

# PM Source Apportionment Modeling for PM NAAQS Implementation

AAPCA Fall Meeting  
Raleigh, NC  
August 29, 2024

Gregory Stella  
Alpine Geophysics, LLC

# Implementation Timeline: Designations, SIPs, and Permitting

EPA [memo](#): “Initial Area Designations for the 2024 Revised Primary Annual Fine Particle National Ambient Air Quality Standard” (February 7, 2024)

**May 6, 2024:** Rule effective date; PSD permitting

**January 1, 2025:** Air agencies must notify EPA of intent to submit exceptional events demonstration(s)

**February 7, 2025:** Deadline for states and tribes to submit attainment recommendations based on a five-factor analysis

**February 7, 2025:** Exceptional events demonstrations due with attainment recommendations

**October 9, 2025:** EPA ‘120-day letters’ with initial area designations

**February 6, 2026:** EPA formal attainment designations

-> Option to extend designations process by up to one year

**February 2027:** ‘Infrastructure’ and Good Neighbor SIPs due

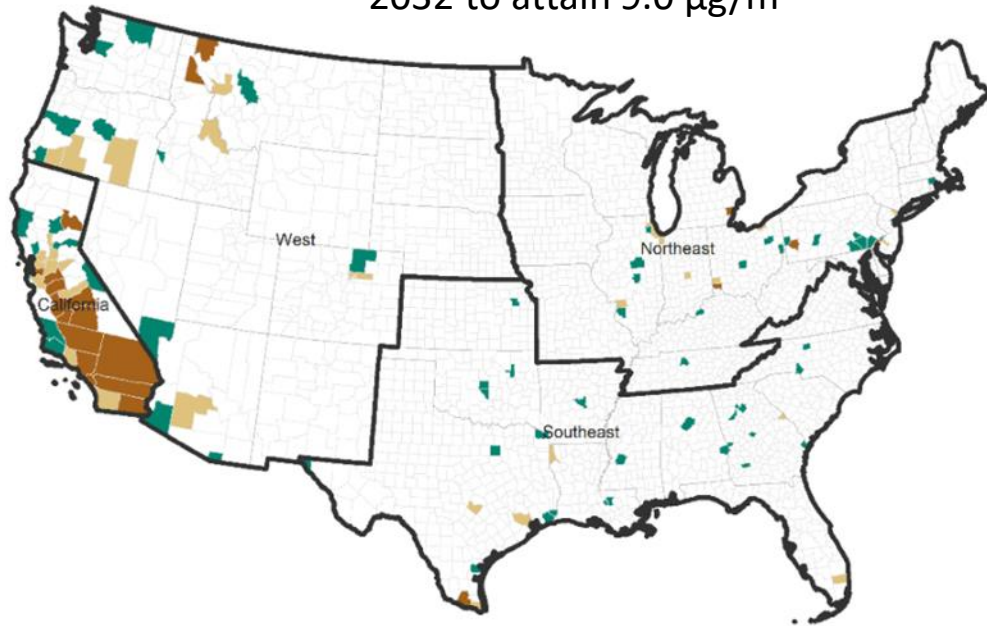
**August 2027:** Nonattainment area SIPs due

**2032:** Attainment deadline for Moderate nonattainment areas

# Nonattainment for PM<sub>2.5</sub> NAAQS at 9.0 µg/m<sup>3</sup>

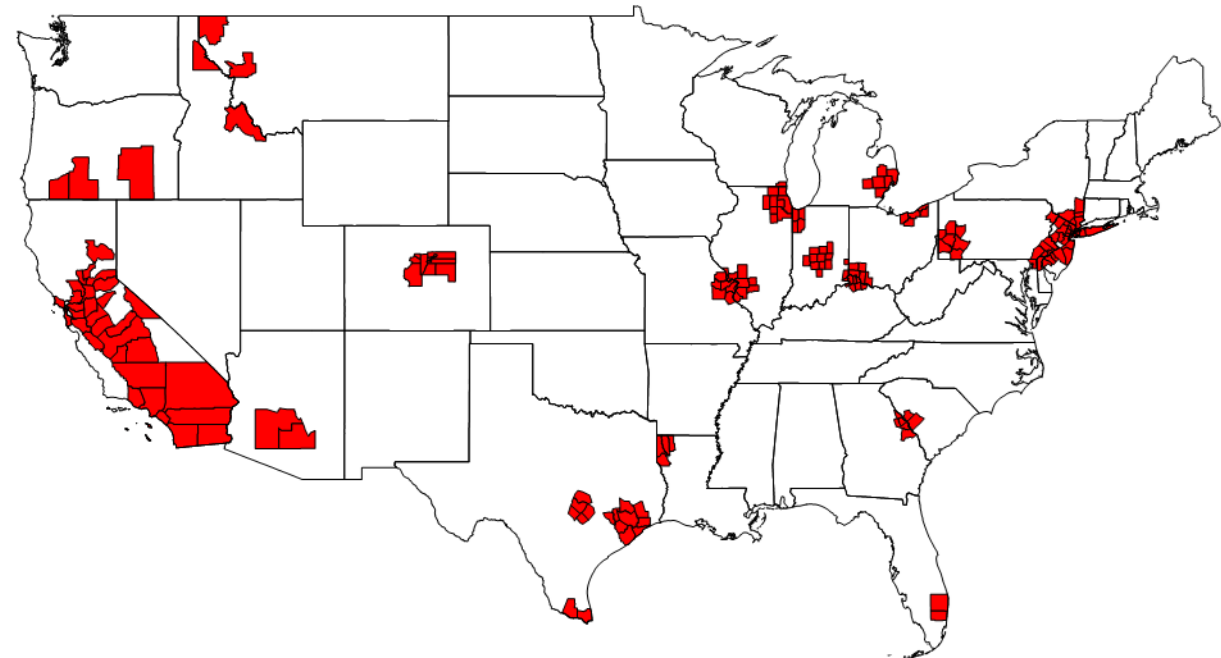
EPA's Monitored County Projection to 2032 (left) and Expanded to CBSAs (right)

EPA says 52 monitored counties would need additional control in 2032 to attain 9.0 µg/m<sup>3</sup>



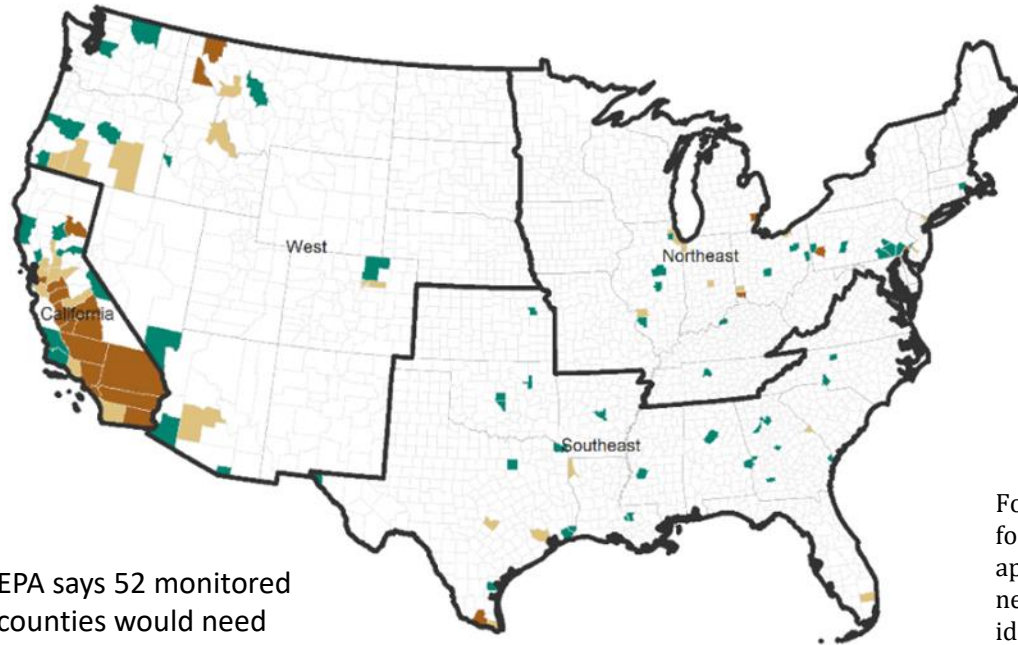
- Reductions required for 10/35, 9/35, and 8/35
- Reductions required for 9/35 and 8/35
- Reductions required for 8/35

187 counties in nonattainment when expanded to CBSA



**Counties Projected to Exceed in Analytical Baseline for the Revised and Alternative Standard Levels of 10/35 µg/m<sup>3</sup>, 9/35 µg/m<sup>3</sup>, and 8/35 µg/m<sup>3</sup>**

