Open Burning and Construction Activities: Improved PM Fine Emission Estimation Techniques in the National Emissions Inventory

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ABSTRACT

This paper discusses improved PM fine emission estimation techniques for open burning and construction. These estimates for PM fine, as well as other criteria and hazardous air pollutants, will be incorporated into the EPA's National Emissions Inventory (NEI). Open burning categories include household waste, yard waste, land clearing for construction, and the burning of logging waste (slash burning). Construction activities include residential, nonresidential, and highway construction.

For many of the open burning categories, current year estimates in the NEI are grown from 1985 National Acid Precipitation Assessment Program (NAPAP) estimates, unless States supplied their own data. Some of the open burning source categories were not accounted for at all (e.g., burning debris from land clearing for construction, burning residential yard waste). Source Classification Codes (SCC) have already been assigned for some types of open burning, and additional SCCs were developed for new open burning categories.

For construction, improvements are made in the activity and a differentiation is made for different construction types. Previously, a single estimate was made for all different types of construction, and recent year emission estimates have been grown from previous years. The new method breaks out construction activities into 3 categories: residential, nonresidential, and highway.

The improved emission estimation techniques described in this paper are "top-down" techniques. This will allow the EPA to allocate open burning estimates down to the county level for the entire United States. Each State can replace the EPA-provided data with their own.

INTRODUCTION

This paper describes the top-down methodologies used to develop updated county-level emission estimates for open burning and construction categories for EPA's National Emissions Inventory (NEI). A top-down method uses national and state data to estimate activity data that are allocated to counties using surrogate indicators (e.g., population, employment). County-level activity estimates are then multiplied by average emission factors.

Open burning contributes to particulate matter (PM), volatile organic compounds (VOC), nitrogen oxides (NO_x), carbon monoxide (CO), and sulfur dioxide (SO_2), as well as hazardous air pollutant (HAP) emissions. Generally, emissions from open burning are estimated by applying emission factors (e.g., pounds pollutant per ton refuse or fuel) to activity data (e.g., tons of waste burned). Emission factors for open burning depend on the type of waste, the type of fire, and the fuel loading. In preparing past emission inventories, one of the particular difficulties with this source category has been the frequent lack of activity information.

Construction activities contribute to fugitive PM_{10} and $PM_{2.5}$ emissions. Construction emissions are estimated using two basic construction parameters, the acres of land disturbed by the construction activity and the duration of the activity. The number of acres disturbed by construction activities is generally not available. As such, this value is typically estimated using surrogate data, which is then

converted to acres using an appropriate conversion factor. The activity data are then multiplied by an average area-based PM_{10} emission factor.

This paper is organized into three main sections. The first section addresses open burning categories, and provides a description of previous and updated emission estimation methodologies. This section is followed by a discussion of the previous and revised procedures for estimating construction emissions. For each category, comparisons are made between data for 1998 and 1999. Finally, the paper identifies limitations of the revised procedures, and discusses potential improvements in future emission estimation methods.

OPEN BURNING

Previous Methods

Open burning emissions in the NEI have been reported under the following source classification codes (SCCs), as shown in Table 1.

Table 1. Open burning emissions reported in the National Emissions Inventory.

SCC	SCC Description
2610000000[1]	Waste Disposal, Treatment, and Recovery Open Burning All Categories
2610010000	Waste Disposal, Treatment, and Recovery Open Burning Industrial
2610020000	Waste Disposal, Treatment, and Recovery Open Burning Commercial/Institutional
2610030000	Waste Disposal, Treatment, and Recovery Open Burning Residential
2810015000	Miscellaneous Area Sources Other Combustion Prescribed Burning for Forest Management
2810005000[1]	Miscellaneous Area Sources Other Combustion Managed Burning, Slash (Logging Debris)

[1]Emissions for these SCCs were only incorporated into the NEI if provided by States.

Current year estimates for the SCCs 2610010000, 2610020000, 2610030000 were grown from 1985 NAPAP estimates, unless States supplied their own data as part of the 1990 Ozone Transport Assessment Group (OTAG) effort, or more recently under the 1996 Periodic Emissions Inventory (PEI). Emission estimates for open burning, all categories (SCC 2610000000) and slash burning (SCC 281000500) were only added to the inventory if provided by States. In addition, EPA has recommended that slash burning emissions be reported under the SCC corresponding to prescribed burning, so State-supplied emission estimates for prescribed burning may include slash burning. However, several States have submitted emissions for slash burning under the SCC 2810005000.

