Preparation of a Base-Year Inventory for Application to Regional Haze in the West

Lee Gribovicz
Wyoming Department of Environmental Quality
Air Quality Division
250 Lincoln Street
Lander, Wyoming 82520
LGRIBO@state.wy.us

Dennis Schwehr
PO Box 2166
Thompson Falls, MT 59873
denniss@simginc.com

Bobby Ramirez
Air Quality Engineer
Salt River Pima_Maricopa Indian Community
10,005 E. Osborn Road
Scottsdale, AZ 85256
bob.ramirez@saltriver.pima-maricopa.nsn.us

Mark Saeger
Pacific Environmental Services, Inc.
5001 S. Miami Boulevard
Research Triangle Park, NC 27709-2077
mlsaeger@mactec.com

William R. Barnard
Harding ESE, Inc.
P.O. Box 1703
Gainesville, FL 32602-1703
Wrbarnard@mactec.com

ABSTRACT

The Emissions Forum of the Western Regional Air Partnership (WRAP) lead an effort to prepare an inventory of point and area sources of haze producing pollutants representing the 1996 base-year. The objective of this inventory development effort was to update the existing 1996 National Emissions Inventory (NEI) with inventory data prepared by state, tribal, and local agencies. The data representing local conditions is considered to be more accurate, in terms of both emissions magnitude and physical characteristics such as location and throughput, than the estimates prepared at the national level. Other entities of the WRAP organization were charged with preparation of updated emissions estimates for mobile sources, dust generated by highway mobile sources, fugitive dust from undisturbed soils, managed burning activities and wildfires.

The inventory covered the western continental United States and included the 22 states west of the eastern border of the line of state from Minnesota through Louisiana. A preliminary estimate for emissions from some sources was included for the north western portions of Mexico. At the completion of the project local data for point sources was included for 17 of the 22 states and local data for area sources was included for 9 of the 22 states.

The paper presents summaries of how emissions of particulate matter and the precursors to fine particulate matter changed when the local data were substituted for emissions estimates prepared at the national-level.

INTRODUCTION

Historically, state, local and tribal agencies have prepared much of the emission inventory data used in implementing state implementation plans and tribal implementation plans (SIP/TIP) to comply with National Ambient Air Quality Standards (NAAQS). SIP/TIP plans for NAAQS have addressed air quality management planning in urban areas that include one or more counties. The geographic scales important in regional haze planning extend over multi-state regions. Emissions inventory data for all sources in all counties over these large geographic areas are needed to address the regional haze problem.

The Emissions Forum (EF) of the Western Regional Air Partnership (WRAP) is charged with preparation of base-year and future-year emissions data to support regional haze analyses in the west. One of the objectives of the EF is the preparation of a base-year, regional-scale emissions inventory that will be used in model testing, model validation, and for developing estimated future-year inventories that can be used to test the effects of various control strategies. This report documents the preparation of the base-year inventory for point and area sources that partially fulfills this objective. The Mobile Sources Forum is charged with preparation of the mobile source emissions inputs (both for highway and non-road sources), and the Fire Emissions Joint Forum is developing emissions inputs specifically for wildfire, prescribed burning and agricultural burning. The Research and Development Forum is developing emissions estimates for most of the important fugitive dust sources.

The 1996 National Emissions Inventory (NEI) was selected as the starting point for the development of the WRAP base-year inventory. The NEI, previously called the National Emissions Trends (NET) inventory, was chosen because it represented the most complete and comprehensive emissions inventory covering the entire region. The base-year of 1996 was chosen because that was the most recent year that incorporated detailed, quality-assured information from selected state, local, and tribal agencies through the Periodic Emissions Inventory program. While the methodologies used to prepare the NEI are generally suitable for the historical purposes of the NEI, some of those methodologies are not well suited for applications to regional modeling analyses. Emissions estimates for some area source categories are simply grown from previous national inventory estimates. Specifically, the emissions estimates in the 1996 NEI inventory for selected area source categories are derived from the 1985 National Acid Precipitation Assessment Program (NAPAP) inventory. While in recent years, there has been a significant effort to locate and apply area source activity data

representative of local spatial scales, many of the estimates in the NEI are based on state-level or regional-level activity data. Specific sources that can benefit from specific local activity data include open burning sources, managed burning activities and wildfire, fugitive dust sources, ammonia sources from agricultural activities, and natural sources.

