Emission and Air Quality Trends Review 1999-2011

Central States

July 2013

Project Objective

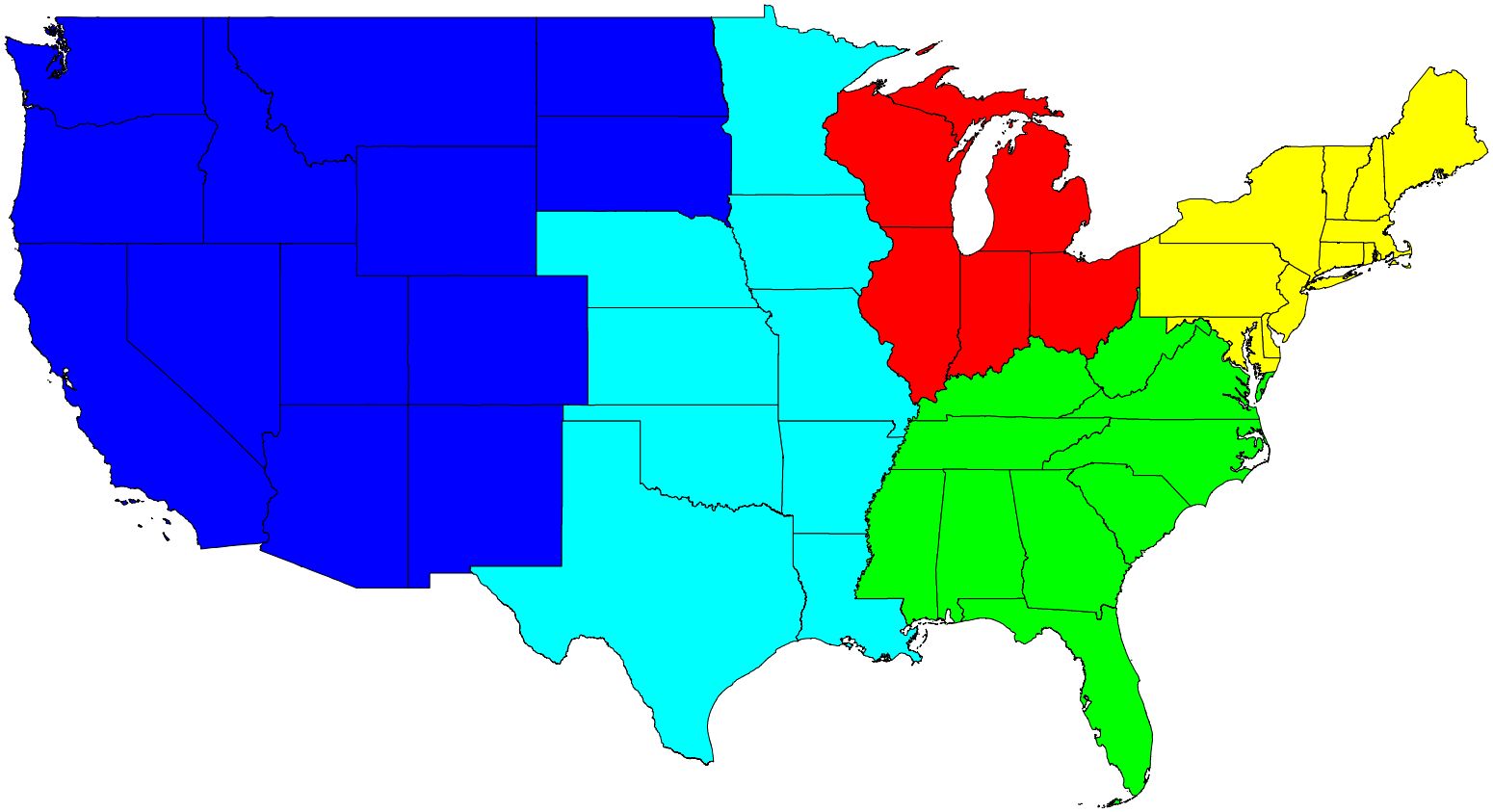
- To develop and present publicly available information on trends in emissions and ambient air quality in the U.S. since 1999 in easy to understand visual and tabular formats

ALPINE GEOPHYSICS

ENVIRON

Trends Analysis

Metrics developed for U.S. by Region



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

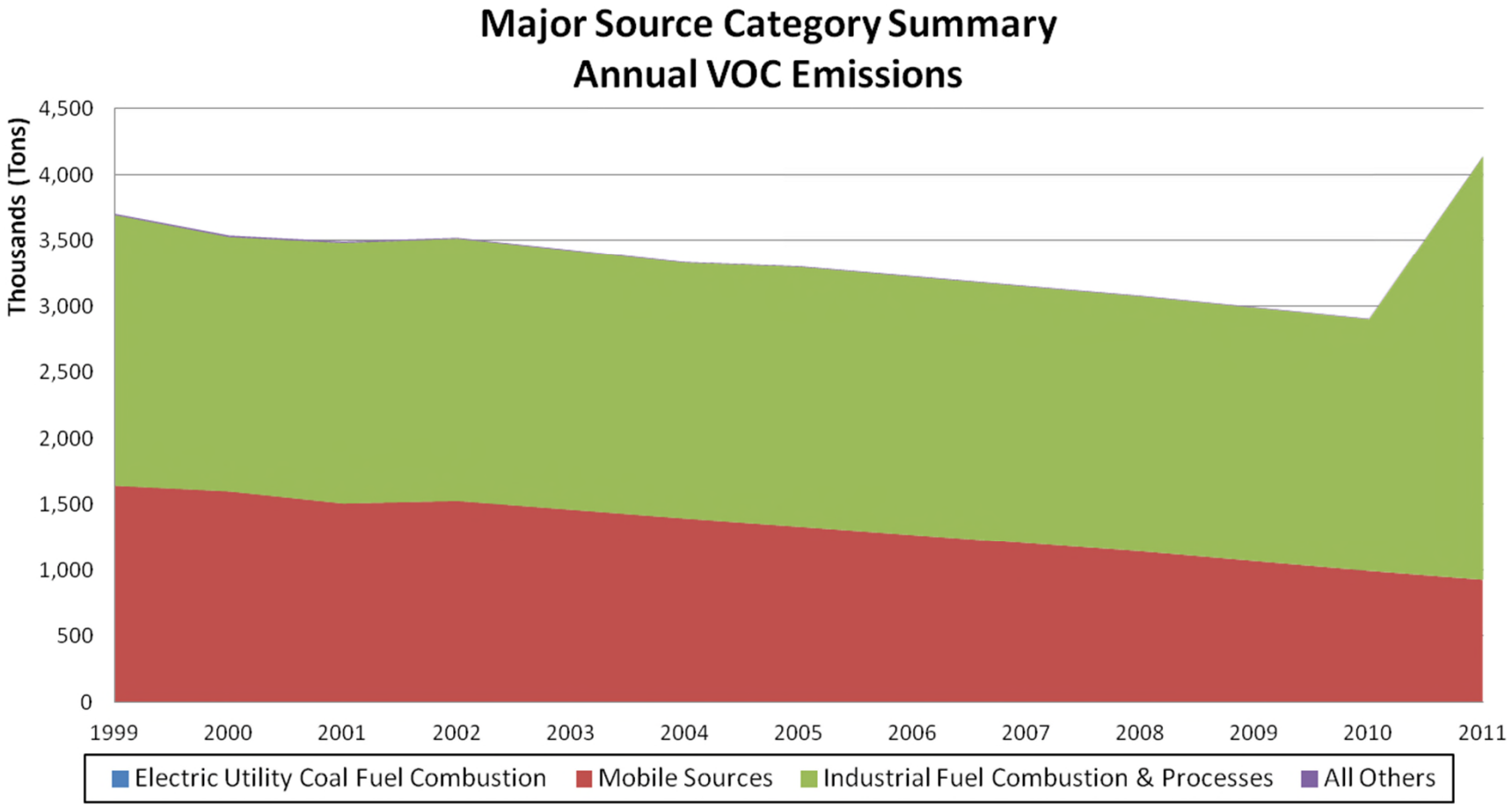
- Negative values indicate decrease in emissions, positive values indicate an increase

Central Emission Trends (VOC)

