

## Particulate Matter Concentrations

“Particulate matter” (PM) is the general term used for a mixture of solid particles and liquid droplets found in the air. Airborne PM comes from many different sources. “Primary” particles are released directly into the atmosphere from sources such as cars, trucks, heavy equipment, forest fires, and other burning activities (e.g., burning waste, woodstoves, wood-fired boilers). Primary particles also consist of crustal material from sources such as unpaved roads, stone crushing, construction sites, and metallurgical operations. “Secondary” particles are formed in the air from reactions involving precursor chemicals such as sulfates (which are formed from sulfur dioxide emissions from power plants and industrial facilities), nitrates (which are formed from nitrogen dioxide emissions from cars, trucks, and power plants), and carbon-containing reactive organic gas emissions from cars, trucks, industrial facilities, forest fires, and biogenic sources such as trees.

Ambient air monitoring stations throughout the country measure air concentrations of different ranges of particles, but most monitoring is for two size ranges: PM<sub>2.5</sub> and PM<sub>10</sub>. PM<sub>2.5</sub> consists of “fine particles” with aerodynamic diameters less than or equal to 2.5 microns (µm). PM<sub>10</sub> includes both fine particles (PM<sub>2.5</sub>) and “coarse particles,” which is the subset of PM<sub>10</sub> that is larger than 2.5 µm and smaller than 10 µm. The chemical makeup of particles varies across the U.S. For example, fine particles in the eastern half of the U.S. contain more sulfates than those in the West, while fine particles in southern California contain more nitrates than those in other areas of the U.S. Carbon is a substantial component of fine particles everywhere (U.S. EPA, 2004, 2009).

Fine particles also have seasonal patterns. PM<sub>2.5</sub> concentrations in the eastern half of the U.S. are typically higher in the third calendar quarter (July-September), when sulfates are more commonly formed from sulfur dioxide emissions from power plants in that part of the country. Fine particle concentrations tend to be higher in the fourth calendar quarter (October-December) in many areas of the West, in part because fine particle nitrates are more readily formed in cooler weather, and wood stove and fireplace use produces more carbon. Additionally, nitrate concentrations within particles are highest during the winter in the upper Midwest (U.S. EPA, 2009).

An extensive body of scientific evidence shows exposure to fine particles (PM<sub>2.5</sub>) can cause premature death and adverse cardiovascular effects, including increased hospital admissions and emergency department visits for heart attacks and strokes and is linked to respiratory effects including increased hospital admissions and emergency department visits for asthma attacks, reduced lung development in children, and increased respiratory symptoms such as coughing, wheezing, and shortness of breath. More limited scientific evidence provides evidence for premature mortality and cardiovascular and respiratory effects associated with different particle size fractions (e.g., thoracic coarse particles, PM<sub>10-2.5</sub>; ultrafine particles, PM<sub>0.1</sub>) as well as a broader range of health effects associated with fine particle exposures (e.g., developmental and reproductive effects, cancer) (U.S. EPA, 2009). Specific groups within the general population are at increased risk for experiencing adverse health effects related to PM exposures including older adults, individuals with cardiopulmonary disease such as asthma or congestive heart disease, children, and persons with lower socioeconomic status (U.S. EPA, 2009). Unlike other criteria pollutants, PM is not a single specific chemical entity, but rather a mixture of particles from different sources with different sizes and chemical compositions. Efforts to evaluate the relationships between PM composition and health effects continue to evolve. While many constituents of PM can be linked with differing health effects, the evidence is not yet sufficient to allow differentiation of those components or sources that may be more closely related to specific health outcomes nor to exclude any individual component or

group of components associated with any source categories from the particle mixture of concern.

PM also can cause adverse impacts to the environment. PM-related welfare effects include visibility impairment, climate impacts, effects on materials, and ecological effects (U.S. EPA, 2009).

This indicator presents trends in PM<sub>10</sub> and PM<sub>2.5</sub> concentrations, using averaging times consistent with the pollutants' corresponding National Ambient Air Quality Standards (NAAQS). For PM<sub>10</sub>, trend data from 1988 to 2013 are presented for the second highest 24-hour concentrations measured at the trend sites during each calendar year. For PM<sub>2.5</sub>, trend data from 1999 to 2013 are presented both for seasonally weighted annual average concentrations and for the 98<sup>th</sup> percentiles of 24-hour average concentrations measured at the trend sites over three consecutive calendar years. Trend data are based on measurements from the State and Local Air Monitoring Stations network and from other special purpose monitors. This indicator presents PM<sub>10</sub> trends for 168 monitoring sites in 113 counties nationwide and annual average PM<sub>2.5</sub> trends for 504 monitoring sites in 372 counties nationwide. For both PM<sub>10</sub> and PM<sub>2.5</sub>, the indicator displays trends for the entire nation and for the ten EPA Regions.

