

## 6. Biogenic Sources

### 6.1 Introduction and scope

Biogenic emissions have been estimated for the 2005 Periodic Emissions Inventory for Ozone Precursors in Maricopa County. In addition, estimates were made for the approximately 5,000 square-miles of the eight-hour ozone nonattainment area. The biogenic emissions were estimated using the Model of Emissions of Gases and Aerosols from Nature (MEGAN). MEGAN is a state-of-the-art biogenic emissions model, developed by Dr. Alex Guenther at NCAR and ENVIRON International Corporation (Guenther, 2006a and 2006b). MAG contracted with ENVIRON and Dr. Guenther in 2005 to develop a reliable and accurate biogenic emissions model. Dr. Guenther conducted field studies in June 2006 to measure the emission rates of dominant plant species in Maricopa County. Dr. Guenther also collected data on desert plant emission rates in Clark County, Nevada in 2006. Due to the incorporation of updated emission rates that are more characteristic of plants growing in the southwest deserts, the MEGAN estimates represent a substantial improvement over previous biogenic emission estimates for Maricopa County. Emissions estimates for volatile organic compounds (VOCs), carbon monoxide (CO), and nitrogen oxides (NO<sub>x</sub>) are included in this biogenic source emissions inventory.

### 6.2 MEGAN input files

To calculate biogenic emissions using MEGAN, seven gridded input files were prepared:

- User domain file: this file describes the user's domain such as the number of grid cells, grid cell size, and latitude and longitude coordinates of each grid cell
- Solar radiation and temperature file
- Monthly Leaf Area Index (LAI) file
- Plant Functional Type (PFT) file
- Emission Factor (EF) file
- Wind speed and humidity
- Soil moisture

MEGAN requires that all input data be provided for the grid cells defined in the user domain file. Gridded meteorological data (e.g., temperature, solar radiation, wind speed, humidity, and soil moisture) generated by the Penn State/NCAR Mesoscale Meteorological Model 5 (MM5) were employed, which were provided to MAG by ENVIRON for the MAG Eight-Hour Ozone Plan (MAG, 2007). The MM5 meteorological data were reformatted for MEGAN input. The LAI, PFT, and EF data files developed and updated by Dr. Guenther for Maricopa County were extracted from the MEGAN database using the MEGAN driving variables processor (ENVIRON, 2006).

The species specific biogenic emission rates identified in the 2006 field study were incorporated with the vegetation distributions in Maricopa County to derive the landscape average emission rates for each grid cell in the 4-km domain. Table 6.2-1 summarizes the average VOC emission rates for the land use categories in the 4-km domain (ENVIRON, 2006). Updated land use and land cover data from different sources were employed in the development of the vegetation distribution, PFT, and LAI databases. The average emission rate represents the net above-canopy emission rate expected at standard conditions (e.g. air temperature of 30°C, photosynthetic photon flux density of 1500

μmol/m<sup>2</sup>/s, humidity of 14 g/kg, wind speed of 3 m/s, and LAI of 5). The standard emission rate was adjusted by the emission activity factor that describes its variation due to physiological and phenological processes. The input data of meteorology and LAI were used in the calculation of the emission activity factor. For details, please refer to Guenther, et al. (2006).

