Visualization and Comparison of recent versions of the National Emissions Inventory As a Prelude to MANE-VU Modeling Inventory

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Purpose

- 2002 inventory is expected to be the basis for upcoming ozone, $PM_{2.5}$, and regional haze modeling
- Modeling inventory is needed by latest at the end of 2004.
- It will be crucial to prepare a high quality 2002 modeling inventory that will require minimal revisions and iterations.
- Contractual work by E. H. Pechan and Associates, Inc.

Purpose (cont'd)

- To help prioritize 2002 emissions inventory improvement needs, identify:
  - most important source categories for precursors of haze in the MANE-VU region
  - gaps and abnormalities in the data
- Lessons learned are being used to improve the 2002 base year modeling inventory and focus base year and future inventory work on those source categories

Purpose (cont'd)

- Regional and state by state summary of total, point, area, highway, and non-road emissions.
- CO, NH_3, NO_x, SO_2, PM_{10}, $PM_{2.5}$, and VOC
- Mid-Atlantic and Northeastern states (MANE-VU states + VA, WV, NC).
- County level density maps for total, point, area, onroad, and nonroad (annual and OSD).
- Compare 2002 with previous inventories.

Purpose (cont'd)

- Identify (SCC based) source categories comprising at least 90% of the emissions.
- Detect those categories where gaps and data abnormalities.
- Detect inconsistencies in calculation methods.
- Establish transparency.

MARAMA web site

- A large suite of summary tables and plots, and county based emissions density maps for those SCC categories comprising a large portion of the inventory for each pollutant of concern (CO, NH_3, NO_x, SO_2, $PM_{2.5}$, PM_{10}, and VOC) are available online. Comments are invited.
- http://www.marama.org/visibility/NEI2002/

or

- http://www.marama.org/
  - Regional Haze
  - Visualization and QA/QC of 2002 NEI

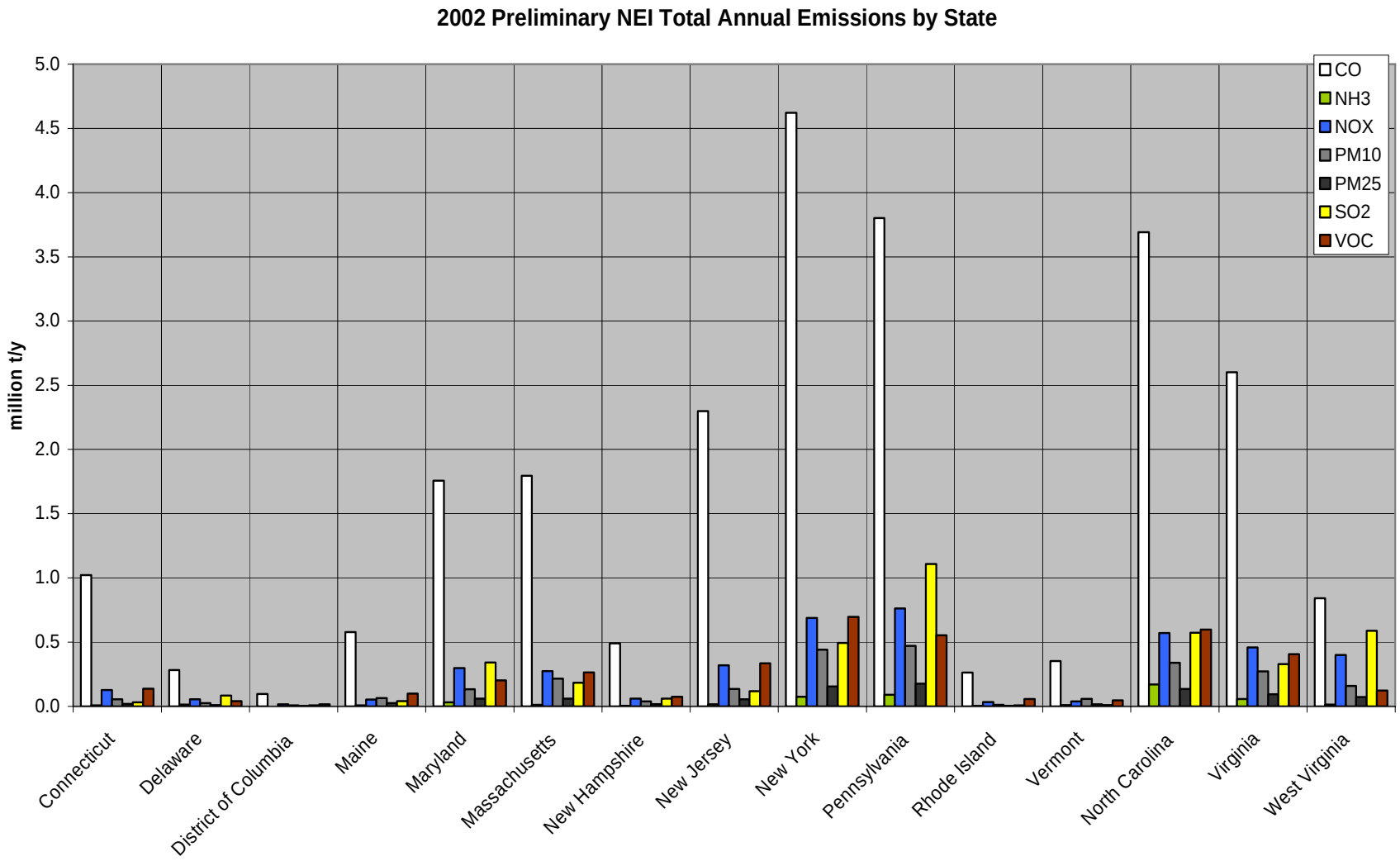
MARAMA web site

- The 2002 Preliminary National Emissions Inventory (NEI) has been used for this study.
- Emissions presented in this study do not necessarily reflect the most up to date NEI data corrected by some of the states.
- However, QA/QC and visualization of the NEI take time, and one must initiate this process in parallel with preparation of new versions of inventories.

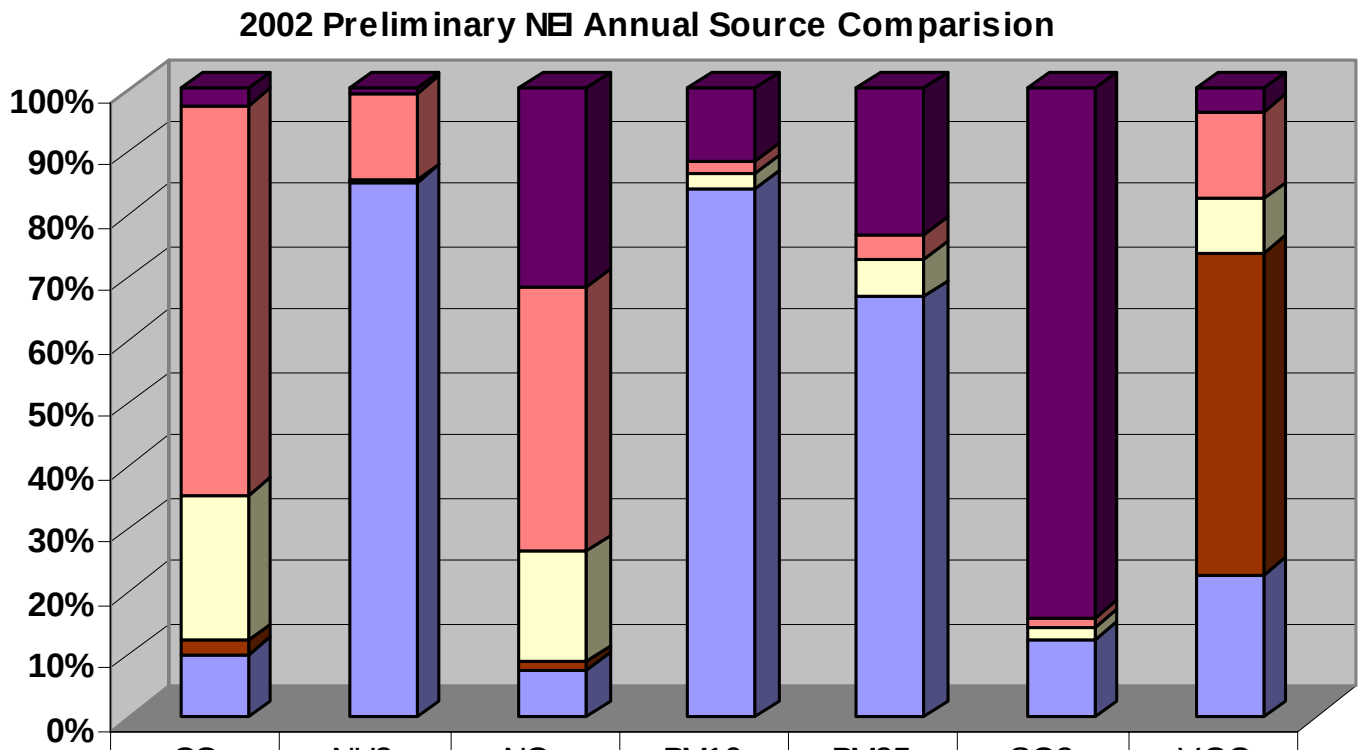
Summary Plots by Major Source Category, Pollutant, and State (Annual and OSD)

