**AGRICULTURAL TILLING**

***a. Source Category Description***

Fugitive dust emissions from agricultural tilling include the airborne soil particulate emissions produced during the preparation of agricultural lands for planting. Fugitive dust emissions from agricultural tilling were estimated for PM10-PRI, PM10-FIL, PM25-PRI, and PM25-FIL. Since there is no PM-CON emissions for this category, PM10-PRI emissions are equal to PM10-FIL emissions and PM25-PRI emissions are equal to PM25-FIL.

For this source category, the following SCC was assigned:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SCC** | **SCC Level 1** | **SCC Level 2** | **SCC Level 3** | **SCC Level 4** |
| 2801000003 | Miscellaneous Area Sources | Agriculture Production - Crops | Agriculture - Crops | Tilling |

Particulate emissions from agricultural tilling were computed by multiplying a crop specific emissions factor by an activity factor, as discussed below.

***b. Emission Factor Equation***

The county-level emissions factors for agricultural tilling (in lbs per acre) are specific to the crop and tilling type and were calculated using the following equation:1,2

*EF = 4.8 × k × s0.6 × pcrop,tilling type*

where:

*k* = dimensionless particle size multiplier (PM10 = 0.21; PM2.5 = 0.042),

*s* = silt content of surface soil (%),

*p* = number of passes or tillings in a year for a given crop and tillage type.

The U.S. Department of Agriculture and the National Cooperative Soil Survey define silt content of surface soil as the percentage of particles (mass basis) of diameter smaller than 50 micrometers (µm) found in the surface soil.[[1]](#footnote-1) The soil sample data used to estimate county-level, average silt content values are from the National Cooperative Soil Survey Microsoft Access Soil Characterization Database.3 This database contains the most commonly requested data from the National Cooperative Soil Survey Laboratories including data from the Kellogg Soil Survey Laboratory and cooperating universities.

EPA applied specific selection criteria to the database to ensure that all samples are comparable and relevant to this analysis. The selection criteria included selecting only samples taken inside the United States with a preparation code of S and a horizon top of zero centimeters or a master horizon of A or O. A preparation code of S signifies that the sample is the air-dried whole soil passing through a 3 inch sieve and a horizon top of zero or master horizon of A or O ensures that the sample is taken at the surface.

In some cases, the sample metadata did not indicate a county, but included latitude and longitude coordinates. In these cases, the state and county information were reverse geocoded from the lat-long coordinates and added to the sample entry in the database.

After gap-filling the missing state and county information, the average silt content for a county was calculated by summing the total silt content of all the samples in the county and dividing by the number of samples in the county. For counties without samples, the average silt content was calculated by summing the total silt content of soil samples in neighboring counties and dividing by the number of samples in the neighboring counties. If neighboring counties also lacked sample data, then the county was assigned the average silt value of soil samples within the state.

Table 1 shows the number of passes or tillings in a year for each crop for conservation use, no-till and conventional use.4 Mulch till and ridge till tillage systems are classified as conservation use, while 0 to 15 percent residue and 15 to 30 percent residue tillage systems are classified as conventional use.

**Table 1. Number of Passes or Tillings per Year.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Crop** | **Conservation Use** | **No-Till** | **Conventional Use** |
| Barley | 3 | 3 | 5 |
| Beans | 3 | 3 | 3 |
| Canola | 3 | 3 | 3 |
| Corn | 2 | 2 | 6 |
| Cotton | 5 | 5 | 8 |
| Cover | 1 | 1 | 1 |
| Fallow | 1 | 1 | 1 |
| Fall-seeded/Winter Wheat | 3 | 3 | 5 |
| Forage | 3 | 3 | 3 |
| Hay | 3 | 3 | 3 |
| Oats | 3 | 3 | 5 |
| Peanuts | 3 | 3 | 3 |
| Peas | 3 | 3 | 3 |
| Permanent Pasture | 0 | 0 | 1 |
| Potatoes | 3 | 3 | 3 |
| Rice | 5 | 5 | 5 |
| Rye | 3 | 3 | 5 |
| Sorghum | 1 | 1 | 6 |
| Soybeans | 1 | 1 | 6 |
| Spring Wheat | 1 | 1 | 4 |
| Sugarbeets | 3 | 3 | 3 |
| Sugarcane | 3 | 3 | 3 |
| Sunflowers | 3 | 3 | 3 |
| Tobacco | 3 | 3 | 3 |

***c. Activity***

The basis of agricultural tilling emission estimates is the number of acres of crops tilled in each county by crop type and tillage type. These data were obtained from the *2012 Census of Agriculture* developed by the United States Department of Agriculture.5 The USDA Census of Agriculture reports acres harvested for a given crop at the county level, but does not provide tilling data for each crop type at the county level. To calculate acres harvested per tilling type for each crop, the breakdown of tilling types (conservation, no-till, and conventional) at the county level was applied to the acres harvested for each crop type at the county level. The county level tilling type data for 2012 was provided by request from the USDA.6

There were several counties that had data for acres harvested by crop type from the USDA Census of Agriculture, but not acres for each tilling type. For these counties, a state average breakdown of conservation versus no-till versus conventional tilling was used as a surrogate for county level data.

