

6. Biogenic Sources

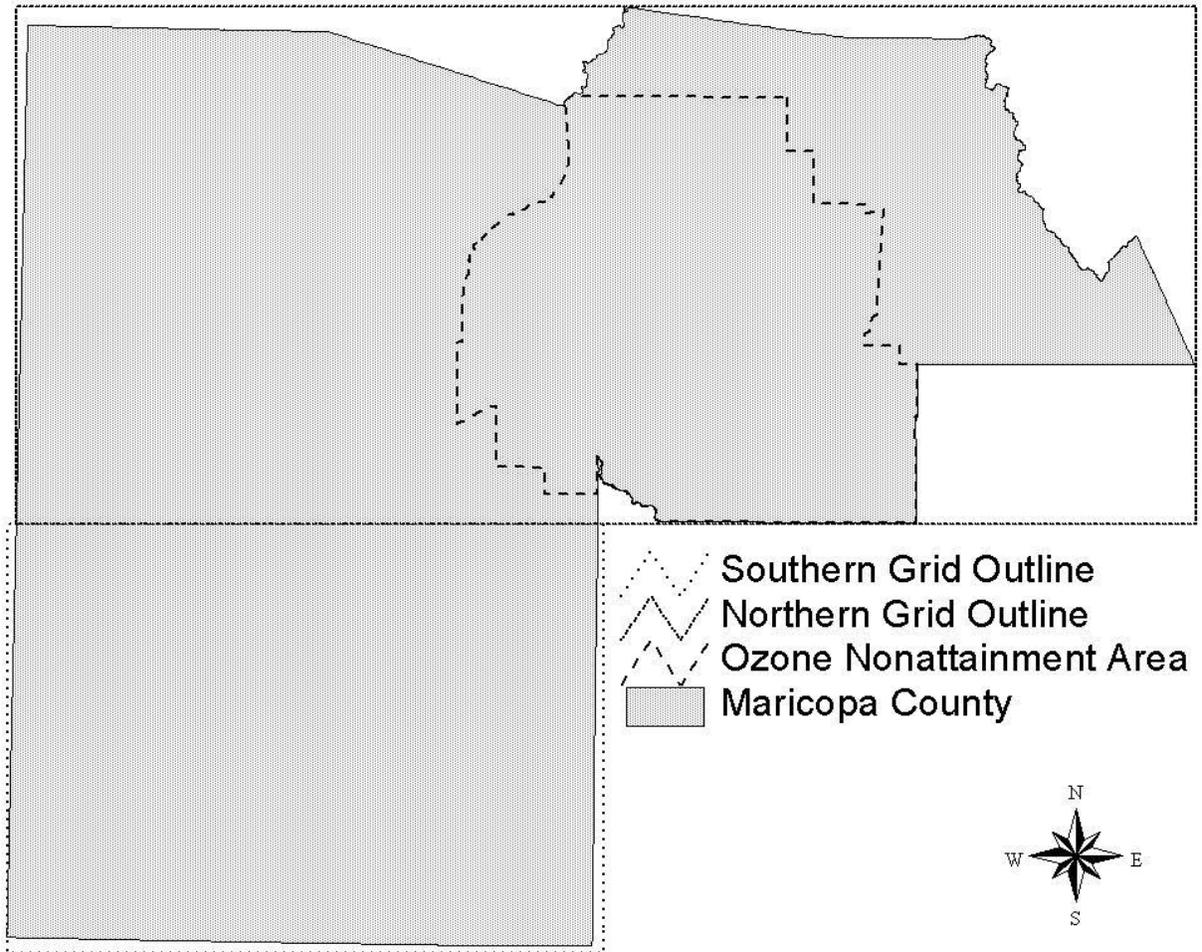
6.1 Introduction and scope

Biogenic source emission estimates have been calculated for ozone precursors for use in the 2002 Periodic Ozone Inventory. These biogenic source emission estimates are for Maricopa County and the 1,872 square-mile ozone nonattainment area within Maricopa County. These emissions were estimated using a modified version of the UAM-BEIS 2 model called MAG-BEIS2. MAGBEIS2 was developed for use in Maricopa County and is documented in Improvements to the Biogenic Emission Estimation Process for Maricopa County (STI, 1996). MAGBEIS2 main modifications to UAM-BEIS2 was the addition of procedures that allow for the input of user-supplied gridded land use and surface temperature data. These procedures included the development of a land-use preprocessor called MAGLAND2 to consolidate the MAG land-use data and to substitute data for missing or incomplete grid cells. The guiding principle used in the development of MAGBEIS2 was the replacement of some EPA defaults with locale-specific data, including: locale-specific land-use data, locale-specific biomass estimates, and the use of a taxonomic approach to develop local-specific emission factors. Overall, MAGBEIS2 constitutes an improvement over the EPA BEIS2 procedures, and is considered to provide reasonable estimates of the biogenic emissions in the study area.

6.2 Modeling domain adjustments

The emissions reported in the periodic inventory are for both the ozone nonattainment area and Maricopa County. Due to the irregular shape of the ozone nonattainment area and Maricopa County, it was not possible to use the ozone nonattainment area or county boundary as the modeling domain for the grid based MAGBEIS2 model. Two modeling domains were used to estimate biogenic emissions for the nonattainment area and Maricopa County. The modeling domains used in the present study are shown in Figure 6.2–1. The northern domain consists of 107 grid cells in the east-west direction and 47 grid cells in the north-south direction, with a uniform grid spacing of two kilometers. The northern domain encompassed the