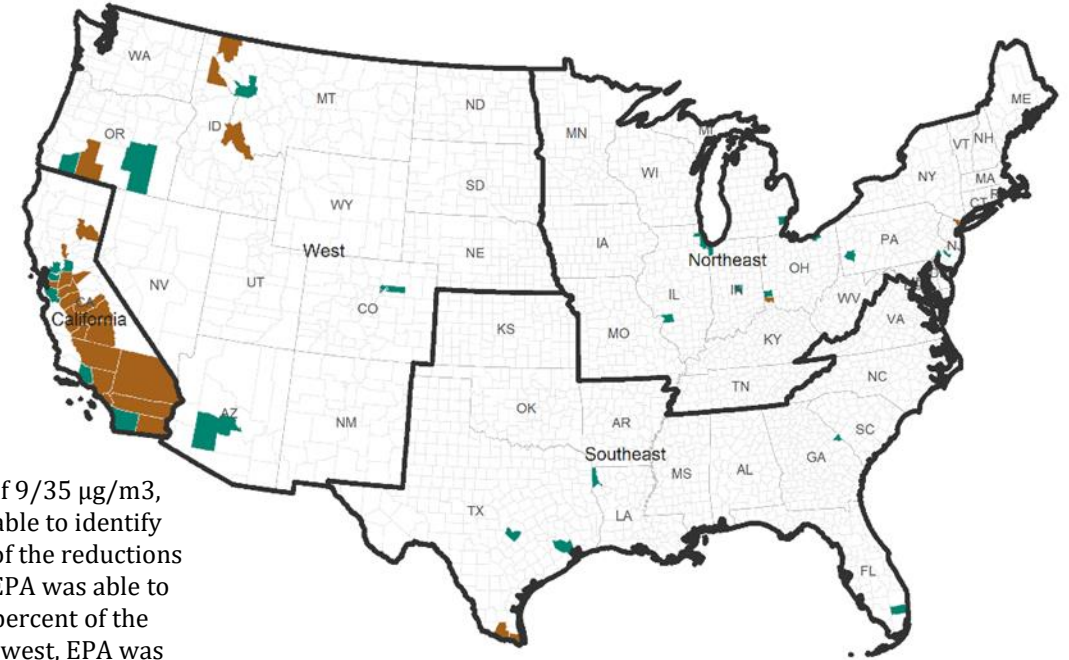
# Counties That Will Still Need Controls in 2032 for PM<sub>2.5</sub> NAAQS at 9.0 µg/m<sup>3</sup>



EPA says 52 monitored counties would need additional control in 2032 to attain 9 µg/m<sup>3</sup>

- Reductions required for 10/35, 9/35, and 8/35
- Reductions required for 9/35 and 8/35
- Reductions required for 8/35

**Counties Projected to Exceed in Analytical Baseline for the Revised and Alternative Standard Levels of 10/35 µg/m<sup>3</sup>, 9/35 µg/m<sup>3</sup>, and 8/35 µg/m<sup>3</sup>**



For the revised standards of 9/35 µg/m<sup>3</sup>, for the northeast EPA was able to identify approximately 98 percent of the reductions needed. For the southeast EPA was able to identify approximately 68 percent of the reductions needed. For the west, EPA was able to identify approximately 44 percent of the reductions needed, and for California the percentage is approximately 26 percent.

- Counties with Sufficient Identified Reductions to Meet 9/35
- Counties Still Needing Reductions to Meet 9/35

**Counties that Still Need PM<sub>2.5</sub> Emissions Reductions for Revised Standard Levels of 9/35 µg/m<sup>3</sup>**

# Project Objective, Processing, Methods, Configuration, Documentation

- Alpine Geophysics adapted an EPA developed nationwide one-atmosphere photochemical grid modeling platform (2016v3 + projections) to assess identified source region and group combinations and to report the relative  $PM_{2.5}$  impact from each of these combinations on downwind monitor locations
- We performed a PM source apportionment modeling run using the Comprehensive Air-quality model with extensions (CAMx) Particulate Matter Source Apportionment Technique (PSAT) algorithms
- *Particulate Source Apportionment Technology Analysis of  $PM_{2.5}$  for Multiple Domains and Categories - Final Report, Alpine Geophysics, July 2024*

<https://www.midwestozonegroup.com/technical-support-documents>

# PSAT Simulation Results

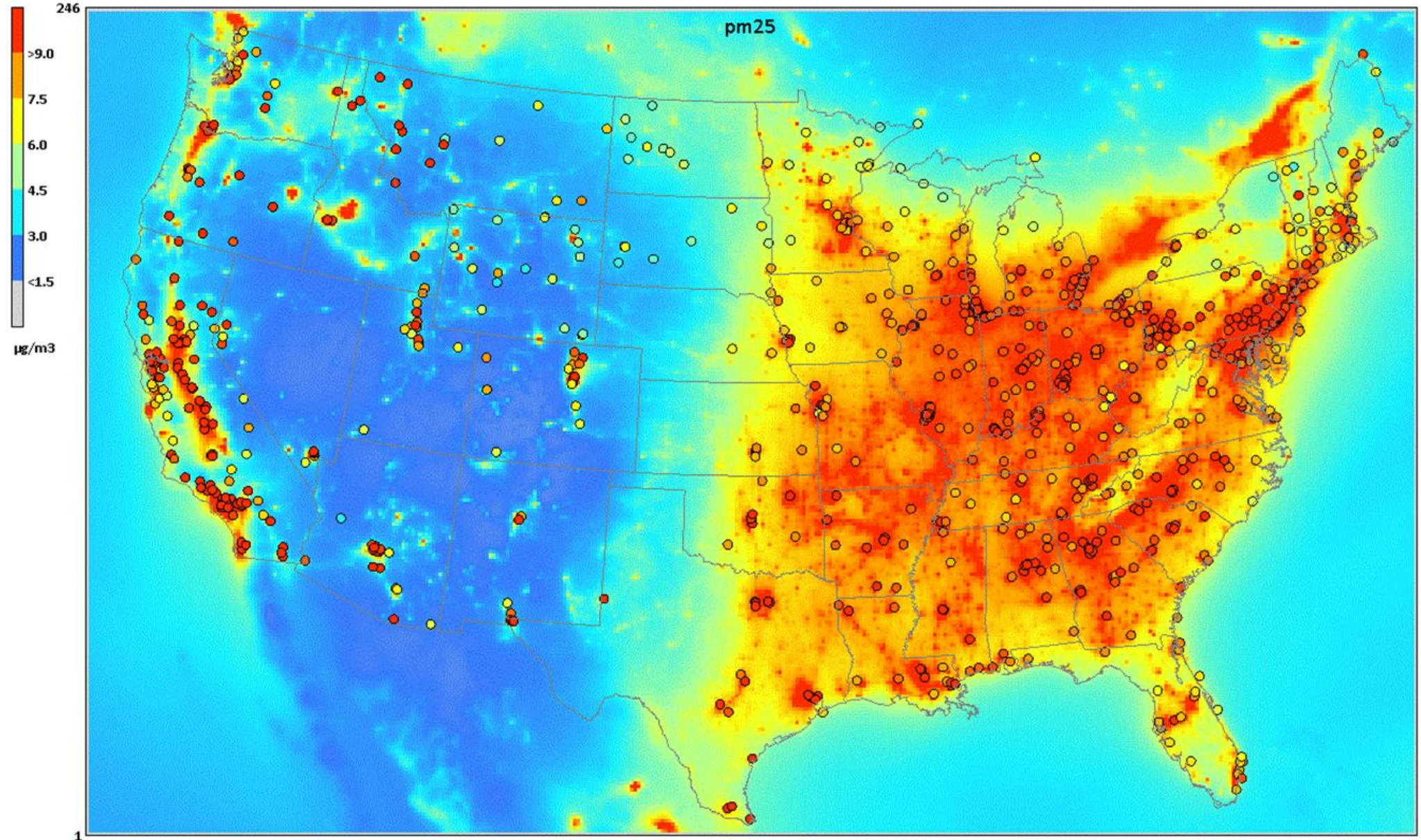
- Base case 2026 DV calculated used EPA methods
- Look at relative contribution of source sector at monitor from modeled concentrations by traced species and as whole
- Relative contribution using EPA attainment test tool (SMAT-CE) and ratio of averaged modeled tag concentration to base case total
  
- Traced Species = sulfate + nitrate + ammonium + OC + EC
- Non-Traced Species = secondary organic aerosols + sea salt + particle bound water + blank mass

# Tagged Source Categories

Ag dust (livestock)	C1 & C2 & C3 Marine	Fertilizer	Petroleum Refineries
Ag dust (tilling)	Canadian & Mexican Anthropogenic	Initial Conditions	Prescribed Fires
Ag Fires	Canadian & Mexican Fires	Lawn & Garden	Pulp & Paper
Ag Nonroad	Cement Manufacturing	Livestock	Railroads
Airports	Coal Fuel Combustion	Mining	Rec Marine
All Other EGUs	Coal-Fired EGUs	Non-diesel Vehicles	Residential Wood Combustion
All Other Fuel Combustion	Commercial Cooking	Oil & Gas	Stationary Non-EGU
Biogenics	Construction	Other Non-Point	Unpaved Roads
Biomass Fuel Combustion	Construction/Industrial	Other Nonroad	Waste Disposal
Boundary Conditions	Diesel Vehicles	Paved Roads	Wildfires

