Climate change and ozone depletion

Nitrogen in the form of nitrous oxide acts as a greenhouse gas thereby contributing to the potential of climate change. Nitric oxide and nitrogen dioxide participate in the depletion of stratospheric ozone. This upper level ozone provides important protection from the sun's ultraviolet rays.

Nitrogen saturation in forests

Nitrogen deposition can acidify and over-fertilize forests. Although moderate levels of nitrogen deposition can stimulate tree growth, excessive nitrogen inputs over a long period of time can reduce tree vigor and induce "leaking" of nitrogen (in the form of nitric acid) to surface waters. The addition of nitric acid exacerbates acidic conditions in Northeastern streams.

Groundwater contamination

Nitrogen in fertilizer runoff has contributed to groundwater contamination in areas of the Northeastern U.S.

Eutrophication of coastal waters

The nitrogen that leaks from watersheds in the Northeastern U.S. enters rivers and flows downstream to coastal waters where it can cause eutrophication. The symptoms of eutrophication include algal blooms, low oxygen events, fish kills, loss of seagrasses and loss of aquatic life. Eutrophication of coastal waters is one of the most widespread water quality problems in the U.S. The National Oceanic and Atmospheric Administration has identified 9 major estuaries in the Northeast that have been severely eutrophied as a result of over-enrichment related to nitrogen pollution.

Nitrogen Policy and Management

Nitrogen originates from numerous sources and requires an integrated management strategy to mitigate its effects. Nitrogen is an example of the need to address multiple pollutants as they occur in the environment, rather than a single pollutant in isolation. Together with efforts to reduce sulfur dioxide, carbon dioxide and other pollutants, nitrogen in the Northeastern U.S. can be further decreased by:

- reducing nitrogen emissions from power plants and vehicles,
- improving wastewater treatment to remove nitrogen from effluent,
- reducing the use and increasing the uptake efficiency of nitrogen fertilizers, and
- creating and restoring natural nitrogen sinks in wetlands and floodplains.

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Hubbard Brook Research Foundation

The Hubbard Brook Research Foundation (HBRF) advances the scientific, policy and public understanding of nitrogen pollution through Science Links, a program to bridge the gap between ecosystem science and public policy. Formed in 1993, HBRF's mission is to promote the understanding and stewardship of terrestrial and aquatic ecosystems through scientific research, long-term monitoring and public education.

Science Links nitrogen project participants: C.T. Driscoll, D.R. Whitall, J. Aber, E.W. Boyer, M. Castro, C. Cronan, C.L. Goodale, P. Groffman, K.F. Lambert, G. Lawrence, C. Hopkinson, S. Ollinger.

HBRF

HUBBARD BROOK RESEARCH FOUNDATION
6 Sargent Place
Hanover, NH 03755
(603) 653-0390
hbrook@hbresearchfoundation.org
www.hbrook.sr.unh.edu

THE HUBBARD BROOK RESEARCH FOUNDATION NITROGEN POLLUTION

NITROGEN POLLUTION: FROM THE SOURCES TO THE SEA

A Science Links™ publication of the Hubbard Brook Research Foundation

Introduction

Nitrogen is a naturally occurring element needed by all living things. While it is the most abundant element in the Earth's atmosphere, nitrogen typically exists in a form that is unusable by most organisms. Only after nitrogen is converted to a reactive form can it support the growth of plants and other organisms.

Over the past century, human activity has greatly increased the amount of reactive nitrogen in the environment. The primary processes that produce new reactive nitrogen are the manufacture of fertilizer, the combustion of fossil fuel and the planting of nitrogen-producing crops and trees. As a by-product of these processes, nitrogen pollution is released to the environment by vehicles, power plants, wastewater treatment plants, and runoff from lawns, farms and paved areas.

Although the enhanced availability of reactive nitrogen offers benefits such as increased food supply, it has many environmental consequences such as air quality degradation, acidification of streams and lakes, soil changes that disrupt forest processes, and oxygen depletion in coastal waters. Nitrogen pollution is not limited to the Northastern U.S. It has been observed worldwide as a *multi-media* and *multi-effect* issue – a single nitrogen atom can have cascading impacts to air, land, and water.

Major Sources of Nitrogen Pollution

Nitrogen from food and wastewater

In order to supply the food needs of the densely populated southern New England region, large volumes of food are imported from other areas. Associated with this food supply and production cycle is a vast amount of nitrogen-rich waste produced by both animals and people. This waste is transferred through sewage treatment plants, septic systems and unconfined manure piles to surface waters and groundwater in the Northeastern U.S.

Nitrogen from fertilizers

Other sources of nitrogen pollution to water courses include nitrogen-laden runoff from lawns, agricultural fields, golf courses, parks and gardens.

Nitrogen from fossil fuels

The two major sources of nitrogen pollution to the air are fossil fuel combustion (e.g. vehicle and power plant emissions) and agriculture (e.g. fertilizer and manure emissions). Once emitted, nitrogen molecules can travel hundreds of miles in the atmosphere before returning to Earth. The molecules return to land and water through rain or through the settling out of particles and gases in a process known as atmospheric deposition.

Rates of atmospheric deposition of nitrogen in the Northeastern U.S. are among the highest in the nation as a result of the region's high population density and downwind location from nitrogen sources in the Midwestern U.S. The fact that nitrogen emitted in one region can travel through the air and be deposited in another region, contributes to nitrogen pollution as a multi-state problem.