2002 NEI Summary by Region and States (annual and OSD)								
Source Category								
Point Sources	CO	NH3	NOx	PM10	PM2.5	SO2	VOC	all pollutants
Area Sources	CO	NH3	NOx	PM10	PM2.5	SO2	VOC	all pollutants
Non-Road Sources	CO	NH3	NOx	PM10	PM2.5	SO2	VOC	all pollutants
Highway Mobile Sources	CO	NH3	NOx	PM10	PM2.5	SO2	VOC	all pollutants
Total	CO	NH3	NOx	PM10	PM2.5	SO2	VOC	all pollutants

2002 Preliminary NEI Total Annual by State



2002 Preliminary NEI Annual Source Comparison



	CO	NH3	NOx	PM10	PM25	SO2	VOC
POINT	633,038	4,250	1,315,213	279,018	208,558	3,347,455	259,963
ONROAD	15,498,276	70,515	1,781,376	48,570	35,171	59,432	1,052,546
NONROAD	5,840,908	675	739,434	60,112	55,109	78,863	628,446
BIOGENIC	493,717		47,562				3,842,430
AREA	2,524,475	437,244	320,953	2,044,336	603,202	494,089	1,710,080

Major Source Category Summary Tables by Pollutant, Region and State (Annual and OSD)

2002 NEI Summary by Source Category							
MANE-VU Total	CO	NH_3	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC
MARAMA + NESCAUM Total	CO	NH_3	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC

SO_2 Emissions – MANE-VU States

Source Category	Source Type	ANNUAL	
		Emissions (tons/year)	Percent of Total
External Combustion Boilers-Electric Generation	Point	1,621,447	65.1
External Combustion Boilers-Industrial	Point	193,523	7.8
Stationary Source Fuel Combustion-Industrial	Area	192,119	7.7
Stationary Source Fuel Combustion-Commercial/Institutional	Area	130,381	5.2
Stationary Source Fuel Combustion-Residential	Area	109,896	4.4
Industrial Processes-Mineral Products	Point	52,469	2.1
Off-highway Vehicle Diesel	Nonroad	31,021	1.2
External Combustion Boilers-Commercial/Institutional	Point	21,812	0.9
Highway Vehicles - Gasoline	Onroad	21,291	0.9
Industrial Processes-Primary Metal Production	Point	19,259	0.8
Top 10 Categories		2,393,218	96.1
Other Point Sources	Point	45,148	1.8
Other Nonroad Sources	Nonroad	24,621	1.0
Other Onroad Sources	Onroad	18,344	0.7
Other Area Sources	Area	7,722	0.3
Total SO2 Emissions		**2,489,053**	**100**

NO_x Emissions – MANE-VU States

Source Category	Source Type	ANNUAL	
		Emissions (tons/year)	Percent of Total
Highway Vehicles - Gasoline	Onroad	698,105	25.6
Highway Vehicles - Diesel	Onroad	596,255	21.9
External Combustion Boilers-Electric Generation	Point	424,705	15.6
Off-highway Vehicle Diesel	Nonroad	225,145	8.3
Marine Vessels, Commercial	Nonroad	128,447	4.7
Stationary Source Fuel Combustion-Residential	Area	112,996	4.1
External Combustion Boilers-Industrial	Point	66,314	2.4
Industrial Processes-Mineral Products	Point	62,679	2.3
LPG	Nonroad	52,711	1.9
Stationary Source Fuel Combustion-Commercial/Institutional	Area	52,265	1.9
Railroad Equipment	Nonroad	44,486	1.6
Stationary Source Fuel Combustion-Industrial	Area	40,964	1.5
Top 12 Categories		2,505,069	91.8
Other Point Sources	Point	132,390	4.9
Other Nonroad Sources	Nonroad	66,488	2.4
Other Onroad Sources	Onroad	0	0
Other Area Sources	Area	23,638	0.9
Total NOX Emissions		**2,727,585**	**100**

NH_3 Emissions – MANE-VU States

Source Category	Source Type	ANNUAL	
		Emissions (tons/year)	Percent of Total
Miscellaneous Area Sources-Agriculture Production - Livestock	Area	151,253	56
Highway Vehicles - Gasoline	Onroad	50,011	18
Miscellaneous Area Sources-Agriculture Production - Crops	Area	29,896	11
Waste Disposal, Treatment, and Recovery-Wastewater Treatment	Area	26,184	10
Miscellaneous Area Sources - Agriculture Production - Livestock - Horses and Ponies	Area	5,810	2
External Combustion Boilers-Electric Generation	Point	1,187	0
Highway Vehicles - Diesel	Onroad	1,096	0
Industrial Processes-Chemical Manufacturing	Point	1,040	0
Stationary Source Fuel Combustion-Industrial	Area	997	0
Stationary Source Fuel Combustion-Commercial/Institutional	Area	942	0
Top 10 Categories		268,416	98.5
Other Point Sources	Point	710	0.3
Other Nonroad Sources	Nonroad	512	0.2
Other Onroad Sources	Onroad	0	0.0
Other Area Sources	Area	2,873	1.1
Total NH3 Emissions		**272,510**	**100**