Revised Methods

Emission estimates for open burning categories were updated for 1999 by obtaining more recent activity data, applying updated emission factors and making further adjustments based on expected open burning practices. The open burning categories for which updated emission estimates were developed are included in Table 2.

Household waste, often referred to as residential municipal solid waste (MSW), is a term for nonhazardous refuse produced by households (e.g., paper, plastics, metals, wood, glass, rubber, leather, textiles, and food wastes). Residential yard waste refers to materials such as leaves, trimmings from trees and shrubs, and grass. Land clearing debris refers to the clearing of land for new construction and the burning of organic material (i.e., trees, shrubs and other vegetation). The SCCs for residential brush burning and land clearing debris burning are new SCCs.

Table 2. Open burning SCCs with updated 1999 emissions.

SCC	SCC Name
2610030000	Waste Disposal, Treatment, and Recovery Open Burning Residential
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
2610000500	Waste Disposal, Treatment, and Recovery Open Burning All Categories Land Clearing Debris

Timber harvesting results in slash (limbs, tops, and unsaleable material that is left on site). Slash burning is a practice used to prepare the soil for the planting of a new stand of timber. Potential top-down emission estimation methods for slash burning were examined, but as explained below, updated estimates for slash burning were not developed.

Residential MSW Burning

Activity data for residential MSW burning (i.e., the amount of waste open burned) can be estimated from the total amount of waste generated. The amount of waste generated for each county in the United States is estimated using a national average per capita waste generation factor, as reported in *Characterization of Municipal Solid Waste in the United States: 1998 Update*.[1] To better reflect the actual amount of household residential waste subject to being burned, non-combustibles (glass and metals) are subtracted out. In addition, since yard waste is considered a separate open burning category, yard waste was subtracted out as well. The latest available per capita waste generation factor was for 1997, and is reported to be 3.28 lbs/person/day. This factor is then applied to the portion of the county's total population that is considered rural based on 1990 Census data on rural and urban population, since open burning is generally not practiced in urban areas.

The percentage of total waste generated that is burned is estimated from survey data as reported in *Emission Characteristics of Burn Barrels*.[2] This study estimated that for rural populations, 25 to 32 percent of the municipal waste generated is burned. A median value of 28 percent is assumed for the nation, and this correction factor is applied to the total amount of waste generated.

Controls (or burning bans) were accounted for by assuming that no burning takes place in counties where the urban population exceeds 80 percent of the total population (i.e., urban plus rural). Zero open burning emissions were attributed to these counties.

The equation for estimating emissions from residential MSW burning is:

$$Ecty = (Pcty \times Rfrac) \times W \times Bfrac \times (EF) \quad (1)$$

where

Ecty = county-level emissions, lbs per year
Pcty = total population in county
Rfrac = fraction of county population that is rural
W = per capita waste generation, 0.60 tons/person/year (converted from 3.28 lbs/person/day)
Bfrac = fraction of waste generated that is burned, 0.28
EF = 38 lbs PM_{10}/ton waste burned, 34.8 lbs $PM_{2.5}$/ton waste burned

PM emissions factors for residential MSW were obtained from a report entitled, *Evaluation of Emissions from the Open Burning of Household Waste in Barrels*.[3]

Residential Yard Waste Burning

Similar to residential MSW, a national per capita waste generation value was used as the basis for yard waste emissions for 1999. EPA reports an average daily generation rate of 0.57 lbs yard waste/person/day.[1] 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. It was determined that open burning of grass clippings is not typically practiced by homeowners, and as such only estimates for leaf burning and brush burning were developed. Emissions for leaves and residential brush were calculated separately, since emission factors vary by yard waste type. It was assumed that 28 percent of the total yard waste generated is burned and that burning occurs primarily in rural areas, similar to the assumptions used for residential MSW burning.

To adjust for variations in vegetation, we obtained data on the percentage of forested acres from Version 3.1 of the Biogenic Emissions Landcover Database (BELD3) within EPA's Biogenic Emission Inventory System (BEIS). This data base contains the number of acres of rural forest, urban forest, agricultural land, and miscellaneous vegetation per county. For each county, the percentage of forested acres per county was calculated (including rural forest and urban forest). To better account for the native vegetation that would likely be occurring in the residential yards of farming States, we subtracted out the agricultural lands before calculating the percentage of forested acres. Table 3 shows the ranges used to make adjustments to the amount of yard waste that is assumed to be generated per county.