Major Effects of Nitrogen Pollution

Nitrogen pollution is linked to several major environmental issues in the Northeastern U.S.

Acid rain

Nitrogen oxides from fossil fuel combustion contribute to the formation of acid rain. Although pollution controls have reduced sulfur dioxide emissions from power plants, nitrogen oxides have not declined and are an increasingly important constituent of acid rain. Further, in Northeastern rivers and streams, nitrogen in the form of nitric acid is the major cause of acid episodes. The well-documented impacts of acid rain include:

- acidification of many lakes and streams such that they are too acidic to support fish life,
- depletion of essential basic nutrients such as calcium from soils, and
- reduction in cold or stress tolerance in some tree species including red spruce and sugar maple.

Air Quality

Nitrogen oxides in the air contribute to the formation of ground level ozone, which can cause respiratory problems in humans and can damage plant tissue.

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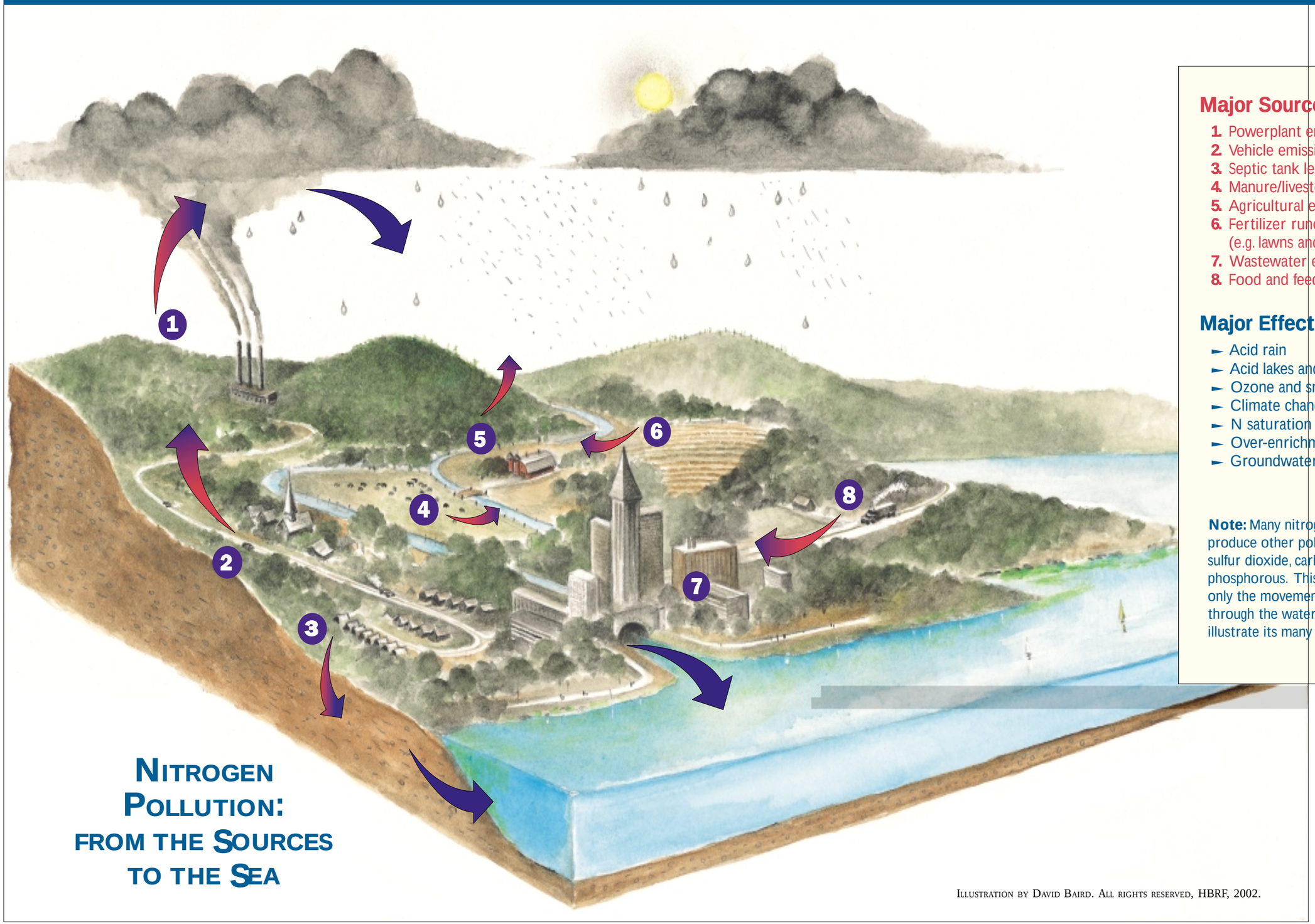

Nitrogen Pollution: from the Sources to the Sea

Major Sources:

1. Powerplant emissions
2. Vehicle emissions
3. Septic tank leakage
4. Manure/livestock runoff
5. Agricultural emissions
6. Fertilizer runoff (e.g. lawns and fields)
7. Wastewater effluent
8. Food and feed imports

Major Effects:

- Acid rain
- Acid lakes and streams
- Ozone and smog
- Climate change & ozone depletion
- N saturation in forests
- Over-enrichment of coastal waters
- Groundwater contamination

Note: Many nitrogen sources also produce other pollutants such as sulfur dioxide, carbon dioxide, and phosphorous. This rendering shows only the movement of nitrogen through the watershed to clearly illustrate its many sources and effects.

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