

Emission and Air Quality Trends Review 1999-2011

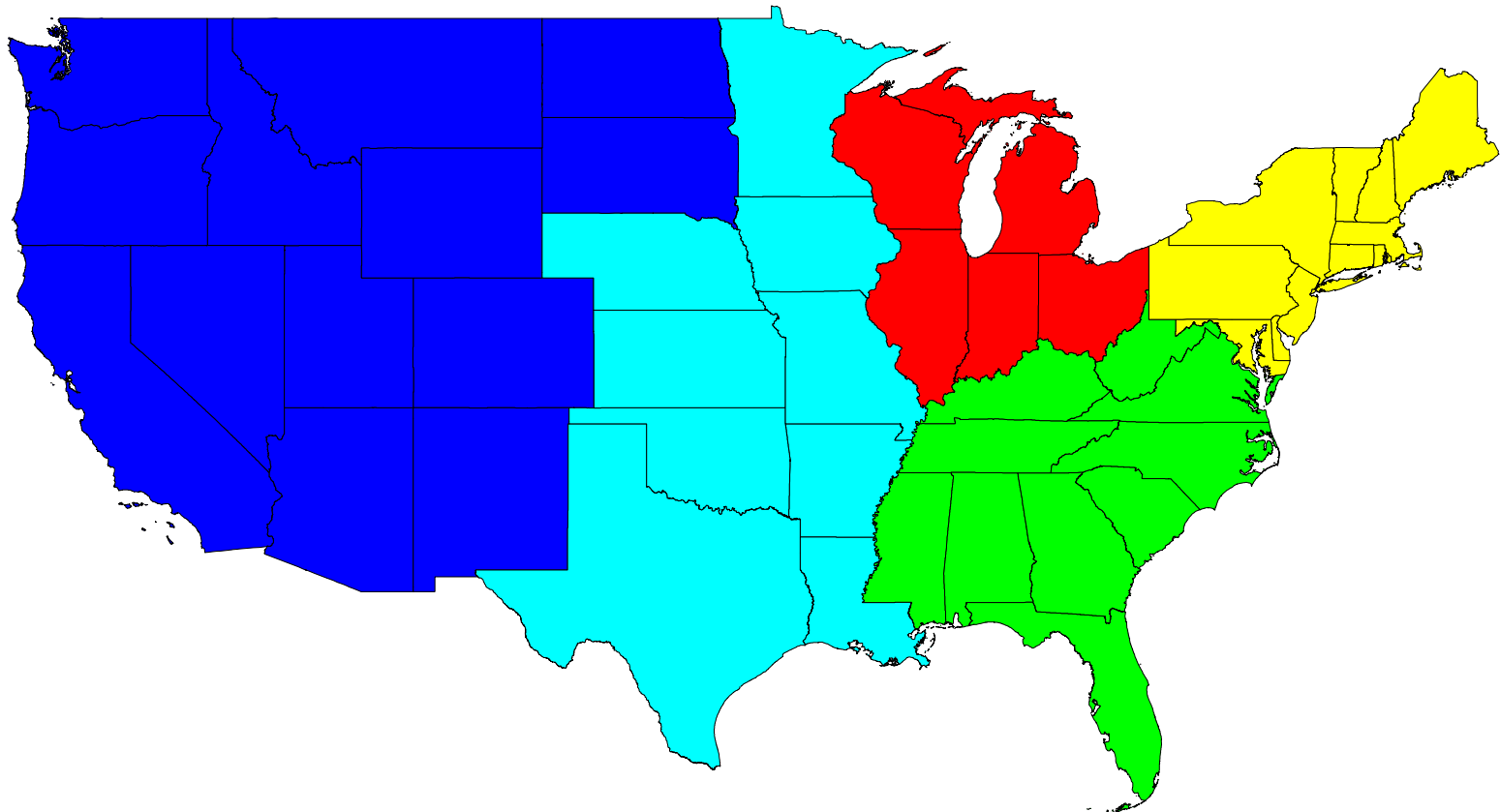
Northeastern States

July 2013

Project Objective

- ❑ To develop and present publicly available information on trends in emissions and ambient air quality in the U.S. since 1999 in easy to understand visual and tabular formats

Metrics developed for U.S. by Region



Emission Trends

- ❑ Study Team collected and processed U.S. EPA emission inventories for years within the study period of interest (1999-2011)

- ❑ By pollutant and source category
 - electric utility coal fuel combustion
 - mobile sources
 - industrial fuel combustion & industrial processes
 - all other

Emissions Data Summary

- Data Obtained from EPA National Emission Inventory (NEI) and Trends Websites
 - EPA's Trends reports and emission comparisons include interpolations of all categories between key years (1999, 2002, 2005, 2008, 2011) at county-pollutant level
 - Represented Pollutants: VOC, NO_x, SO₂, and PM_{2.5}
- Project Improvement
 - The Study Team augmented above data with year specific CEM emissions (2002 through 2011)

Emission Changes

- ❑ The following slides also include the tonnage-based emissions change from 1999 to 2011 for each pollutant
- ❑ Negative values indicate decrease in emissions, positive values indicate an increase

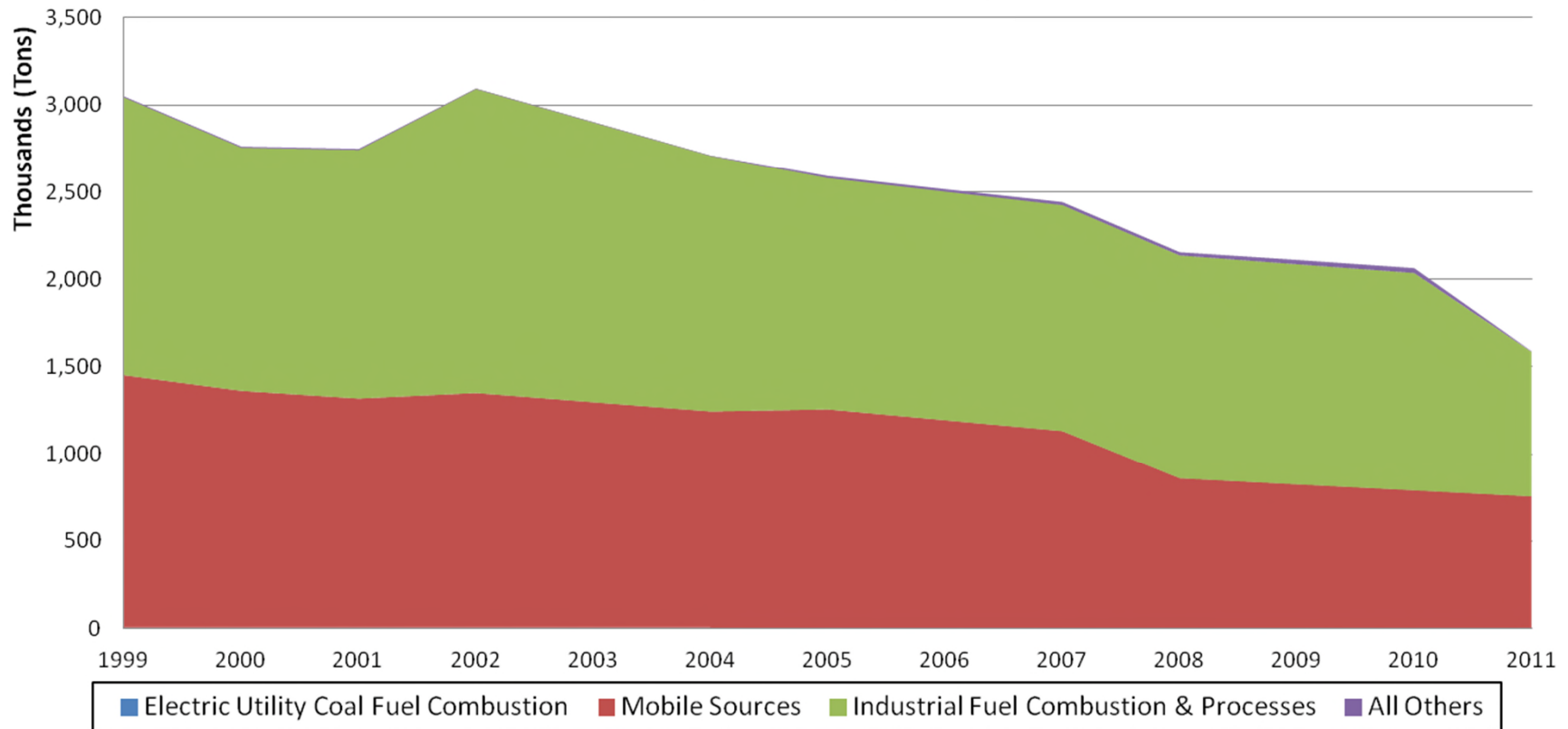
Northeast Emission Trends (VOC)

