Emission and Air Quality Trends Review 1999-2011

Midwestern States

July 2013

Project Objective

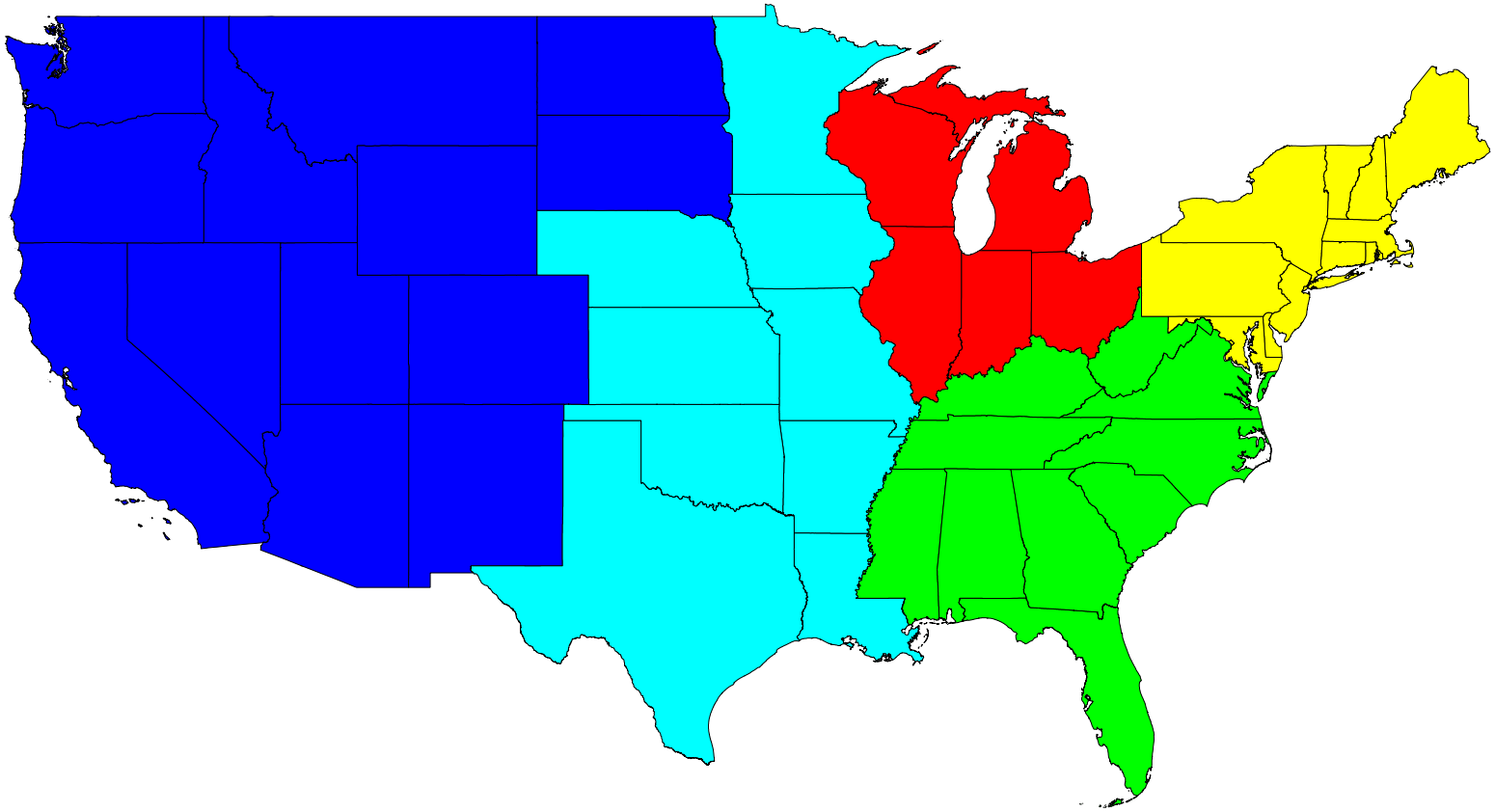
- To develop and present publicly available information on trends in emissions and ambient air quality in the U.S. since 1999 in easy to understand visual and tabular formats

ALPINE GEOPHYSICS

ENVIRON

Trends Analysis

Metrics developed for U.S. by Region



ALPINE GEOPHYSICS

ENVIRON

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, NOx, SO_2, 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

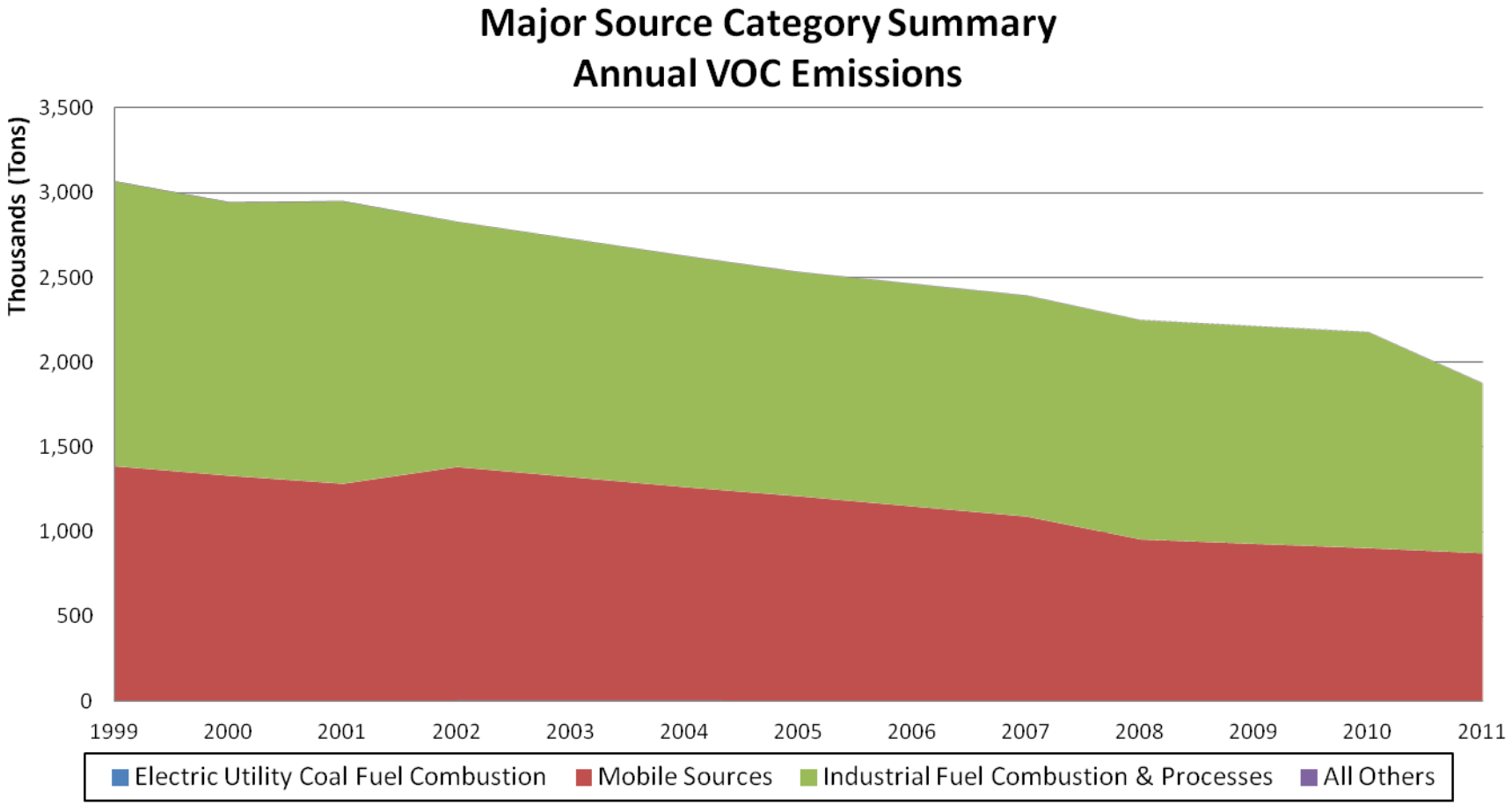
- Negative values indicate decrease in emissions, positive values indicate an increase

Midwestern Emission Trends (VOC)

	Annual Emissions (Tons)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	5,728	6,241	7,153	6,117	6,014	6,118	5,981	5,424	5,632	6,111
Mobile Sources	1,382,078	1,278,264	1,316,851	1,204,468	1,144,627	1,084,785	949,761	924,245	898,729	868,248
Industrial Fuel Combustion & Processes	1,680,792	1,667,034	1,405,326	1,322,600	1,312,834	1,303,071	1,293,318	1,283,556	1,273,793	1,002,317
All Others	1,956	2,455	1,347	1,505	1,395	1,461	1,402	1,360	1,441	1,975
Total	**3,070,555**	**2,953,995**	**2,730,677**	**2,534,691**	**2,464,869**	**2,395,436**	**2,250,462**	**2,214,586**	**2,179,595**	**1,878,651**