$PM_{2.5}$ Emissions – MANE-VU States

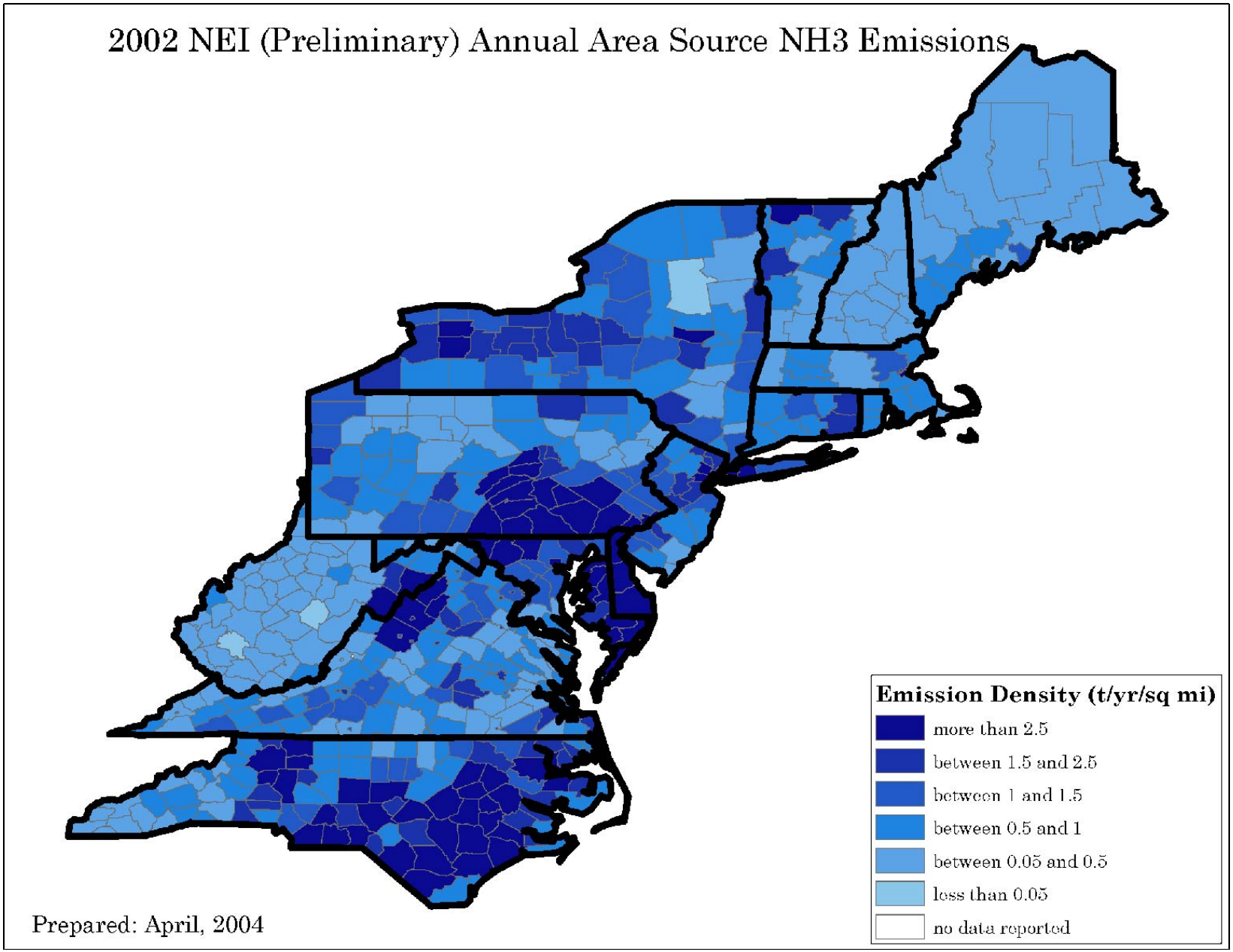
Source Category	Source Type	ANNUAL	
		Emissions (tons/year)	Percent of Total
External Combustion Boilers-Electric Generation	Point	100,938	16.8
Stationary Source Fuel Combustion-Residential	Area	85,297	14.2
Open Burning-Waste Disposal, Treatment, and Recovery	Area	69,692	11.6
Unpaved Roads	Area	56,900	9.5
Industrial Processes-Construction: SIC 15 - 17	Area	53,792	9.0
Paved Roads	Area	49,481	8.2
Miscellaneous Area Sources-Agriculture Production - Crops	Area	24,684	4.1
Off-highway Vehicle Diesel	Nonroad	21,017	3.5
Stationary Source Fuel Combustion-Commercial/Institutional	Area	17,894	3.0
Highway Vehicles - Diesel	Onroad	17,248	2.9
Industrial Processes-Food and Kindred Products: SIC 20	Area	13,494	2.2
Industrial Processes-Mining and Quarrying: SIC 14	Area	10,845	1.8
External Combustion Boilers-Industrial	Point	9,523	1.6
Miscellaneous Area Sources-Other Combustion	Area	9,220	1.5
Highway Vehicles - Gasoline	Onroad	8,325	1.4
Top 15 Categories		548,350	91.4
Other Point Sources	Point	18,660	3.1
Other Nonroad Sources	Nonroad	19,598	3.3
Other Onroad Sources	Onroad	0	0
Other Area Sources	Area	13,240	2.2
Total PM25-PRI Emissions		**599,847**	**100**

VOC Emissions – MANE-VU States

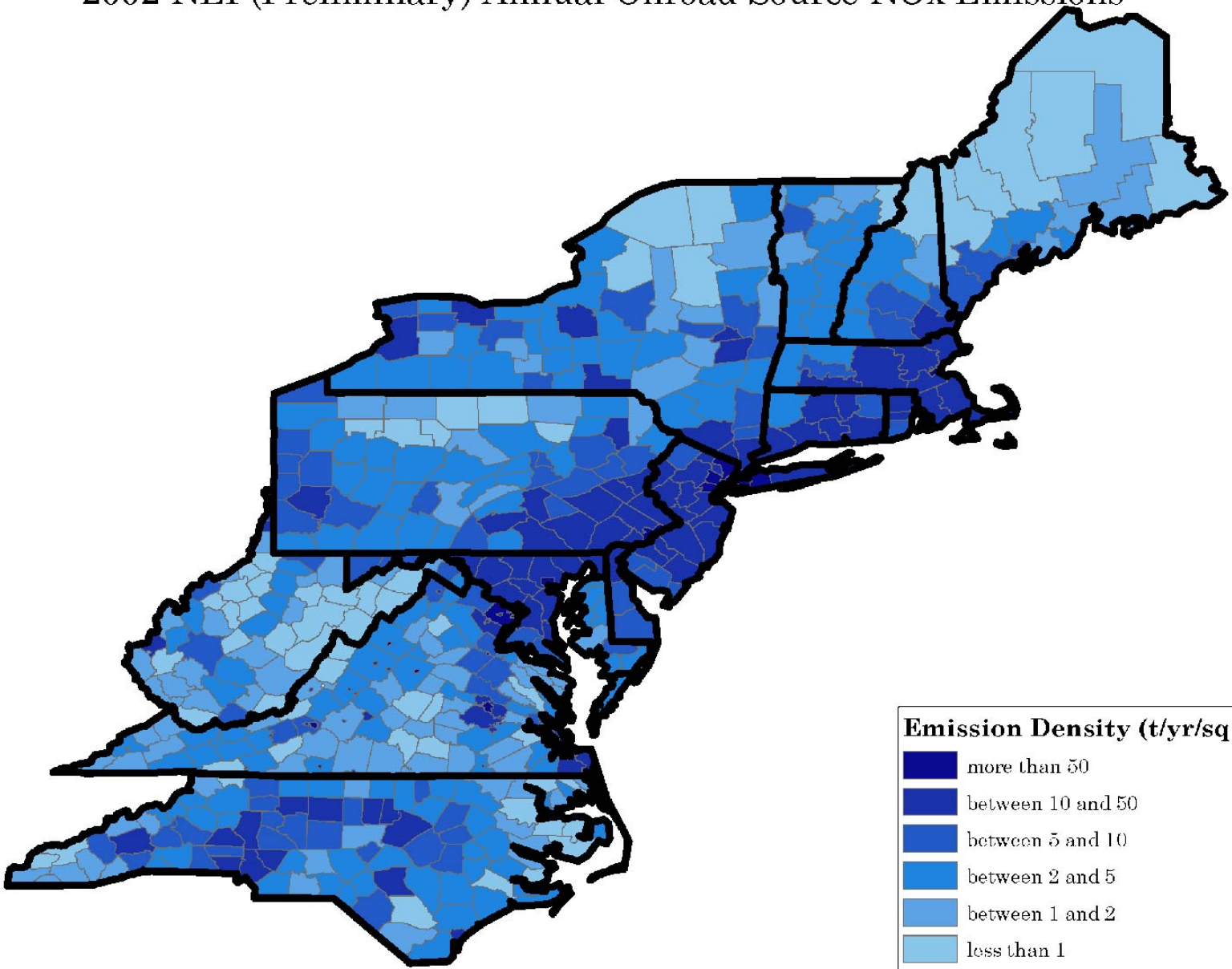
Source Category	Source Type	ANNUAL	
		Emissions (tons/year)	Percent of Total
Highway Vehicles - Gasoline	Onroad	707,804	28.0
Consumer And Commercial Solvents	Area	220,252	8.7
Off-highway Vehicle Gasoline, 2-Stroke	Nonroad	179,026	7.1
Stationary Source Fuel Combustion-Residential	Area	176,757	7.0
Industrial Surface Coating	Area	174,661	6.9
Pleasure Craft	Nonroad	145,766	5.8
Off-highway Vehicle Gasoline, 4-Stroke	Nonroad	106,523	4.2
Degreasing	Area	105,871	4.2
Architectural Coatings	Area	95,323	3.8
Gas Marketing Stage I	Area	61,884	2.5
Gas Marketing Stage II	Area	51,148	2.0
Open Burning-Waste Disposal, Treatment, and Recovery	Area	50,916	2.0
Graphic Arts	Area	46,916	1.9
Highway Vehicles - Diesel	Onroad	35,754	1.4
Solvent Utilization-Miscellaneous Industrial	Area	29,585	1.2
Petroleum and Petroleum Product Storage & Transport - Other	Area	27,296	1.1
Top 16 Categories		2,215,481	87.8
Other Point Sources	Point	117,498	4.7
Other Nonroad Sources	Nonroad	50,456	2.0
Other Onroad Sources	Onroad	0	0
Other Area Sources	Area	140,908	5.6
Total VOC Emissions		**2,524,344**	**100**