Source Category	Annual Emissions (Tons)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	4,154	3,296	2,637	2,386	2,267	2,193	2,318	1,815	2,008	915
Mobile Sources	1,448,459	1,315,512	1,295,177	1,254,474	1,192,419	1,130,363	857,801	823,346	788,892	754,789
Industrial Fuel Combustion & Processes	1,593,632	1,425,127	1,603,332	1,324,338	1,308,558	1,292,777	1,277,040	1,261,260	1,245,467	829,815
All Others	6,085	6,961	3,253	11,772	13,676	17,558	18,531	24,845	28,159	3,070
Total	3,052,330	2,750,896	2,904,399	2,592,970	2,516,920	2,442,891	2,155,691	2,111,266	2,064,526	1,588,589

Source Category	Annual Emissions Change (Percent since 1999)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	0%	-21%	-37%	-43%	-45%	-47%	-44%	-56%	-52%	-78%
Mobile Sources	0%	-9%	-11%	-13%	-18%	-22%	-41%	-43%	-46%	-48%
Industrial Fuel Combustion & Processes	0%	-11%	1%	-17%	-18%	-19%	-20%	-21%	-22%	-48%
All Others	0%	14%	-47%	93%	125%	189%	205%	308%	363%	-50%
Total	0%	-10%	-5%	-15%	-18%	-20%	-29%	-31%	-32%	-48%

Northeast Emission Trends (VOC)

**Major Source Category Summary
Annual VOC Emissions**



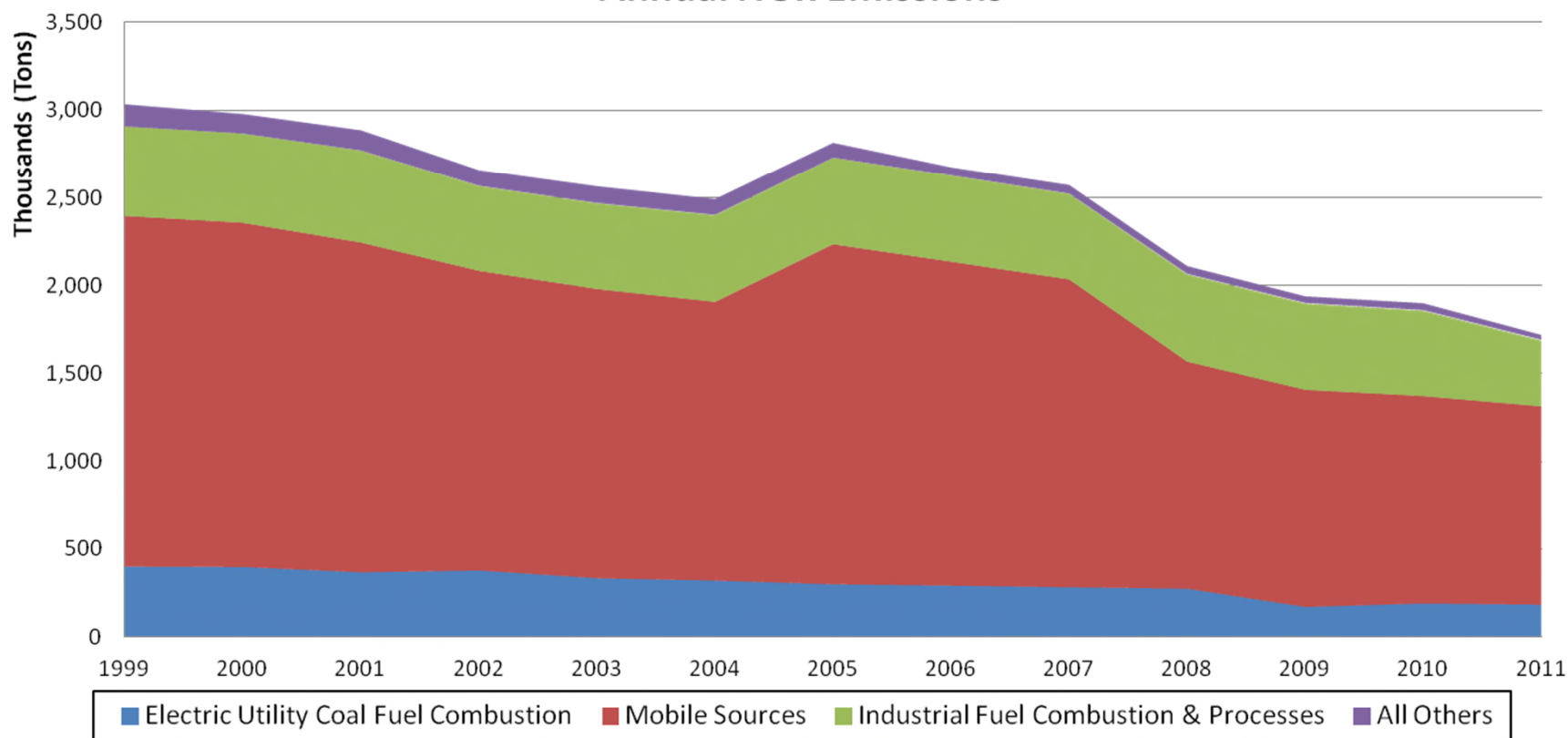
Northeast Emission Trends (NO_x)

Source Category	Annual Emissions (Tons)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	399,962	367,023	333,542	299,068	291,711	282,507	273,935	170,110	190,276	183,111
Mobile Sources	1,995,832	1,877,687	1,647,345	1,935,874	1,844,469	1,753,064	1,295,753	1,239,736	1,183,720	1,132,323
Industrial Fuel Combustion & Processes	512,711	526,259	487,422	495,116	490,732	486,611	495,147	489,265	484,248	373,850
All Others	126,895	115,626	95,945	84,620	46,779	48,822	44,212	37,262	39,196	27,837
Total	3,035,399	2,886,594	2,564,254	2,814,678	2,673,690	2,571,005	2,109,046	1,936,373	1,897,440	1,717,120

Source Category	Annual Emissions Change (Percent since 1999)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	0%	-8%	-17%	-25%	-27%	-29%	-32%	-57%	-52%	-54%
Mobile Sources	0%	-6%	-17%	-3%	-8%	-12%	-35%	-38%	-41%	-43%
Industrial Fuel Combustion & Processes	0%	3%	-5%	-3%	-4%	-5%	-3%	-5%	-6%	-27%
All Others	0%	-9%	-24%	-33%	-63%	-62%	-65%	-71%	-69%	-78%
Total	0%	-5%	-16%	-7%	-12%	-15%	-31%	-36%	-37%	-43%

Northeast Emission Trends (NO_x)

**Major Source Category Summary
Annual NO_x Emissions**



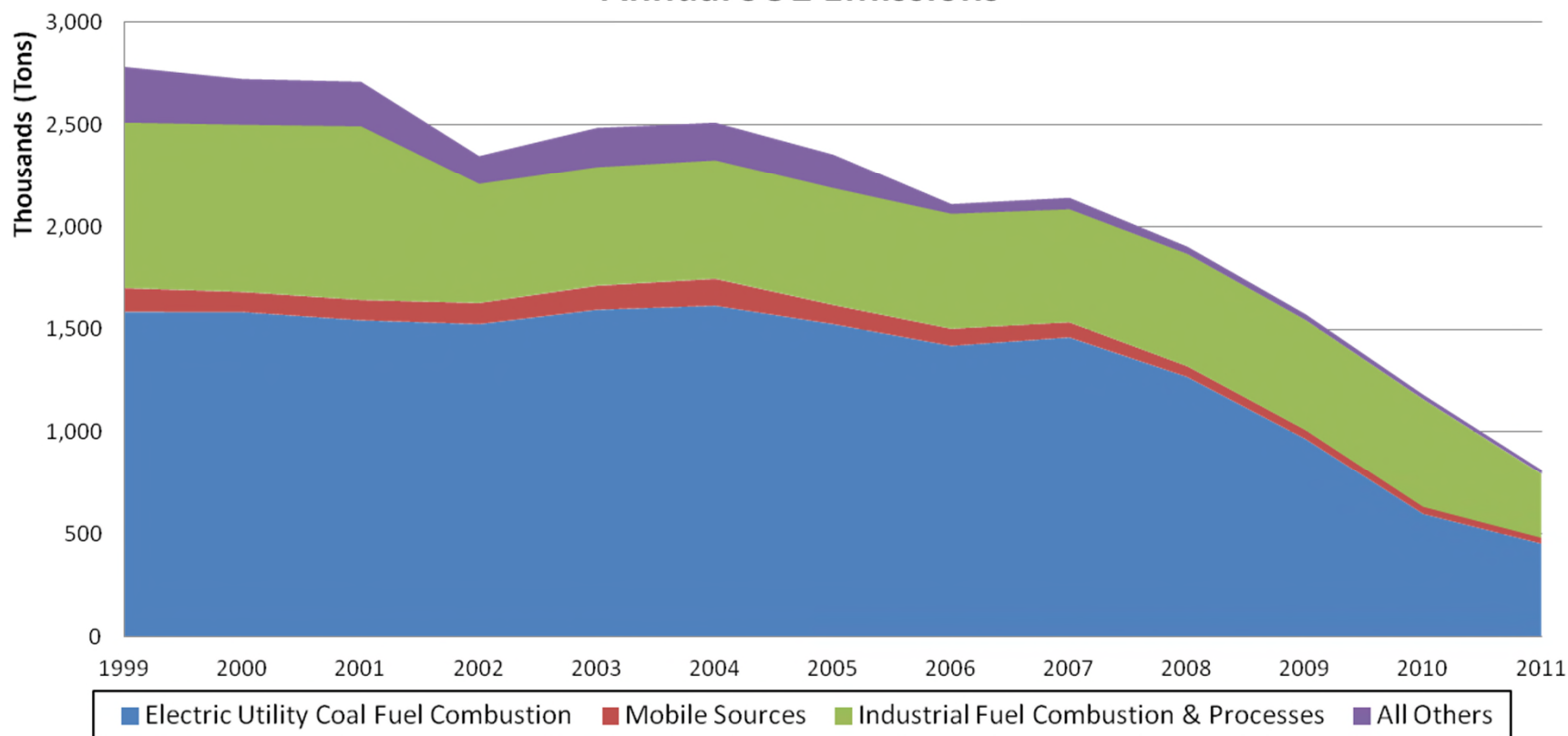
Northeast Emission Trends (SO₂)

