1.2 Acid Deposition

Sulfur dioxide and NO_X emissions in the atmosphere react with water, oxygen, and oxidants to form acidic components, also referred to as acid deposition or "acid rain." Air contaminants can be deposited on land or water through precipitation (wet deposition) or directly by dry deposition. Wet acid deposition is monitored by the National Atmospheric Deposition Program/National Trends Network, a cooperative program of federal and state agencies, universities, electric utilities, and other industries. Dry deposition is measured by the Clean Air Status and Trends Network (CASTNET), operated by EPA and the National Park Service.

The acidity in precipitation in the eastern U.S. is at least twice as high as in pre-industrial times (EPA, ORD, January 2003). To reduce emissions of SO_2 and NO_X, EPA established the Acid Rain Program under the Clean Air Act. This program focuses on the largest and highest-emitting coal-fired power plants, which are significant contributors to acid deposition.

This section addresses the following questions:

- What are the deposition rates of pollutants that cause acid rain? (Section 1.2.1)
- What are the emissions of pollutants that form acid rain? (Section 1.2.2)
- What ecological effects are associated with acid deposition? (Section 1.2.3)

1.2.1 What are the deposition rates of pollutants that cause acid rain?

Indicators

Deposition: wet sulfate and wet nitrogen

Efforts to reduce sulfur dioxide and nitrogen oxides emissions from power plants have helped to significantly reduce wet sulfate deposition and to contain increases in nitrogen deposition. Wet sulfate deposition levels for 1999 to 2001 showed reductions of 20 to 30 percent compared to levels for 1989 to 1991 over widespread areas in the Midwest and the Northeast, where acid rain has had its greatest impact. Nitrogen deposition levels showed no major changes. Although NO_X emissions from power plants decreased, nitrogen emissions from sources other than power plants (e.g., motor vehicles, non-road vehicles, and agricultural activities) increased between 1990 and 2001 (EPA, OAR, November 2002).

Deposition of wet sulfate and wet nitrogen is the indicator used to address this question.

Indicator: Deposition: wet sulfate and wet nitrogen - Category 2

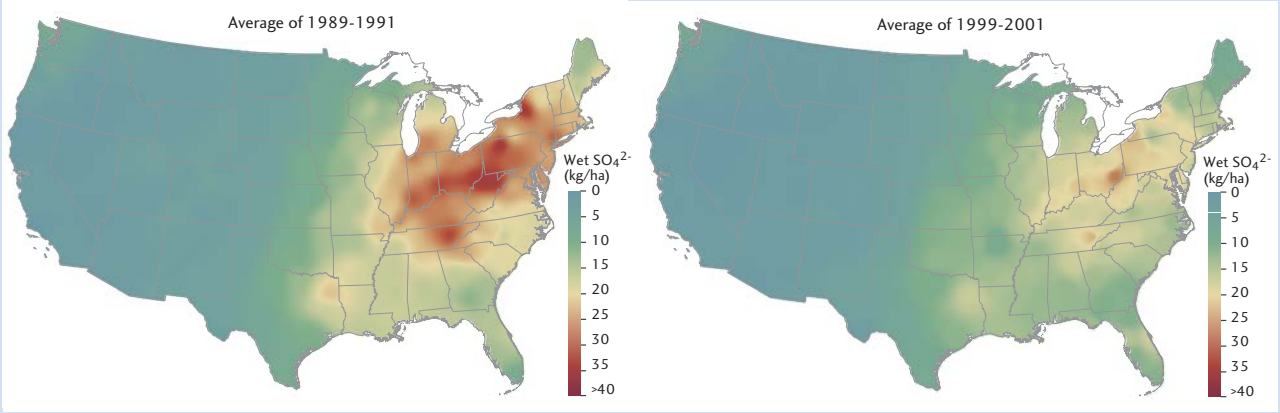
Measures of wet sulfate and wet nitrogen deposition in kilograms per hectare (kg/ha), are a key indicator of acid deposition.