In general, point source information is more precise and current. Many state, local and tribal agencies keep high quality emissions inventory data for point sources for use in their own air quality management activities and provide that information to EPA for use in the NEI inventory. There are remaining weaknesses for point sources in the NEI database. The causes of inaccurate point source information include the use of SO_2 and NO_x information from the acid rain program for fossil fuel-fired utility sources, the neglect of some recently installed smaller sources, such as gas turbines used during peak load conditions, and the neglect of new or inclusion of retired plants from previous inventories. In addition, point source emissions estimates provided by state, local and tribal agencies are often incomplete in terms of physical parameters describing the operations. Examples of important physical parameters that are often missing or inaccurate include: activity rates, seasonal operating rates, stack parameters, and location data. These data are important in modeling and forecasting applications. Additional details describing some of the more important weaknesses of the NEI methodologies for regional haze applications have been presented elsewhere. [1,2]

The use of local data for all point sources and for the activity rates associated with many area sources can significantly improve the quality and reliability of the NEI estimates. The primary objective of this project was to collect additional information from state, local and tribal agencies to update the NEI estimates.

Area sources are also important for regional haze applications. Many of the sources of primary fine particulate, and important gaseous precursors to the formation of secondary fine particulate arise from source categories that are too numerous and dispersed to inventory individually as point sources. Examples include residential wood burning, dust from construction activities, open burning sources, and agricultural sources. Historically, state, local and tribal agencies have not prepared comprehensive inventories for area sources outside of their nonattainment areas for traditional criteria pollutants. The U.S. EPA develops a national inventory of all area sources to satisfy the CAA requirements for an annual assessment of emissions trends, among other purposes. There are different assumptions made about point/area source size cutoffs, uncertainties in the allocation of state or regional activity estimates to county resolution, and variable control requirements in different local jurisdictions that introduce bias and inconsistencies in the resulting inventories. These inconsistencies will only be corrected when comprehensive emissions information based on local data and knowledge is available.

INVENTORY PREPARATION METHODOLOGY

Information Collection

Prior to the beginning of this project, several states in the study area had supplied emissions inventory data to EPA for use in the version of the 1996 NEI inventory used in this study. Specifically, the States of Washington, California, Oklahoma, Texas, Missouri and

Louisiana had submitted both point and area source information, and Montana, North Dakota, South Dakota, Nebraska, Kansas and Colorado had submitted point source information.

Version 3.12 of the 1996 NEI inventory was downloaded on September 29, 2000. Separate files were created for point sources and area sources (without mobile sources) for each of the states in the study region. The files were developed in the flat file format (.dbf) and the Access® NEI input format Version 1.2 (NIF 1.2). Emission inventory staff in each state were notified and provided with an explanation of the objectives of the project, and information that directed users to the files.

The original project scope included the 17 western states identified by the column of states from North Dakota to Texas and west. All states in the original 17 state region, including those that had already provided data to EPA, were notified of the project and the availability of the files for review. EPA replaces state data for electricity generating units (EGU) in the NEI inventories with data prepared by the Clean Air Markets Division to support the acid rain control program. Therefore, states that had submitted data previously to EPA were given an opportunity to use their own emissions data for the EGUs, and to review the remaining data to include any additional modifications that had been identified since they submitted data to EPA. After the initial analyses were complete information for the next column of states represented by Minnesota through Louisiana were necessary for modeling studies and these 5 additional states were added to the base-year inventory. Time constraints prohibited the collection of local data from these 5 additional states. Information retrieved from the NEI inventory was used in the subsequent analyses. Table 1 summarizes the state-specific emissions inventory estimates that were received during the project. Data were reviewed and merged with the NEI data in a format that could be converted for use in the emissions processing systems used to prepare modeling input files. Figure 1 is a map showing the states that contributed local data for the final WRAP base-year emissions inventory.