entire ozone nonattainment area. The southern domain encompassed the southern portion of Maricopa County and consisted of 54 grid cells in the east-west direction and 39 grid cells in the north-south direction, with a uniform grid spacing of two kilometers. Both domains are primarily located within Maricopa County, although small fractions of the modeling areas extend into other neighboring counties. The emissions estimated using the MAGBEIS2 model are for the rectangular modeling domain previously described. These estimates were adjusted to calculate the nonattainment area emissions and Maricopa County emissions through the use of ARCVIEW. ARCVIEW was used to remove the portions of the modeling domain outside of the Maricopa County area for the county emission estimates and outside of the nonattainment area for the nonattainment area emission estimates.

Figure 6.2–1. Ozone nonattainment area, Maricopa County, and biogenic modeling domains (northern and southern grid outlines).



6.3 Land-use categories

The most critical input for the biogenic emission modeling is the land-use data file. The most recent land-use information was incorporated into the EPA BELD3 land-use data to create a merged land-use data set. The most recent land-use data compiled by MAG included over 40 land-use types using 2000 information as listed in Table 6.3–1. MAG residential, commercial, water, and agricultural land-use categories were merged into the BELD3 USGS coniferous, deciduous, mixed forest, grassland, savanna, and shrubland land-use types, listed in Table 6.3–2, to create a county-wide composite land-use data set. The MAGLAND2 and MAGBEIS2 programs described in the 1996 study by STI and used in previous periodic ozone emission inventories had to be modified to accept the land-use categories from the merged BELD3/MAG 2000 land-use data set. Due to lack of information for the spatial distribution of the agricultural types in the BELD3/MAG 2000 land-use data there is only one category for agriculture. The agricultural emission factor was updated based on 2002 Maricopa County crop statistics.

Table 6.3–1. MAG 2000 land-use categories.

