**OPEN BURNING - YARD WASTE - LEAF AND BRUSH SPECIES**

***a. Source Category Description***

Open burning of yard waste is the purposeful burning of leaf and brush species in outdoor areas. Criteria air pollutant (CAP) and hazardous air pollutant (HAP) emission estimates for leaf and brush waste burning are a function of the amount of waste burned per year.

For this source category, the following SCCs were assigned:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SCC** | **SCC Level 1** | **SCC Level 2** | **SCC Level 3** | **SCC Level 4** |
| 2610000100 | Waste Disposal, Treatment, and Recovery | Open Burning | All Categories | Yard Waste – Leaf Species Unspecified |
| 2610000400 | Waste Disposal, Treatment, and Recovery | Open Burning | All Categories | Yard Waste – Brush Species Unspecified |

***b. Activity Data***

The amount of leaf and brush waste burned was estimated using data from EPA’s report *Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2010.*1,2 The report presents the total mass of waste generated from the residential and commercial sectors, including yard waste, in the United States by type of waste for the calendar year 2010. According to the EPA report, residential waste generation accounts for 55-65 percent of the total waste from the residential and commercial sectors.3 For the calculation of per capita yard waste subject to burning, the median value of 60 percent was assumed. This information was used to calculate a daily estimate of the per capita yard waste of 0.36 lbs/person/day. Of the total amount of yard waste generated, the yard waste composition was assumed to be 25 percent leaves, 25 percent brush, and 50 percent grass by weight.4

Open burning of grass clippings is not typically practiced by homeowners, and as such only estimates for leaf burning and brush burning were developed. Approximately 25 to 32 percent of all waste that is subject to open burning is actually burned.4 A median value of 28 percent is assumed to be burned in all counties in the United States.

The per capita estimate was then multiplied by the 2010 population in each county that is expected to burn waste. Since open burning is generally not practiced in urban areas, only the rural population of each county was assumed to practice open burning. The ratio of urban to rural population was obtained from 2010 U.S. Census data.5 This ratio was then multiplied by the 2010 U.S. Census Bureau estimate of the population in each county to obtain the county-level rural population for 2010.6

The percentage of forested acres from Version 2 of BELD2 within BEIS was used to adjust for variations in vegetation. The percentage of forested acres per county (including rural forest and urban forest) was then determined. To better account for the native vegetation that would likely be occurring in the residential yards of farming States, agricultural land acreage was subtracted before calculating the percentage of forested acres. Table 1 presents the ranges that were used to make adjustments to the amount of yard waste that is assumed to be generated per county. All municipios in Puerto Rico and counties in the U.S. Virgin Islands, Hawaii, and Alaska were assumed to have greater than 50 percent forested acres.

**Table 1. Adjustment for Percentage of Forested Acres**

|  |  |
| --- | --- |
| **Percent Forested Acres per County** | **Adjustment for**  **Yard Waste Generated** |
| < 10% | 0% generated |
| >= 10%, and < 50% | 50% generated |
| >= 50% | 100% generated |

***c. Controls***

Controls for yard waste burning are generally in the form of a ban on open burning of waste in a given municipality or county. Counties that were more than 80% urban were assumed not to practice any open burning. Therefore, criteria pollutant and HAP emissions from residential yard waste burning are zero in these counties. In addition, the State of Colorado implemented a state-wide ban on open burning. Emissions from open burning of residential yard waste in all Colorado counties were assumed to be zero.

***d. Emission Factors***

Emission factors are specific to yard waste type and are reported in Tables 2 and 3 below. Emission factors for CAPs were developed by the U.S. Environmental Protection Agency (EPA) in consultation with the Eastern Regional Technical Advisory Committee.7 For leaf burning, emission factors for PM2.5 were calculated by multiplying the PM10 leaf burning emission factors by the PM2.5 to PM10 emission factor ratio for brush burning (0.7709). Emission factors for HAPs are from an EPA Control Technology Center report.8 Forest fire simulation emission factors were used to estimate emissions for 17 dioxin congeners.9

***e. Emissions***

County-level criteria pollutant and HAP emissions were calculated by multiplying the total amount of yard waste (either leaf or brush) burned per year by an emission factor. Emissions for leaves and residential brush were calculated separately, since emission factors vary by yard waste type.

