RoMANS

Rocky Mountain Atmospheric Nitrogen and Sulfur Study






Nitrogen and Sulfur in Rocky Mountain National Park

Nitrogen deposition in the park is increasing and is currently about 15-20 times higher than natural levels.

Nitrogen concentration in the park's rain and snow has been increasing about 2.5% per year for the last two decades.

Nitrogen deposition is highest during the spring and summer.

Atmospheric deposition of pollutants is one of the most important potential threats to aquatic and terrestrial resources in the park. Lakes and streams have low concentrations of most dissolved constituents, making them very sensitive to acidification.

There is more nitrogen deposited in high elevation ecosystems than park plants can use. Excess is leaking into lakes and streams during certain times of the year.

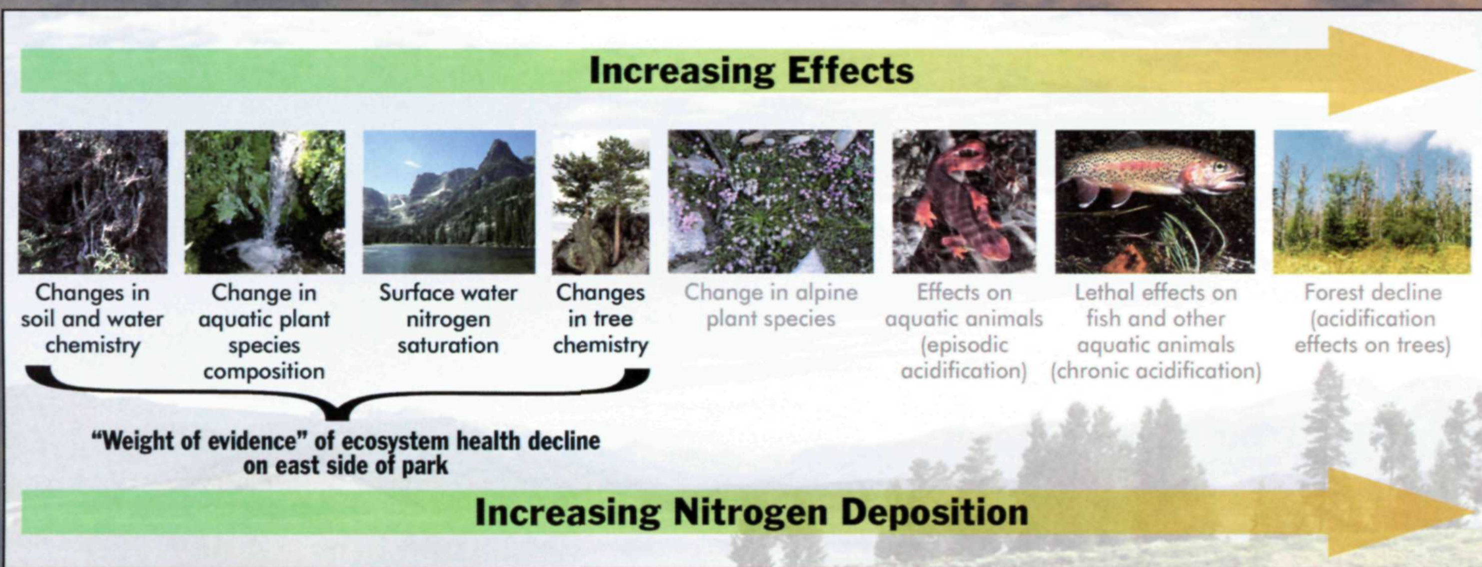
Alpine tundra studies just outside the park show that excess nitrogen in atmospheric deposition has increased the type and number of grasses and sedges. This is a concern because studies in other areas show that grasses tend to eventually outcompete flowering plants when nitrogen continues to accumulate in soils.

At 25-45%, sulfur is a significant contributor to haze at the park. The same pollutants responsible for sulfur and nitrogen deposition also impair visibility.