	Annual Emissions Change (Percent since 1999)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	0%	9%	25%	7%	5%	7%	4%	-5%	-2%	7%
Mobile Sources	0%	-8%	-5%	-13%	-17%	-22%	-31%	-33%	-35%	-37%
Industrial Fuel Combustion & Processes	0%	-1%	-16%	-21%	-22%	-22%	-23%	-24%	-24%	-40%
All Others	0%	25%	-31%	-23%	-29%	-25%	-28%	-30%	-26%	1%
Total	**0%**	**-4%**	**-11%**	**-17%**	**-20%**	**-22%**	**-27%**	**-28%**	**-29%**	**-39%**

Midwestern Emission Trends (VOC)

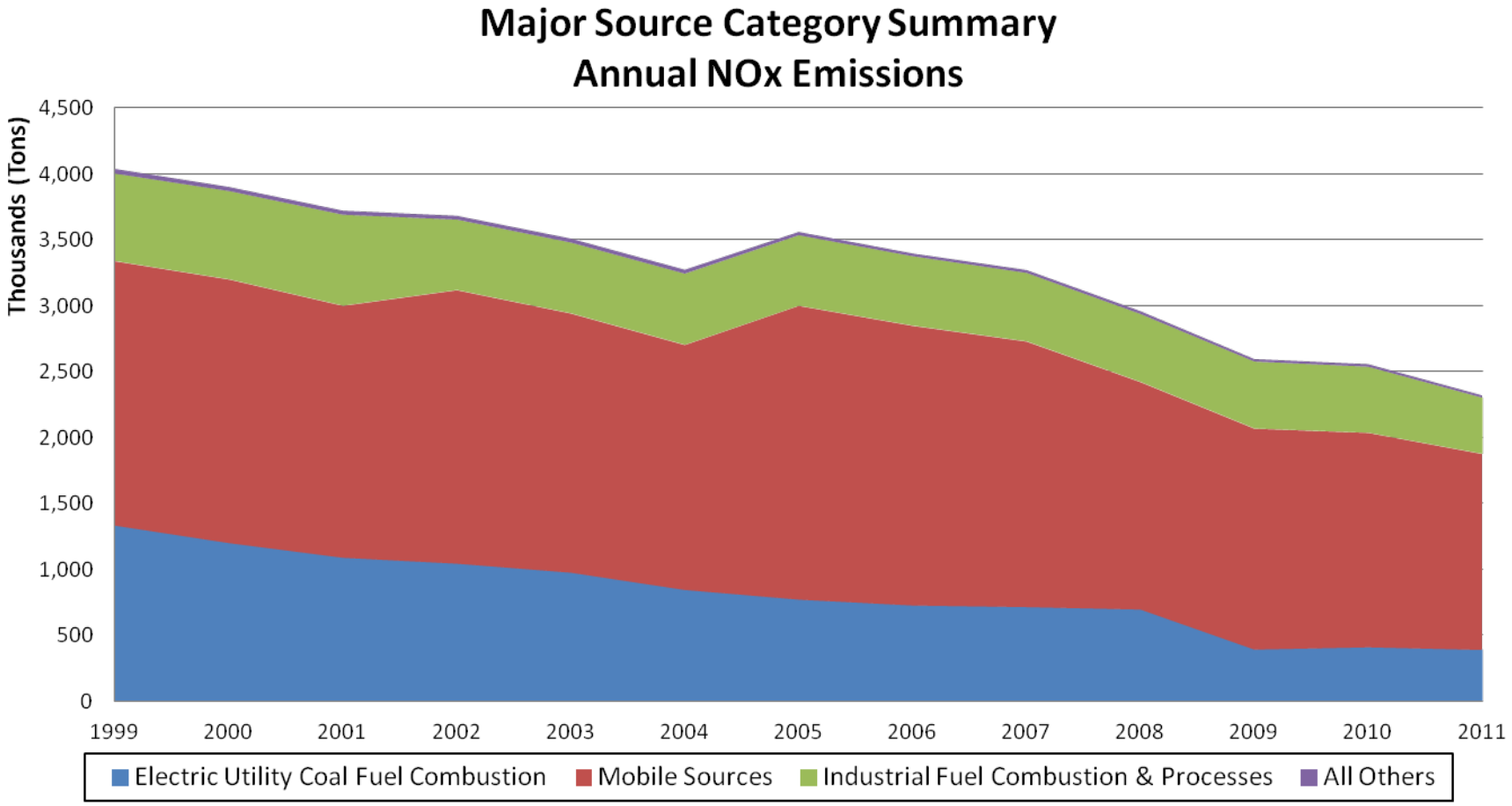


Midwestern Emission Trends (NOx)

	Annual Emissions (Tons)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	1,334,163	1,090,608	977,116	773,068	728,143	715,789	697,592	393,798	410,491	390,644
Mobile Sources	2,007,299	1,912,766	1,968,105	2,230,013	2,123,388	2,016,764	1,726,763	1,677,491	1,628,217	1,487,992
Industrial Fuel Combustion & Processes	664,370	690,429	537,347	535,334	527,384	519,676	515,969	508,002	500,831	425,969
All Others	35,236	30,700	29,729	24,366	20,483	21,389	21,165	18,170	19,183	17,310
Total	**4,041,068**	**3,724,502**	**3,512,297**	**3,562,781**	**3,399,399**	**3,273,618**	**2,961,489**	**2,597,460**	**2,558,723**	**2,321,916**

	Annual Emissions Change (Percent since 1999)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	0%	-18%	-27%	-42%	-45%	-46%	-48%	-70%	-69%	-71%
Mobile Sources	0%	-5%	-2%	11%	6%	0%	-14%	-16%	-19%	-26%
Industrial Fuel Combustion & Processes	0%	4%	-19%	-19%	-21%	-22%	-22%	-24%	-25%	-36%
All Others	0%	-13%	-16%	-31%	-42%	-39%	-40%	-48%	-46%	-51%
Total	**0%**	**-8%**	**-13%**	**-12%**	**-16%**	**-19%**	**-27%**	**-36%**	**-37%**	**-43%**

Midwestern Emission Trends (NOx)

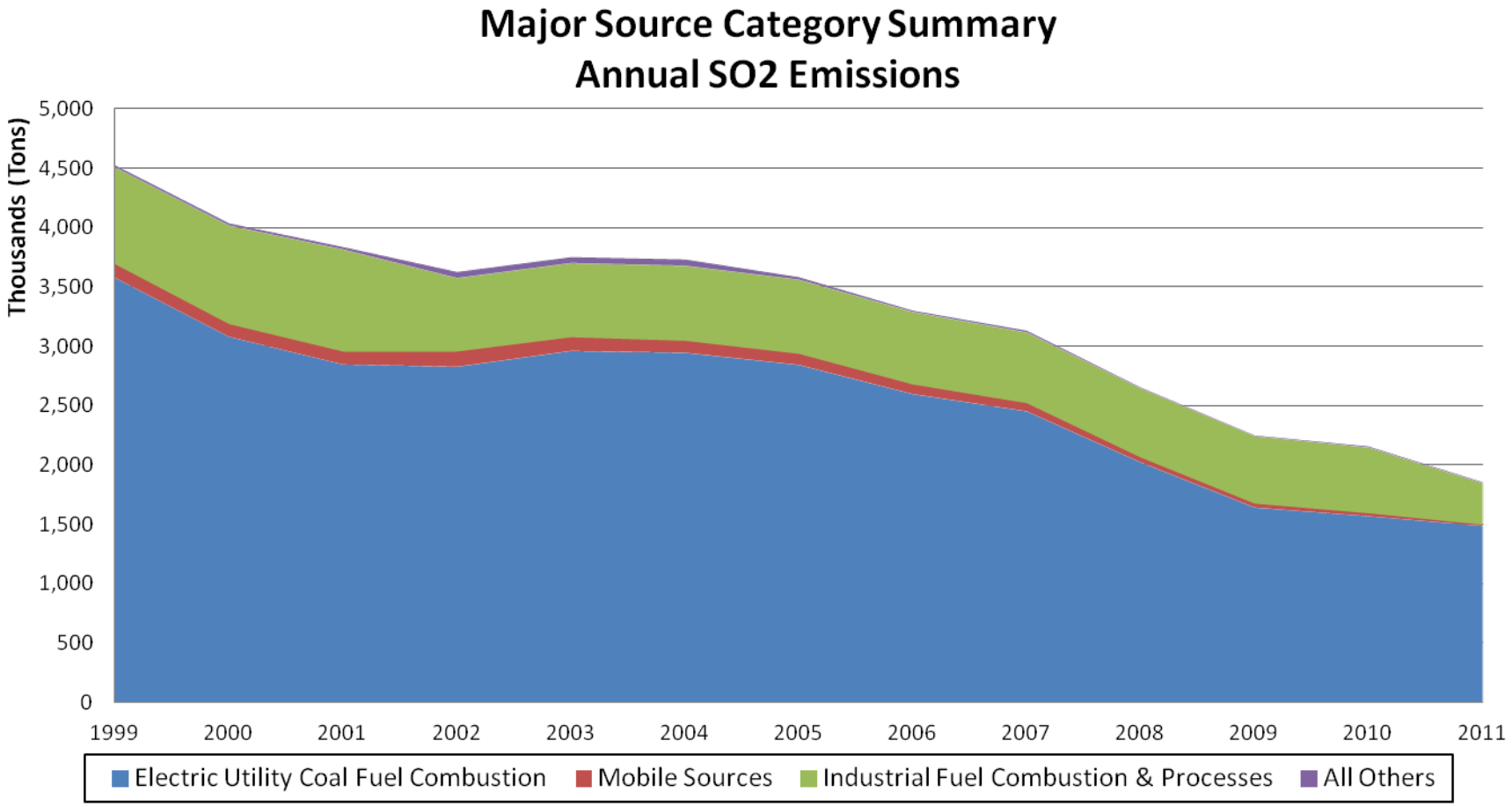


Midwestern Emission Trends (SO_2)