Table 3. Adjustments made to county-level yard waste generation.

Percent forested acres per county	Adjustment for yard waste generated
< 10%	Zero out
>=10%, and <50%	Multiply by 50%
>=50%	Assume 100%

The equation for estimating emissions from residential MSW burning is:

$$Ecty = (Pcty \times Rfrac) \times (YW \times YWfrac) \times CF \times Bfrac \times EF \quad (2)$$

where

Ecty = county-level emissions, lbs per year
Pcty = total population in county
Rfrac = fraction of population that is rural
YW = per capita yard waste generation, 0.10 tons/person/year (converted from 0.57 lbs/person/day)
YWfrac = fraction of yard waste components (0.25 for leaves, 0.25 for brush, 0.5 for grass)
CF = correction factor to adjust yard waste estimates (see Table 3)
Bfrac = fraction of waste generated that is burned, 0.28
EF = 17 lbs PM_{10}/ton brush burned, or 38 lbs PM_{10}/ton leaves burned

PM emission factors for brush burning and leaf burning are obtained from Tables 2.5-5 and Table 2.5-6, respectively, from EPA's AP-42.[4] $PM_{2.5}$ emission factors are equivalent to PM_{10} emission factors.

Land Clearing Debris Burning

Emissions for this category are based on an estimate of the acres cleared, multiplied by a fuel loading factor, and multiplied by an emission factor. National data on the number of acres cleared for all States are not available from any known data sources. As such, a value for the acres disturbed by construction activity is estimated using surrogate data, which is then converted to acres using an appropriate conversion factor.[5] Three general types of construction are accounted for to estimate land clearing activity: 1) residential construction; 2) nonresidential construction; and 3) roadway construction. This approach assumes that all land clearing debris that is cleared is then burned.

The formula for calculating the county-level emissions from land clearing debris is:

$$Emissions = Acres \times LF \times EF \quad (3)$$

where

Acres = total acres disturbed by construction
LF = weighted loading factor to convert acres to tons of available fuel
EF = 17 lbs PM_{10}/ton of fuel

The procedures used to estimate the activity for land clearing debris (i.e., total acres disturbed) are based on the activity data methods described later in this paper under "Construction, Revised Methods." After the number of acres disturbed per county was estimated for each construction type, these values were added together to obtain a county-level estimate of total acres disturbed by land clearing.

National average fuel loading factors, as presented in Table 4, are applied to the number of acres cleared.[6] The fuel loading for softwoods represents the average values reported for long-needle pine slash (21 tons/acre) and mixed conifer slash (54 tons/acre). The fuel loading at any given location will vary depending on the predominant vegetation in the area being cleared. Ideally, one would account for where within the county the land clearing is actually occurring, and what type of vegetation is being cleared. In the absence of these data, we used the BELD3 data base in BEIS to determine the number of acres of hardwoods, softwoods, and grasses in each county. Average loading factors are weighted according to the percent contribution of each type of vegetation class to the total land area for each county. Using engineering judgement, the loading factors for slash hardwood and slash softwood were further adjusted by a factor of 1.5 to account for the mass of tree that is below the soil surface that would also be subject to burning once the land is cleared. $PM_{2.5}$ emission factors are equivalent to PM_{10} emission factors, and were obtained from the same report as the loading factors.[6]

Table 4. Loading factors for land clearing debris burning.

Fuel type	Fuel loading (tons/acre)[1]
Hardwood	99
Softwood	57
Grass	4.5

[1]Original values for hardwood and softwood slash were adjusted by a factor of 1.5 to account for the mass of tree below the soil surface.

Slash Burning

Slash burning is generally estimated by accounting for the number of acres that are slash burned, applying a fuel loading factor that best represents the weight of consumable fuel per acre, and multiplying by an average emission factor. Several States have reported emissions in the NEI for slash burning under 2810005000. These States include: Alabama, Arizona, Florida, Georgia, Maine, Maryland, North Carolina, Texas, and Virginia.

