Profile of the 2011 National Air Emissions Inventory

U.S. EPA 2011 NEI Version 1.0
Office of Air Quality Planning & Standards
Emissions Inventory & Analysis Group
April 2014

Acknowledgements
EIAG Data Analysis Team and NEI Team

This report is an overview of the air pollutant emissions in the 2011 National Emissions Inventory (NEI) Version 1.0[1] (v1) (2011 NEI v1) published by the U.S. Environmental Protection Agency (EPA) in July 2013. The pollutants included in the NEI are the pollutants related to implementation of the National Ambient Air Quality Standards (NAAQS), known as criteria air pollutants (CAPs), as well as hazardous air pollutants (HAPs) associated with EPA's Air Toxics Program. The CAPs have ambient concentration limits from the NAAQS program. These pollutants include lead (Pb), carbon monoxide (CO), nitrogen oxide (NOx), sulfur dioxide (SO_2), particulate matter 10 microns in diameter or less (PM_{10}) and particulate matter 2.5 microns in diameter or less ($PM_{2.5}$). Precursors to CAPs include volatile organic compounds (VOCs), SO_2, ammonia (NH_3), and nitrogen oxide (NO_x) emissions. The HAP pollutants include the 187 remaining HAP pollutants from the original 189 listed in Section 112(b) of the 1990 Clean Air Act Amendments[2]. In this report, we will be presenting information on CAPs, HAPs, and precursors.

The NEI is developed every three years, i.e., 2005, 2008, 2011, etc. This overview of the 2011 NEI applies the concepts developed in the 2008 NEI Report[3] as well as many of the graphics and tables contained in that report. In some cases, 2011 data are compared to figures in the 2008 Report. A process is underway to update the 2011 NEI v1 to version 2.0 (v2), with v2 expected to be released in the fall of 2014. In this overview, emission profiles are presented for most of the CAPs and precursors, black carbon (which is a component of particulate matter), and for some specific HAPs that account for a large portion of the nationwide cancer or non-cancer risks[4] as well as contribute to the formation of ozone or fine particulate matter.

The information presented here about the 2011 NEI v1 includes the following:

- **Key emissions source contributions**
- **National and state emissions trends**
- **National emissions density maps**
- **Emission differences between 2008 and 2011 ("2011" will pertain to the 2011 NEI v1 throughout report)—it should be noted that methods changes contribute to some of the noted emission changes from 2008 to 2011. These will be appropriately noted in this report for affected sectors.**
- **Distribution of emissions by climate region**

To keep the amount of materials associated with this report at the level of an overview, graphical summaries are provided for some, but not all, pollutants. Some detailed tabular emissions summaries associated with a graphic are not included in this overview document. Such additional materials are available by request, and readers who would like additional information associated with a given graphic or analysis are encouraged to contact the Emissions Inventory and Analysis Group, Data Analysis Team at info.chief@epa.gov.

1. 2011 NEI Version 1 (v1): Emissions data and documentation
2. 1990 Clean Air Act Amendments (CAA)
3. 2008 National Emissions Inventory: Review, Analysis and Highlights
4. U.S. EPA National Air Toxics Assessment 2005

(Remainder of page left intentionally blank)

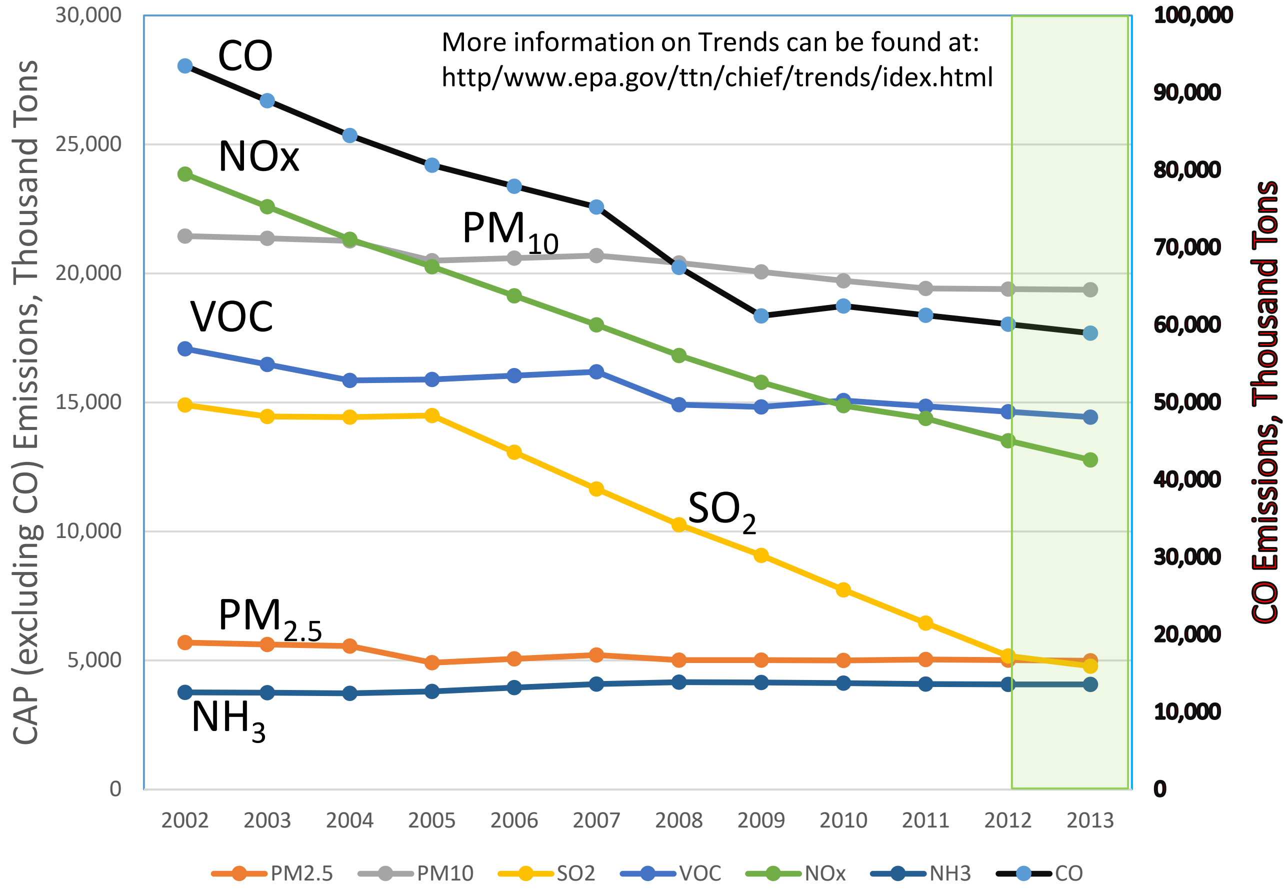
Table 1: Total Emissions all Sectors 2008 NEI v3[5] vs 2011 NEI v1

Pollutant	Anthropogenic, x1000 Tons (Man-made)		Biogenic, x1000 Tons (Natural)		Total, x1000 Tons[6]		% Reduction in 2011 Total compared to 2008 Total
	2008	2011	2008	2011	2008	2011	
CO	79,655	75,760	6,474	6,528	86,129	82,288	4
NH_3	4,359	4,316	NA	NA	4,359	4,316	1
NO_x	16,909	14,574	1,078	1,018	17,987	15,592	13
PM_{10}	21,580	20,907	NA	NA	21,580	20,907	3
$PM_{2.5}$	6,014	6,306	NA	NA	6,014	6,306	-5
SO_2	10,324	6,557	NA	NA	10,324	6,557	42
VOCs	17,759	18,169	38,909	39,653	56,668	57,822	-2
Pb	0.95	0.80	NA	NA	0.95	0.80	16
Total HAPs	2,749	3,643	5,000	5,101	7,749	8,744	-13

- **Table 1 summarizes total emissions (all source sectors included) in the 2011 NEI v1 as compared with 2008 NEI v3.**
- **CO, NO_X and VOC are emitted in the greatest amounts in 2008 and 2011.**
- **The greatest percent reductions from 2008 to 2011 have occurred in SO_2, NOx, and Pb emissions. The increases in PM2.5, VOCs, and HAPs are covered later in Figures 3 and 4.**
- **Only CO, VOC, NO_X and total HAPs have a biogenic emissions component. Most of the biogenic HAP emissions consist of formaldehyde, methanol, and acetaldehyde. The 13% increase in total HAPs from 2008 to 2011 reflects all HAPs, including biogenic HAP and non-VOC, non-PM HAPs, and is caused mainly by an increase in fire activity.**
- **Pb, total HAPs and NO_X emissions occur more commonly (greater than 65%) in urban than rural areas[7]. VOCs, SO_2, and CO emissions are also more prevalent in urban than rural areas (greater than 55%). All of the other pollutants, including PM and NH_3 occur more commonly in rural areas, though the PM urban/rural percentages are closer to 50:50.**

5. 2008 NEI v3 represents EPA's final inventory for the year 2008
6. Total Emissions sum includes continental U.S., Alaska, Hawaii, all territories, tribal lands, and excludes off-shore areas of federal waters.
7. As defined in the CAA, urban and rural definitions based on population density in a given county

Figure 1: National CAP Emission Trends, 2002-2013 (no Wildfires)