	Annual Emissions (Tons)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	7,013	8,063	7,738	6,668	6,621	6,618	6,542	6,179	6,252	6,864
Mobile Sources	1,634,386	1,499,174	1,452,123	1,324,357	1,261,006	1,197,653	1,135,430	1,060,960	986,491	918,106
Industrial Fuel Combustion & Processes	2,054,574	1,977,325	1,963,265	1,967,054	1,955,090	1,943,150	1,931,188	1,919,246	1,907,283	3,215,248
All Others	10,233	11,077	6,618	5,369	5,695	5,457	5,031	4,825	4,745	3,829
Total	**3,706,206**	**3,495,640**	**3,429,744**	**3,303,448**	**3,228,412**	**3,152,878**	**3,078,191**	**2,991,210**	**2,904,770**	**4,144,048**

	Annual Emissions Change (Percent since 1999)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	0%	15%	10%	-5%	-6%	-6%	-7%	-12%	-11%	-2%
Mobile Sources	0%	-8%	-11%	-19%	-23%	-27%	-31%	-35%	-40%	-44%
Industrial Fuel Combustion & Processes	0%	-4%	-4%	-4%	-5%	-5%	-6%	-7%	-7%	56%
All Others	0%	8%	-35%	-48%	-44%	-47%	-51%	-53%	-54%	-63%
Total	**0%**	**-6%**	**-7%**	**-11%**	**-13%**	**-15%**	**-17%**	**-19%**	**-22%**	**12%**

Central Emission Trends (VOC)

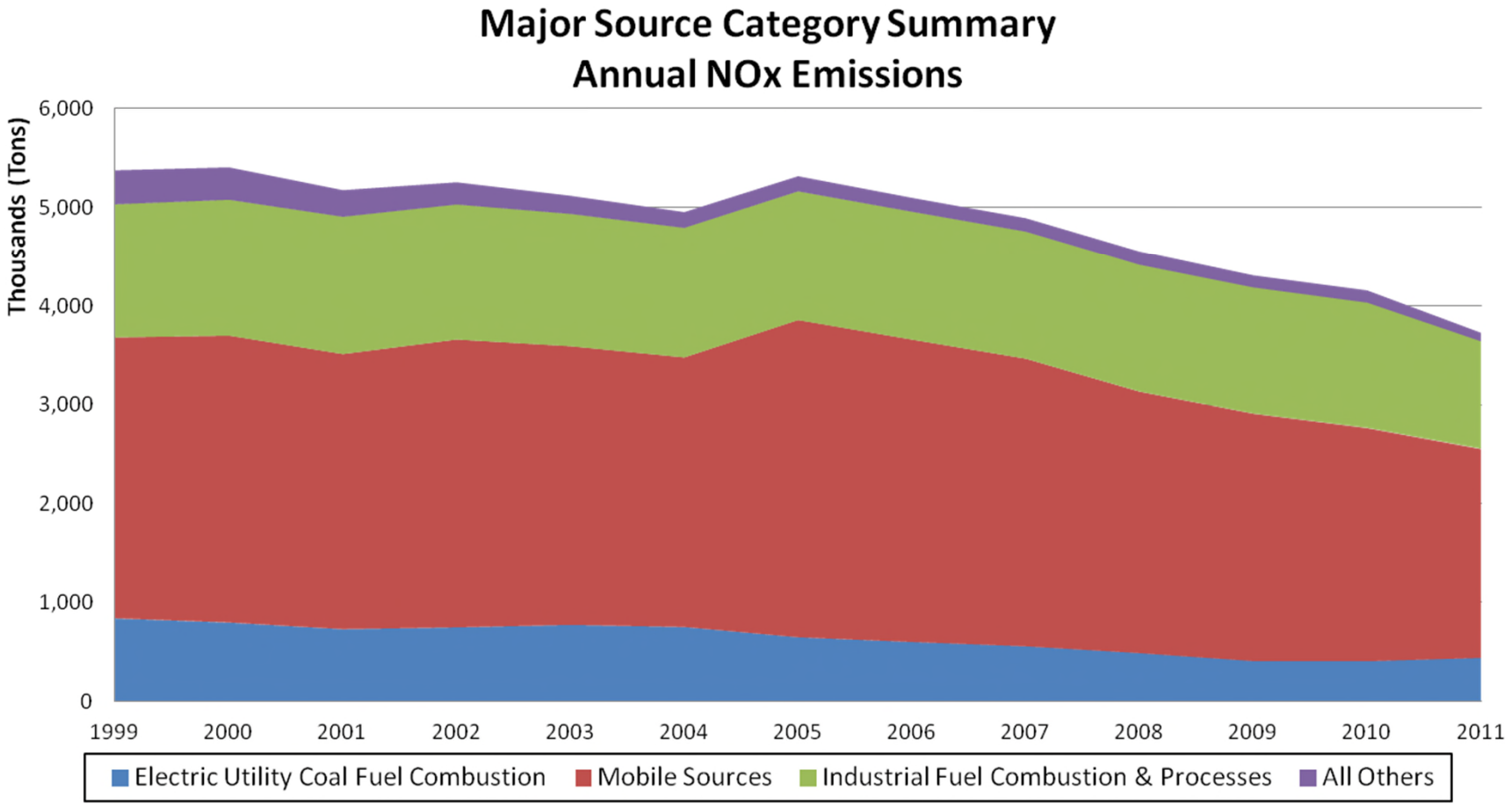


Central Emission Trends (NOx)

	Annual Emissions (Tons)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	840,883	731,402	775,211	649,707	602,100	558,892	490,177	410,117	408,131	442,027
Mobile Sources	2,836,391	2,777,875	2,813,306	3,202,369	3,052,989	2,903,608	2,640,297	2,497,862	2,355,427	2,110,600
Industrial Fuel Combustion & Processes	1,360,494	1,401,860	1,352,174	1,316,626	1,307,438	1,297,842	1,289,149	1,282,218	1,273,081	1,093,364
All Others	343,647	270,005	183,195	152,975	140,590	136,857	137,878	122,160	123,264	86,767
Total	**5,381,414**	**5,181,142**	**5,123,886**	**5,321,677**	**5,103,118**	**4,897,199**	**4,557,501**	**4,312,357**	**4,159,902**	**3,732,757**

	Annual Emissions Change (Percent since 1999)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	0%	-13%	-8%	-23%	-28%	-34%	-42%	-51%	-51%	-47%
Mobile Sources	0%	-2%	-1%	13%	8%	2%	-7%	-12%	-17%	-26%
Industrial Fuel Combustion & Processes	0%	3%	-1%	-3%	-4%	-5%	-5%	-6%	-6%	-20%
All Others	0%	-21%	-47%	-55%	-59%	-60%	-60%	-64%	-64%	-75%
Total	**0%**	**-4%**	**-5%**	**-1%**	**-5%**	**-9%**	**-15%**	**-20%**	**-23%**	**-31%**

Central Emission Trends (NOx)

