Nitrogen Dioxide Concentrations

Nitrogen dioxide (NO_2) is a reddish-brown, highly reactive gas that is formed in the ambient air through the oxidation of nitric oxide (NO). Nitrogen dioxide is one in a group of highly reactive gases generically referred to as "nitrogen oxides" (NO_x), all of which contain nitrogen and oxygen in varying amounts. NO_x plays a major role in the formation of ozone in the atmosphere through a complex series of reactions with volatile organic compounds. NO_2 is the most widespread and commonly found nitrogen oxide (U.S. EPA, 2003).

Short-term exposures (e.g., less than 3 hours) to low levels of NO_2 may lead to changes in airway responsiveness and lung function in individuals with preexisting respiratory illnesses. These exposures may also increase respiratory illnesses in children. Long-term exposures to NO_2 may lead to increased susceptibility to respiratory infection and may cause irreversible alterations in lung structure (U.S. EPA, 2008).

Atmospheric transformation of NO_x can lead to the formation of ozone and nitrogen-bearing particles (e.g., nitrates, nitric acid). Deposition of nitrogen can lead to fertilization, eutrophication, or acidification of terrestrial, wetland, and aquatic (e.g., fresh water bodies, estuaries, coastal water) systems. These effects can alter competition among existing species, leading to changes in species abundance and distribution within communities. For example, eutrophic conditions in aquatic systems can produce explosive growth of algae leading to hypoxia or an increase in levels of toxins harmful to fish and other aquatic life (U.S. EPA, 1993).

This indicator presents ambient NO_2 concentrations in parts per billion (ppb) from 1980 to 2011 using two averaging times: 1-hour averages to be consistent with the short-term primary National Ambient Air Quality Standard (NAAQS) and annual averages to present trends consistent with the long-term NO_2 NAAQS. Trend data are based on measurements from the State and Local Air Monitoring Stations network and from other special purpose monitors. The number and spatial coverage of monitoring sites vary: between 1980 and 2011, 75 monitoring sites in 57 counties nationwide have sufficient data to characterize annual average trends; and between 1980 and 2011, 34 monitoring sites in 27 counties nationwide have sufficient data to characterize 1-hour trends. Trends are displayed for the entire nation and for each EPA Region with monitoring sites with sufficient long-term data.

Trends in 1-hour NO_2 concentrations are presented for the 98th percentile of 1-hour daily maximum concentrations. All exhibits in this indicator present the NO_2 NAAQS as a point of reference. The fact that the national or regional concentrations fall below the standards does not mean that all monitoring sites nationally or in the EPA Region also are below the standards. The indicator displays trends in the number of trend sites nationwide at which NO_2 concentrations exceeded the level of the standards, but these statistics are not displayed for the EPA Regions.

What the Data Show

The national annual average NO_2 concentration in 2011 was 52 percent lower than that recorded in 1980 (Exhibit 1). Also shown on this graph are the 90th and 10th percentiles of NO_2 concentrations 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, for each year, the graphic displays the concentration range where 80 percent

of measured values occurred. The highest annual average NO_2 concentrations are typically found in urban areas. In addition, of the 75 sites used to determine the trend for annual average concentrations (out of 330 total monitoring sites that were operating in 2011), the number reporting NO_2 concentrations above the level of the NO_2 standard declined from six sites in 1981 to zero sites since 1992 (Exhibit 2). Annual average NO_2 levels in all EPA Regions with trend sites have steadily decreased since 1980, with percent reductions over this time ranging from 37 percent in Region 8 to 60 percent in Region 5 (Exhibit 3). The decrease in NO_2 concentrations in this indicator is consistent with the decreasing NO_x emissions observed between 1990 and 2008 (the Nitrogen Oxides Emissions indicator).

The 98th percentile of 1-hour NO_2 concentrations also exhibited a downward trend. From 1980 to 2011, the concentrations decreased by 59 percent across the 34 sites with sufficient data (Exhibit 4). Among these sites, the number reporting concentrations above the level of the 2010 1-hour NAAQS decreased from 15 sites in 1982 to zero sites since 2005 (Exhibit 5).