The USDA Census of Agriculture redacts some county level data to avoid disclosing data for individual farms. Missing county-level data for acres harvested by crop type and tilling type were calculated using the difference between the state and national level reported data and the sum of the count- level data by state.

Tilling data for permanent pasture followed a different methodology. Conventional tilling data were available for the state of Utah.7 A ratio of the conventional tilling acres to the total acres of permanent pasture for Utah was developed (0.0023) and applied to the total acreage data for permanent pasture from the *2012 Census of Agriculture* to determine the number of conventional tilled permanent pasture acres by county in other states. It is assumed that the remainder of the permanent pasture acres is not tilled, so the remaining distribution of permanent pasture acres was distributed to no till acres and conservation tilling acres were left as zero.

A summary of national-level acres tilled in 2012 for each tilling type are presented in Table 2.

**Table 2. Acres Tilled by Tillage Type, in 2012**

|  |  |  |
| --- | --- | --- |
| **Tillage System** | **Actual National Number of Acres Tilled in 2012 (million acres)** | |
| No-Till | 658.07 |
| Conservation | 162.19 |
| Conventional | 273.16 |
| **Total** | **1,093.42** |

***d. Emissions***

The following equation was used to determine the emissions from agricultural tilling for 2012.1,2 The county-level activity data are the acres of land tilled for a given crop and tilling type. The equation is adjusted to estimate PM10 and PM2.5 emissions using the following parameters: a particle size multiplier, the silt content of the surface soil, the number of tillings per year for a given crop and tilling type, and the acres of land tilled for a given crop and tilling type.

*E = Σc × k × s0.6 × pcrop,tilling type × acrop,tilling type*

where: *E* = PM10-FIL or PM25-FIL emissions

*c* = constant 4.8 lbs/acre-pass

*k* = dimensionless particle size multiplier (PM10=0.21; PM2.5=0.042)

*s* = percent silt content of surface soil, defined as the mass fraction of particles smaller than 50 μm diameter found in surface soil

*p* = number of passes or tillings in a year

*a* = acres of land tilled (activity data)

***e. Controls***

No controls were accounted for in the emission estimations.

***f. Changes from 2011 Methodology***

The 2008 emission estimates were based on data from the Conservation Technology Information Center’s *National Crop Residue Management Survey.*8This survey was discontinued in 2008. Therefore, in 2011, the agricultural tilling emissions were created by applying growth factors to the 2008 agricultural tilling dataset. These growth factors were derived from state- level USDA statistics on various crop types.

The 2014 agricultural tilling emissions were estimated using data on harvested acres and tillage type obtained from the USDA’s *2012 Census of Agriculture*. This included data on cover crop, fallow, and permanent pasture that were previously estimated using a top-down allocation approach based on farm numbers.

***g. Puerto Rico and US Virgin Islands Emissions Calculations***

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory’s activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are “EACH”.

***h. References***

1. *The Role of Agricultural Practices in Fugitive Dust Emissions*, T.A. Cuscino, Jr., et al., California Air Resources Board, Sacramento, CA, June 1981.

2. Memorandum from Chatten Cowherd of Midwest Research Institute, to Bill Kuykendal of the U.S. Environmental Protection Agency, Emission Factor and Inventory Group, and W.R. Barnard of E.H. Pechan & Associates, Inc., September 1996.

3. U.S. Department of Agriculture, National Cooperative Soil Survey, NCSS Microsoft Access Soil Characterization Database, available at <http://ncsslabdatamart.sc.egov.usda.gov/> , Accessed September 2015.

4. *Agricultural Activities Influencing Fine Particulate Matter Emissions*, Woodard, Kenneth R., Midwest Research Institute, March 1996.

5. *2012 Census of Agriculture,* United States Department of Agriculture, available at <http://www.agcensus.usda.gov/Publications/2012/> and through Quickstats 2.0, <http://quickstats.nass.usda.gov/>, Accessed September 2015.

6. Email from Christy Meyer, U.S. Department of Agriculture, National Agricultural Statistics Service to Marissa Hoer, Abt Associates, September 2015.

7. Email from Greg Mortensen, Utah Department of Environmental Quality to Jonathan Dorn, Abt Associates, 2014\_UtahDeptAg\_DNR\_Tilling\_Stats.xlsx, February 2016.

8. *National Crop Residue Management Survey*, Conservation Technology Information Center, 2008 <http://www.ctic.purdue.edu/CRM/> , Accessed September 2015.

1. Note that this is different than the U.S. Environmental Protection Agency’s definition that includes all particles (mass basis) of diameter smaller than 75 micrometers. [↑](#footnote-ref-1)