Climate-Induced Changes in High Elevation Nitrogen Dynamics

J.S. Baron, T.M. Schmidt, M.D. Hartman

Abstract

Mountain terrestrial and aquatic ecosystems are responsive to external drivers of change, especially climate change and atmospheric deposition of nitrogen. This is of interest to public land managers with responsibilities for protecting Class 1 Clean Air Act Areas and Wilderness from human-caused alterations. We explored the consequences of an overlay of climate change on an alpine and subalpine watershed in the Colorado Front Range that has long been the recipient of elevated atmospheric N deposition. Mean annual nitrate concentrations increased by 33 percent, and mean annual nitrogen export has increased by 28 percent from Loch Vale watershed since 2000. Measured inorganic nitrogen values since 2000 are the highest observed since monitoring began in 1982. The substantial increase in nitrogen dynamics comes as a surprise, since atmospheric N deposition has not increased during this period. Coincident with the increase in watershed nitrogen loss and stream nitrogen concentrations, there has been a period of below normal precipitation and an increase in temperatures, especially mean annual temperature, which increased from a mean of 1.3˚C for the years 1985–1999 to a mean of 1.7˚C for 2000–2006. The temperature increase is driven by a strong increase in July mean and minimum temperatures. Nitrate concentrations, as well as the weathering products calcium and sulfate, were higher for the period 2000–2006 in rock glacier meltwater at the top of the watershed, suggesting minimal influence of alpine and subalpine vegetation and soils. We conclude the observed N increases in Loch Vale are climatically induced, caused by melting ice in glaciers and rock glaciers that have exposed microbially active sediments. The phenomenon observed in Loch Vale may be indicative of nitrogen release from ice features worldwide as mountain glaciers retreat. In regions that are chronically ultra-oligotrophic, additional nitrate may stimulate algal productivity and affect species assemblages, such as we have already observed.

Baron is a research ecologist with the U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO, and senior research scientist with the Natural Resource Ecology Laboratory, Colorado State University. Schmidt is a Mendenhall postdoctoral fellow with the U.S. Geological Survey, Mineral Resource Program, Denver, CO. Hartman is a research associate with the Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO. Email: jill@nrel.colostate.edu; tschmidt@usgs.gov; melannie@nrel.colostate.edu.