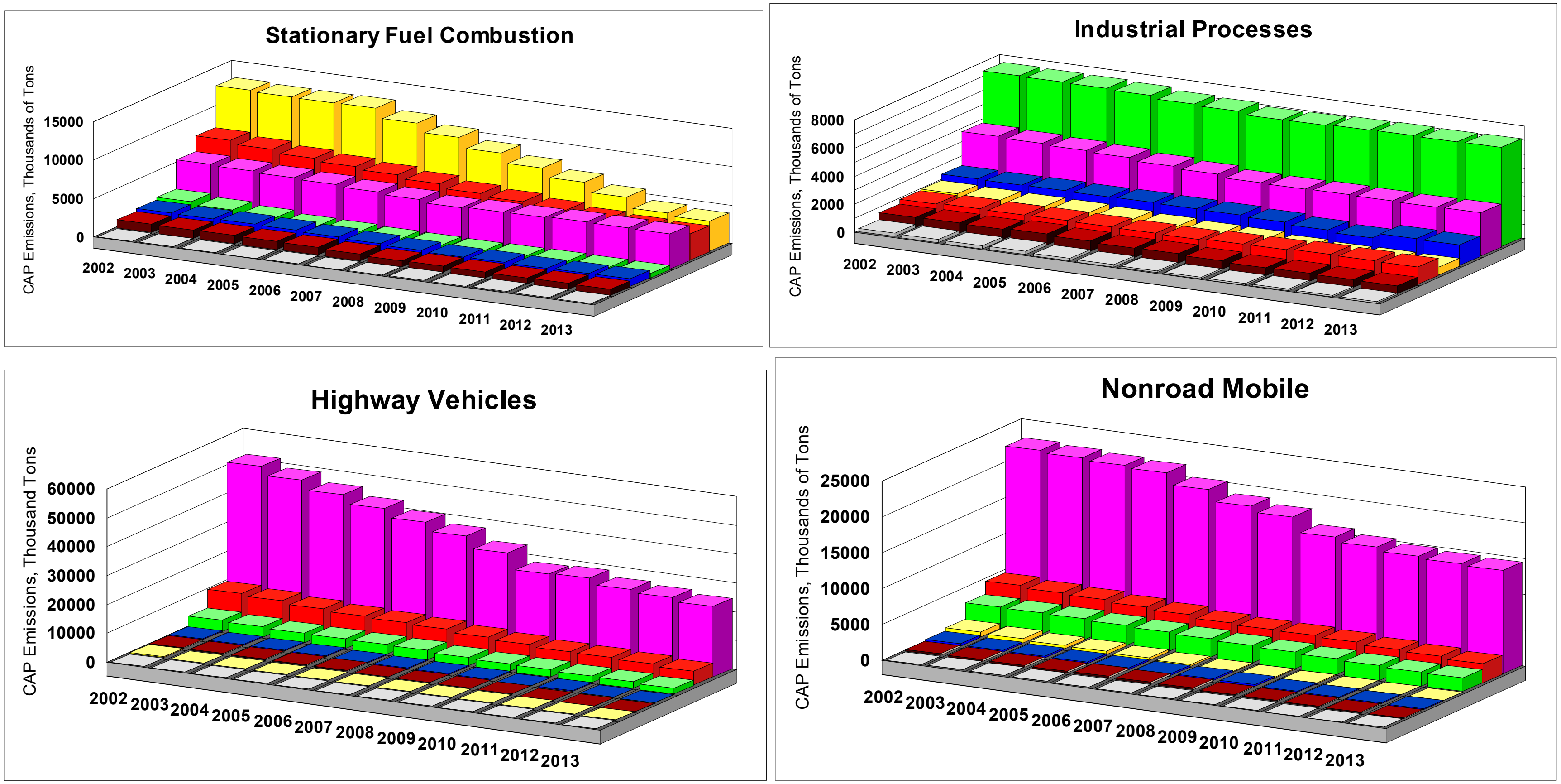


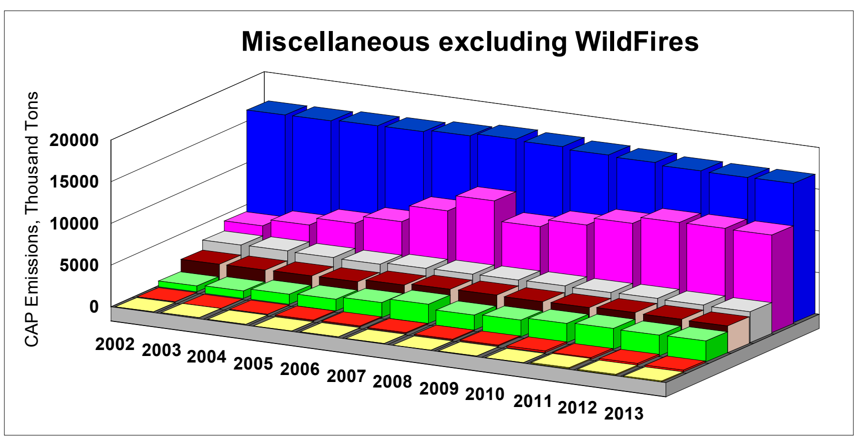
Pollutant	Percent Reduction from 2008-2011	Percent Reduction from 2009-2013	Percent Reduction from 2002-2013
CO	9	4	33
NH_3	2	2	-8
NO_x	14	18	46
PM_{10}	4	3	4
$PM_{2.5}$	-0.5	0.5	-7
SO_2	37	44	66
Anthropogenic VOCs	0.4	3	15

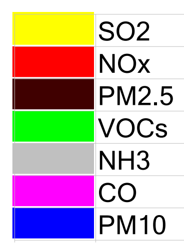
- **Figure 1 shows national CAP emission trends[8] from 2002 to 2013. Note that these emission totals differ slightly from the emission totals in Table 1 because wildfire emissions are included in Table 1 but not in Figure 1.**
- **The shaded area after 2011 indicates that specific NEI data are not available for 2012-2013 except for power plant data and mobile sources. 2011 emissions values for all other sectors are used for 2012 and 2013 in the figure.**
- **From 2002 to 2013, all pollutants other than NH_3 and PM show decreases greater than 10%. The slight increase in NH_3 is partly due to a methods change between the years 2005 and 2008 for prescribed fires and the addition of waste disposal emissions in the 2008 NEI for municipal and commercial composting. The small increase noted in PM2.5 is mostly due to methods change for fires and increased dust emissions.**
- **SO_2 and NO_X show the largest decreases from 2002 to 2013: 66% and 46%, respectively.**
- **The table shows that decreases in $PM_{2.5}$, VOC, CO, and NH_3 are lower from 2008-2011 and 2009-2013 than for the entire 12 years.**

8. U.S. National CAP Emission Trends include explanation of the data sources, method for developing trends, and description of the 'Tier' emissions categories.

Figure 2: Sector-based National CAP Trends 2002-2013







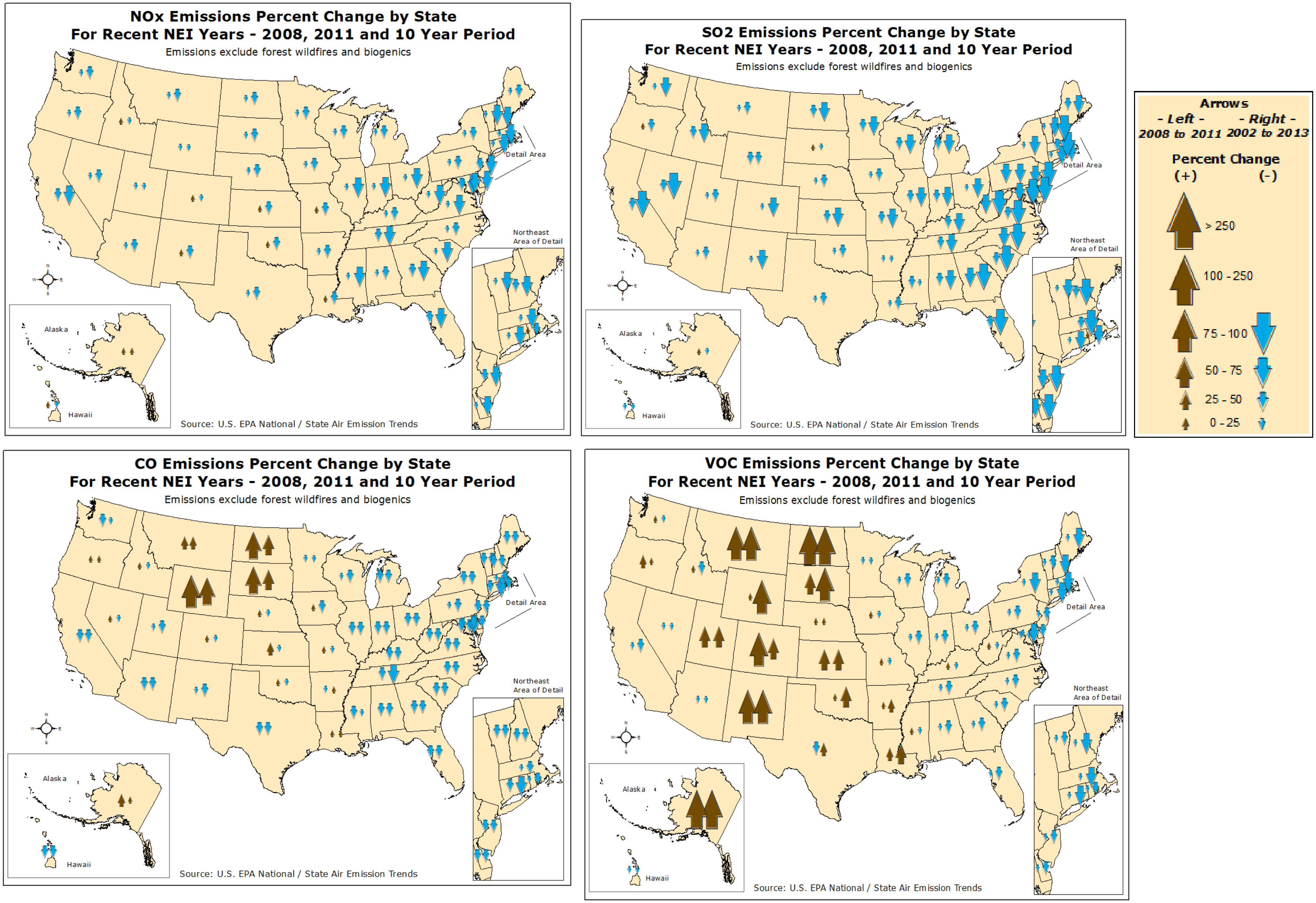
See footnote 10 (next page) for a detailed listing of sectors included in “Miscellaneous” Category

