

Rocky Mountain National Park

Loch Vale Watershed in Rocky Mountain National Park has been the subject of intense scrutiny since 1981. The NPS has been investigating whether there is an acidic deposition problem, and how acidic deposition affects high elevation ecosystems of the southern Rocky Mountains. The first question was addressed by reconstructing lake and atmospheric chemistries from lake sediments and combining that with knowledge of current deposition chemistry. The conclusion was that there has been no discernible trend toward increasing acidity in either lakes or deposition over the past 150 years, and current deposition chemistry, while exhibiting some industrial and automotive influence, is not yet acidic enough to cause ecological damage. The values of acid, sulfate, and nitrate deposition are still well below the levels known to have been responsible for effects elsewhere in the world. The results of this work are published (*Water Resources Bulletin* and *Water, Air, Soil Pollution*) or in press (*Canadian Journal of Fisheries and Aquatic Science*). The latter should be in print by early summer. (See Recent Publications)

In 1982 Loch Vale Watershed (an NADP site) was instrumented with an acid deposition collector, a weather station, a flume to quantify stream flow, and a number of smaller instruments to measure ecosystem processes that might help to mitigate acidic deposition. An intense sampling program was initiated with the help of the U.S. Geological Survey, U.S. Forest Service, Bureau of Reclamation, Solar Energy Research Institute, and Environmental Protection Agency. Measurements are taken on the chemistry of lakes and streams, soils, vegetation, rain, throughfall, snow, and bedrock minerals. Some of the more important results are discussed below.

The high elevation ecosystems of Rocky Mountain National Park are among the most sensitive to acidification of any in the world. The alpine and subalpine lakes are

surrounded by slow-weathering granitic bedrock, thin to nonexistent soils, and little or no vegetation. These ingredients add up to a minimal source of buffering capacity with which to counter increasing acidity. Lakes and streams reflect this with alkalinity values averaging 60 microequivalents/liter over a normal water year. Many lakes within Rocky Mountain NP support healthy populations of trout, and streams show a diverse community of benthic macroinvertebrates. The sensitivity of these lake systems is further increased by the strong seasonality of inputs. Deposition may build up in the snowpack for up to seven months of the year, then melt out in a very short time. Currently, with only a slight increase in atmospheric deposition of acids, spring pH values drop as low as 5.7, a value not much above the threshold for biological effects.

Other factors which restrict the ability to withstand an increase in acidic deposition are complex. Because these high elevation systems (often over 3000m elevation) are so cold and are stressed by a short growing season, lack of sufficient moisture, and dessicating high winds, they do not seem to be limited by lack of the nutrient nitrogen. Consequently, increased NO_3 in deposition (a result largely of automotive emissions and industrial combustion of oil or coal) may cause increased acidity in lakes and streams, just as SO_4 will cause loss of acid neutralizing capacity. Soils in these very cold environments accumulate a lot of organic matter because temperature and moisture regimes prevent rapid decomposition. These soils are already very acidic, with low base recharging capability and low sulfate adsorption capacity. There will be very little replenishment of lake and stream neutralizing capacity from soils. Similarly, bedrock minerals will not provide much buffering, and in-lake processes do not seem to be a source of acid neutralizers.

These results, which have been determined empirically, correlate well with another method of ecosystem analysis employed: systems analysis with computer models. Researchers are currently working with a model developed at the University of Virginia called MAGIC (Model of Acidification of Groundwater in Catchments). The model was first tested on data collected from Shenandoah National Park. This model, which was developed for an environment with a lot of soil and no yearly accumulation of snow, works fairly well in Rocky Mountain NP, in spite of these drawbacks. Portions of it are being modified to better reflect western conditions.

All of this could have important implications for the management of Rocky Mountain National Park. Here is an ecosystem that is very sensitive to acidic deposition but which is not yet affected. Its location in the southern Rockies puts it near growing urbanization, smelting of copper and other metals, and the possible development of oil shale and natural gas facilities. The chances

of atmospheric deposition causing biological effects here in the future are great. With improvement in the computer modeling, it may be possible to make educated guesses about how long it will take for effects to occur given different deposition scenarios. This allows Park managers possibly to prevent the damage before it occurs by offering convincing evidence of how, when, and why. The loss of trout populations, for instance, would be a severe blow to Rocky Mountain National Park. This research may be one way to see that it doesn't occur.

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