No reliable source of national data were identified for estimating the number of acres slash burned. In addition, state-level acres of land logged or harvested were not available for all United States Forest Service (USFS) regions. These data could potentially be used as the basis to estimate the number of acres subject to slash burning. Based on available data, it was recommended to use State-supplied data on slash burning, without further development of default emission estimates. States are typically able to obtain more reliable estimates of the number of acres burned (e.g., from a State or local forest service, or agricultural extension), as well as temporal information on the burns to determine whether the emissions source would be included in a seasonal inventory.

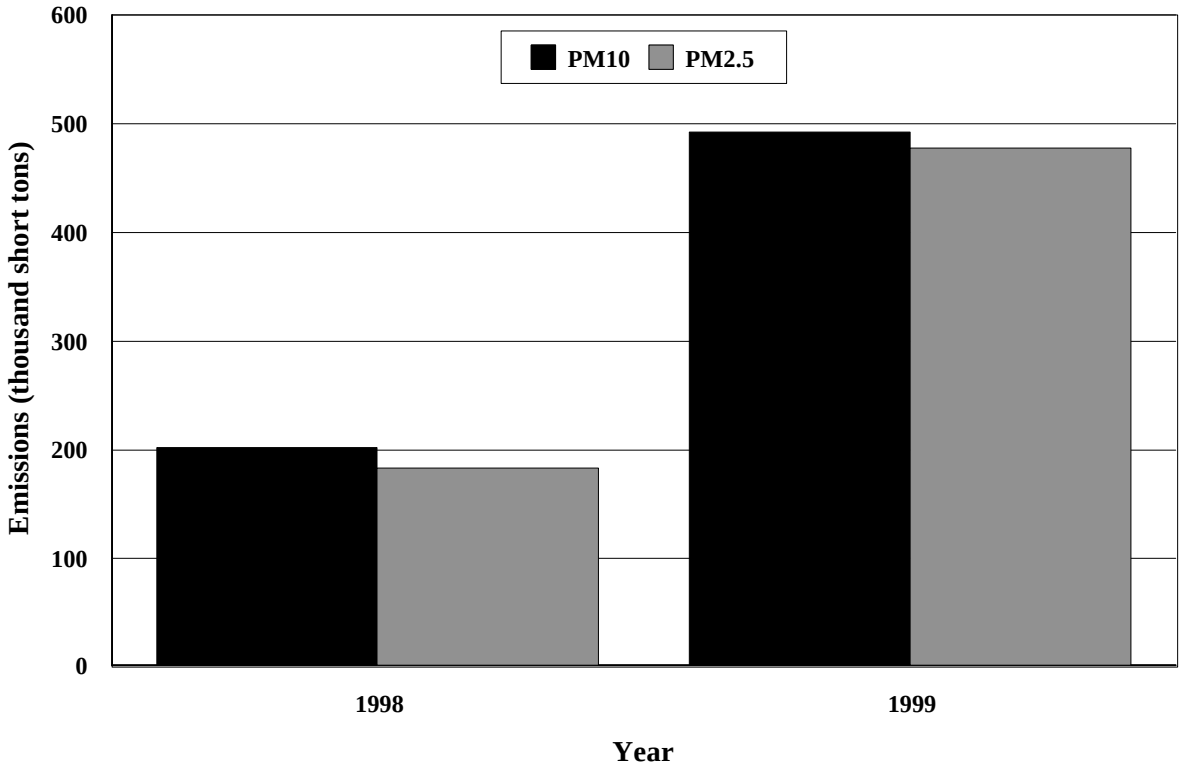
Summary of Emissions Data

Table 5 presents 1998 and 1999 emission estimates by category for PM_{10} and $PM_{2.5}$ in Version 4 of the NEI. Figure 1 shows 1998 and 1999 PM emissions for all categories combined. Emissions for household waste were reported in previous versions of the NEI, and those estimates are provided for 1998 and 1999. Some States supplied estimates for open burning under SCC 2610000000 (Open burning, all categories). In the 1999 NET, this SCC was removed to avoid double-counting of emissions. Emissions for yard waste burning and land clearing debris burning have not been reported in the NEI prior to 1999. The increase in open burning PM emissions from 1998 to 1999 is largely due to the addition of the land clearing debris burning category to the inventory.

Table 5. National open burning emission estimates for PM_{10} and $PM_{2.5}$, short tons per year.