Critical Load

Set atop the continental divide, Rocky Mountain National Park includes the headwaters of the Colorado River, dozens of high mountain peaks, lower-elevation meadows, and evergreen forests. At the highest elevations, wildflowers dot the tundra where bighorn sheep, moose, elk, and marmots exist in delicate balance with their habitat.

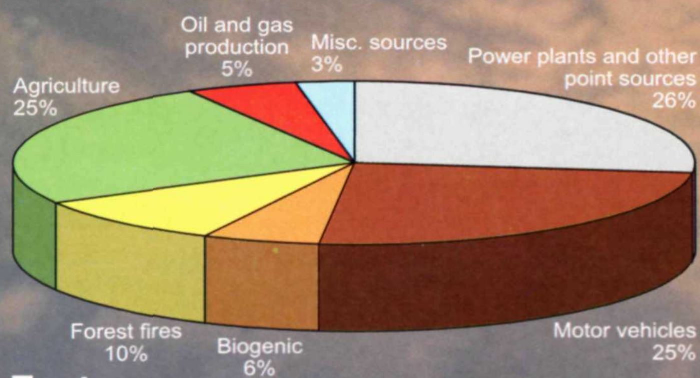
The accumulation of nitrogen compounds in Rocky Mountain National Park has crossed a crucial threshold called the "critical load". It means that changes are occurring to park ecosystems and may soon reach a point where the changes are difficult or impossible to reverse. Soils, waters, and aquatic plants are showing evidence of change from wet deposition of nitrogen species in rain and snow, dry particles, and gases. Nitrogen acts like a fertilizer, creating an imbalance in natural ecosystems. It also acts as an acidifying agent in water and soil, leaving these resources vulnerable to acidification effects on fish and forests in the future. The park has set a resource management goal for a critical load of 1.5 kg/ha/yr of wet nitrogen deposition as a level that would be protective of park ecosystems. This is approximately a 50% reduction in wet deposition from current 5-year averages of around 3.1 kg/ha/yr of wet nitrogen deposition.



Sources

Nitrogen compounds (e.g., NO_X, ammonia) and sulfur compounds are emitted into the atmosphere from a variety of air pollution sources, including automobiles, power plants, industry, agriculture, and fires. Colorado's Front Range is an area of rapid population growth, escalating urbanization, oil and gas development, and agricultural production. Increases in these activities result in corresponding increases in nitrogen deposition in mountain ecosystems.

Nitrogen Emissions in Colorado



Facts

- 2/3 of the state's population lives along the Front Range.
- Ammonium nitrate is a common crop fertilizer and results in emissions of ammonia.
- Some chemical transport models suggest that 25-30% of nitrate and 45-50% of sulfate is associated with emissions from within Colorado.

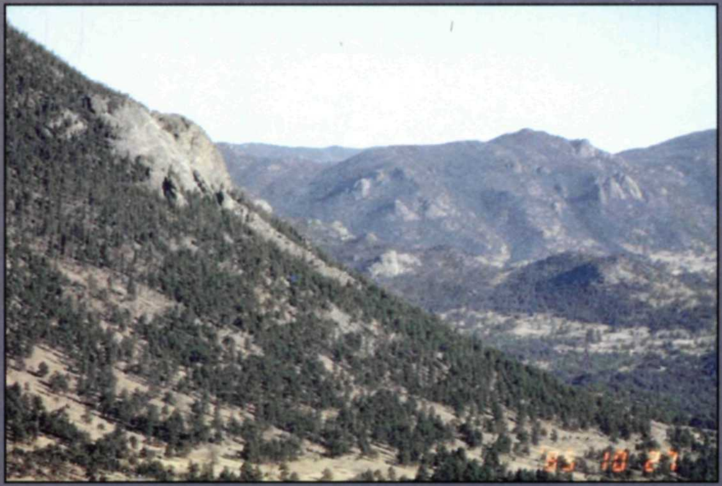
The RoMANS Study

While the effects of nitrogen and sulfur compounds on visibility and the park ecosystem have been documented, less is known about the origin of precursor sulfur and nitrogen species. The RoMANS study is underway to further our understanding of the origins of emissions currently affecting ecosystems and visibility in the Rocky Mountain region of Colorado and to explore how emission controls or reduction strategies can help mitigate pollution effects.