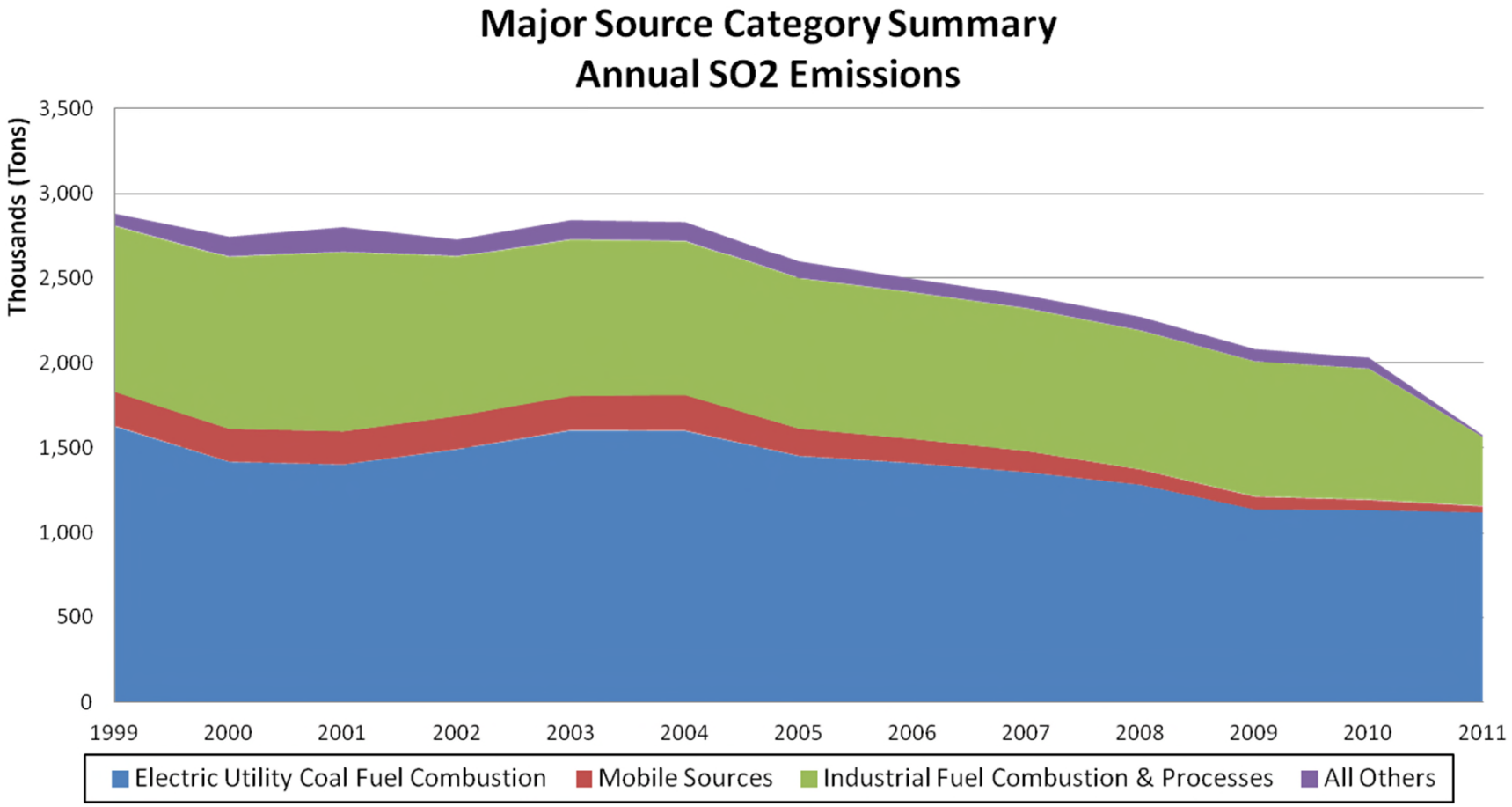


Central Emission Trends (SO_2)

	Annual Emissions (Tons)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	1,627,232	1,403,993	1,603,947	1,453,912	1,411,939	1,358,743	1,285,149	1,141,691	1,138,022	1,123,286
Mobile Sources	200,841	193,304	201,780	159,927	141,318	122,710	88,690	73,953	59,216	36,266
Industrial Fuel Combustion & Processes	983,629	1,060,905	926,063	885,828	862,164	839,887	816,932	794,280	769,621	406,726
All Others	69,427	144,194	112,615	96,131	78,108	74,507	78,996	71,241	64,062	9,581
Total	**2,881,128**	**2,802,396**	**2,844,405**	**2,595,797**	**2,493,529**	**2,395,848**	**2,269,767**	**2,081,164**	**2,030,920**	**1,575,859**

	Annual Emissions Change (Percent since 1999)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	0%	-14%	-1%	-11%	-13%	-16%	-21%	-30%	-30%	-31%
Mobile Sources	0%	-4%	0%	-20%	-30%	-39%	-56%	-63%	-71%	-82%
Industrial Fuel Combustion & Processes	0%	8%	-6%	-10%	-12%	-15%	-17%	-19%	-22%	-59%
All Others	0%	108%	62%	38%	13%	7%	14%	3%	-8%	-86%
Total	**0%**	**-3%**	**-1%**	**-10%**	**-13%**	**-17%**	**-21%**	**-28%**	**-30%**	**-45%**

Central Emission Trends (SO_2)

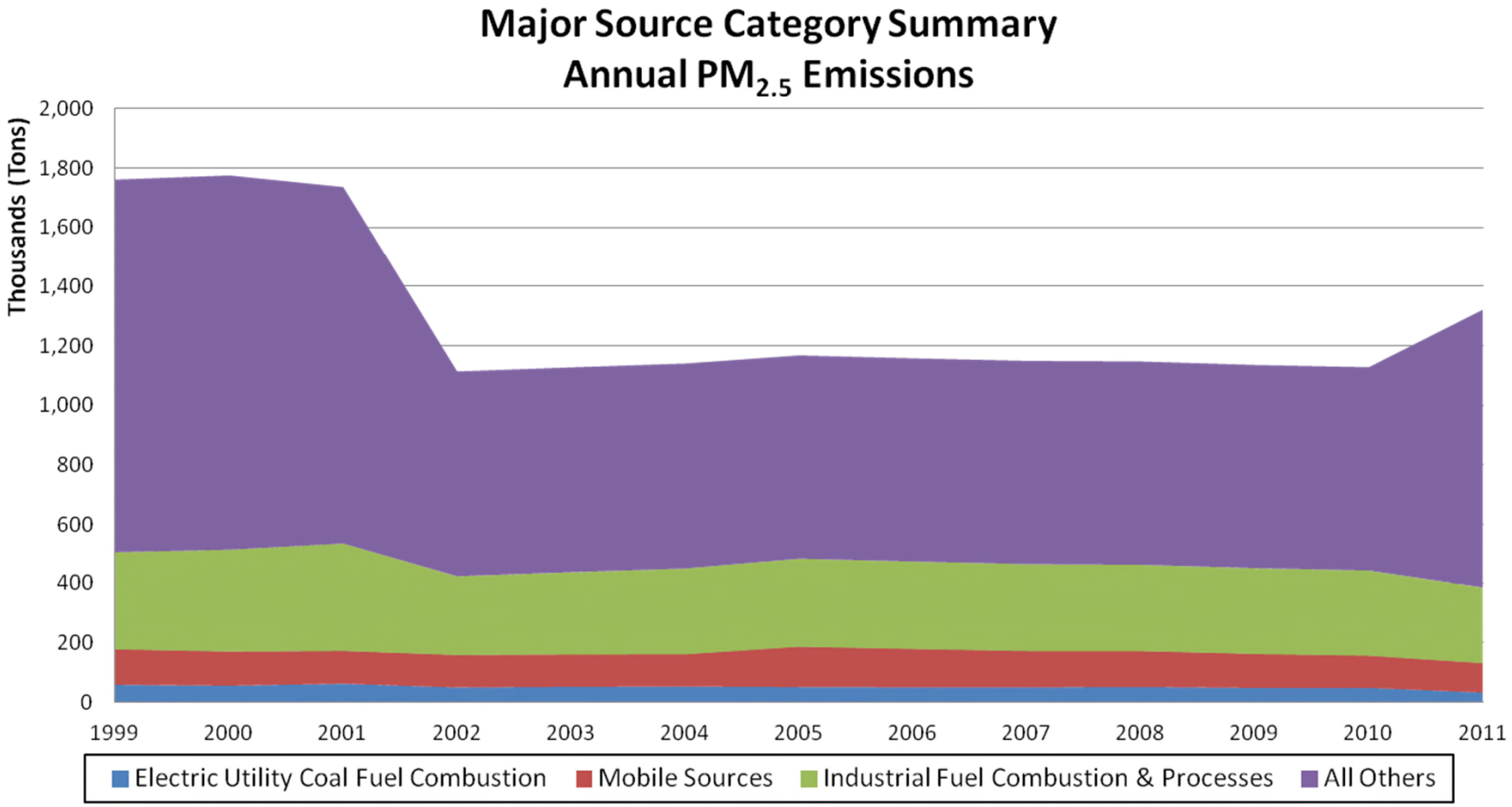


Central Emission Trends ($PM_{2.5}$)

