Resource Brief

National Park Service
U.S. Department of the Interior

Rocky Mountain I&M Network
Natural Resource Stewardship and Science

Cleaner Snow Reveals Cleaner Air



In a Nutshell

Concentrations of select atmospheric pollutants mostly improved at snow monitoring stations in Glacier National Park, Rocky Mountain National Park, and Great Sand Dunes National Park and Preserve from 1996 to 2018.

Why Monitor Snow?

Few things look more pristine than a fresh blanket of snow, yet each snowflake naturally carries small particles from the atmosphere. Nitrogen and sulfur historically have increased in the atmosphere due to power plant emissions, vehicle exhaust, livestock operations, fertilizer application, and other human sources. When snowflakes build around these particles, the resulting snowfall can bring pollutants from far away into our national parks. Excessive nitrogen and sulfur can acidify and over-enrich soil and water, contributing to exotic plant invasions, algal blooms in lakes, and more. The Rocky Mountain Network supports snow chemistry monitoring by the U.S. Geological Survey to investigate how these contaminants are changing over time in Glacier National Park, Rocky Mountain National Park, and Great Sands Dunes National Park and Preserve (Fig. 1). As part of a larger regional monitoring network, park results can also be placed within the broader context of the Rocky Mountains.

National Park Conditions

Monitoring results through 2018 mostly show good news (Table 1). Using a Mann-Kendall test for trend ($p < 0.05$), sulfate and nitrate decreased at 4 out of 5 park monitoring stations. Sulfate has consistently decreased over time at monitoring stations in Glacier

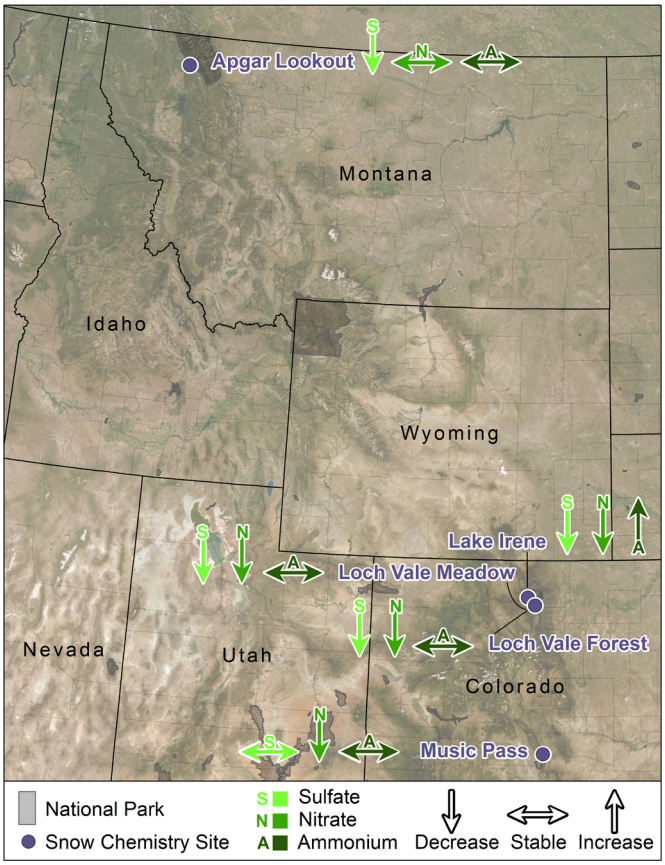


Figure 1. Trends over time in sulfate, nitrate, and ammonium at Rocky Mountain Network snow chemistry monitoring sites.

Table 1. Trends in atmospheric pollutants at snow chemistry monitoring stations in Rocky Mountain Network parks. Trends were determined using a Mann-Kendall test with $p < 0.05$.

Park	Location	Period of record	Sulfate	Nitrate	Ammonium
Glacier National Park	Apgar Lookout	1996–2018	Decrease	Stable	Stable
Rocky Mountain National Park	Lake Irene	1993–2018	Decrease	Decrease	Increase
Rocky Mountain National Park	Loch Vale Forest	1994–2018	Decrease	Decrease	Stable
Rocky Mountain National Park	Loch Vale Meadow	1993–2018	Decrease	Decrease	Stable
Great Sand Dunes National Park and Preserve	Music Pass	2006–2018	Stable	Decrease	Stable

(Fig. 2) and Rocky Mountain National Parks. Nitrate concentrations increased or were fairly stable through the early 2000s and have since decreased at monitoring stations in all 3 parks for the past 10+ years, with significant decreases over the period of record at Rocky Mountain National Park, and Great Sand Dunes National Park and Preserve (Fig. 3). Ammonium has been variable over time but does not show a long-term upward or downward tendency at most stations. The exception is ammonium at Lake Irene in Rocky Mountain National Park, which saw an increase in the 1990s that stabilized in the 2000s (Fig. 4). Mercury sampling began in 2009, and trends will become more apparent as sampling continues.