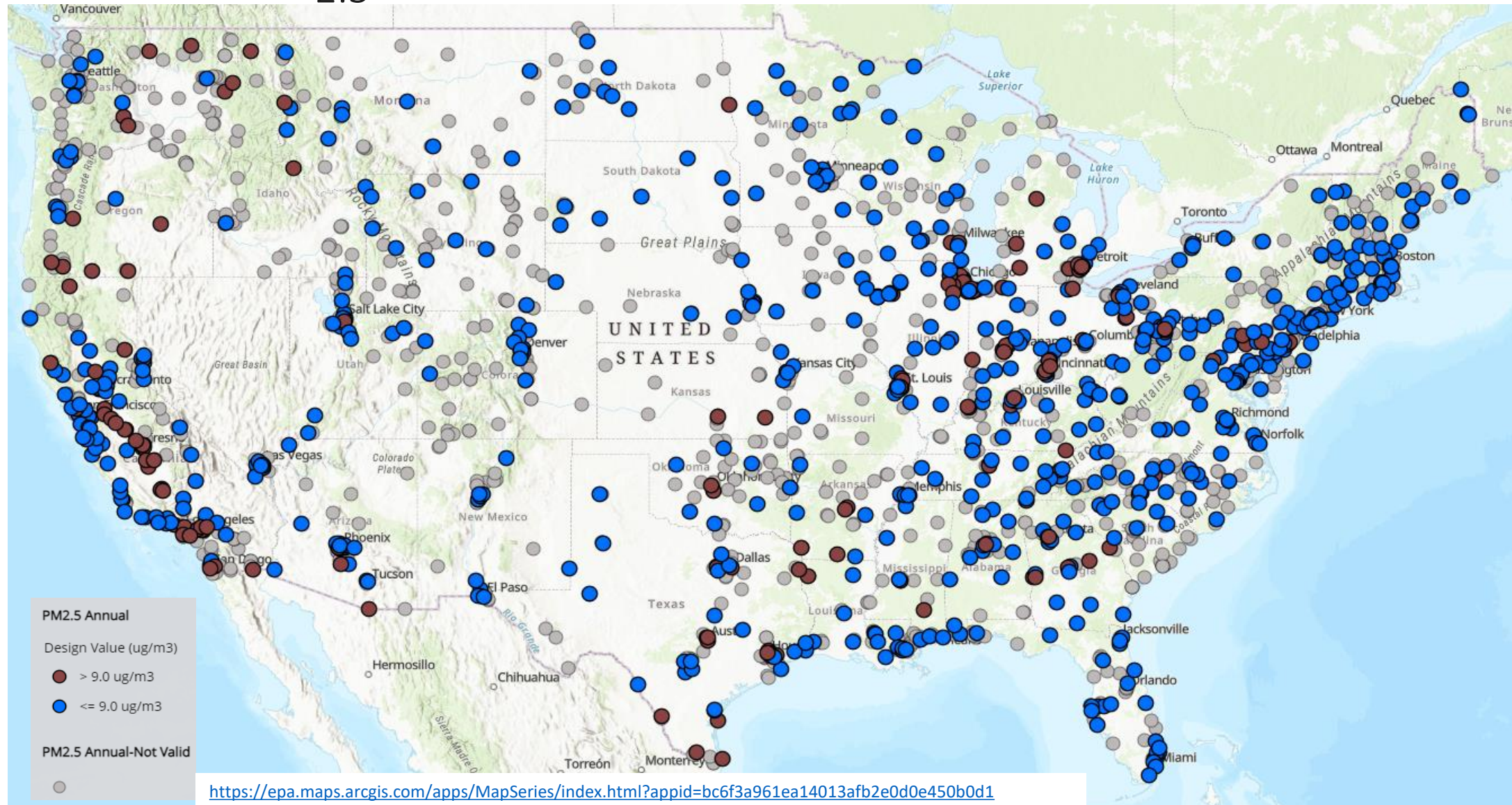


# 2026v3 Projected Annual PM<sub>2.5</sub> DV ( $\mu\text{g}/\text{m}^3$ )





# 2023 Design Value Interactive Map – Annual PM<sub>2.5</sub> Design Values

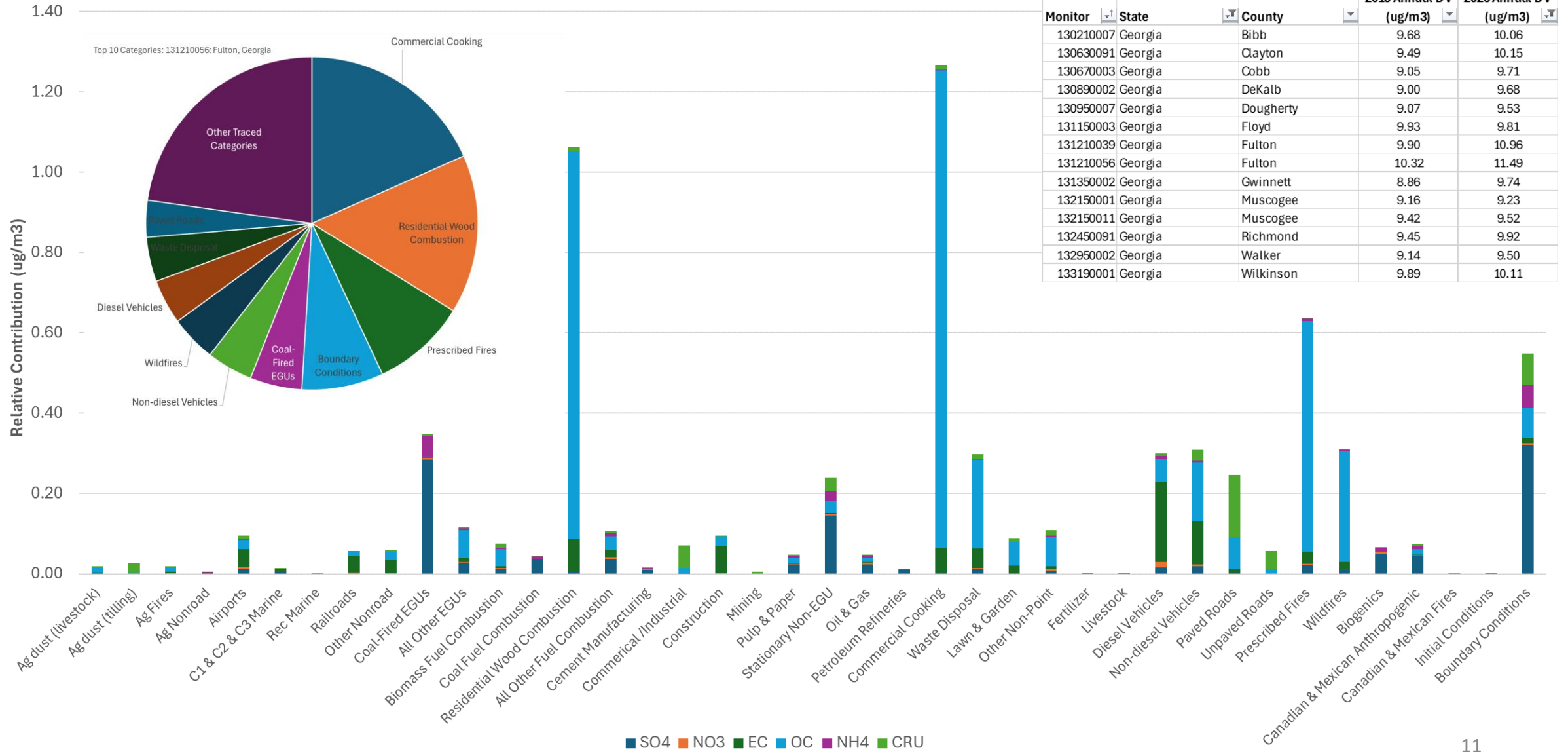


# PSAT Results Analysis

- Processed data to provide speciated relative contribution of contribution by species and category
- Data available for total PM<sub>2.5</sub>, particulate sulfate, particulate nitrate, elemental carbon, organic carbon, and crustal material
- Presentation today focuses on result output which can be generated for all monitors in CONUS modeling domain
  - Appendix B of Alpine's PSAT TSD

# Relative Contribution by PM<sub>2.5</sub> Species and Monitor

131210056: Fulton, Georgia: 2026 Annual PM<sub>2.5</sub> DV (ug/m<sup>3</sup>) ->11.49



