2020 National Emissions Inventory Technical Support Document: Waste Disposal – Open Burning – Land Clearing Debris

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34 Waste Disposal - Open Burning – Land Clearing Debris

34.1 Sector Description and Overview

This source category covers intentional burning for waste disposal purposes of land clearing debris. Open burning of land clearing debris is the purposeful burning of debris, such as trees, shrubs, and brush, from the clearing of land for the construction of new buildings and highways. Emission estimates from open burning of land clearing debris are a function of the amount of material or fuel subject to burning per year. The SCC (2610000500) description for land clearing debris is "Waste Disposal, Treatment, and Recovery; Open Burning; All Categories; Land Clearing Debris (use 28-10-005-000 for Logging Debris Burning)".

Section 35 covers open burning for municipal solid waste. Section 36 covers open burning for leaf and brush yard waste.

A list of agencies that submitted open burning, land clearing debris emissions is provided in Section 6.2.3.

34.2 EPA-developed estimates

The emissions from open burning from land clearing debris are estimated based on the number of acres disturbed from non-residential, residential, and road construction. The number of acres disturbed is multiplied by a fuel loading factor to determine the amount of land clearing debris burned in each county. This number is multiplied by emissions factors to determine emissions of CAPs and HAPs.

34.2.1 Activity data

The amount of material burned is estimated using the county-level total number of acres disturbed by residential, non-residential, and road construction. County-level weighted loading factors are applied to the total number of construction acres to convert acres to tons of available fuel.

Acres Disturbed from Non-Residential Construction

The activity data for this non-residential construction is the acreage disturbed from non-residential construction, which is estimated using data from the U.S. Census Bureau's *Annual Value of Construction Put in Place in the U.S* [ref 1]. and a conversion factor from MRI's *Estimating Particulate Matter Emissions from Construction Operations, Final Report* [ref 2]. The national-level non-residential construction spending data are allocated to the county-level based on the proportion of non-residential construction employees in each county. Employment data are taken from the U.S. Census Bureau's County Business Patterns (CBP), and gaps in employment data are filled using a process described in detail in section 34.2.2.

$$EmpFr_c = \frac{Emp_c}{Emp_{US}} \quad (1)$$

$$CS_c = EmpFr_c \times CS_{US} \quad (2)$$

Where:

$EmpFr_c$ = The fraction of non-residential construction employees in county *c*
Emp_c = The number of non-residential construction employees in county *c*
Emp_{US} = The number of non-residential construction employees in the US
CS_c = Non-residential construction spending in county *c*
CS_{US} = Non-residential construction spending in the US

Non-residential construction spending is converted to acres disturbed using a conversion factor from MRI's report [ref 2]. For the average acres disturbed per million dollars of non-residential construction, MRI reported a conversion factor of 2 acres/$1 million (in 1992 constant dollars). The 1992 conversion factor is adjusted to 2020 using the Price Deflator (Fisher) Index of New Single-Family Houses under Construction [ref 3]. In 2020 the conversion factor was 0.84 acres per million dollars spent on non-residential construction activities.

$$Apd_{2020} = \frac{2\ acres}{\$1\ million} \times \frac{PD_{1992}}{PD_{2020}} \quad (3)$$

Where:

Apd_{2020} = Acres disturbed per million dollars in 2020
PD_{1992} = Price Deflator (Fisher) Index value in 1992
PD_{2020} = Price Deflator (Fisher) Index value in 2020

County-level non-residential construction spending (from equation 2) is then multiplied by this conversion factor to estimate county-level acreage disturbed from non-residential construction activities.

$$ANR_c = CS_c \times Apd_{2020} \quad (4)$$

Where:

ANR_c = Acres disturbed from non-residential construction in county *c*
CS_c = Non-residential construction spending in county *c*, in million dollars
Apd_{2017} = Acres disturbed per million dollars in 2020

Acres Disturbed from Residential Construction

The US Census Bureau has 2020 data for Housing Starts - New Privately Owned Housing Units Started [ref 4, ref 5], which provides regional level housing starts based on the groupings of 1 unit, 2-4 units, 5 or more units. Regional-level results are also provided for quarterly totals and 1-unit structures [ref 5]. The 2- to 4-unit category is broken down using a ratio calculated from the 2000 US Census Bureau National Housing Starts data for 2 and 3-4 units [ref 6], for each quarter of the NEI year. Note that 2000 is the last full year when Census housing starts data were available separately for 2-unit and 3-4-unit homes.

$$S_{Q,n} = \left(\frac{U_n}{U_t}\right) \times S_{Q,2-4} \quad (5)$$

Where:

- $S_{Q,n}$ = Housing starts, by quarter, *Q*, and number of units*, n* (2 units or 3-4 units), in thousand units
- U_n = Number of housing starts by number of units, *n*, from the 2000 *National Housing Starts* data, in thousand housing starts
- U_t = Total number of housing starts for both 2 units and 3-4 units from the 2000 *National Housing Starts* data, in thousand housing starts
- $S_{Q,2\text{-}4}$ = Number of 2-4 units by quarter, *Q*, from the *New Privately Owned Housing Units Started by Purpose and Design* data, in thousand units

Ratios of the number of 2, 3 and 4, and 5-unit structures are then used to estimate the number of structures of each type in each region. The ratios are calculated by dividing the housing starts by quarter for each unit type by the total housing starts for buildings with more than 2 units.

$$r_{Q,n} = \frac{S_{Q,n}}{S_{Q.t}} \quad (6)$$

Where:

- $r_{Q,n}$ = Ratio of structures with number of units, *n*, to total number of units by quarter, *Q*
- $S_{Q,n}$ = Housing starts, by quarter, *Q*, and number of units*, n*, from distributed calculation in Step 1 for the 2-unit or 3-4-unit categories or directly from the *New Privately Owned Housing Units Started by Purpose and Design* data for the 5 units or more category, in thousand housing starts
- $S_{Q,t}$ = Housing starts, by quarter, *Q*, for total number of units greater than 2 units, *t* (excludes 1-unit category), in thousand housing starts

The ratio is then used to distribute the *New Privately Owned Housing Units Started by Purpose and Design* [ref 5] regional data for all unit types to the 2, 3-4, or 5 or more unit categories within each Census region – Northeast, Midwest, South, and West.

$$A_{Q,n,rgn} = r_{Q,n} \times (RS_{t,rgn} - RS_{1,rgn}) \quad (7)$$

Where:

- $A_{Q,n,rgn}$ = Number of housing units started in quarter *Q,* by number of units*, n*, and region of the country*, rgn*, in thousand units
- $r_{Q,n}$ = Ratio of structures with number of units, *n*, to total number of units by quarter, *Q*
- $RS_{t,rgn}$ = Total regional starts from *New Privately Owned Housing Units Started by Purpose and Design* data, in thousand housing starts
- $RS_{1,rgn}$ = Regional starts of structures with 1 unit from the *New Privately Owned Housing Units Started by Purpose and Design* data, in thousand housing starts

Data from the Census report *New Privately Owned Housing Units Authorized Unadjusted Units* [ref 7] is

used to calculate a conversion factor to determine the ratio of structures to units in the 5 or more unit category. The conversion factor is calculated by dividing the total number of units in structures with 5 or more units by region [ref 6] by the total number of buildings with 5 or more units by region [ref 7].

$$CF_5 = \frac{U_{5,rgn}}{B_{5,rgn}} \quad (8)$$

Where:

$CF_{5,rgn}$ = Ratio of 5 units or more to the number of buildings with 5 units or more by region, *rgn*
$U_{5,rgn}$ = Total number of 5 or more units by region, *rgn*
$B_{5,rgn}$ = Total number of buildings with 5 or more units by region, *rgn*

Structures started by category are then calculated at a regional level by summing the number of housing unit starts across all four quarters and dividing the by number of units in each building type. For the 3-4-unit type, the number of units per building is 3.5. The value is multiplied by 1,000 because the Census data are in units of thousand building starts.

For buildings with 1, 2, or 3-4 units:

$$B_{n,rgn} = \frac{(\sum_{Q1}^{Q4} A_{Q.n.rgn}) \times 1{,}000}{n} \quad (9)$$

Where:

$B_{n,rgn}$ = Number of building starts by the unit number category, *n*, and by region, *rgn*
$A_{Q,n,rgn}$ = Number of housing units started in quarter *Q,* by number of units*, n*, and region of the country*, rgn*, in thousand units
n = Number of units per building

For buildings with 5 or more units:

$$B_{n,rgn} = \frac{(\sum_{Q1}^{Q4} A_{Q.n.rgn}) \times 1{,}000}{CF_5} \quad (10)$$

Where:

$B_{n,rgn}$ = Number of building starts by the unit number category, *n*, and by region, *rgn*
$A_{Q,n,rgn}$ = Number of housing units started in quarter *Q,* by number of units*, n*, and region of the country*, rgn*, in thousand units
CF_5 = Ratio of 5 units or more to the number of buildings with 5 units or more

Annual county building permit data were obtained from the US Census Bureau [ref 8]. The County Level Residential Building Permit dataset has data to allocate regional housing starts to the county level. This results in county level housing starts by number of units for the NEI year.