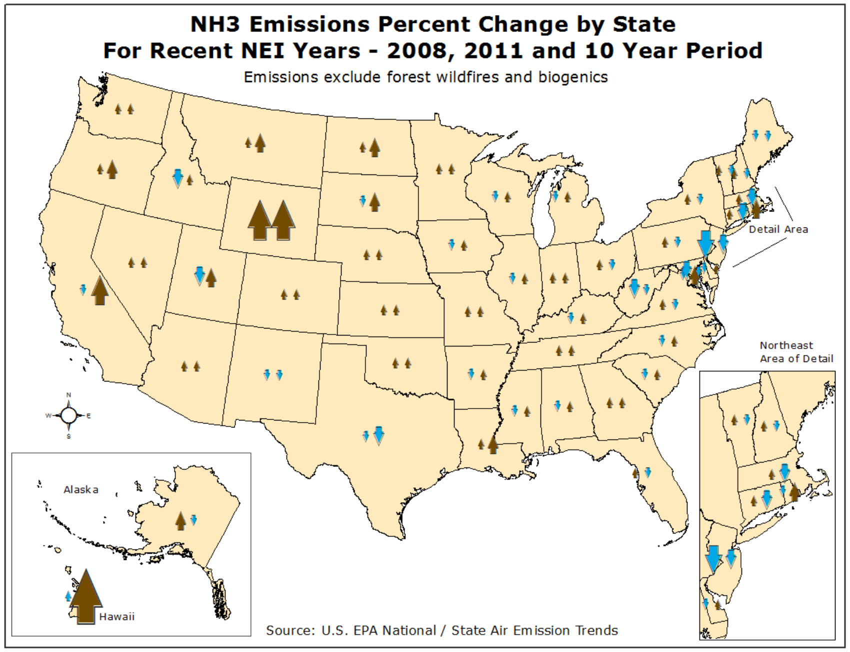
- **Figure 2 shows the national emissions data from Figure 1 by five major source Tier[9] categories.**
- **CO emissions are largest for the mobile sources, which drive the overall CO reductions.**
- **There are large amounts of NO_X emissions for stationary fuel combustion and mobile source sectors, and the overall reductions are driven by both these sectors.**
- **SO_2 emissions are largest for the fuel combustion sector and for electric generating utilities in particular.**
- **Miscellaneous sectors[10] show uneven changes, in part due to changes in estimation methods for some of the sources included, e.g., prescribed fires. Prescribed fires contribute to the increase in CO emissions in 2007 and then decrease in 2008.**
- **Mobile sources highway vehicles and nonroad mobile emissions are based on use of a consistent version of the EPA's emissions estimation model "MOVES" (2010b) for on-road emissions and "NONROAD" (2008) for nonroad emissions[11]. The 2011 NEI v2 is expected to switch to the MOVES2014 model.**
- **After 2011, the Electric-Utility Generation sector (EGUs) emissions (within the stationary fuel combustion sector) and mobile source emissions show a decrease based on available year-specific data for 2012 and 2013. Other Tiers show no changes after 2011 (beyond 2011, these Tiers use constant emissions due to lack of year-specific emissions).**

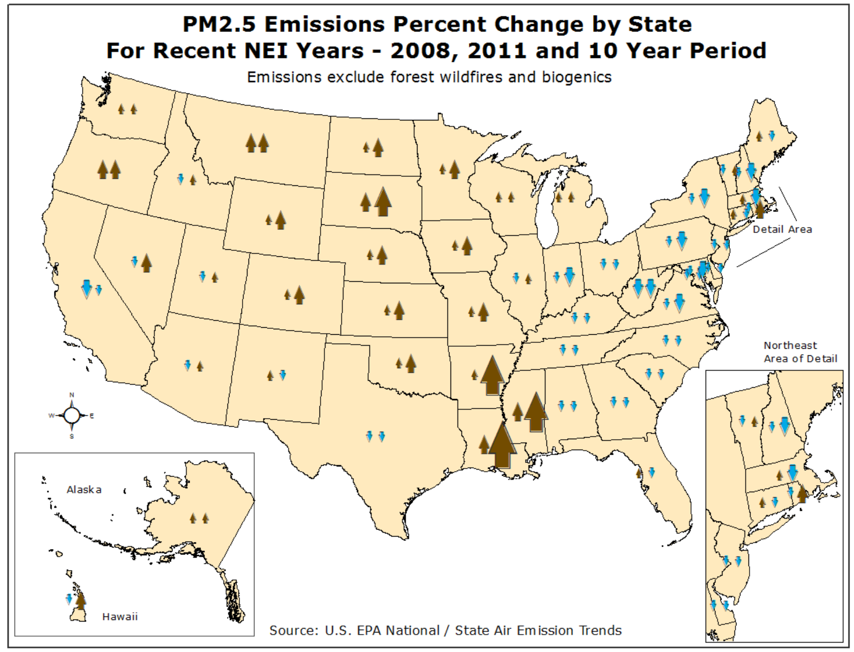
9. The five "Tier" categories shown in Figure 2 are aggregated from the 13 Tier categories described in the national air emissions trends page
10. A detailed listing of sectors included in "Miscellaneous" are outlined in the 2008 NEI Report (Page 12, Table 3—last column)
11. More information on mobile source emissions models

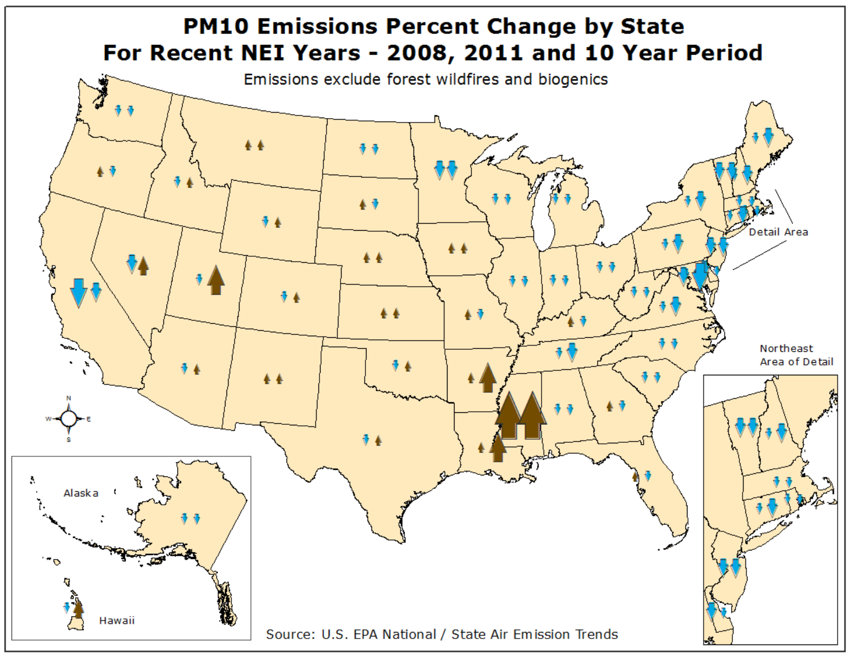
Figure 3: State Trends of CAP Emissions

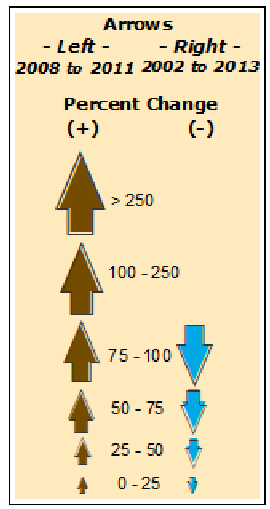
Note: Percent change shown on maps does not equal magnitude of emissions (see Table 2)




NH3 Emissions Percent Change by State
For Recent NEI Years - 2008, 2011 and 10 Year Period
Emissions exclude forest wildfires and biogenics
Detail Area
Northeast Area of Detail
Alaska
Hawaii
Source: U.S. EPA National / State Air Emission Trends


PM2.5 Emissions Percent Change by State
For Recent NEI Years - 2008, 2011 and 10 Year Period
Emissions exclude forest wildfires and biogenics
Detail Area
Northeast Area of Detail
Alaska
Hawaii
Source: U.S. EPA National / State Air Emission Trends


PM10 Emissions Percent Change by State
For Recent NEI Years - 2008, 2011 and 10 Year Period
Emissions exclude forest wildfires and biogenics
Detail Area
Northeast Area of Detail
Alaska
Hawaii
Source: U.S. EPA National / State Air Emission Trends


Arrows
- Left - 2008 to 2011
- Right - 2002 to 2013
Percent Change
(+) (-)
> 250
100 - 250
75 - 100
50 - 75
25 - 50
0 - 25

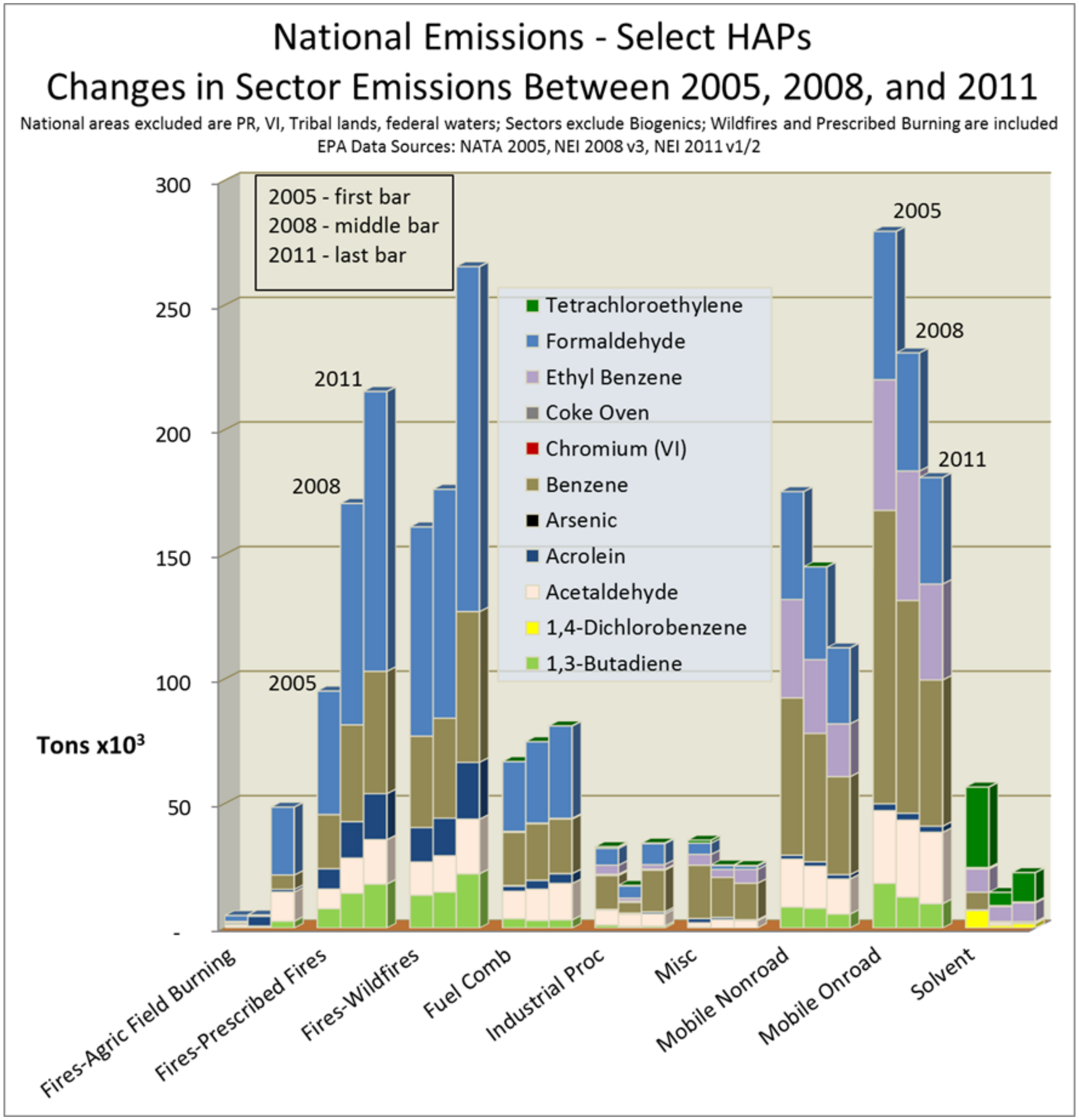
- **Building on Table 1 and Figure 2, the maps in Figure 3 describe the difference in state CAP emissions as the percent change between the two recent NEIs – the 2008 v3 and the 2011 v1; and the percent change over the last 10 years, during the period 2002-2013. The brown (up) arrows are emissions increases and the blue (down) arrows are emission decreases. The size of the arrow describes the amount of the percent change in emissions that occurred, a larger arrow means a larger percent change in emissions during the noted time period; a smaller arrow indicates a smaller percent change. The percent change does not describe the magnitude of the emissions. For instance, there are some cases where a large percent change refers to a relatively small emissions magnitude.**
- **While there may be an overall decrease in pollutant emissions at the national level, some states experience emission increases over time. The states listed in the Table 2 below have some of the larger percent emission increases for specific pollutants, mostly over the 10-year time period, and also several increases over the time period for the recent NEIs 2008 and 2011, particularly for VOC and CO. The table corresponds to the pollutant maps and details the predominant sector(s) that drive the emissions increase in the states with the larger percent increases in emissions. The reasons for these increases can include not only actual increases, but also methods changes. Such issues may be considered when assessing the potential impacts on air quality.**

