	755	1,588	132		282	518
Lea Co	–	137	1,602	32	305	1,386	9,824	6,847	85	1,257
Lincoln Co	–	44		2	683	1,063	140		1,641	668
Los Alamos Co	–	32		26	137	250			1,297	6
Luna Co	–	86	95	2	1,237	3,725	87		7	519
Mc Kinley Co	–	128	3,369	428	3,099	5,330	121	62	2	353
Mora Co	–	8		0	40	532			28	188
Otero Co	–	116		4	1,107	2,057			983	760
Quay Co	–	20		1	707	3,194		1	6	1,022
Rio Arriba Co	–	78		0	202	1,159	2,097	12,086	41	377
Roosevelt Co	–	50		35	766	746		95	317	1,176
San Juan Co	–	278	17,205	127	511	4,222	7,410	19,311	2	493
San Miguel Co	–	52		0	121	1,359			21	835
Sandoval Co	–	280		32	302	3,578	33	201	6,242	318
Santa Fe Co	–	260		8	479	4,923			521	184
Sierra Co	–	29		1	276	956			5	545
Socorro Co	–	34		0	512	1,578			24	730
Taos Co	–	61		1	147	1,015			28	128
Torrance Co	–	32		1	3,208	2,686	94		12	488
Union Co	–	9		0	382	411			58	743
Valencia Co	–	143		149	2,484	1,626	61		1	153
State Total	**–**	**5,075**	**23,152**	**2,919**	**31,676**	**76,247**	**21,411**	**49,063**	**16,124**	**18,881**

Table 4. New Mexico county 2011 annual total volatile organic compound emissions (tons/year)

County	Fugitive Dust	Nonpoint	EGU Point	NonEGU Point	Nonroad	Onroad	Point O&G	Area O&G	Fires	Biogenic
Bernalillo Co	–	7,104	3	479	2,415	8,925			21	7,121
Catron Co	–	118		0	17	161			4,550	42,523
Chaves Co	–	1,037		12	162	1,418	161	4,722	1,785	30,021
Cibola Co	–	481		1	206	1,218			19	18,702
Colfax Co	–	357		1	251	617		721	6,509	21,529
Curry Co	–	684		18	180	927			873	10,468
De Baca Co	–	41		0	223	121			39	12,032
Dona Ana Co	–	3,004	22	13	635	5,165	1		1,119	17,755
Eddy Co	–	950		1,028	557	1,333	441	40,566	3,658	20,972
Grant Co	–	473		8	200	982			10,735	26,686
Guadalupe Co	–	204		0	153	945		4	8	13,883
Harding Co	–	20		0	13	28		1	29	8,589
Hidalgo Co	–	203	2	1	90	461	2		890	12,689
Lea Co	–	913	25	41	152	1,346	1,282	38,486	189	21,845
Lincoln Co	–	323		1	343	689	4		5,708	23,075
Los Alamos Co	–	190		3	72	362			11,144	714
Luna Co	–	757	11	5	180	1,328	2		15	11,343
Mc Kinley Co	–	1,795	30	42	378	2,490	150	133	13	20,697
Mora Co	–	149		0	142	293			237	9,872
Otero Co	–	1,016		61	517	1,536			5,279	37,925
Quay Co	–	283		2	164	942		3	12	16,648
Rio Arriba Co	–	666		0	517	1,147	1,287	19,949	421	37,018
Roosevelt Co	–	367		4	145	538		365	630	17,462
San Juan Co	–	1,955	198	82	477	3,254	1,718	21,528	13	21,969
San Miguel Co	–	545		1	512	975			164	32,267
Sandoval Co	–	1,576		5	308	3,044	11	603	53,621	21,366
Santa Fe Co	–	2,346		9	762	4,218			4,504	9,862
Sierra Co	–	288		2	749	545			46	18,409
Socorro Co	–	473		1	63	867			131	26,115
Taos Co	–	492		1	274	979			236	12,937
Torrance Co	–	479		2	232	1,060	2		79	14,762
Union Co	–	107		0	113	211			114	14,719
Valencia Co	–	1,050		12	252	1,796	1		3	5,269
State Total	**–**	**30,448**	**291**	**1,834**	**11,451**	**49,921**	**5,060**	**127,081**	**112,793**	**617,244**

Table 5. New Mexico county 2011 annual total ammonia emissions (tons/year)