The number of building permits for each unit number category by region is calculated by summing the county-level Census data to the region level.

$$BP_{n,rgn} = \sum BP_{n,c} \tag{11}$$

Where:

$BP_{n,rgn}$ = Number of building permits by the unit number category, *n*, and by region, *rgn*
$BP_{n,c}$ = Number of building permits by the unit number category, *n*, and by county, *c*

The ratio of the number of building permits by county to the total number of building permits by region in which the county is located, for each unit number category, is then calculated.

$$R_{BP,c} = \frac{BP_{n,c}}{BP_{n,rgn}} \tag{12}$$

Where:

$R_{BP,c}$ = Ratio building permits, *BP*, to total regional building permits in county *c*
$BP_{n,c}$ = Number of building permits by the unit number category, *n*, and by county, *c*
$BP_{n,rgn}$ = Number of building permits by the unit number category, *n*, and by region, *rgn*

The final number of building starts for each unit type category is then calculated at the county-level by multiplying the number of structures started at the regional level and the building permit ratio.

$$B_{n,c} = B_{n,rgn} \times R_{BP,c} \tag{13}$$

Where:

$B_{n,c}$ = Number of building starts by the unit number category, *n*, and by county, *c*
$B_{n,rgn}$ = Number of building starts by the unit number category, *n*, and by region, *rgn*
$R_{BP,c}$ = Ratio building permits, *BP*, to total regional building permits in county, *c*

The number of acres of surface area disturbed by the construction of residential buildings is calculated for apartment buildings, buildings with 2 units, and buildings with 1 unit. Table 34-1 shows the assumptions used for the surface area disturbed for each unit type. Buildings with unit types of 3-4 and 5 or more are grouped together as apartments in this step.

Table 34-1: Surface soil removed per unit type

Structure	**Acres disturbed**
1-Unit	1/4 acre/structure
2-Unit	1/3 acre/structure
Apartment	1/2 acre/structure

The acres of soil disturbed by the construction of residential buildings are calculated for apartment buildings, buildings with 2 units, and buildings with 1 unit.

$$AR_{n,c} = B_{n.c} \times a_n \tag{14}$$

Where:

$AR_{n,c}$ = Surface soil disturbed by building construction by county, *c*, and unit type category, *n*, in acres
$B_{n,c}$ = Number of building starts by the unit number category, *n*, and by county, *c*
a_n = Acres of surface soil disturbed by each unity type category, *n*. See Table 34-1.

Acres Disturbed by Road Construction

The activity data for this source category is the acreage disturbed from new road construction, which is estimated using data from FHWA's *Highway Statistics, State Highway Agency Capital Outlay, Table SF-12A* [ref 9] and FLDOT's *Generic Cost per Mile Models* [ref 10]. From the FHWA table, the following columns are used: New Construction, Relocation, Added Capacity, Major Widening, and Minor Widening. These columns are also differentiated according to the following six classifications:

1. Interstate, urban
2. Interstate, rural
3. Other arterial, urban
4. Other arterial, rural
5. Collectors, urban
6. Collectors, rural

Construction spending for each road type is summed across all construction types to determine the total annual highway spending for each road type.

$$HS_{s,r} = \sum_{ct} S_{s,r} \tag{15}$$

Where:

$HS_{s,r}$ = Annual highway spending for road type *r* in state *s*, in dollars
ct = Construction type
$S_{s,r}$ = Annual spending per construction type for road type *r* in state *s*, in dollars

State expenditure data are converted to miles of new road and acres disturbed per mile of new road based on conversions obtained from FLDOT [ref 10]. These conversions are shown in Table 34-2 and the acres disturbed per mile conversions are calculated by multiplying the total affected roadway width (including all lanes, shoulders, and areas affected beyond the road width) by one mile and converting the resulting land area to acres.

$$RC_{m,s,r} = \frac{HS_{s,r}}{TDM} \tag{16}$$

$$RC_{a,s,r} = RC_{m,s,r} \times ADM \tag{17}$$

Where:

$RC_{m,s,r}$ = Miles of FHWA road type *r* constructed in state *s*
$RC_{a,s,r}$ = Acres of land disturbed for construction of FHWA road type *r* in state *s*

$HS_{s,r}$ = Annual highway spending for road type *r* in state *s*
TDM = Conversion of dollars spent to road miles constructed, in thousand dollars per mile
ADM = Conversion of road miles constructed to acres disturbed, in acres per mile

Table 34-2: Spending per Mile and Acres Disturbed per Mile by Highway Type

Road Type	Thousand Dollars per mile	Total Affected Roadway Width (ft)*	Acres Disturbed per mile
Urban Areas, Interstate	9,636	94	11.4
Rural Areas, Interstate	4,796	89	10.8
Urban Areas, Other Arterials	4,829	63	7.6
Rural Areas, Other Arterials	2,643	55	6.6
Urban Areas, Collectors	4,829	63	7.6
Rural Areas, Collectors	2,643	55	6.6
*Total Affected Roadway Width = (lane width (12 ft) * number of lanes) + (shoulder width * number of shoulders) + area affected beyond road width (25 ft)			