What the Data Show

Wet sulfate decreased substantially throughout the Midwest and Northeast between 1989-1991 and 1999-2001 (Exhibit 1-22). By 2001, wet sulfate deposition had decreased more than 8 kilograms per hectare (kg/ha) from 30-40 kg/ha/year in 1990 in much of the Ohio River Valley and northeastern U.S. The greatest reductions occurred in the mid-Appalachian region (EPA, OAR, November 2002).

There were no dramatic regional changes in wet nitrogen deposition between 1989-1991 and 1999-2001 (Exhibit 1-23). Since 1990, nitrogen deposition decreased slightly in areas of the eastern U.S., while increases occurred in some areas with significant agricultural activity (e.g., the Plains and coastal North Carolina) or substantial mobile source emissions (e.g., southern California). (EPA, OAR, November 2002).

Exhibit 1-22: Wet sulfate deposition, 1989-1991 vs. 1999-2001

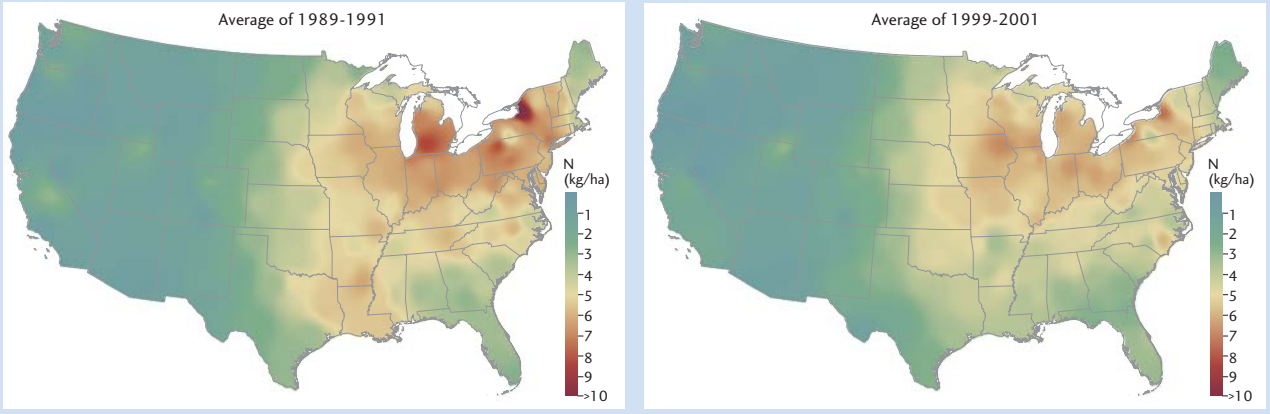


Coverage : 250 National Atmospheric Deposition Program National Trends Network (NADP/NTN) monitoring stations located throughout the lower 48 states.

Note: Map colors represent relative concentrations and do not imply ecological or human health status

Source: EPA, Office of Air and Radiation, Clean Air Markets Program. *EPA Acid Rain Program: 2001 Progress Report*. November 2002.

Exhibit 1-23: Wet nitrogen deposition, 1989-1991 vs. 1999-2001



Coverage : 250 National Atmospheric Deposition Program National Trends Network (NADP/NTN) monitoring stations located throughout the lower 48 states.

Note: Map colors represent relative concentrations and do not imply ecological or human health status

Source: EPA, Office of Air and Radiation, Clean Air Markets Program. *EPA Acid Rain Program: 2001 Progress Report*. November 2002.

Indicator Deposition: wet sulfate and wet nitrogen - Category 2 (continued)

Wet and dry sulfur deposition make up roughly the same percentages of total sulfur deposition in the Midwest, whereas, in most other areas, wet deposition makes up a greater percentage of the total. Wet deposition also makes up most of the total nitrogen deposition load at the majority of the monitoring sites in the eastern U.S. In southern California, dry deposition makes up a greater percentage of the total (Exhibit 1-24).

Using National Atmospheric Deposition Program data, a U.S. Department of Agriculture (USDA) report on sustainable forests observed that annual wet sulfate deposition decreased significantly between 1994 and 2000, especially in the North and South Resource Planning Act regions, where deposition was the highest. Nitrate deposition rates were lowest in the Pacific and Rocky Mountain regions, where approximately 84 percent of the regions experienced deposition rates of less than 4.2 pounds per acre (4.8kg/ha) per year. Only 2 percent of the sites in the eastern U.S. received less than that amount (USDA, FS, 2002).

