Chapter 9: Ecosystem Response

Ecosystem Health

Acidic deposition resulting from SO_2 and NO_x emissions may negatively affect the biological health of lakes, streams, and other ecosystems in the United States. Trends in measured chemical indicators allow scientists to determine whether water bodies are improving and heading towards recovery or if they are still acidifying. Assessment tools such as critical load analysis provide a quantitative estimate of whether acidic deposition levels of sulfur and nitrogen, resulting from reduction in SO_2 and NO_x emissions, may protect aquatic resources.

Analysis and Background Information

Acidified Surface Water Trends

Acidified surface water mobilizes toxic forms of aluminum from soils, particularly in clay rich soils, harming fish, other aquatic life, and wildlife. Four chemical indicators of aquatic ecosystem response to emission changes are presented here: trends in sulfate and nitrate anions, acid neutralizing capacity (ANC), and sum of base cations. Recovery of an aquatic ecosystem is indicated by increasing trends in ANC and base cations and decreasing trends in sulfate and nitrate concentrations in surface waters. The following is a description of each indicator:

- **Sulfate** is the primary anion in most acid-sensitive waters and has the potential to acidify surface waters and leach base cations and toxic forms of aluminum from soils.
- **Nitrate** has the same potential as sulfate to acidify surface waters. However, nitrogen is an important nutrient for plant and algae growth and most of the nitrogen inputs from deposition are quickly taken up by plants and algae, leaving less in surface waters.
- **Acid Neutralizing Capacity (ANC)** is a measure of overall buffering capacity of surface waters against acidification, and indicates the ability to neutralize strong acids that enter aquatic systems from deposition and other sources.
- **Base cations** neutralize both sulfate and nitrate anions, thereby preventing surface water acidification. Base cation availability is largely a function of underlying geology, weathering of base cations from the underlying rocks, soil age, and vegetation community.

Highly weathered soils of the Central Appalachians are able to store deposited sulfate, such that the decrease in acidic deposition has not yet resulted in lower sulfate concentrations in many of the monitored streams. However, as long-term sulfate deposition exhausts the soil's ability to store additional sulfate, a decreasing proportion of the deposited sulfate will be retained in the soil and an increasing proportion is exported to surface waters. Thus, sulfate concentrations in some streams in this region are not changing or are still increasing despite reduced sulfate deposition.[11]

Monitoring Networks

In collaboration with other federal and state agencies and universities, EPA administers two monitoring programs that provide information on the impacts of acidic deposition on otherwise pristine aquatic systems: the Temporally Integrated Monitoring of Ecosystems (TIME) and the Long-term Monitoring (LTM) programs. These programs are designed to track changes in surface water chemistry in the four regions sensitive to acid rain: New England, the Adirondack Mountains, the Northern Appalachian Plateau, and the central Appalachians (the Valley, Ridge and Blue Ridge Provinces).

Key Points

Regional Trends in Water Quality

- Significant improving trends in sulfate concentrations are found at nearly all LTM monitoring lakes and streams in New England, the Adirondacks, and the Catskill mountains/Northern Appalachian Plateau.
- On the other hand, lakes and streams in the Central Appalachian region have experienced mixed results with only 21 percent of monitored streams showing lower sulfate concentrations (and statistically significant trends), while 20 percent show increased sulfate concentrations.
- Nitrate concentrations and trends are highly variable and many sites do not show improving trends, despite reductions in NO_x emissions and inorganic nitrogen deposition.
- Levels of Acid Neutralizing Capacity (ANC), a key indicator of ecosystem recovery, have increased significantly from 1990 in lake and stream sites in the Adirondack Mountains, New England and the Northern Appalachian Plateau.