The acres of land disturbed by road type can then be summed across all road types in a state to calculate the total state-level acreage disturbed due to new road construction.

$$ARC_s = \sum_r RC_{a,s} \tag{18}$$

Where:

ARC_s = Acres of land disturbed for all road construction in state *s*
$RC_{a,s}$ = Acres of land disturbed for construction of FHWA road type *r* in state *s*

Similar to residential construction, county-level building permits data from the U.S. Census Bureau are used to allocate the state-level acres disturbed by road construction to the county [ref 8]. Specifically, the ratio of the county-to state-level number of building starts is calculated and multiplied by the state-level acreage disturbed (from equation 18) to estimate the county-level acreage disturbed by road construction.

$$BFrac_c = \frac{Build_c}{Build_s} \tag{19}$$

$$ARC_c = ARC_s \times BFrac_c \tag{20}$$

Where:

$BFrac_c$ = The fraction of building starts in county *c*
$Build_c$ = The number of building starts in county *c*
$Build_s$ = The number of building starts in state *s*
ARC_c = Acres of land disturbed for road construction in county *c*
ARC_s = Acres of land disturbed for all road construction in state *s*

Converting Acres Disturbed to Tons of Land Clearing Debris Burned

The total acres disturbed by all construction types is calculated by summing the acres disturbed from residential, non-residential, and road construction.

$$TAD_c = ANR_c + (\sum AR_{n.c}) + ARC_c \quad (21)$$

Where:

TAD_c = Total acres disturbed in from nonresidential, residential, and road construction in county *c*

ANR_c = Acres disturbed from non-residential construction in county *c*

$AR_{n,c}$ = Acres of surface soil disturbed from residential construction in county *c* and unit type category *n* (summed to one value for residential construction for the county)

ARC_c = Acres of land disturbed for road construction in county *c*

Version 2 of the Biogenic Emissions Land cover Database (BELD2) within EPA's Biogenic Emission Inventory System (BEIS) [ref 11] is used to identify the acres of hardwoods, softwoods, and grasses in each county.

Because BELD2 does not contain data on Alaska and Hawaii, the acres of hardwoods, softwoods, and grasses in each county is estimated by using the state-level land cover statistics from the USGS National Land Cover Database on the percent land cover under each vegetation type [ref 12]. These percentages are multiplied by the county area (acres), from the U.S. Census Bureau [ref 13].

$$A_{AK/HI,c,f} = LA_{AK/HI,c} \times LC_{AK/HI,\%,f} \quad (22)$$

Where:

$A_{AK/HI,c,f}$ = Total acres of each fuel type, *f*, for each county, *c*, in Alaska or Hawaii

$LA_{AK/HI,c,}$ = County acres from the U.S. Census Bureau of each fuel type, *f*, for each county, *c*, in Alaska or Hawaii

$LC_{AK/HI,\%,f}$ = Land cover percentages for each fuel type (hardwood, softwood, grass) in Alaska or Hawaii

Table 34-3 presents the average fuel loading factors by vegetation type. The average loading factors for slash hardwood and slash softwood are adjusted by a factor of 1.5 to account for the mass of tree that is below the soil surface that would be subject to burning once the land is cleared [ref 14]. Weighted average county-level loading factors are calculated by multiplying the average loading factors by the percent contribution of each type of vegetation class to the total land area for each county.

$$WFLF_{c,f} = \frac{A_{c,f}}{A_{c,total}} \times LF_f \quad (23)$$

Where:

$WFLF_{c,f}$ = Weighted average fuel loading factor by for fuel type *f* in county *c*

$A_{c,f}$ = Acres of land cover in county *c*, by fuel type *f* (from BELD2 for continental U.S. [ref.

11]; from equation 22 for Alaska and Hawaii)

$A_{c,total}$ = Total acres of land cover of all fuel types in county *c*

LF_f = Fuel loading factor by fuel type, *f*, in tons/acre, from Table 34-3

Table 34-3: Fuel Loading Factors by Vegetation Type

Vegetation Type	Unadjusted Average Fuel Loading Factor (Ton/acre)	Adjusted Average Fuel Loading Factor (Ton/acre)
Hardwood	66	99
Softwood	38	57
Grass	4.5	Not Applicable

The weighted average county-level loading factors for each fuel type are then summed across fuel types to calculate a single weighted average loading factor for each county.

$$WFLF_c = \sum_f WFLF_{c,f} \quad (24)$$

Where:

$WFLF_c$ = Weighted average fuel loading factors for county *c*

$WFLF_{c,f}$ = Weighted average fuel loading factor by for fuel type *f* in county *c*

The county-level total acres disturbed are then multiplied by the weighted average loading factor to derive tons of land clearing debris.