Table 2: Sectors with Emission Increases

Sector	Pollutant							States with increases
	NO_X	VOC	SO_2	CO	NH_3	$PM_{2.5}$	PM_{10}	
agriculture livestock operations					✓			CA, HI (very small emissions), LA, MT, ND, SD, WY
chemical manufacturing		✓						LA
commercial marine vessels	✓							AK
consumer commercial solvent use		✓						KS
dust - agriculture operations						✓	✓	$PM_{2.5}$: AR, MS, SD; PM_{10}: AR, LA, MS
dust – roads						✓	✓	$PM_{2.5}$: AR, MS, SD; PM_{10}: AR, LA, MS, UT
fertilizer application					✓			CA, HI (very small emissions), LA, MT, ND, SD, WY
fires – agricultural burning		✓	✓					VOC, SO_2, $PM_{2.5}$, CO: SD; CO: AK, ND
fires – prescribed (Note: method changes in estimating agricultural fire and prescribed fire emissions occurred in going from 2008 to 2011)	✓	✓	✓	✓	✓	✓	✓	NOx: KS VOC: AK, AR, CO, KS, LA, MT, ND, NM, SD, UT, WY SO_2: SD, OR CO: AK, ND, SD, WY NH_3: AK, LA $PM_{2.5}$: AR, LA, MS, SD; PM_{10}: AR, LA
fuel combustion EGU oil	✓		✓					NOx: HI; SO_2: OR
fuel comb industrial boilers oil	✓		✓					NOx: LA; SO_2: OR
fuel comb indust boilers natural gas	✓							OK
fuel comb indust boilers biomass			✓			✓		SO_2: OR; $PM_{2.5}$, PM_{10}: LA
fuel comb residential other nat gas					✓			AK (very small emissions)
highway vehicles heavy duty diesel	✓							ID
oil & gas production* (Note: improved reporting in 2011)	✓	✓		✓				NOx: CO, KS, LA, NM, OK VOC: AK, AR, CO, KS, LA, MT, ND, NM, UT CO: MT, ND
stone quarrying/ mining							✓	LA
waste disposal & recycling compost					✓			CA

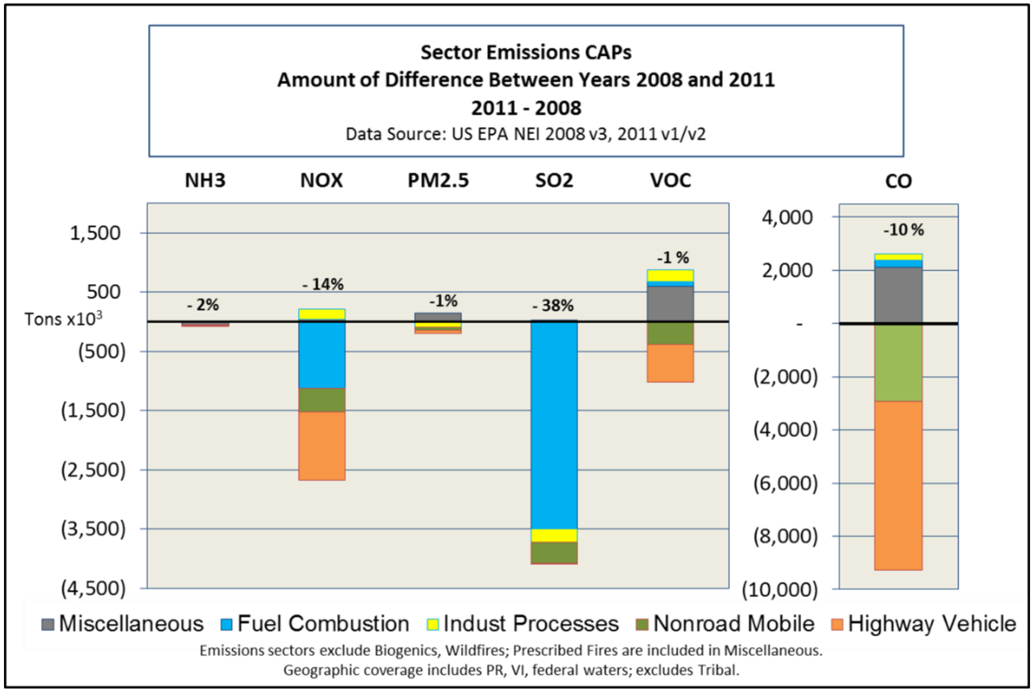
* Oil and gas emissions are based on state-submitted point and nonpoint data as well as data from an EPA oil and gas emissions estimation tool. More information on the data and tool is available in the 2011 NEI documentation

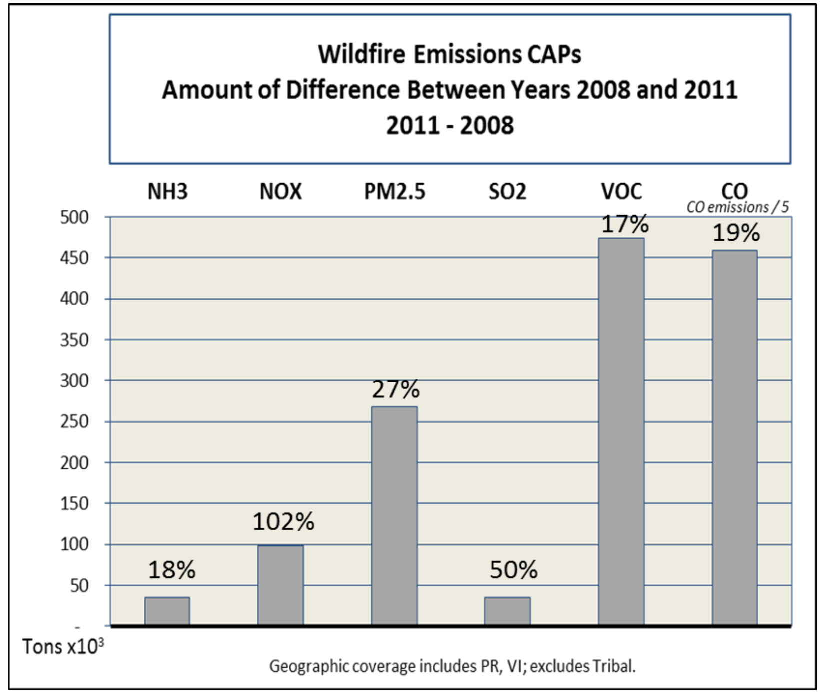
Figure 4: National Select HAP Trends, 2005-2011



- **For the select HAPs shown, many of the largest emission increases going from 2005 to 2011 are driven by fires. In the case of prescribed and wildfires, 2008 and 2011 were more active seasons than 2005. The 2011 emissions for agriculture burning are from the draft 2011 NEI v2 which corrects overestimated emissions for many Midwestern states in v1 of the 2011 NEI.**
- **The small emission increase in 2011 for the fuel combustion sectors is mostly for formaldehyde and acetaldehyde from residential wood combustion.**
- **The 2011 emissions for the solvents sector are from the draft 2011 NEI v2 to illustrate some known HAP corrections, including for tetrachloroethylene from drycleaning.**
- **All of these HAP emissions have decreased over the time period for the mobile source sectors.**
- **Solvent emissions are included in "industrial" sector in Figure 2.**