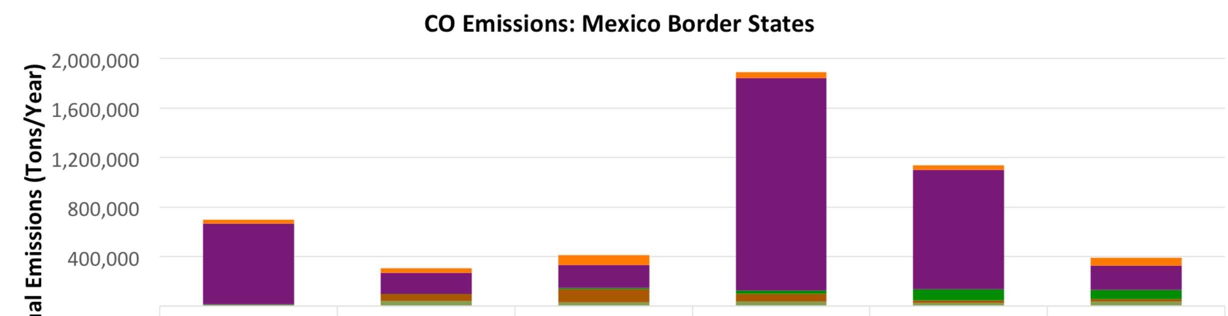
County	Fugitive Dust	Nonpoint	EGU Point	NonEGU Point	Nonroad	Onroad	Point O&G	Area O&G	Fires	Biogenic
Bernalillo Co	–	443	2	0	3	226			1	–
Catron Co	–	175		–	0	4			176	–
Chaves Co	–	6,185		–	0	26	–	–	77	–
Cibola Co	–	137		–	1	37			1	–
Colfax Co	–	184		–	0	13		–	255	–
Curry Co	–	6,046		0	1	13			45	–
De Baca Co	–	192		–	1	3			2	–
Dona Ana Co	–	5,288	23	–	1	105	–		47	–
Eddy Co	–	1,171		19	0	23	–	–	228	–
Grant Co	–	167		–	0	20			414	–
Guadalupe Co	–	206		–	1	25		–	0	–
Harding Co	–	155		–	0	1		–	2	–
Hidalgo Co	–	198	–	–	0	12	–		61	–
Lea Co	–	1,754	32	–	0	21	–	–	11	–
Lincoln Co	–	363		–	0	17	–		260	–
Los Alamos Co	–	7		–	0	4			430	–
Luna Co	–	272	49	–	1	27	–		1	–
Mc Kinley Co	–	674	16	15	2	66	–	–	1	–
Mora Co	–	204		–	0	7			9	–
Otero Co	–	151		–	1	33			217	–
Quay Co	–	293		–	0	22		–	1	–
Rio Arriba Co	–	210		–	0	23	–	–	26	–
Roosevelt Co	–	4,985		–	0	11		–	32	–
San Juan Co	–	1,155	112	–	1	78	–	–	1	–
San Miguel Co	–	405		–	0	21			6	–
Sandoval Co	–	196		6	0	63	–	–	2,070	–
Santa Fe Co	–	100		–	1	90			176	–
Sierra Co	–	194		–	0	10			3	–
Socorro Co	–	845		–	0	21			6	–
Taos Co	–	80		–	0	19			9	–
Torrance Co	–	482		–	2	29	–		3	–
Union Co	–	1,899		–	0	6			6	–
Valencia Co	–	908		0	1	27	–		0	–
State Total	**–**	**35,725**	**235**	**39**	**21**	**1,101**	**–**	**–**	**4,574**	**–**

Table 6. New Mexico county 2011 annual total sulfur dioxide emissions (tons/year)