$$LCD_c = TAD_c \times WFLF_c \quad (25)$$

Where:

LCDc = Land clearing debris in county *c*, in tons

TAD_c = Total acres disturbed in county *c*

$WFLF_c$ = Weighted average fuel loading factors for county *c*

The total land clearing debris burned per county is calculated by multiplying acres of land clearing debris by county by a control factor, based on the percent of urban land from the 2010 U.S. Census data [ref 13]. See Section 34.2.4 for more information on the control factor.

$$BLCD_c = LCD_c \times CF_c \quad (26)$$

Where:

$BLCD_c$ = Land clearing debris burned in county *c*, in tons

LCDc = Land clearing debris in county *c*, in tons

CF_c = Control factor. The control factor is 1 for counties with less than 80% urban population and 0 for Colorado or in counties with an urban population of 0.8% or more based on the 2010 U.S. Census data [ref 13] as no burning occurs in these counties. See

Section 34.2.4 for more information on the control factor.

34.2.2 Allocation procedure

Acres disturbed by Non-residential Construction – County business patterns allocation

Employment data are obtained from the U.S. Census Bureau's County Business Patterns (CBP) [ref 15]. Due to concerns with releasing confidential business information, the *CBP* does not release exact numbers for a given NAICS code if the data can be traced to an individual business. Instead, a series of employment flags is used. To estimate employment in counties and states with withheld data, the following procedure is used for NAICS code 2362 (non-residential construction).

To gap-fill withheld state-level employment data:

1. State-level data for states with known employment are summed to the national level.
2. State-level known employment is subtracted from the national total reported in the national-level CBP.
3. Each of the withheld states is assigned the midpoint of the employment flag. Table 34-4 lists the employment flags and midpoints.
4. The midpoints for the states with withheld data are summed to the national level.
5. An adjustment factor is created by dividing the number of withheld employees (calculated in step 2 of this section) by the sum of the midpoints (step 4)
6. For the states with withheld employment data, the midpoint of the range for that state (step 3) is multiplied by the adjustment factor (step 5) to calculate the adjusted state-level employment for non-residential construction.

These same steps are then followed to fill in withheld data in the county-level business patterns.

1. County-level data for counties with known employment are summed by state.
2. County-level known employment is subtracted from the state total reported in state-level CBP (or, if the state-level data are withheld, from the state total estimated using the procedure discussed above).
3. Each of the withheld counties is assigned the midpoint of the employment flag (Table 34-4).
4. The midpoints for the counties with withheld data are summed to the state level.
5. An adjustment factor is created by dividing the number of withheld employees (step 2) by the sum of the midpoints (step 4).
6. For counties with withheld employment data, the midpoints (step 3) are multiplied by the adjustment factor (step 5) to calculate the adjusted county-level employment for non-residential construction.

Note that step 5 adjusts all counties within each state with withheld employment data by the same state-based proportion. It is unlikely that actual employment corresponds exactly with this smoothed adjustment method, but this method is the best option given the availability of the data.

Table 34-4: Ranges and midpoints for data withheld from State and County Business Patterns

Employment Flag	Employment Range	Midpoint
A	0-19	10
B	20-99	60
C	100-249	175
E	250-499	375
F	500-999	750

Employment Flag	Employment Range	Midpoint
G	1,000-2,499	1,750
H	2,500-4,999	3,750
I	5,000-9,999	7,500
J	10,000-24,999	17,500
K	25,000-49,999	37,500
L	50,000-99,999	75,000
M	100,000+	

For example, take the CBP data for NAICS 2362 (nonresidential construction) in an example state provided in Table 34-5. The values in this table are only for example purposes and are not representative of any specific NEI year or state.

Table 34-5: Example CBP vales for NAICS 2362 for a state

County FIPS	NAICS	Employment Flag	Employment
001	2362	B	withheld
003	2362		125
005	2362		166
007	2362		24
011	2362	B	withheld
012	2362	A	withheld
013	2362		8,580
015	2362		64
017	2362		53
019	2362		2,085
021	2362		115
023	2362		16
025	2362		260
027	2362		233

1. The total of employees not including withheld counties is 11,831.
2. The state-level CBP reports 11,721 employees for NAICS 2362. The difference is 110.
3. Withheld counties are given the midpoint of the employment range. County 001 is given a midpoint of 60 (since employment flag A is 20 – 99) and County 012 is given a midpoint of 10 (since employment flag H is 0 – 19).
4. State total for these all-withheld counties is 130.
5. 110/130 = 0.846.
6. The adjusted employment for county 001 is 60 × 0.846 = 51.36 employees. County 012 has an adjusted employment of 10 × 0.846 = 8.46 employees.

The county-level employment data are used to allocate the national-level non-residential construction spending data to the county-level (see equation 1).