Source Category	Annual Emissions (Tons)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	1,585,941	1,544,828	1,596,323	1,526,371	1,419,822	1,461,492	1,268,617	965,972	596,064	450,927
Mobile Sources	115,134	98,531	116,479	93,272	83,380	73,488	52,353	45,302	38,251	32,511
Industrial Fuel Combustion & Processes	811,872	851,679	581,755	570,768	561,152	551,540	547,398	535,768	525,978	313,196
All Others	272,031	217,844	192,987	165,490	47,781	56,255	35,585	28,799	22,237	18,584
Total	2,784,978	2,712,880	2,487,545	2,355,901	2,112,134	2,142,774	1,903,952	1,575,841	1,182,531	815,217

Source Category	Annual Emissions Change (Percent since 1999)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	0%	-3%	1%	-4%	-10%	-8%	-20%	-39%	-62%	-72%
Mobile Sources	0%	-14%	1%	-19%	-28%	-36%	-55%	-61%	-67%	-72%
Industrial Fuel Combustion & Processes	0%	5%	-28%	-30%	-31%	-32%	-33%	-34%	-35%	-61%
All Others	0%	-20%	-29%	-39%	-82%	-79%	-87%	-89%	-92%	-93%
Total	0%	-3%	-11%	-15%	-24%	-23%	-32%	-43%	-58%	-71%

Northeast Emission Trends (SO₂)

Major Source Category Summary
Annual SO₂ Emissions



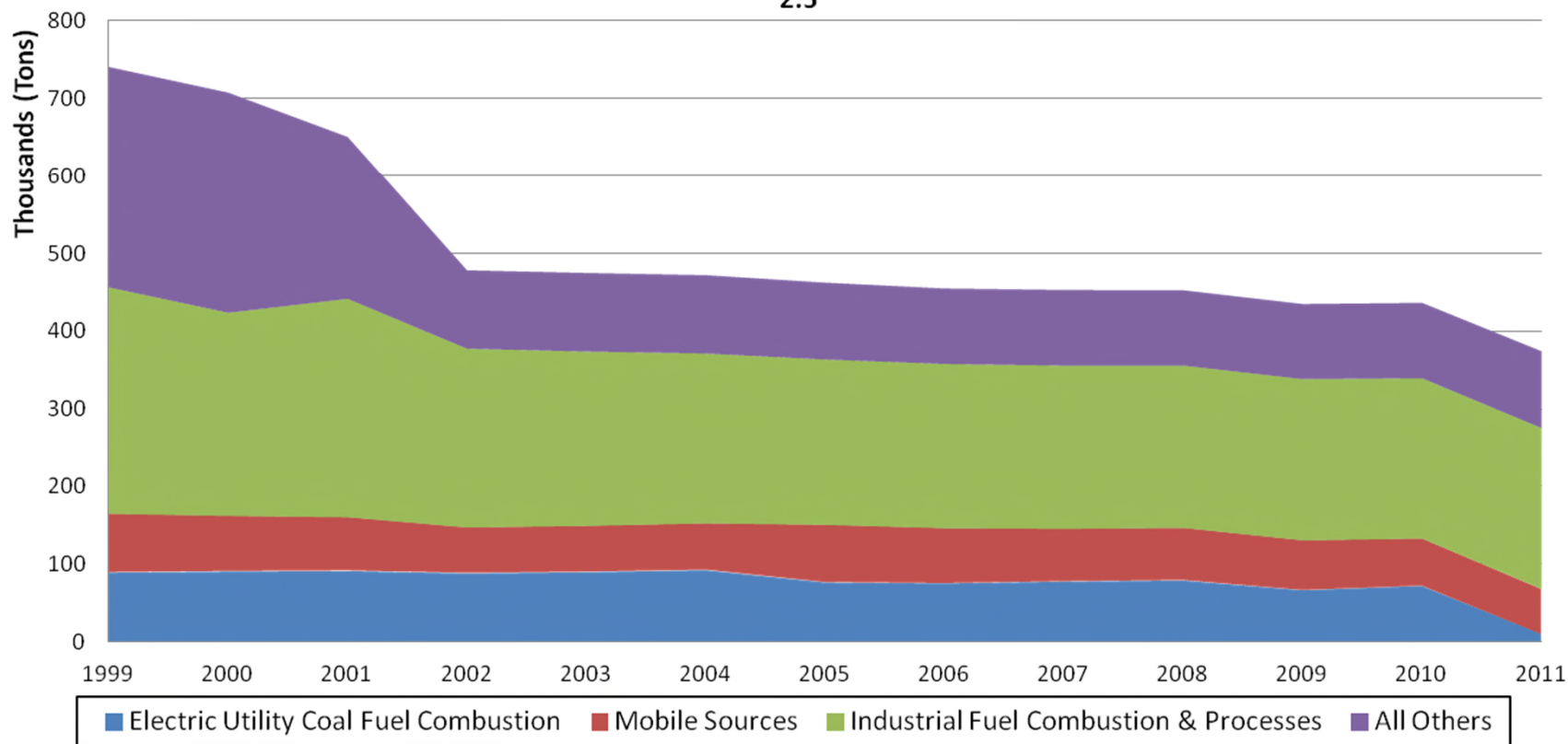
Northeast Emission Trends (PM_{2.5})

Source Category	Annual Emissions (Tons)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	89,444	91,486	90,014	76,539	75,377	77,679	79,181	66,424	72,060	10,002
Mobile Sources	74,994	68,587	58,921	73,756	70,592	67,428	67,161	63,891	60,623	57,874
Industrial Fuel Combustion & Processes	292,332	281,976	225,381	213,737	212,433	211,144	209,932	208,616	207,320	208,128
All Others	284,381	209,056	100,902	98,678	96,829	97,065	96,672	96,396	96,831	98,724
Total	741,151	651,105	475,217	462,708	455,230	453,316	452,945	435,327	436,833	374,728

Source Category	Annual Emissions Change (Percent since 1999)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	0%	2%	1%	-14%	-16%	-13%	-11%	-26%	-19%	-89%
Mobile Sources	0%	-9%	-21%	-2%	-6%	-10%	-10%	-15%	-19%	-23%
Industrial Fuel Combustion & Processes	0%	-4%	-23%	-27%	-27%	-28%	-28%	-29%	-29%	-29%
All Others	0%	-26%	-65%	-65%	-66%	-66%	-66%	-66%	-66%	-65%
Total	0%	-12%	-36%	-38%	-39%	-39%	-39%	-41%	-41%	-49%

Northeast Emission Trends (PM_{2.5})

Major Source Category Summary
Annual PM_{2.5} Emissions



Emission Trends Summary

- All pollutants have decreased since 1999 in aggregate across the northeastern United States
- NOx and SO2 from Electric Utility Fuel Combustion sources show significant decrease over time as a result of Acid Rain Program, NOx Budget Trading Program and CAIR control implementation
- Onroad emission step increase seen between 2004 and 2005 is the result of EPA's method change and MOVES model integration for estimating onroad mobile source emissions

AQ Trends Scope

- Compute, summarize and display ozone and PM_{2.5} design value trends in the Northeastern states for the period 1999 – 2011
- Create a spreadsheet database of O₃ and PM_{2.5} values at each monitoring site for additional analyses

Design Values

□ Ozone

- Annual 4th highest daily maximum 8-hour average averaged over three consecutive years
- Current standard = 0.075 ppm

□ PM_{2.5} Annual

- Annual arithmetic mean of quarterly means averaged over three consecutive years
- Current standard = 12 ug/m³

□ PM_{2.5} 24-Hour

- Annual 98th percentile of daily averages averaged over three consecutive years
- Current standard = 35 ug/m³

Area-Wide Design Values

- For regional and state trends: for each three-year period, calculated **average** of DVs over all monitoring sites within the region/state meeting data completeness requirements
- For non-attainment areas: for each three-year period, calculated **maximum** DV over all monitoring sites within the non-attainment area meeting data completeness requirements (conforms with EPA methodology for determining attainment/non-attainment designation)