Emissions Density Maps by Pollutant and County for Major Source Categories (Annual and OSD)

2002 NEI Ozone Season Daily Emissions Density Maps							
Source Category							
Point Sources	CO	NH_3	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC
Area Sources	CO	NH_3	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC
Non-Road Sources	CO	NH_3	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC
Highway Mobile Sources	CO	NH_3	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC
Total	CO	NH_3	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC
High. Vhl. - Gasoline	CO	NH_3	-	-	-	-	VOC
Off High. Vhl. - Gas. 4 stroke	CO	-	-	-	-	-	-
Agr. Prod. Livestock - Cattle	-	NH_3	-	-	-	-	-
Agr. Prod. Livestock - Poultry	-	NH_3	-	-	-	-	-
Agr. Prod. - Crops	-	NH_3	-	-	-	-	-
Waste Water Treatment	-	NH_3	-	-	-	-	-
Ext. Comb. Boil. - EGU	-	-	NOx	-	-	SO_2	-
Ext. Comb. Boil. - Industrial	-	-		-	-	SO_2	-
High. Vhl. - Diesel	-	-	NOx	-	-	-	-
Paved Roads	-	-	-	PM_{10}	$PM_{2.5}$	-	-
Unpaved Roads	-	-	-	PM_{10}	$PM_{2.5}$	-	-
Industrial Construction	-	-	-	PM_{10}	-	-	-
Residential Wood Comb.	-	-	-	-	$PM_{2.5}$	-	-
Open Burning	-	-	-	-	$PM_{2.5}$	-	-
Residential Combustion	-	-	-	-	-	-	VOC
Consumer Solvents	-	-	-	-	-	-	VOC

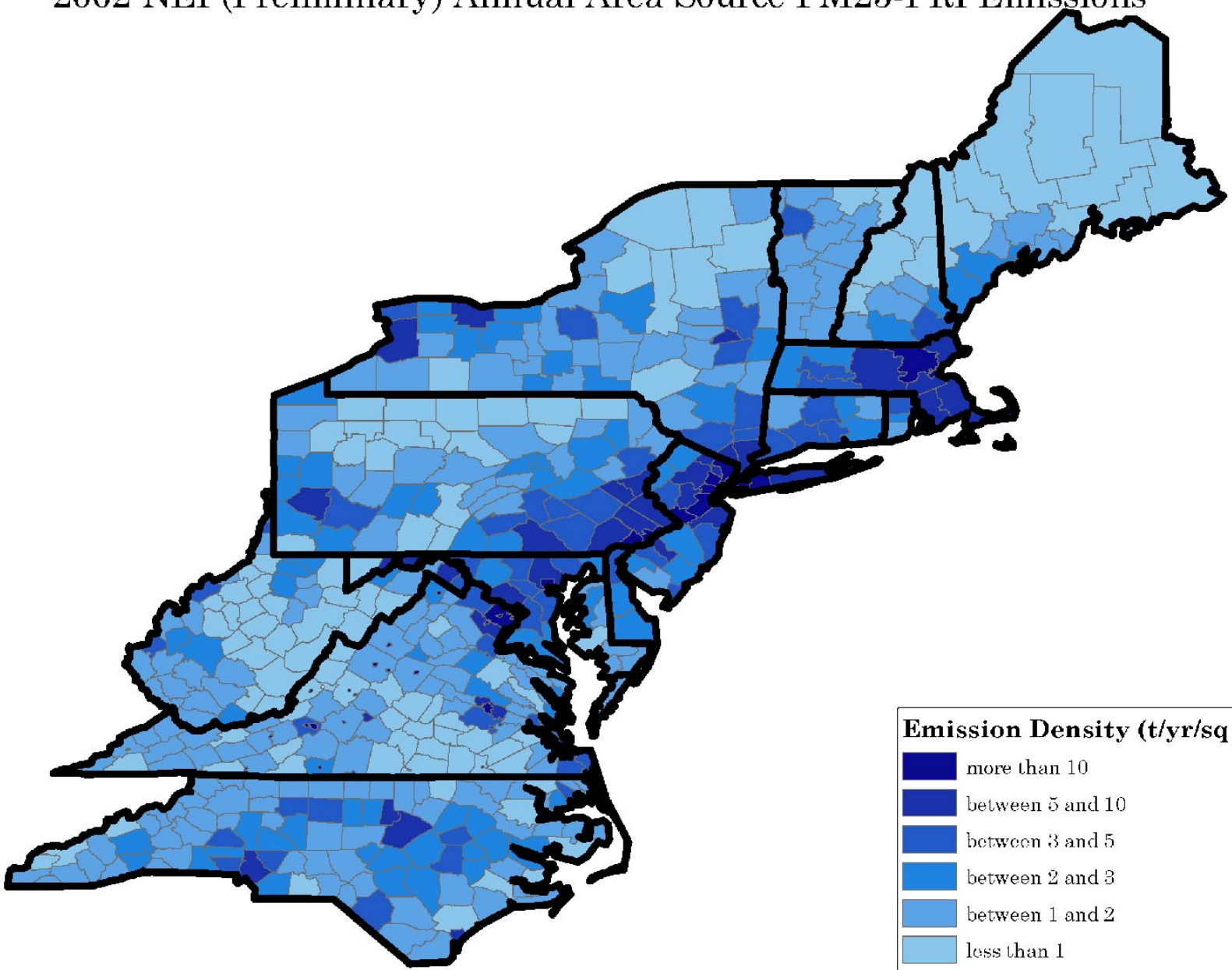

2002 NEI (Preliminary) Annual Area Source NH3 Emissions
Emission Density (t/yr/sq mi)
more than 2.5
between 1.5 and 2.5
between 1 and 1.5
between 0.5 and 1
between 0.05 and 0.5
less than 0.05
no data reported
Prepared: April, 2004