	Annual Emissions (Tons)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	3,572,790	2,843,401	2,957,537	2,839,725	2,593,785	2,448,292	2,017,849	1,637,440	1,564,262	1,481,991
Mobile Sources	121,854	115,674	121,575	99,872	87,581	75,291	48,048	39,779	31,510	17,508
Industrial Fuel Combustion & Processes	814,837	859,282	624,480	623,848	609,466	595,139	581,868	567,486	553,566	349,556
All Others	16,498	18,812	47,868	19,637	10,360	13,330	5,795	4,721	6,922	5,965
Total	**4,525,979**	**3,837,168**	**3,751,459**	**3,583,082**	**3,301,193**	**3,132,051**	**2,653,559**	**2,249,427**	**2,156,260**	**1,855,020**

	Annual Emissions Change (Percent since 1999)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	0%	-20%	-17%	-21%	-27%	-31%	-44%	-54%	-56%	-59%
Mobile Sources	0%	-5%	0%	-18%	-28%	-38%	-61%	-67%	-74%	-86%
Industrial Fuel Combustion & Processes	0%	5%	-23%	-23%	-25%	-27%	-29%	-30%	-32%	-57%
All Others	0%	14%	190%	19%	-37%	-19%	-65%	-71%	-58%	-64%
Total	**0%**	**-15%**	**-17%**	**-21%**	**-27%**	**-31%**	**-41%**	**-50%**	**-52%**	**-59%**

Midwestern Emission Trends (SO_2)

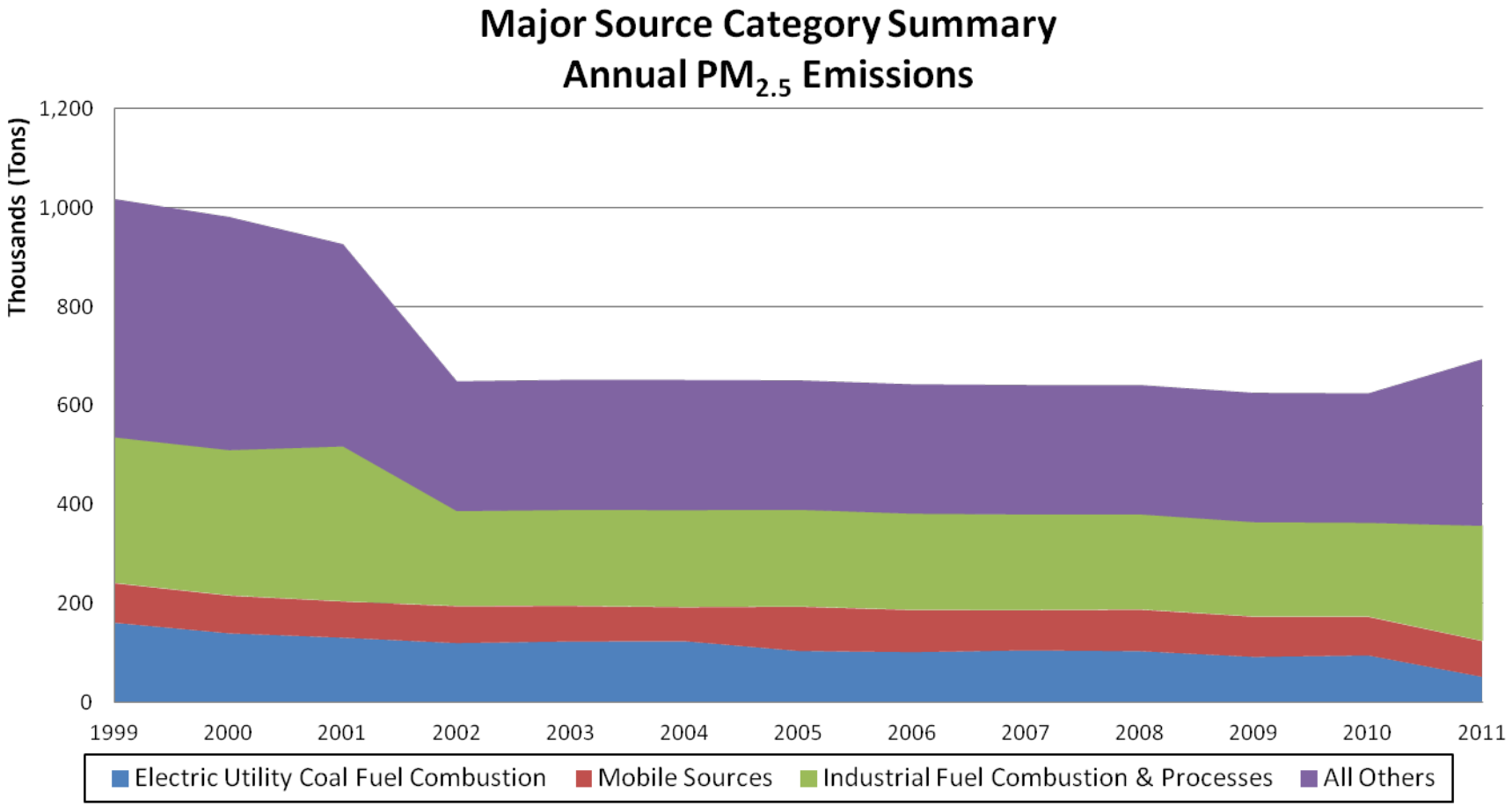


Midwestern Emission Trends ($PM_{2.5}$)

	Annual Emissions (Tons)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	160,606	130,507	122,956	103,587	101,077	104,825	103,012	91,561	94,525	50,992
Mobile Sources	80,159	73,433	71,751	89,725	85,637	81,549	84,432	81,394	78,357	72,748
Industrial Fuel Combustion & Processes	295,543	314,060	195,102	196,766	195,556	194,360	193,227	192,015	190,817	233,813
All Others	481,752	409,200	263,039	261,607	261,550	261,591	261,575	261,568	261,618	337,044
Total	**1,018,061**	**927,201**	**652,848**	**651,684**	**643,819**	**642,325**	**642,247**	**626,538**	**625,317**	**694,597**

	Annual Emissions Change (Percent since 1999)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	0%	-19%	-23%	-36%	-37%	-35%	-36%	-43%	-41%	-68%
Mobile Sources	0%	-8%	-10%	12%	7%	2%	5%	2%	-2%	-9%
Industrial Fuel Combustion & Processes	0%	6%	-34%	-33%	-34%	-34%	-35%	-35%	-35%	-21%
All Others	0%	-15%	-45%	-46%	-46%	-46%	-46%	-46%	-46%	-30%
Total	**0%**	**-9%**	**-36%**	**-36%**	**-37%**	**-37%**	**-37%**	**-38%**	**-39%**	**-32%**

Midwestern Emission Trends ($PM_{2.5}$)



Emission Trends Summary

- All pollutants have decreased since 1999 in aggregate across the midwestern 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 Midwestern states for the period 1999 – 2011

- Create a spreadsheet database of O_3 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/m^3
- $PM_{2.5}$ 24-Hour
  - Annual 98th percentile of daily averages averaged over three consecutive years
  - Current standard = 35 ug/m^3

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)