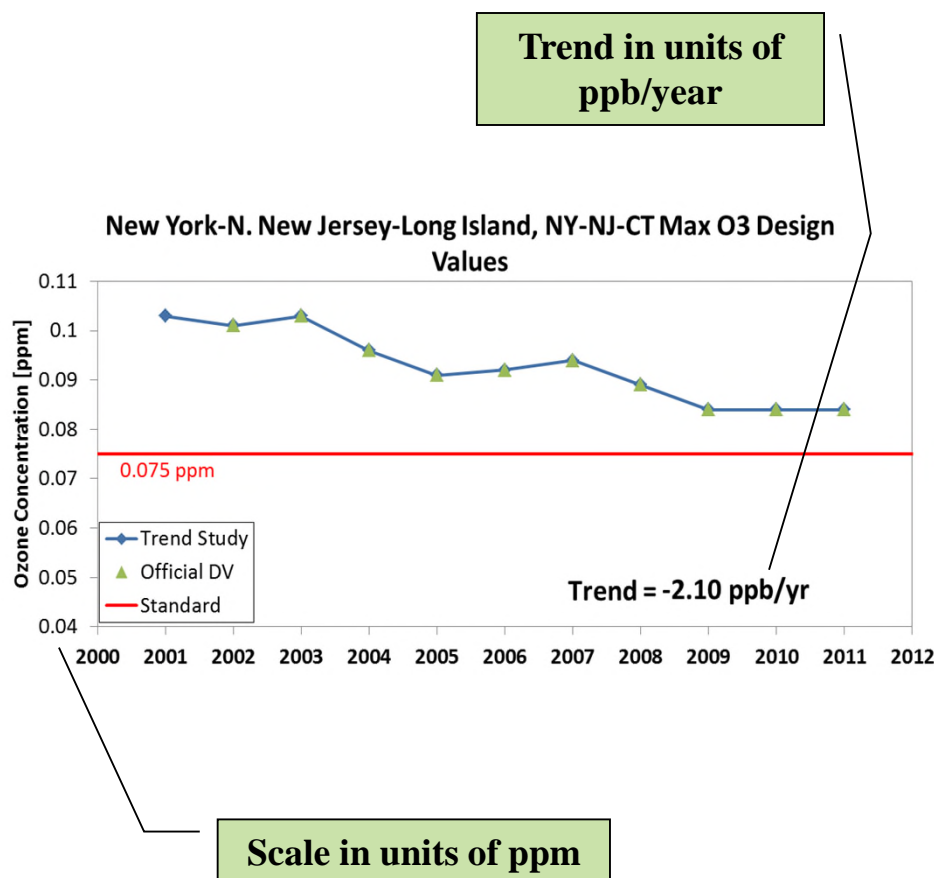
Data Handling Procedures

- O₃ design value (DV) for each overlapping three-year period starting with 1999-2001 and ending with 2009-2011
 - DV calculated using annual 4th highest daily max 8-hr averages and percent of valid observations, based on EPA data handling conventions
 - Data associated with exceptional events that have received EPA concurrence are omitted
 - Selection of trend sites require valid DV in 9 out of 11 three-year periods between 1999 and 2011
 - Identification of nonattainment areas is with respect to the 2008 8-hour standard only

Data Handling Procedures

- Annual PM_{2.5} DV and 24-hr PM_{2.5} DV for each overlapping three-year period starting with 1999-2001 and ending with 2009-2011
 - DV calculations based on EPA data handling conventions
 - Data extracted from monitors that have a non-regulatory monitoring type are omitted
 - Selection of trend sites require valid DV in at least 9 out of 11 three-year periods between 1999 and 2011

Trend Calculation

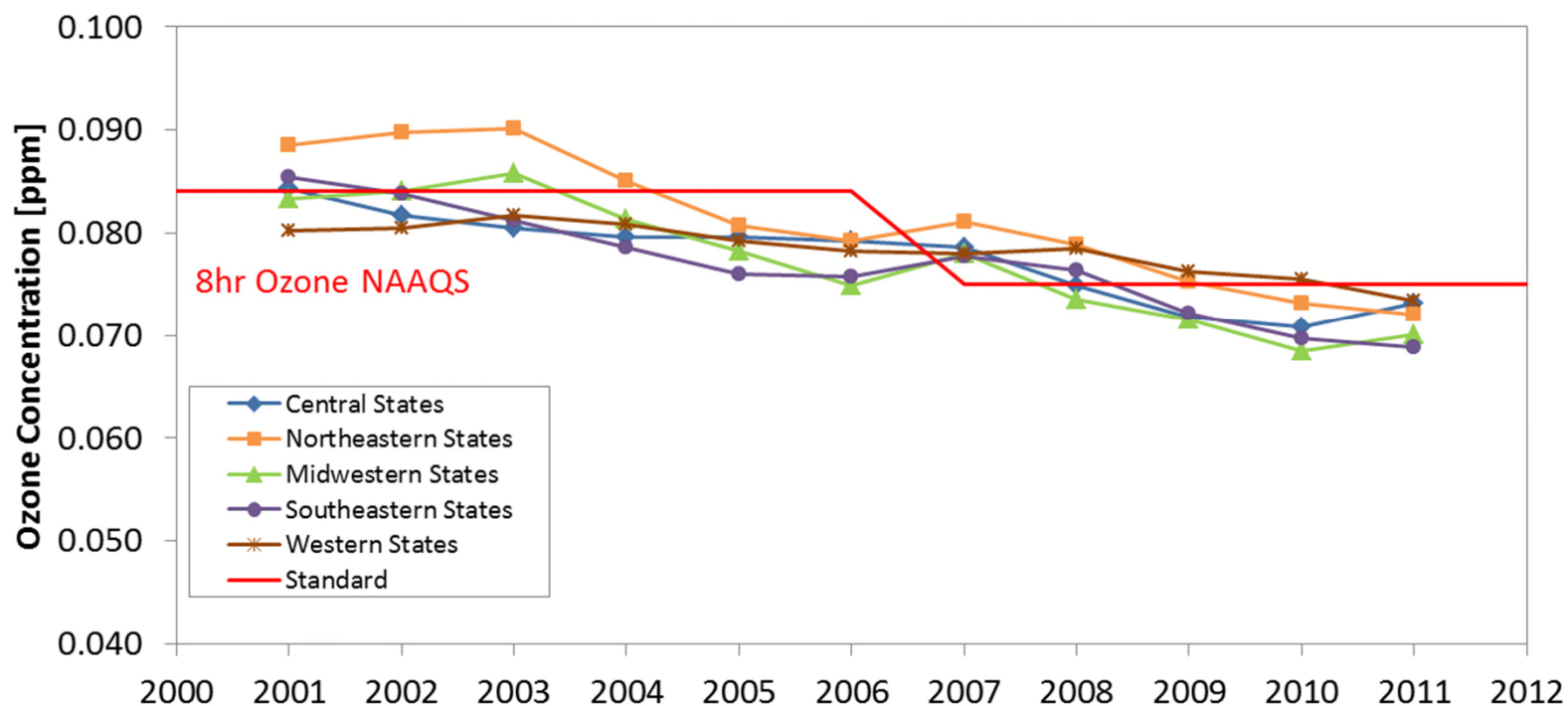


- Trends based on linear least squares fit to rolling three year design values (DVs)
- Negative trend indicates improving air quality
- DVs based on each 3-year period: 1999-2001, 2000-2002, ... 2009-2011
- Notes

- On plots, DVs are for three year period ending in year shown (i.e., 2009-2011 DV plotted as 2011 value)
- Ozone trend values expressed as ppb/year (1,000 ppb = 1 ppm); DVs are plotted as ppm

