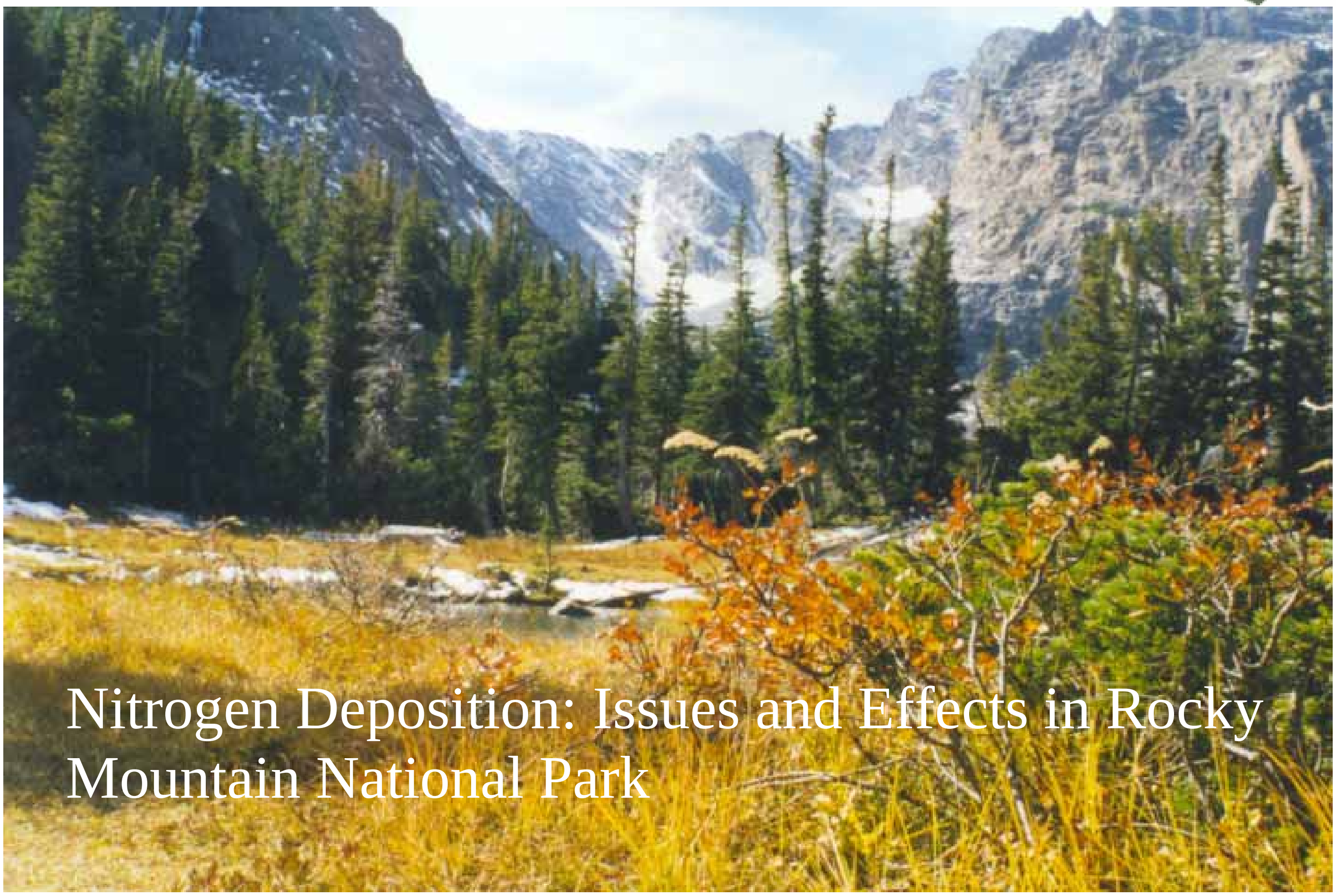
Rocky Mountain National Park

National Park Service
Department of the Interior



Nitrogen Deposition: Issues and Effects in Rocky Mountain National Park

Updated March 2005

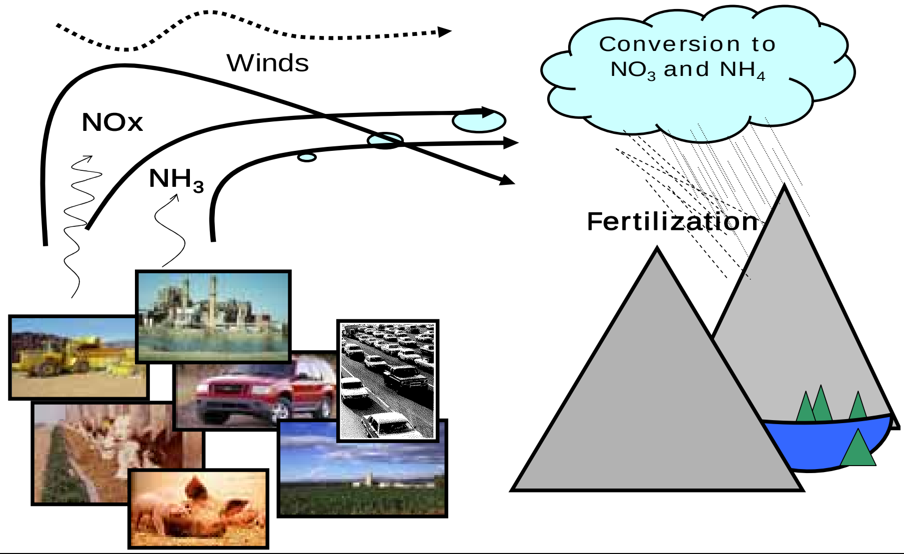
Nitrogen Loading in Rocky Mountain National Park

National Park ecosystems are managed to be as natural or **unimpaired** as possible. Man-made air pollutants may cause unnatural ecosystem changes that can be described as exceeding a **critical load**. Ecosystems in Rocky Mountain National Park are beginning to reflect changes caused by nitrogen deposition. Effects to ecosystem structure (species composition) and function (soil and water and tree chemistry) have been documented in some areas of the Park, and this indicates that nitrogen deposition is above critical loads for sensitive Park ecosystems. Total annual (wet and dry) nitrogen deposition monitored in the park since the mid 1990s averages around 3.9 kg/ha/yr. Pre-industrial or "natural" levels of nitrogen deposition are estimated to be about 20 times lower than current deposition, at around 0.2 kg/ha/yr.

Background

Rocky Mountain National Park is downwind of many man-made sources of air pollution. While the Park's air is relatively clean compared to other national parks near large cities, pollutants from sources in Colorado's Front Range, as well as from other areas in the U.S. and abroad, are carried into the Park on the wind. These pollutants are deposited in rain, snow, and as dry particles. Researchers from the U.S. Geological Survey and National Park Service have been working for over 20 years to determine whether the amounts of air pollution found in Rocky Mountain National Park are sufficient to affect Park ecosystems. Adequate data now exist to show that soils, waters, and plants are beginning to show evidence of changes from nitrogen deposition. Nitrogen pollution in the air comes from vehicles, industrial emissions, and agricultural sources such as farm fertilizer and animal waste (figure 1). Nitrogen carried in air currents and deposited in ecosystems can act as a fertilizer, favoring some types of plants and leaving others at a disadvantage. This creates an imbalance in natural ecosystems, and it is not known whether these changes can be reversed even if nitrogen deposition is reduced later. Nitrogen uses up natural buffering agents in waters and soils, leaving Park ecosystems vulnerable to future acidification. Nitrogen pollution also contributes to visibility reducing haze and formation of ozone, a pollutant harmful to human health and vegetation.