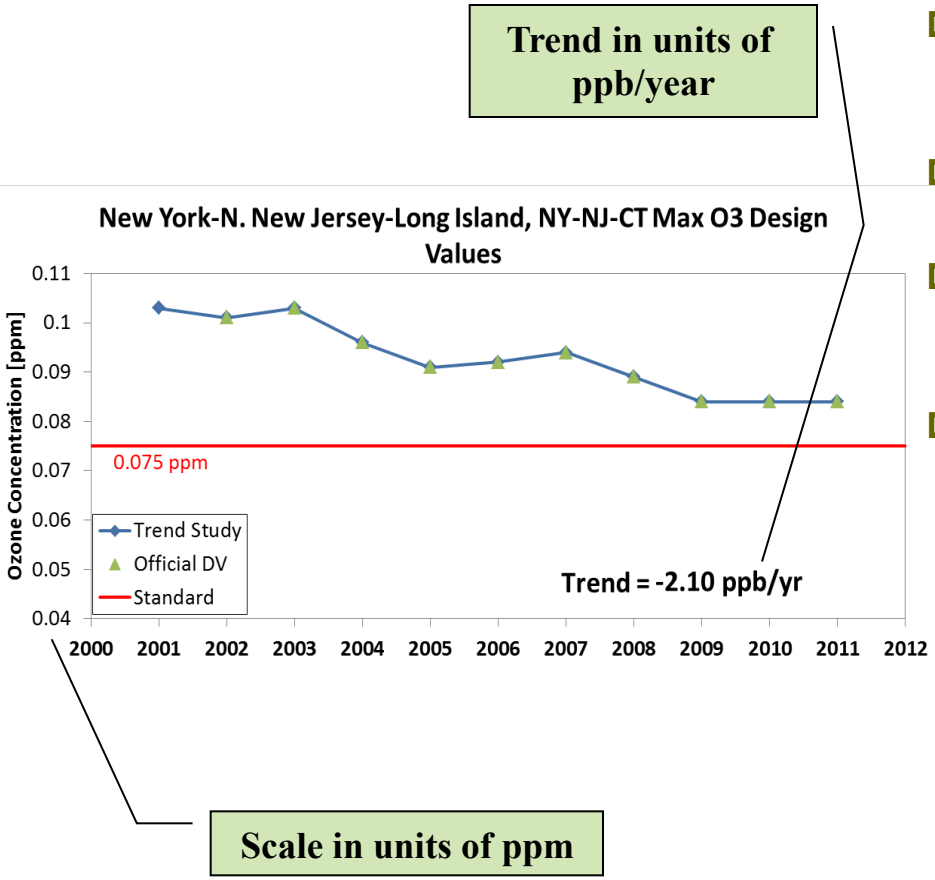
Data Handling Procedures

- O_3 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

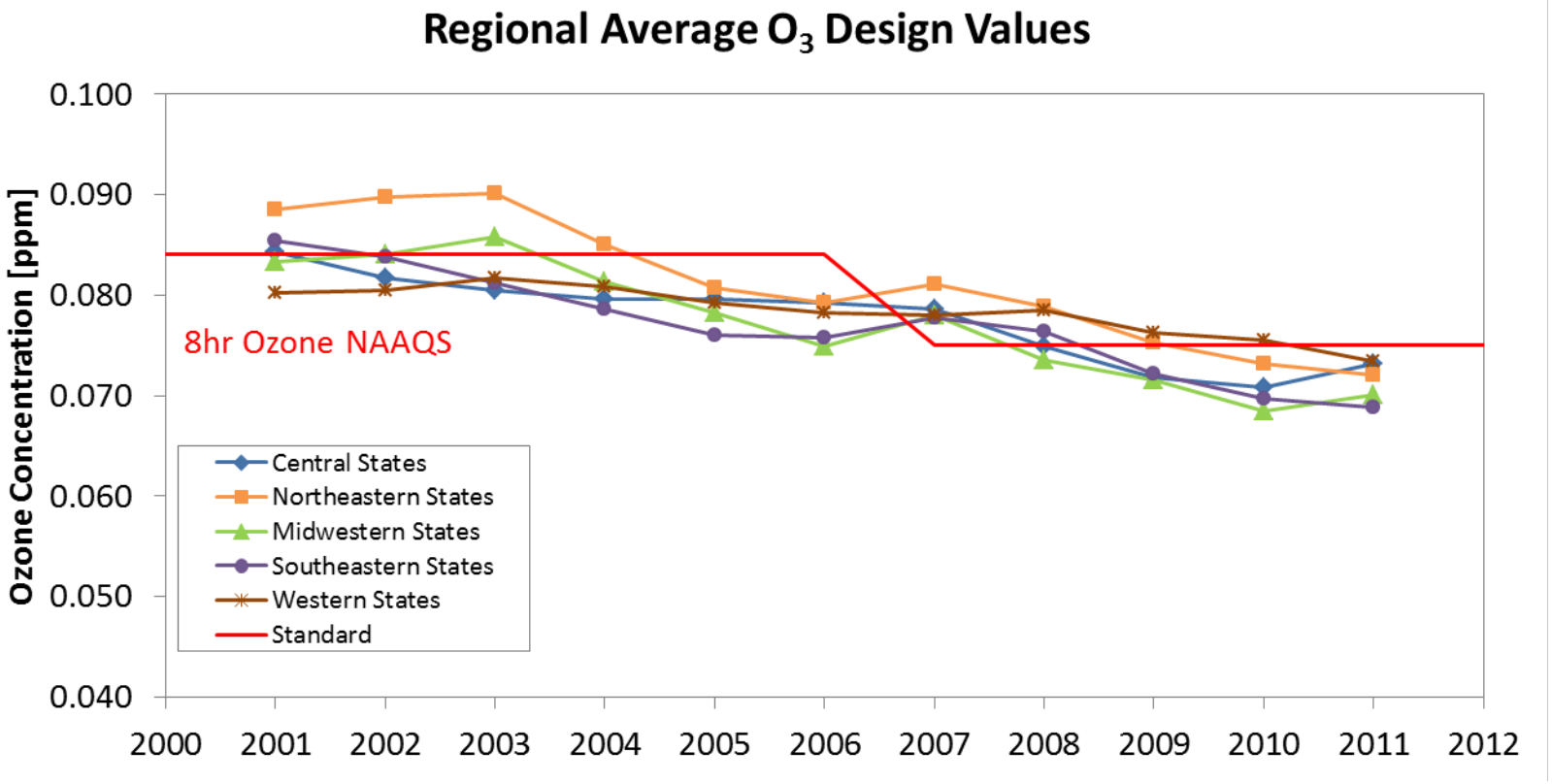
- Annual $PM_{2.5}$ DV and 24-hr $PM_{2.5}$ DV for each overlapping three-year period starting with 1999-2001 and ending with 2009-2011
  - DV calculations based on EPA data handling conventions
  - Data extracted from monitors that have a non-regulatory monitoring type are omitted
  - Selection of trend 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

O_3 Trends by Regions



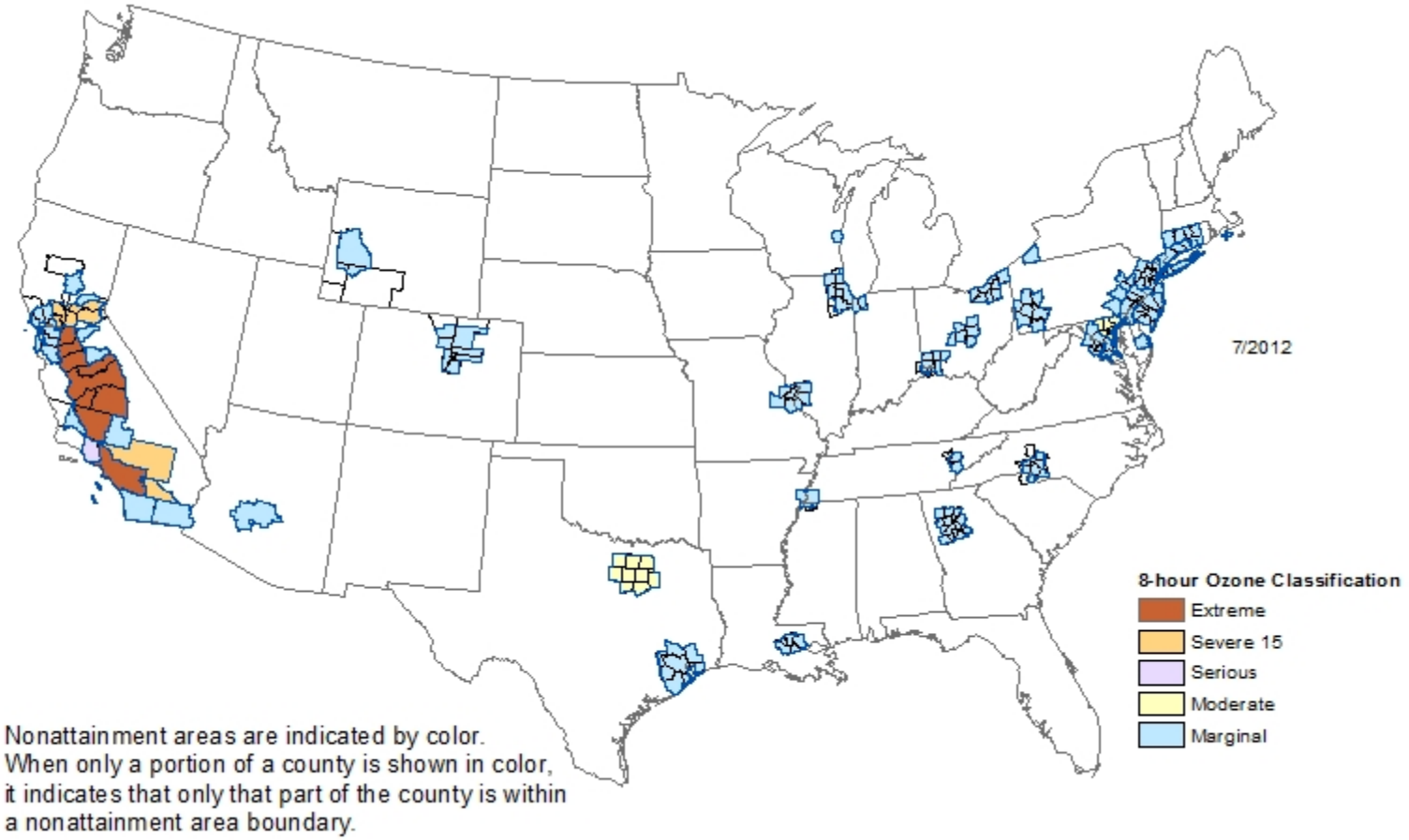
- Average ozone DVs have decreased in all five regions
- Trends are not monotonic, possibly reflecting influence of meteorology

