Nitrogen Dioxide Concentrations

Nitrogen dioxide (NO_2) is one of many highly reactive gases collectively referred to as "nitrogen oxides" (NO_x), all of which contain nitrogen and oxygen in varying amounts. Direct air emissions of NO_x generally comprise a mix of nitric oxide (NO) and NO_2, with a ratio in favor of NO. Specific emissions sources of NO_x that can affect local air quality include on-road vehicles, airports, railyards, shipping ports, home wood burning, intense industrial and chemical processes, activities for oil and gas development, and wildfires (see Nitrogen Oxides Emissions indicator). Once emitted to the air, NO reacts rapidly in the presence of ozone to form NO_2. In fact, in U.S. urban locations, most measured airborne NO_2 comes from the reaction of these two precursors, rather than from direct NO_2 emissions (U.S. EPA, 2008b).

Scientific evidence links short-term NO_2 exposures, ranging from 30 minutes to 24 hours, with an array of adverse respiratory effects including increased asthma symptoms, more difficulty controlling asthma, and an increase in respiratory illnesses and symptoms. Studies also show a connection between short-term NO_2 exposure and increased visits to emergency departments and hospital admissions for respiratory illnesses, particularly in at-risk populations and lifestages including children, the elderly, and persons with pre-existing respiratory disease (e.g., asthmatics). More limited evidence is available regarding long-term NO_2 exposure and respiratory effects (e.g., development of asthma) (U.S. EPA, 2008b).

Atmospheric transformation of NO_x and other pollutants leads to the formation of nitrogen-bearing particles that can eventually deposit to the surface, causing acidification, nitrogen enrichment, and other ecological effects. Acidification from the deposition resulting from current emission levels causes a cascade of effects that harm susceptible aquatic and terrestrial ecosystems, including slower growth and injury to forests and localized extinction of fishes and other aquatic species (see Acid Deposition indicator). Further, deposition of reactive nitrogen particles along with other non-atmospheric sources (e.g., fertilizers and wastewater) causes a suite of ecological changes within sensitive ecosystems. Examples include increased primary productivity in most nitrogen-limited ecosystems, biodiversity losses, changes in carbon cycling, and eutrophication and harmful algal blooms in freshwater, estuarine, and ocean ecosystems (U.S. EPA, 2008a).

This indicator presents ambient NO_2 concentrations in parts per billion (ppb) from 1980 to 2013 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 2013, 69 monitoring sites in 51 counties nationwide have sufficient data to characterize annual average trends; and between 1980 and 2013, 29 monitoring sites in 24 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 98^{th} 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 2013 was 58 percent lower than that recorded in 1980 (Exhibit 1). Also shown on this graph are the 90^{th} and 10^{th} 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 69 sites used to determine the trend for annual average concentrations (out of 357 total monitoring sites that were operating in 2013), 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 62 percent in Region 1 (Exhibit 3). The decrease in NO_2 concentrations in this indicator is consistent with the decreasing NO_x emissions observed between 1990 and 2011 (the Nitrogen Oxides Emissions indicator).

The 98^{th} percentile of 1-hour NO_2 concentrations also exhibited a downward trend. From 1980 to 2013, the concentrations decreased by 60 percent across the 29 sites with sufficient data (Exhibit 4). Among these sites, the number reporting concentrations above the level of the 2010 1-hour NAAQS decreased from 12 sites in 1982 to zero sites since 2004 (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 concentrations 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 69 trend sites with sufficient data for annual trends are not dispersed uniformly across all states in the EPA Regions. The 69 sites are located in 19 states. In the remaining 31 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 2013, 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, 2014a) (https://www.epa.gov/aqs). 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