Colorado's temperatures, wind patterns, and storm tracks are heavily influenced by the state's complex topography. Prevailing winds are westerly but with typical easterly upslope / westerly downslope patterns. Air quality in the park is particularly affected when winds blow from the northeast, east, and southeast. Long-range transport has been traced from Mexico, Texas, as well as southern California. The heaviest precipitation occurs from late May through early June and late July through early September. Nighttime inversions, which trap pollutants, are a common occurrence, especially during the winter months.

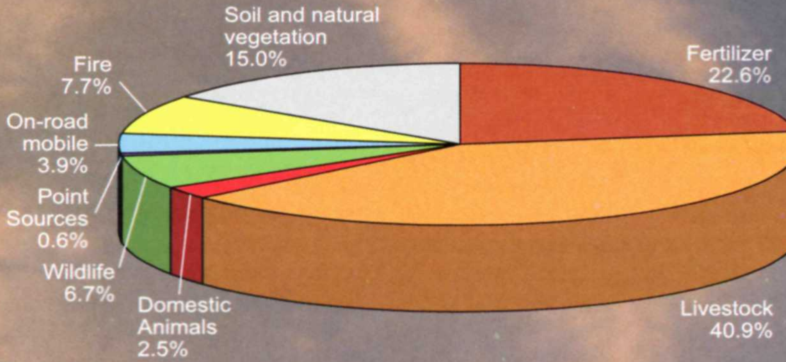
RoMANS Study Partners

National Park Service
EPA, NOAA, USGS, USDA Forest Service
Cooperative Institute for Research in the Atmosphere
Colorado State University
State of Colorado Department of Health and Environment
Air Resource Specialists
University of California at Davis
Community Collaborative Rain, Hail, & Snow Network



The same pollutants responsible for sulfur and nitrogen deposition also impair visibility, as shown in these photos from the IMPROVE network. In Rocky Mountain Natl. Park, visibility is impaired to some degree 90% of the time. Viewing distance in the summer months averages 83 miles but can drop to 30 miles on high pollution days.