# Top 10 Relative Contributing Categories and Traced PM<sub>2.5</sub> Species

131210056: Fulton, Georgia		2026 Annual PM2.5 DV (ug/m3) ->						11.49
Relative Contribution (ug/m3)								
Top 10 Categories	Species Total	SO4	NO3	EC	OC	NH4	CRU	
Commercial Cooking	1.267	0.003	0.000	0.062	1.188	0.001	0.012	
Residential Wood Combustion	1.063	0.006	0.001	0.081	0.964	0.001	0.010	
Prescribed Fires	0.637	0.023	0.003	0.030	0.574	0.005	0.002	
Boundary Conditions	0.549	0.319	0.006	0.012	0.075	0.059	0.078	
Coal-Fired EGUs	0.349	0.284	0.005	0.002	0.001	0.049	0.007	
Non-diesel Vehicles	0.310	0.018	0.006	0.107	0.148	0.005	0.026	
Wildfires	0.309	0.012	0.001	0.016	0.277	0.002	0.000	
Diesel Vehicles	0.300	0.017	0.013	0.199	0.057	0.007	0.007	
Waste Disposal	0.298	0.013	0.001	0.050	0.220	0.003	0.011	
Paved Roads	0.246	0.004	0.000	0.009	0.080	0.001	0.153	
SO4 = Particulate Sulfate								
NO3 = Particulate Nitrate								
EC = Elemental Carbon								
OC= Organic Carbon								
NH4 = Ammonium								
CRU = Crustal Material								



**Table 3-7 Summary of Estimated PM<sub>2.5</sub> Emissions Reductions from CoST by Inventory Source Classification Code Sectors for Alternative Primary Standard Levels of 10/35 µg/m<sup>3</sup>, 10/30 µg/m<sup>3</sup>, 9/35 µg/m<sup>3</sup>, and 8/35 µg/m<sup>3</sup> in 2032 (tons/year)**

Sector	SCC Sector	10/35	10/30	9/35	8/35
Non-EGU Point	Agriculture - Livestock Waste	0	6.2	6.8	6.8
	Fuel Combustion - Commercial/Institutional Boilers - Biomass	0	0	0	15.6
	Fuel Combustion - Commercial/Institutional Boilers - Coal	0	0	8.0	8.0
	Fuel Combustion - Commercial/Institutional Boilers - Natural Gas	0	0	0	85.9
	Fuel Combustion - Commercial/Institutional Boilers - Other	64.7	64.7	64.7	69.8
	Fuel Combustion - Industrial Boilers, ICES - Biomass	0	76.0	5.2	402.2
	Fuel Combustion - Industrial Boilers, ICES - Coal	0	0	16.4	211.2
	Fuel Combustion - Industrial Boilers, ICES - Natural Gas	6.1	75.4	81.7	405.8
	Fuel Combustion - Industrial Boilers, ICES - Oil	0	0	0	18.1
	Fuel Combustion - Industrial Boilers, ICES - Other	110.9	140.7	689.5	1,023.9
	Industrial Processes - Cement Manufacturing	0	0	89.8	688.5
	Industrial Processes - Chemical Manufacturing	29.3	40.3	136.5	953.8
	Industrial Processes - Ferrous Metals	142.8	150.1	836.0	2,378.0
	Industrial Processes - Mining	0	7.4	239.4	326.9
	Industrial Processes - Non-ferrous Metals	55.9	55.9	502.1	918.0
	Industrial Processes - Not Elsewhere Classified	304.3	456.1	2,169.9	6,818.0
	Industrial Processes - Petroleum Refineries	178.5	216.6	875.8	2,204.2
	Industrial Processes - Pulp & Paper	0	18.3	119.5	848.1
	Industrial Processes - Storage and Transfer	8.9	18.0	186.7	887.4
	Waste Disposal - Excavation/Soils Handling	0	0	0	5.8
Waste Disposal - General Processes	0	0	7.0	7.0	
Waste Disposal - Landfill Dump	0	0	0	5.5	
Oil & Gas Point	Industrial Processes - Not Elsewhere Classified	0	0	0	3.6
	Industrial Processes - Oil & Gas Production	0	0	0	54.9
	Industrial Processes - Petroleum Refineries	0	0	0	1.8

*“For the revised standard levels of 9/35 µg/m<sup>3</sup>, the inventory sectors with the most potentially controllable emissions are the non-point (area) and area fugitive dust sectors.”*  
 – PM NAAQS RIA

Sector	SCC Sector	10/35	10/30	9/35	8/35
Non-Point (Area)	Commercial Cooking	950.2	1,176.5	2,336.9	6,823.5
	Fuel Combustion - Commercial/Institutional Boilers - Biomass	16.3	20.2	52.8	258.6
	Fuel Combustion - Commercial/Institutional Boilers - Coal	0	0	0	0.5
	Fuel Combustion - Commercial/Institutional Boilers - Natural Gas	18.9	22.2	49.8	95.5
	Fuel Combustion - Commercial/Institutional Boilers - Oil	0	0	3.0	14.4
	Fuel Combustion - Industrial Boilers, ICES - Biomass	66.0	103.3	345.0	1,499.0
	Fuel Combustion - Industrial Boilers, ICES - Coal	0	2.4	17.8	39.1
	Fuel Combustion - Industrial Boilers, ICES - Natural Gas	4.0	4.0	32.7	65.5
	Fuel Combustion - Industrial Boilers, ICES - Oil	1.0	1.0	1.0	5.4
	Fuel Combustion - Industrial Boilers, ICES - Other	2.0	2.0	2.0	2.0
	Industrial Processes - Chemical Manufacturing	0	0	77.4	199.1
	Waste Disposal - All Categories	603.2	880.0	2,641.3	14,623.5
	Waste Disposal - Residential	109.2	360.5	709.7	3,725.4
	Residential Wood Combustion	296.2	555.6	1,275.9	4,193.4
Area Source Fugitive Dust	Dust - Paved Road Dust	199.9	611.0	768.9	4,903.3
	Dust - Unpaved Road Dust	392.7	1,319.3	861.3	6,523.6
Total		3,561.0	6,383.7	15,210.0	61,320.7

Source: [https://www.epa.gov/system/files/documents/2024-02/naaqs\\_pm\\_reconsideration\\_ria\\_final.pdf](https://www.epa.gov/system/files/documents/2024-02/naaqs_pm_reconsideration_ria_final.pdf)

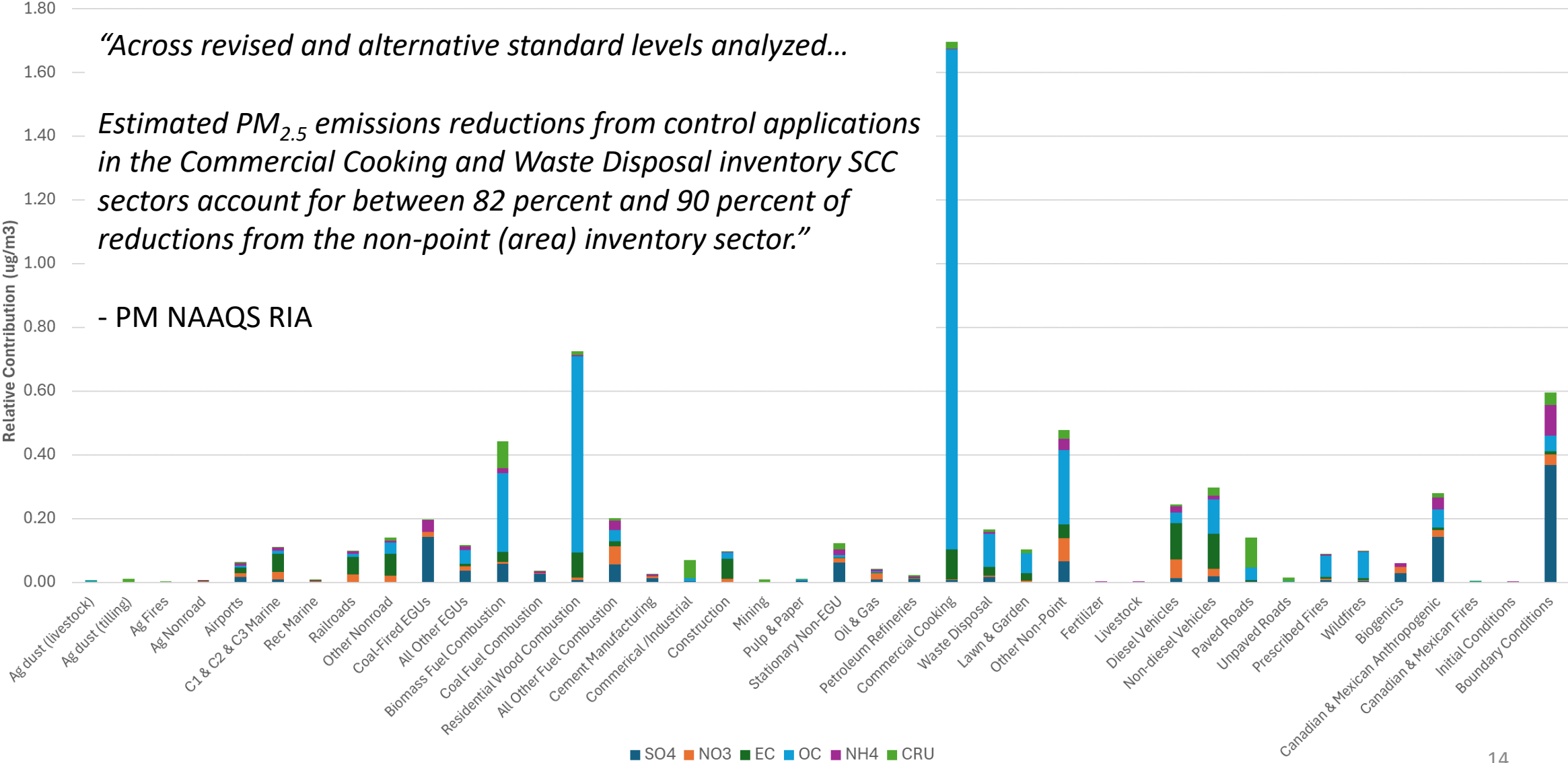
# Relative Contribution by PM<sub>2.5</sub> Species and Monitor