O₃ Trends by Regions

Regional Average O₃ Design Values



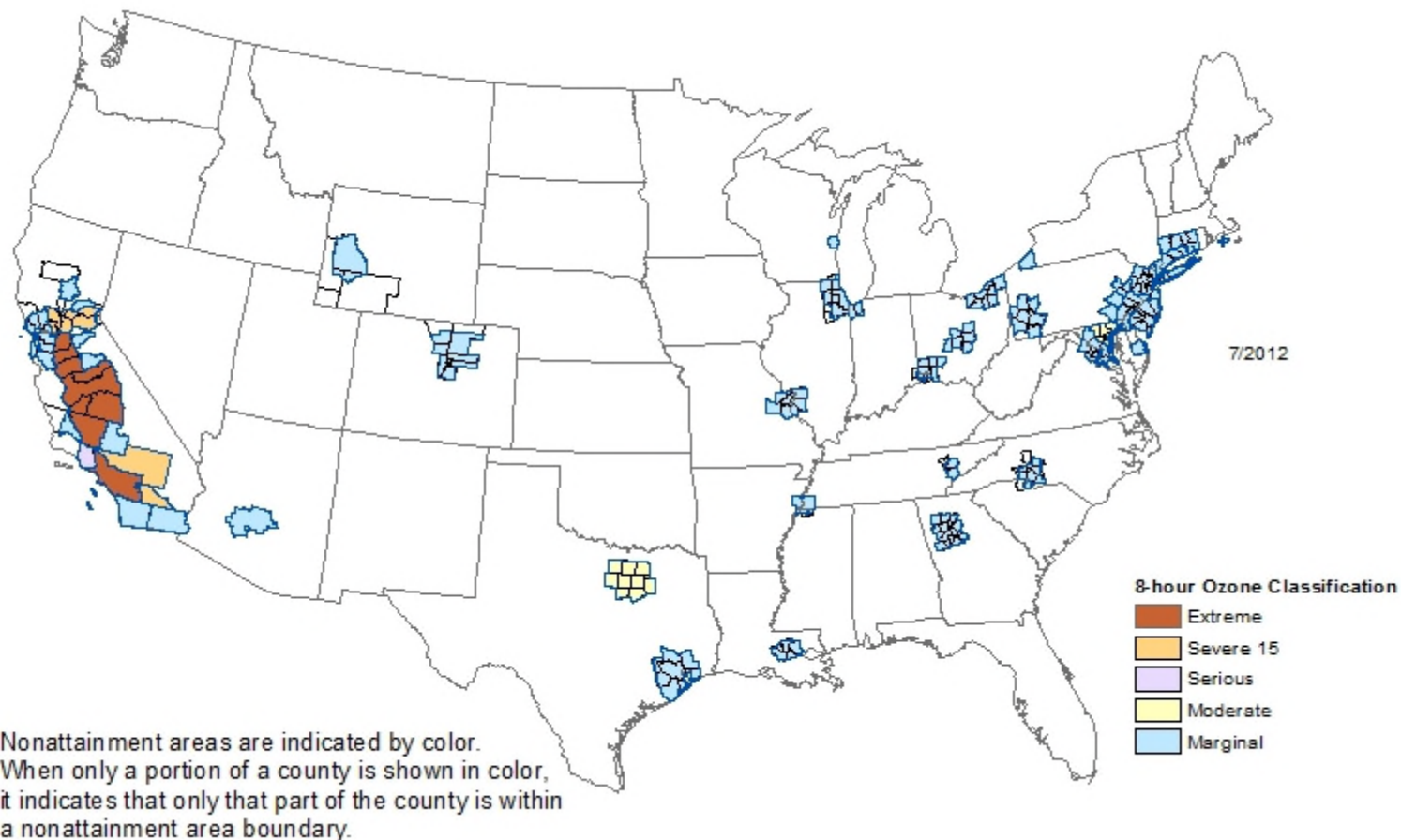
- Average ozone DVs have decreased in all five regions
- Trends are not monotonic, possibly reflecting influence of meteorology

O₃ Trend Slopes by Region

Region	O ₃ Trend Slope
Central States	-1.2 ppb/year
Northeastern States	-1.9 ppb/year
Midwestern States	-1.7 ppb/year
Southeastern States	-1.5 ppb/year
Western States	-0.7 ppb/year

Note: 1 ppb = 0.001 ppm

Designated O₃ Non-Attainment Areas (based on 2008 8-Hour Ozone standard)

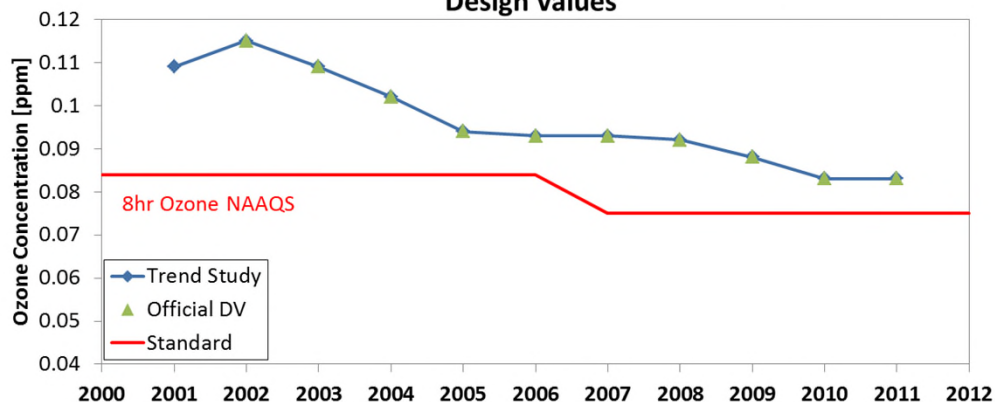


Source: EPA Green Book
(<http://www.epa.gov/oar/oaqps/greenbk/index.html>)

Trends in Northeast States Non-Attainment Areas

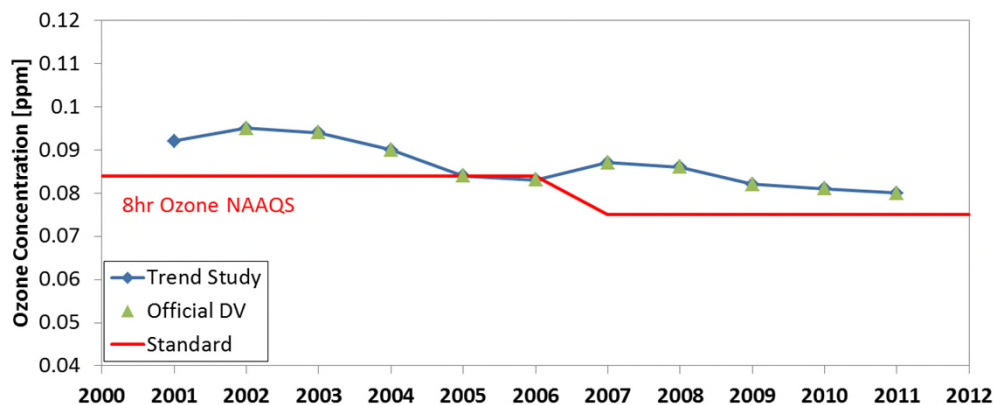
Philadelphia-Wilmington-Atlantic City, PA-NJ-MD-DE Max O3

Design Values



- Trends range from -3.11 ppb/yr (Philadelphia-Wilmington-Atlantic City, PA-NJ-MD-DE) to -1.43 ppb/yr (Pittsburgh-Beaver Valley, PA)

Pittsburgh-Beaver Valley, PA Max O3 Design Values



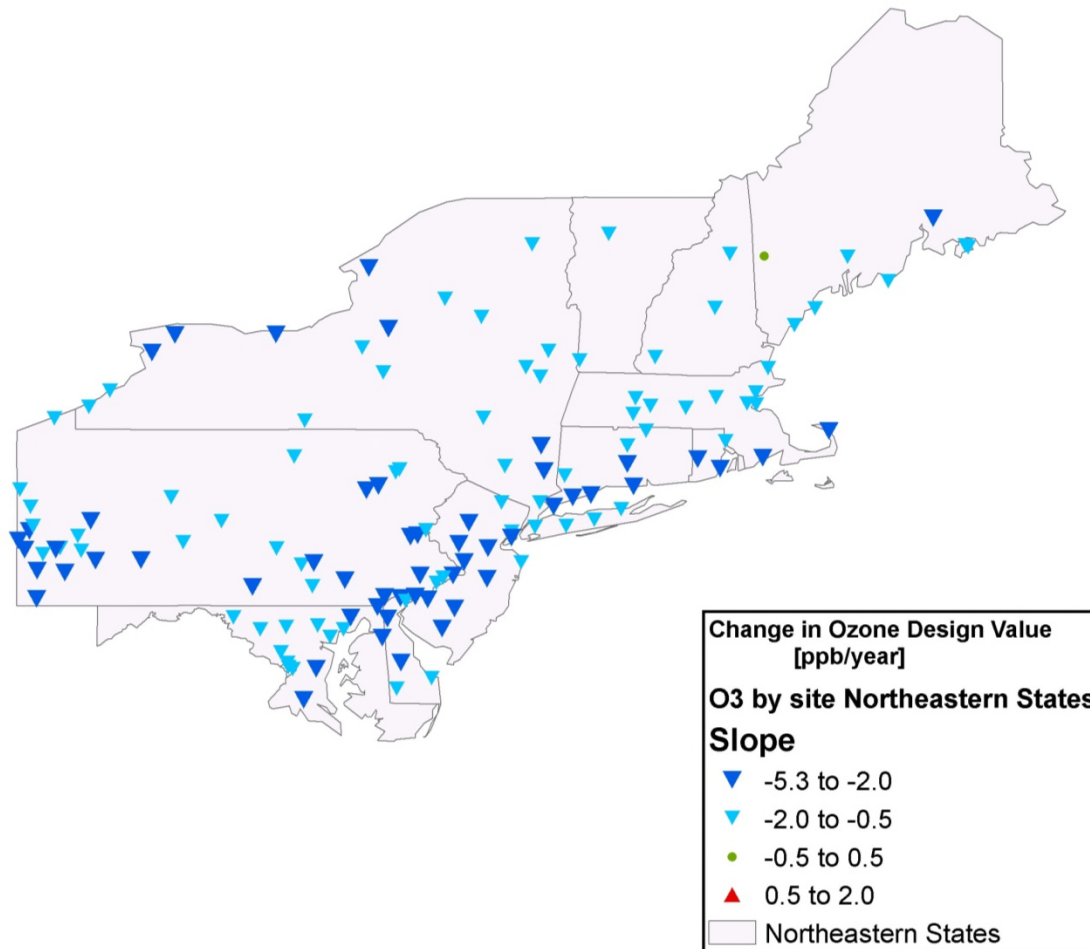
- Trends are negative (downward) in 10 out of 12 non-attainment areas in Northeast states. The trends at Dukes County, MA and Reading, PA are not determined due to limited data available

