

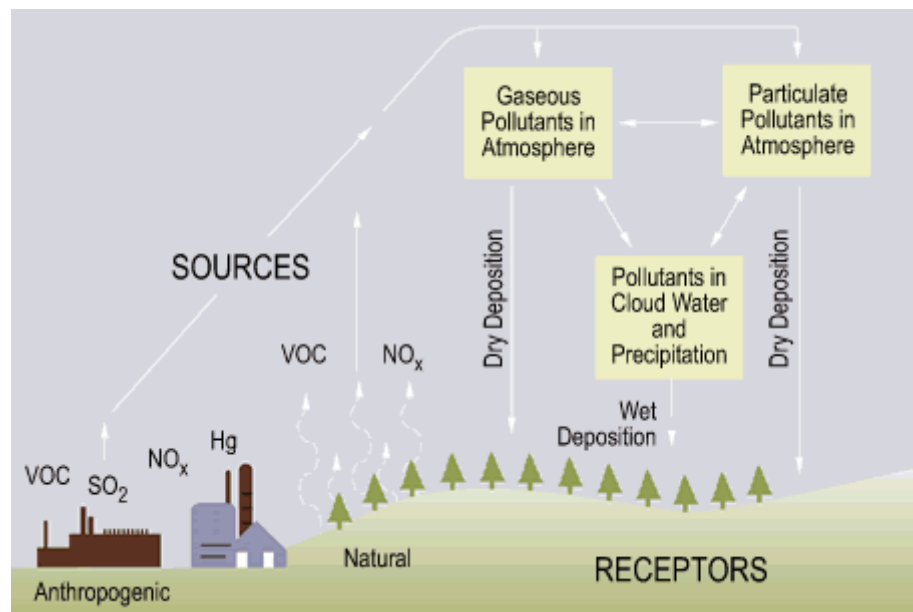
# What is Acid Rain?



"Acid rain" is a broad term referring to a mixture of wet and dry deposition (deposited material) from the atmosphere containing higher than normal amounts of nitric and sulfuric acids. The precursors, or chemical forerunners, of acid rain formation result from both natural sources, such as volcanoes and decaying vegetation, and man-made sources, primarily emissions of [sulfur dioxide \(SO<sub>2</sub>\)](#) and [nitrogen oxides \(NO<sub>x</sub>\)](#) resulting from fossil fuel combustion. In the United States, roughly 2/3 of all SO<sub>2</sub> and 1/4 of all NO<sub>x</sub> come

from electric power generation that relies on burning fossil fuels, like coal. Acid rain occurs when these gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds.

The result is a mild solution of sulfuric acid and nitric acid. When sulfur dioxide and nitrogen oxides are released from power plants and other sources, prevailing winds blow these compounds across state and national borders, sometimes over hundreds of miles.



## Wet Deposition

[Wet deposition](#) refers to

acidic rain, fog, and snow. If the acid chemicals in the air are blown into areas where the weather is wet, the acids can fall to the ground in the form of rain, snow, fog, or mist. As this acidic water flows over and through the ground, it affects a variety of plants and animals. The strength of the effects depends on several factors, including how acidic the water is; the chemistry and [buffering capacity](#) of the soils involved; and the types of fish, trees, and other living things that rely on the water.

## Dry Deposition

In areas where the weather is dry, the acid chemicals may become incorporated into dust or smoke and fall to the ground through [dry deposition](#), sticking to the ground, buildings, homes, cars, and trees. Dry deposited gases and particles can be washed from these surfaces by rainstorms, leading to increased runoff. This runoff water makes the resulting mixture more acidic. About half of the acidity in the atmosphere falls back to earth through dry deposition.



## Effects of Acid Rain - Surface Waters and Aquatic Animals

The ecological effects of acid rain are most clearly seen in the aquatic, or water, environments, such as streams, lakes, and marshes. Acid rain flows into streams, lakes, and marshes after falling on forests, fields, buildings, and roads. Acid rain also falls directly on aquatic habitats. Most lakes and streams have a pH between 6 and 8, although some lakes are naturally acidic even without the effects of acid rain. Acid rain primarily affects sensitive bodies of water, which are located in watersheds whose soils have a limited ability to neutralize acidic compounds (called "buffering capacity"). Lakes and streams become acidic (i.e., the pH value goes down) when the water itself and its surrounding soil cannot buffer the acid rain enough to neutralize it. In areas where buffering capacity is low, acid rain releases aluminum from soils into lakes and streams; aluminum is highly toxic to many species of aquatic organisms.