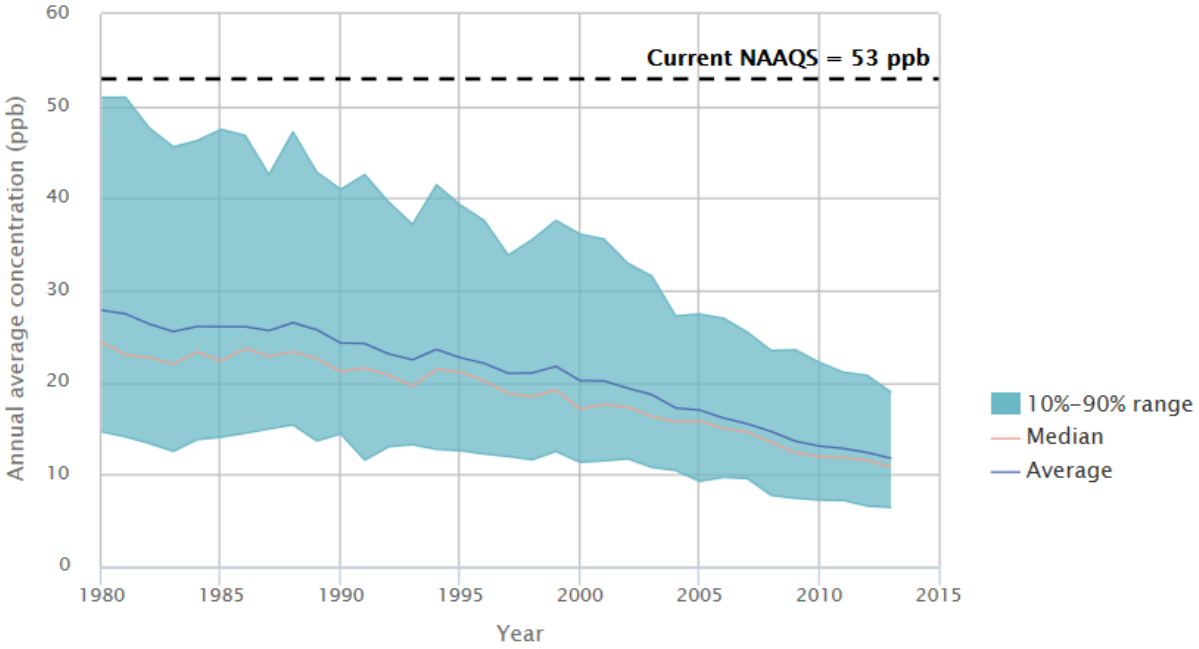
U.S. EPA (United States Environmental Protection Agency). 2014a. Data from the Air Quality System. Accessed 2014. https://www.epa.gov/aqs.

U.S. EPA. 2014b. History of the national ambient air quality standards for oxides of nitrogen. https://www3.epa.gov/ttn/naaqs/standards/nox/s_nox_history.html.

U.S. EPA. 2008a. Integrated science assessment for oxides of nitrogen—health criteria. EPA/600/R-08/071. Research Triangle Park, NC. http://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=194645.

U.S. EPA. 2008b. Integrated science assessment for oxides of nitrogen and sulfur—ecological criteria. EPA/600/R-08/082F. Research Triangle Park, NC. http://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=201485.

Exhibit 1. Ambient annual NO_2 concentrations in the U.S., 1980–2013



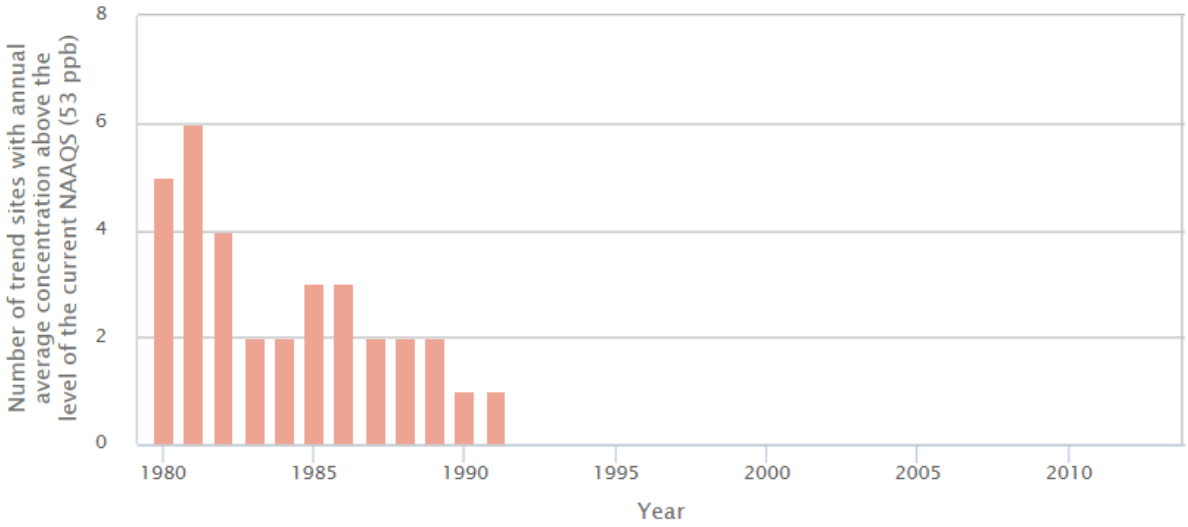
The current annual average NO_2 NAAQS was established in 1971 and has not been revised since (U.S. EPA, 2014b).