Indicator Gaps and Limitations

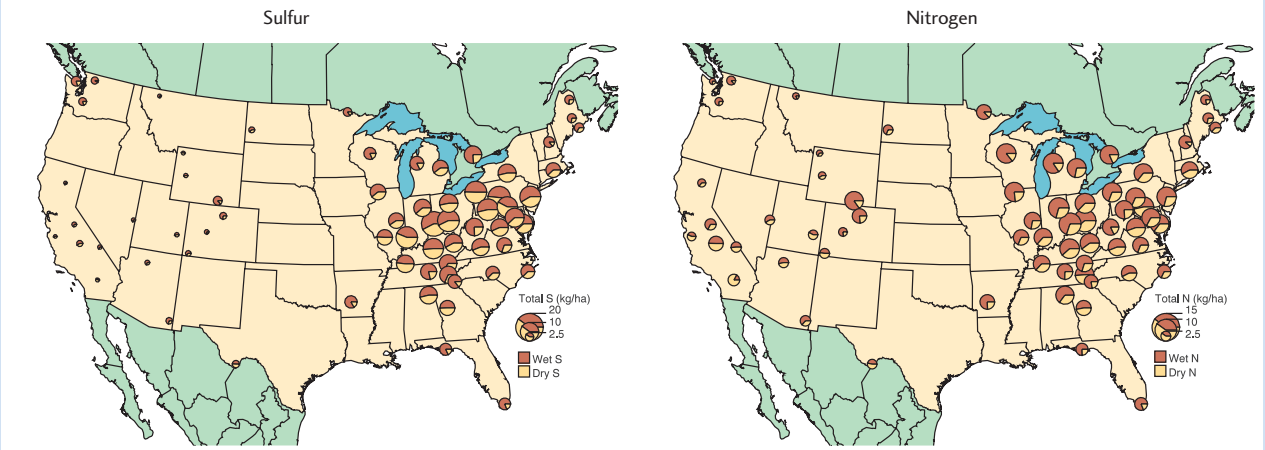
Limitations of this indicator include the following:

- Geographic coverage is limited for measuring wet deposition and even more so for measuring dry deposition. Additional monitoring sites for both in coastal areas in the Southeast would support improved measurement of nitrogen deposition to estuaries. Additional dry deposition monitoring would provide a better understanding of acid deposition in the Ohio Valley and Central and Rocky Mountain areas.
- Measurement techniques for dry deposition have improved substantially, but still lag behind operational wet deposition techniques.

Data Source

The data source for this indicator was *EPA Acid Rain Program: 2001 Progress Report*, EPA, 2002. (See Appendix B, page B-6, for more information.)

Exhibit 1-24: Total sulfur and total nitrogen deposition, 2001



Coverage: 70 Clean Air Status and Trends Network (CASTNet) monitoring stations concentrated in the eastern half of the lower 48 states.

Note: The size of the "pies" indicates the total magnitude of deposition; the colors indicate the percentage of wet and dry deposition.

Source: EPA, Office of Air and Radiation, Clean Air Markets Program. *EPA Acid Rain Program: 2001 Progress Report.* November 2002.

1.2.2 What are the emissions of pollutants that form acid rain?

Indicators

Emissions (utility): sulfur dioxide and nitrogen oxides

Acid deposition occurs when emissions of SO_2 and NO_X in the atmosphere react with water, oxygen, and oxidants to form acidic compounds. Electric utility plants that burn fossil fuels are a significant source of SO_2 and NO_X and monitor their emissions continuously. NO_X is also emitted from other high-temperature combustion sources, including automobiles.

The indicator used to address this question is emissions of sulfur dioxide and nitrogen oxides from utilities.