- [Where Does Acid Rain Affect Lakes and Streams?](#)
- [How Does Acid Rain Affect Fish and Other Aquatic Organisms?](#)
- [How Does Acid Rain Affect Ecosystems?](#)
- [What is the Role of Nitrogen in Acid Rain and Other Environmental Problems?](#)
- [How is EPA's Acid Rain Program Addressing These Issues?](#)

### Where Does Acid Rain Affect Lakes and Streams?

Many lakes and streams examined in a National Surface Water Survey (NSWS) suffer from chronic acidity, a condition in which water has a constant low pH level. The survey investigated the effects of acidic deposition in over 1,000 lakes larger than 10 acres and in thousands of miles of streams believed to be sensitive to acidification. Of the lakes and streams surveyed, acid rain caused acidity in 75 percent of the acidic lakes and about 50 percent of the acidic streams. Several regions in the U.S. were identified as containing many of the surface waters sensitive to acidification. They include the Adirondacks and Catskill Mountains in New York state, the mid-Appalachian highlands along the east coast, the upper Midwest, and mountainous areas of the Western United States. In areas like the Northeastern United States, where soil-buffering capacity is poor, some lakes now have a pH value of less than 5. One of the most acidic lakes reported is Little Echo Pond in Franklin, New York. Little Echo Pond has a pH of 4.2.

Acidification is also a problem in lakes that were not surveyed in federal research projects. For example, although lakes smaller than 10 acres were not included in the NSWS, there are from one to four times as many of these small lakes as there are larger lakes. In the

Adirondacks, the percentage of acidic lakes is significantly higher when it includes smaller lakes.

Streams flowing over soil with low buffering capacity are as susceptible to damage from acid rain as lakes. Approximately 580 of the streams in the Mid-Atlantic Coastal Plain are acidic primarily due to acidic deposition. In the New Jersey Pine Barrens, for example, over 90 percent of the streams are acidic, which is the highest rate of acidic streams in the nation. Over 1,350 of the streams in the Mid-Atlantic Highlands (mid-Appalachia) are acidic, primarily due to acidic deposition.

The acidification problem in both the U.S. and Canada grows in magnitude if "episodic acidification" is taken into account. Episodic acidification refers to brief periods during which pH levels decrease due to runoff from melting snow or heavy downpours. Lakes and streams in many areas throughout the U.S. are sensitive to episodic acidification. In the Mid-Appalachians, the Mid-Atlantic Coastal Plain, and the Adirondack Mountains, many additional lakes and streams become temporarily acidic during storms and spring snowmelt. For example, approximately 70 percent of sensitive lakes in the Adirondacks are at risk of episodic acidification. This amount is over three times the amount of chronically acidic lakes. In the mid-Appalachians, approximately 30 percent of sensitive streams are likely to become acidic during an episode. This level is seven times the number of chronically acidic streams in that area. Episodic acidification can cause "fish kills."

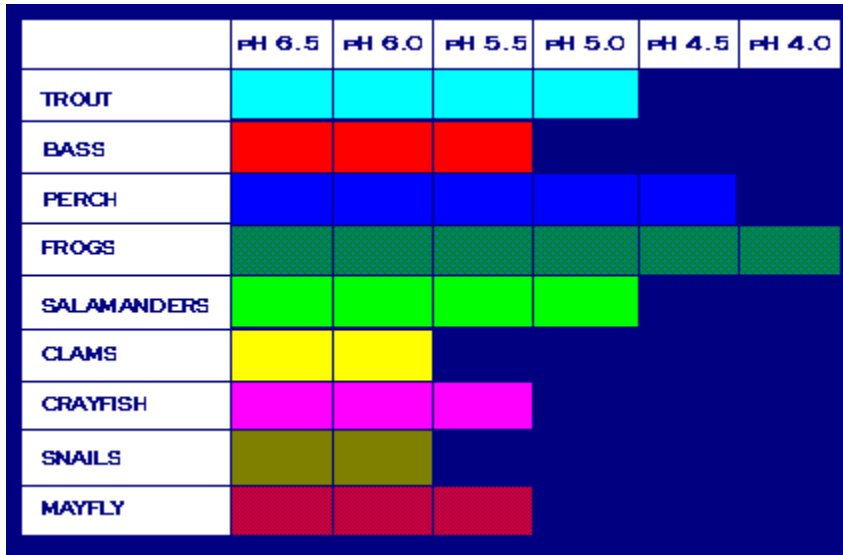
Emissions from U.S. sources also contribute to acidic deposition in eastern Canada, where the soil is very similar to the soil of the Adirondack Mountains, and the lakes are consequently extremely vulnerable to chronic acidification problems. The Canadian government has estimated that 14,000 lakes in eastern Canada are acidic.

### **How Does Acid Rain Affect Fish and Other Aquatic Organisms?**

Acid rain causes a cascade of effects that harm or kill individual fish, reduce fish population numbers, completely eliminate fish species from a waterbody, and decrease biodiversity. As acid rain flows through soils in a watershed, aluminum is released from soils into the lakes and streams located in that watershed. So, as pH in a lake or stream decreases, aluminum levels increase. Both low pH and increased aluminum levels are directly toxic to fish. In addition, low pH and increased aluminum levels cause chronic stress that may not kill individual fish, but leads to lower body weight and smaller size and makes fish less able to compete for food and habitat.