Limitations

- Because ambient monitoring for NO_2 occurs almost exclusively in high-traffic urban areas, the average concentrations presented in this indicator likely may not reflect NO_2 levels in rural areas. Also, in rural areas, air mass aging could foster greater relative levels of peroxyacetyl nitrate (PAN) and nitric acid, which can cause a positive interference in NO_2 measurements.
- The measurement of NO_2 is based on the conversion of NO_2 to NO and the subsequent detection of NO using the chemiluminescence technique. Because there are other nitrogen-containing compounds, such as PAN and nitric acid, that can be converted to NO, the chemiluminescence technique may overestimate NO_2 concentrations due to these interferences. Measurement devices with ultraviolet photolytic converters are less prone to interferences than devices with heated surfaces (or catalysts) upstream of the chemiluminescence detector, but are not in widespread use.
- Because of the relatively small number of trend 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 75 trend sites with sufficient data for annual trends are not dispersed uniformly across all states in the EPA Regions. The 75 sites are located in 21 states. In the remaining 29 states, there currently are insufficient long-term NO_2 data from monitoring 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 NO_2 monitoring sites with sufficient data to assess trends since 1980. Monitoring sites without sufficient data are not included in the trend analysis. Some excluded monitoring sites reported NO_2 concentrations above the level of the NO_2 standard over the time frame covered by this indicator. In 2011, however, no monitoring sites in the U.S. measured annual average NO_2 concentrations above the level of the NAAQS.

Data Sources

Summary data in this indicator were provided by EPA's Office of Air Quality Planning and Standards, based on NO_2 ambient air monitoring data in EPA's Air Quality System (U.S. EPA, 2012) (http://www.epa.gov/ttn/airs/airsaqs/). National and regional trends in this indicator are based on the subset of NO_2 monitoring stations that have sufficient data to assess trends since 1980.

References

U.S. EPA (United States Environmental Protection Agency). 2014. History of the national ambient air quality standards for oxides of nitrogen. http://www.epa.gov/ttn/naaqs/standards/nox/s_nox_history.html.

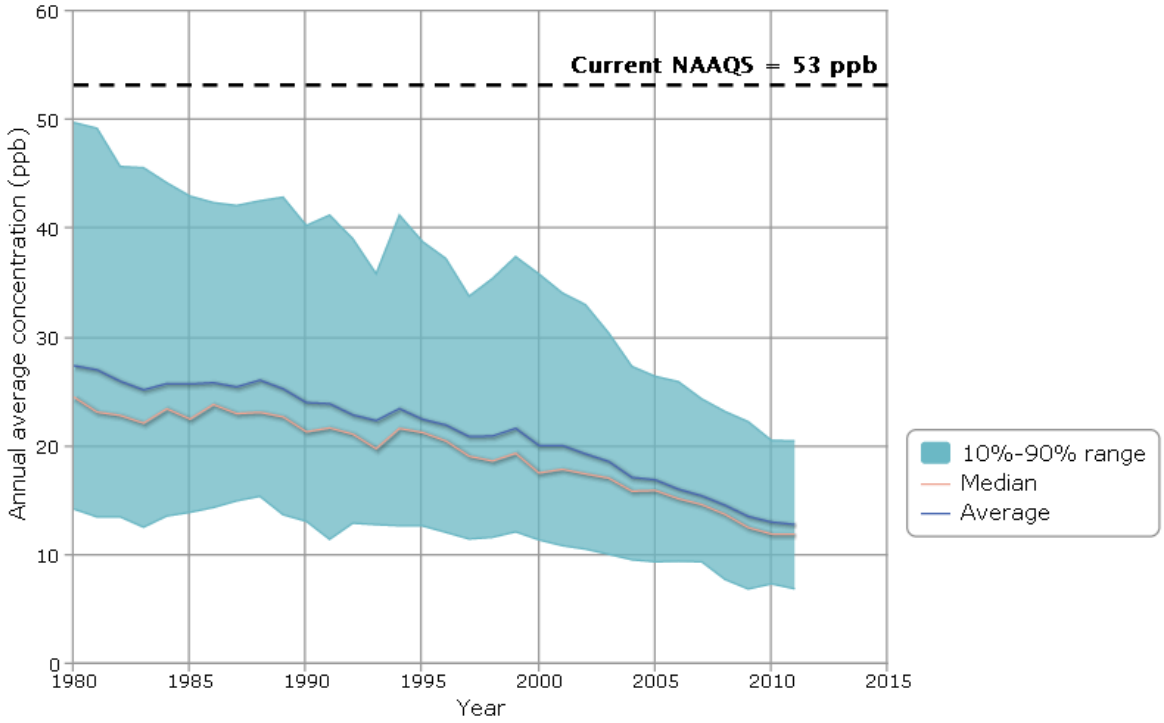
U.S. EPA. 2012. Data from the Air Quality System. Accessed 2012. http://www.epa.gov/ttn/airs/airsaqs/.