Figure 5: National CAP Emission Differences between 2008 and 2011, a closer look





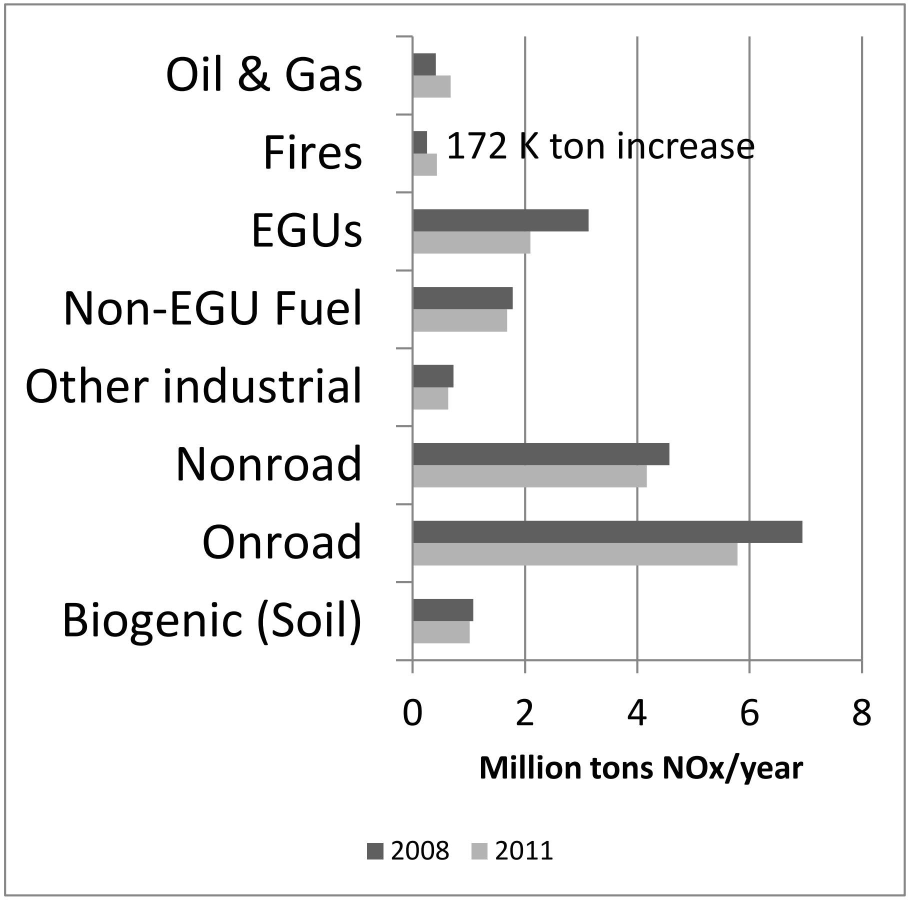
The difference in CAP emissions between 2008 and 2011 are shown for five major source sectors[12]. The chart on the left shows all sectors other than wildfires, while the chart on the right shows just wildfires. While emissions increased in 2011 from 2008 for some sectors, overall emissions are still lower in 2011 than in 2008. Corrected values from the draft 2011 v2 are used for agriculture field burning (in Miscellaneous) and for solvent sectors (in Industrial Processes).

- **Nationally, emission increases in 2011 occur in the following sectors:**
  - **Miscellaneous—Waste disposal (CO); prescribed fires (CO, VOC)**
  - **Fuel Combustion—residential wood burning (CO, VOC)**
  - **Industrial Processes—oil and gas production (CO, VOC, NO_X)[13]**
- **In general, CAP decreases in 2011 are due to mobile sources and coal combustion, and emission increases are largely attributable to fires and the oil and gas production sector.**
- **The chart on the right shows emissions from wildfires to be somewhat higher in 2011 compared to 2008, due to higher fire activity in 2011. Note that the CO bar reflects CO emissions divided by 5.**

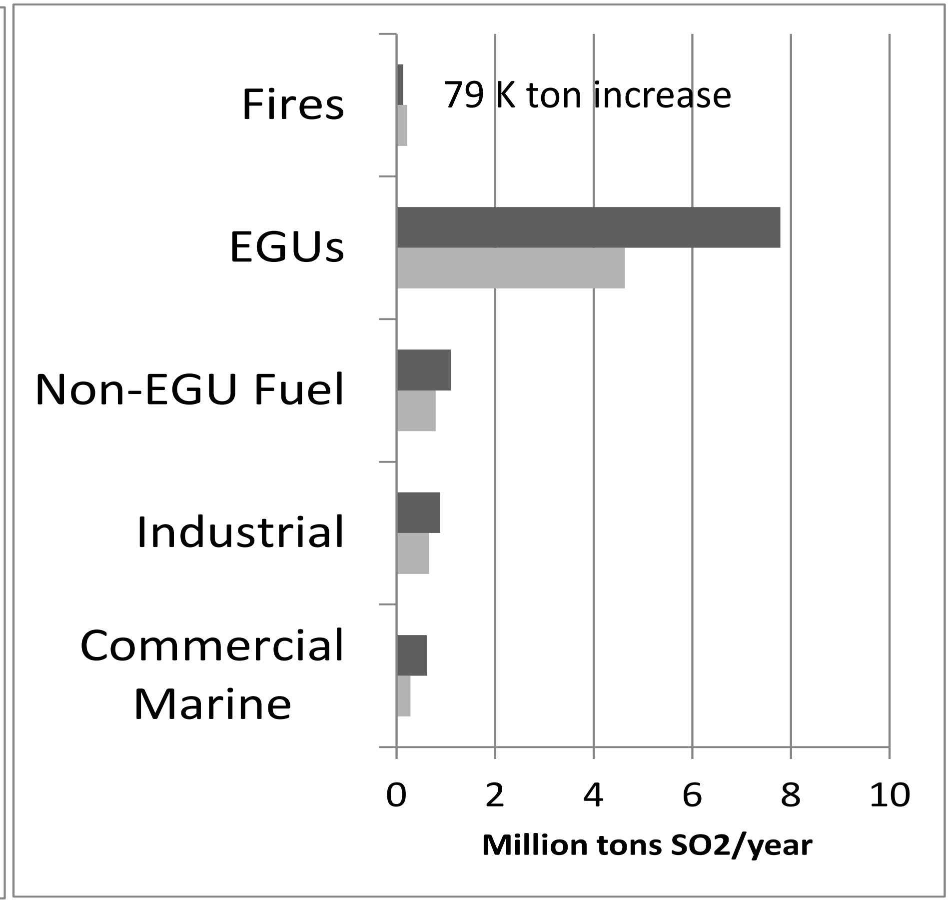
12. A description of the type of sources included in these major sectors, i.e.,Sectors_7, is found in the 2008 NEI Report, page 12

Figure 6: Closer Look at National NO_X and SO_2 differences between 2008 and 2011

NO_X: 18 to 15.6 million tons decrease



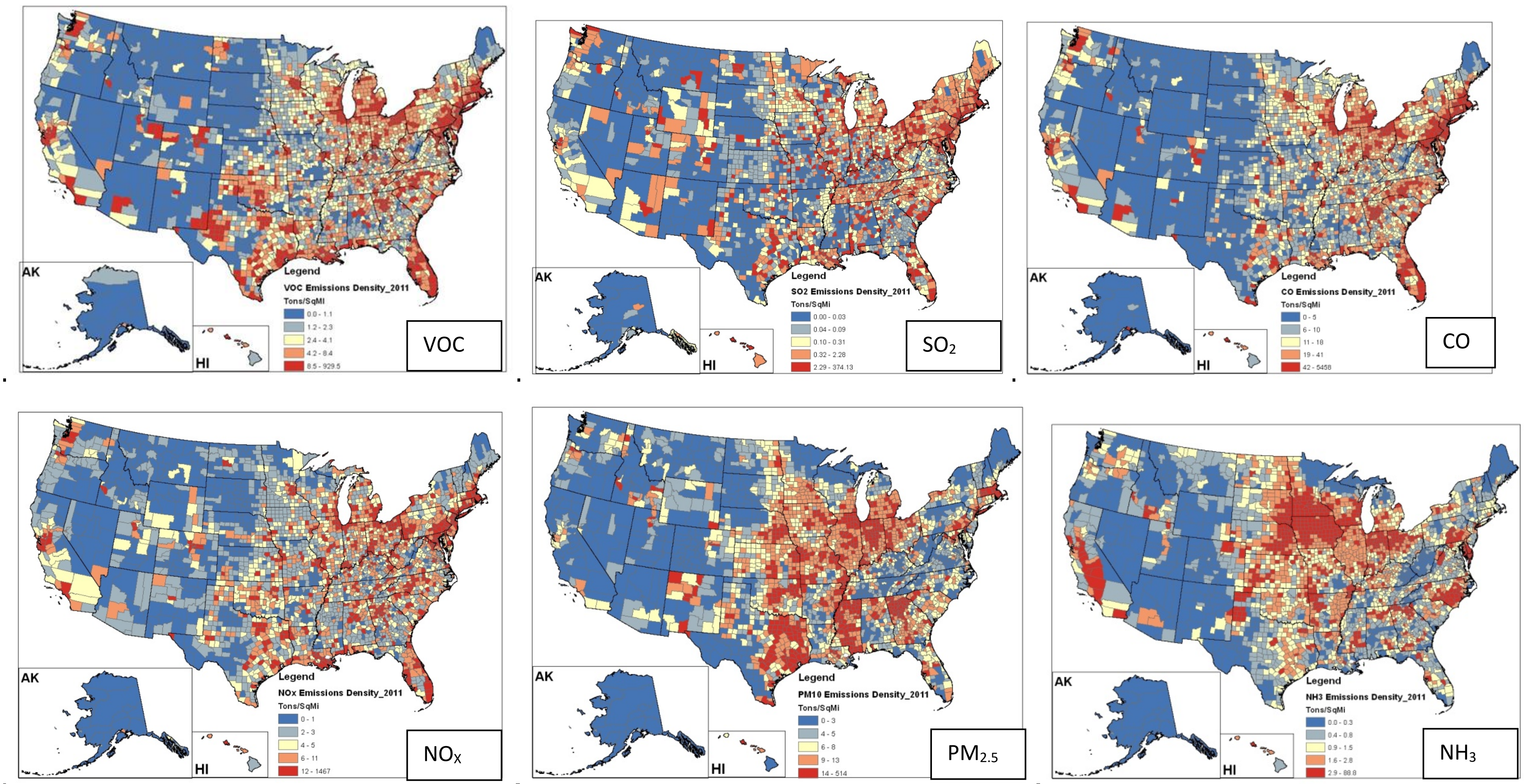
SO_2: 10.3 to 6.6 million tons decrease



- **NO_X and SO_2 have shown the most decrease from 2008 to 2011.**
- **Much of the SO_2 emissions decreases are a result of emission reductions in the EGU sector, a very small increase is noted for fires.**
- **Mobile sources and EGUs account for much of the NO_X decreases from 2008 to 2011. The increase in NO_X from 2008 to 2011 is from the Oil & Gas and Fires sectors[13].**

13. Oil and gas emissions are based on state-submitted point and nonpoint data as well as data from an EPA oil and gas emissions estimation tool. More information on the data and tool is available in the [2011 NEI documentation]