Acres disturbed by Residential Construction – Building permits allocation

Annual county building permit data were obtained from the U.S. Census Bureau [ref 8] and used to allocate regional housing starts to the county level. This results in county level housing starts by number of units. See equations 11-13 in section 34.2.1 .

Acres Disturbed by Road Construction – Building permits allocation

State-level estimates of acres disturbed by road construction is distributed to the counties based on county-level data on residential building starts from the U.S. Census Bureau [ref 4]. See equations 19 and 20 in section 34.2.1.

34.2.3 Emission factors

Emissions factors are provided in the "Wagon Wheel Emission Factor Compendium" on the 2020 NEI Supporting Data and Summaries site. Emissions factors for CAPs and HAPs are from the AP-42 and U.S. EPA Emissions Inventory Improvement Program [ref 16, ref 17]. The PM25 to PM10 emissions factor ratio for brush burning (0.7709) is multiplied by the PM10 emissions factors for land clearing debris burning to develop PM25 emissions factors. Emission factors for NH3 were derived from the 2002 NEI crop residue emission estimates using the ratio of NH3/NOx for pasture grass from Pouliot et al. (2017) [ref 18] and the NOx emission factor from AP-42 [ref 16]. Emissions factors for HAPs are from an EPA Control Technology Center report [ref 19].

34.2.4 Controls

Controls for land clearing debris burning are generally in the form of a ban on open burning of waste in a given municipality or county. Counties that are more than 80% urban by land area determined by the 2010 U.S. Census data [ref 13], are assumed not to practice any open burning of land clearing debris. Therefore, CAP and HAP emissions from open burning of land clearing debris are zero in these counties.

Additionally, it is assumed that even in counties that are less than 80% urban by land area, open burning will only be practiced in areas that are rural. Therefore, the total land clearing debris burned per county (from equation 26) will be scaled based on the fraction of rural land area in each county from the 2010 Census.

$$BLCD_{r,c} = BLCD_c \times \frac{RLand_c}{TLand_c} \quad (27)$$

Where:

$BLCD_{r,c}$ = Land clearing debris burned in rural areas by county, *c*, in tons
$BLCD_c$ = Land clearing debris burned by county, *c*, in tons
$RLand_c$ = Amount of rural land by land area in county *c*
$TLand_c$ = Total amount of land in county *c*

Further controls on burning (i.e., burn bans in rural areas) are represented by multiplying the land clearing debris burned in rural counties by a burn ban's effectiveness; effectiveness is a value between 0 and 1.

$$BLCD_{r,c} = BLCD_{r,c} \times BE_c \quad (28)$$

Where:

$BLCD_{r,c}$ = Land clearing debris burned in rural areas by county, *c*, in tons
BE_c = Burn ban effectiveness in county *c*

In this methodology, burn ban effectiveness is represented by a single value between 0 and 1 that is multiplied by the amount of land clearing debris burned in the rural areas of each county. In practice, the burn ban effectiveness is a function of both a rule's penetration and effectiveness. Rule penetration refers to the extent to which a regulation covers emissions for a specified controlled area, and effectiveness concerns the ability of the regulatory program to achieve emissions reductions compared to full compliance. By default, the burn ban effectiveness for each county is 1 (i.e., the methodology assumes no burn bans in each county), although this may be updated by state, local, or tribal agencies.

34.2.5 Emissions

County-level criteria pollutant and HAP emissions are calculated by multiplying the mass of land clearing debris burned in rural areas per year (from equation 28) by an emissions factor.

$$E_{c,p} = BLCD_{r,c} \times EF_p \times \frac{1\ ton}{2000\ lb} \quad (29)$$

Where:

$E_{c,p}$ = Emissions by county, *c*, and pollutant, *p*, in tons
$BLCD_{r,c}$ = Land clearing debris burned in rural areas by county, *c*, in tons
EF_p = Emissions factor by pollutant, *p*, in pounds/ton

34.2.6 Example calculations

Table 34-6 shows sample calculations for PM25-PRI emissions from open burning of land clearing debris for a county in the Midwest. The values in these equations are demonstrating program logic and are not representative of any specific NEI year or county. Equations 5 through 7 use the first quarter (Q1) for 2-unit structures as an example. However, these calculations would need to be repeated to calculate values for all 4 quarters for all 3 unit sizes. Note that structures with 5 or more units and structures with 1 unit with or without a basement have additional steps not shown in the sample calculations here. Equations 15 through 20 use urban roads as an example for acres of land disturbed from road construction. For full calculations of acres of land disturbed from road construction the calculations for rural roads would also need to be incorporated.

