Snow Chemistry and Deposition in Alpine Areas

LONG-TERM MONITORING
PROJECT SUMMARY

Introduction

Snowmelt in the alpine areas of the Rocky Mountains is critical to both the quality and quantity of water in freshwater lakes, streams, and wetlands. In the alpine and subalpine areas of Glacier National Park, Great Sand Dunes National Park and Preserve, and Rocky Mountain National Park, winter deposition is principally in the form of snow that develops into a seasonal snowpack. This snowpack incorporates atmospheric deposition in the form of particles and gases, including chemicals, both naturally occurring and human produced. Some of the important chemicals in snow include: nitrogen and sulfur compounds, base cations, mercury, and other metals, and organic compounds (e.g., pesticides and herbicides).

Annual monitoring of snowpack water content and chemistry is critical to understanding air pollution stressors in the alpine regions of mountainous parks in the Rocky Mountain Network (ROMN). Deposition of nitrogen, sulfur, and organic compounds is a known stressor to aquatic and terrestrial ecosystems in Rocky Mountain, and a potential concern at Glacier and Great Sand Dunes. Climate dynamics and surrounding land uses that provide new sources of chemicals create the potential for precipitation chemistry to emerge as an issue at other ROMN parks. Snowpack sampling is a cost effective method of collecting a substantial portion of annual precipitation in a single sample. The Snow Chemistry protocol addresses atmospheric deposition as an ecosystem stressor and addresses a single ROMN vital sign, Wet and Dry Deposition.

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The ROMN supports snow chemistry and deposition monitoring in Great Sand Dunes NP and Pr.

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USGS researchers Don Campbell and Alisa Mast in a snow sampling pit, Rocky Mountain NP.

Objectives

The goal of the ROMN Snow Chemistry protocol is to monitor changes in snow chemistry and snow water equivalent in snowpack at locations in Glacier, Great Sand Dunes, and Rocky Mountain. The core monitoring objectives are to:

1. *Determine annual status and trends in snow chemistry at locations in Glacier, Great Sand Dunes, and Rocky Mountain*

2. *Analyze winter snowpack for snow water equivalent or water content (the amount of liquid water contained in solid snow when it is melted) and chemicals (e.g., major ions with emphasis on nitrate, sulfate, and ammonium; free acidity or pH; conductance; calcium, sodium, potassium, magnesium, chloride, and mercury)*

3. *Based on snowpack chemistry estimates, update network atmospheric deposition models and estimate loadings of chemicals to sensitive alpine ecosystems*

4. *Provide snow chemistry data for regional data comparison*

Network park units with ongoing Snow Chemistry monitoring

Glacier NP
Rocky Mountain NP
Great Sand Dunes NP and Pr

NP = National Park; Pr = Preserve

Protocol Development and Status

The ROMN is cooperating with the U.S. Geological Survey (USGS) Water Resources Discipline to develop a standard protocol for annual snowpack sample collection—including snow water equivalent and major ion chemistry—within the three ROMN mountain parks. Protocol development began in 2006 through an Interagency Agreement with George Ingersoll and others at the USGS Water Resources Discipline Alpine Hydrology Group. The draft protocol was completed in spring 2007. This protocol will follow USGS snowpack monitoring protocols related to the collection of samples and sample processing (chemical analyses) in a central laboratory. The ROMN will continue to work with the USGS Rocky Mountain Snow Chemistry Network to conduct annual sampling in the spring and to report, understand, and interpret results.

Based on the techniques and recommendations of the USGS Water Resources Discipline, the ROMN snowpack monitoring design uses "sentinel" sites that are selected for their potential to accumulate a seasonal snowpack. Chemical deposition profiled in seasonal snowpack can be used as a surrogate for continuous monitoring of wet deposition across the Rocky Mountains between November through March at elevations that do not experience mid-winter melt.

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) was established to monitor the chemistry of wet deposition (major anions and cations, especially dissolved species of nitrogen and sulfur). Data from the NADP/NTN will be used to track changes in precipitation chemistry in ROMN parks that have existing sample collections (Glacier, Rocky Mountain, and Little Bighorn Battlefield National Monument), and will be extrapolated to the other ROMN parks (Great Sand Dunes, Florissant Fossil Beds National Monument, and Grant-Kohrs Ranch National Historic Site). The ROMN protocol addresses atmospheric deposition estimates provided by NADP/NTN monitoring sites, but it should be noted this data often lack accuracy at high-elevation sites due to problems with maintaining samplers in these harsh environments.

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Fred Bunch, Resource Manager at Great Sand Dunes NP and Pr, skis to snow sampling sites in the park.

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Sampling equipment and park staff in Rocky Mountain NP.

Preliminary Results

The USGS began monitoring snowpack at Apgar Lookout in Glacier in 1999 and continues to do so each spring. Personnel from the USGS Glacier Field Station collect the samples and the USGS Rocky Mountain Snowpack Program analyzes the melted snow samples and reports the data. The ROMN continues to work with park staff at Glacier and the National Park Service Air Resources Division to monitor snow chemistry. At Rocky Mountain, USGS snow sampling efforts on both the east and west side of the park has been continuous since 1999, with assistance from park staff and Air Resources Division staff. Snowpack chemistry monitoring will continue in the park at Loch Vale and Lake Irene. Great Sand Dunes staff annually monitor two snowpack sites in the Sangre de Cristo range. Data summaries for snow chemistry at the Rocky Mountain and Glacier sites for 2004 can be found in a USGS Open File report at http://pubs.usgs.gov/of/2007/1045/.

Future Plans

The ROMN will continue to support and contribute to snow chemistry monitoring in collaboration with network parks, the National Park Service Air Resources Division, and the USGS Rocky Mountain Snow Chemistry Monitoring Network.

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