O₃ Trend Slopes in Northeast States Non-Attainment Areas

Non-Attainment Areas	O ₃ Trend Slope [ppb/year]
Philadelphia-Wilmington-Atlantic City, PA-NJ-MD-DE	-3.11
Allentown-Bethlehem-Easton, PA	-2.25
New York-N. New Jersey-Long Island, NY-NJ-CT	-2.10
Lancaster, PA	-2.02
Seaford, DE	-1.98
Washington, DC-MD-VA	-1.92
Jamestown, NY	-1.92
Greater Connecticut, CT	-1.71
Baltimore, MD	-1.69
Pittsburgh-Beaver Valley, PA	-1.43
Dukes County, MA *	#N/A
Reading, PA *	#N/A

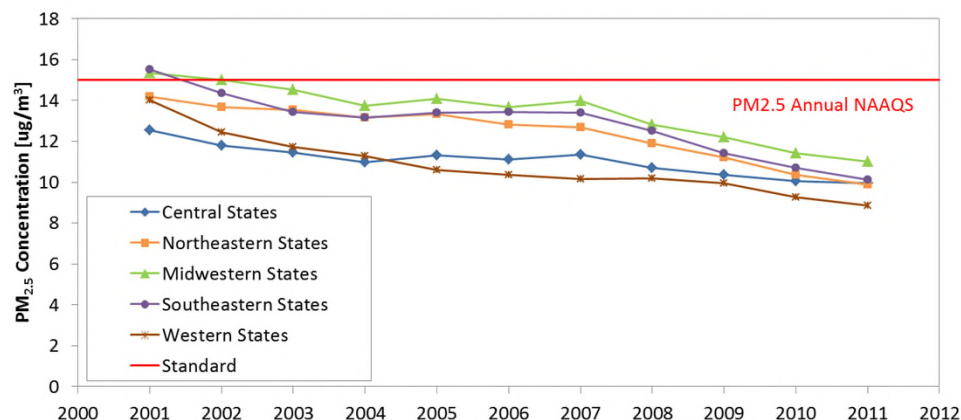
* Monitoring sites in this NAA do not meet completeness requirement for trend analysis

Northeast States Monitoring Sites O₃ Trend Slopes



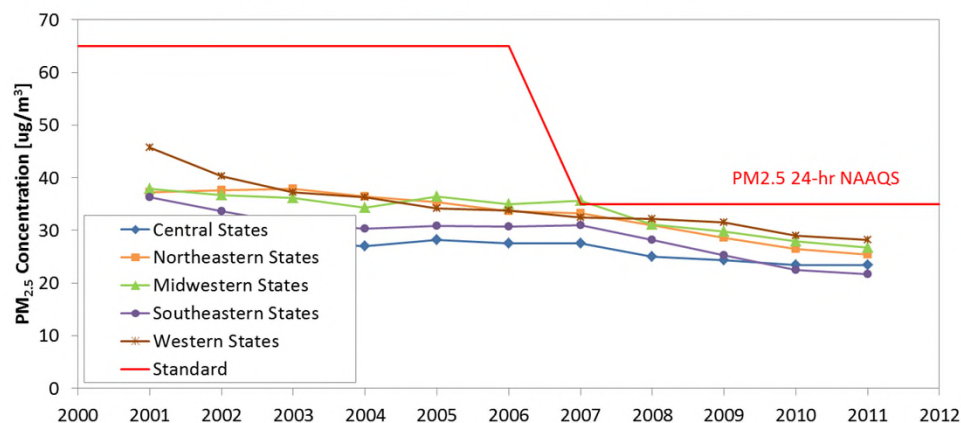
PM_{2.5} Trends by Regions

Regional Average PM_{2.5} Annual Design Values



- Both average and 24-hr PM_{2.5} DVs have decreased (negative trends) in all five regions
- Trends are not monotonic, possibly reflecting influence of meteorology

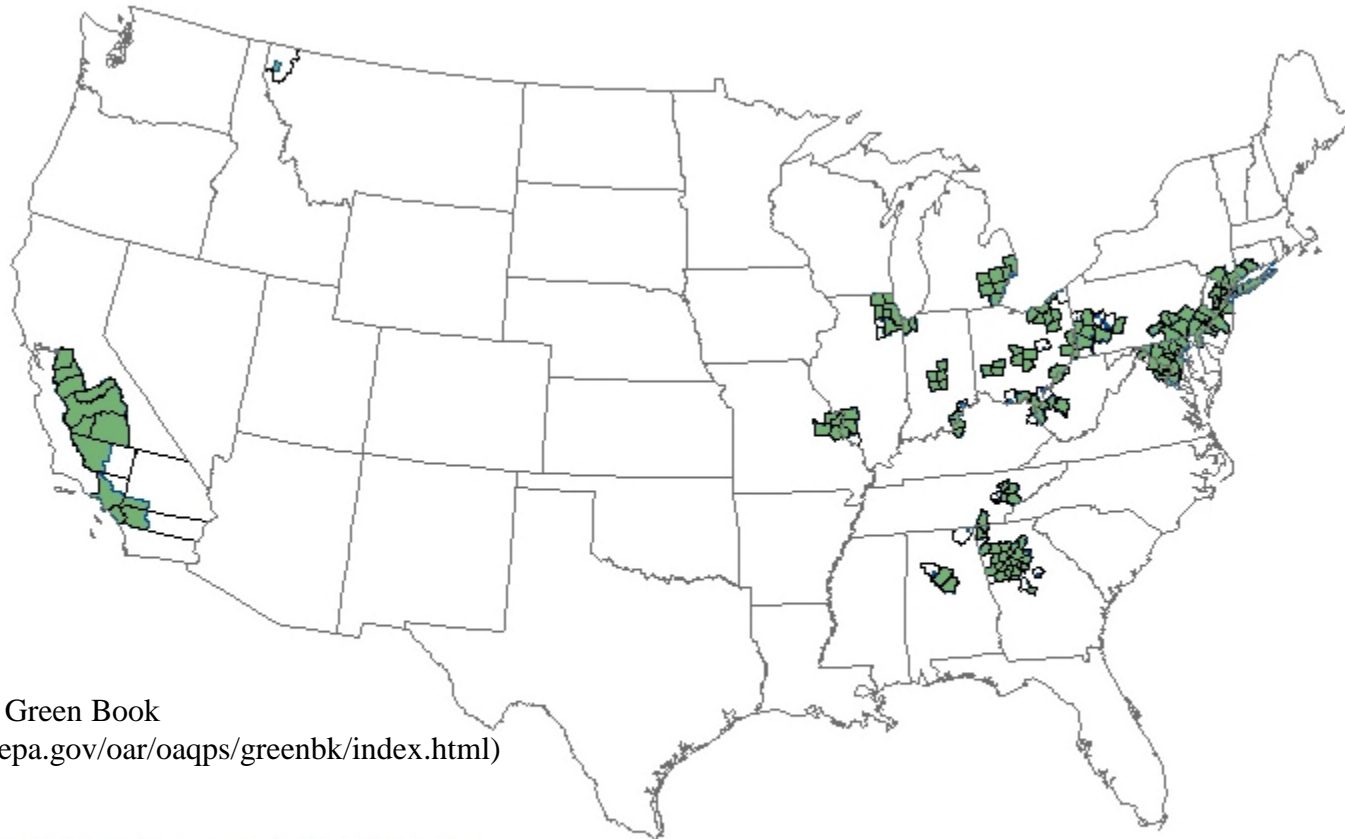
Regional Average PM_{2.5} 24-Hour Design Values



PM_{2.5} Trend Slopes by Region

Region	Annual PM _{2.5} Trend Slope	24-Hr PM _{2.5} Trend Slope
Central States	-0.22 ug/m ³ /year	-0.61 ug/m ³ /year
Northeastern States	-0.41 ug/m ³ /year	-1.32 ug/m ³ /year
Midwestern States	-0.41 ug/m ³ /year	-1.07 ug/m ³ /year
Southeastern States	-0.45 ug/m ³ /year	-1.27 ug/m ³ /year
Western States	-0.42 ug/m ³ /year	-1.45 ug/m ³ /year

Designated PM_{2.5} Non-Attainment Areas (based on 1997 Annual PM_{2.5} Standards)