County	Fugitive Dust	Nonpoint	EGU Point	NonEGU Point	Nonroad	Onroad	Point O&G	Area O&G	Fires	Biogenic
Bernalillo Co	–	422	0	772	7	63			1	–
Catron Co	–	1		0	0	1			230	–
Chaves Co	–	31		1	1	7	–	7	88	–
Cibola Co	–	6		0	24	9			1	–
Colfax Co	–	5		0	0	3		0	328	–
Curry Co	–	15		2	17	4			41	–
De Baca Co	–	0		0	27	1			2	–
Dona Ana Co	–	65	2	1	16	27	0		55	–
Eddy Co	–	38		48	1	6	2,161	92	166	–
Grant Co	–	6		1	5	5			542	–
Guadalupe Co	–	1		0	20	7		0	0	–
Harding Co	–	0		0	0	0		0	1	–
Hidalgo Co	–	2	0	0	8	3	1		35	–
Lea Co	–	21	12	1	1	6	10,179	91	9	–
Lincoln Co	–	3		0	7	4	0		278	–
Los Alamos Co	–	2		1	0	1			563	–
Luna Co	–	18	4	0	12	7	1		1	–
Mc Kinley Co	–	23	1,257	50	30	16	3	0	1	–
Mora Co	–	0		–	0	1			12	–
Otero Co	–	8		1	10	8			263	–
Quay Co	–	2		0	7	6		0	1	–
Rio Arriba Co	–	7		0	1	5	10	8	17	–
Roosevelt Co	–	12		5	6	3		1	30	–
San Juan Co	–	47	4,727	28	1	20	699	11	1	–
San Miguel Co	–	3		0	1	5			8	–
Sandoval Co	–	72		1	1	16	1	0	2,705	–
Santa Fe Co	–	28		1	2	22			226	–
Sierra Co	–	2		0	2	2			2	–
Socorro Co	–	3		0	5	5			6	–
Taos Co	–	5		0	0	4			12	–
Torrance Co	–	3		0	33	7	0		4	–
Union Co	–	1		0	3	1			5	–
Valencia Co	–	24		2	25	6	0		0	–
State Total	**–**	**876**	**6,002**	**916**	**271**	**281**	**13,056**	**210**	**5,634**	**–**

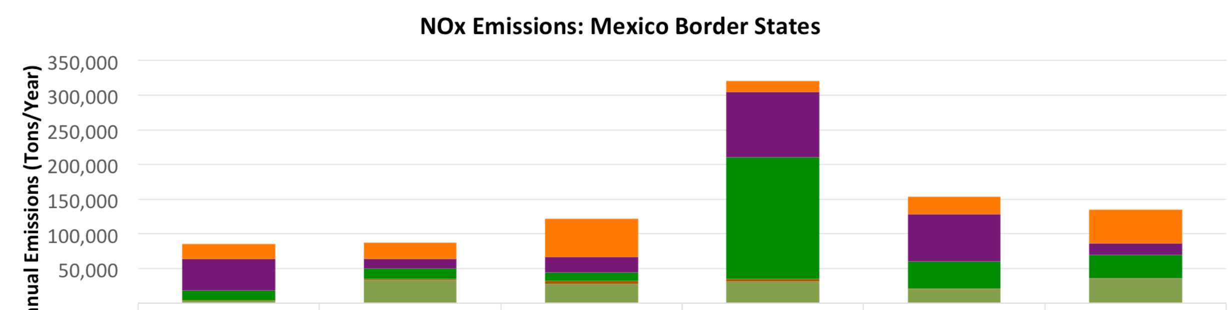
Table 7. New Mexico county 2011 annual total fine particulate matter ($PM_{2.5}$) emissions (tons/year)

County	Fugitive Dust	Nonpoint	EGU Point	NonEGU Point	Nonroad	Onroad	Point O&G	Area O&G	Fires	Biogenic
Bernalillo Co	6,417	826	4	121	239	386			4	–
Catron Co	734	13		0	1	6			838	–
Chaves Co	3,319	102		4	18	48	1	60	529	–
Cibola Co	2,867	51		1	77	99			4	–
Colfax Co	1,405	38		1	12	28		3	1,196	–
Curry Co	2,003	46		5	60	27			793	–
De Baca Co	408	5		0	82	9			17	–
Dona Ana Co	7,723	141	40	9	105	212	0		401	–
Eddy Co	2,527	115		311	27	47	22	239	836	–
Grant Co	2,708	46		67	23	44			1,962	–
Guadalupe Co	440	11		0	62	107		0	7	–
Harding Co	143	2		0	3	1		0	25	–
Hidalgo Co	975	12	2	0	26	46	1		608	–
Lea Co	3,177	153	126	11	19	38	147	214	138	–
Lincoln Co	2,099	60		1	33	33	1		2,784	–
Los Alamos Co	408	26		3	13	8			2,035	–
Luna Co	2,082	50	20	5	45	108	1		13	–
Mc Kinley Co	8,217	161	13	28	109	165	2	1	3	–
Mora Co	929	13		0	5	15			44	–
Otero Co	3,690	106		11	59	64			1,637	–
Quay Co	1,080	18		1	28	93		0	11	–
Rio Arriba Co	3,880	93		0	18	35	53	137	141	–
Roosevelt Co	2,202	33		14	37	23		3	570	–
San Juan Co	8,942	268	313	161	37	128	189	199	3	–
San Miguel Co	2,669	55		1	17	37			34	–
Sandoval Co	4,555	124		9	27	107	1	5	9,812	–
Santa Fe Co	7,141	255		6	57	147			840	–
Sierra Co	816	20		1	18	26			14	–
Socorro Co	1,740	36		0	19	42			38	–
Taos Co	3,777	101		1	18	32			43	–
Torrance Co	3,174	43		1	102	76	0		20	–
Union Co	1,139	12		0	18	13			104	–
Valencia Co	2,483	66		11	87	42	0		1	–
State Total	**95,871**	**3,100**	**518**	**785**	**1,501**	**2,292**	**418**	**862**	**25,502**	**–**