U.S. EPA. 2008. Integrated Science Assessment for Oxides of Nitrogen – Health Criteria (Final Report). EPA/600/R-08/071. Research Triangle Park, NC. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=194645.

U.S. EPA. 2003. National air quality and emissions trends report—2003 special studies edition. EPA/454/R-03/005. Research Triangle Park, NC. http://www.epa.gov/air/airtrends/aqtrnd03/.

U.S. EPA. 1993. Air quality criteria for oxides of nitrogen. EPA/600/8-91/049aF-cF. Research Triangle Park, NC.

Exhibit 1. Ambient annual NO_2 concentrations in the U.S., 1980-2011



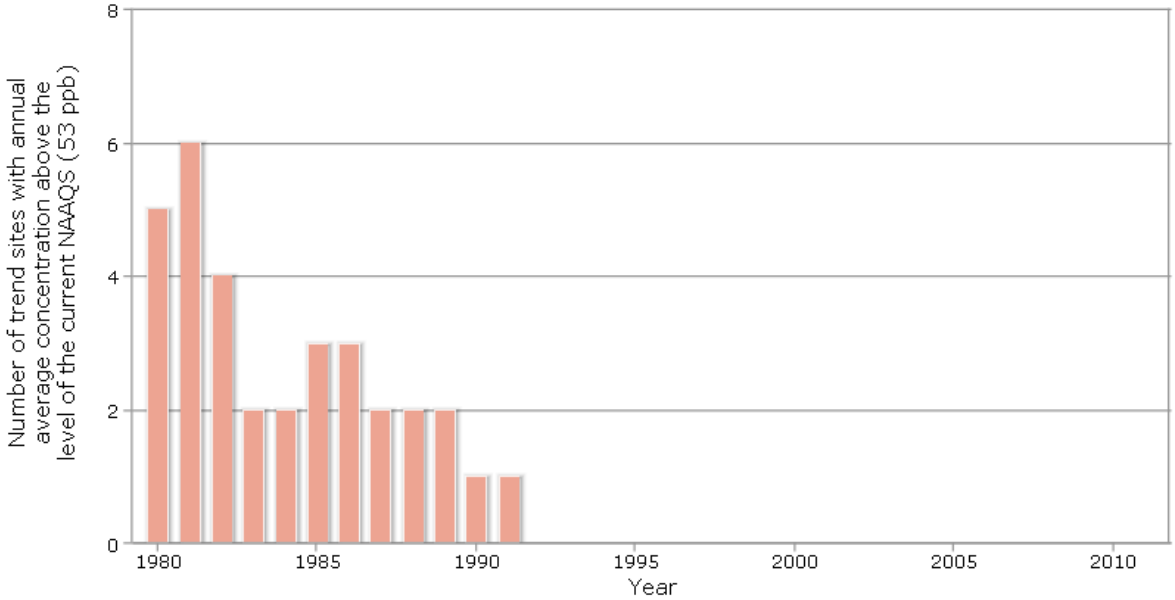
The current annual NAAQS was established in 1971 and has not been revised since (U.S. EPA, 2014).

Coverage: 75 monitoring sites in 57 counties nationwide (out of a total of 330 sites measuring NO_2 in 2011) that have sufficient data to assess NO_2 trends since 1980.

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, 2012

Exhibit 2. Ambient annual NO_2 concentrations above the level of the current NAAQS in the U.S., 1980-2011