Some types of plants and animals are able to tolerate acidic waters. Others, however, are acid-sensitive and will be lost as the pH declines. Generally, the young of most species are more sensitive to environmental conditions than adults. At pH 5, most fish eggs cannot

hatch. At lower pH levels, some adult fish die. Some acid lakes have no fish. The chart below shows that not all fish, shellfish, or the insects that they eat can tolerate the same amount of acid; for example, frogs can tolerate water that is more acidic (i.e., has a lower pH) than trout.



### How Does Acid Rain Affect Ecosystems?

Together, biological organisms and the environment in which they live are called an ecosystem. The plants and animals living within an ecosystem are highly interdependent. For example, frogs may tolerate relatively high levels of acidity, but if they eat insects like the mayfly, they may be affected because part of their food supply may disappear. Because of the connections between the many fish, plants, and other organisms living in an aquatic ecosystem, changes in pH or aluminum levels affect biodiversity as well. Thus, as lakes and streams become more acidic, the numbers and types of fish and other aquatic plants and animals that live in these waters decrease.

### What is the Role of Nitrogen in Acid Rain and Other Environmental Problems?

The impact of nitrogen on surface waters is also critical. Nitrogen plays a significant role in episodic acidification and new research recognizes the importance of nitrogen in long-term chronic acidification as well. Furthermore, the adverse impact of atmospheric nitrogen deposition on estuaries and near-coastal water bodies is significant. Scientists estimate that 10 to 45 percent of the nitrogen produced by various human activities that reaches estuaries and coastal ecosystems is transported and deposited via the atmosphere. For example, about 30 percent of the nitrogen in the Chesapeake Bay comes from atmospheric deposition. Nitrogen is an important factor in causing eutrophication (oxygen depletion) of water bodies. The symptoms of eutrophication include blooms of algae (both toxic and non-

toxic), declines in the health of fish and shellfish, loss of seagrass beds and coral reefs, and ecological changes in food webs. According to the National Oceanic and Atmospheric Administration (NOAA), these conditions are common in many of our nation's coastal ecosystems. These ecological changes impact human populations by changing the availability of seafood and creating a risk of consuming contaminated fish or shellfish, reducing our ability to use and enjoy our coastal ecosystems, and causing economic impact on people who rely on healthy coastal ecosystems, such as fishermen and those who cater to tourists.

### **How is EPA's Acid Rain Program Addressing These Issues?**

Acid rain control will produce significant benefits in terms of lowered surface water acidity. If acidic deposition levels were to remain constant over the next 50 years (the time frame used for projection models), the acidification rate of lakes in the Adirondack Mountains that are larger than 10 acres would rise by 50 percent or more. Scientists predict, however, that the decrease in SO<sub>2</sub> emissions required by the [Acid Rain Program](#) will significantly reduce acidification due to atmospheric sulfur. Without the reductions in SO<sub>2</sub> emissions, the proportions of acidic aquatic ecosystems would remain high or dramatically worsen.

### **Effects of Acid Rain - Human Health**

Acid rain looks, feels, and tastes just like clean rain. The harm to people from acid rain is not direct. Walking in acid rain, or even swimming in an acid lake, is no more dangerous than walking or swimming in clean water. However, the pollutants that cause acid rain—sulfur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>)—do damage human health. These gases interact in the atmosphere to form fine sulfate and nitrate particles that can be transported long distances by winds and inhaled deep into people's lungs. Fine particles can also penetrate indoors. Many scientific studies have identified a relationship between elevated levels of fine particles and increased illness and premature death from heart and lung disorders, such as asthma and bronchitis.



Based on health concerns, SO<sub>2</sub> and NO<sub>x</sub> have historically been regulated under the Clean Air Act, including the [Acid Rain Program](#). In the eastern U.S., sulfate aerosols make up about 25 percent of fine particles. By lowering SO<sub>2</sub> and NO<sub>x</sub> emissions from power generation, the Acid Rain Program will reduce the levels of fine sulfate and nitrate particles and so reduce the incidence and the severity of these health problems. When fully implemented by the year 2010, the public health benefits of

the Acid Rain Program are estimated to be valued at \$50 billion annually, due to decreased mortality, hospital admissions, and emergency room visits.

Decreases in NO<sub>x</sub> emissions are also expected to have a beneficial impact on human health by reducing the nitrogen oxides available to react with volatile organic compounds and form ozone. Ozone impacts on human health include a number of morbidity and mortality risks associated with lung inflammation, including asthma and emphysema.

Resource

<http://www.epa.gov/acidrain/index.html>