	PM_{10}		**$PM_{2.5}$**	
Category Name	**1998**	**1999**	**1998**	**1999**
All categories	2,777	0	1,900	0
Residential MSW	196,806	188,454	178,787	172,584
Residential leaves	0	6,654	0	6,654
Residential brush	0	2,977	0	2,977
Land clearing debris	0	293,218	0	293,218
Slash burning	2,748	2,748	2,498	2,498
Total	**202,330**	**494,052**	**183,184**	**477,932**

Figure 1. National PM open burning emission estimates for 1998 and 1999.



CONSTRUCTION

Previous Methods

Historically, construction emissions in the NEI have not been reported according to the different types of construction, but have been added together and reported under the SCC 23110001000 (Industrial Processes, Construction: Standard Industrial Classification (SIC) codes 15-17, All Processes, Wind Erosion). As part of the PEI submittal for 1996, some States supplied emissions for more specific construction SCCs.

For the NEI, PM emissions for the years 1990 through 1995 are calculated from an estimate of the acres of land under construction, the average duration of construction activity, and an emission factor. The acres of land under construction are estimated from the dollars spent on construction for each EPA Region. The PM_{10} emission factor used for the years 1990 through 1995 for construction activities is obtained from the report, *Improvement of Specific Emission Factors*.[7] This study reports an emission factor of 0.11 ton PM_{10}/acre-month. The $PM_{2.5}$ emission factor used for the years 1990-1995 is the PM_{10} emission factor multiplied by a particle size adjustment factor of 0.2.

Starting in 1995, a control efficiency is applied to emissions for counties classified as PM nonattainment areas. The PM_{10} control efficiency used for 1995 through 1998 for PM nonattainment areas is 62.5. The $PM_{2.5}$ control efficiency for these years and areas is 37.5. Regional-level PM_{10} estimates are distributed to the county-level using county estimates of payroll for construction (SICs 15, 16, 17) from *County Business Patterns*.[8]

To estimate 1996, 1997, and 1998 emissions, EPA estimated emissions using the ratio between the state-level number of residential construction permits issued for each of these 3 years, and the number

issued in 1995.[9] Growth factors calculated from these ratios are then applied to the 1995 emissions to estimate county-level emissions for the years 1996, 1997, and 1998.

For additional details on the methods used for estimating construction emissions for years prior to 1999, the reader is referred to, *National Air Pollutant Emission Trends, Procedures Document*.[10]

Revised Methods

Three general types of construction were accounted for to estimate 1999 total construction emissions for the NEI including residential, nonresidential and roadway construction. These emissions are reported under the SCCs listed in Table 6.

Table 6. Construction SCCs with updated 1999 emissions.

Construction Category	SCC	SCC Description
Residential	2311010000	Industrial Processes Construction: Standard Industrial Classification (SIC) codes 15-17 General Building Construction Total
Nonresidential	2311020000	Industrial Processes Construction: SIC codes 15-17 Heavy Construction Total
Roadway	2311030000	Industrial Processes Construction: SIC codes 15-17 Road Construction Total

Construction emissions are estimated using two basic activity parameters, the acres of land disturbed by the construction activity and the duration of the activity. The actual acres disturbed by the various types of construction are generally not available. As such, this value is typically estimated using surrogate data, which is then converted to acres using an appropriate conversion factor. The methodology is based upon procedures documented in the EPA report, *Estimating Particulate Matter Emissions from Construction Operations* with some adjustments.[5]

Residential Construction

For residential construction, housing permit data for single-family units, two-family units, and apartments are obtained at the county level from the U.S. Department of Commerce's (DOC) Bureau of the Census.[11] County permit data are adjusted to equal regional housing start data, which would more accurately reflect actual construction, also available from the Bureau of the Census.[12] Once the number of buildings in each category is estimated, the total acres disturbed by construction is estimated by applying conversion factors to the housing start data for each category as follows:

- Single family - 1/4 acre/building
- Two-family - 1/3 acre/building
- Apartment - 1/2 acre/building

Housing construction emissions are calculated using an emission factor of 0.032 tons PM_{10}/acre/month, the number of housing units created, a units-to-acres conversion factor, and the duration of construction activity. The duration of construction activity for houses is assumed to be 6 months. The formula for calculating emissions from residential construction is:

$$Emissions = (0.032\ tons\ PM_{10}/acre/month)\ x\ B\ x\ f\ x\ m \quad (4)$$

where

B = the number of single or two-family houses constructed
f = buildings-to-acres conversion factor
m = the duration of construction activity in months

Apartment construction emissions are calculated separately using an emission factor of 0.11 tons PM_{10}/acre/month. A duration of 12 months is assumed for apartment construction.

