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Preface

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Catchment-scale intensive and extensive research conducted over the last decade shows that our understanding of the biogeochemical and hydrologic processes in subalpine and alpine basins is not yet sufficiently mature to model and predict how biogeochemical transformations and surface water quality will change in response to climatic or human-driven changes in energy, water, and chemicals. A better understanding of these processes is needed for input to decision-making regulatory agencies and federal land managers. In recognition of this problem the *National Research Council* [1998] has identified as a critical research need an improved understanding of how global change will affect biogeochemical interactions with the hydrologic cycle and biogeochemical controls over the transport of water, nutrients, and materials from land to freshwater ecosystems. Improved knowledge of alpine and subalpine ecosystems is particularly important since high-elevation catchments are very sensitive to small changes in the flux of energy, chemicals, and water. Furthermore, alpine ecosystems may act as early warning indicators for ecosystem changes at lower elevations.

A different, recent *National Research Council* [1997] report listed three main components of an effective watershed research program: measurement and monitoring, intense (experimental) study of processes, and a modeling program component to help interpret measurements. The Loch Vale watershed program incorporates all of these, and this special section of *Water Resources Research* demonstrates the breadth and vitality that is possible from long-term watershed programs.

Loch Vale watershed is a 7.7-ha alpine/subalpine catchment located entirely within Rocky Mountain National Park, Colorado. Biogeochemical and hydrologic information have been collected from Loch Vale since 1983 [*Baron*, 1992]. Because Loch Vale is located in a national park, it has had minimal prior direct human-caused disturbances such as settlement, logging, grazing, or water diversions that influence much of the rest of the Rocky Mountains. An open-door policy toward collaborators, coupled with free and ready distribution of high-quality long-term meteorologic, wet-deposition chemistry, discharge, and water-quality records, has attracted many researchers, who have contributed greatly to the knowledge of subalpine and alpine structure, function, and flux. This special section presents recent results from Loch Vale watershed research.

The flux of water, solutes, and energy through mountain catchments of the western United States is dominated by the storage and release of water from seasonal snowpacks. The development of physically based, spatially distributed snowmelt models requires improved estimates of the spatial distribution of snow water equivalent. The paper by *Balk and Elder* [this issue] combines geostatistical techniques, binary decision trees, and field measurements of snow depths and density to model the spatial distribution of snow in rugged and varied terrain characteristic of mountain environments.

The contribution of individual flow paths to discharge, and transit times along flow paths, is often variable at the catchment scale. This complicates understanding of biogeochemical processes that determine the chemical content of surface waters. Water isotope hydrology and solute isotope biogeochemistry in combination with field measurements can address these problems. The paper by *Michel et al*. [this issue] offers a unique approach that uses the cosmogenically produced radioisotope ^{35}S as an effective tracer for the movement and resident time of atmospherically derived sulphate in watersheds. *Campbell et al*. [this issue] take a landscape approach to describe the flux of inorganic nitrogen species through Loch Vale as a function of landscape heterogeneity, hydrologic flow paths, and climatic influences. *Clow and Sueker* [this issue] extend these site-specific results to eight additional basins in the Rocky Mountains to identify controlling parameters that appear to govern the magnitude, timing, and flux of solutes in surface waters. Changes in solute concentration along with stable isotopes of water are used by *Sueker et al*. [this issue] in two- and three-component hydrograph separation models in six basins proximal to Loch Vale to partition source waters and quantify seasonal changes in hydrologic flow paths. Spatial and field data are used iteratively in a process-based model by *Meixner et al*. [this issue] to evaluate our understanding of biogeochemical and hydrologic processes at the catchment scale and to guide in the development of new hypotheses.

The paper by *Baron et al*. [this issue] builds on spatial and long-term data in an attempt to project changes in runoff and ecosystem properties of high-elevation catchments under conditions of climate change and increasing CO_2.

There is value in colocated interdisciplinary and multidisciplinary research. It allows for integration of the many drivers, climatic, biogeochemical, hydrologic, and biological, that govern the biogeochemical and hydrologic processes. As scientific understanding grows, the boundaries between traditional disciplines blur, and laboratories such as Loch Vale watershed and other long-term research and monitoring sites provide the resources and mass of scientists needed to understand and interpret environmental issues. Integrated research facilitates the linkages between cause and effect, particularly where processes are complex and intertwined. Interdisciplinary research makes for a stimulating learning environment for students and scientists alike.

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