The indicator's exhibits display the pollutants' NAAQS as points of reference. However, the fact that the national values or those shown for EPA Regions fall below the standards does not mean that all monitoring sites nationally or in any particular EPA Region also are below the standards. The indicator displays trends in the number of PM<sub>10</sub> monitoring sites and PM<sub>2.5</sub> monitoring sites nationwide that recorded ambient air concentrations above the level of the standards, but these statistics are not displayed for each EPA Region.

## **What the Data Show**

### *PM<sub>10</sub> Concentration Trends*

In 2013, the national 24-hour PM<sub>10</sub> concentration (based on the second highest 24-hour concentration at each site) was 39 percent lower than the average 1988 level (Exhibit 1). Additionally, of the 168 sites used to determine this trend (out of 738 total monitoring sites that were operating in 2013), the number reporting PM<sub>10</sub> concentrations above the level of the 24-hour standard declined 68 percent between 1988 and 2013 (Exhibit 2). All EPA Regions experienced a decrease in 24-hour PM<sub>10</sub> levels over this period (Exhibit 3). EPA Regions 3 and 10 showed the greatest relative decrease (67 percent) since 1988.

Also shown in Exhibit 1 are the 90<sup>th</sup> and 10<sup>th</sup> percentiles based on the distribution of annual statistics at the monitoring sites. This provides additional graphical representation of the distribution of measured concentrations across the monitoring sites for a given year. Thus, the graphic displays the concentration range where 80 percent of measured values occurred for that year. (Note that this presentation style also applies to Exhibits 4 and 7, discussed below.)

### *PM<sub>2.5</sub> Concentration Trends*

The seasonally weighted annual average PM<sub>2.5</sub> concentrations decreased 32 percent between the 1999-2001 averaging period and the 2011-2013 averaging period (Exhibit 4). This trend is based on measurements collected at 504 monitoring stations that have sufficient data to assess trends over that period. The number of monitoring sites in this trend (504 out of 800 total sites that were operating in 2013) reporting ambient air concentrations above the level of the annual average PM<sub>2.5</sub> standard decreased by 92 percent over this period (Exhibit 5). Regional declines were greatest in EPA Region 4, where seasonally weighted average PM<sub>2.5</sub> concentrations over the 2011-2013 averaging period were 38 percent lower than those in the 1999-2001 averaging period (Exhibit 6).

In 2011-2013, the average of 98<sup>th</sup> percentiles of 24-hour PM<sub>2.5</sub> concentrations at the 507 monitoring sites used for the trend was 34 percent lower than the 1999-2001 level (Exhibit 7). The number of monitoring sites in this trend (507 out of a total of 817 sites that were operating in 2013) reporting ambient air concentrations above the level of the 24-hour PM<sub>2.5</sub> standard declined 89 percent over this period (Exhibit 8). All ten EPA Regions experienced decreasing 24-hour PM<sub>2.5</sub> concentrations between the 1999-2001 averaging period and the 2011-2013 averaging period, with Region 4 showing the largest decline (40 percent) (Exhibit 9).

## Limitations

- Because there are far more PM<sub>10</sub> and PM<sub>2.5</sub> monitors in urban areas than in rural areas, the trends might not accurately reflect conditions outside the immediate urban monitoring areas.
- PM<sub>10</sub> and PM<sub>2.5</sub> measurement data are based on monitoring methods that are consistent with those used to establish EPA's health-related standards. These "indicator" measurements provide mass concentrations that may be different than the concentrations of particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>) in the ambient air. These potential differences are due to losses from volatilization of nitrates and other semi-volatile materials and retention of particle-bound water associated with hygroscopic species. A study of six locations in the Eastern U.S. showed that the net difference was less than 10 percent (Frank, 2006).
- Due to the relatively small number of monitoring sites in some EPA Regions, the regional trends are subject to greater uncertainty than the national trends. Some EPA Regions with low average concentrations may include areas with high local concentrations, and vice versa. In addition, the trend sites in this indicator are not dispersed uniformly across all states in the EPA Regions. For instance, the 168 PM<sub>10</sub> trend sites are located in 35 states and Puerto Rico. In the remaining 15 states, there currently are insufficient long-term data from the existing PM<sub>10</sub> monitoring sites to include in this indicator. In contrast, the 504 annual average PM<sub>2.5</sub> trend sites are located in 49 states, the District of Columbia, and Puerto Rico. Only one state did not have sufficient long-term data from the existing PM<sub>2.5</sub> sites to include in this indicator.
- To ensure that long-term trends are based on a consistent set of monitoring sites, selection criteria were applied to identify the subset of PM monitoring sites with sufficient data to assess trends over the time frames covered by this indicator. Monitoring sites without sufficient data are not included in the trend analysis. Some excluded monitoring sites reported PM concentrations above the level of the PM standard during the years covered by this indicator. In 2013, for example, 60 monitoring sites nationwide recorded 24-hour PM<sub>10</sub> concentrations above the level of the NAAQS: this includes the six sites shown in Exhibit 2, and 54 sites that did not have sufficient long-term data to be included in this indicator.