***f. Example Calculations***

VOC emissions in Autauga County, Alabama from open burning of leaf waste:

Population of Autauga County in 2010 = 54,571

Rural fraction of Autauga County population = 0.42

Per capita waste yard waste generated (lb/person/day) = 0.3557

Leaf fraction of waste = 0.25

Fraction of rural population that burns yard waste = 0.28

Adjustment factor based on % forested acres = 1

Number of days in a year = 365

Factor to convert from lbs to tons = 1/2000

2010 leaf burning activity in Autauga County = 54,571 \* 0.42 \* 0.3557 \* 0.25 \* 0.28 \* 1 \* 365 \* 1/2000

2010 leaf burning activity in Autauga County = 104.15 tons

VOC emissions = tons of leaves burned \* VOC emission factor

VOC emission factor = 28 lb/ton

VOC emissions from leaf burning in Autauga County in 2010 = 104.15 tons \* 28 lbs/ton \* 1 ton/2000 lbs

VOC emissions from leaf burning in Autauga County in 2010 = 1.46 tons

***g. References***

1. U.S. Environmental Protection Agency, [*Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2010*, "Table 1. Materials Generated in the Municipal Waste Stream, 1960 to 2010,"](https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/advancing-sustainable-materials-management-0) December 2011, (accessed June 2019).

2. U.S. Environmental Protection Agency, [*Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2010*,](https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/advancing-sustainable-materials-management-0) "Table 2. Materials Recovered in the Municipal Waste Stream, 1960 to 2010," December 2011, (accessed June 2019).

3. U.S. Environmental Protection Agency, [*Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2010—Fact Sheet*,"](https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/advancing-sustainable-materials-management-0) p. 4,December 2011, (accessed June 2019).

4. Two Rivers Regional Council of Public Officials and Patrick Engineering, Inc. “Emission Characteristics of Burn Barrels,” prepared for the U.S. Environmental Protection Agency, Region V. June 1994.

5. U.S. Census Bureau, Decennial Censuses, 2010 Census: SF1, Table P2

6. U.S. Census Bureau. [*Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2011*](https://www.census.gov/library/visualizations/2010/geo/population-distribution-2010.html) *(NST-EST2011-01),* (accessed June 2019).

7. Huntley, Roy, U.S. Environmental Protection Agency, “state\_comparison ERTAC SS\_version7\_3 Oct 20 2009 [electronic file],” November 5, 2009.

8. U.S. Environmental Protection Agency, *Evaluation of Emissions from the Open Burning of Household Waste in Barrels*, EPA-600/R-97-134a, Control Technology Center. November 1997.

9. Gullet, B.K. and T. Abderrahmne, “PCDD/F Emissions from Forest Fire Simulations,” *Atmospheric Environment*, Vol. 37, No. 6, pp. 803-813. February 2003.

**Table 2. Emission Factors for Open Burning of Leaf Species (SCC 2610000100)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Pollutant** | **Pollutant Code** | **Emission Factor**  **(lb/ton)** | **Emission**  **Factor**  **Reference** |
| 1,2,3,4,6,7,8-heptachlorodibenzofuran | 67562394 | 5.08E-08 | Reference 9 |
| 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin | 35822469 | 3.32E-07 | Reference 9 |
| 1,2,3,4,7,8,9-heptachlorodibenzofuran | 55673897 | 6.12E-09 | Reference 9 |
| 1,2,3,4,7,8-hexachlorodibenzofuran | 70648269 | 3.34E-08 | Reference 9 |
| 1,2,3,4,7,8-hexachlorodibenzo-p-dioxin | 39227286 | 1.136E-08 | Reference 9 |
| 1,2,3,6,7,8-hexachlorodibenzofuran | 57117449 | 1.428E-08 | Reference 9 |
| 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin | 57653857 | 2.14E-08 | Reference 9 |
| 1,2,3,7,8,9-hexachlorodibenzofuran | 72918219 | 2.22E-09 | Reference 9 |
| 1,2,3,7,8,9-hexachlorodibenzo-p-dioxin | 19408743 | 3.46E-08 | Reference 9 |
| 1,2,3,7,8-pentachlorodibenzofuran | 57117416 | 1.268E-06 | Reference 9 |
| 1,2,3,7,8-pentachlorodibenzo-p-dioxin | 40321764 | 7.66E-09 | Reference 9 |
| 2,3,4,6,7,8-hexachlorodibenzofuran | 60851345 | 1.962E-08 | Reference 9 |
| 2,3,4,7,8-pentachlorodibenzofuran | 57117314 | 2.02E-08 | Reference 9 |
| 2,3,7,8-tetrachlorodibenzofuran | 51207319 | 1.396E-08 | Reference 9 |
| 2,3,7,8-tetrachlorodibenzo-p-dioxin | 1746016 | 2.3E-09 | Reference 9 |
| CO | CO | 112 | Reference 7 |
| Cumene | 98828 | 0.01325 | Reference 8 |
| Ethyl Benzene | 100414 | 0.048 | Reference 8 |
| Nitrogen Oxides | NOX | 6.2 | Reference 7 |
| Octachlorodibenzofuran | 39001020 | 2.06E-08 | Reference 9 |
| Octachlorodibenzo-p-dioxin | 3268879 | 1.328E-06 | Reference 9 |
| Phenol | 108952 | 0.115 | Reference 8 |
| PM10-FIL | PM10-FIL | 22 | Reference 7 |
| PM10-PRI | PM10-PRI | 22 | Reference 7 |
| PM25-FIL | PM25-FIL | 16.96 | 0.7709 \* PM10 |
| PM25-PRI | PM25-PRI | 16.96 | 0.7709 \* PM10 |
| Styrene | 100425 | 0.1015 | Reference 8 |
| Sulfur Dioxide | SO2 | 0.76 | Reference 7 |
| VOC | VOC | 28 | Reference 7 |