Table 34-6: Sample calculations for PM25-PRI emissions from open burning of land clearing debris

Eq. #	Equation	Values	Result
1	$EmpFr_c = \frac{Emp_c}{Emp_{US}}$	$\frac{140\ nonres\ construction\ employees}{581{,}963\ nonres\ construction\ employees}$	0.000241 fraction on non-residential construction employees

Eq. #	Equation	Values	Result
2	$CS_c = EmpFr_c \times CS_{US}$	$0.000241 fraction\ of\ employees \times \$\ 347{,}666\ million\ in\ nonres\ construction\ spending\ in\ the\ US$	$83.79 million in non-residential construction spending
3	$Apd_{2017} = \frac{2\ acres}{\$1\ million} \times \frac{PD_{1992}}{PD_{2017}}$	$\frac{2\ acres\ disturbed}{\$1\ million} \times \frac{57\ in\ 1992}{113\ in\ NEI\ year}$	1.009 acres disturbed per million dollars spent on non-residential construction spending, nationally
4	$ANR_c = CS_c \times Apd_y$	$\$83.79\ million \times 1.009 \frac{acres\ disturbed}{million\ \$}$	84.4 acres disturbed from non-residential construction
5	$S_{Q,n} = \left(\frac{U_n}{U_t}\right) \times S_{Q,2-4}$	$\left(\frac{14\ two\ unit\ housing\ starts\ in\ 2002}{38\ total\ housing\ starts\ in\ 2002}\right) \times 2\ two\ to\ four\ unit\ housing\ starts\ in\ Q1$	0.74 thousand housing starts for 2-unit structures in Q1 2017, nationally
6	$r_{Q,n} = \frac{S_{Q,n}}{S_{Q.t}}$	$\frac{0.74\ two\ unit\ housing\ starts}{72\ two\ or\ more\ unit\ housing\ starts}$	0.01 ratio of buildings with 2 units to all units greater than 2 for Q1, nationally
7	$A_{Q,n,rgn} = r_{Q,n} \times (RS_t - RS_1)$	$0.01 \times (21\ total\ Q1\ housing\ starts\ in\ Midwest - 14\ one\ unit\ housing\ starts\ in\ Midwest$	0.07 thousand housing starts for 2-unit structures for Q1 in the Midwest
8	$CF_5 = \frac{U_{5,rgn}}{B_{5,r}}$	N/A	Equation is for 5 or more unit buildings; example is for 2-unit buildings
9	$B_{n,rgn} = \frac{(\sum A_{Q.n.rgn}) \times 1{,}000}{n}$	$\frac{0.775\ two\ unit\ structures\ \times 1{,}000}{2\ units\ per\ building}$	388 2-unit structures constructed in the Midwest

Eq. #	Equation	Values	Result
10	$B_{n,rgn} = \frac{(\sum A_{Q.n.rgn}) \times 1{,}000}{CF_5}$	N/A	Equation is for 5 or more unit buildings; example is for 2-unit buildings
11	$BP_{n,rgn} = \sum BP_{n,c}$	$\sum Midwest\ two\ unit\ building\ permits$	1,571 2-unit structure building permits in the Midwest
12	$R_{BP,c} = \frac{BP_{n,c}}{BP_{n,rgn}}$	$\frac{1\ County\ building\ permits}{1{,}571\ Midwest\ building\ permits}$	0.000637 ratio of county-level building permits to regional-level building permits
13	$B_{n,c} = B_{n,rgn} \times R_{BP,c}$	$388\ two\ unit\ building\ starts\ in\ the\ Midwest \times 0.000637$	0.25 total 2-unit structure building starts
14	$AR_{n,c} = B_{n.c} \times a_n$	$0.25\ two\ unit\ structures \times 0.33\ acres\ per\ structure$	0.08 acres surface soil disturbed by 2-unit structures
15	$HS_{s,r} = \sum_{ct} S_{s,r}$	$\$20{,}399{,}000 + \$33{,}029{,}000 + \$93{,}892{,}000$	\$147,320,000 spent on urban interstate construction in the state
		$\$58{,}519{,}000 + \$2{,}626{,}000 + \$35{,}1367{,}000 + \$206{,}057{,}000 + \$17{,}193{,}000$	\$319,532,000 spent on urban other arterial construction in the state
		$\$16{,}093{,}000 + \$338{,}000 + \$355{,}000$	\$16,786,000 spend on urban collector construction in the state
16	$RC_{m,s,r} = \frac{HS_{s,r}}{TDM}$	$\frac{\$147{,}320{,}000}{6{,}895{,}000\ \$\ per\ mile}$	21.4 miles of urban interstate constructed in the state