| ID | Type | Assigned to | ID | Type | Assigned to |
|-----|-------------------------------|----------------|-----|-------------------------|----------------|
| 100 | General Residential | Residential | 510 | Hotel, Motel or Resort | Commercial |
| 110 | Rural Residential | USGS Shrubland | 520 | Educational | Commercial |
| 120 | Estate Residential | USGS Shrubland | 530 | Institutional | Commercial |
| 130 | Large Lot Residential | Residential | 540 | Cemeteries | USGS Grassland |
| 140 | Medium Lot Residential | Residential | 550 | Public Facilities | Commercial |
| 150 | Small Lot Residential | Residential | 560 | Special Events | Commercial |
| 160 | Very Small Lot Residential | Residential | 570 | Other Employment Low | Nonemit |
| 170 | Medium Density Residential | Residential | 580 | Other Employment Medium | Commercial |
| 180 | High Density Residential | Residential | 590 | Other Employment High | Commercial |
| 190 | Very High Density Residential | Residential | 600 | General Transportation | Nonemit |
| 200 | General Commercial | Commercial | 610 | Transportation | Nonemit |
| 210 | Specialty Commercial | Commercial | 611 | Parking Structures | Nonemit |
| 220 | Neighborhood Retail Center | Commercial | 612 | Parking Surfaces | Nonemit |
| 230 | Community Commercial | Commercial | 620 | Airport | Nonemit |
| 240 | Regional Retail Center | Commercial | 700 | Recreation | not merged |
| 250 | Super-Regional Commercial | Commercial | 710 | Active Open Spaces | USGS Grassland |
| 300 | General Industrial | Commercial | 720 | Golf Courses | USGS Grassland |
| 310 | Warehouse/Distribution | Commercial | 730 | Dedicated Open Space | not merged |
| 320 | Industrial | Commercial | 740 | Water | Water |
| 400 | Office General | Commercial | 750 | Agriculture | Agriculture |
| 410 | Office Low Rise | Commercial | 800 | Multiple Use | Commercial |
| 420 | Office Mid Rise | Commercial | 810 | Business Park | Commercial |
| 430 | Office High Rise | Commercial | 820 | Mixed Use | Commercial |
| 500 | General Employment | Commercial | 830 | Planned Developments | Commercial |
| | | | 900 | Vacant | not merged |

Table 6.3–2. Land-use categories from BELD3 used in the emission inventory.

| <u>BELD3 Land-use category</u> |
|--------------------------------|
| USGS_Coniferous |
| USGS_Deciduous |
| USGS_Mixed Forest |
| USGS_Grassland |
| USGS_Savanna |
| USGS_Shrubland |

6.4 Derivation of emission factors

For each of the 11 land-use groups, MAGBEIS2 requires as input a standardized emission factor for isoprene, monoterpene, other volatile organic compounds (OVOCs), and oxides of nitrogen (NO_x). The emission factors selected for use in MAGBEIS2 are listed in Table 6.4–1. The commercial emission factor is identical to the one developed for the 1996 STI study. The “Agricultural” and “Residential” categories were adjusted based on updated data or assumptions described below.

Table 6.4-1. VOC and NO_x standardized emission factors, by land-use category (µg/m²·hr).

| Land-use category | Emission Factor | | | |
|------------------------------|--------------------|--------------------|--------------------|--------------------|
| | Isoprene | Monoterpene | OVOC | NO _x |
| Commercial/Industrial | 102 ^e | 22 ^e | 22 ^a | 1.8 ^b |
| Residential/Schools/Churches | 961.3 ^e | 206.5 ^e | 206.5 ^a | 17.4 ^c |
| Agricultural | 20.8 ^e | 44.7 ^e | 49.9 ^e | 140.0 ^e |
| USGS Coniferous | 2276.6 | 1375.0 | 457.0 | 2.0 |
| USGS Deciduous | 1646.4 | 90.0 | 249.0 | 2.0 |
| USGS Mixed Forest | 1545.8 | 225.0 | 374.0 | 2.0 |
| USGS Grassland | 9.8 | 21.0 | 249.0 | 27.0 |
| Water | 0 ^d | 0 ^d | 0 ^d | 0 ^d |
| USGS Savanna | 353.0 | 60.0 | 83.0 | 27.0 |
| USGS Shrubland | 110.0 | 55.0 | 33.0 | 57.8 |
| Non-emitting | 0 | 0 | 0 | 0 |

a. OVOC emission rate set equal to monoterpene emissions rate.

b. US EPA emission factor for grass multiplied by the landscape fraction.

c. US EPA emission factor for commercial and industrial multiplied by the landscape fraction.

d. US EPA-recommended values.

e. Based on locale-specific data.

The development of the emission rate estimate for the “Agricultural” category utilized Arizona crop statistics for 2002 obtained for Maricopa County by land-use type as documented in 2002 Arizona Agricultural Statistics, Arizona Agricultural Statistics Service, 2003. These values are shown in Table 6.4-2. The acreage shown in this table were used to derive the percentages of these crop types relative to the total crop land-use area: Cotton - 25.04 percent, Alfalfa - 37.64 percent, Other Hay - 4.09 percent, Wheat - 7.42 percent, Barley - 9.27 percent, Corn - 0.11 percent, Vegetables - 10.91 percent, Citrus - 5.51 percent. These percentages, as fractions, were multiplied by the US EPA reported standardized emission factors for isoprene, monoterpenes, OVOC, and NO_x for each crop type to get a composite emission factor for harvested cropland areas. The emission factor for “Citrus” is the same as that reported by EPA for orange. Since the 2000 MAG land-use data only contain a single agriculture category, MAG calculated a composite emission factor based on the land distribution fractions for harvested cropland and non-harvested croplands from the latest available Census of Agriculture, 1997.