Indicator: Emissions (utility): sulfur dioxide and nitrogen oxides - Category 2

This indicator is millions of tons of NO_X and SO_2 emissions from sources covered under the Acid Rain Program from 1990 to 2001 and 1980 to 2001, respectively. These emissions data are an important component of a market-based trading program to reduce emissions and consequent impacts on the environment.

What the Data Show

SO_2 emissions from sources covered under the Acid Rain Program were 10.6 million tons in 2001, compared to 15.7 million tons in 1990. Emissions of NO_X from these sources declined from 6.7 million tons in 1990 to 4.7 million tons in 2001 (Exhibit 1-25) (EPA, OAR, June 2002).

Indicator Gaps and Limitations

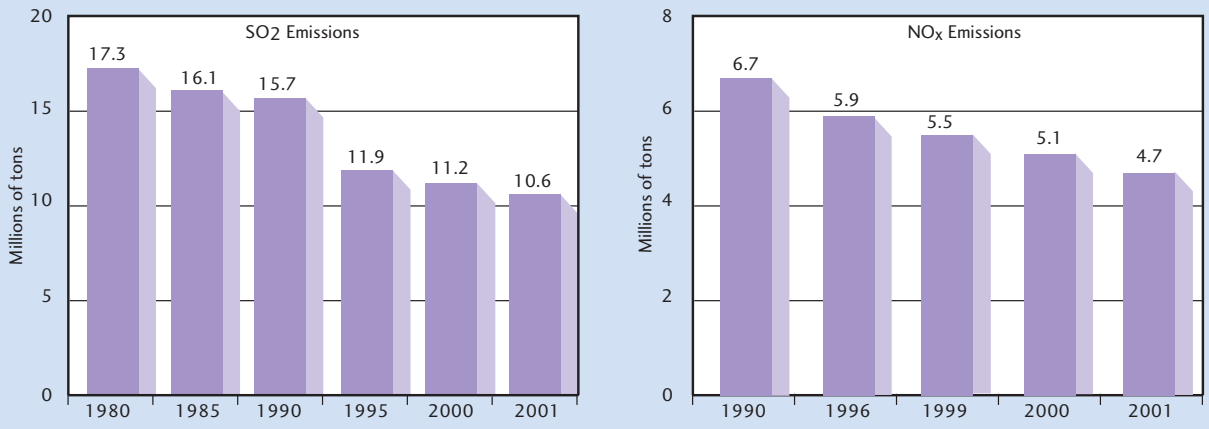
Limitations of this indicator include the following:

- Although electric utilities and large boilers are key sources of SO_2 and NO_X, they are not the only sources. It is estimated that about 64 percent of annual SO_2 emissions and 26 percent of NO_X emissions are produced by electric utility plants that burn fossil fuels (EPA, OAQPS, September 2002).
- Information on mobile source emissions is particularly useful for completing the picture of NO_X contributions to acid deposition.

Data Source

The data source for this indicator was *EPA Acid Rain Program: 2001 Progress Report*, Appendices A and B1, EPA, 2002. (See Appendix B, page B-6, for more information.)

Exhibit 1-25: Power plant sulfur dioxide (SO_2), 1980-2001, and nitrogen oxides (NO_X), 1990-2001, emissions



Source: EPA, Office of Air and Radiation, Clean Air Markets Program. *EPA Acid Rain Program: 2001 Progress Report*. November 2002. Appendix A: Acid Rain Program - Year 2001 SO2 Allowance Holdings and Deductions. (April 8, 2003; *http://www.epa.gov/airmarkets/cmprpt/arp01/appendixa.pdf*) and Appendix B1: 2001 Compliance Results for NOx Affected Units. (April 8, 2003; *http://www.epa.gov/airmarkets/cmprpt/arp01/appendixb1.pdf*).

1.2.3 What ecological effects are associated with acid deposition?

Increased acid levels damage soils, lakes, and streams, rendering some waterbodies unfit for certain fish and wildlife species. Indirect effects of acid deposition are also responsible for damage to forest ecosystems (see Chapter 5, Ecological Condition). Acidic ions in the soil displace calcium and other nutrients from plant roots, inhibiting growth. Acidic deposition can also mobilize toxic amounts of aluminum, increasing its availability for uptake by plants and by fish and other aquatic life (EPA, OAR, November 2002).