340030003: Bergen, New Jersey: 2026 Annual PM2.5 DV (ug/m3) ->9.71

*“Across revised and alternative standard levels analyzed...”*

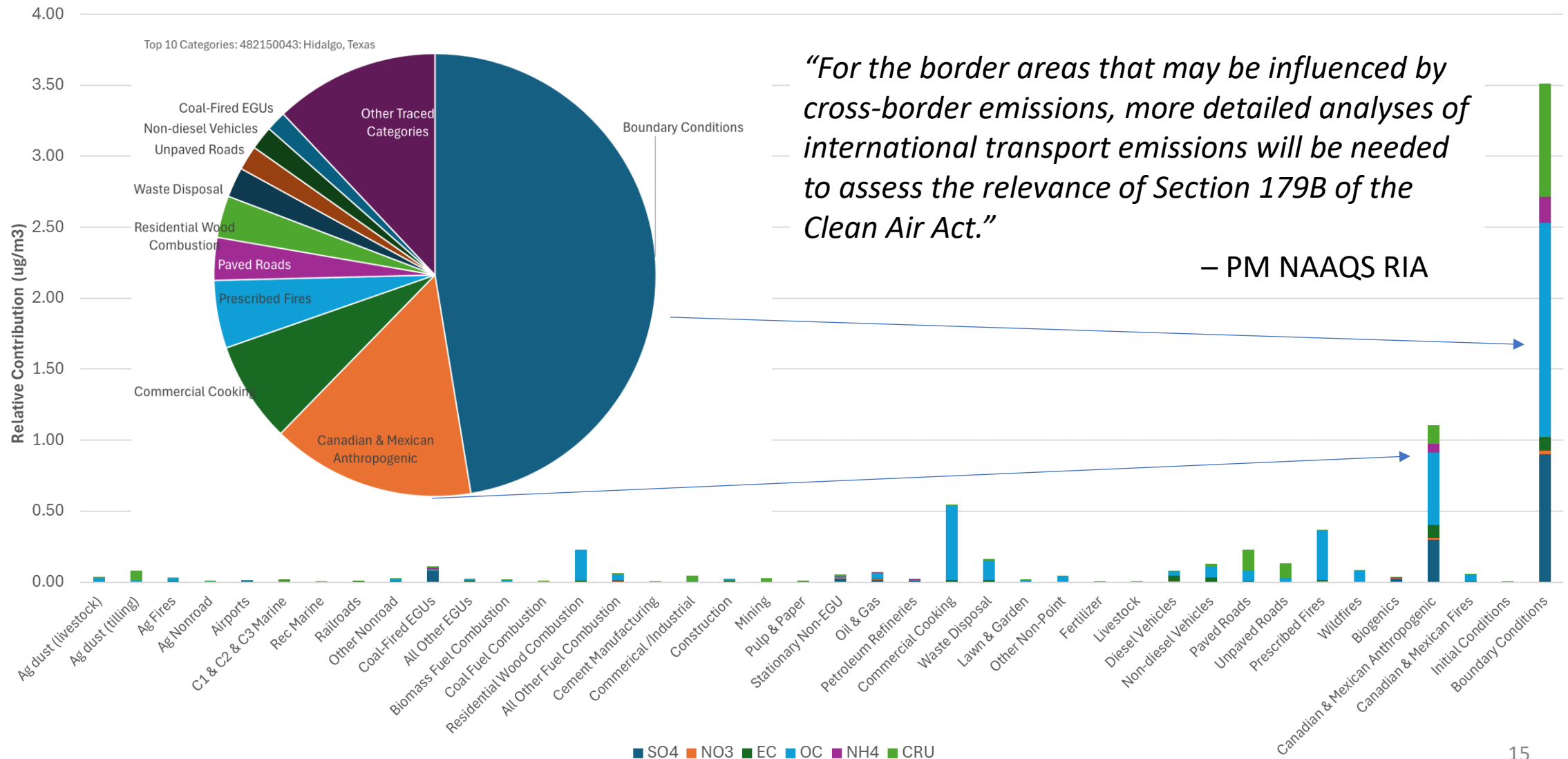
*Estimated PM<sub>2.5</sub> emissions reductions from control applications in the Commercial Cooking and Waste Disposal inventory SCC sectors account for between 82 percent and 90 percent of reductions from the non-point (area) inventory sector.”*

- PM NAAQS RIA



# Relative Contribution by PM<sub>2.5</sub> Species and Monitor

482150043: Hidalgo, Texas: 2026 Annual PM<sub>2.5</sub> DV (ug/m3) ->11.14



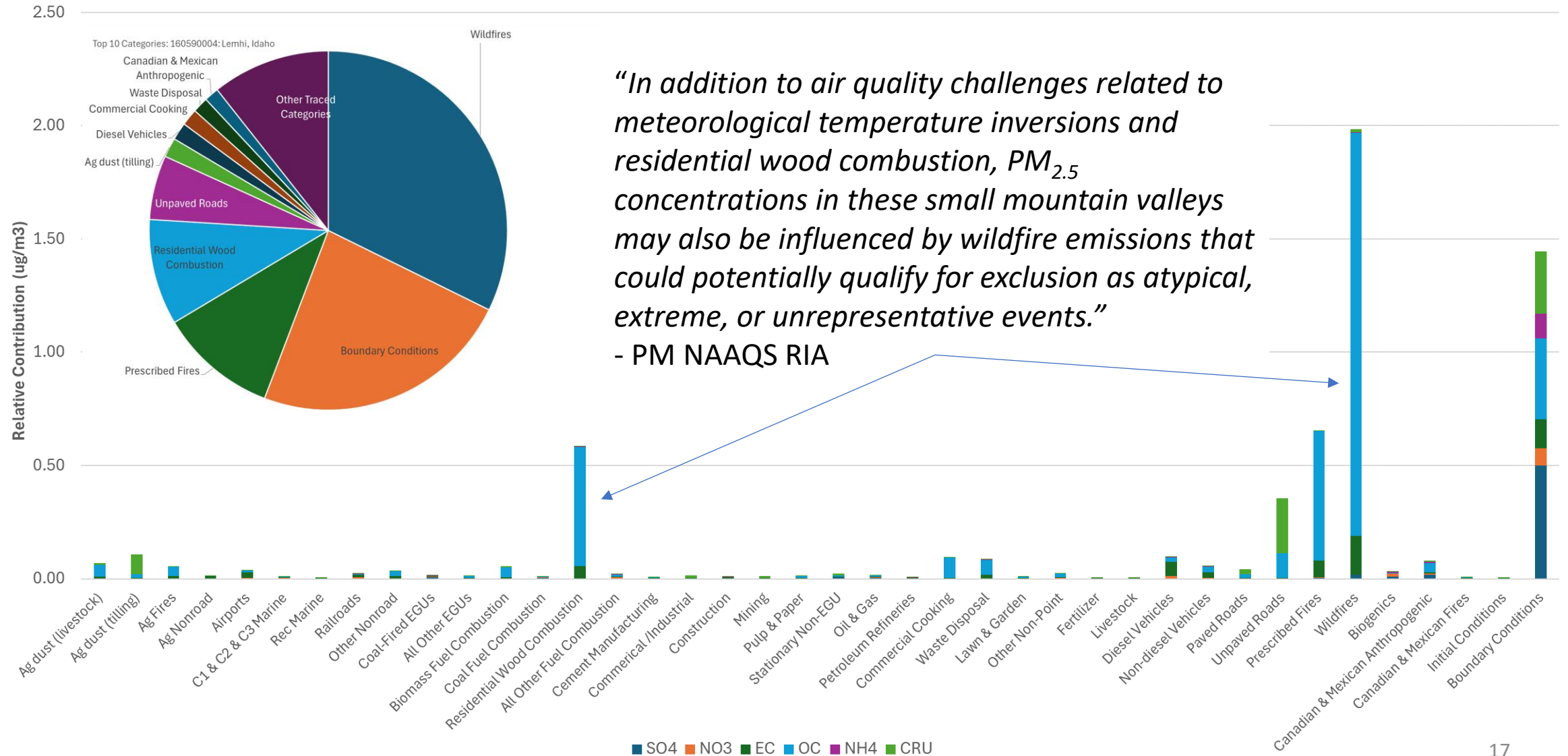
# Top 10 Relative Contributing Categories and Traced PM<sub>2.5</sub> Species