	Annual Emissions (Tons)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	57,972	61,577	51,279	50,259	49,505	49,407	50,848	47,417	47,791	31,730
Mobile Sources	120,011	110,956	109,397	136,531	129,735	122,938	121,240	115,024	108,807	99,845
Industrial Fuel Combustion & Processes	325,501	360,241	275,417	294,740	292,847	291,001	289,136	287,245	285,390	253,140
All Others	1,259,845	1,205,495	692,147	686,813	686,574	686,761	686,718	686,521	686,676	937,347
Total	**1,763,329**	**1,738,269**	**1,128,240**	**1,168,344**	**1,158,661**	**1,150,108**	**1,147,942**	**1,136,207**	**1,128,663**	**1,322,063**

	Annual Emissions Change (Percent since 1999)									
Source Category	**1999**	**2001**	**2003**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Electric Utility Coal Fuel Combustion	0%	6%	-12%	-13%	-15%	-15%	-12%	-18%	-18%	-45%
Mobile Sources	0%	-8%	-9%	14%	8%	2%	1%	-4%	-9%	-17%
Industrial Fuel Combustion & Processes	0%	11%	-15%	-9%	-10%	-11%	-11%	-12%	-12%	-22%
All Others	0%	-4%	-45%	-45%	-46%	-45%	-45%	-46%	-45%	-26%
Total	**0%**	**-1%**	**-36%**	**-34%**	**-34%**	**-35%**	**-35%**	**-36%**	**-36%**	**-25%**

Central Emission Trends ($PM_{2.5}$)



Emission Trends Summary

- All pollutants with the exception of VOC have decreased since 1999 in aggregate across the central United States
  - Increases attributed to Industrial Processes
- NOx and SO2 from Electric Utility Fuel Combustion sources show 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 Central 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)

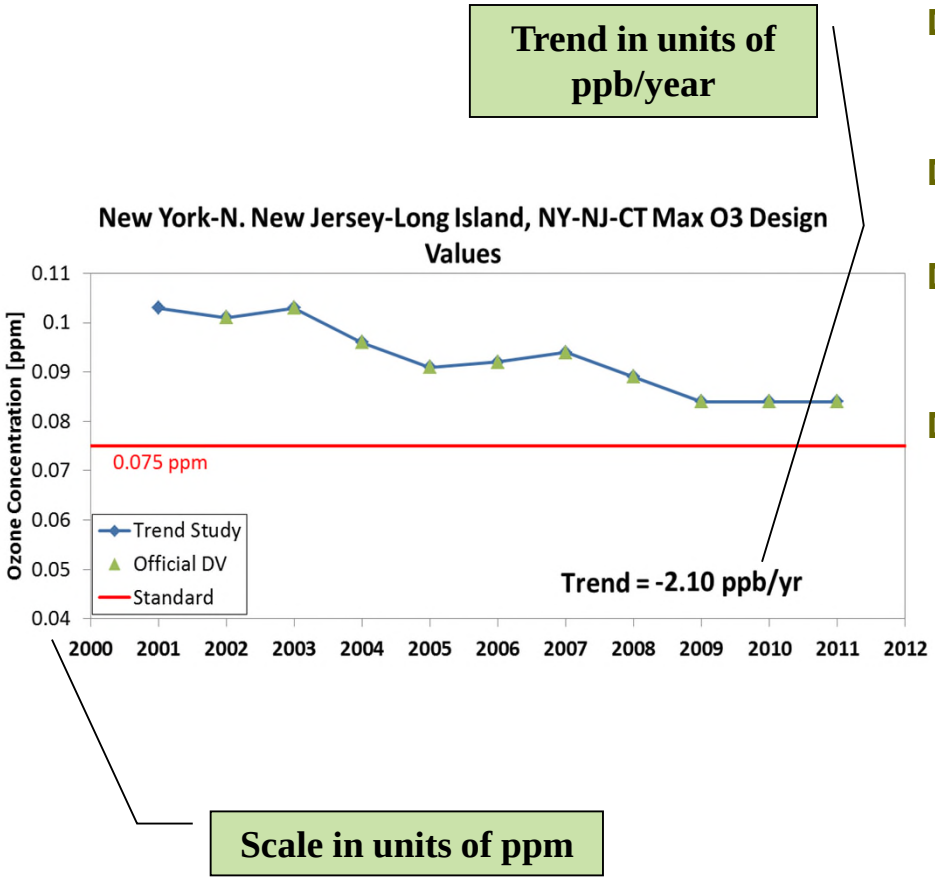
Data Handling Procedures

- 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

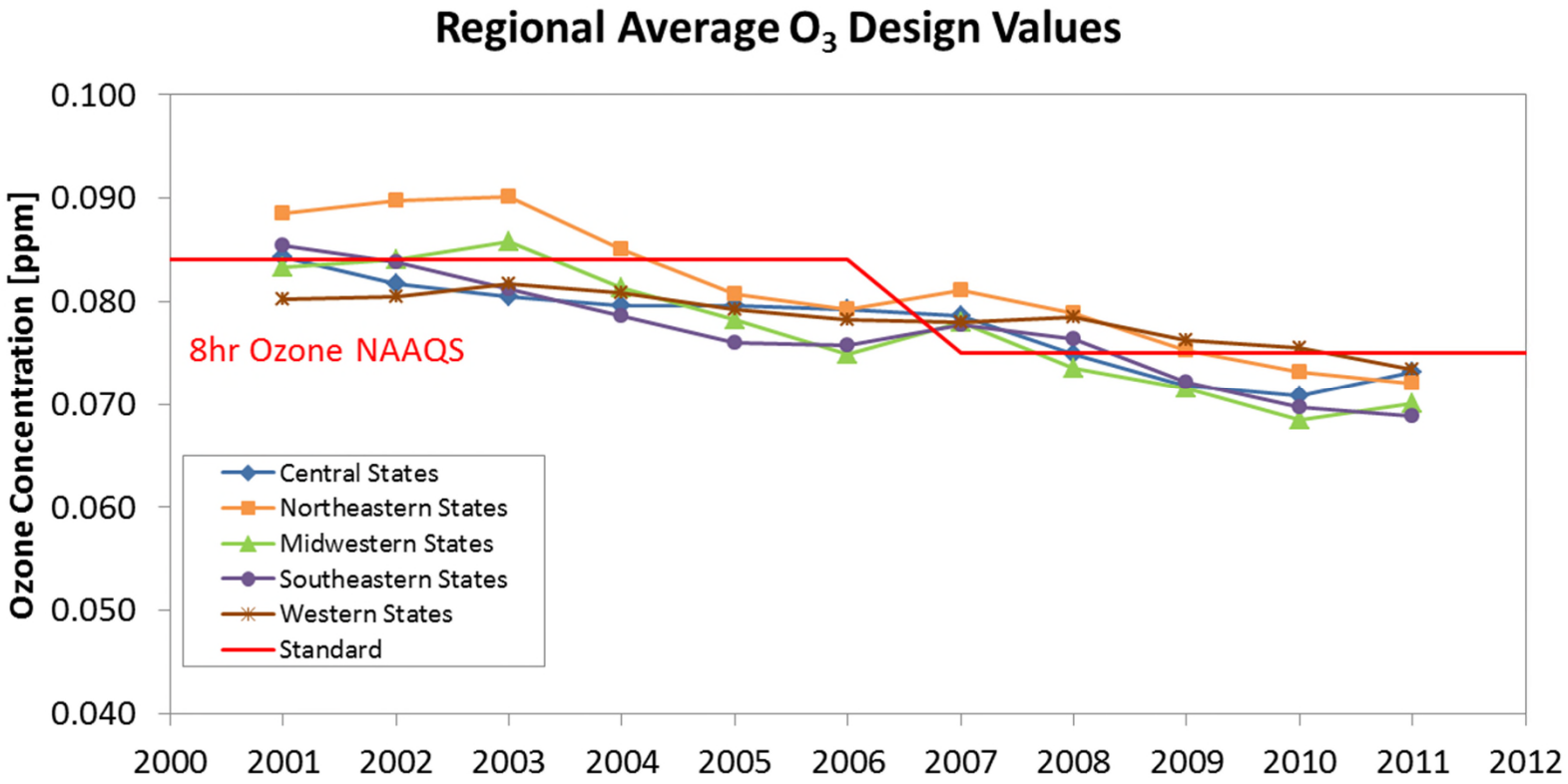
- Annual $PM_{2.5}$ DV and 24-hr $PM_{2.5}$ DV for each overlapping three-year period starting with 1999-2001 and ending with 2009-2011
  - DV calculations based on EPA data handling conventions
  - Data extracted from monitors that have a non-regulatory monitoring type are omitted
  - Selection of trend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