Quality assurance checks were completed to check the coverage and consistency of data submitted by the agencies. State submitted data were augmented by adding important haze pollutants (PM-2.5, and NH_3), and filling gaps for missing source categories. Fuel use totals and emissions totals were compared for the major categories of point sources as a test to verify that the replacement information were in line with anticipated totals.

Table 1. Summary of data submitted

STATE	SUBMISSION	ACTION TAKEN
Washington	Minor updates to the earlier submission for 1996 NEI	Incorporated minor corrections
Oregon	Area Source data submitted for some categories	Merged data provided and augmented with selected categories that were not provided from NEI inventory
Idaho	Plant level data for point sources were extracted from AIRS	Plant and point identifiers could not be matched and the data could not be incorporated
Wyoming	Point Source data submitted	Data were incorporated
Utah	Point Source and Area Source data submitted	Incorporated data with minor augmentation
Colorado	Point Source data for utilities, and Area Source data for all sources submitted	Merged data provided to replace the NEI data.
Arizona	Point Source data submitted	Substituted data provided by the State and Maricopa county, and retained NEI data for Pinal, and Pima counties, and major sources on Tribal lands.
New Mexico	Point Source data submitted	Replaced data in NEI file with some minor augmentations

Information Processing

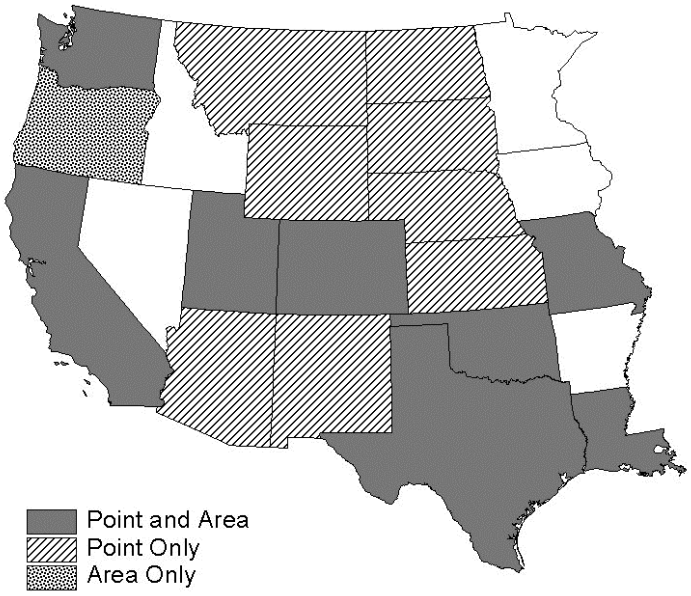
The information supplied by the state, local and tribal agencies represented varying formats and level of detail. The information were converted into NEI compatible dbf format represented by individual records representing each identified process at point source facilities, and by source category at the county-level for area sources. The data were reviewed and summaries for pollutant totals were calculated at the state- and county-levels. These totals were compared to similar summaries taken directly from the NEI database to identify significant discrepancies. All such significant discrepancies were investigated to determine if major groups of sources were omitted in the data developed by the state, local and tribal agencies. Other checks included similar comparisons for emissions totals from subsets of sources in major categories, a check of activity rates in major fuel use categories, identification of missing or erroneous stack parameters and location data. Checks for area sources included completeness checks to ensure that major source categories were represented. In most cases, the significant discrepancies and problems identified in this review were resolved through subsequent discussions with the appropriate state, local and tribal representatives who were responsible for the preparation of the data.

Some examples of problems that were identified while completing these checks include:

- missing major point sources from submittals by state agencies for selected sources that are operated on tribal lands,
- inclusion of movable sources (e.g., asphalt and concrete batch plants) in point source files without a recognizable county code,
- missing or inaccurate fuel use or other activity totals, and
- different totals for some area source categories that arose from differences in point/area source size cutoff assumptions.

Estimates for emissions of primary PM-2.5 and NH_3 were missing from nearly all of the state, local and tribal data submissions for both point and area sources. The database was augmented to account for these pollutants by adding the appropriate totals based on the NEI inventory. For PM-2.5, emissions were calculated for individual sources by applying the NEI PM-2.5 to PM-10 ratio to the PM-10 emissions estimate submitted by the state agency for each source. The NEI estimates for NH_3 emissions were simply added to the final WRAP database. NEI NH_3 emissions were substituted in all cases, even for those states that had submitted NH_3 emissions estimates. Ammonia was treated this way to avoid any large differences among states resulting from different assumptions and methodologies.