482150043: Hidalgo, Texas		2026 Annual PM2.5 DV (ug/m3) ->						11.14
Relative Contribution (ug/m3)								
Top 10 Categories	Species Total	SO4	NO3	EC	OC	NH4	CRU	
Boundary Conditions	3.513	0.900	0.026	0.094	1.507	0.185	0.800	
Canadian & Mexican Anthropogenic	1.105	0.298	0.013	0.093	0.508	0.063	0.129	
Commercial Cooking	0.546	0.000	0.000	0.013	0.527	0.000	0.006	
Prescribed Fires	0.367	0.004	0.000	0.009	0.350	0.001	0.002	
Paved Roads	0.231	0.001	0.000	0.004	0.075	0.000	0.150	
Residential Wood Combustion	0.227	0.000	0.000	0.009	0.215	0.000	0.003	
Waste Disposal	0.163	0.002	0.000	0.015	0.132	0.000	0.013	
Unpaved Roads	0.132	0.001	0.000	0.000	0.027	0.000	0.104	
Non-diesel Vehicles	0.128	0.003	0.001	0.027	0.080	0.001	0.016	
Coal-Fired EGUs	0.109	0.082	0.001	0.001	0.003	0.016	0.005	
SO4 = Particulate Sulfate								
NO3 = Particulate Nitrate								
EC = Elemental Carbon								
OC= Organic Carbon								
NH4 = Ammonium								
CRU = Crustal Material								



# Relative Contribution by PM<sub>2.5</sub> Species and Monitor

160590004: Lemhi, Idaho: 2026 Annual PM<sub>2.5</sub> DV (ug/m<sup>3</sup>) ->12.53



*“In addition to air quality challenges related to meteorological temperature inversions and residential wood combustion, PM<sub>2.5</sub> concentrations in these small mountain valleys may also be influenced by wildfire emissions that could potentially qualify for exclusion as atypical, extreme, or unrepresentative events.”*

- PM NAAQS RIA

# Top 10 Relative Contributing Categories and Traced PM<sub>2.5</sub> Species

160590004: Lemhi, Idaho		2026 Annual PM2.5 DV (ug/m3) ->						12.53
Relative Contribution (ug/m3)								
Top 10 Categories	Species Total	SO4	NO3	EC	OC	NH4	CRU	
Wildfires	1.984	0.019	0.000	0.169	1.780	0.004	0.012	
Boundary Conditions	1.445	0.499	0.077	0.127	0.358	0.109	0.274	
Prescribed Fires	0.655	0.005	0.001	0.074	0.573	0.001	0.001	
Residential Wood Combustion	0.586	0.001	0.001	0.055	0.527	0.000	0.003	
Unpaved Roads	0.356	0.002	0.000	0.003	0.108	0.000	0.243	
Ag dust (tilling)	0.108	0.000	0.000	0.003	0.019	0.000	0.086	
Diesel Vehicles	0.097	0.000	0.011	0.064	0.018	0.003	0.001	
Commercial Cooking	0.093	0.000	0.000	0.005	0.087	0.000	0.000	
Waste Disposal	0.087	0.001	0.000	0.017	0.066	0.000	0.002	
Canadian & Mexican Anthropogenic	0.081	0.016	0.006	0.008	0.040	0.005	0.006	
SO4 = Particulate Sulfate								
NO3 = Particulate Nitrate								
EC = Elemental Carbon								
OC = Organic Carbon								
NH4 = Ammonium								
CRU = Crustal Material								

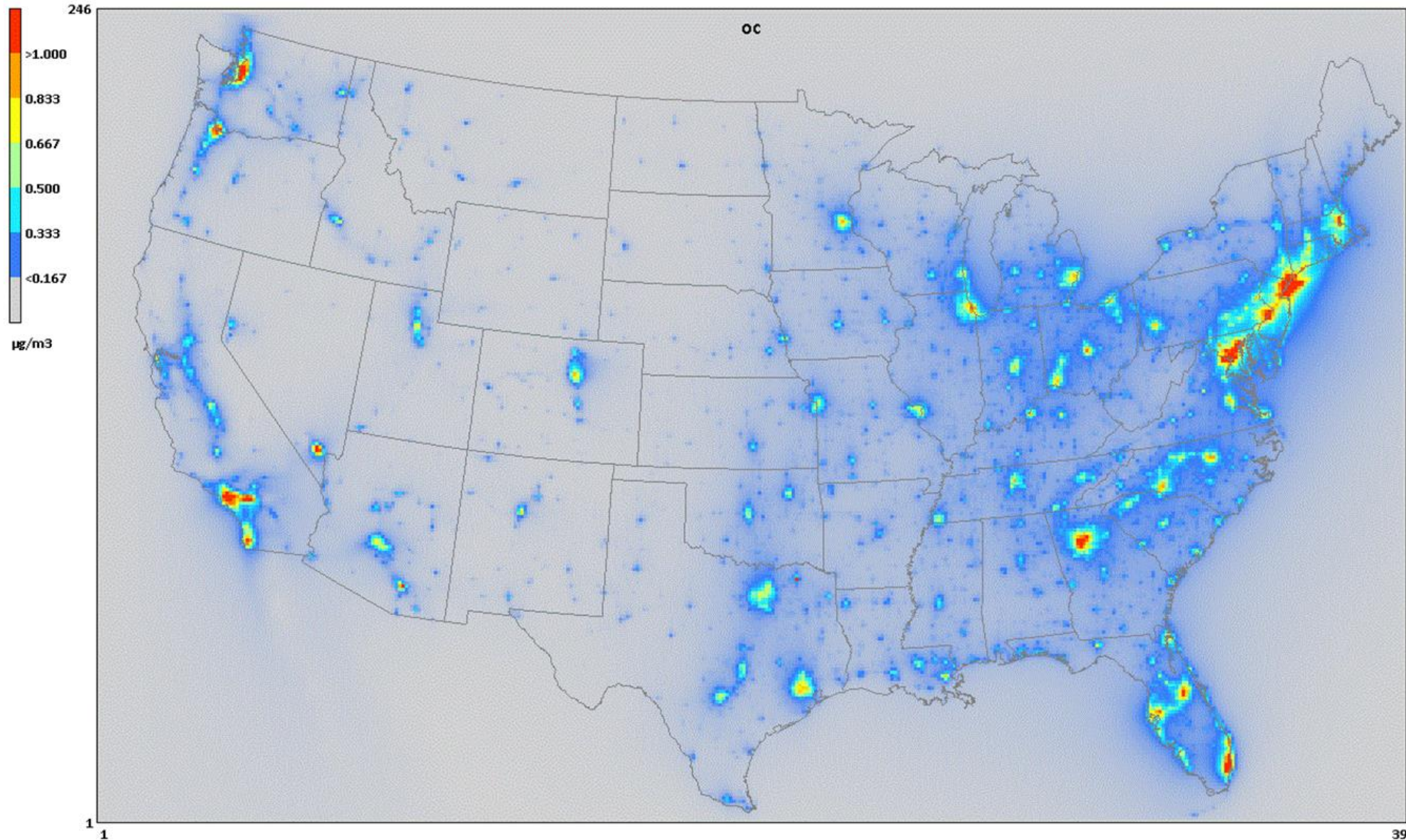
# Frequency of Category Modeled in Top 10

Category	Number of Times in Top 10			
	All Conc #	All Conc %	> 9.0 $\mu\text{g}/\text{m}^3$ #	> 9.0 $\mu\text{g}/\text{m}^3$ %
All Monitors	834	-	306	-
Boundary Conditions	834	100%	306	100%
Residential Wood Combustion	818	98%	303	99%
Commercial Cooking	669	80%	296	97%
Waste Disposal	643	77%	216	71%
Coal-Fired EGUs	614	74%	196	64%
Prescribed Fires	582	70%	186	61%
Stationary non-EGUs	555	67%	188	61%
Wildfires	480	58%	182	59%
Can/Mex Anthropogenic	432	52%	111	36%
Biomass Fuel Combustion	373	45%	147	48%
Diesel Vehicles	373	45%	170	56%
Non-Diesel Vehicles	318	38%	163	53%