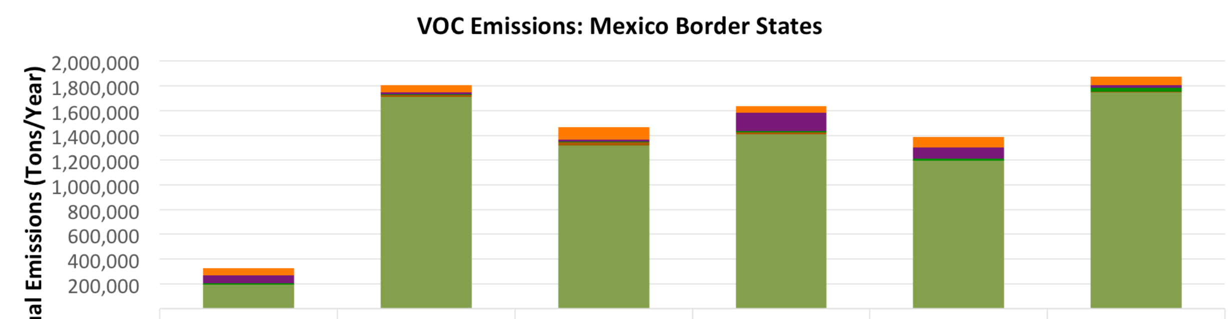
	Baja Norte	Sonora	Chihuahua	Coahuila	Nuevo Leon	Tamaulipas
Area	28,140	37,270	82,705	44,811	37,524	61,657
Mobile	652,161	167,579	184,816	1,718,861	961,884	195,799
Point	7,549	4,112	10,474	26,640	94,052	76,447
Fires	3,628	58,080	103,908	63,232	20,562	20,549
Biogenic	4,399	37,910	31,882	34,496	22,516	34,111

Figure 12. 2008 Mexico border state carbon monoxide (CO) emissions



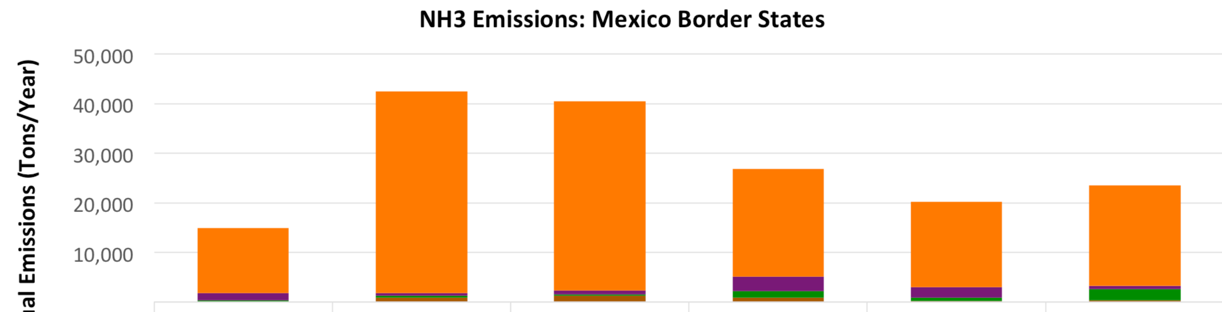
	Baja Norte	Sonora	Chihuahua	Coahuila	Nuevo Leon	Tamaulipas
Area	21,493	23,438	55,087	16,370	25,018	47,906
Mobile	46,346	14,338	21,893	94,558	68,375	17,073
Point	13,521	14,689	12,138	174,978	38,330	33,404
Fires	258.25	2,425	4,817	3,525	926	1,073
Biogenic	3,969	32,770	27,789	31,465	20,486	34,889