## Data Sources

Summary data in this indicator were provided by EPA's Office of Air Quality Planning and Standards, based on PM ambient air monitoring data in EPA's Air Quality System (U.S. EPA, 2014a) (<https://www.epa.gov/aqs>). National and regional trends in this indicator are based on the subset of PM monitoring stations that have sufficient data to assess trends over the period of record (i.e., since 1988 for PM<sub>10</sub> and since 1999 for PM<sub>2.5</sub>).

## References

Frank, N.H. 2006. Retained nitrate, hydrated sulfates, and carbonaceous mass in federal reference

method fine particulate matter for six eastern U.S. cities. Journal of the Air and Waste Management Association 56:500-11.

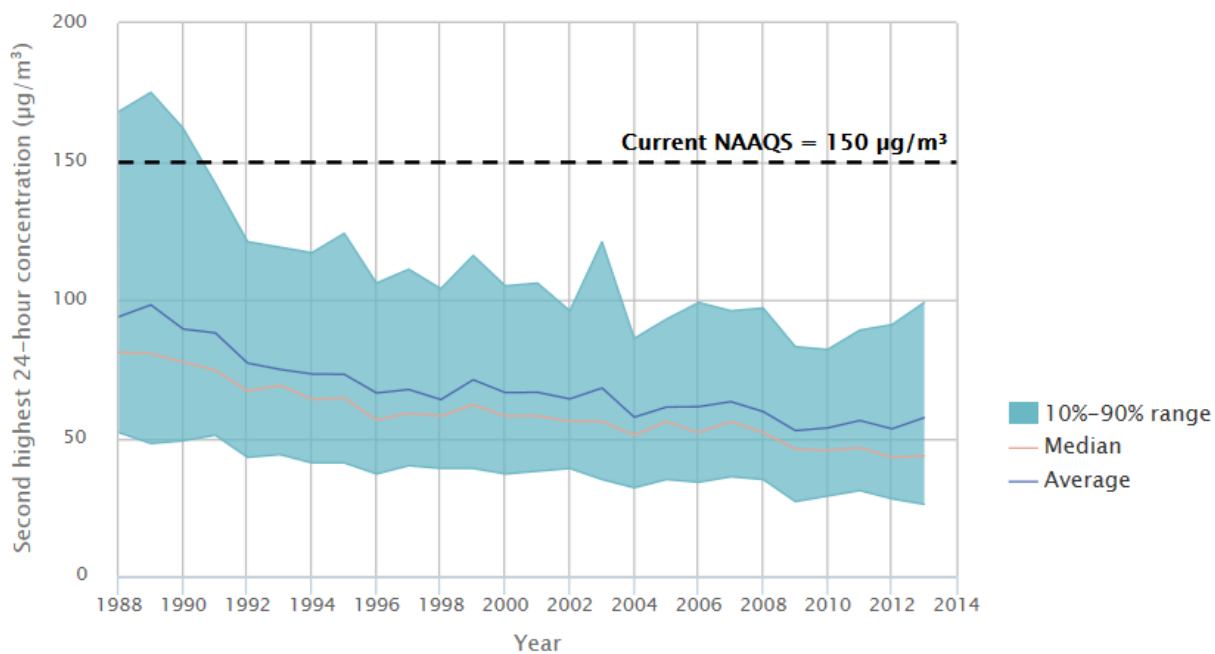
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U.S. EPA. 2004. The particle pollution report: Current understanding of air quality and emissions through 2003. EPA 454/R-04/002. Research Triangle Park, NC. <https://nepis.epa.gov/Exe/ZyPDF.cgi/30005VAS.PDF?Dockey=30005VAS.pdf> (PDF) (32 pp, 4.8MB).