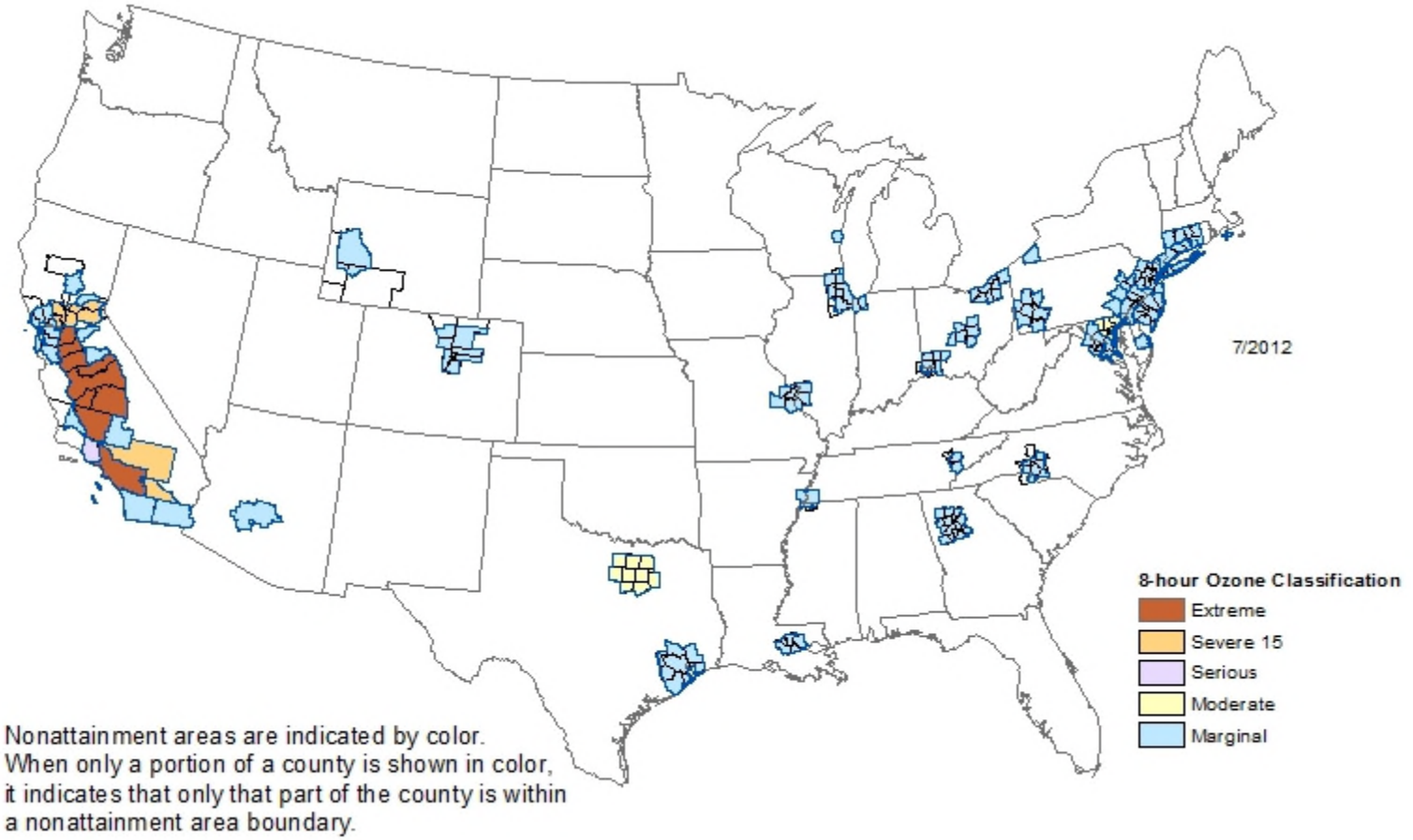
- Average ozone DVs have decreased in all five regions
- Trends are not monotonic, possibly reflecting influence of meteorology

O_3 Trend Slopes by Region

Region	O_3 Trend Slope
Central States	-1.2 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

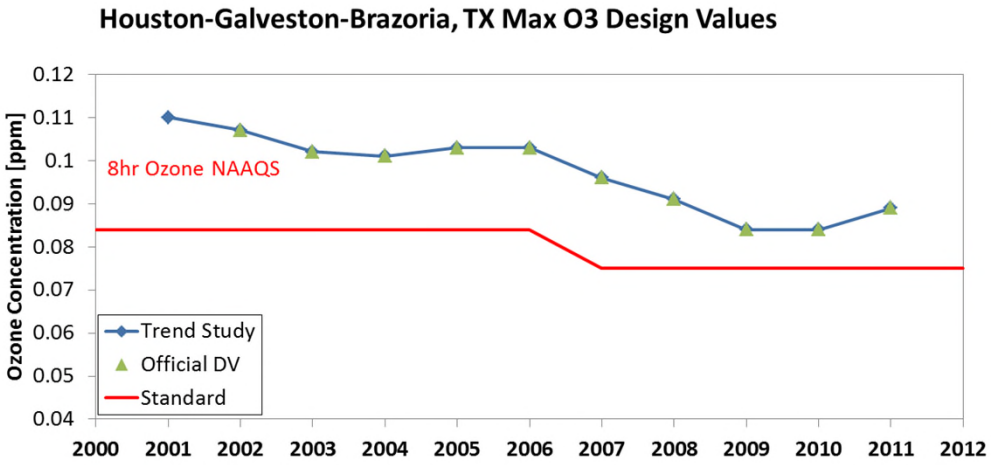
Note: 1 ppb = 0.001 ppm

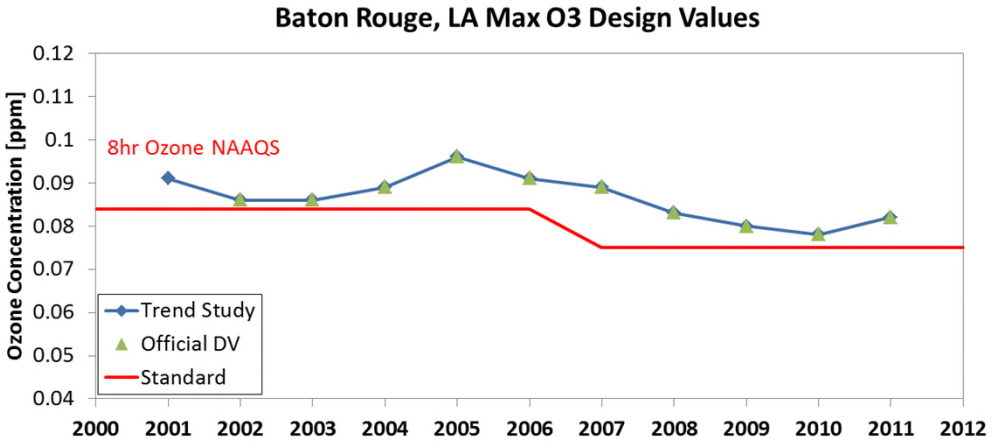
Designated O_3 Non-Attainment Areas (based on 2008 8-Hour Ozone standard)