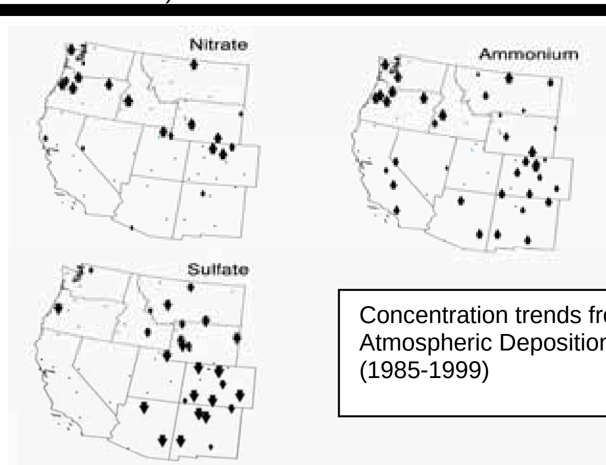
Figure 1: Unnatural Fertilization of Sensitive Park Ecosystems
Nitrogen in the form of nitrogen oxides (NO_x) and ammonium (NH_4) is carried by the wind until it deposits in high-elevation areas. The extra nitrogen can act as a fertilizer, causing unnatural changes to water and soil chemistry and plants and animals in the ecosystem. (figure source: J. Baron, USGS)



Sensitive Ecosystems

High elevation ecosystems at Rocky Mountain National Park are more vulnerable to atmospheric nitrogen deposition than many ecosystems in the eastern U.S. or in other countries. This is because the granitic bedrock and shallow soils found in the Park don't provide much chemical buffering. In addition, short growing seasons at high elevation limit the amount of time plants have to absorb nitrogen during the year. These plants evolved under very low nitrogen conditions, so they are more accustomed to low nitrogen environments. High elevation ecosystems in Rocky Mountain National Park currently show subtle changes from the effects of deposition (see sidebar at right). Studies from areas with higher nitrogen deposition levels, like the eastern U.S. and Europe, indicate that detrimental effects to aquatic and terrestrial ecosystems in the Park will continue to be seen at current deposition levels and effects may increase in severity if nitrogen continues to increase at current rates (figure 2). The National Park Service and air quality regulators at the State of Colorado and the Environmental Protection Agency are working together to determine options for reducing nitrogen deposition impacts to the Park.

Figure 2: Nitrogen Trends in the Western U.S.
The concentration of nitrogen (nitrate and ammonium) in rain and snow has been increasing in many areas of the western U.S., including Rocky Mountain National Park, while sulfate has been decreasing (figure source: Clow and others. 2003. Water Resources Research 39:6)



Concentration trends from National Atmospheric Deposition Program (NADP) data (1985-1999)

Facts about excess nitrogen in Rocky Mountain National Park

- Nitrogen concentration in the Park's rain and snow has been increasing (figure 2). Nitrogen deposition (concentration x precipitation) has been increasing by about 2% per year over the last two decades in the Park.
- There is more nitrogen deposited in high elevation ecosystems at the Park than plants can use, and excess nitrogen is leaking into Park lakes and streams at certain times of the year.
- Chemical changes are occurring now in surface waters, soils, and trees on the east side of the Park.
- Lake sediment analysis shows that excess nitrogen deposition has altered diatom species composition. This change began to occur around 1950. Diatoms are algae, small oxygen producing plants in lakes.
- Nitrogen deposition has been shown in other parts of the country to use up natural buffering chemicals in lakes and soils. Eventually these resources become acidic and cease to support sensitive species such as fish. Ecologists and data modelers are working to determine how long it would take, at current rates of nitrogen deposition, for this to occur in Rocky Mountain National Park.
- Experiments on nearby Niwot Ridge show that increasing nitrogen changes the species of plants that live on the tundra. Grasses and sedges outcompete flowering plants, a change that could reduce habitat for some animals and diminish alpine flowers in the Park.

More information about nitrogen deposition research, monitoring, and ecosystem effects at Rocky Mountain National Park is available at:
http://co.water.usgs.gov/lochvale/index.html
http://www.nrel.colostate.edu/projects/lvws/pages/homepage.htm
http://www2.nature.nps.gov/air/Permits/ARIS/index.cfm