Rocky Mountain Region Conditions

A regional analysis of snow chemistry from 1993 to 2012 showed similar decreases in sulfate and nitrate concentrations throughout the Rocky Mountains and linked these to improvements in air quality[1]. In contrast, ammonium concentrations increased regionally during the same time period, although the Northern Rockies subregion, including Glacier National Park, did not show a trend. Ammonium trends were strongest in Wyoming, which is not represented by our park units. It is encouraging that monitoring stations in our national parks continue to show decreases in sulfate and nitrate another 6 years after the regional analysis was completed.

Working towards Clean Air

Park managers can't control the air or snow, but park monitoring can highlight the success of improving air quality to reduce atmospheric deposition in remote and wild places. All 3 national parks in this project have special protections under the Clean Air Act, passed in the 1970s, to maintain sensitive ecosystems and protect long distance views. The National Park Service cooperates with states, tribes, and other entities to develop strategies for reducing air pollution in parks, like the Rocky Mountain National Park Air Quality Initiative. By working with others, the National Park Service strives to maintain a clean and healthy landscape for visitors to enjoy for years to come.

Learn More

Current data tables and graphs for each station can be found on the USGS Rocky Mountain Regional Snowpack Chemistry Monitoring Study website

National Parks and the Clean Air Act
https://www.nps.gov/subjects/air/cleanairact.htm

Rocky Mountain National Park Air Quality Initiative
https://www.colorado.gov/pacific/cdphe/rocky-mountain-national-park-initiative

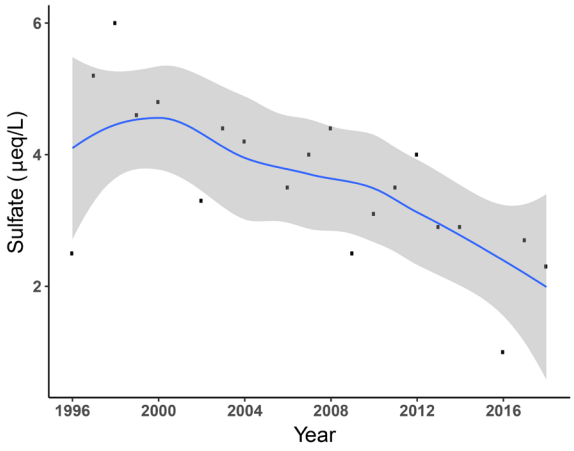


Figure 2. Decrease in dissolved sulfate (SO4) concentrations in snow at Apgar Lookout Mountain, Glacier National Park, Montana. Blue trend line is a LOESS smooth of the data with 95% confidence limits shaded gray.Source: USGS CO Water Science Center.

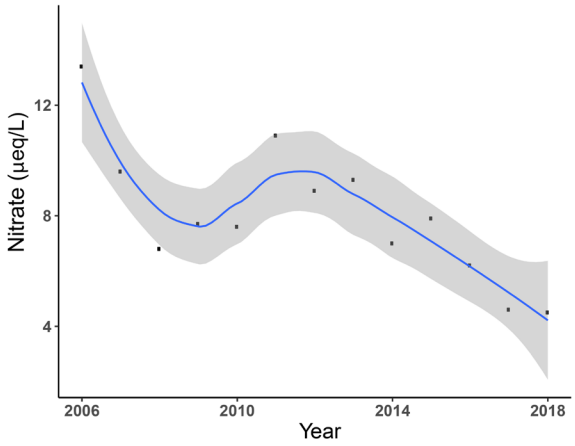


Figure 3. Decrease in dissolved nitrate (NO3) concentrations in snow at Music Pass, Great Sand Dunes National Park and Preserve, Colorado. Blue trend line is a LOESS smooth of the data with 95% confidence limits shaded gray. Source: USGS CO Water Science Center.

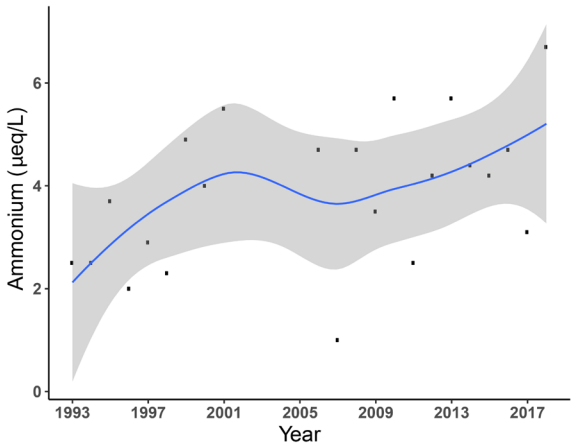


Figure 4. Increase in dissolved ammonium (NH4) concentrations in snow at Lake Irene, Rocky Mountain National Park, Colorado. Blue trend line is a LOESS smooth of the data with 95% confidence limits shaded gray. Source: USGS CO Water Science Center.

[1] Ingersoll et al. 2016. Changing regional emissions of airborne pollutants reflected in the chemistry of snowpacks and wetfall in the Rocky Mountain region, USA, 1993-2012. Water, Air, and Soil Pollution 227:94.