O_3 Trend Slopes by Region

Region	O_3 Trend Slope
Central States	-1.2ppb/year
Northeastern States	-1.9ppb/year
Midwestern States	-1.7ppb/year
Southeastern States	-1.5ppb/year
Western States	-0.7ppb/year

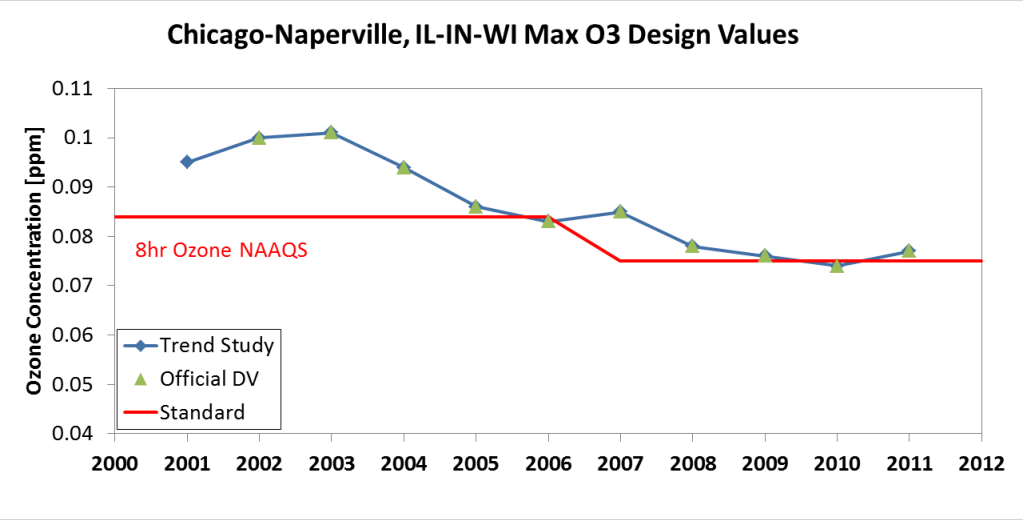
Note: 1 ppb = 0.001 ppm

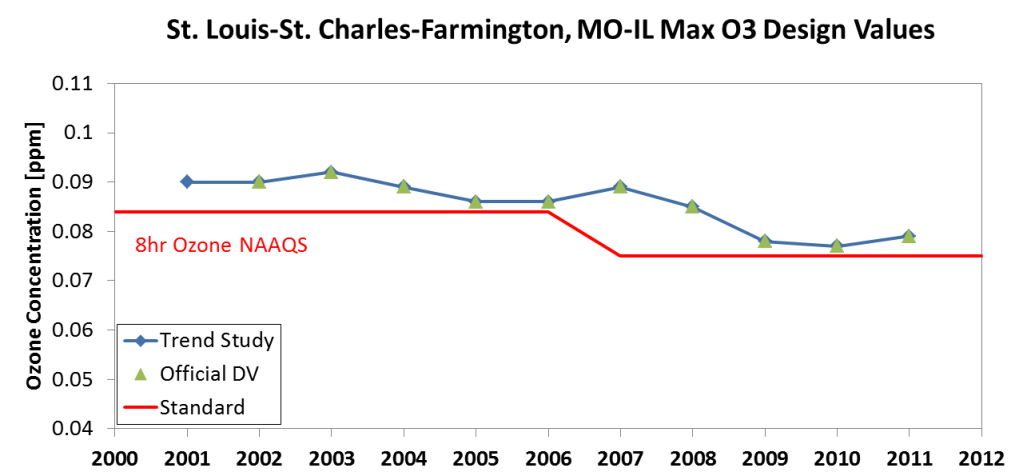
Designated O_3 Non-Attainment Areas (based on 2008 8-Hour Ozone standard)



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

Trends in Midwest States Non-Attainment Areas



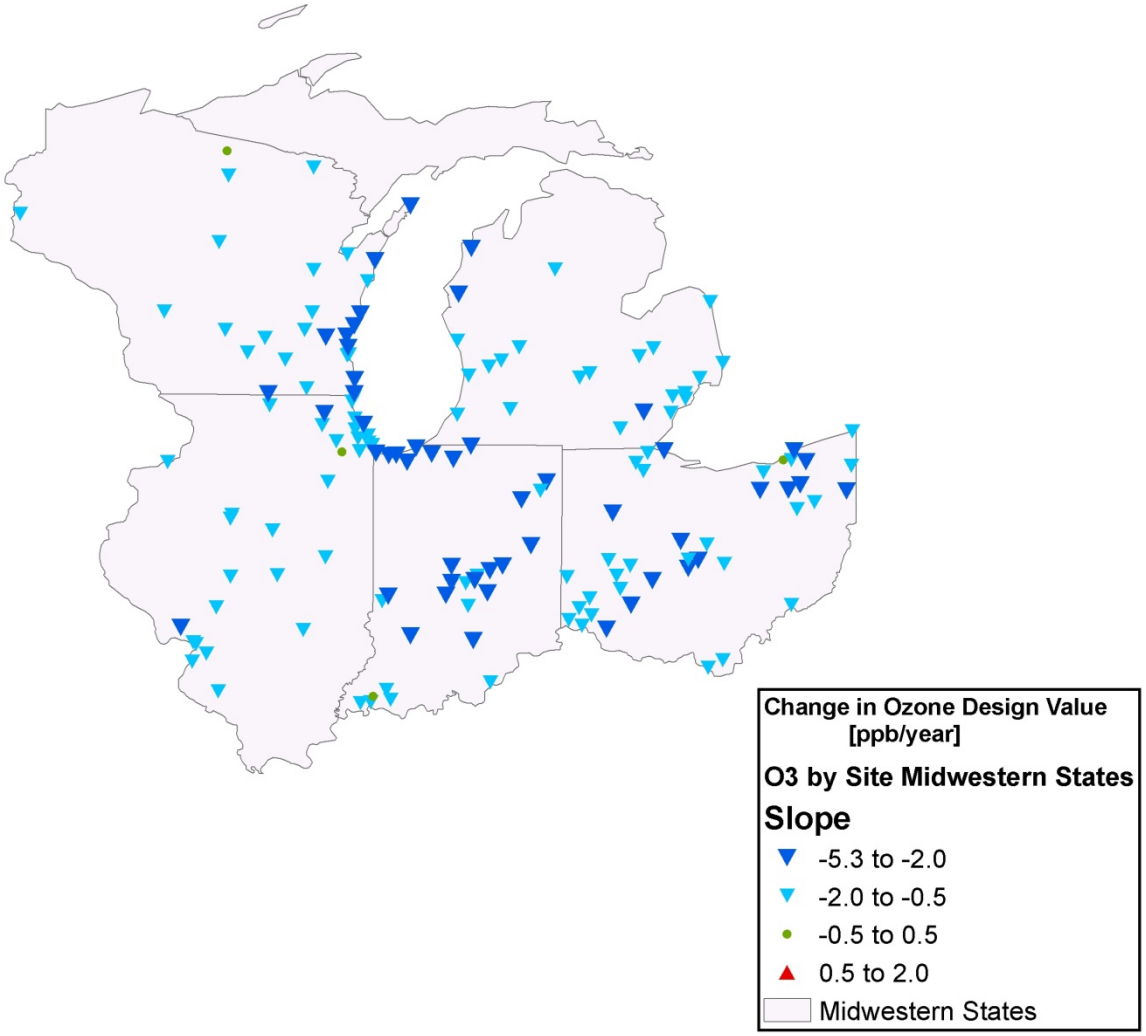


- Trends range from -2.75 ppb/yr (Chicago-Naperville, IL-IN-WI) to -1.40 ppb/yr (St. Louis-St. Charles-Farmington, MO-IL)
- Trends are negative (downward) in all 6 non-attainment areas in Midwest states.