**Exhibit 1. Ambient 24-hour PM<sub>10</sub> concentrations in the U.S., 1988–2013**



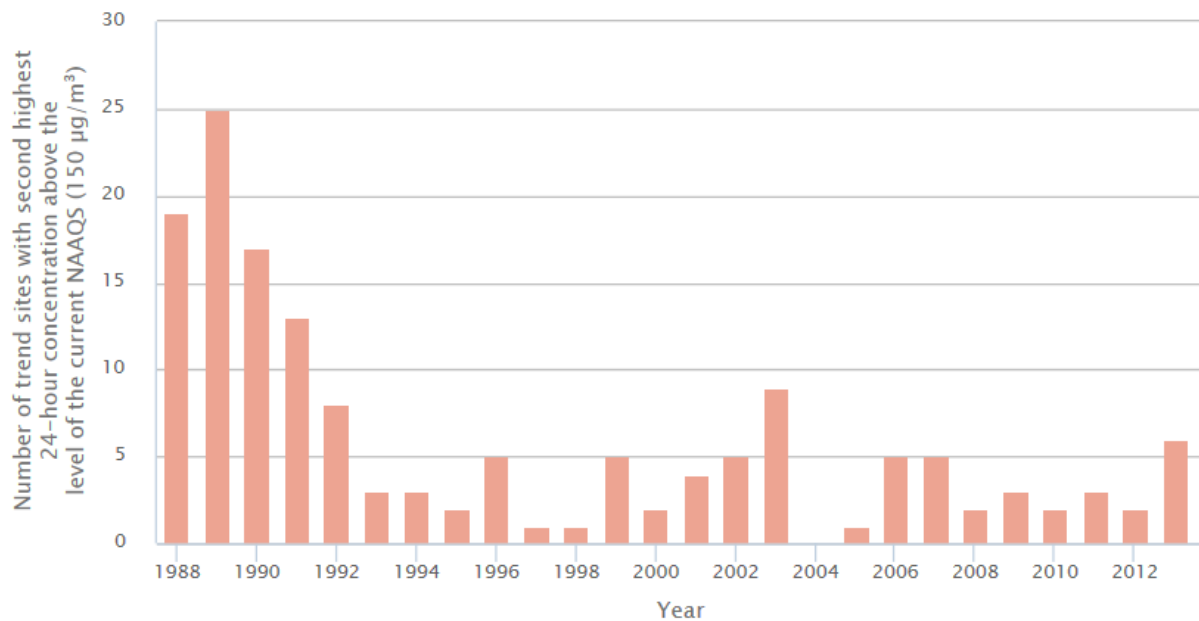
The current 24-hour PM<sub>10</sub> NAAQS was established in 1987 and has not been revised since (U.S. EPA, 2014b).

**Coverage:** 168 monitoring sites in 113 counties nationwide (out of a total of 738 sites measuring PM<sub>10</sub> in 2013) that have sufficient data to assess PM<sub>10</sub> trends since 1988.

Information on the statistical significance of the trend in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

**Data source:** U.S. EPA, 2014a

## Exhibit 2. Ambient 24-hour PM<sub>10</sub> concentrations above the level of the current NAAQS in the U.S., 1988–2013



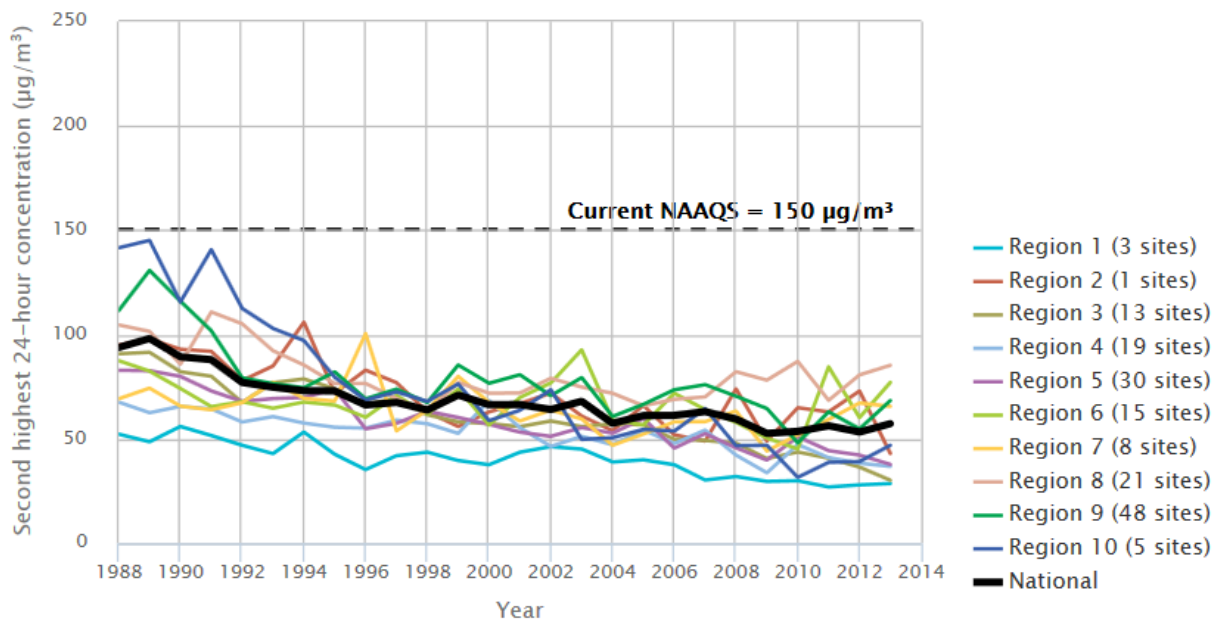
The current 24-hour PM<sub>10</sub> NAAQS was established in 1987 and has not been revised since (U.S. EPA, 2014b).

**Coverage:** 168 monitoring sites in 113 counties nationwide (out of a total of 738 sites measuring PM<sub>10</sub> in 2013) that have sufficient data to assess PM<sub>10</sub> trends since 1988.