Table 6.4-2. Maricopa County crop statistics for 2002.

| Crop | Acres * | % of total |
|----------------|----------------|-------------|
| Cotton | 45,900 | 25.04 |
| Alfalfa | 69,000 | 37.64 |
| Other Hay | 7,500 | 4.09 |
| Wheat | 13,600 | 7.42 |
| Barley | 17,000 | 9.27 |
| Corn | 200 | 0.11 |
| Vegetables | 20,000 | 10.91 |
| Citrus | 10,100 | 5.51 |
| Totals: | 183,300 | 100. |

* All values were derived from 2002 Arizona Agricultural Statistics, Arizona Agricultural Statistics Service, 2003.

Table 6.4-3 shows the total areas and percentages for harvested cropland and total cropland. This approach relies on the assumption that the changes occurring in harvested and non-harvested areas has not changed significantly since 1997. As a result, the emission factor for the new “Agricultural” category was computed by calculating a weighted average of the harvested

cropland emission factor and the non-harvested (grassland) emission factor for each VOC species (paraffin, olefins, aldehyde, and isoprene), OVOC, and NO_x.

Table 6.4-3. Distribution of harvested cropland and total cropland.

| Category | Area* (acres) | Fraction (%) |
|------------------------|---------------|--------------|
| Total Cropland | 340,563 | 100 |
| Harvested Cropland | 296,150 | 87 |
| Non-Harvested Cropland | 44,413 | 13 |

* USDA 1997 Census of Agriculture.

Maricopa County lies in the arid Sonoran desert. The residential/schools/churches emission factor used the EPA “desert cities” alternative splits which assumes that 70 percent of the urban land use is barren.

All emission factors for the BELD3 land-use types were taken from the EPA BEIS version 3.09 data set.

6.5 Meteorological inputs

Consistent with previous periodic inventories, for 1990 and onward, the meteorological episode day used was September 9, 1988. The procedures of selecting the episode day was in accordance with the EPA guidance documented in the User’s Guide to the Personal Computer Version of the Biogenic Emissions Inventory System (PC-BEIS), Version 2.0, EPA, 1991. Meteorological data are input to MAGBEIS2 from two separate files. The first file called “SURMET1” was created using observed data from the Sky Harbor Airport. The file includes the following meteorological fields:

- Opaque sky cover
- Total sky cover
- Fraction of sky occupied by the lowest level clouds and height of that cloud level
- Fraction of sky occupied by the second lowest level clouds and height of that cloud level
- Fraction of sky occupied by the third lowest level clouds and height of that cloud level

The above fields are used to determine the solar radiation fluxes in the current version of MAGBEIS2. The following fields in the data file are not used by the program but the format is reserved for the program to read successfully:

- Sea level pressure
- Wind direction
- Wind speed
- Surface temperature
- Dew point
- Station pressure

The second meteorological data file, “TEMPRTR”, consists of 24 hours per day of gridded surface temperature fields created from a UAM preprocessor program. TEMPRTR is in binary format and can be used as an input to UAM. Data used to generate the surface temperature fields were obtained from ten monitoring sites for the episode day. Table 6.5-1 presents more information about the ten monitoring sites for this analysis.