2002 NEI (Preliminary) Annual Onroad Source NOx Emissions



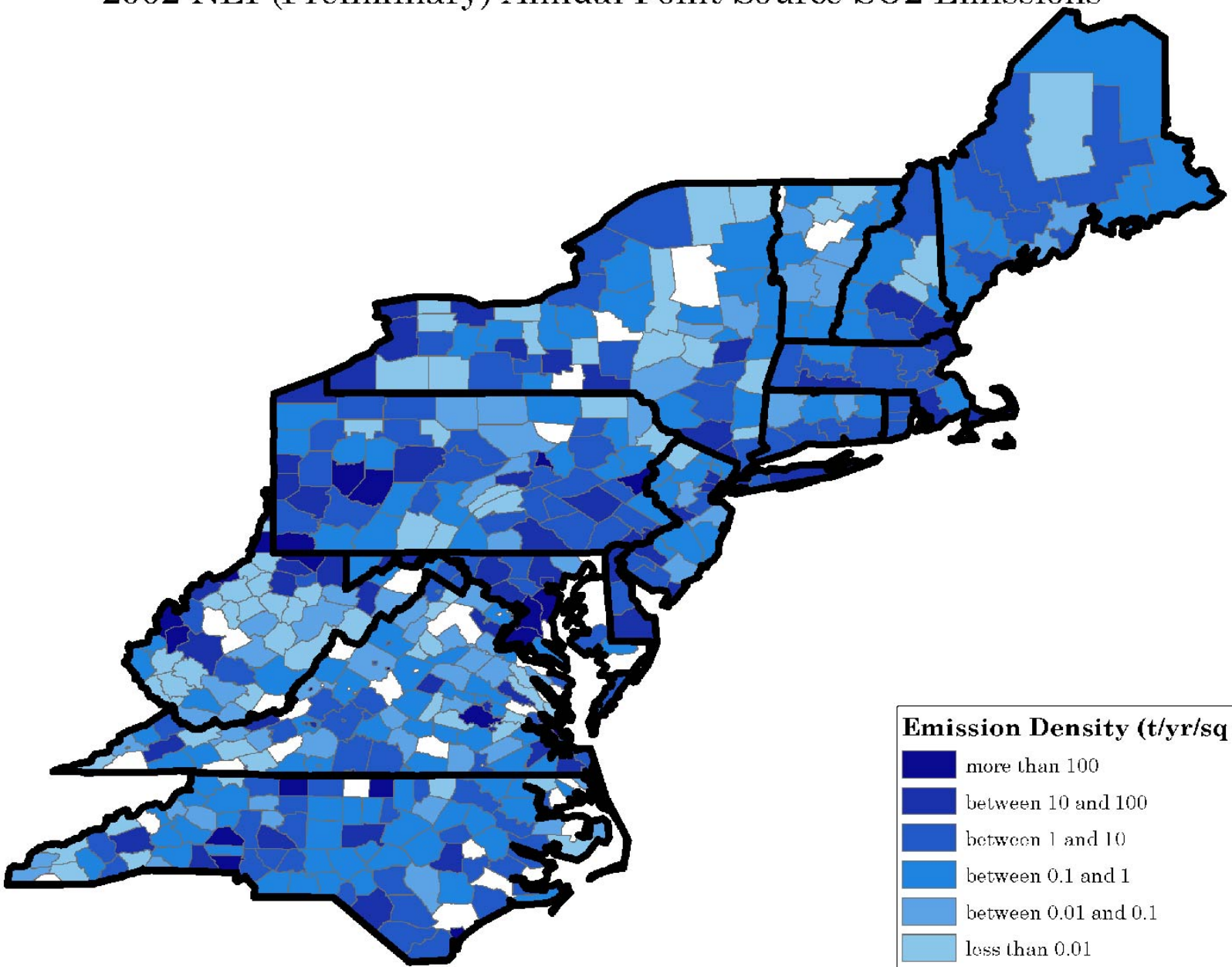
Prepared: April, 2004

2002 NEI (Preliminary) Annual Area Source PM25-PRI Emissions



Prepared: April, 2004

2002 NEI (Preliminary) Annual Point Source SO2 Emissions

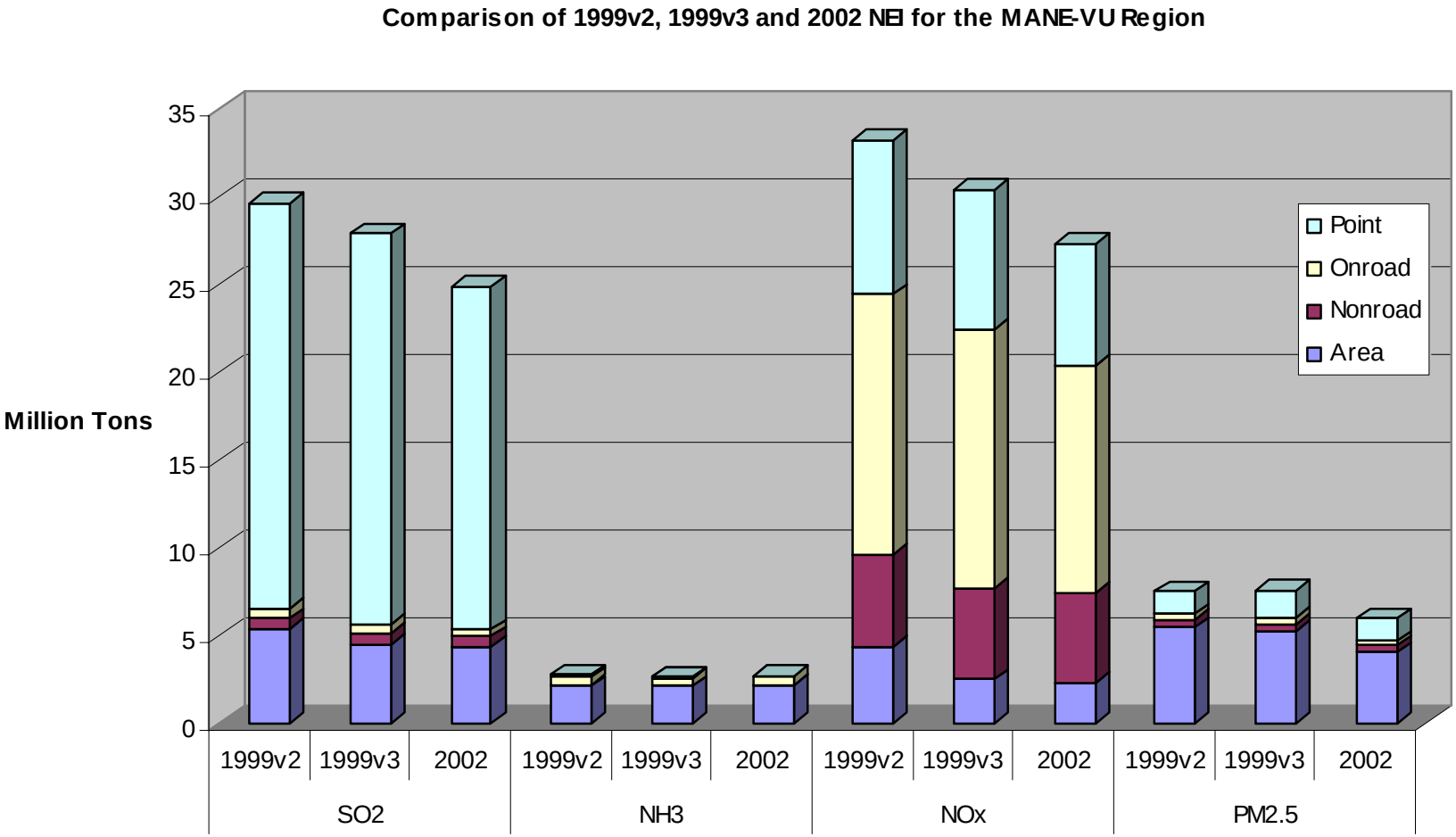