# Species-Category Specific Relative Modeled Contribution

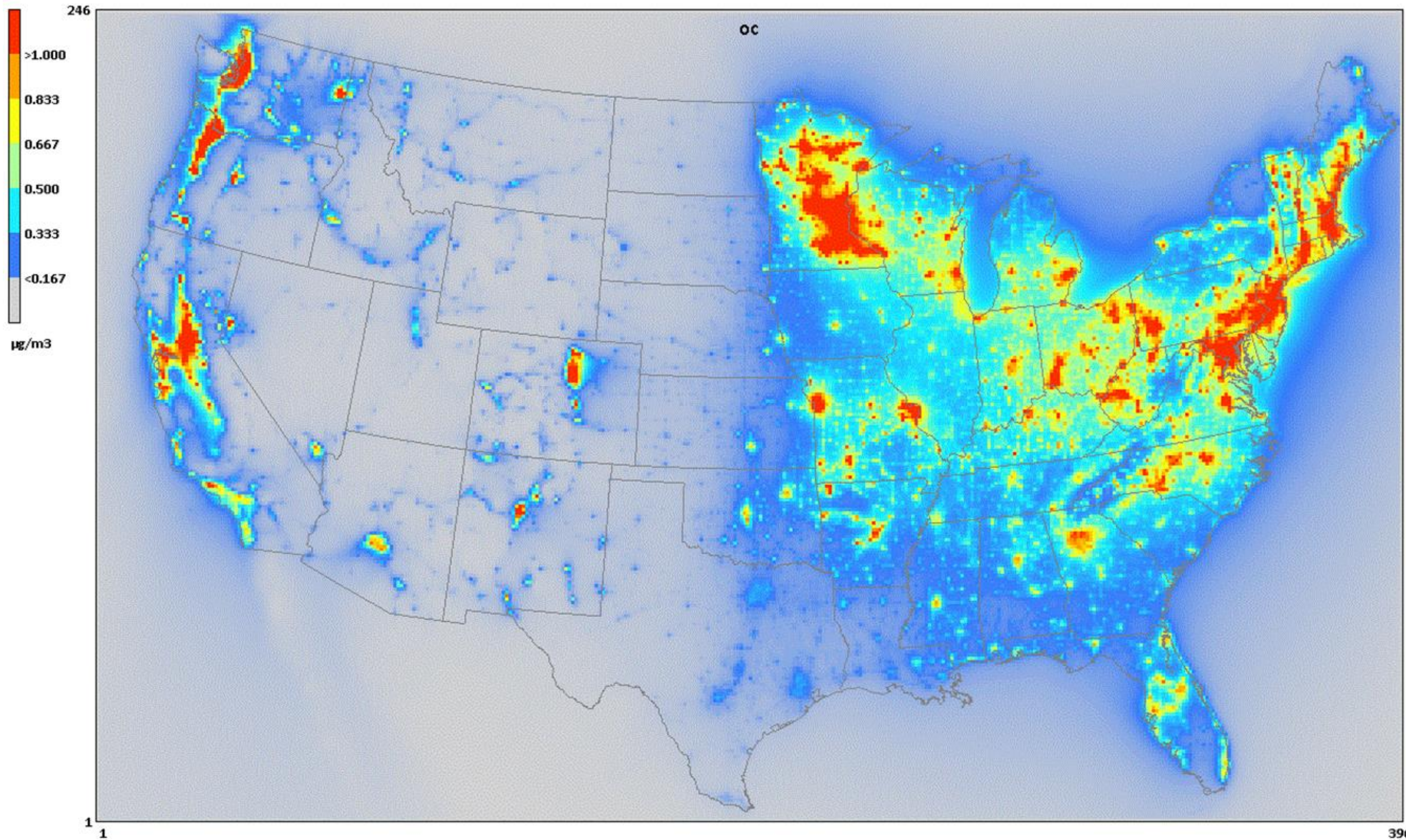
## Example: Organic Carbon from Commercial Cooking





# Species-Category Specific Relative Modeled Contribution

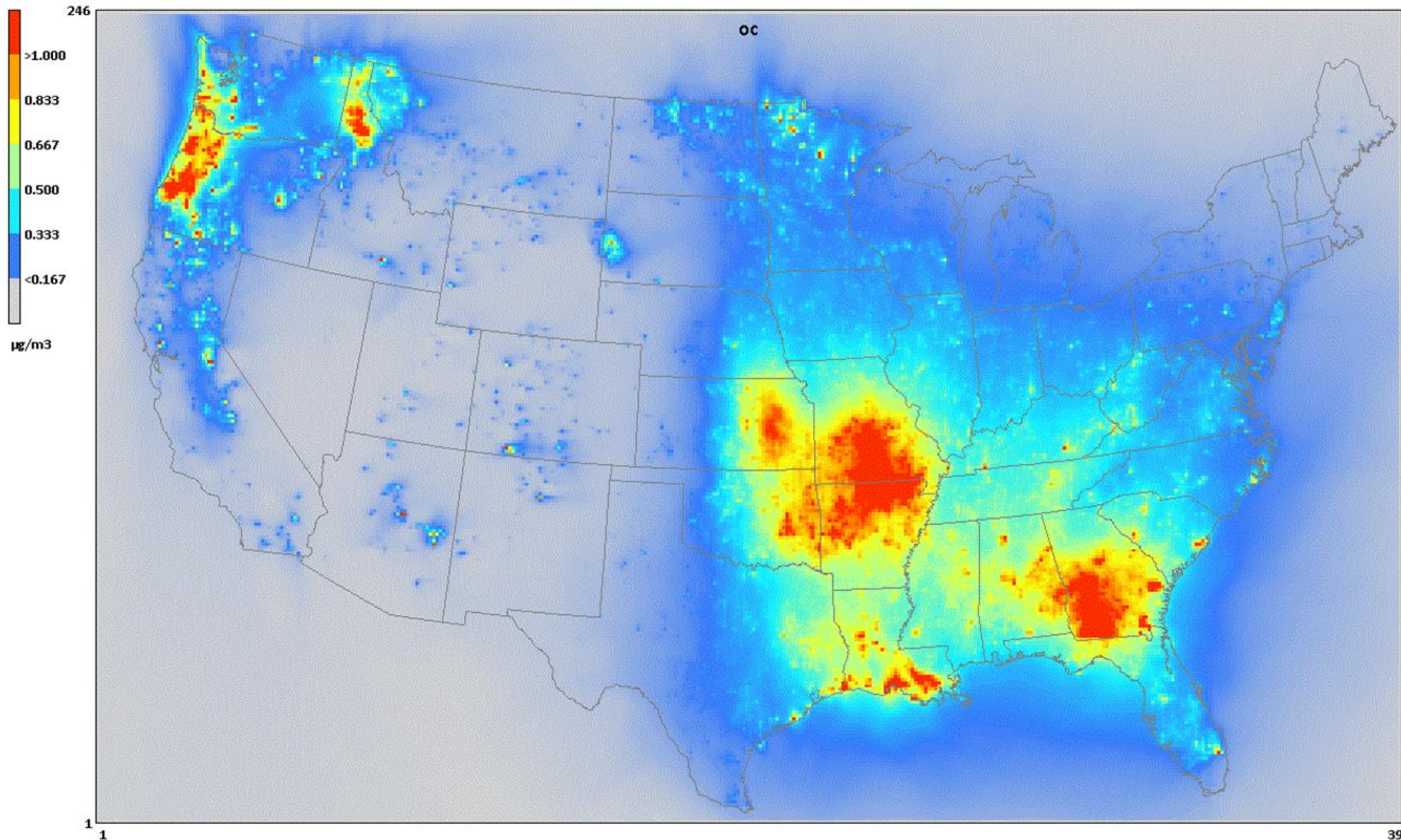
## Example: Organic Carbon from Residential Wood Combustion