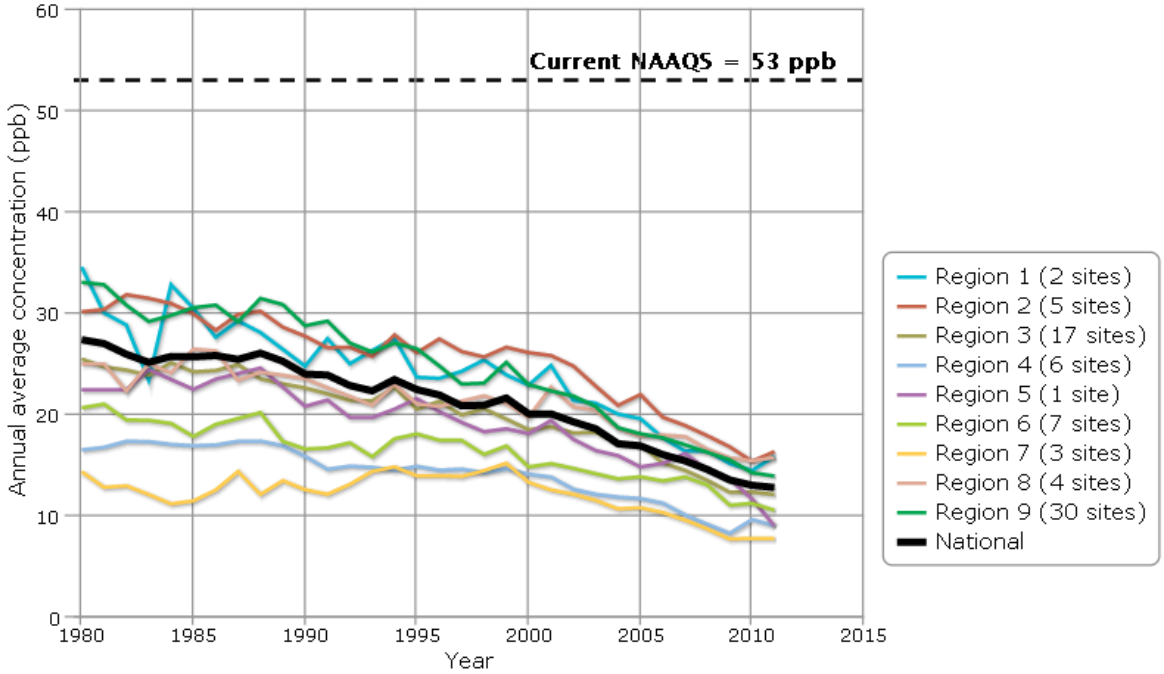
The current annual NAAQS was established in 1971 and has not been revised since (U.S. EPA, 2014).

Coverage: 75 monitoring sites in 57 counties nationwide (out of a total of 330 sites measuring NO_2 in 2011) that have sufficient data to assess NO_2 trends since 1980.

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, 2012

Exhibit 3. Ambient annual NO_2 concentrations in the contiguous U.S. by EPA Region, 1980-2011



The current annual NAAQS was established in 1971 and has not been revised since (U.S. EPA, 2014).

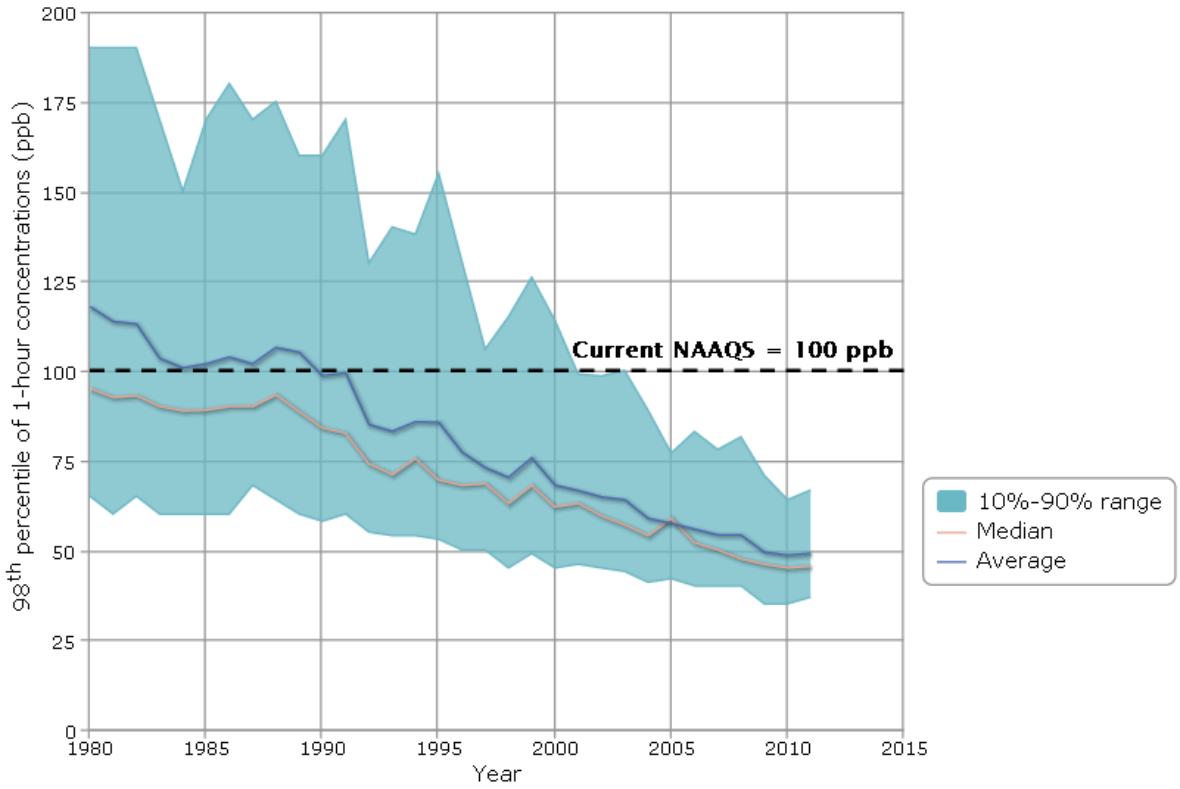
Coverage: 75 monitoring sites in 57 counties nationwide (out of a total of 330 sites measuring NO_2 in 2011) that have sufficient data to assess NO_2 trends since 1980.