Residential Construction with Basements

For estimating emissions from residential construction with basements, an alternative formula is used. A value of 2000 square feet is assumed to be the average area for both single-family and two-family homes, and is used to estimate the amount of dirt moved per house. To estimate the cubic yards of earth moved during residential construction, one first multiplies the average total square feet by an average basement depth of 8 feet, and then adds in 10 percent of the cubic feet calculated for peripheral dirt removed. The added 10 percent accounts for the footings, space around the footings, and other backfilled areas adjacent to the basement.

Four activity data variables are needed for using the emission factor equation for houses with basements, including: 1) the number of houses built with basements; 2) the number of acres disturbed due to the estimated number of houses built with basements; 3) the duration of construction; and 4) the cubic yards of earth moved per house. To estimate the number of houses built with basements, the percentage of one-family houses with basements is obtained from the DOC report, *Characteristics of New Houses*.[13] The percentage of houses per Census region (Northeast, Midwest, South, and West) that contain full or partial basements is applied to the housing start estimates for each of these respective regions.

The formula for calculating emissions from residential construction with basements is:

$$Emissions = (0.011\ tons\ PM_{10}/acre/month)\ x\ B\ x\ f\ x\ m\ +\ (0.059\ tons\ PM_{10}/1000\ cubic\ yards\ dirt\ moved)\ x\ B\ x\ d \quad (5)$$

where

B = the number of single or two-family houses constructed with basements
f = buildings-to-acres conversion factor
m = the duration of construction activity in months
d = cubic yards of dirt moved per house, assumed to be 652 cubic yards

Nonresidential Construction

Nonresidential construction represents building construction, including commercial, institutional, industrial, government, and also public works. The emissions due to the construction of nonresidential buildings is calculated using the value of construction put in place. The national value of construction put in place is obtained from the Bureau of the Census,[14] and is allocated to counties using construction employment data for SIC 154.[15] A conversion factor of 1.6 acres/10^6 dollars ($) is applied to the construction valuation data. This conversion factor is developed by adjusting the 1992 value of 2 acres/ 10^6 to 1999 constant dollars using the Price and Cost Indices for Construction.

The duration of construction activity for nonresidential construction is estimated to be 11 months. The formula for calculating the emissions from nonresidential construction is:

$$Emissions = (0.19\ tons\ PM_{10}/acre/month)\ x\ \$\ x\ f\ x\ m \quad (6)$$

where

$ = dollars spent on nonresidential construction in millions
f = dollars-to-acres conversion factor
m = duration of construction activity in months

Road Construction

The emissions produced by road construction are estimated using an emission factor for heavy construction and the State capital outlay for new road construction. To estimate the acres disturbed by road construction, FHWA State expenditure data for capital outlay was obtained for the following six classifications:[16]

- Interstate, urban;
- Interstate, rural;
- Other arterial, urban;
- Other arterial, rural;
- Collectors, urban; and
- Collectors, rural

The North Carolina Department of Transportation (NCDOT) provided data on the $/mile spent on various road construction projects.[17] For interstate expenditures, an average of $4 million/mile is assumed for freeways and interstate projects including: 1) new location; 2) widen existing 2-lane shoulder section; and 3) widen existing 4-lane w/ median. For expenditures on other arterial and collectors, an average of $1.9 million/mile is assumed for all projects except freeways and interstate projects, including: 1) new location; 2) widen existing 2-lane shoulder section; and 3) widen existing 4-lane w/ median. After new miles of road constructed are estimated using the above $/mile conversions, miles are converted to acres for each of the 6 road types using the following estimates of acres disturbed per mile:

- Interstate, urban and rural; Other arterial, urban - 15.2 acres/mile
- Other arterial, rural - 12.7 acres/mile
- Collectors, urban - 9.8 acres/mile
- Collectors, rural - 7.9 acres/mile

State-level estimates of acres disturbed are distributed to counties according to the housing starts per county (similar to residential construction).