# Species-Category Specific Relative Modeled Contribution

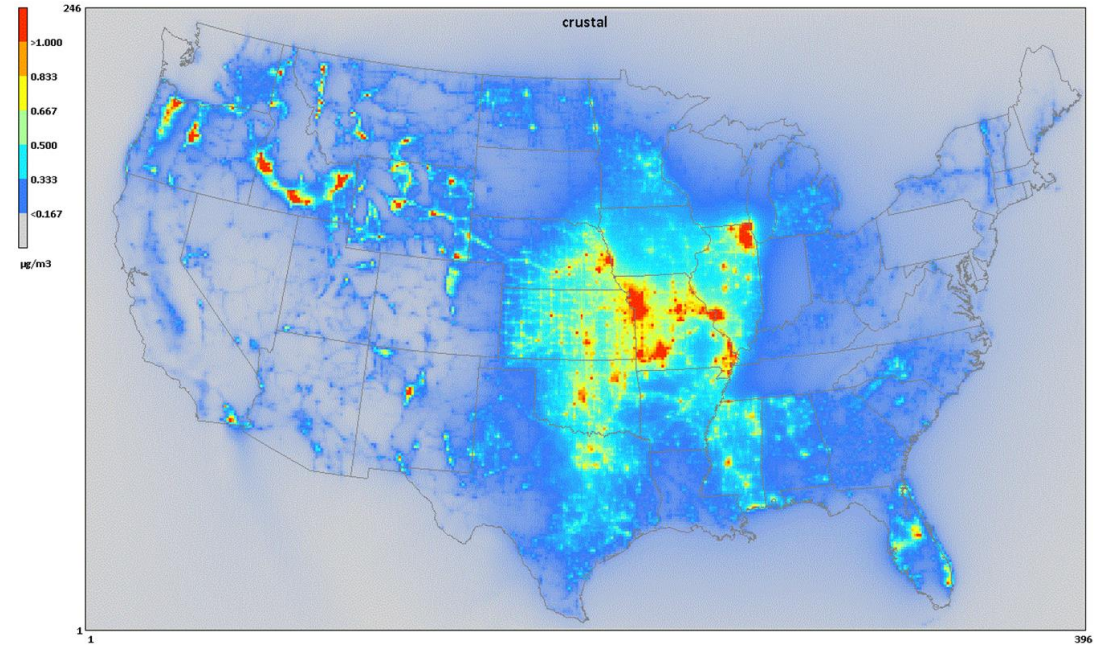
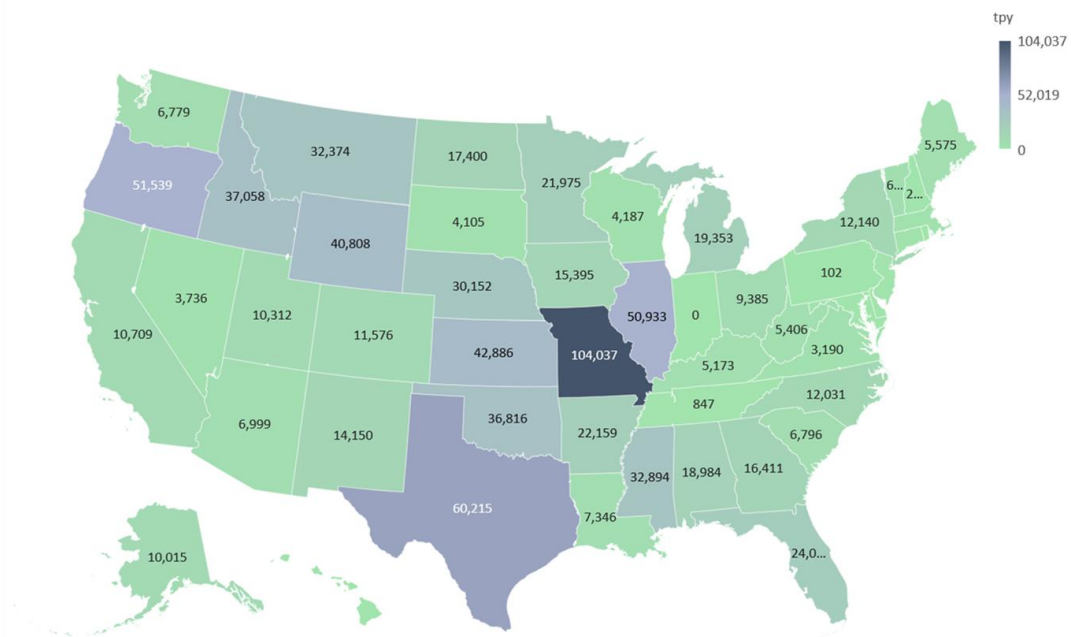
## Example: Organic Carbon from Prescribed Fires





# Inventory Issues

## Example: Unpaved Roads – Consistency in Reporting



Annual PM<sub>2.5</sub> Emissions- 2023v2 Projections

Crustal PM<sub>2.5</sub> Concentrations - 2026v3 Projections

FIPSST 18, Indiana, still missing in EPA's 2022 NEI

See also: MO, PA, TN

State FIP	State	EIS Sector	Pollutant	2016	2017	2018	2019	2020	2021	2022
1	Alabama	Dust - Unpaved Road Dust	PM25-PRI	5,199	4,582	4,090	4,709	3,125	4,442	4,681
2	Alaska	Dust - Unpaved Road Dust	PM25-PRI	1,148	1,191	1,275	1,959	627	3,738	11,352
4	Arizona	Dust - Unpaved Road Dust	PM25-PRI	4,296	4,445	4,476	4,395	1,265	4,220	3,775
5	Arkansas	Dust - Unpaved Road Dust	PM25-PRI	5,859	6,070	5,289	4,951	3,750	6,201	6,247
6	California	Dust - Unpaved Road Dust	PM25-PRI	5,410	5,484	5,901	5,387	5,293	6,194	5,945
8	Colorado	Dust - Unpaved Road Dust	PM25-PRI	5,043	5,234	5,476	4,829	2,534	5,563	4,613
9	Connecticut	Dust - Unpaved Road Dust	PM25-PRI	148	145	123	134	108	153	145
12	Florida	Dust - Unpaved Road Dust	PM25-PRI	12,211	12,479	12,716	12,902	1,880	3,751	3,441
13	Georgia	Dust - Unpaved Road Dust	PM25-PRI	4,252	4,084	3,364	3,853	2,779	3,848	4,203
15	Hawaii	Dust - Unpaved Road Dust	PM25-PRI	166	169	168	155	181	159	245
16	Idaho	Dust - Unpaved Road Dust	PM25-PRI	17,578	16,740	18,068	17,590	6,776	15,505	11,512
17	Illinois	Dust - Unpaved Road Dust	PM25-PRI	16,535	19,253	15,807	13,501	10,072	16,996	17,547
19	Iowa	Dust - Unpaved Road Dust	PM25-PRI	5,069	6,353	4,274	3,877	3,222	6,255	6,005
20	Kansas	Dust - Unpaved Road Dust	PM25-PRI	21,787	23,289	21,406	19,355	8,241	20,358	20,237
21	Kentucky	Dust - Unpaved Road Dust	PM25-PRI	1,134	1,087	860	1,016	734	1,016	1,294

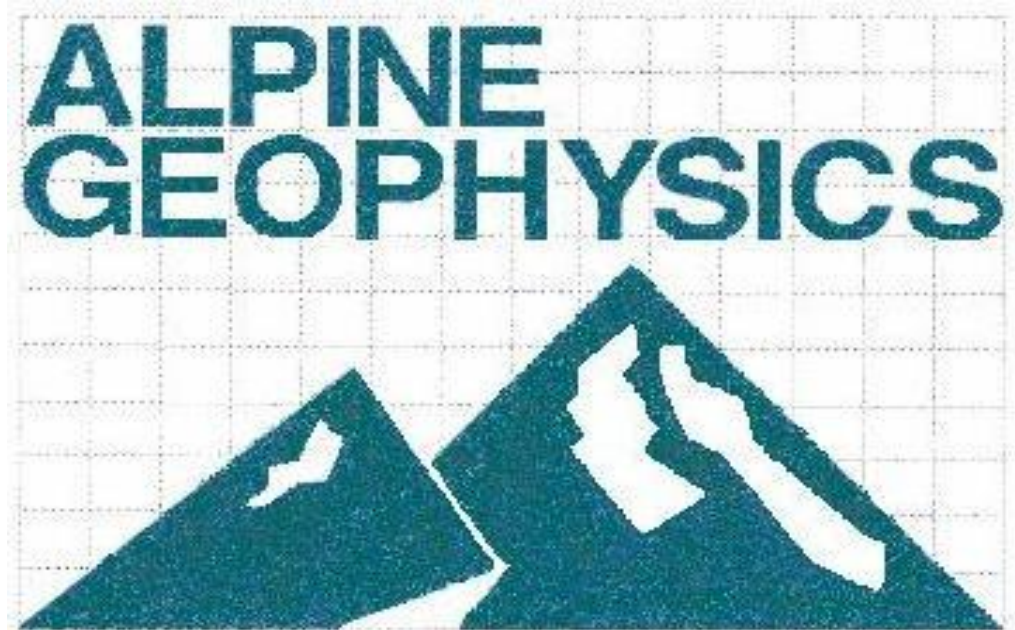
# Observations

- In urban area locations, anthropogenic emissions from commercial cooking, residential wood combustion, and waste disposal have the highest percentage of modeled  $PM_{2.5}$  concentrations
- At monitors near international borders, total traced species from boundary conditions and Canadian and Mexican anthropogenic categories dominate the modeled contribution to the overall annual  $PM_{2.5}$
- At remote mountain monitors, wildfire, boundary conditions, prescribed fires, and residential wood combustion dominate the composition to the total annual  $PM_{2.5}$  concentrations



# Observations (con't)

- Modeled attainment of  $9.0 \mu\text{g}/\text{m}^3$  annual NAAQS may prove challenging in areas where limited anthropogenic control options are available
- Current, available modeling may prove to be best option in determining relative contributing categories until (and if) EPA generates category-specific PM source apportionment modeling with 2022v1 platform
- Additional findings in Alpine TSD (not presented here) corroborate EPA's findings of NAAQS exceedances being driven by the urban  $\text{PM}_{2.5}$  increment and the relatively high responsiveness of  $\text{PM}_{2.5}$  concentrations to primary  $\text{PM}_{2.5}$  emission reductions within these urban cores



Gregory Stella  
Managing Partner  
Alpine Geophysics, LLC  
[gms@alpinegeophysics.com](mailto:gms@alpinegeophysics.com)  
828-675-9045