Coverage: 69 monitoring sites in 51 counties nationwide (out of a total of 357 sites measuring NO_2 in 2013) 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, 2014a

Exhibit 2. Ambient annual NO_2 concentrations above the level of the current NAAQS in the U.S., 1980–2013



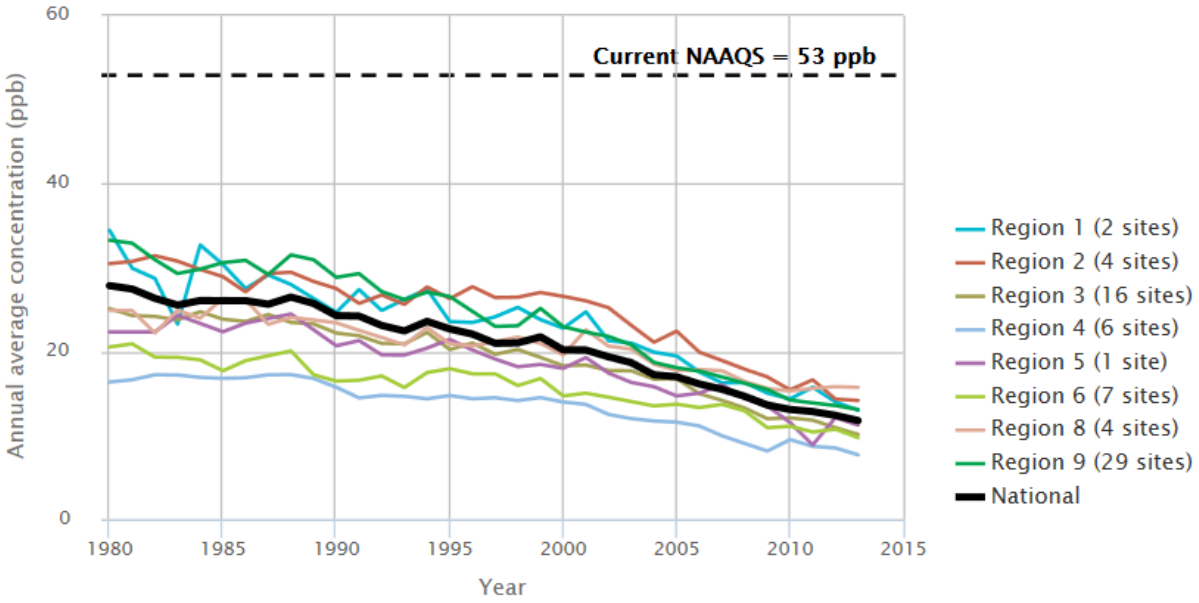
The current annual average NO_2 NAAQS was established in 1971 and has not been revised since (U.S. EPA, 2014b).

Coverage: 69 monitoring sites in 51 counties nationwide (out of a total of 357 sites measuring NO_2 in 2013) 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, 2014a

Exhibit 3. Ambient annual NO_2 concentrations in the contiguous U.S. by EPA Region, 1980–2013



The current annual average NO_2 NAAQS was established in 1971 and has not been revised since (U.S. EPA, 2014b).

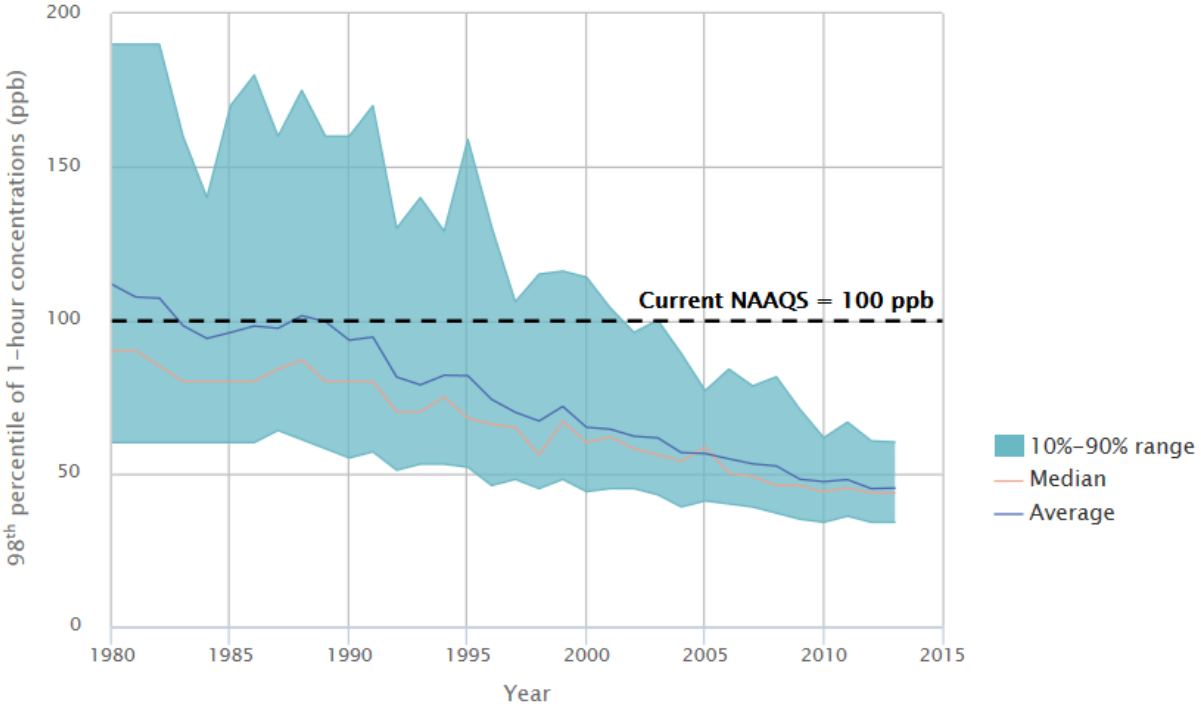
Coverage: 69 monitoring sites in 51 counties nationwide (out of a total of 357 sites measuring NO_2 in 2013) that have sufficient data to assess NO_2 trends since 1980.