Figure 13. 2008 Mexico border state nitrogen oxide (NOx) emissions



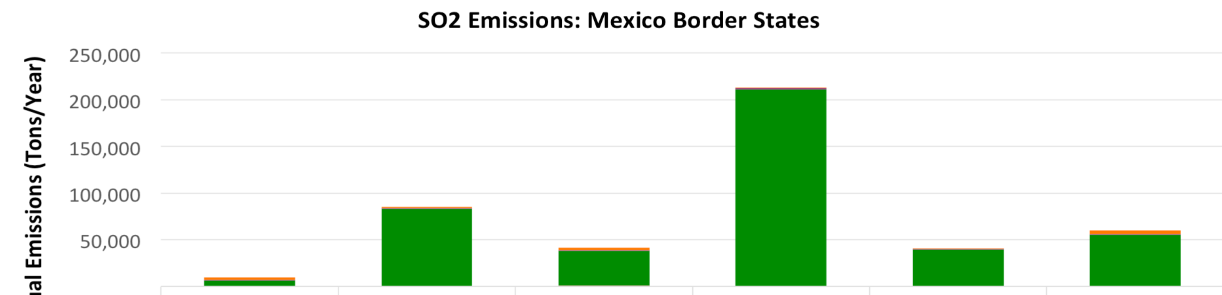
	Baja Norte	Sonora	Chihuahua	Coahuila	Nuevo Leon	Tamaulipas
Area	60,078	58,422	97,197	49,052	85,480	70,068
Mobile	60,638	19,174	20,205	152,252	89,465	21,019
Point	12,886	4,511	5,223	6,833	14,872	33,404
Fires	865.142	13348.262	25305.1	15319.742	4991.66	4900.772
Biogenic	191,424	1,712,026	1,316,655	1,410,076	1,193,319	1,746,057

Figure 14. 2008 Mexico border state volatile organic compound (VOC) emissions



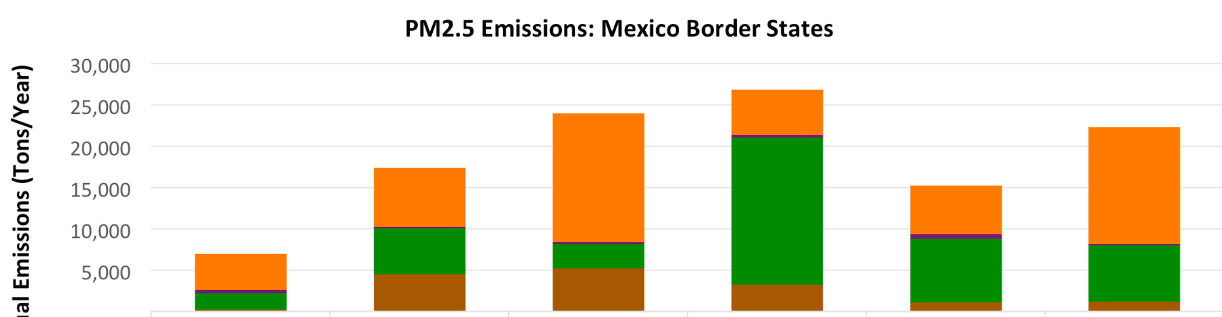
	Baja Norte	Sonora	Chihuahua	Coahuila	Nuevo Leon	Tamaulipas
Area	13,082	40,595	38,169	21,692	17,172	20,239
Mobile	1,498	602	796	2,913	2,210	756
Point	280	359	290	1,343	559	2,280
Fires	59	882	1,248	842	251	278
Biogenic						

Figure 15. 2008 Mexico border state ammonia (NH_3) emissions



	Baja Norte	Sonora	Chihuahua	Coahuila	Nuevo Leon	Tamaulipas
Area	2,563	1,146	2,522	671	646	3,465
Mobile	716	646	964	989	1,056	865
Point	6,159	82,676	36,692	210,505	39,182	55,287
Fires	37	543	1,213	720	236	223
Biogenic						

Figure 16. 2008 Mexico border state sulfur dioxide (SO_2) emissions



	Baja Norte	Sonora	Chihuahua	Coahuila	Nuevo Leon	Tamaulipas
Area	4,370	7,156	15,590	5,518	5,877	14,136
Mobile	338	136	223	320	499	173
Point	2,025	5,636	2,925	17,822	7,756	6,785
Fires	198	4,461	5,224	3,197	1,074	1,186
Biogenic						

Figure 17. 2008 Mexico border state fine particulate matter ($PM_{2.5}$) emissions

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