Information on the statistical significance of the trend in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

**Data source:** U.S. EPA, 2014a

### Exhibit 3. Ambient 24-hour PM<sub>10</sub> concentrations in the contiguous U.S. by EPA Region, 1988–2013



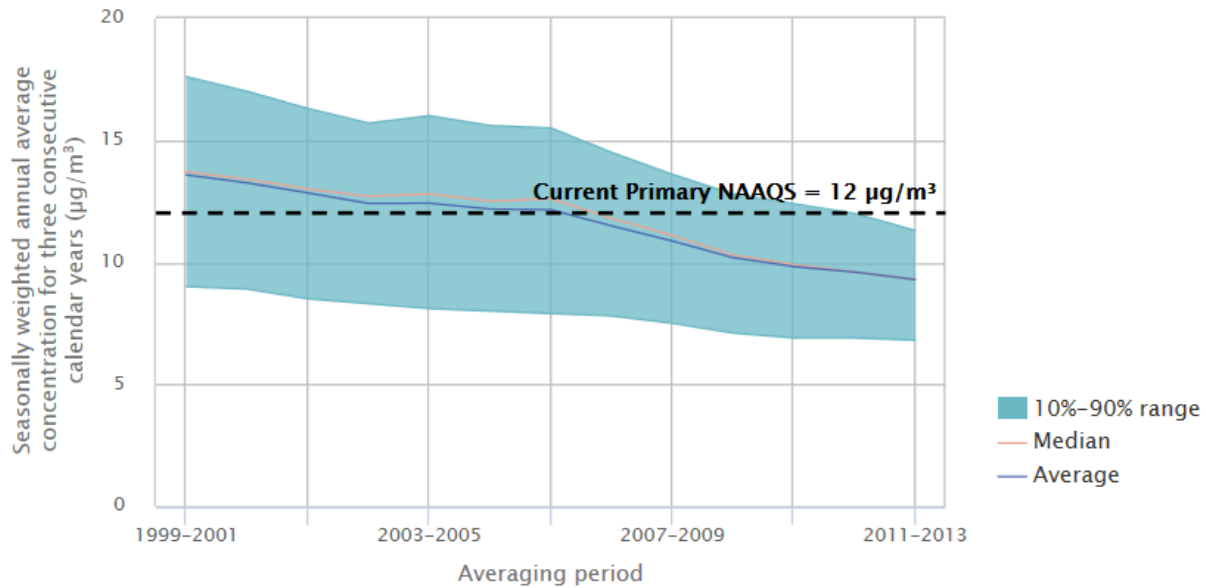
The current 24-hour PM<sub>10</sub> NAAQS was established in 1987 and has not been revised since (U.S. EPA, 2014b).

**Coverage:** 168 monitoring sites in 113 counties nationwide (out of a total of 738 sites measuring PM<sub>10</sub> in 2013) that have sufficient data to assess PM<sub>10</sub> trends since 1988.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

**Data source:** U.S. EPA, 2014a

#### Exhibit 4. Ambient annual PM<sub>2.5</sub> concentrations in the U.S., 1999–2013



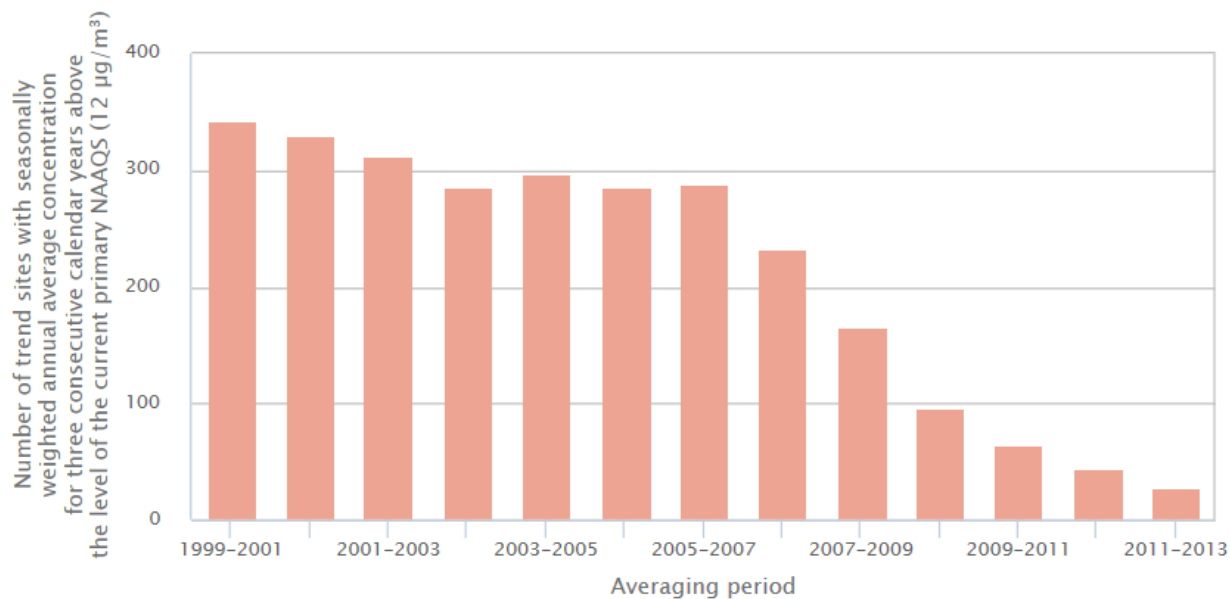
The current annual average PM<sub>2.5</sub> NAAQS was established in 2012 and is shown to provide context for the magnitude of pollutant concentrations. It is more stringent than all previous annual average PM<sub>2.5</sub> NAAQS (e.g., the concentration levels for the previous annual average PM<sub>2.5</sub> NAAQS are higher) (U.S. EPA, 2014b).