Prepared: April, 2004

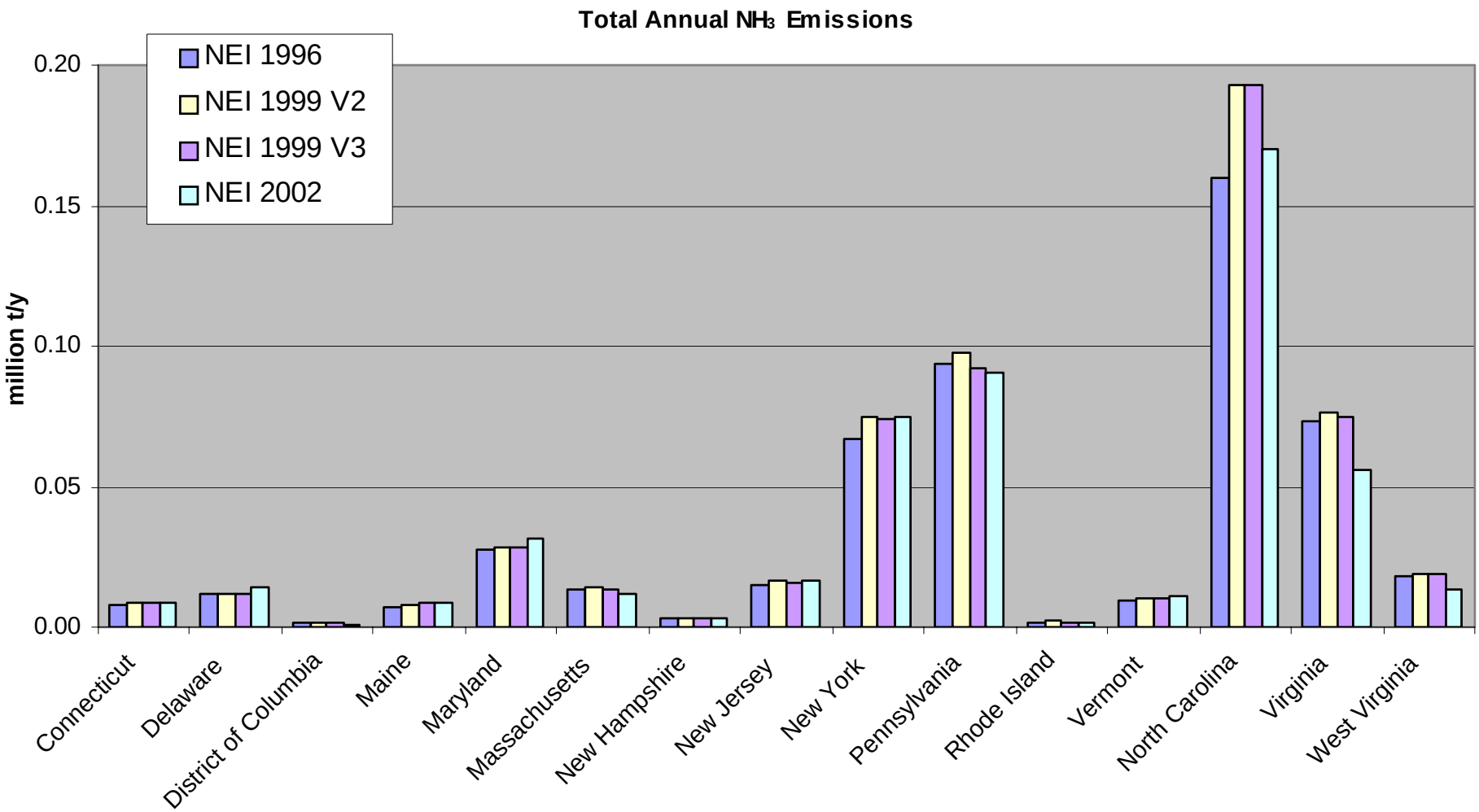
Comparison of 1996, 1999v2, v3 and 2002 NEI

Comparison of 1996, 1999v2, v3 and 2002 NEI						
Annual Total						
MARAMA + NESCAUM	NH_3	NO_x	PM_{10}	$PM_{2.5}$	SO_2

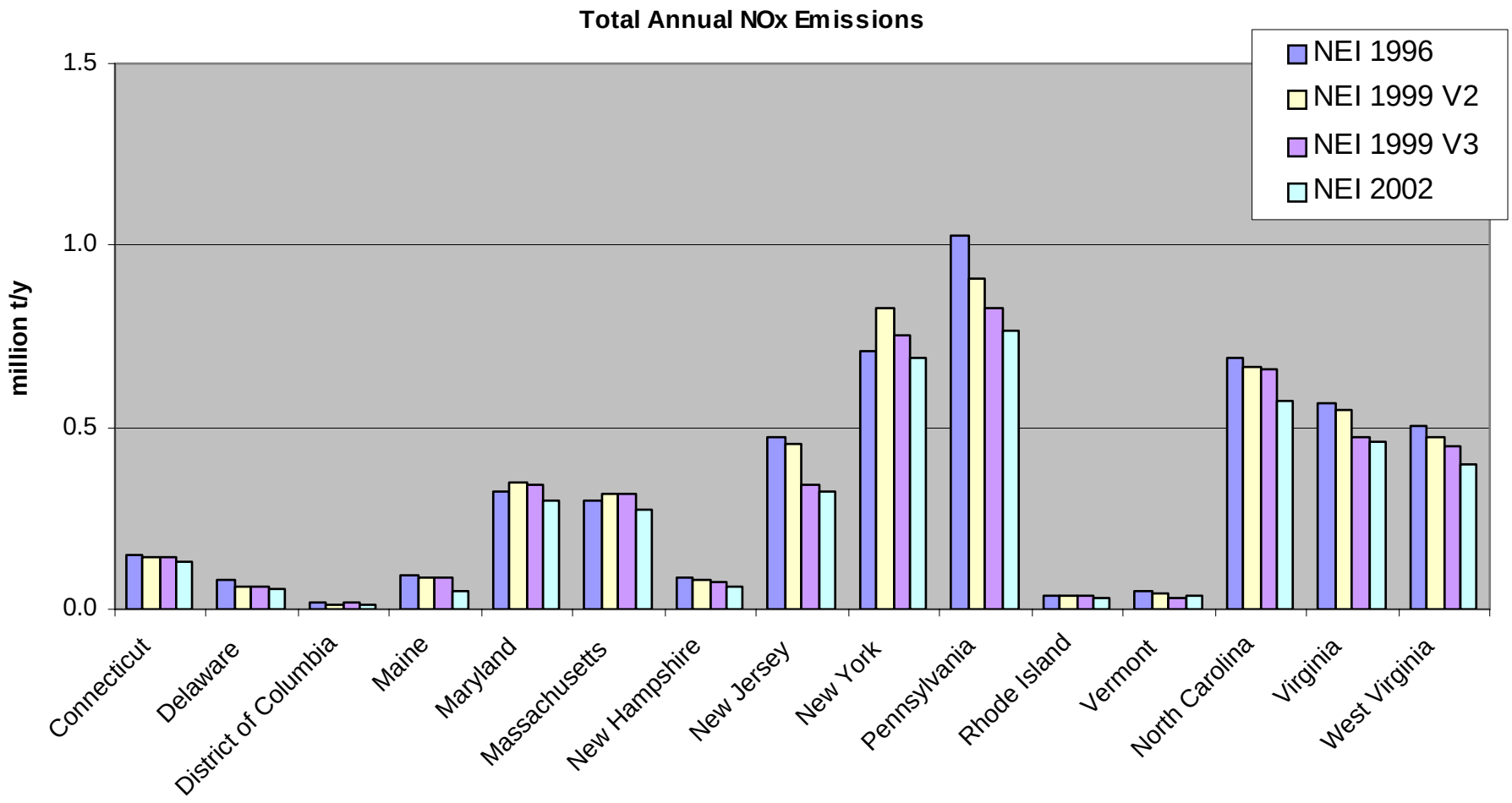
Comparison of 1999v2, 1999v3 and 2002 NEI for MANE-VU