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

Trends in Central States Non-Attainment Areas



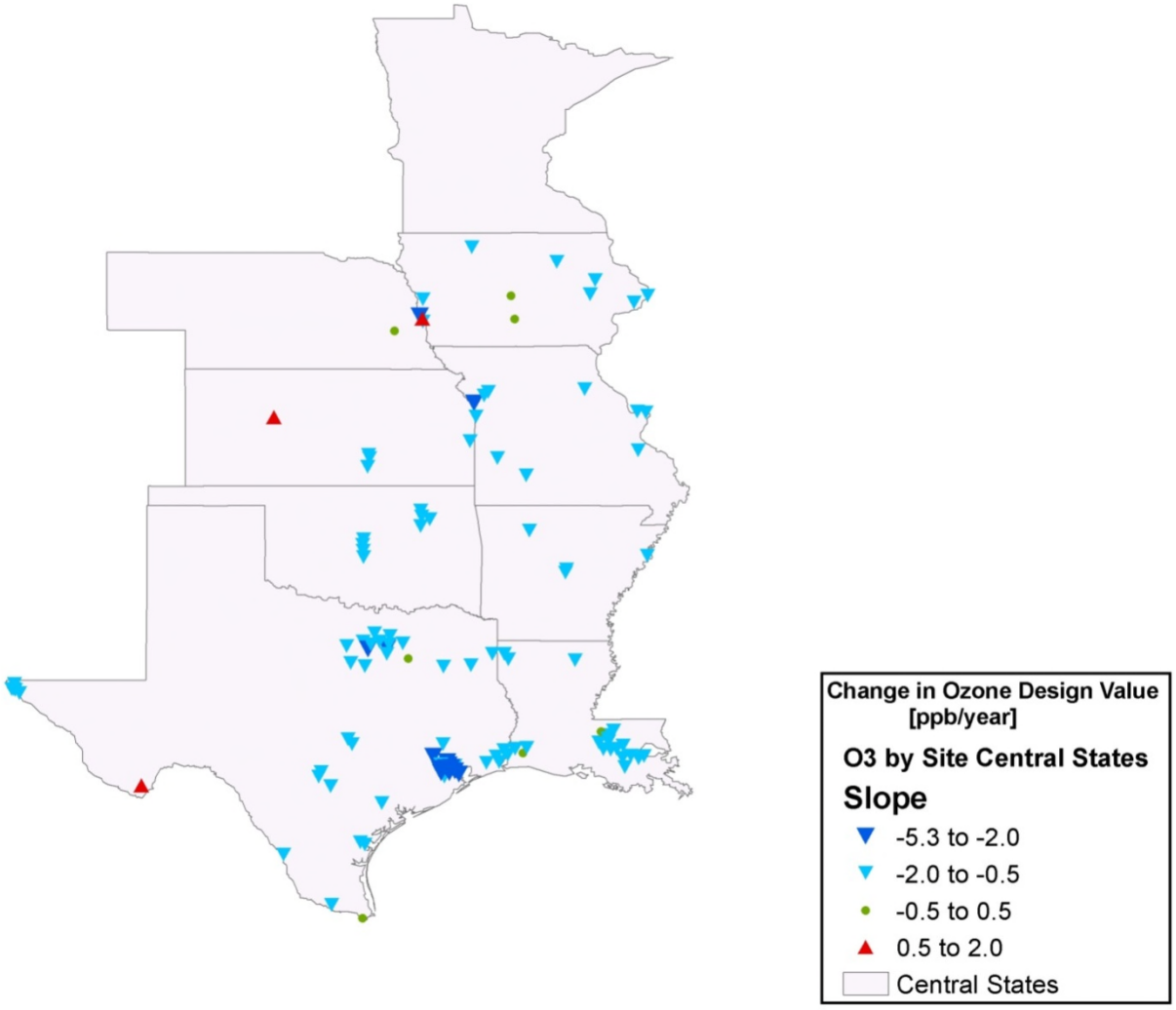


- Trends range from -2.53 ppb/yr (Houston-Galveston-Brazoria, TX) to -1.04 ppb/yr (Baton Rouge, LA)
- Trends are negative (downward) in all 5 non-attainment areas in Central states.

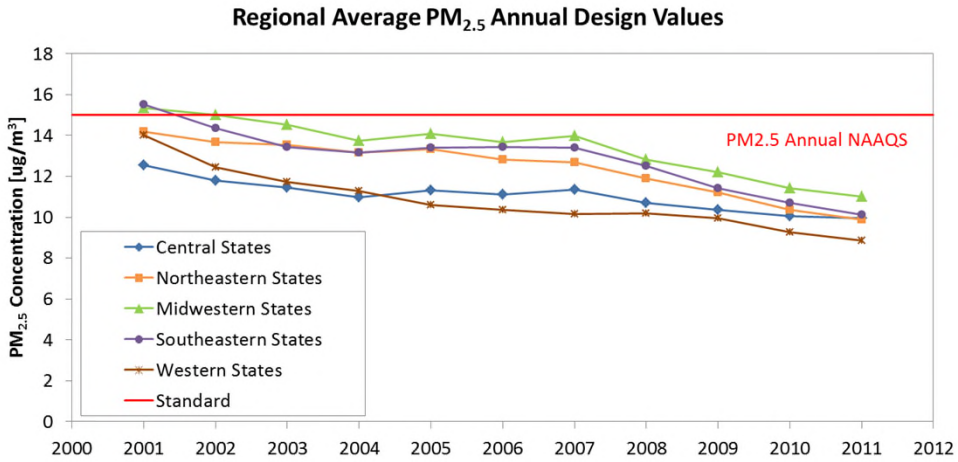
O_3 Trend Slopes in Central States Non-Attainment Areas

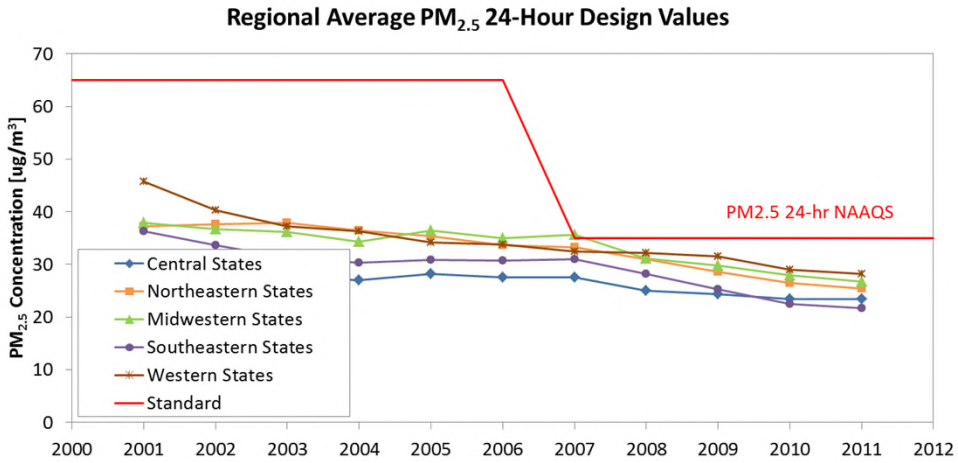
Non-Attainment Areas	O_3 Trend Slope [ppb/year]
Houston-Galveston-Brazoria, TX	-2.53
Memphis, TN-MS-AR	-1.83
Dallas-Fort Worth, TX	-1.48
St. Louis-St. Charles-Farmington, MO-IL	-1.40
Baton Rouge, LA	-1.04