Figure 1. States that submitted data for the WRAP base-year inventory



Finally initial processing of the draft database revealed quite a few cases of missing data for stack parameters and inaccurate data for location coordinates in selected states. A set of default stack parameters by point source SCC code was developed from the remaining sources with similar SCCs from the completed database. These default stack parameters were substituted for all records with missing stack information. In selected cases, the location data included in the submittals was obviously incorrect. A program was written to identify records that contained location data that was outside a rectangle that enclosed the state. Latitude and longitude coordinates representing the county centroid were substituted for all records that failed that location check. These substitutions for stack parameters and location data were the only changes that were made to the completed database. A set of flags were added to each record to indicate those records that have modified data for these parameters to assist users in identifying problem records that may be updated with more accurate data in the future.

A draft version of the inventory was made available for review and comment by state, local and tribal agency staff as well as by other interested WRAP representatives. Appropriate revisions were made in response to the comments received. The final base-year inventory was delivered to WRAP for use in modeling base case scenarios and for use in the development of the future year base and control case inventories. The final inventory was posted to the WRAP emissions forum web page on October 26, 2001.

RESULTS

Point Sources

Table 2 summarizes the changes in state total point source emissions for the important haze pollutants that have been included in the WRAP base year inventory relative to the totals in the NEI inventory. These summaries represent the difference expressed as WRAP inventory – NEI inventory so negative numbers indicate a net reduction in emissions when state/local/tribal data were substituted for data included in the original NEI inventory. Ammonia is not included in Table 2 since the development methodology used the NEI estimates for ammonia in all cases. Although the total regional change in emissions magnitude is less than 10% for all pollutants, the differences are large on a percentage basis for some of the pollutants in selected states. Some of the significant differences in SO2 and NOx emissions result from some plant closures and some fuel switching that has not been reflected in the NEI inventory. Differences in PM emissions seem to be related to different assumptions about throughputs and control equipment.

The changes in emissions magnitude for Washington and Colorado are very small relative to the other states. Both Washington and Colorado had provided point source information for the EPA version of the 1996 NEI used as the starting point for this effort and only minor corrections are reflected in the data submittal for the WRAP effort. Specifically, Colorado submitted data for electric utilities to correct for two known problems in the acid rain database. First a bias is introduced in the acid rain emissions estimates as a result of the method that is used to calculate stack flow rates. Also in the acid rain program, SO_2 emissions must be set equal to the maximum possible emissions rate (e.g., full capacity and no controls) when the continuous emissions monitors are inoperative. These data are reflective of the types of differences that can result when acid rain information is used instead of actual emissions

estimates based on true operating rates.

Table 2. Summary of point source differences between state supplied emission estimates and NEI emissions estimates (units are in tons/year)

State	SO_2	%	NO_x	%	PM-10	%	PM-2.5	%
Washington	- 1,848	- 1.5	- 2,958	- 5.0	+ 193	+ 1.5	+ 221	+ 2.5
Colorado	- 750	- 0.7	- 1,356	- 1.0	- 1,054	- 5.0	- 690	- 5.5
Wyoming	-26,688	-17.2	-23,109	-14.9	- 935	- 2.8	- 137	- 0.7
Utah	-16,713	-28.6	-12,795	-12.9	-10,426	- 43.3	-12,063	- 65.8
Arizona	-20,716	- 9.6	-43,549	-28.6	-12,755	- 36.5	- 6,837	- 36.9
New Mexico	-19,567	-10.9	- 3,413	- 2.2	- 6,621	- 39.2	- 7,073	- 69.4
Entire Study Area	-86,282	- 2.3	-87,180	- 2.5	-31,598	- 5.8	-26,579	- 8.4