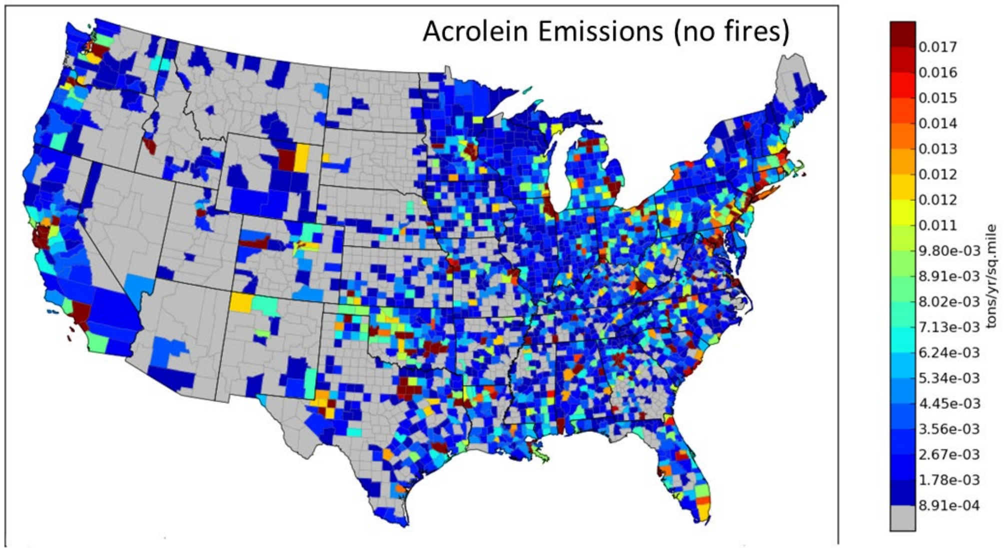
Figure 7: 2011 NEI CAP Emissions Density Maps (Tons/Sq. Mi.), no prescribed burning or wildfires

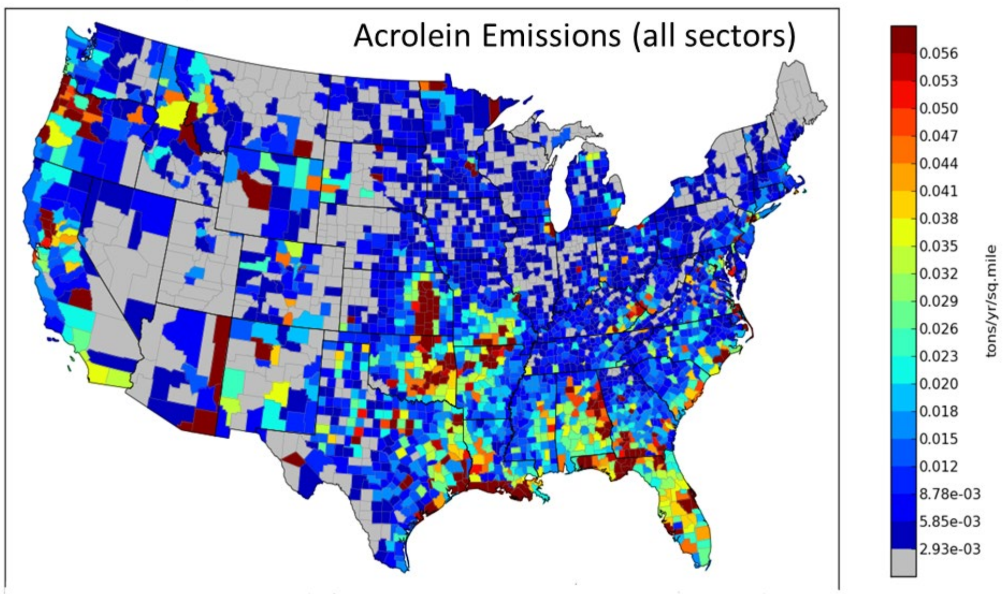


- **These maps show 2011 CAP emissions at a county level using an emissions density metric.**
- **County-specific emissions density is defined as: emissions in Tons/square-mile.**
- **With fire emissions omitted from the analysis, most of the CAP emissions are concentrated on the East Coast and in major urban areas. They compare well to similar maps generated using 2008 data**[14]
- **While some of these CAPs are more concentrated in urban areas (CO, NO_X, VOCs), others are more prominent in rural areas (NH_3) and others are split evenly ($PM_{2.5}$).**
- **PM_{10} is not shown, but its spatial pattern is very similar to the $PM_{2.5}$ map.**

14. 2008 NEI Report, Figures 13-14, page 19

Figure 8: Acrolein Emission Density Maps, 2011 NEI v1





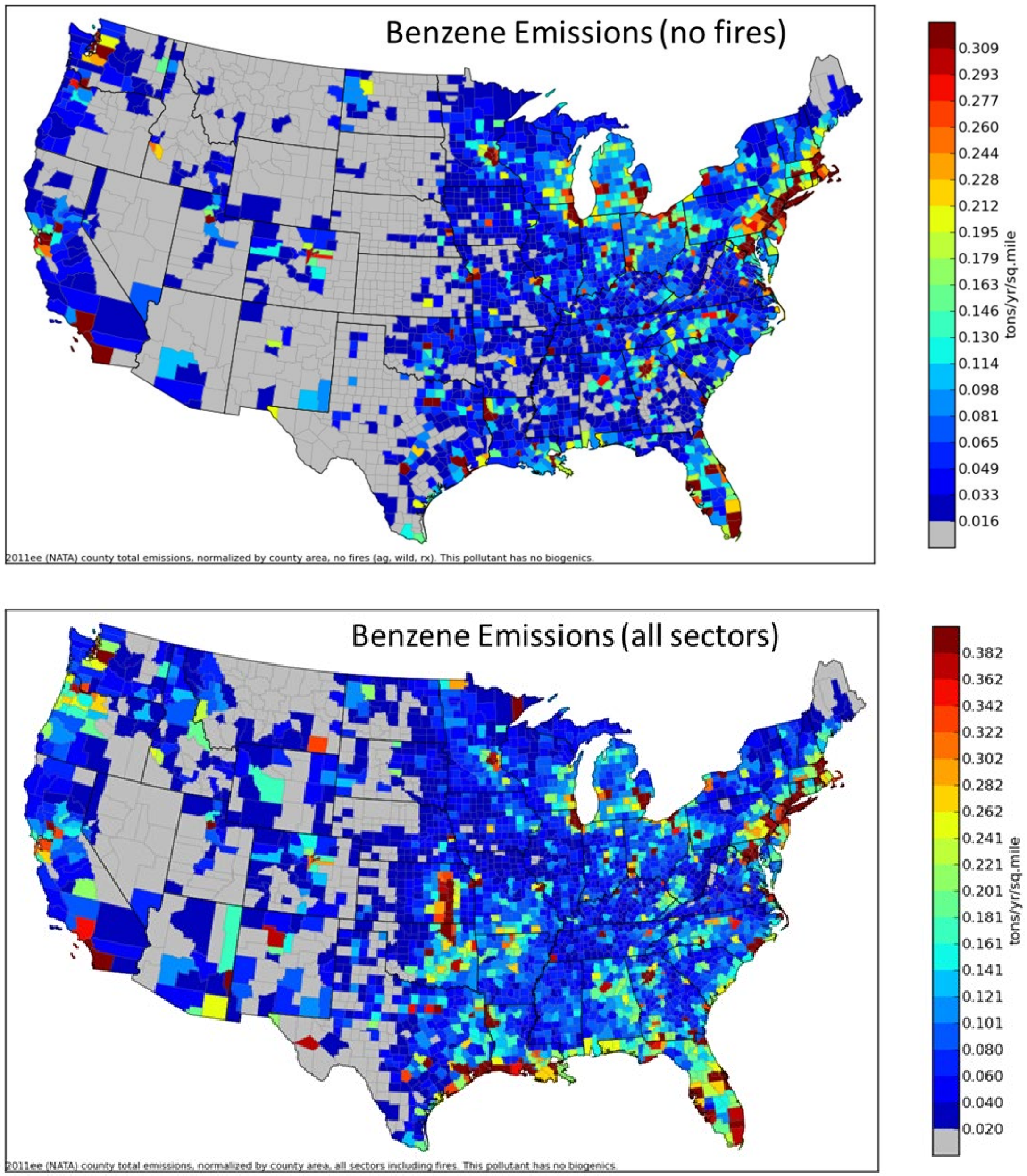
- **These maps provide examples of HAP emission density (tons/year/sq mile) for acrolein (Figure 8) and benzene (Figure 9).**

- **While these sample maps describe the national and regional patterns of HAP emission distributions in the 2011 NEI v1, they do not assess or predict the absolute risks to human health and ecosystems that may be associated with the presence of any of these specific air pollutants. Rather, they focus on the intensity of emission releases.**

- **The top map excludes fires (wild, prescribed and agricultural). The bottom map shows emissions when these large fires are included.**

- **Fires are a significant contributor to acrolein emissions. The bottom map indicates a higher magnitude of emissions when fires are included. Including fires also changes the spatial pattern - highlighting the western U.S. where many large wildfires occurred in 2011 and in the southeast as well as for some of the middle states where many prescribed fires occurred in 2011.**

Figure 9: Benzene Emission Density Maps, 2011 NEI v1

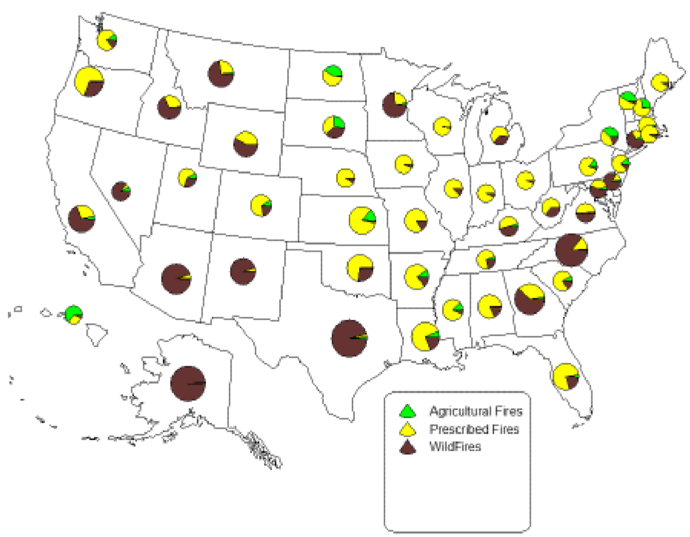


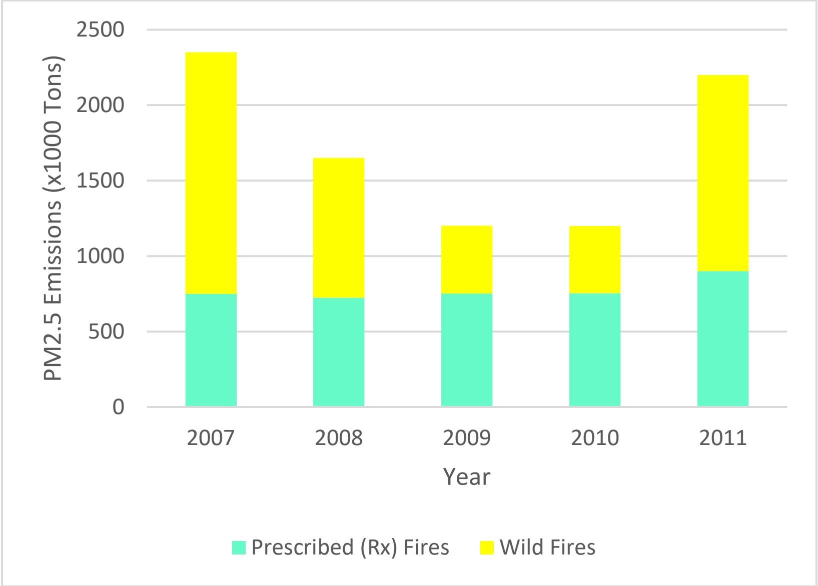
- **Fires are also a significant contributor to benzene emissions. The bottom map in Figure 9 indicates a higher magnitude of emissions when fires are included. Including fires also changes the spatial pattern - highlighting the western U.S. where many large wildfires occurred in 2011 and in the southeast as well as for some of the middle states where many prescribed fires occurred in 2011.**

- **Urban areas are seen to have higher emission densities as mobile sources and some industrial processes are also important contributors to benzene emissions.**

Other HAP density maps are available upon request. See Page 2 of this report for contact information.