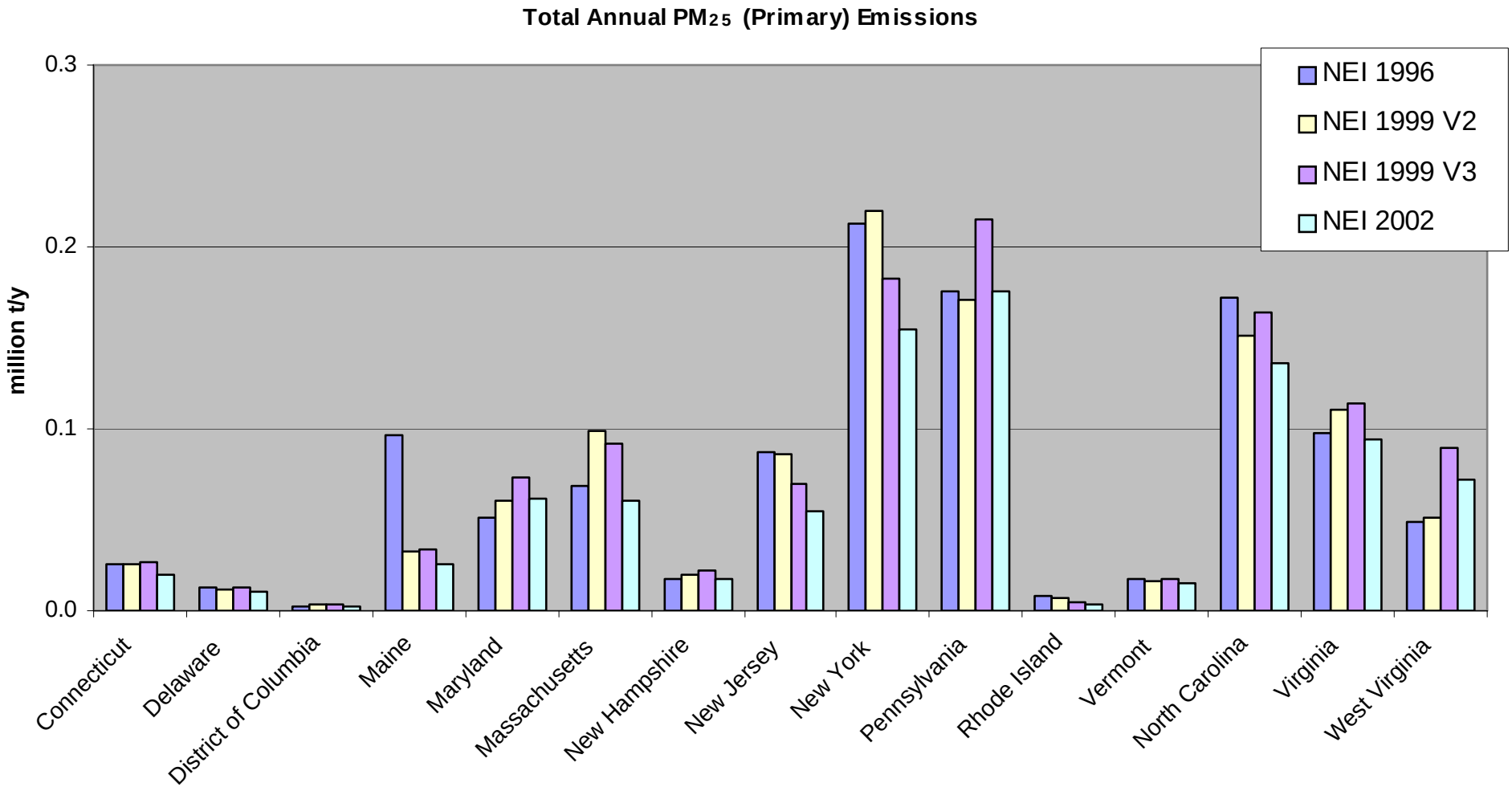
Comparison of 1996, 1999v2, v3 and 2002 NEI total annual NH3 emissions by state



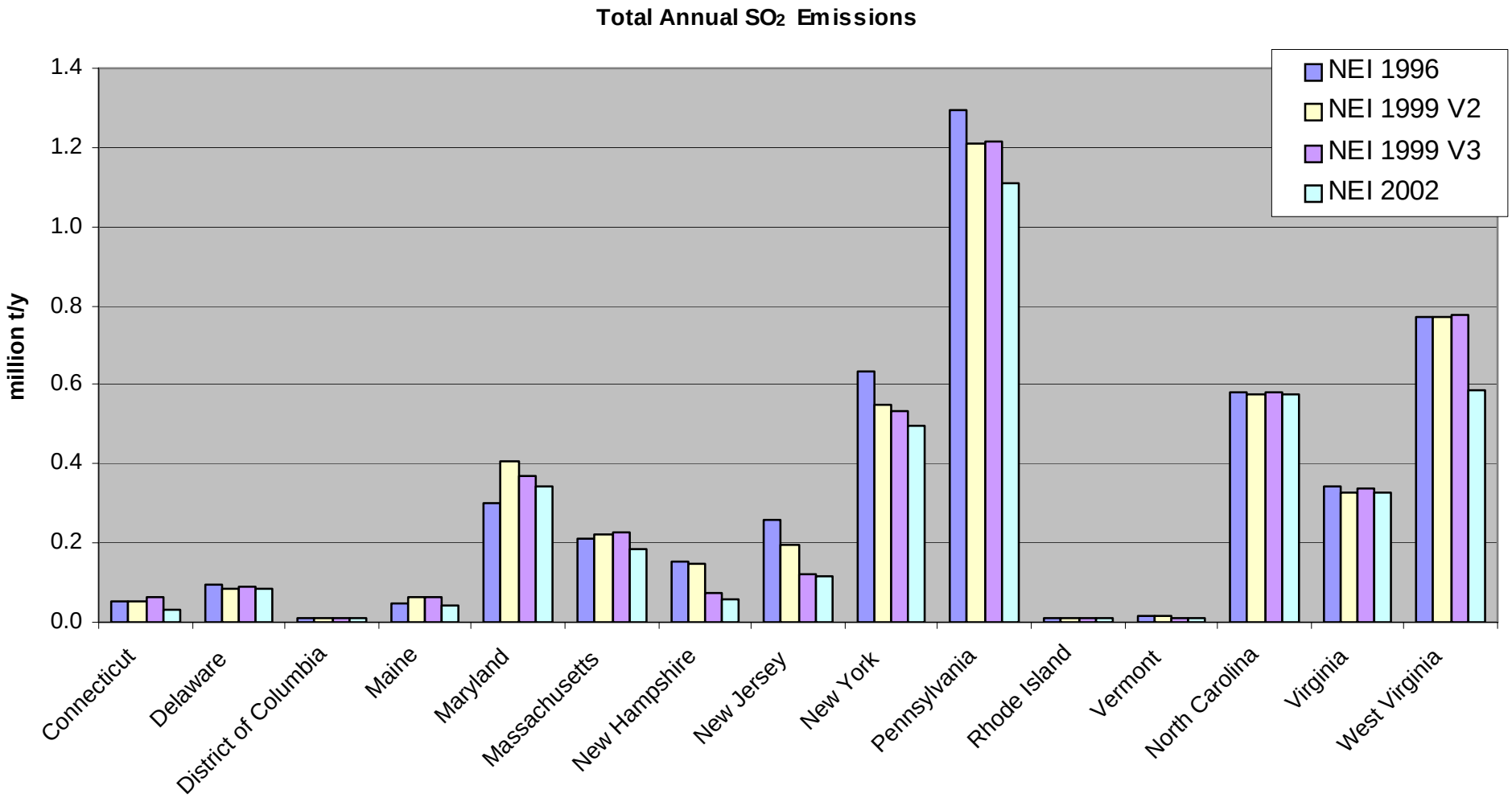
Comparison of 1996, 1999v2, v3 and 2002 NEI total annual NOx emissions by state