More Information

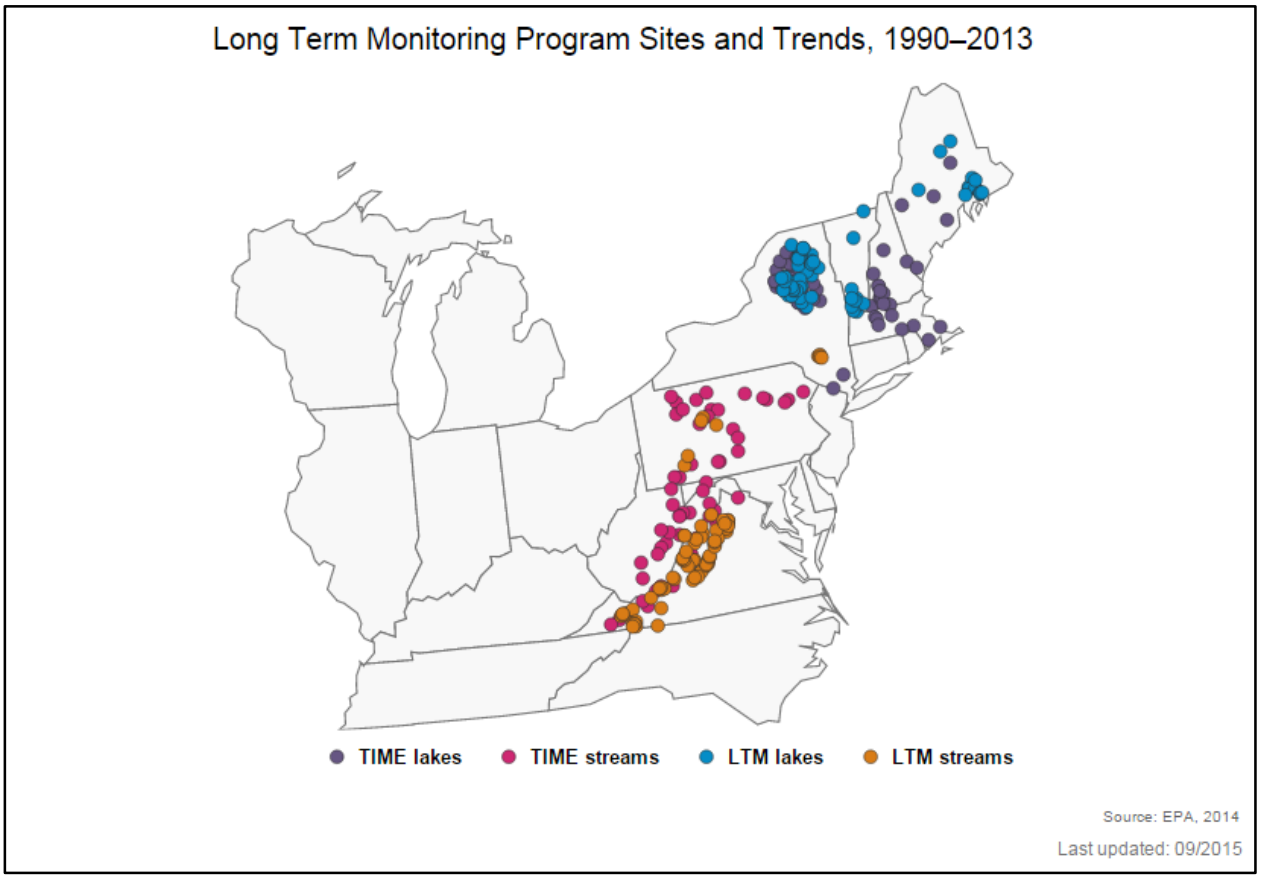
Surface Water Monitoring at EPA http://www.epa.gov/airmarkets/monitoring-surface-water-chemistry
Acid Rain http://www.epa.gov/acidrain/

References

11. Burns, D.A., Lynch, J.A., Cosby, B.J., Fenn, M.E., Baron, J.S., US EPA Clean Air Markets Div., 2011, *National Acid Precipitation Assessment Program Report to Congress 2011: An Integrated Assessment*, National Science and Technology Council, Washington, DC, 114 p.

Figures

Subtopic: Ecosystem Health



Notes:

- Trends are significant at the 95 percent confidence interval ($p < 0.05$).
- Base cations are calculated as the sum of calcium, magnesium, potassium, and sodium ions.
- Trends are determined by multivariate Mann-Kendall tests.

Figure 1. Long Term Monitoring Program Sites and Trends, 1990–2013

Regional Trends in Sulfate, Nitrate, ANC, and Base Cations at Long-term Monitoring Sites, 1990–2013

Region	Water Bodies Covered	% of Sites with Improving Sulfate Trend	% of Sites with Improving Nitrate Trend	% of Sites with Improving ANC Trend	% of Sites with Improving Base Cations Trend
Adirondack Mountains	50 lakes in NY	100%	56%	86%	88%
New England	26 lakes in ME and VT	100%	25%	58%	74%
Catskills/N. Appalachian Plateau*	9 streams in NY and PA	80%	40%	58%	90%
Central Appalachians	66 streams in VA	21%	59%	12%	14%

Source EPA, 2014

Last updated: 09/2015

Notes:

- Trends are statistically significant at the 95 percent confidence interval ($p < 0.05$).
- Base cations are calculated as the sum of calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na) ions.
- Trends are determined by multivariate Mann-Kendall tests.
- *Data for PA streams in N. Appalachian Plateau is only through 2011.

Figure 2. Regional Trends in Sulfate, Nitrate, ANC, and Base Cations at Long-term Monitoring Sites, 1990–2013