



Ecosystem Responses to Nitrogen

The Question: How have otherwise undisturbed ecosystems of the Colorado Front Range responded to atmospheric nitrogen deposition?

High elevation locations along the Front Range are generally considered to be undisturbed, as development and human impact appears to be far off in the distance. In the Colorado Front Range, however, mountainous locations on the eastern slope of the Continental Divide, including those in the park, receive approximately two to three times the amount of atmospheric nitrogen deposition as similar elevations along the western side, and eight times more than natural background values. The sources of nitrogen include cars and other mobile sources, power plants, industry, and oil and gas extraction, agricultural fertilizers, and animal feedlots. Upon emission into the air, anthropogenic nitrogen is transported through the atmosphere to high elevation environments such as the park where it can be deposited in snow, rain, particles, and aerosols.

Led by Dr. Jill Baron, a long-term ecological research and monitoring program investigates high elevation terrestrial and aquatic ecosystems, including many locations within the park, where inputs of nitrogen are unnaturally high. The research team explores the consequences of persistent inputs of nitrogen to forests and lakes. These scientists look for evidence of ecological changes related to unnatural nitrogen deposition.



Life in Sky Pond has changed.

The Project: Compare ecosystem processes and properties east and west of the Continental Divide.

Ecological and chemical changes due to atmospheric deposition were uncovered by comparing ecosystems on both sides of the Divide. Due to high population, agriculture, and industry in and around Denver on the eastern slope of the Colorado Front Range, air is more polluted than on the western slope, and the Continental Divide serves as a meteorological barrier that prevents most mixing of east and west side air masses. Baron's team explored high elevation (>3000m) responses to nitrogen in (1) forests and soil in areas of low and higher N deposition; (2) surface water quality of lakes influenced by nitrogen; and (3) the response of diatom communities, a type of algae that is sensitive to changes in their environment. They analyzed forests and forest soils for nitrogen content and soil microbial activity in twelve old-growth stands of Engelmann spruce, six east and six west of the Continental Divide on both park lands and national forest. Forty-four lakes including The Loch were sampled for water chemistry. Algal diatoms from lake sediments, which create a fossil record that dates back thousands of years, were collected from Sky Pond and Lake Louise and analyzed to reconstruct past conditions in the lakes.

The Results: Research suggests that even slight increases in atmospheric deposition lead to measurable changes in ecosystems.

Greater nitrogen deposition on the eastern slope of the Continental Divide was reflected in forest and lake ecosystems. Forest stands and soils on the eastern slope had significantly greater percentages of nitrogen and greater soil microbial activity, indicators of abundant nitrogen in the system. East side lakes had significantly higher average nitrate concentrations than west side lakes. Lake sediment cores revealed marked changes in diatom assemblages. Around 1950 species associated with disturbance and high nutrients became common, while those indicative of undisturbed, naturally low nutrient levels abruptly declined. This is likely due to an increase in nitrogen emissions beginning in the 1950s from increases in human population, cattle, and the use of synthetic nitrogen fertilizer in the Front Range counties of the South Platte River Basin. Because the 1916 Organic Act establishing the National Park Service states that natural and cultural resources are to remain "unimpaired for the enjoyment of future generations," such scientific findings bear significant weight upon present-day air quality regulations.



The Continental Divide is a barrier for atmospheric nitrogen deposition.

This summary is based on published, peer-reviewed and/or unpublished reports available at the time of writing. It is not intended as a statement of park policy or as a definitive account of research results.

For more information on the park's research program, see www.nps.gov/romo. Written by: Colleen Flanagan Date: May 2006 Updated: January 2008 Photo credit: NPS-RMNP J.S. Baron, H.M. Rueth, A.M. Wolfe, K.R. Nydick, E.J. Allstott, J.T. Minear, and B. Moraska. 2000. Ecosystem Responses to Nitrogen Deposition in the Colorado Front Range. Ecosystems 3: 352-368.