**Coverage:** 504 monitoring sites in 372 counties nationwide (out of a total of 800 sites measuring PM<sub>2.5</sub> in 2013) that have sufficient data to assess PM<sub>2.5</sub> trends since 1999.

Information on the statistical significance of the trend in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

**Data source:** U.S. EPA, 2014a

### Exhibit 5. Ambient annual $PM_{2.5}$ concentrations above the level of the current primary NAAQS in the U.S., 1999–2013



The current annual average  $PM_{2.5}$  NAAQS was established in 2012 and is shown to provide context for the magnitude of pollutant concentrations. It is more stringent than all previous annual average  $PM_{2.5}$  NAAQS (e.g., the concentration levels for the previous annual average  $PM_{2.5}$  NAAQS are higher) (U.S. EPA, 2014b).

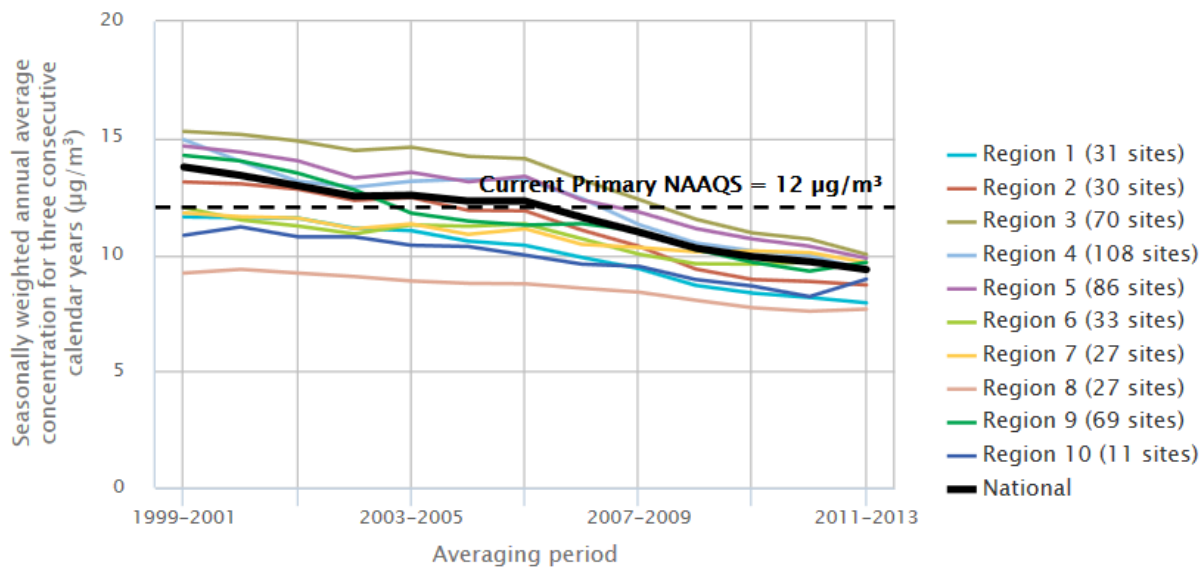
**Coverage:** 504 monitoring sites in 372 counties nationwide (out of a total of 800 sites measuring  $PM_{2.5}$  in 2013) that have sufficient data to assess  $PM_{2.5}$  trends since 1999.