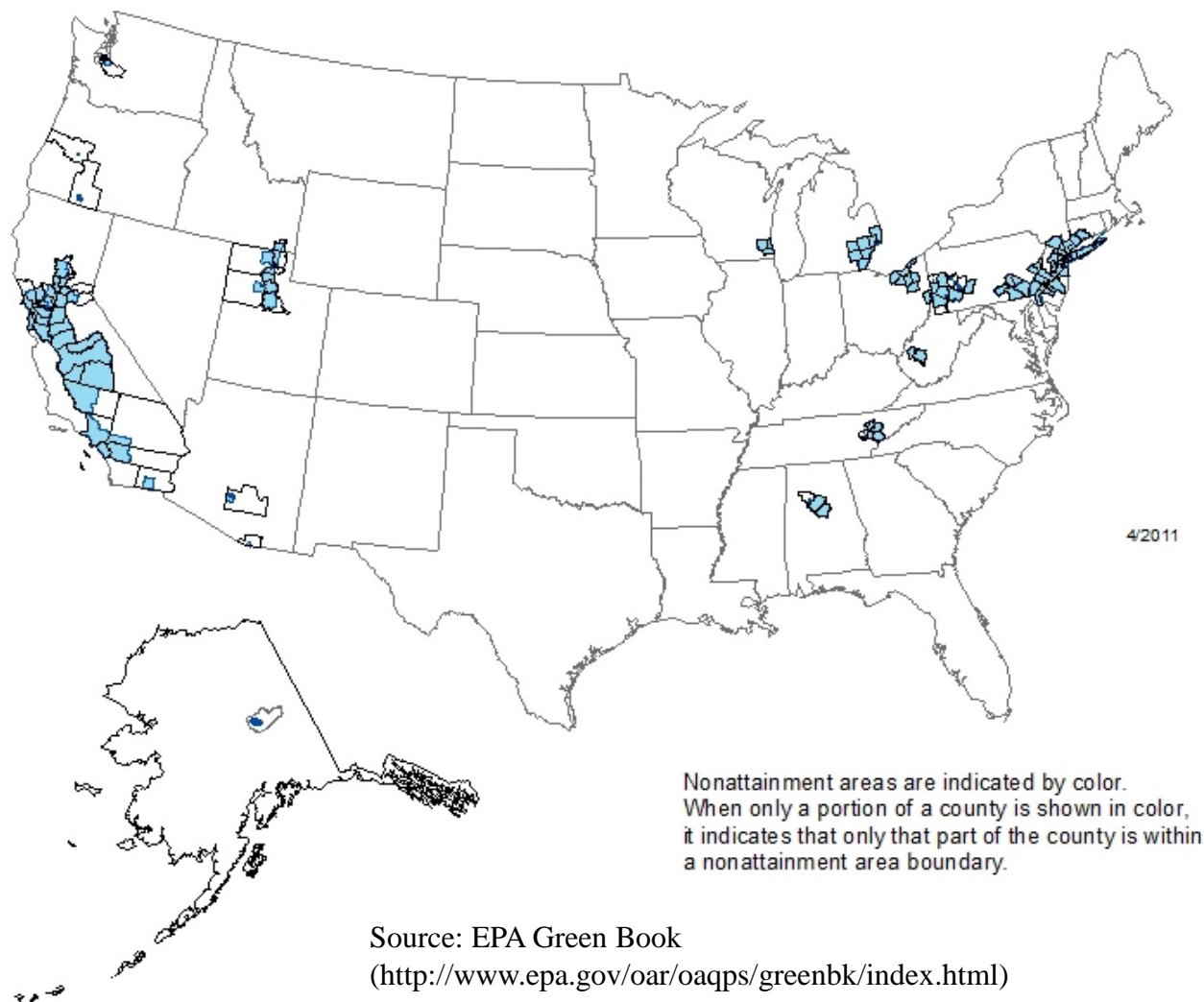


Source: EPA Green Book
(<http://www.epa.gov/oar/oaqps/greenbk/index.html>)

Nonattainment areas are indicated by color.
When only a portion of a county is shown in color,
it indicates that only that part of the county is within
a nonattainment area boundary.

3/2012

Designated PM_{2.5} Non-Attainment Areas (based on 2006 24-Hr PM_{2.5} Standards)

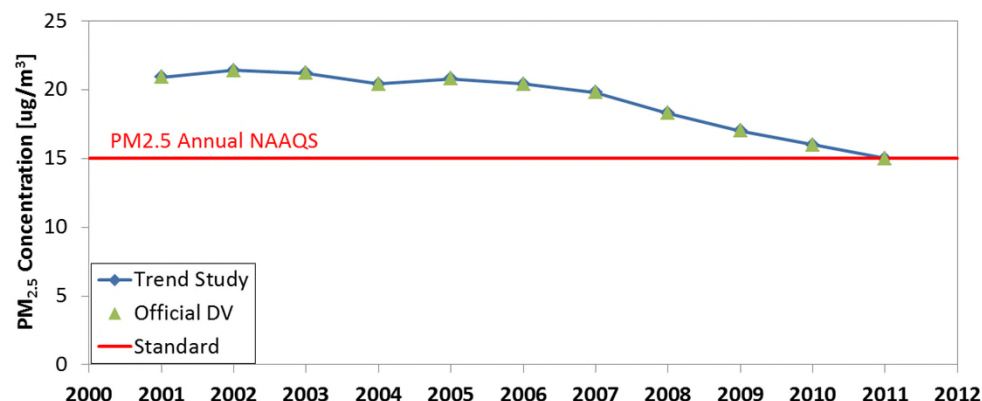


Source: EPA Green Book
(<http://www.epa.gov/oar/oaqps/greenbk/index.html>)

Annual PM_{2.5} DV Trends in Northeast States

Non-Attainment Area

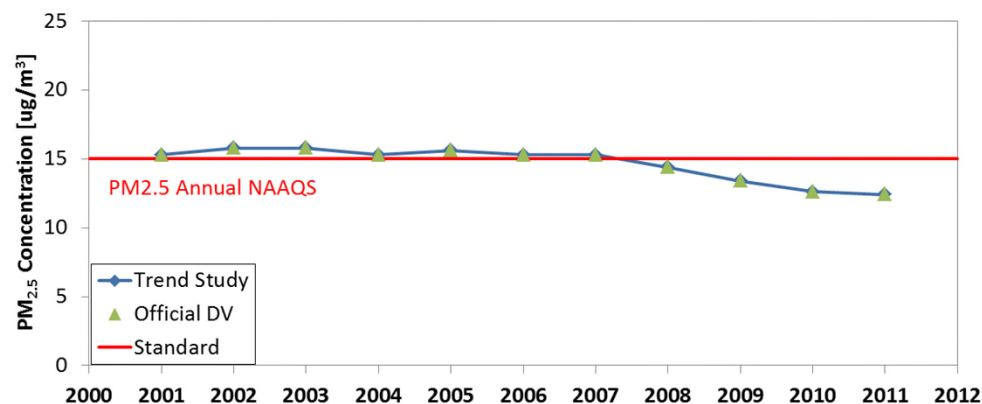
Liberty-Clairton, PA Max PM_{2.5} Annual Design Values



■ Trends range from -0.63 ug/m³/yr (Liberty-Clairton, PA) to -0.33 ug/m³/yr (Johnstown, PA)

■ Trends are negative (downward) in all 12 non-attainment areas in the Northeast States.

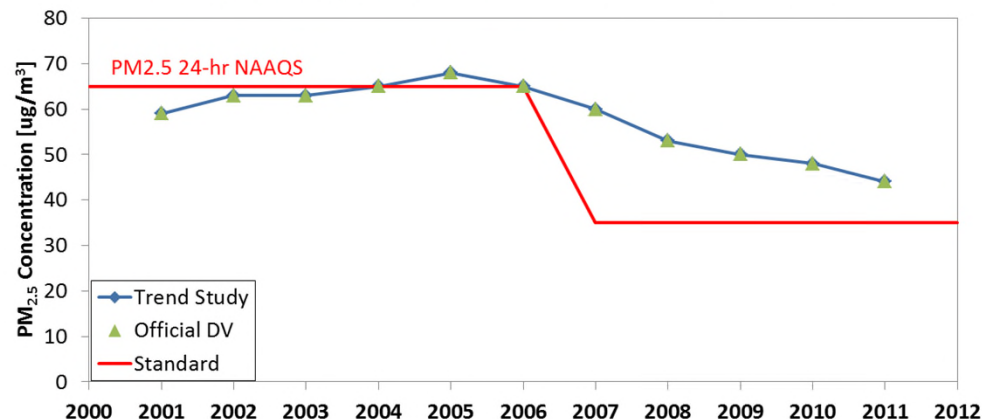
Johnstown, PA Max PM_{2.5} Annual Design Values



24-Hour PM_{2.5} DV Trends in Northeast States

Non-Attainment Area

Liberty-Clairton, PA Max PM_{2.5} 24-Hour Design Values



■ Trends range from -1.87 $\mu\text{g}/\text{m}^3/\text{yr}$ (Liberty-Clairton, PA) to -0.81 $\mu\text{g}/\text{m}^3/\text{yr}$ (Allentown, PA)

■ Trends are negative (downward) in all 8 non-attainment areas in Northeast states.