Figures 2 and 3 show how point source emissions magnitudes changed at county resolution for SO_2 and NO_x, respectively. These maps reveal that while the overall magnitude of emissions change is low when the national inventory estimates are replaced with data generated by state, tribal, and local agencies, there can often be significant changes in the location of the emissions. Differences in location of sources can arise from two primary conditions. First, errors were sometimes made in the original identification of the

Figure 2. Point Source SO_2 emissions difference in tons per year (NEI minus WRAP)

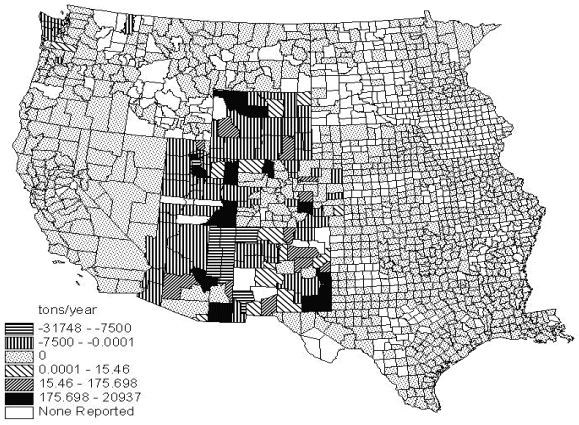
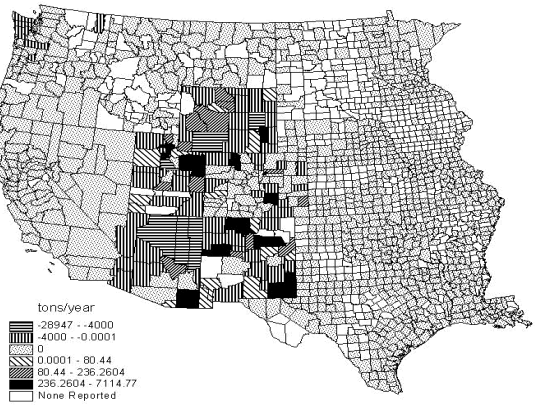


Figure 3. Point Source NOx emissions difference in tons per year (NEI minus WRAP)



county in which the sources operate. In other cases, company headquarters offices were coded as the location information, which often differ from the actual plant locations. It is possible that the use of the corrected location information may influence how sources contribute to haze under specific episodic meteorological conditions. It should be noted that the sensitivity of model results to these types of location differences is being considered through an ongoing project overseen by the EIIP Emissions Modeling Committee.

Area Sources

Table 3 represents a similar comparison between the WRAP final inventory and the original NEI inventory estimates for area sources. While the absolute magnitude of emissions changes as a result of this effort are small (except for NO_x emissions for Colorado) the percent changes at the state level are significant in many cases. The patterns in the changes for area sources of PM are of particular interest. Emissions increases were observed for area source PM emissions from Oregon, while moderate to significant negative changes were observed for Colorado and Utah.

Table 3. Summary of area source differences between state supplied emission estimates and NEI emissions estimates (units are in tons/year)

State	SO_2	%	NO_x	%	PM-10	%	PM-2.5	%
Oregon	- 15,735	- 87.5	+ 5,982	+ 65.6	+ 35,648	+ 23.3	+ 34,363	+ 71.2
Colorado	- 2,593	- 57.5	- 41,579	- 79.1	- 44,466	- 17.1	- 15,796	- 26.1
Utah	- 2,968	- 26.7	- 13,412	- 72.6	- 23,892	- 36.5	- 5,393	- 30.1
Entire Study Area	- 21,296	- 6.0	- 49,009	- 6.6	- 32,710	- 0.6	+ 13,174	+ 1.0

Most of the increase in PM emissions in Oregon is attributable to differences in activity estimates for residential wood combustion (RWC) and selected open burning sources. Oregon has completed detailed studies of RWC activity and it is apparent for these results that the locally generated information was significantly different that the wood burning activity estimated using the national methodologies that were in effect during the creation of the 1996 NEI inventory. The increase in NOx emissions for Oregon is also associated with the increase in activity rates for RWC and open burning sources. For example, Oregon has an open burning law that prohibits many forms of open burning and severely restricts selected types of open an open burning law eliminates all such emissions and subsequently sets emissions equal to zero for open burning categories in states that have such laws. This across the board assumption to remove all such emissions neglects certain types of burning that occur either in violation of the law or in accordance with special permits that can be granted for selected types of burning. The inventory based on knowledge of the actual fires permitted and practices of people that ignore the open burning statutes improves the estimates for these types of categories significantly relative to the national methodologies.