Information on the statistical significance of the trend in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

**Data source:** U.S. EPA, 2014a



## Exhibit 6. Ambient annual PM<sub>2.5</sub> concentrations in the contiguous U.S. by EPA Region, 1999–2013



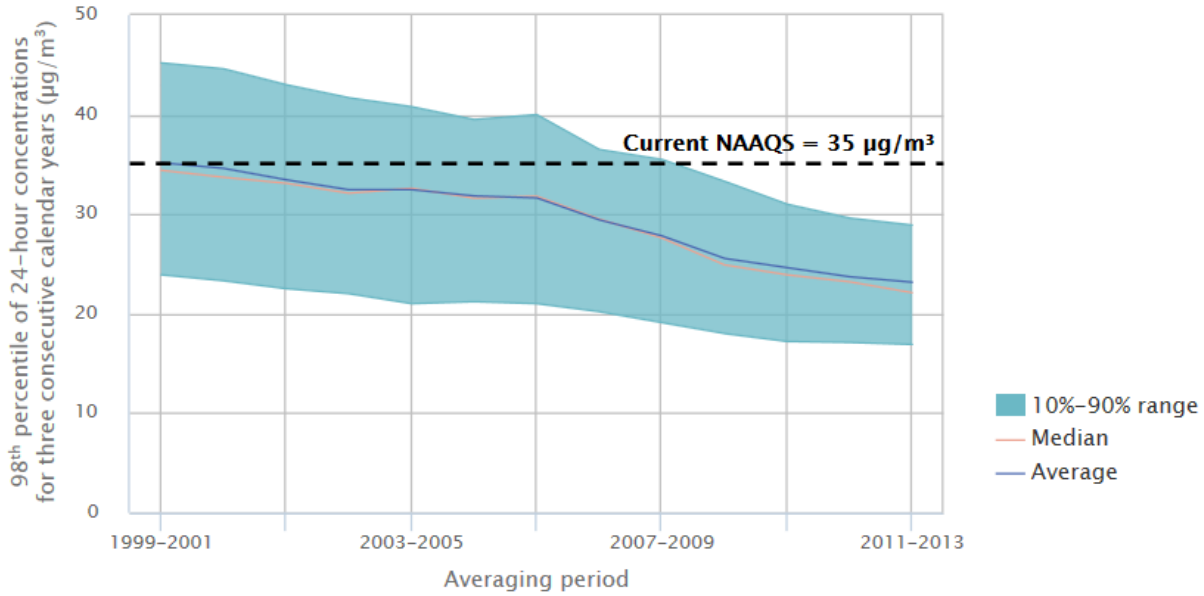
The current annual average PM<sub>2.5</sub> NAAQS was established in 2012 and is shown to provide context for the magnitude of pollutant concentrations. It is more stringent than all previous annual average PM<sub>2.5</sub> NAAQS (e.g., the concentration levels for the previous annual average PM<sub>2.5</sub> NAAQS are higher) (U.S. EPA, 2014b).

**Coverage:** 492 monitoring sites in 372 counties in the EPA Regions (out of a total of 800 sites measuring PM<sub>2.5</sub> in 2013) that have sufficient data to assess PM<sub>2.5</sub> trends since 1999.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

**Data source:** U.S. EPA, 2014a

### Exhibit 7. Ambient 24-hour PM<sub>2.5</sub> concentrations in the U.S., 1999–2013



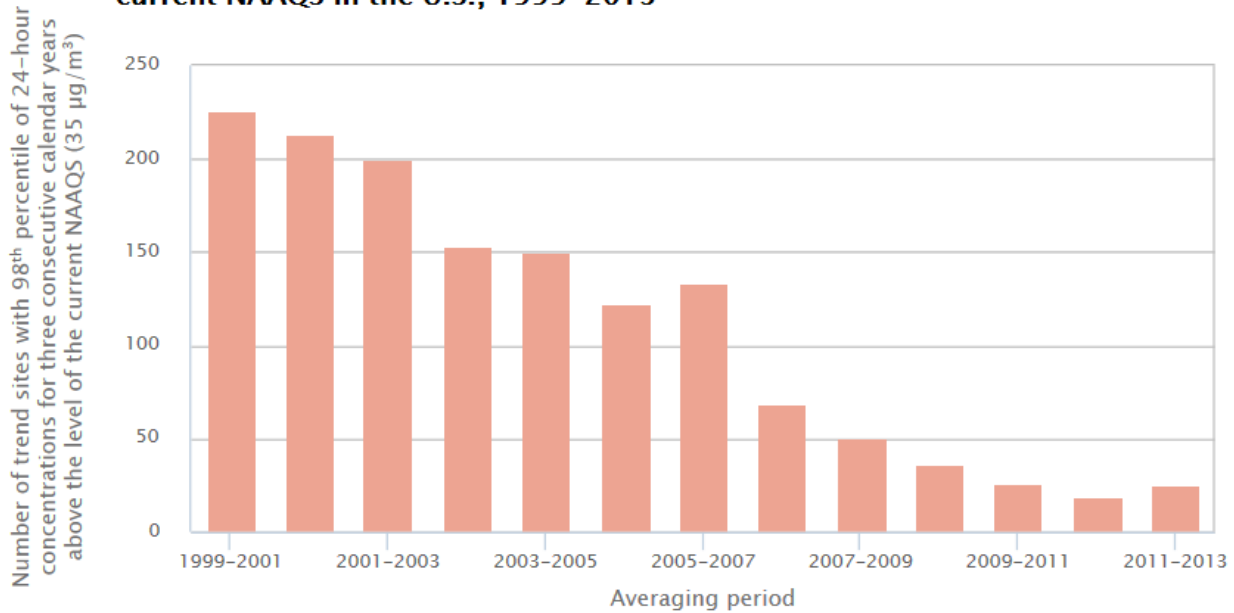
The current 24-hour PM<sub>2.5</sub> NAAQS was established in 2006 and is shown to provide context for the magnitude of pollutant concentrations. It is more stringent than all previous 24-hour PM<sub>2.5</sub> NAAQS (e.g., the concentration levels for the previous 24-hour PM<sub>2.5</sub> NAAQS are higher) (U.S. EPA, 2014b).