States in Region 7 and 10 have removed NO_2 monitors in recent years because of low concentrations, and consequently none of these Regions' monitoring sites has a complete record dating back to 1980. Thus, no trend lines for Regions 7 and 10 are 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, 2014a

Exhibit 4. Ambient 1-hour NO_2 concentrations in the U.S., 1980–2013



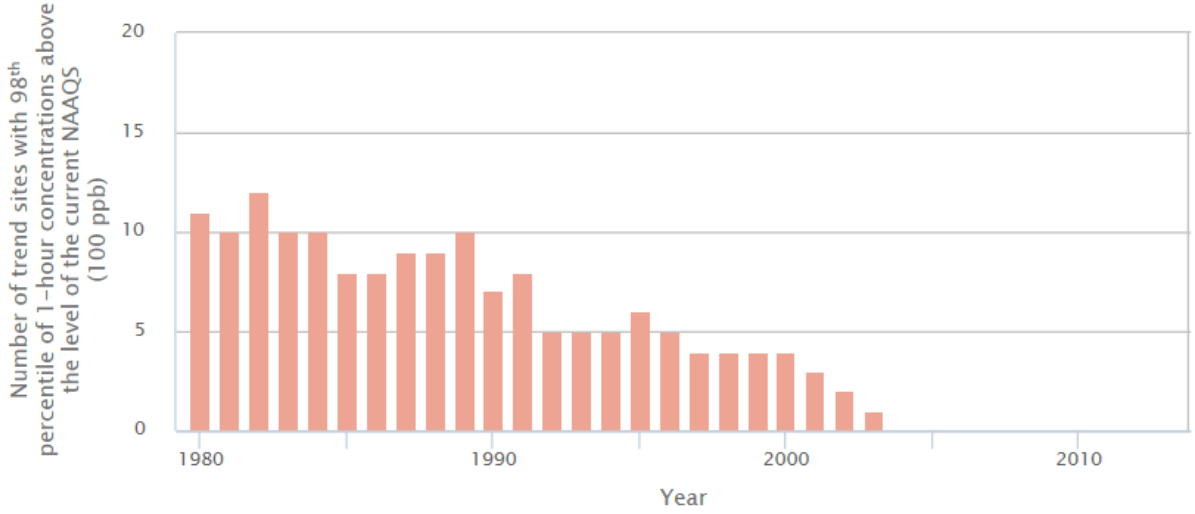
The current 1-hour NO_2 NAAQS was established in 2010 and is shown to provide context for the magnitude of pollutant concentrations. No 1-hour NO_2 NAAQS existed prior to 2010 (U.S. EPA, 2014b).

Coverage: 29 monitoring sites in 24 counties nationwide (out of a total of 308 sites measuring NO_2 in 2013) 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, 2014a

Exhibit 5. Ambient 1-hour NO_2 concentrations above the level of the current NAAQS in the U.S., 1980–2013



The current 1-hour NO_2 NAAQS was established in 2010 and is shown to provide context for the magnitude of pollutant concentrations. No 1-hour NO_2 NAAQS existed prior to 2010 (U.S. EPA, 2014b).

Coverage: 29 monitoring sites in 24 counties nationwide (out of a total of 308 sites measuring NO_2 in 2013) 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, 2014a