States in Region 10 have removed NO_2 monitors in recent years because of low concentrations, and consequently none of this Region's monitoring sites have a complete record dating back to 1980. Thus, no trend line for Region 10 is shown.

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, 2012

Exhibit 4. Ambient 1-hour NO_2 concentrations in the U.S., 1980-2011



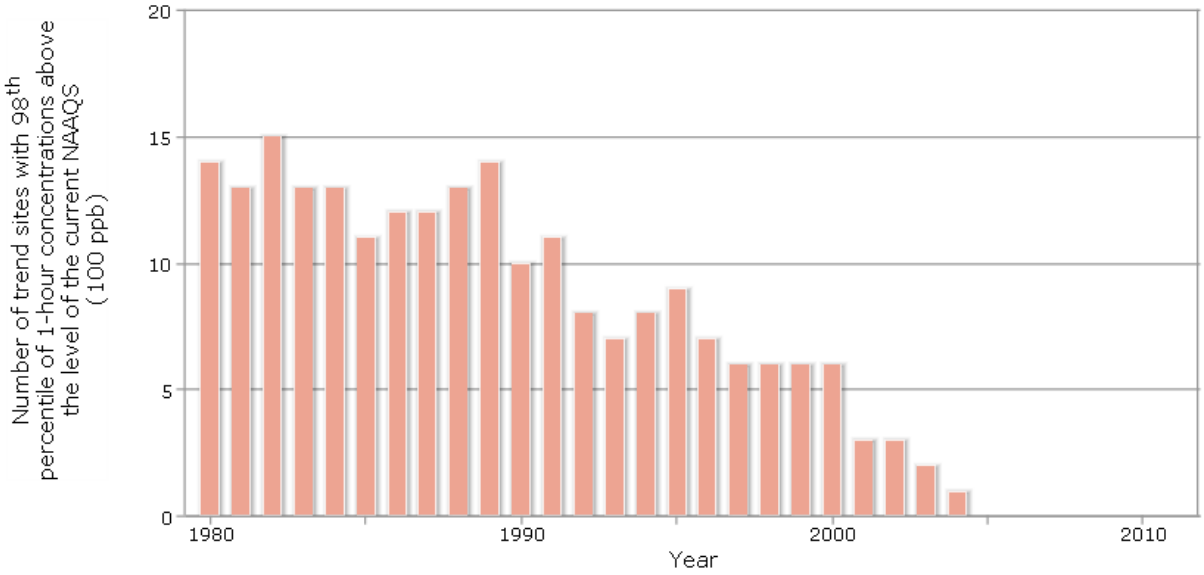
The current 1-hour NAAQS was established in 2010 and is shown to provide context for the magnitude of pollutant concentrations. No 1-hour NAAQS existed prior to 2010 (U.S. EPA, 2014).

Coverage: 34 monitoring sites in 27 counties nationwide (out of a total of 292 sites measuring NO_2 in 2011) that have sufficient data to assess NO_2 trends since 1980.

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, 2012

Exhibit 5. Ambient 1-hour NO_2 concentrations above the level of the current NAAQS in the U.S., 1980-2011



The current 1-hour NAAQS was established in 2010 and is shown to provide context for the magnitude of pollutant concentrations. No 1-hour NAAQS existed prior to 2010 (U.S. EPA, 2014).

Coverage: 34 monitoring sites in 27 counties nationwide (out of a total of 292 sites measuring NO_2 in 2011) that have sufficient data to assess NO_2 trends since 1980.

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, 2012