Table 6.5–1. Information for surface temperature monitoring sites.

| Site ID | Station Name | Latitude | Longitude | Network* |
|---------|--------------------|-------------|--------------|----------|
| SKY | Sky Harbor Airport | 33° 26' 03" | 112° 03' 04" | NWS |
| SMPK | S. Mt. Park | 33° 20' 46" | 112° 02' 59" | FCDMC |
| GILA | Gila Bend Mt. | 33° 14' 28" | 113° 12' 14" | FCDMC |
| HORS | Horsethief Basin | 34° 06' 19" | 112° 20' 49" | FCDMC |
| MTUN | Mt. Union | 34° 24' 54" | 112° 24' 17" | FCDMC |
| CARE | Carefree Ranch | 33° 52' 03" | 111° 51' 00" | FCDMC |
| WADD | Waddell | 33° 37' 05" | 112° 27' 35" | AZMET |
| GREE | Phx. Greenway | 33° 29' 07" | 112° 06' 30" | AZMET |
| ENCA | Phx. Encanto | 33° 28' 45" | 112° 05' 47" | AZMET |
| LITC | Litchfield | 33° 28' 02" | 112° 23' 53" | AZMET |

* NWS: National Weather Service, MDMS on EPA NCC/IBM server

FCDMC: Flood Control Department Maricopa County, Julie Riemenschneider

AZMET: The Arizona Meteorological Network, <http://ag.arizona.edu/azmet/>

6.6 Summary of emissions from biogenic sources

Total biogenic emissions for the Maricopa County 2002 periodic ozone emission inventory are summarized in Tables 6.6–1 and 6.6–2 for both the ozone nonattainment area and Maricopa County.

Table 6.6–1. Summary of biogenic source emissions (typical ozone season day).

| Pollutant | Maricopa County | | Ozone nonattainment area | |
|-----------------|-----------------|---------|--------------------------|--------|
| | kg/day | lb/day | kg/day | lb/day |
| NO _x | 32,499 | 71,648 | 6,291 | 13,870 |
| Total VOC | 140,392 | 309,511 | 41,737 | 92,015 |
| –Isoprenes | 48,340 | 106,571 | 16,252 | 35,830 |
| –Paraffins | 66,581 | 146,786 | 18,921 | 41,713 |
| –Aldehydes | 16,063 | 35,413 | 3,951 | 8,711 |
| –Olefins | 9,408 | 20,741 | 2,613 | 5,761 |

Table 6.6–2. Summary of biogenic source emissions (annual totals).

| Pollutant | Maricopa County | | Ozone nonattainment area | |
|-----------------|-----------------|-----------------|--------------------------|-----------------|
| | metric tons/yr | English tons/yr | metric tons/yr | English tons/yr |
| NO _x | 7,554 | 8,327 | 1,455 | 1,604 |
| Total VOC | 21,910 | 24,152 | 6,552 | 7,223 |
| –Isoprenes | 7,331 | 8,081 | 2,459 | 2,711 |
| –Paraffins | 10,551 | 11,630 | 3,040 | 3,351 |
| –Aldehydes | 2,538 | 2,798 | 633 | 698 |
| –Olefins | 1,490 | 1,643 | 420 | 463 |

6.7 Biogenic emissions comparison

The biogenic source portion of the 2002 ozone season day emissions inventory for the ozone nonattainment area was compared with the biogenic source portions of the 1993, 1996, and 1999 periodic emissions inventories. The results are in Table 6.7–1. Estimates for Maricopa County in its entirety were not prepared for previous inventories, so no county wide comparison is possible.

Table 6.7–1. Comparison of biogenic source ozone season day emissions.

| Pollutant | Biogenic emissions within the ozone nonattainment area (metric tons/day) | | | |
|------------------|---|-------------|-------------|-------------|
| | 1993 | 1996 | 1999 | 2002 |
| NO _x | | 10.51 | 10.3 | 6.3 |
| Hydrocarbons | 46.99 | 47.23 | 48.67 | 41.7 |
| –Paraffin | | 19.17 | 19.65 | 18.9 |
| –Olefins | | 2.43 | 2.49 | 2.6 |
| –Aldehyde | | 6.61 | 6.76 | 3.9 |
| –Isoprene | | 19.03 | 19.77 | 16.2 |

The modeled biogenic emissions vary over time due to changes in land use and emission factors. The 1993 modeled biogenic emissions used the MAG 1990 land-use database. The 1996 and 1999 modeled biogenic emissions used the MAG 1995 land-use database and the 2002 modeled biogenic emissions used the MAG 2000 land-use database and the BELD3 land-use database. The agricultural emission factors were updated each year based on available crop reports and for 2002, the residential emission factor was adjusted as described above.

6.8 References

- Arizona Agricultural Statistics Service, 2003. 2002 Arizona Agricultural Statistics. July 2003.
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