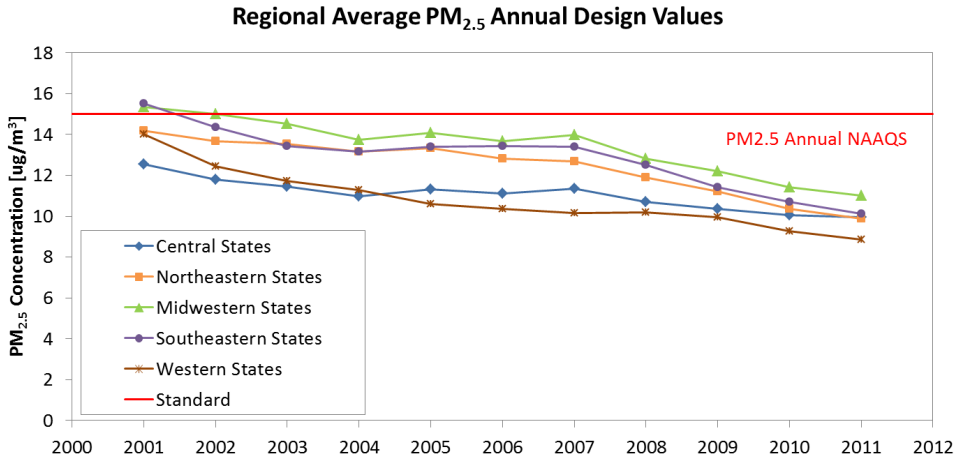
O_3 Trend Slopes in Midwest States Non-Attainment Areas

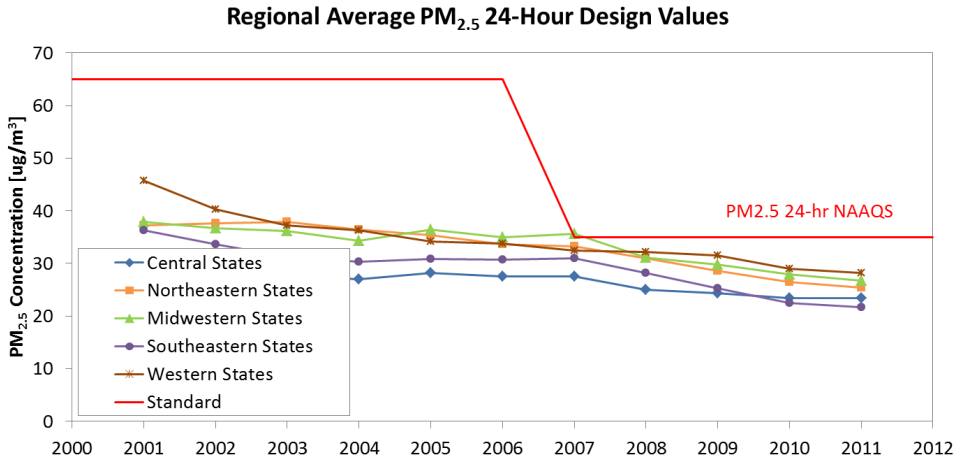
Non-Attainment Areas	O_3 Trend Slope [ppb/year]
Chicago-Naperville, IL-IN-WI	-2.75
Cleveland-Akron-Lorain, OH	-2.32
Sheboygan, WI	-2.15
Cincinnati, OH-KY-IN	-1.79
Columbus, OH	-1.54
St. Louis-St. Charles-Farmington, MO-IL	-1.40

Midwest States Monitoring Sites O_3 Trend Slopes



$PM_{2.5}$ Trends by Regions



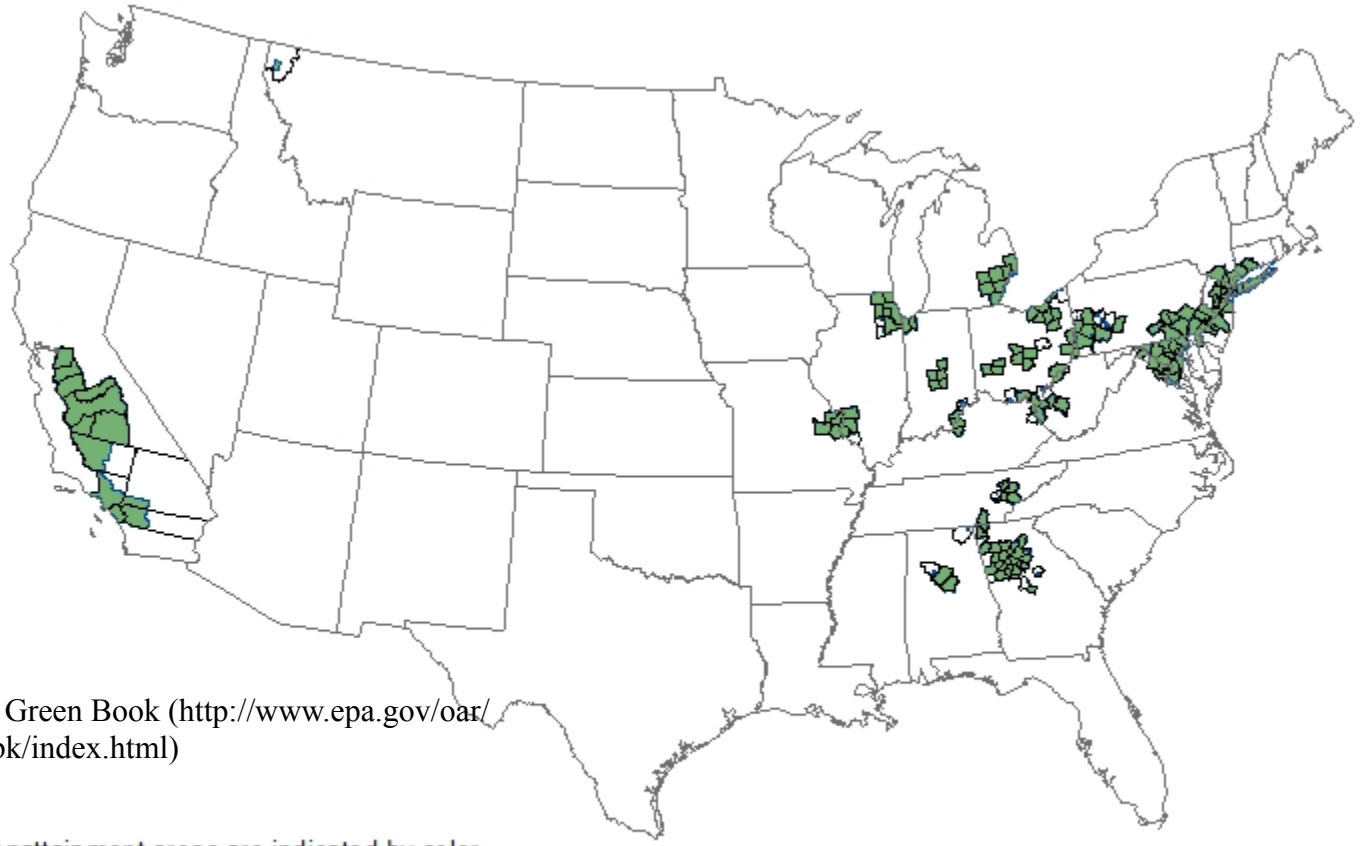


- Both average and 24-hr $PM_{2.5}$ DVs have decreased (negative trends) in all five regions
- Trends are not monotonic, possibly reflecting influence of meteorology

$PM_{2.5}$ 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)