**Table 6.2–1. The average VOC emission rates for the land use categories in the 4-km domain.**

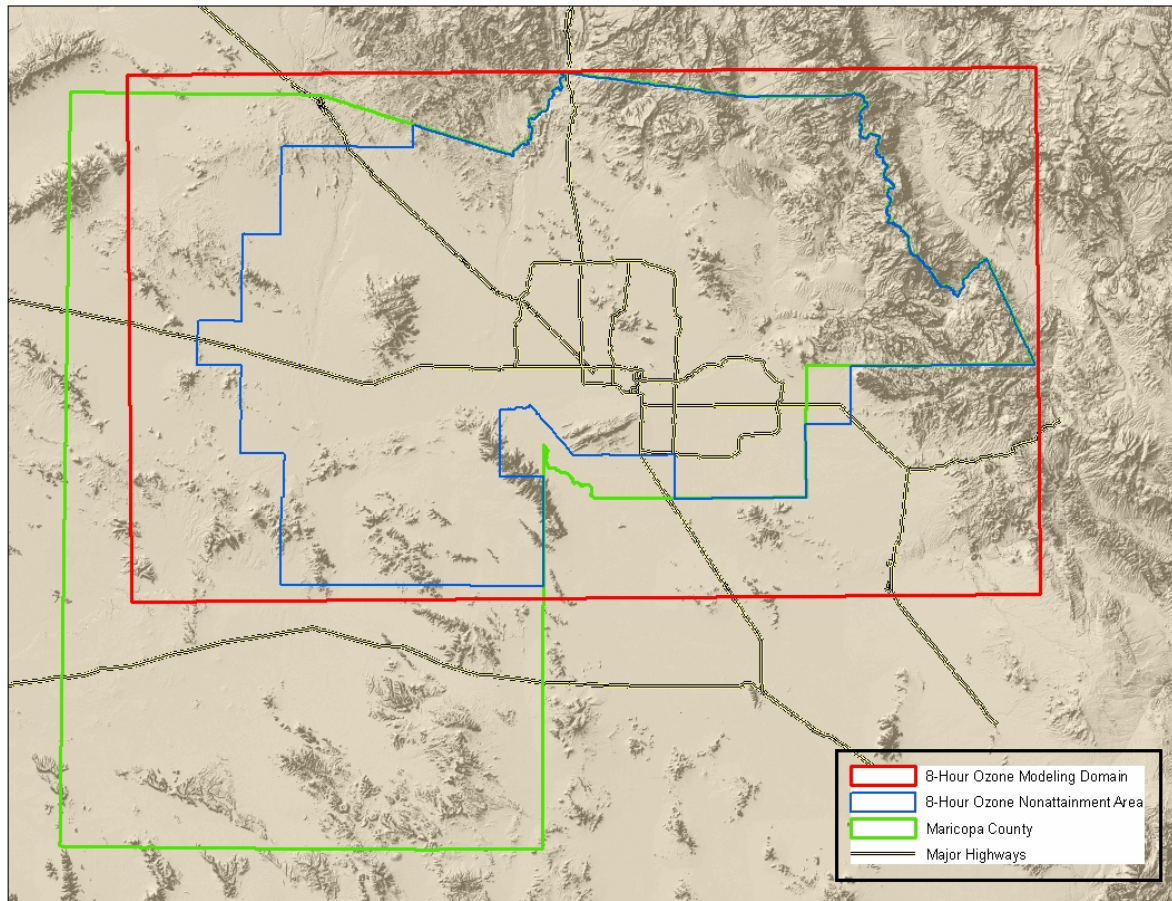
MEGAN Land Use	Land Use Subcategory	Area* in 4-km Domain		Average Emission Rate (μg/m <sup>2</sup> /hr)
		km <sup>2</sup>	acres	
Urban	Residential	1,875	463,313	162
	Developing & Other Residential	321	79,319	39
	Commercial	690	170,499	157
	Parks/golf/commercial	289	71,412	62
	Transportation	884	218,436	162
	<b>Total</b>	<b>4,059</b>	<b>1,002,979</b>	
Agriculture	Agriculture (Maricopa + Pinal)	1,291	319,006	175
	<b>Total</b>	<b>1,291</b>	<b>319,006</b>	
Wildlands	Pine	116	28,664	381
	Pine/Oak/Pinyon	38	9,390	636
	Madrean Oak	89	21,992	658
	Cypress	12	2,965	186
	Riparian/Wetland	358	88,462	958
	Interior Chaparral	2,391	590,816	969
	Pinyon-Juniper	869	214,730	2,131
	Basin Grassland	5	1,236	250
	Creosote-Bursage	6,889	1,702,272	67
	Palo verde-Mixed Cacti-Scrub	14,852	3,669,929	331
	Semi-desert Mixed Grass	47	11,614	503
	Water	346	85,497	248
	Other urban	2,140	528,794	225
	Barren	3	741	232
		<b>Total</b>	<b>28,155</b>	<b>6,957,101</b>

\* The area for each land use category is approximate.

### 6.3 Emission estimation

Since MM5 meteorological data for all days in 2005 were not available, emission estimates from MEGAN for May 31 to June 7, 2002 for the MAG eight-hour ozone modeling area were employed to derive the 2005 ozone season daily average VOC, NO<sub>x</sub>, and CO emissions for the eight-hour ozone nonattainment area and Maricopa County. Maricopa County and the eight-hour ozone nonattainment and modeling areas are delineated in Figure 6.3–1.

**Figure 6.3–1. Boundaries of the eight-hour ozone modeling domain, eight-hour ozone nonattainment area, and Maricopa County.**



The daily average emissions for the eight-hour ozone nonattainment area and Maricopa County were extracted from emissions for the eight-hour ozone modeling area using GIS. The extracted daily emissions for May 31 to June 7, 2002 for the Maricopa County portion of the eight-hour ozone modeling area and nonattainment area are provided in Tables 6.3-1 and 6.3-2, respectively. However, the emissions developed for the eight-hour ozone modeling area do not cover the 7,295 square kilometers of the western and southern parts of Maricopa County outside of the modeling area. To obtain emissions for all of Maricopa County, emissions per square kilometer were calculated using MEGAN emission estimates for a 1,600 square kilometer area in the southwest corner of the eight-hour ozone modeling area. This relatively remote and largely unpopulated area was assumed to be representative of vegetation in the portion of Maricopa County that was not modeled for the eight-hour ozone attainment plan. The average emissions per square kilometer for the 1,600 square kilometer area given in Table 6.3-3 were multiplied by 7,295 square kilometers to obtain the biogenic emissions in Maricopa County outside of the eight-hour ozone modeling area. The result was added to the ozone precursor emissions estimated for the eight-hour ozone modeling area within Maricopa County (Table 6.3-1) to obtain total biogenic ozone precursor emissions for the whole Maricopa County.