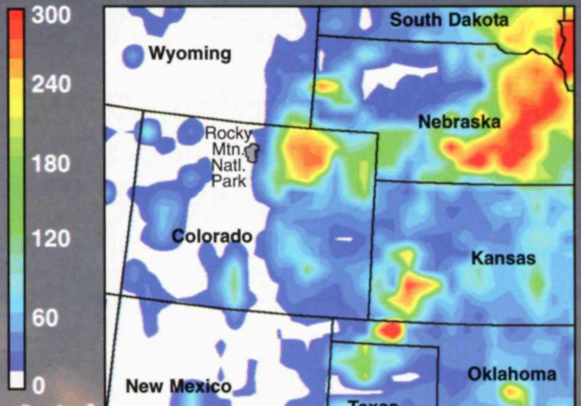
Ammonia Emissions in Colorado



Facts

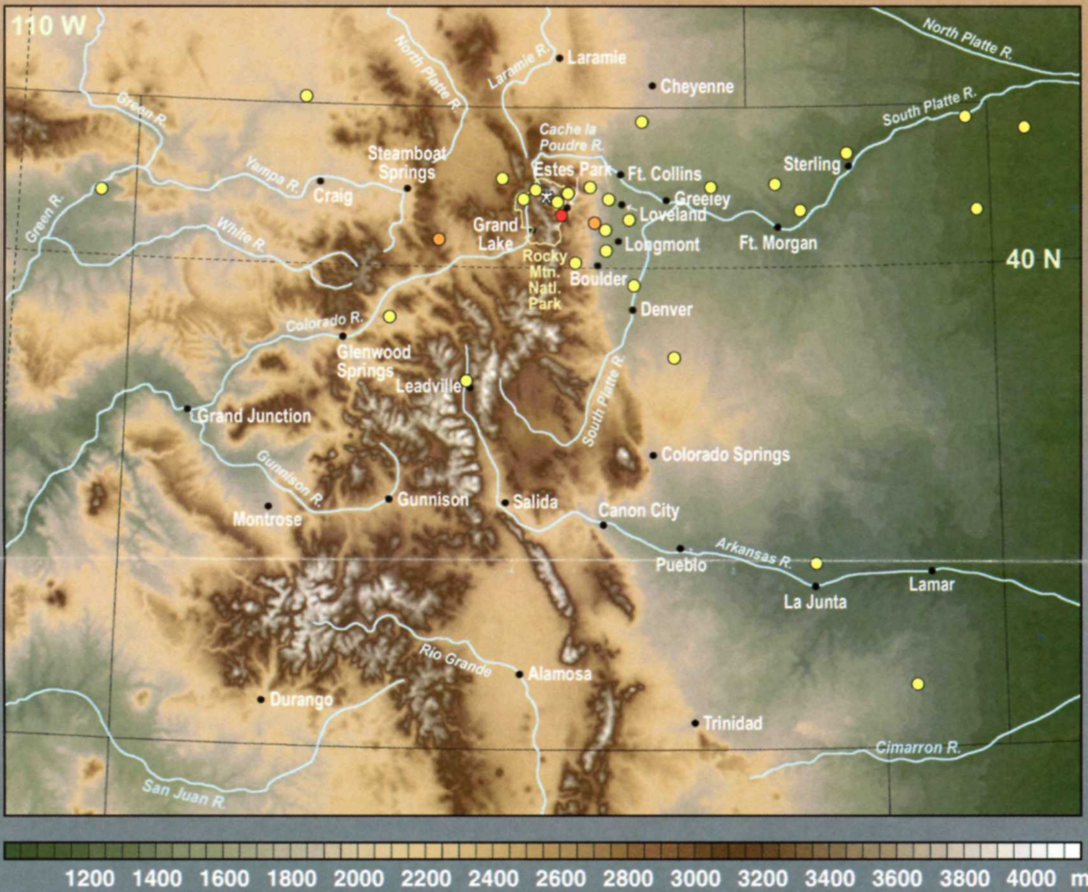
- Northeastern Colorado is a highly productive agricultural region.
- Colorado ranks 4th in the United States for confined-fed cattle, sheep, and lamb production.
- Colorado ranks 11th in the United States for pig production.

Regional Ammonia Emissions



Typical summertime ammonia emissions, primarily from agricultural sources, in the region surrounding Rocky Mountain National Park

Measurements were made at a core site within Rocky Mountain National Park, at two secondary sites (one located on Gore Pass in the Gore Range, west of Rocky Mountain National Park, and one on the Front Range), and at an array of 27 satellite sites across eastern Colorado and the western slope.



Two one-month intensive sampling periods were conducted in 2006. One sampling period was completed between March and April when upslope flow events are likely to occur with contributions from the Front Range and beyond. A second sampling period from July to August was conducted to capture wet deposition associated with convective activity.

Measurements of fine and coarse particle species concentrations, trace gas concentrations (SO_2, NO_X, NH_3, HNO_3, CO, and O_3), ion size distributions, wet deposition, particle light scattering, and meteorology were made at the core site. Secondary site measurements focused on concentrations of key particle species and wet deposition. Satellite site measurements varied between sites and depended on the type of sampling equipment available.

RoMANS Study Objectives

- Identify the overall mix of sulfur and oxidized and reduced nitrogen in the air and precipitation on both the east and west sides of the continental divide.
- Identify the relative contribution to atmospheric oxidized sulfur and oxidized and reduced nitrogen at Rocky Mountain National Park from emissions originating within the state of Colorado vs. outside the state.
- Identify the relative contribution to atmospheric oxidized sulfur and oxidized and reduced nitrogen at Rocky Mountain National Park from emissions originating along the Front Range vs. other regions within the state.
- Identify the relative contribution of various source types within the state of Colorado to nitrogen and sulfur species, including mobile, agricultural, other area sources, and large and small point sources.
- Map spatial and temporal variability of atmospheric deposition within the park and relate observed patterns to likely source types and locations.
- Characterize the meteorological conditions that lead to various atmospheric chemical conditions.