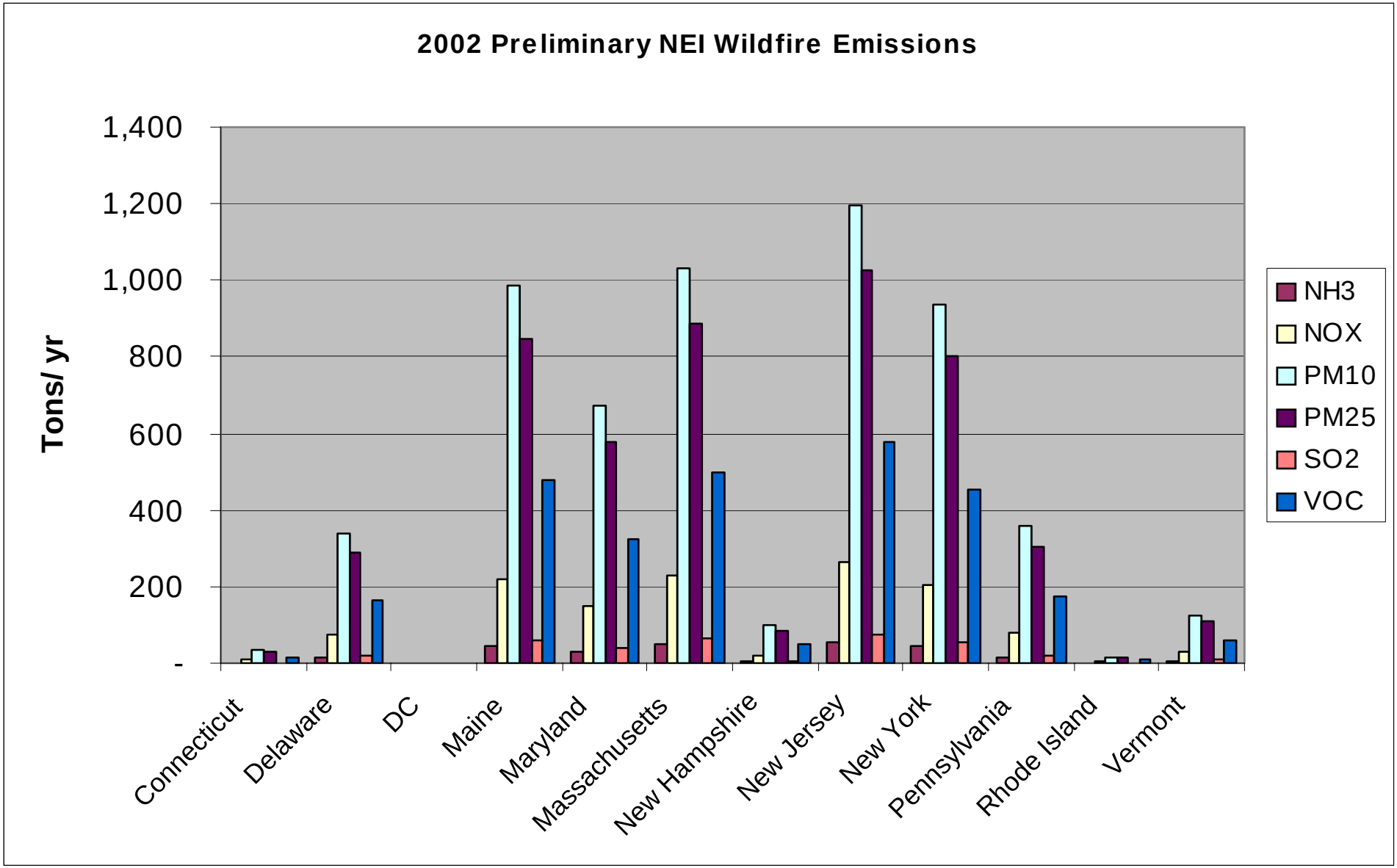


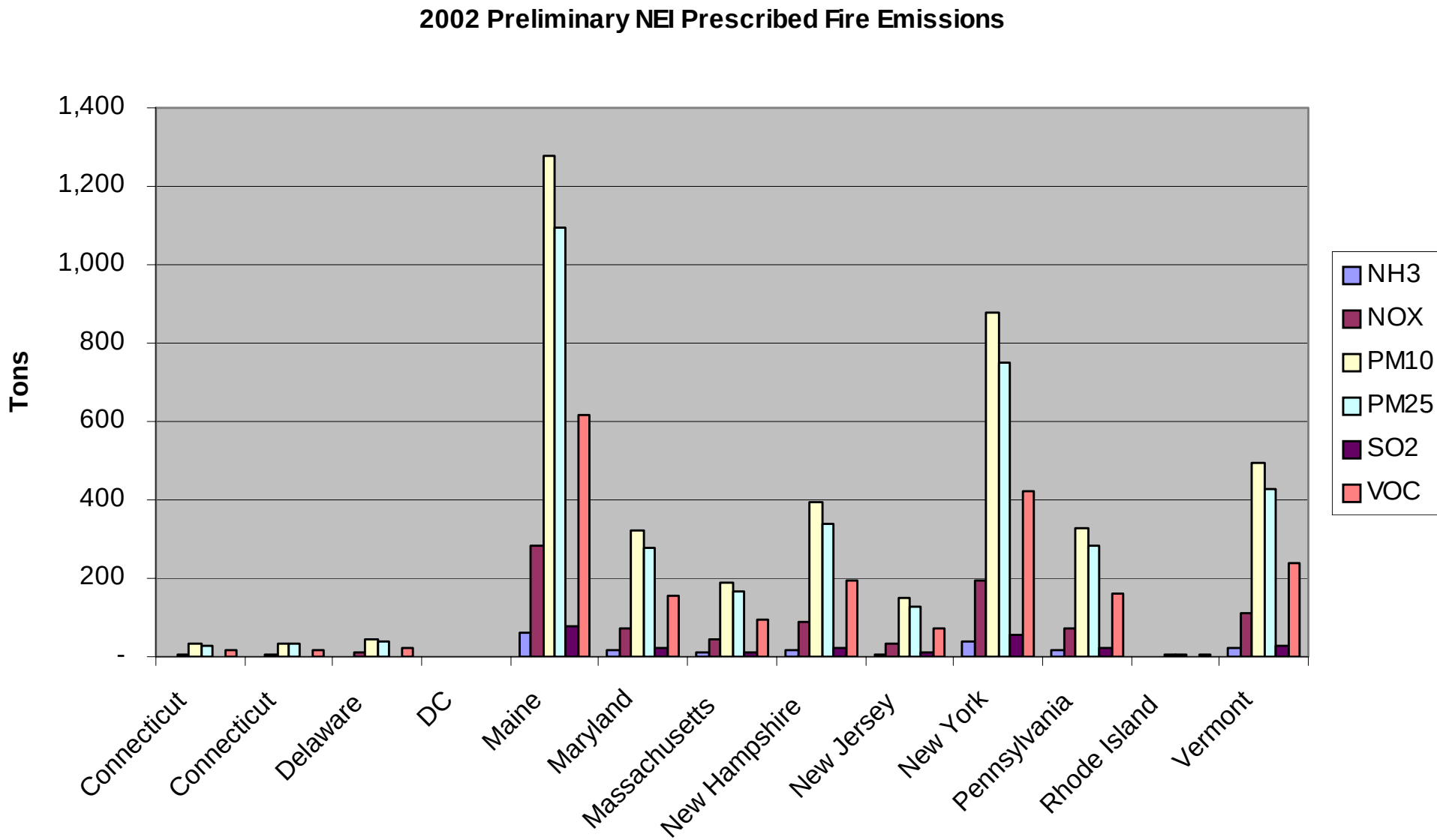
Comparison of 1996, 1999v2, v3 and 2002 NEI total annual PM2.5 (Primary) emissions by state



Comparison of 1996, 1999v2, v3 and 2002 NEI total annual SO_2 emissions by state




2002 Preliminary NEI Wildfire Emissions
Tons/ yr
1,400
1,200
1,000
800
600
400
200
-
Connecticut
Delaware
DC
Maine
Maryland
Massachusetts
New Hampshire
New Jersey
New York
Pennsylvania
Rhode Island
Vermont
NH3
NOX
PM10
PM25
SO2
VOC


2002 Preliminary NEI Prescribed Fire Emissions
Tons
1,400
1,200
1,000
800
600
400
200
-
NH3
NOX
PM10
PM25
SO2
VOC
Connecticut
Connecticut
Delaware
DC
Maine
Maryland
Massachusetts
New Hampshire
New Jersey
New York
Pennsylvania
Rhode Island
Vermont

Conclusions

- QA/QC of emissions inventories is a non-trivial and ambiguous task.
- Emissions modeling tools (SMOKE and EMS) have visualization capabilities, only for the processed emissions.
- Visualization of raw NEI data is beneficial to detect errors, data gaps, abnormalities, and inconsistencies.
- To help detect those problems in preparing 2002 MANE-VU modeling inventory, MARAMA visualized and summarized the Preliminary 2002 NEI.

Conclusions

• Regional totals:	2002	1999
– **Carbon Monoxide:**	17.3 M t/y	19 M t/y
– **Ammonia:**	0.273 M t/y	0.267 M t/y
– **Oxides of Nitrogen:**	2.7 M t/y	3.0 M t/y
– **Particulate Matter:**	1.7 M t/y	2.0 M t/y
– **Fine PM:**	0.6 M t/y	0.75 M t/y
– **Sulfur Dioxide:**	2.5 M t/y	2.8 M t/y
– **VOC:**	2.5 M t/y	3.0 M t/y

Next Steps

- MANE-VU mobile, point and area modeling inventory by the end of 2004
- Inter-RPO Emissions Inventory Database Project (for the Eastern RPOs) in 2005.
- Project management by MARAMA.
- Projection inventories in 2005.

Acknowledgements

- MANE-VU Emissions Inventory workgroup, under the leadership of Ray Malenfant.
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- E. H. Pechan and Associates, Inc.