An emission factor of 0.42 tons/acre/month is used to account for the large amount of dirt moved during the construction of roadways. Since most road construction consists of grading and leveling the land, the higher emission factor more accurately reflects the high level of cut and fill activity that occurs at road construction sites. The duration of construction activity for road construction is estimated to be 12 months. The formula for calculating roadway construction emissions is:

$$Emissions = (0.42\ tons\ PM_{10}/acre/month)\ x\ \$\ x\ f1\ x\ f2\ x\ m \quad (7)$$

where

$ = State expenditures for capital outlay on road construction
f1 = $-to-miles conversion factor
f2 = miles-to-acres conversion factor
m = duration of roadway construction activity in months

Construction Correction Parameters

After emissions are calculated as described above, regional variances in construction activity are accounted for by using correction parameters including soil moisture, silt content, and control efficiency. The recommended emission factors are representative of uncontrolled emissions.

To account for the soil moisture level, the following equation is used:

$$\textit{Moisture Level Corrected Emissions} = \textit{Base Emissions} \times (24/PE) \quad (8)$$

where

PE = Precipitation-Evaporation value for county

Precipitation-Evaporation (PE) values are obtained from Thornethwaite's PE Index. We determined the average Thornethwaite PE value for each State based on a map presenting PE values for specific climatic divisions within a State.[5] Alaska and Hawaii were assigned default average PE values by examining rainfall data, and using PE values from those States whose 30-year average rainfall was most comparable to Alaska and Hawaii.

To account for the silt content, the following equation is used:

$$\textit{Silt Content Corrected Emissions} = \textit{Base Emissions} \times (s/9\%) \quad (9)$$

where

s = % dry silt content in soil for area being inventoried

County-level dry silt values are applied to PM_{10} emissions for each county. Soil types were assigned to all counties of the continental United States by comparing the USDA[18] surface soil map with a U.S. county map. Silt percentages are determined by using a soil texture classification triangle.[19] These silt factors, which represent wet silt values, are then corrected to dry silt values using information from *Spatial Distribution of PM_{10} Emissions from Agricultural Tilling in the San Joaquin Valley*.[20]

In reviewing EPA's Green Book,[21] controls were applied to PM emissions in additional nonattainment counties in Arizona, Colorado, and Oregon that were assumed to be uncontrolled in previous version of the NEI. For 1999 construction emissions, a control efficiency of 50 percent is used to represent best available control measures (BACM) for both PM_{10} and $PM_{2.5}$ for PM nonattainment areas.

The emission factors presented for all construction categories are for calculating PM_{10} emissions. Once PM_{10} estimates are developed, $PM_{2.5}$ emissions are estimated by applying a particle size multiplier of 0.20 to PM_{10} emissions.