Figures 4 and 5 represent the original NEI county emissions density for fugitive dust represented as PM-10 from unpaved roads and for SO_2 from area source fossil fuel combustion sources, respectively. In the WRAP base-year emissions inventory development program dust from unpaved roads were estimated from local information and updated methodologies. Figure 4 is shown here simply as a clear example of how the national methodologies can result in unusual distributions of pollutants. In this case, assumptions about the number of miles traveled on unpaved roads and silt content of the soils combine to create emissions patterns that follow selected state boundaries. In this case, Wyoming, New Mexico, and Missouri are display anomalies in terms of emissions magnitude in surrounding states.

Figure 5 displays a similar result for SO2 from area source fuel combustion sources. While the effects are less dramatic than that for unpaved roads, it should be remembered that these emissions are actually being used in the WRAP base-year modeling. Figure 5 represents SO2 emissions from all sources of fossil fuel combustion including residential, commercial and industrial. The relatively high emissions densities observed in much of North Dakota for example result from an unusually high amount of coal combustion in area source industrial categories. The emissions totals represented in Figure 5 are based on estimates originally prepared in the late 1980's for the NAPAP program and have simply been grown using population and industrial growth factors.

Figure 4. Distribution of PM-10 emissions from unpaved roads in 1996 NEI

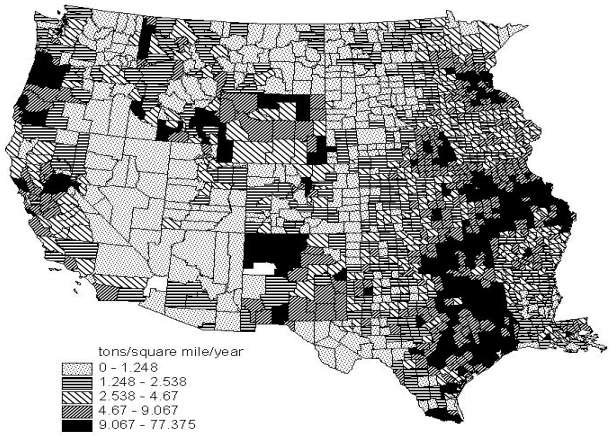
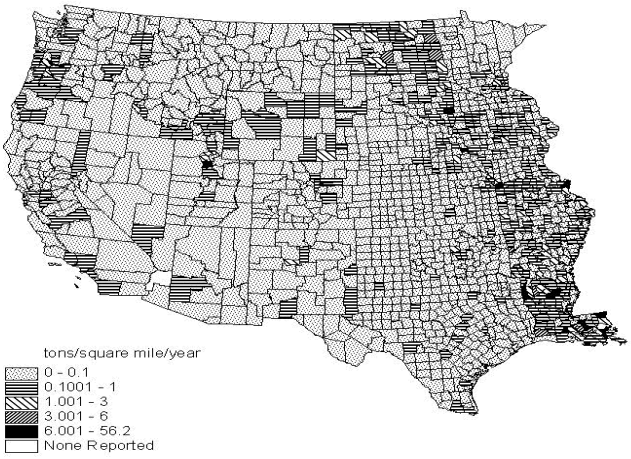


Figure 5. Distribution of SO2 emissions from area source fuel combustion in 1996 NEI



Differences in local assumptions about activity rates for RWC and open burning sources also are seen in the summaries for Colorado and Utah. Much of the large negative change observed for NOx and some of the difference in PM categories in Colorado, however, result from Colorado's use of 2 tons per year cutoff for point sources. This cutoff value moves many sources that are historically treated as area sources in the NEI inventory into the point sector and Colorado has reduced its area source inventory accordingly.