The nitrogen in acid rain adds to the total loading of nitrogen in waterbodies. As coastal ecosystems become overly rich in nitrogen, conditions favor more frequent and more severe emergence of algal blooms, which deplete oxygen, harming fish and reducing plant and animal diversity (see Chapter 2, Purer Water).

A recent report assessing deposition-related changes in surface water chemistry in the northern and eastern U.S. found that the Clean Air Act has resulted in a large and widespread decrease in the deposition of sulfur by approximately 40 percent in the 1990s. In the same period, surface water sulfate concentrations declined in all regions except the Ridge and Blue Ridge provinces (Virginia). Acid neutralizing capacity (ANC), a key indicator of recovery, increased in three of the regions (Adirondacks, Northern Appalachian Plateau and Upper Midwest) and was unchanged in the New England and the Ridge/Blue Ridge region. Modest increases in ANC have reduced the number of acidic lakes and stream segments in some regions:

- In the Adirondacks, 8.1 percent of lakes (150 lakes) were acidic in 2000. In the early 1990s, 13 percent (240 lakes) were acidic.
- In the Upper Midwest, an estimated 80 of 250 lakes that were acidic in the mid-1980s are no longer acidic.
- In the Northern Appalachian Plateau region in 2000, there were an estimated 3,393 kilometers (2,104 miles) of acidic streams in the region, or 7.9 percent of the total population; this compares to 5,014 kilometers (3,109 miles) of acidic streams (12 percent) in 1993-94.
- There was no evidence of recovery in New England, or in the Ridge and Blue Ridge Provinces; the latter region is not expected to recover immediately, due to the nature of forest soils in the province.
- In the three regions showing recovery, approximately one-third of formerly acidic surface waters are no longer acidic, although still subject to episodes of acidification.
- Nitrogen deposition levels changed little between 1989 and 2001, and surface water nitrate concentrations are largely unchanged as well. Nitrogen deposition remains a concern, because future increases in surface water nitrate concentrations could retard surface water recovery (EPA, ORD, January 2003).

No specific indicators have been identified at this time to address the ecological effects associated with acid deposition.

1.3 Indoor Air Quality

People in the U.S. spend 90 percent of their time indoors, and indoor air pollutant levels may exceed those allowable outside. Radon and environmental tobacco smoke (ETS) are the two indoor air pollutants of greatest concern from a health perspective (EPA, ORD, December 1992; NRC, 1988).

Although methods to monitor and measure indoor air quality (IAQ) exist, there is no practical way to assess the general quality of indoor air nationwide. There are millions of residences, thousands of workplaces, and more than a hundred thousand schools in the U.S., and representative samples are not practical because of cost and access issues. This section, therefore, presents indoor air quality data from limited studies, not from ongoing monitoring efforts.

This section addresses the following questions:

- What is the quality of the air in buildings in the United States? (Section 1.3.1)
- What contributes to indoor air pollution? (Section 1.3.2)
- What human health effects are associated with indoor air pollution? (Section 1.3.3)

1.3.1 What is the quality of the air in buildings in the United States?

Indicators

U.S. homes above EPA's radon action levels
Percentage of homes where young children are exposed to environmental tobacco smoke

While it is difficult to make general statements about the quality of indoor air nationwide, two studies–the National Residential Radon Survey and an analysis of ETS exposure based on data from the National Health Interview Survey–offer important insights. These studies provide data about residential levels of radon and ETS, presented in the description of two indicators on the following pages.

In addition, several studies have attempted to characterize environmental issues inside office buildings and schools. The Building Assessment Survey and Evaluation (BASE) study, conducted from 1994 to 1998, is a study of office IAQ. The study was designed with input from more than 40 national IAQ experts and reviewed by the EPA Science Advisory Board. The consensus of these national experts was that a sample of 100 to 200 office buildings would be sufficient to characterize the central tendency of IAQ in office buildings nationwide.

Limited information about IAQ in schools is available from a 1999 survey of about 900 public schools by the National Center for Education Statistics. This survey addressed concerns related to