Allentown, PA Max PM_{2.5} 24-Hour Design Values



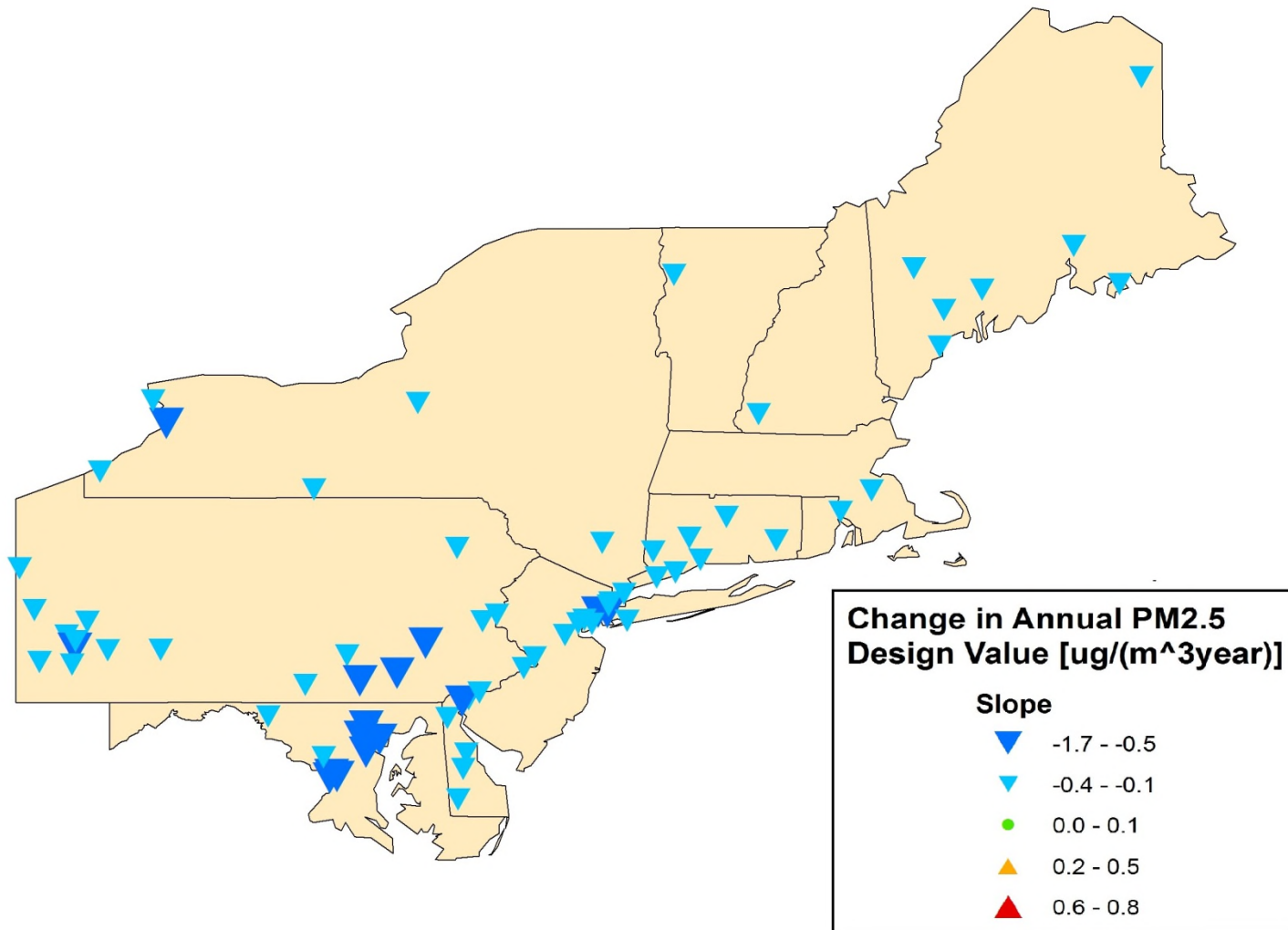
Annual PM_{2.5} Trend Slopes for Northeast States Non-Attainment Areas

Non-Attainment Area	Annual PM _{2.5} Slopes (ug/m ³ /yr)
Liberty-Clairton, PA	-0.63
Washington, DC-MD-VA	-0.60
Reading, PA	-0.60
Lancaster, PA	-0.53
York, PA	-0.53
Baltimore, MD	-0.52
Pittsburgh-Beaver Valley, PA	-0.42
Martinsburg, WV-Hagerstown, MD	-0.40
New York-N. New Jersey-Long Island, NY-NJ-CT	-0.40
Philadelphia-Wilmington, PA-NJ-DE	-0.40
Harrisburg-Lebanon-Carlisle, PA	-0.38
Johnstown, PA	-0.33

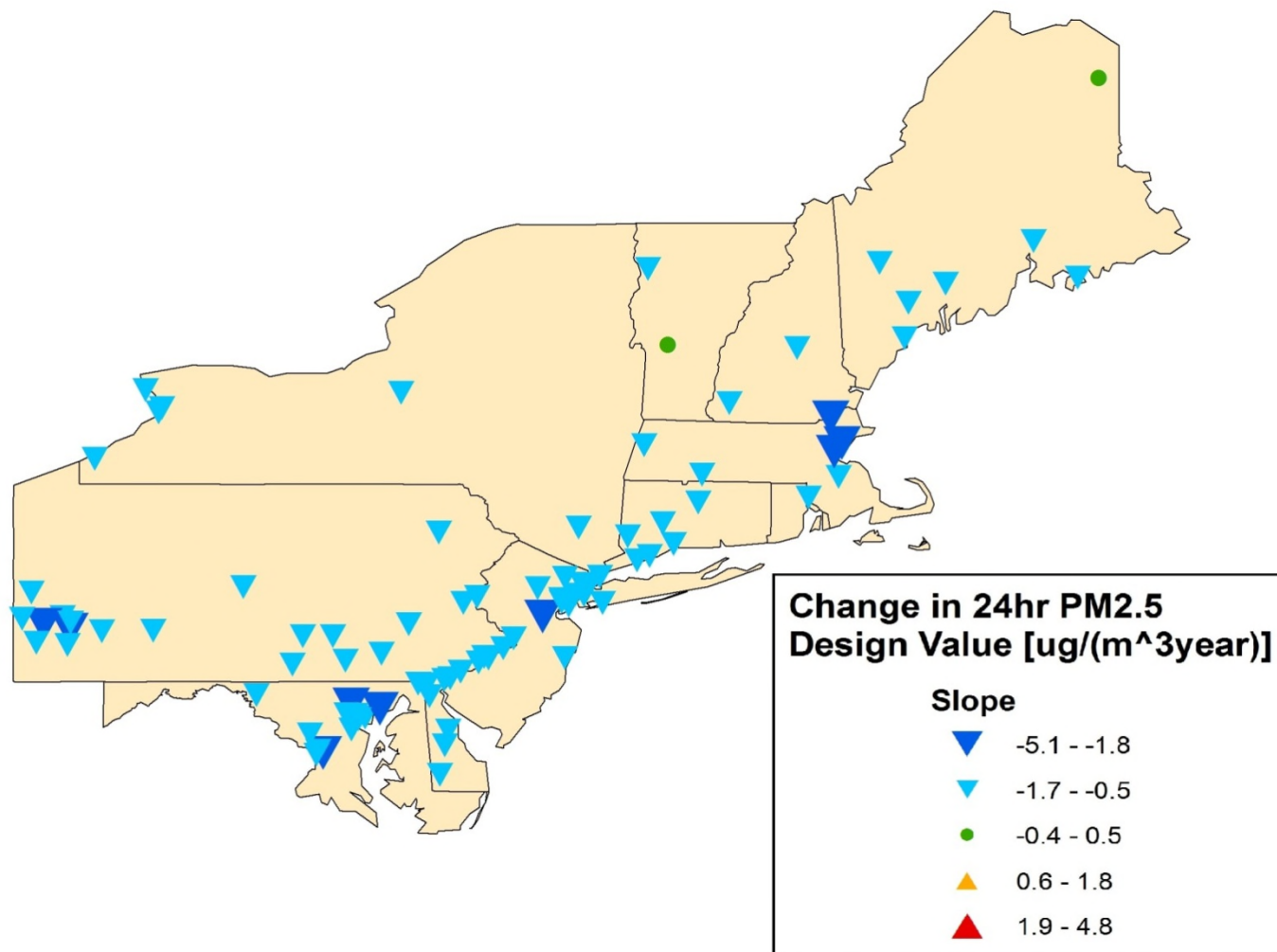
24-Hour PM_{2.5} Trend Slopes for Northeast States Non-Attainment Areas

Non-Attainment Area	24-Hour PM _{2.5} Slopes (ug/m ³ /yr)
Liberty-Clairton, PA	-1.87
Harrisburg-Lebanon-Carlisle-York, PA	-1.56
Johnstown, PA	-1.34
Philadelphia-Wilmington, PA-NJ-DE	-1.29
Lancaster, PA	-1.26
New York, NY-NJ-CT	-1.19
Pittsburgh-Beaver Valley, PA	-1.17
Allentown, PA	-0.81

Annual PM_{2.5} Trend Slopes at Northeast States Monitoring Sites



24-Hr PM_{2.5} Trend Slopes at Northeast States Monitoring Sites



Air Quality Trends Summary

- Average O_3 and $PM_{2.5}$ design values have decreased since 1999 in the Northeast States domain
- O_3 and $PM_{2.5}$ design values have decreased since 1999 in all currently designated O_3 and $PM_{2.5}$ non-attainment areas in the Northeastern States in which monitoring data met the 1999–2011 trends completeness criteria. Additional O_3 or $PM_{2.5}$ nonattainment areas in which monitoring data did not meet the 1999–2011 trends completeness criteria include:
 - Dukes County, MA (Ozone)
 - Reading, PA (Ozone)