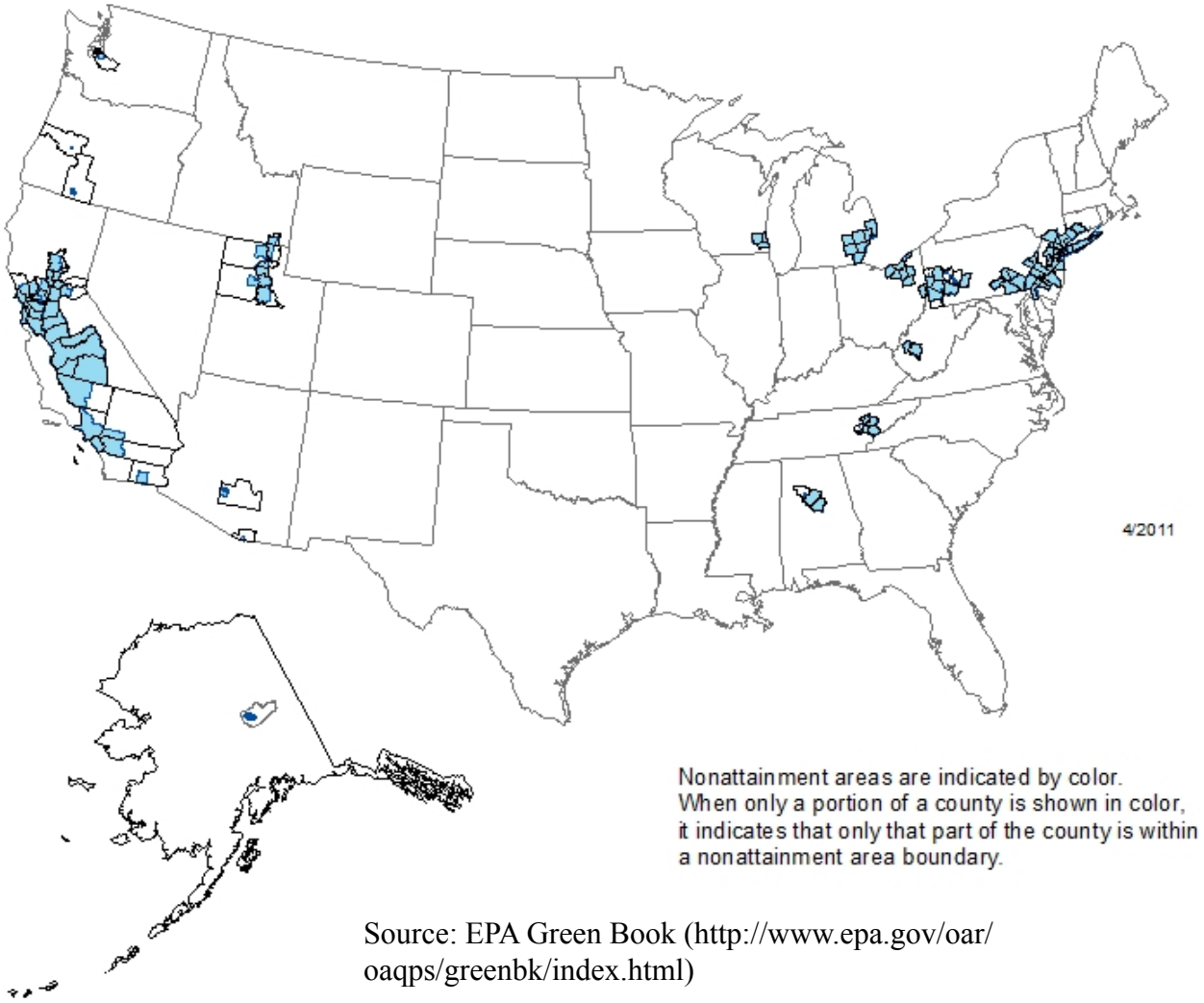


Source: EPA Green Book (http://www.epa.gov/oar/oaqps/greenbk/index.html)

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.

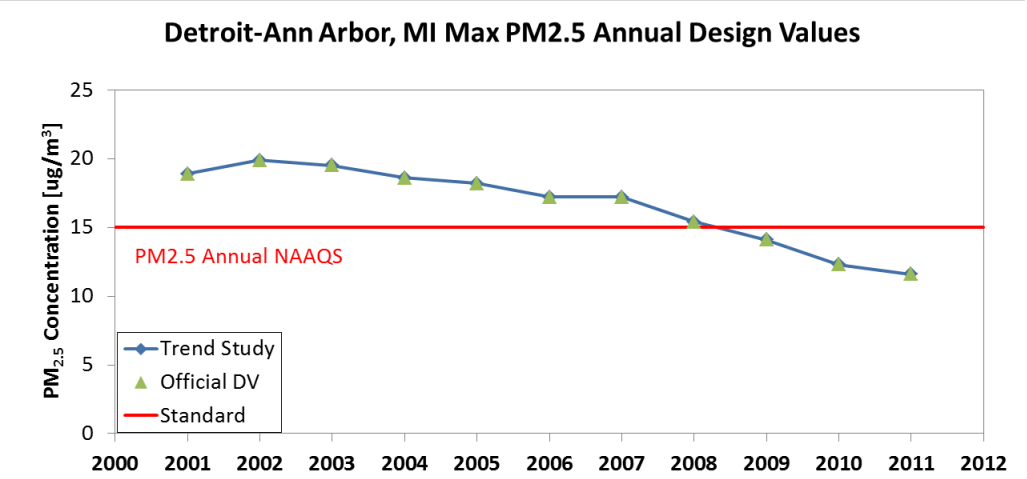
3/2012

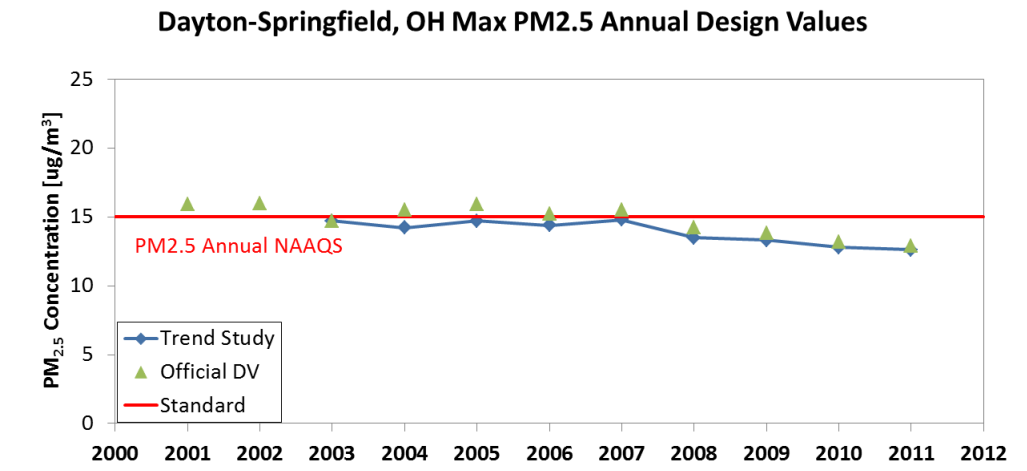
Designated $PM_{2.5}$ Non-Attainment Areas (based on 2006 24-Hr $PM_{2.5}$ Standards)



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

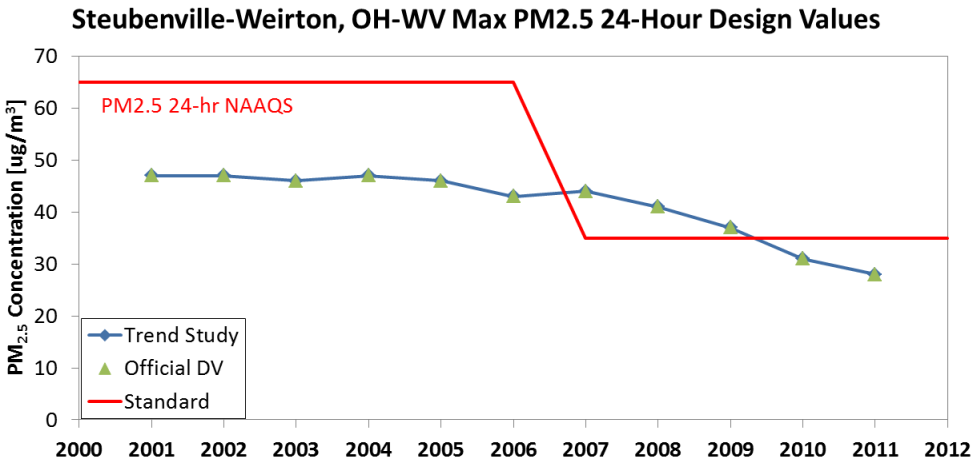
Annual $PM_{2.5}$ DV Trends in Midwest States Non-Attainment Area

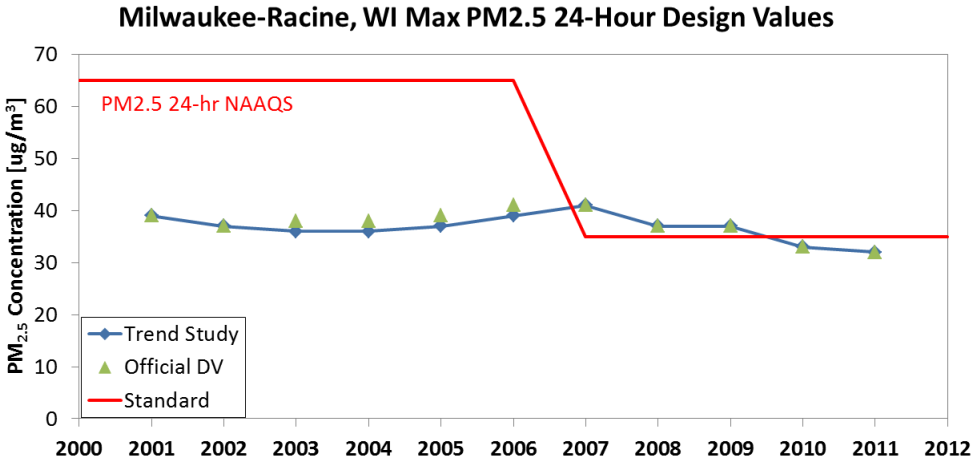




- Trends range from -0.82 ug/m^3/yr (Detroit-Ann Arbor, MI) to -0.27 ug/m^3/yr (Dayton-Springfield, OH)
- Trends are negative (downward) in 12 of 13 non-attainment areas in the Midwest States. The trend at Canton-Massillon, OH is not determined due to limited data available.