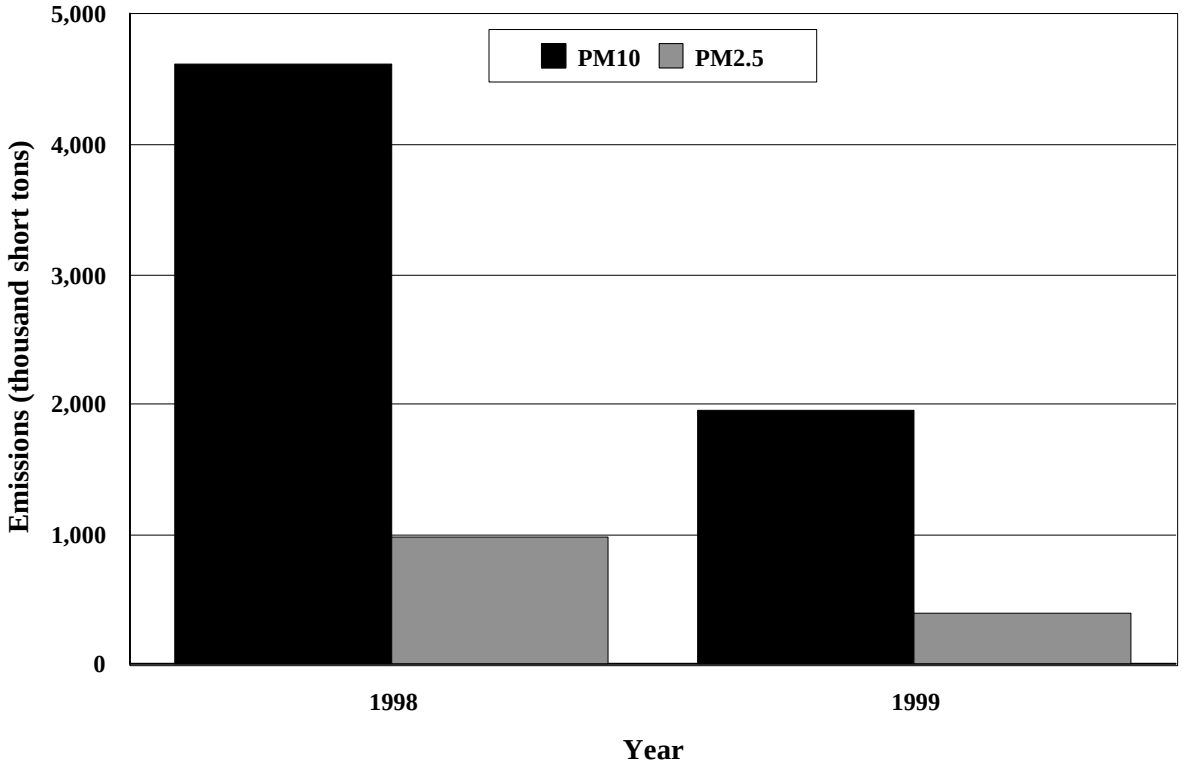
Summary of Emissions Data

Table 7 presents 1998 and 1999 national construction emission estimates by category for PM_{10} and $PM_{2.5}$ in Version 4 of the NEI. Figure 2 shows 1998 and 1999 emissions for all categories combined. Between 1998 and 1999, total PM emissions due to construction decrease by approximately 60 percent. The new method includes adjustments for variables such as soil silt content and moisture content that may be causing this decrease. However, the contribution of emissions from the road construction category may also be underestimated since the FHWA expenditure data used to estimate the number of acres disturbed do not account for housing development roads paid for and maintained by private contractors. This is identified as a potential improvement in the "Conclusions" section.

Table 7. National PM construction emission estimates, short tons per year.

	PM_{10}		$PM_{2.5}$	
Construction Type	**1998**	**1999**	**1998**	**1999**
Residential	34,183	310,354	6,837	62,070
Nonresidential	5,682	707,214	1,136	141,439
Roadway	40,053	938,094	8,011	187,615
Wind erosion, all	4,545,250	0	968,255	0
Total	**4,625,168**	**1,955,662**	**984,239**	**391,124**

Figure 2. National PM construction emission estimates for 1998 and 1999.



CONCLUSIONS

Further Improvements

With the NEI, EPA endeavors to provide reasonable and representative default estimates for area source categories, including open burning and construction. The top-down methods employed present limitations because national data is used that may not truly reflect the actual activity for a specific State or county. As such, EPA encourages States to develop their own estimates for these categories for incorporation into the NEI. In this manner, activity data based on State or local data sources form the basis of the estimates, and area-specific or seasonal controls (e.g., open burning bans or restrictions) can be more accurately accounted for.

For developing default estimates for slash burning in the future, contacts at the USFS have indicated that reporting standards are currently being implemented to ensure consistency in future data

collection and reporting procedures among USFS Regions. This may result in a consistent source of data for statistics such as acres logged per State, which could form the basis of estimates of the number of acres slash burned. Per EPA's recommendation, some States may be combining emissions for slash burning with prescribed burning emissions. It is possible that other States calculate and report slash burning separately from prescribed burning, and will report these categories separately for future inventories.

For each construction category, the number of acres disturbed by construction activity is estimated using surrogate data. Activity data representing the actual number of acres disturbed would result in improved emission estimates. Additional improvements to the top-down method for construction include:

- For road construction, obtaining data on the actual number of road miles constructed. The current method relies on expenditure data, which are then converted to road miles using assumptions on the dollars spent per mile of road constructed. Although the conversions do account for two different classes of road, this value can vary widely depending on the nature of the construction project and location of the project (e.g., in a rural versus urban area).
- Only expenditures for State or federal maintained roads are reflected in the FHWA expenditure data. As such, the method does not account for roads built to serve new housing developments and subdivisions that may be paid for by private contractors.
- Calculating and applying PE correction values for soil moisture content at the county level. The current revised method applies PE values at an average state-level.
- The area-based PM_{10} emission factors for construction include PM emissions due to nonroad exhaust, as well as fugitive PM. EPA's draft NONROAD model allows a user to estimate PM_{10} and $PM_{2.5}$ emissions from nonroad construction equipment. Nonroad exhaust emissions may be double counted in the inventory, so this issue needs to be examined further.

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KEY WORDS

PM
Emission Inventories
Area Sources