Central States Monitoring Sites O_3 Trend Slopes



$PM_{2.5}$ Trends by Regions



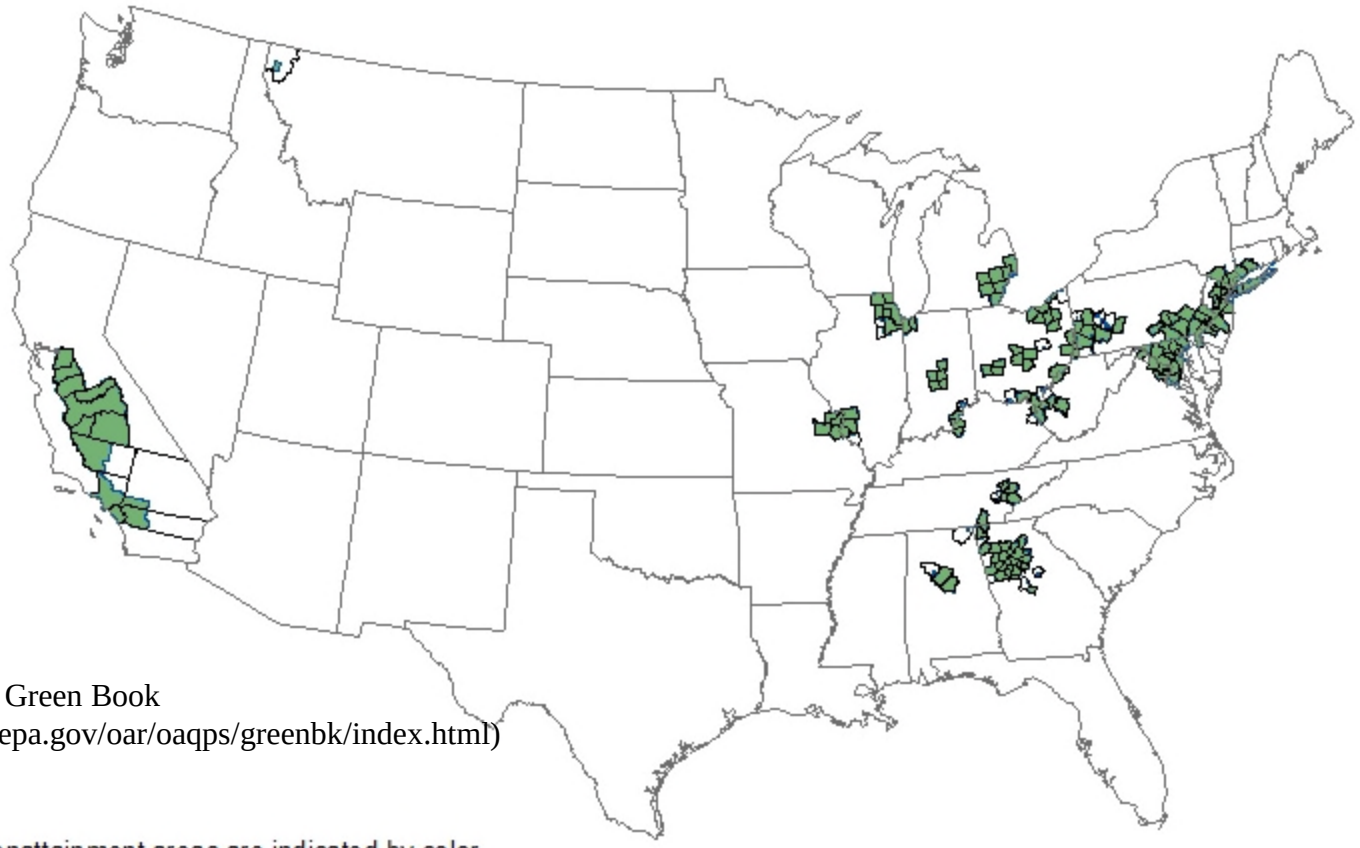


- Both average and 24-hr $PM_{2.5}$ DVs have decreased (negative trends) in all five regions
- Trends are not monotonic, possibly reflecting influence of meteorology
- Lowest trend occurred in cleanest region (Central States)

$PM_{2.5}$ 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)

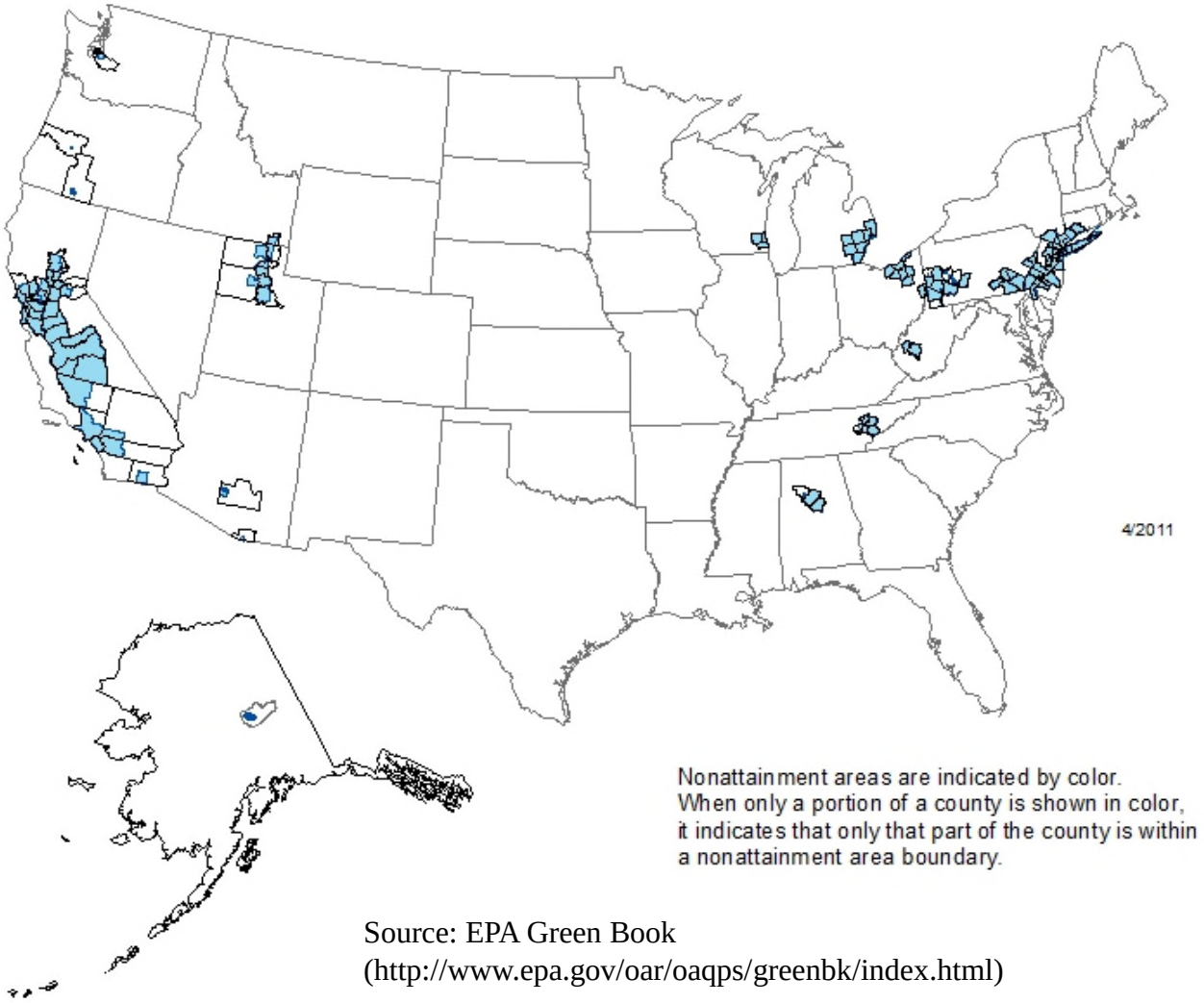


Source: EPA Green Book
(http://www.epa.gov/oar/oaqps/greenbk/index.html)

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.

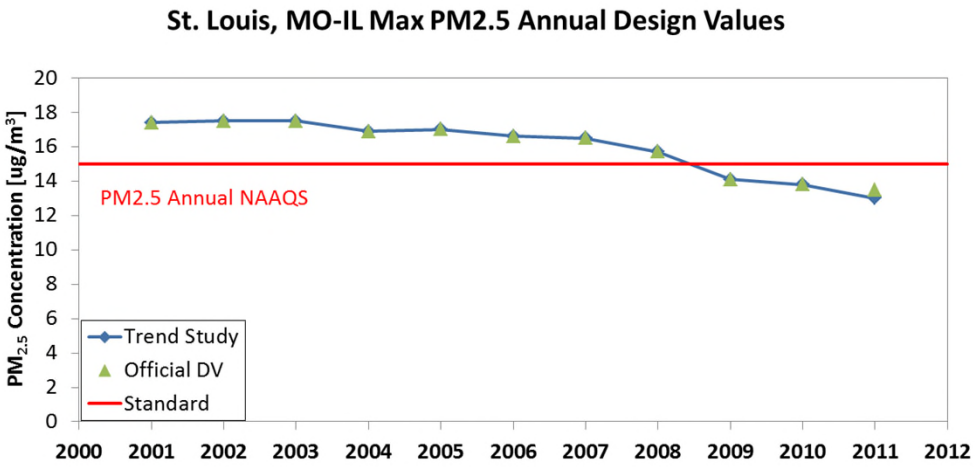
3/2012

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 Central States Non-Attainment Area