Maps showing differences similar to those presented for point sources are not as instructive for area sources because of the limited number of states for which area source information was received. The data presented in Table 4 represents the magnitude of area source emissions changes from the three states that submitted data for this effort. The information in Table 4 summarizes results for three particularly interesting source categories. These results demonstrate the magnitude of improvement in emissions estimates that can be achieved using locally generated activity information relative to the methodologies applied for the national inventory. Similar types of differences in emissions can be expected in other source categories. It is clear that national methodologies underestimate emission magnitude for residential wood combustion (RWC) in states where RWC is expected to be widely used. This underestimation arises primarily as an artifact of the methods used to distribute the wood fuel consumption in the national methodology.

Table 4. Examples of emissions difference for selected area source categories (NEI versus state supplied data)

Source Category	Pollutant Species	Utah		Colorado		Oregon	
		Emissions, tpy		Emissions, tpy		Emissions, tpy	
		NEI Data	State Data	NEI Data	State Data	NEI Data	State Data
Residential Wood Combustion	PM-2.5	1,747	3,860	4,724	9,037	20,764	50,352
	NO_x	179	356	485	725	2,130	5,467
	VOC	2,803	10,140	7,581	41,050	33,319	127,325
	SO_2	26	54	69	115	304	743
Open Burning	PM-2.5	787	0	1,757	0	0	5,723
	NO_x	224	0	499	0	0	493
	VOC	1,179	0	2,635	0	0	3,928
	SO_2	32	0	71	0	0	82
Area Source Fuel Use	PM-2.5	443	1,893	541	315	903	2
	NO_x	17,968	4,707	51,445	10,266	6804	8652
	VOC	304	4,796	646	149	719	241
	SO_2	10,991	8,094	4,291	1,800	17635	948

The results for open burning sources in Utah and Colorado may be influenced by how these sources are assigned SCC codes in the state submittals. In the Table, open burning categories represent yard waste burning, construction and land clearing debris burning, residential waste burning and some other waste management burning categories. It is also

possible that these sources were simply neglected in the state submittals. The result for Oregon, however, demonstrate the effect of one of the assumptions used to prepare the NEI inventory. Open burning emissions are removed from the NEI for those states that have an open burning law. Representatives of the Oregon state agency, however, have better information on the burns that were allowed under special permit and that burning that goes on in spite of the law.

Much of the differences in emissions magnitude for area source fuel use may arise from the same artifact discussed in reference to Figure 5. The differences for Colorado, however, also include the effect of the source size cutoff for point sources used in Colorado. All identifiable sources with emissions greater than 2 tpy are included in Colorado's point source file. The inclusion of that fuel use as point sources results in a significant decrease in the activity rates, and therefore emissions, that are associated with area sources. Without further detailed analyses inclusion of point source information for Colorado with the national estimates for area sources would have resulted in a significant double counting of emissions from this category. While the effect of point source size cutoffs is clearly applicable in fuel combustion categories, the effects of cutoff size extend to many other types of sources as well.

SUMMARY AND RECOMMENDATIONS

Regional scale inventory information is needed to support regional haze and other air quality management programs. Currently, the national emissions inventory (NEI) is the best comprehensive database that includes all of the sources and pollutants of interest in regional haze studies over the regional scales of interest. The methodologies and activity assumptions used to develop the NEI do not always reflect local conditions and situations accurately. Use of state, tribal, and local information sources can improve the estimates considerably, but differences in assumptions, methodologies, and coverage among the various agencies responsible for collecting and processing emissions information still causes inconsistencies in regional scale emissions databases.

The Western Regional Air Partnership has assembled a regional emissions database using input from state, tribal and local agencies from many of the western United States that represents local conditions more accurately than the national inventories. The state, tribal and local agencies have not yet expanded their inventory development programs to include specific estimates for PM-2.5 or NH3, two of the important emissions species in haze programs. Therefore, it was necessary to augment the local data with information based on the NEI methods for those pollutants. There were additional cases where local data did not include all of the sources and activities that are currently thought to be part of the regional haze problem, and the final database was adjusted to add estimates for those sources as well.

While the current regional emissions data are being used in a comprehensive modeling study designed to understand the regional haze issues in the west, this inventory can be improved and expanded. WRAP is initiating a quality assurance assessment of the existing inventory to identify the most significant uncertainties that can be used to direct future research efforts.

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