**Table 3. Emission Factors for Open Burning of Brush Species (SCC 2610000400)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Pollutant** | **Pollutant Code** | **Emission Factor**  **(lb/ton)** | **Emission**  **Factor**  **Reference** |
| CO | CO | 140 | Reference 7 |
| Nitrogen Oxides | NOX | 5 | Reference 7 |
| PM10-PRI | PM10-PRI | 19.73 | Reference 7 |
| PM10-FIL | PM10-FIL | 19.73 | Reference 7 |
| PM25-PRI | PM25-PRI | 15.21 | Reference 7 |
| PM25-FIL | PM25-FIL | 15.21 | Reference 7 |
| Sulfur Dioxide | SO2 | 1.66 | Reference 7 |
| VOC | VOC | 19 | Reference 7 |
| 1,2,3,4,6,7,8-heptachlorodibenzofuran | 35822469 | 3.32E-07 | Reference 9 |
| 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin | 67562394 | 5.08E-08 | Reference 9 |
| 1,2,3,4,7,8,9-heptachlorodibenzofuran | 55673897 | 6.12E-09 | Reference 9 |
| 1,2,3,4,7,8-hexachlorodibenzofuran | 70648269 | 3.34E-08 | Reference 9 |
| 1,2,3,4,7,8-hexachlorodibenzo-p-dioxin | 39227286 | 1.136E-08 | Reference 9 |
| 1,2,3,6,7,8-hexachlorodibenzofuran | 57117449 | 1.428E-08 | Reference 9 |
| 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin | 57653857 | 2.14E-08 | Reference 9 |
| 1,2,3,7,8,9-hexachlorodibenzofuran | 72918219 | 2.22E-09 | Reference 9 |
| 1,2,3,7,8,9-hexachlorodibenzo-p-dioxin | 19408743 | 3.46E-08 | Reference 9 |
| 1,2,3,7,8-pentachlorodibenzofuran | 57117416 | 1.268E-06 | Reference 9 |
| 1,2,3,7,8-pentachlorodibenzo-p-dioxin | 40321764 | 7.66E-09 | Reference 9 |
| 2,3,4,6,7,8-hexachlorodibenzofuran | 60851345 | 1.962E-08 | Reference 9 |
| 2,3,4,7,8-pentachlorodibenzofuran | 57117314 | 2.02E-08 | Reference 9 |
| 2,3,7,8-tetrachlorodibenzofuran | 51207319 | 1.396E-08 | Reference 9 |
| 2,3,7,8-tetrachlorodibenzo-p-dioxin | 1746016 | 2.3E-09 | Reference 9 |
| Cumene | 98828 | 0.01325 | Reference 8 |
| Ethyl Benzene | 100414 | 0.048 | Reference 8 |
| Octachlorodibenzofuran | 39001020 | 2.06E-08 | Reference 9 |
| Octachlorodibenzo-p-dioxin | 3268879 | 1.328E-06 | Reference 9 |
| Phenol | 108952 | 0.115 | Reference 8 |
| Styrene | 100425 | 0.1015 | Reference 8 |