24-Hour $PM_{2.5}$ DV Trends in Midwest States Non-Attainment Area





- Trends range from -1.82 ug/m^3/yr (Steubenville-Weirton, OH-WV) to -0.38 ug/m^3/yr (Milwaukee-Racine, WI)
- Trends are negative (downward) in 4 out of 5 non-attainment areas in Midwest states. The trend at Canton-Massillon, OH is not determined due to limited data available

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

Non-Attainment Area	Annual $PM_{2.5}$ Slope ($ug/m^3/yr$)
Detroit-Ann Arbor, MI	-0.82
Huntington-Ashland, WV-KY-OH	-0.77
Cleveland-Akron-Lorain, OH	-0.69
Chicago-Gary-Lake County, IL-IN	-0.61
Columbus, OH	-0.58
Steubenville-Weirton, OH-WV	-0.51
Parkersburg-Marietta, WV-OH	-0.46
St. Louis, MO-IL	-0.45
Indianapolis, IN	-0.39
Louisville, KY-IN	-0.35
Wheeling, WV-OH	-0.34
Dayton-Springfield, OH	-0.27
Canton-Massillon, OH *	#N/A

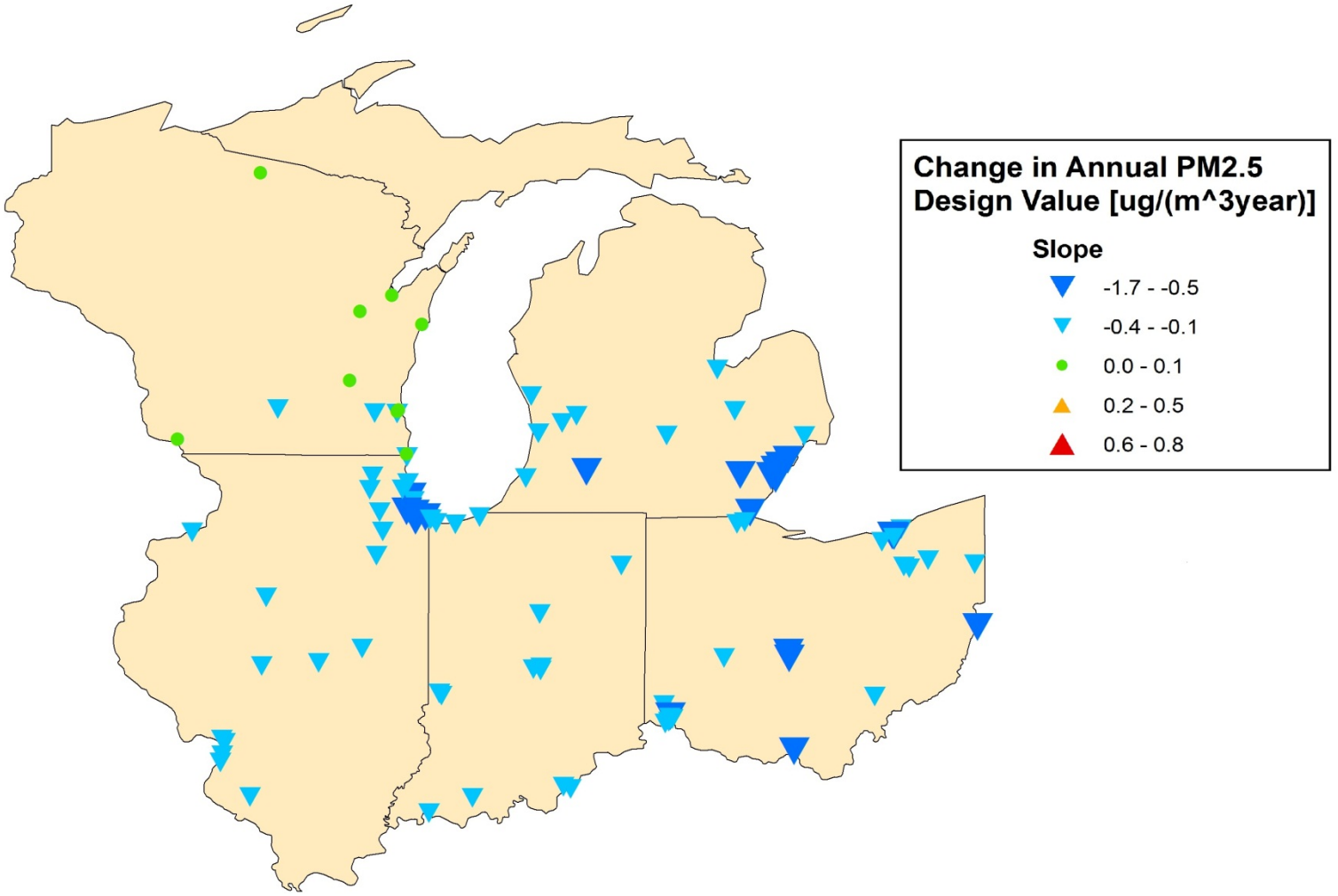
* Monitoring sites in this NAA do not meet completeness requirement for trend analysis

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

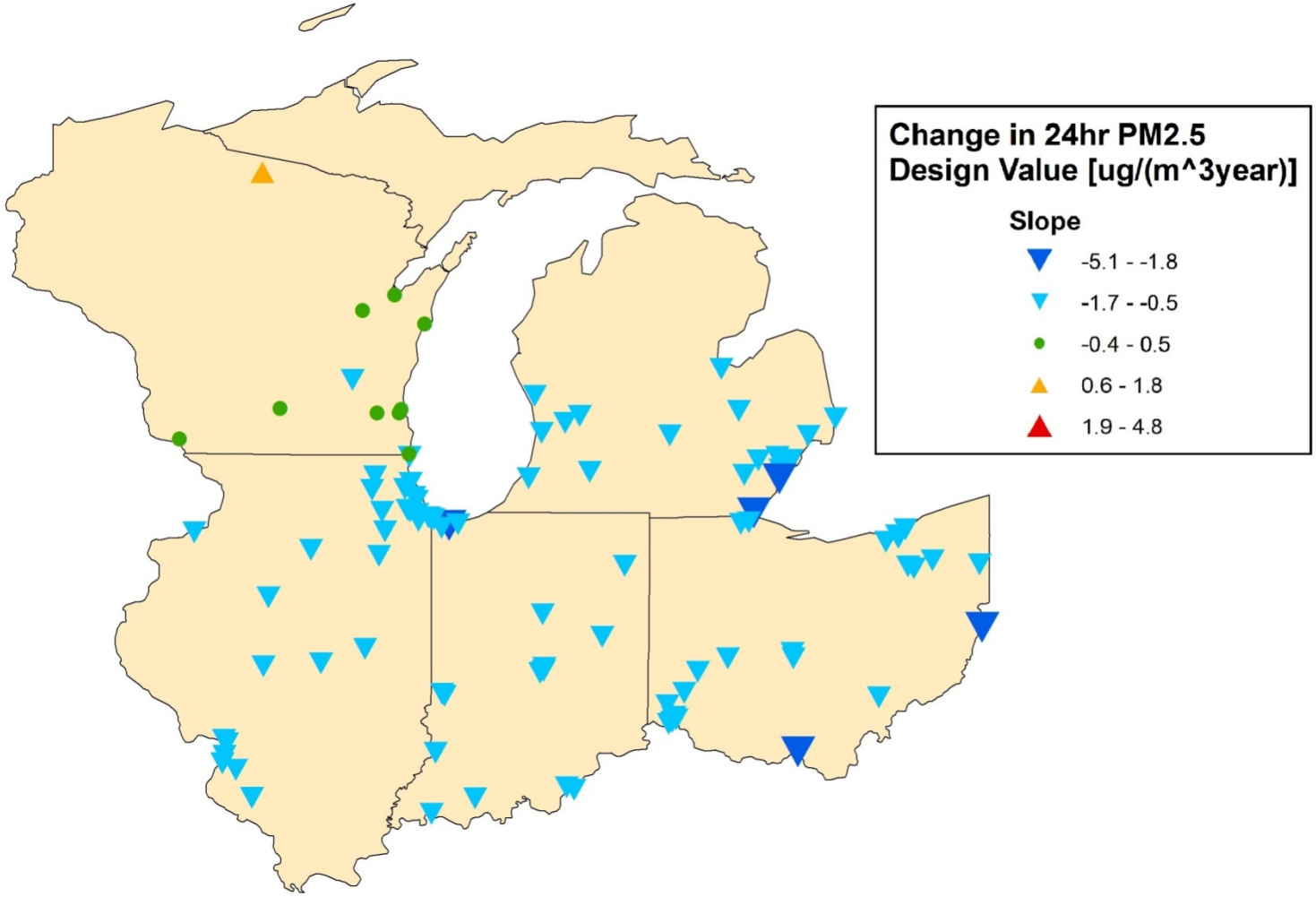
Non-Attainment Area	24-Hour $PM_{2.5}$ Slope ($ug/m^3/yr$)
Steubenville-Weirton, OH-WV	-1.82
Cleveland-Akron-Lorain, OH	-1.61
Detroit-Ann Arbor, MI	-1.48
Milwaukee-Racine, WI	-0.38
Canton-Massillon, OH *	#N/A

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

Annual $PM_{2.5}$ Trend Slopes at Midwest States Monitoring Sites



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



Air Quality Trends Summary

- Average O_3 and $PM_{2.5}$ design values have decreased since 1999 in the Midwest 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 Midwest 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:
  - Canton-Massillon, OH (Annual and 24-hour $PM_{2.5}$)