**Coverage:** 507 monitoring sites in 372 counties nationwide (out of a total of 817 sites measuring PM<sub>2.5</sub> in 2013) that have sufficient data to assess PM<sub>2.5</sub> trends since 1999.

Information on the statistical significance of the trend in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

**Data source:** U.S. EPA, 2014a

### Exhibit 8. Ambient 24-hour PM<sub>2.5</sub> concentrations above the level of the current NAAQS in the U.S., 1999–2013



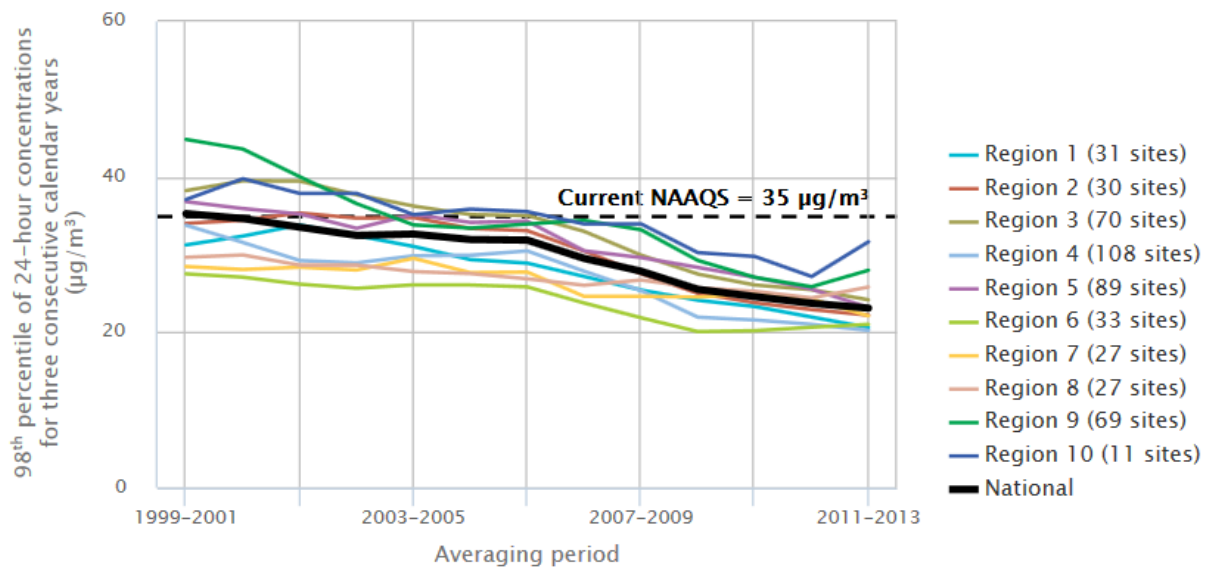
The current 24-hour PM<sub>2.5</sub> NAAQS was established in 2006 and is shown to provide context for the magnitude of pollutant concentrations. It is more stringent than all previous 24-hour PM<sub>2.5</sub> NAAQS (e.g., the concentration levels for the previous 24-hour PM<sub>2.5</sub> NAAQS are higher) (U.S. EPA, 2014b).

**Coverage:** 507 monitoring sites in 372 counties nationwide (out of a total of 817 sites measuring PM<sub>2.5</sub> in 2013) that have sufficient data to assess PM<sub>2.5</sub> trends since 1999.

Information on the statistical significance of the trend in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

**Data source:** U.S. EPA, 2014a

### Exhibit 9. Ambient 24-hour PM<sub>2.5</sub> concentrations in the contiguous U.S. by EPA Region, 1999–2013



The current 24-hour PM<sub>2.5</sub> NAAQS was established in 2006 and is shown to provide context for the magnitude of pollutant concentrations. It is more stringent than all previous 24-hour PM<sub>2.5</sub> NAAQS (e.g., the concentration levels for the previous 24-hour PM<sub>2.5</sub> NAAQS are higher) (U.S. EPA, 2014b).

**Coverage:** 495 monitoring sites in 372 counties in the EPA Regions (out of a total of 817 sites measuring PM<sub>2.5</sub> in 2013) that have sufficient data to assess PM<sub>2.5</sub> trends since 1999.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

**Data source:** U.S. EPA, 2014a