Eq. #	Equation	Values	Result
		$\frac{\$319{,}532{,}000}{4{,}112{,}000\ \$\ per\ mile}$	77.7 miles of urban other arterial constructed in the state
		$\frac{\$16{,}786{,}000}{4{,}112{,}000\ \$\ per\ mile}$	4.1 miles of urban collector constructed in the state
17	$RC_{a,s,r} = RC_{m,s,r} \times ADM$	$21.4\ miles \times 11.4\ acres\ per\ mile$	242.9 acres disturbed from urban interstate construction in the state
		$77.7\ miles \times 7.6\ acres\ per\ mile$	589.6 acres disturbed from urban other arterial construction in the state
		$4.1\ miles \times 7.6\ acres\ per\ mile$	31 acres disturbed from urban collector construction in the state
18	$ARC_s = \sum_r RC_{a,s}$	$242.9\ acres + 589.6\ acres + 31\ acres$	863.5 acres disturbed from urban road construction in the state
19	$BFrac_c = \frac{Build_c}{Build_s}$	$\frac{246\ building\ starts\ in\ County}{20{,}578\ building\ starts\ in\ State}$	0.012 fraction of building starts
20	$ARC_c = ARC_s \times BFrac_c$	$863.5\ acres \times 0.012$	10.4 acres disturbed from urban road construction

Eq. #	Equation	Values	Result
21	$TAD_c = ANR_c + (\sum S_{n.c}) + ARC_c$	$84.4\ acres + 62.02^{*}\ acres + 13.95^{**}\ acres$ * note that the value for residential construction is for all unit types, not just 2-unit buildings as shown in example above ** note the value for road construction is for all road types, not just urban roads as shown in the example above	160.4 total acres disturbed
22	$A_{AK/HI,c,f} = LA_{AK/HI,c} \times LC_{AK/HI,\%,f}$	N/A	Equation is for Alaska or Hawaii
23	$WFLF_{c,f} = \frac{A_{c,f}}{A_{total}} \times LF_f$	$\frac{17{,}516\ acres}{758{,}793\ acres} \times 99\ tons\ per\ acre$	2.3 tons/ acre weighted factor for hardwood fuel
		$\frac{0\ acres}{758{,}793\ acres} \times 57\ tons\ per\ acre$	0.0 tons/ acre weighted factor for softwood fuel
		$\frac{741{,}276\ acres}{758{,}793\ acres} \times 4.5\ tons\ per\ acre$	4.4 tons/ acre weighted factor for grass fuel
24	$WFLF_c = \sum WFLF_{c,f}$	$2.3\frac{tons}{acre} + 0.0\frac{tons}{acre} + 4.4\frac{tons}{acre}$	6.7 tons/acre weighted factor for all fuels
25	$LCD_c = TAD_c \times WFLF_c$	$160.4\ acres \times 6.7\frac{tons}{acre}$	1,071 tons of land clearing debris
26	$BLCD_c = LCD_c \times CF_c$	$1{,}071\ tons \times 1\ control\ factor$	1,071 tons of land clearing debris burned
27	$BLCD_{r,c} = BLCD_c \times \frac{RLand_c}{TLand_c}$	$1{,}071\ tons \times \frac{2{,}923{,}414{,}473\ m^2\ rural\ land}{3{,}064{,}933{,}852\ m^2\ total\ land}$	1,022 tons of land clearing debris burned in rural areas
28	$E_{c,p} = BLCD_{r,c} \times EF_p \times \frac{1\ ton}{2000\ lb}$	$1{,}022\ tons \times 13.1053\frac{lb}{ton} \times \frac{1\ ton}{2000\ lb}$	6.7 tons PM25-PRI emissions

34.2.7 Improvements/Changes in the 2020 NEI

For the 2020 NEI, ammonia emissions factors were developed so that ammonia emissions are estimated for land clearing debris. The ammonia emissions factors are developed by applying the ratio of NH3 to NOx emissions from pasture grass, using emissions data from Table 1 in Pouliot et al. (2011) [ref 18] to the NOx emissions factor used for these sources, from AP-42 [ref 16].

For prior inventory years, the U.S. Census Bureau denoted counties for which County Business Patterns (CBP) data was withheld and reported an employment size range. A gap-filling procedure was implemented using state-level data, which was used to estimate the number of employees not reported in the county-level dataset. An average value for number of employees for each employment size range was used to allocate the difference to the counties with withheld data. Beginning in reference year 2018, data are still only published for a county and NAICS code if there are three or more establishments. However, the CBP data no longer includes an employment size range for counties in which data is withheld for a NAICS code. For the 2020 NEI, the gap-filling method was updated. 2020 employment data from the CBP dataset is used to determine the total amount of withheld data in each state. The 2017 version of the CBP is then used to determine the counties for which data is withheld and the employment size range in those counties. The difference between the state-level total employment and the county-level total employment is allocated to the counties identified using 2017 CBP.

34.2.8 Puerto Rico and U.S. Virgin Islands

Since insufficient data exist 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 emissions factor. For each Puerto Rico and US Virgin Island County, the tons per capita emissions 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".

34.2.9 References

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