Figure 10: Wild, Prescribed and Agricultural Fires in the 2011 NEI





- **Fires are significant emitters of $PM_{2.5}$, VOC, and several HAPs, i.e., acrolein, formaldehyde, and acetaldehyde.**
- **The map on the left shows $PM_{2.5}$ emissions by fire type with yellow indicating prescribed fires, green indicating agricultural fires and brown indicating wildfires. The Southeast is dominated by prescribed burning, while the western U.S. has more wildfire activity.**
- **These three fire types account for about 20 million acres burned and 2.9 million tons of $PM_{2.5}$, which is approximately 32% of total $PM_{2.5}$ emissions in the 2011 NEI.**
- **The chart on the right shows the trend of $PM_{2.5}$ emissions from wildfires and prescribed fires from 2007 using a relative consistent methodology (2007 was chosen as the base year due to the fact that previous years used a very different method for estimating these fire emissions). These two fires types contribute about 2.3 million tons of $PM_{2.5}$ emissions. Wildfires account for the variability seen in total emissions from these large fires.**

Figure 11: Sector Distribution of 2011 CAP and HAP Emissions

2011 CAP and Select HAP Emission Tons Distribution Within Stationary and Mobile Sources

Percent Contributions greater than or equal (GTE) to 15% of the National Pollutant Sum Total (stationary + mobile) Are Also Indicated

	NH3	CO	PM10	PM2.5	NOX	SO2	VOC	Ethylbenzene	Acetaldehyde	Acrolein	Formaldehyde	Tetrachloroethylene	1,4-Dichlorobenzene	1,3-Butadiene	Chromium Compounds	Lead	Arsenic
Stationary																	
Agriculture	90%		25%	22%													
DustConstrc																	
DustPavedUnPaved			52%	27%													
Fire Ag Field Burning									15%		18%						
FC-Biomass										18%							
FC-Coal						77%									44%		46%
FC-Ngas										18%							
FC-Oil																	
FC-Other																	
Industrial Proc							26%								40%	28%	27%
MiscBulkGas																	
MiscCommCook																	
MiscGasStations																	
MiscNon-IndustNEC																	
MiscWasteDisp																	
SolvCommIndust												82%					
SolvConsumerComm													97%				
Mobile																	
Aircraft																59%	
CMV																	
MobNR-Diesel																	
MobNR-Gas		25%					15%	28%						22%			
MobNR-Other																	
MobOR-DieselHD					18%												
MobOR-DieselLD																	
MobOR-GasHD																	
MobOR-GasLD		47%			18%		17%	48%	24%					39%			
Railroad																	

Footnote:

The pollutant emissions contribution in sector is calculated as the portion of the pollutant/sector emissions in each group sum - Stationary and Mobile.

Percent of pollutant/ sector emissions in group: GTE 70% | 50%-69% | 21-69% | 0-20% | no emission

A percent value in a cell indicates that the portion of the pollutant/sector emissions is greater than or equal to 15% of the national sum for that pollutant.

Selected HAPs are those indicated by NATA 2005 as nationally significant risk drivers.

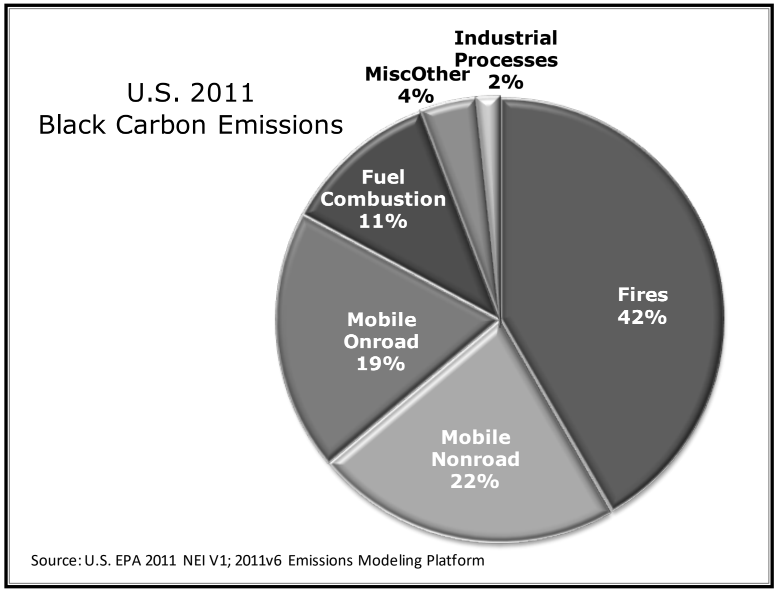
FC = fuel combustion; CMV = commercial marine vessel

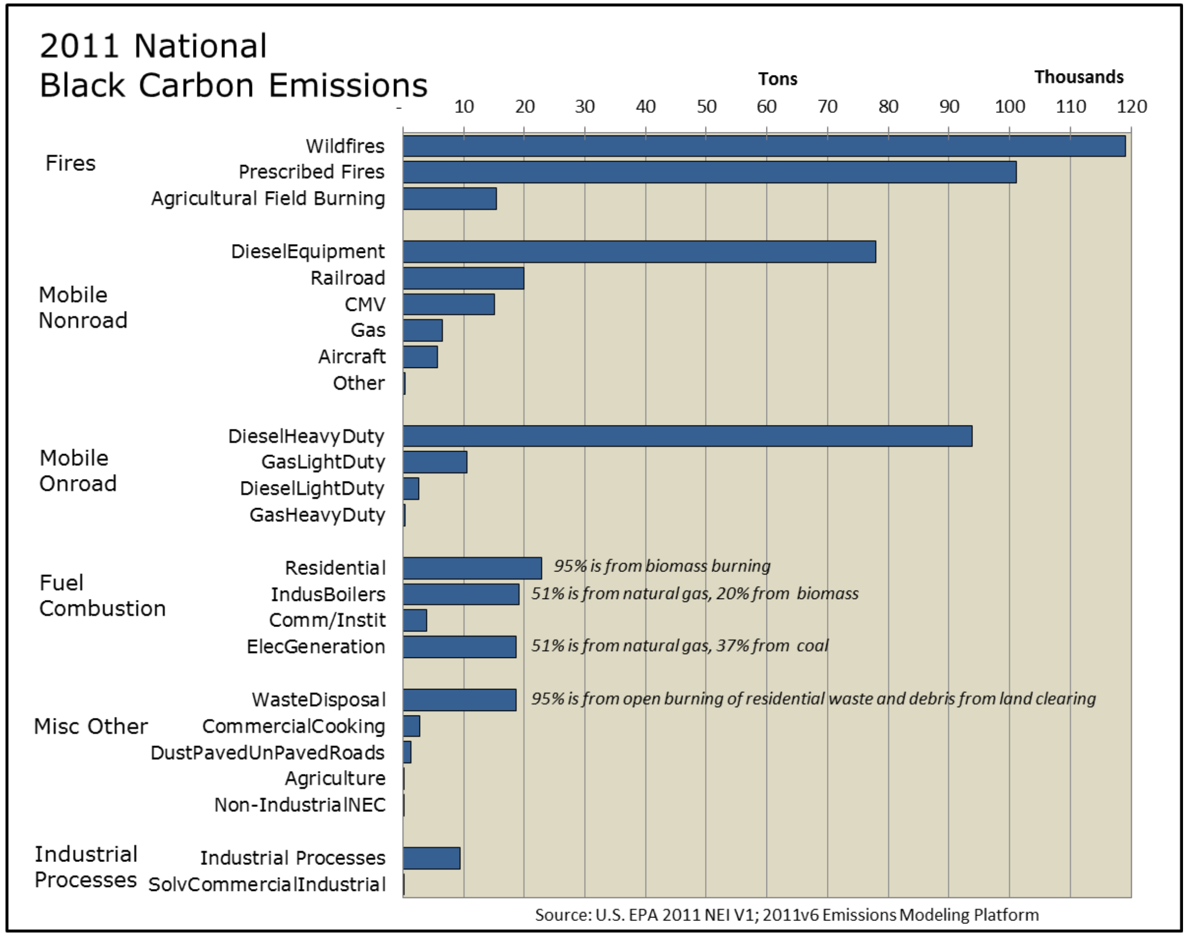
Data source = NEI 2011 v1/v2 draft, includes federal waters, PR, and VI; excludes Tribal; excludes sectors - prescribed fires, wildfires, and biogenics.