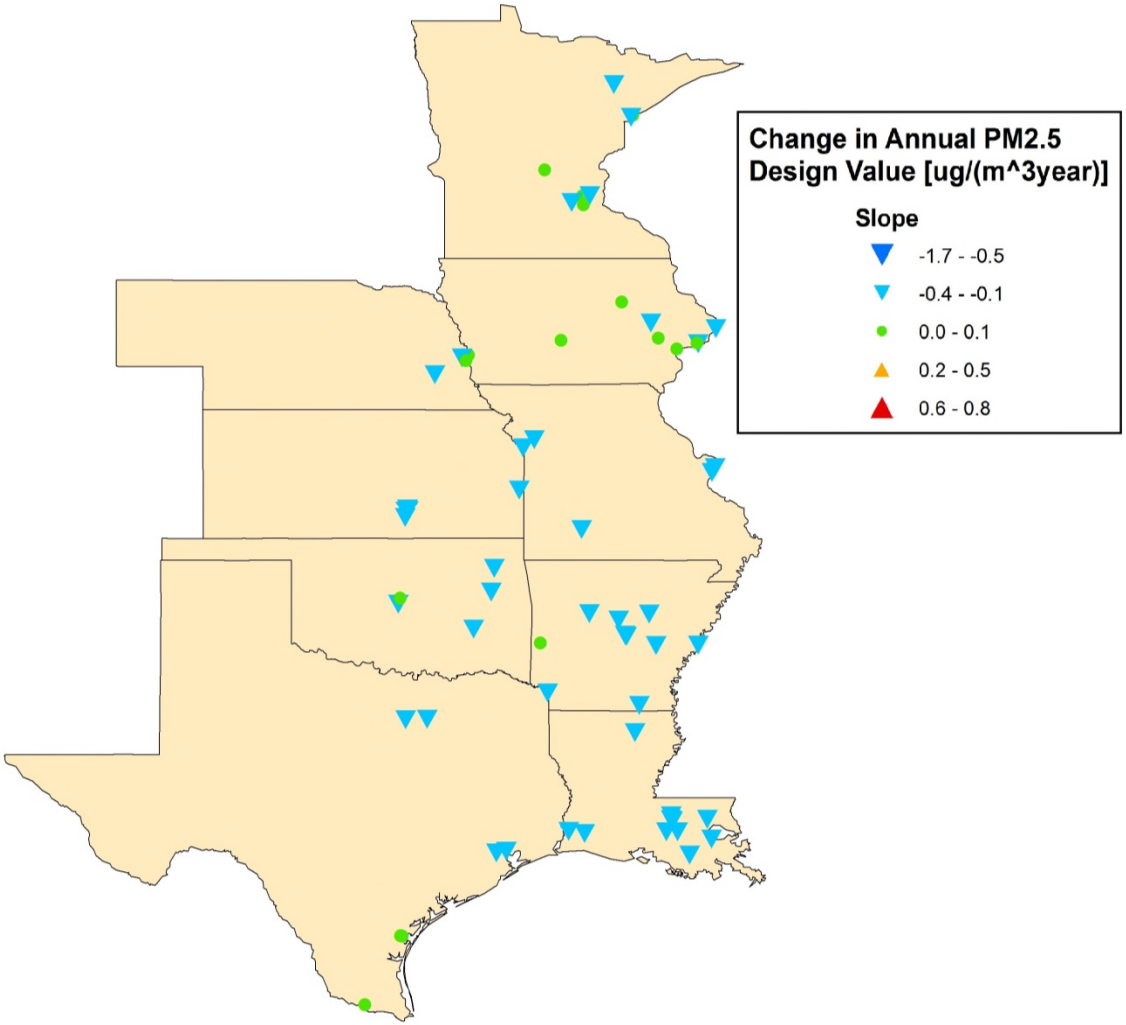


- St. Louis, MO-IL is the only Annual $PM_{2.5}$ non-attainment area in the Central states; there are no 24-hour $PM_{2.5}$ non-attainment areas in the Central states
- The maximum annual $PM_{2.5}$ DVs show a negative (downward) trend since 1999 at -0.45 ug/m^3/yr

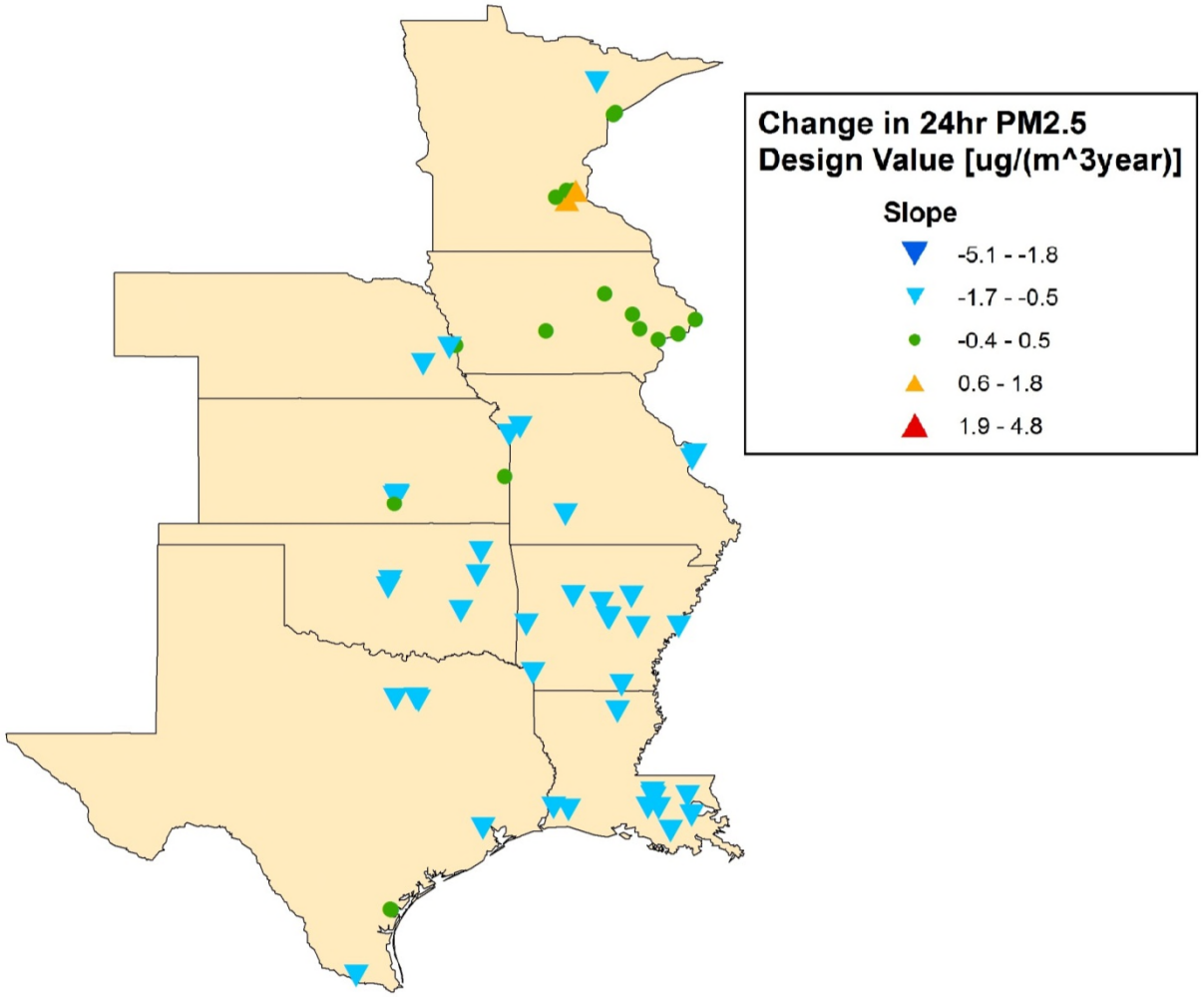
Annual $PM_{2.5}$ Trend Slopes for Central States Non-Attainment Areas

Non-Attainment Area	Annual $PM_{2.5}$ Slope ($ug/m^3/yr$)
St. Louis, MO-IL	-0.45

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



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



Air Quality Trends Summary

- Average O_3 and $PM_{2.5}$ design values have decreased since 1999 in the Central States domain

- O_3 and $PM_{2.5}$ design values have decreased since 1999 in all currently designated Central States O_3 and $PM_{2.5}$ non-attainment areas