**Table 6.3–1. Daily biogenic emissions in the eight-hour ozone modeling area in Maricopa County.**

Date	VOC		NO <sub>x</sub>		CO	
	kg/day	lb/day	kg/day	lb/day	kg/day	lb/day
5/31/2002	309,523	682,374	6,414	14,140	42,687	94,108
6/1/2002	278,847	614,746	5,921	13,053	39,253	86,537
6/2/2002	228,687	504,163	5,197	11,457	32,372	71,367
6/3/2002	196,524	433,257	4,742	10,454	28,318	62,430
6/4/2002	207,750	458,006	4,926	10,859	29,778	65,649
6/5/2002	257,443	567,559	5,655	12,467	36,357	80,153
6/6/2002	309,992	683,408	6,536	14,409	43,243	95,334
6/7/2002	299,573	660,439	6,182	13,629	41,942	92,465
<b>Average</b>	<b>261,042</b>	<b>575,493</b>	<b>5,697</b>	<b>12,560</b>	<b>36,744</b>	<b>81,006</b>

**Table 6.3–2. Daily biogenic emissions in the eight-hour ozone nonattainment area.**

Date	VOC		NO <sub>x</sub>		CO	
	kg/day	lb/day	kg/day	lb/day	kg/day	lb/day
5/31/2002	268,009	590,853	5,084	11,208	35,722	78,753
6/1/2002	241,200	531,750	4,702	10,366	32,773	72,251
6/2/2002	198,160	436,864	4,127	9,098	27,076	59,691
6/3/2002	169,941	374,652	3,761	8,292	23,646	52,129
6/4/2002	179,182	395,025	3,913	8,627	24,814	54,705
6/5/2002	222,363	490,222	4,495	9,910	30,325	66,855
6/6/2002	267,560	589,863	5,191	11,444	36,056	79,489
6/7/2002	259,420	571,917	4,921	10,849	35,070	77,315
<b>Average</b>	<b>225,729</b>	<b>497,640</b>	<b>4,524</b>	<b>9,974</b>	<b>30,685</b>	<b>67,648</b>

**Table 6.3–3. Average emissions per square kilometer for the 1,600 square-kilometer area in the southwest corner of the eight-hour ozone modeling area.**

VOC		NO <sub>x</sub>		CO	
kg/day	lb/day	kg/day	lb/day	kg/day	lb/day
268,009	590,853	5,084	11,208	35,722	78,753

#### 6.4 Summary of biogenic source emissions

Ozone season-day and annual biogenic emissions for Maricopa County and the eight-hour ozone nonattainment area are summarized in Tables 6.4–1 and 6.4-2. The annual emissions were scaled up from the ozone season-day emissions multiplied by 365 days. It is noted that this is a conservative estimate, since biogenic emissions are higher during the ozone season than in winter. However, the available data does not permit MAG to perform a whole year of modeling.

**Table 6.4–1. Ozone season-day biogenic emissions.**

Geographic area	VOC		NO <sub>x</sub>		CO	
	kg/day	lb/day	kg/day	lb/day	kg/day	lb/day
Maricopa County	329,414	726,221.8	8,254	18,196.4	48,610	107,165.1
Ozone NAA	225,729	497,639.7	4,524	9,974.1	30,685	67,648.3

**Table 6.4–2. Annual biogenic emissions.**

Geographic area	VOC		NO <sub>x</sub>		CO	
	tonnes*/yr	tons*/yr	tonnes/yr	tons/yr	tonnes/yr	tons/yr
Maricopa County	120,236	132,535.47	3,013	3,320.83	17,743	19,557.63
Ozone NAA	82,391	90,819.25	1,651	1,820.27	11,200	12,345.81

\* “tonne” denotes metric ton; “ton” denotes short (English) ton.

## 6.5 References

- ENVIRON International Corp., 2006. Final Report, Maricopa Association of Governments 2006 Biogenics Study.
- Guenther, A., 2006a. User’s Guide to Processing Driving Variables for Model of Emissions of Gases and Aerosols from Nature (MEGAN).
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- Guenther, A., T. Karl, P. Harley, C. Wiedinmyer, P. I. Palmer, and C. Geron, 2006. Estimates of global terrestrial isoprene emissions using MEGAN (Model of Emissions of Gases and Aerosols from Nature), *Atmos. Chem. Phys.*, 6, 1-30.
- Maricopa Association of Governments, 2007. Eight-Hour Ozone Plan for the Maricopa Nonattainment Area.