- **This chart shows the distribution of HAP and CAP emissions within sector groups for stationary (top) and mobile sources (bottom).**
- **The colors in the cell represent emission contributions within either the stationary or mobile group, and the dark blue color indicates sources that contribute greater than or equal to 70% of the emissions to that sector group.**
- **A percent value is shown in cells for pollutant/sector combinations where the pollutant emissions contribution to that sector is greater than 15% of the national pollutant total.**
- **For example, the agriculture sector contributes greater than 70% of NH_3 emissions within stationary sources (as indicated by the dark blue box) and also contributes 90% of the total NH_3 emissions across all sectors (mobile + stationary) in the 2011 NEI v1.**
- **This distribution pattern for 2011 is very similar to the pattern described for the 2008 NEI[15] except that for 2011 several HAPs have a higher emissions contribution from agricultural fires and solvent operations. Corrected values from the draft 2011 v2 are used for agriculture field burning and for solvent sectors.**

15. 2008 National Emissions Inventory: Review, Analysis and Highlights, Figure 36, page 42

Figure 12: Black Carbon Emissions in the 2011 NEI v1

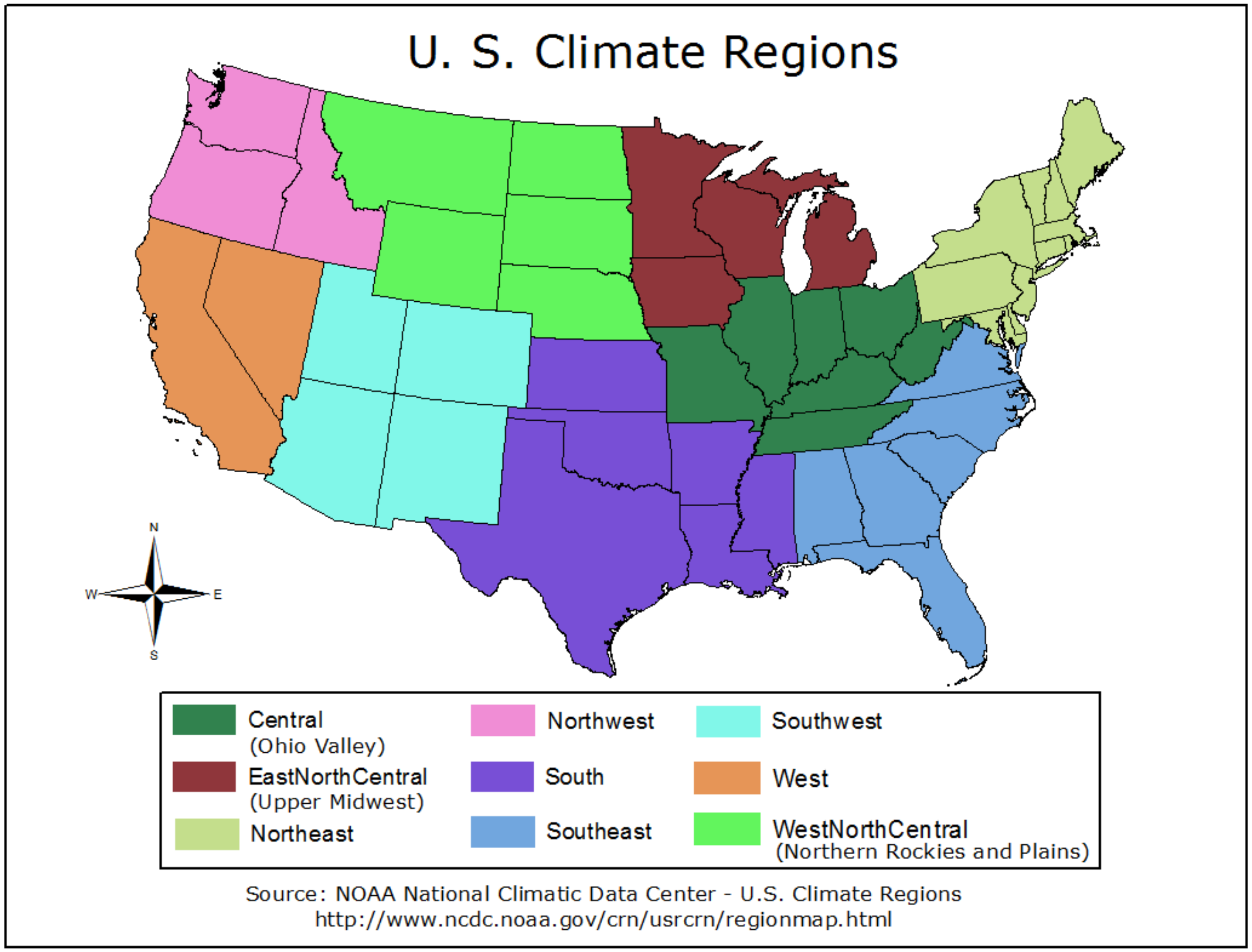




- **Black carbon (BC) is a component of $PM_{2.5}$ emissions. For most sectors, BC is estimated by applying speciation profiles to the $PM_{2.5}$ emissions.**
- **BC is about 9% of total $PM_{2.5}$ emissions in the 2011 NEI v1.**
- **The chart on the left shows that in 2011, fires (wild, prescribed, and agricultural fires) account for 42% of BC emissions and mobile sources about 41%. 90% of the mobile source BC emissions come from diesel fuel combustion.**
- **EPA previously reported BC for 2005[16]. In that inventory, about 52% of total BC came from mobile sources and about 35% from open burning.**
- **The chart on the right shows that significant BC contributions for 2011 are from: mobile source diesel equipment and engines; biomass burning from wild and prescribed fires; and fuel combustion - residential wood and EGUs.**

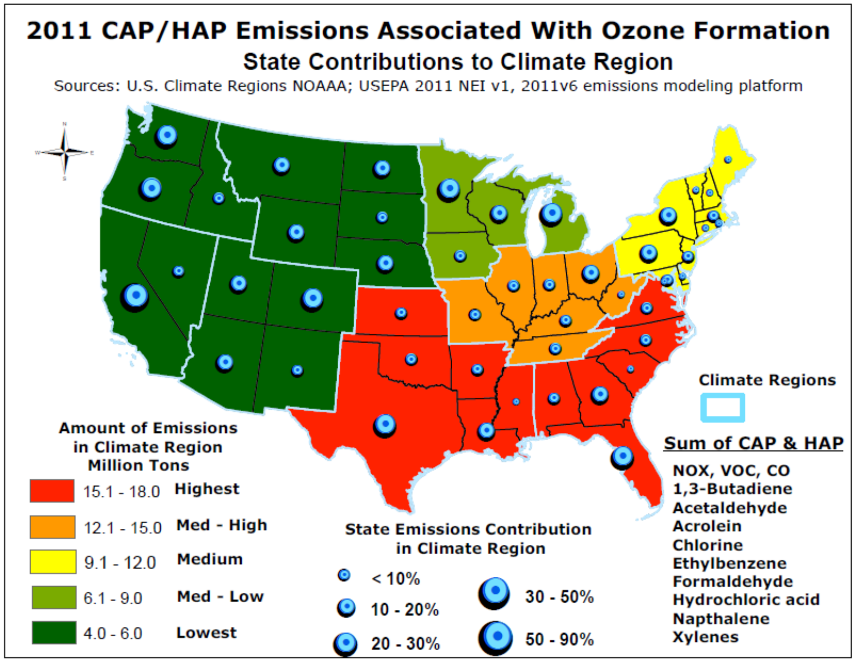
16. EPA Report to Congress, Chapter 4

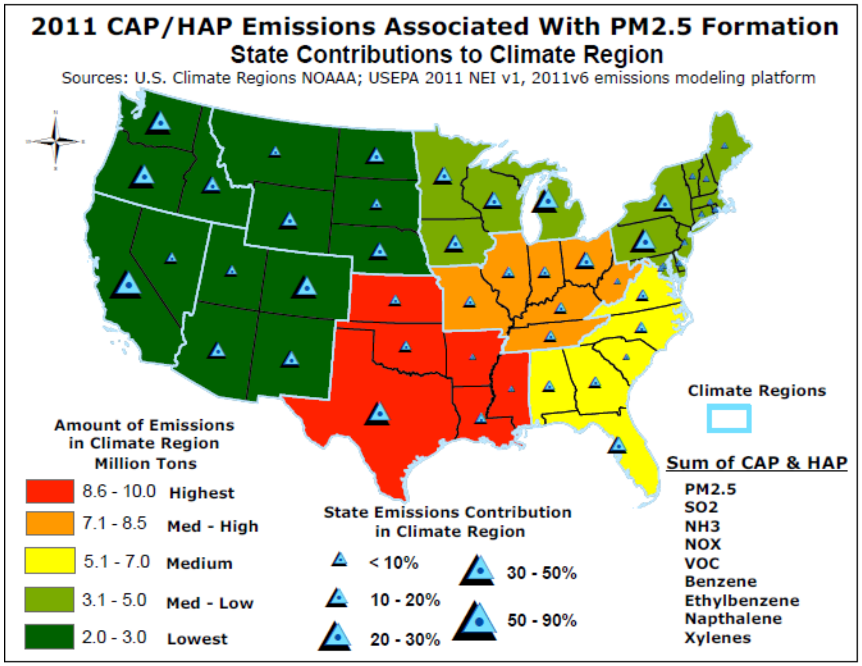
Figure 13: 2011 Emissions by Climate Region



- **This map describes the National Climatic Data Center (NCDC) Regions based on the climatological map developed and maintained by NOAA (U.S. National Oceanic and Atmospheric Administration). The U.S. is split into 9 regions based on homogeneity in meteorological conditions (meteorology, in turn, affects many emissions and emission processes) as determined by data analysis conducted by NOAA. HI and AK are excluded from these maps and related analyses.**
- **This map is basis of the regional analysis shown in Figure 14.**

Figure 14: Regional Ozone and $PM_{2.5}$ Formation Potential Based on State CAP/ HAP Emission Intensity





- **These maps use the 9 climate regions defined on the previous page and show the state CAP and HAP emission contributions associated with the formation of ozone (top) and $PM_{2.5}$ (bottom map). Emissions from biogenics and wildfires are excluded.**

- **The pollutants listed on each map are CAPs and HAPs known to be ozone and $PM_{2.5}$ precursors. The HAPs listed have been identified for these maps due to their cancer and non-cancer risks[17].**

- **The intensity of color for each climate region indicates the amount of emissions in a given region and how regions rank against each other, with red and orange being high emission zones. For both $PM_{2.5}$ and ozone, the-higher emission areas are in the south, southeast, and the industrial midwest regions.**

- **The symbols located on each state indicate the relative percent contribution of the state emissions to the corresponding climate region. Larger symbols indicate a larger contribution of emissions to the region. For example, the south, southeast, and central regions have relatively large amounts of both $PM_{2.5}$ and ozone forming emissions, and Texas, Florida, and Ohio contribute the most in each region respectively.**

- **In regions with relatively low amounts of $PM_{2.5}$ and ozone forming emissions, states such as Michigan, Colorado, Wyoming, Nebraska, and North Dakota contribute significant amounts of emissions to their respective regions. In the western climate region, California is the dominant contributor to both ozone and $PM_{2.5}$.**

17. U.S. EPA National Air Toxics Assessment 2005