How Do Geology and Biology Determine Watershed Nitrogen Export? A Paired Catchment Study

Nick Bouskill[1], Michelle Newcomer[1], Rosemary Carroll[2,3], Curtis Beutler[3], Markus Bill[1], Wendy Brown[3], Mark Conrad[1], Wenming Dong[1], Amanda Henderson[3], Nicola Falco[1], Benjamin Gilbert[1], Susan Hubbard[1], Aizah Khurram[1], Taylor Maavara[4], Alex Newman[3], Patrick Sorensen[1], Heidi Steltzer[5], Tetsu Tokunaga[1], Jiamin Wan[1], Haruko Wainwright[1], Helen Weierbach[1], Eoin Brodie[1], Kenneth Hurst Williams[1]

[1]Lawrence Berkeley National Laboratory, Berkeley, CA;
[2]Desert Research Institute, Reno, NV;
[3]Rocky Mountain Biological Laboratory, Gothic, CO;
[4]Yale University, New Haven, CT;
[5]Fort Lewis College, Durango, CO

Contact: (njbouskill@lbl.gov)

Project Lead Principal Investigator (PI): Eoin Brodie

BER Program: ESS

Project: Berkeley Lab Watershed Function SFA

Project Website: watershed.lbl.gov

Abstract:

Nitrogen is a limiting element within mountainous ecosystems. Coarse soils, sparse vegetation, and strong hydrological events, such as snowmelt and monsoonal precipitation, can flush nitrogen prior to assimilation and retention in plant and microbial biomass. However, the role that discrete landscape properties play in determining the retention and release of nitrogen at the watershed scale is poorly understood. Our study focuses on two catchments within the East River watershed in the Upper Colorado River Basin: At 56 km^2, Coal Creek exhibits an east-west orientation, with north- and south-facing hillslope aspects, ~70% land cover by conifer tree species, and bedrock dominated by Upper Cretaceous and Eocene sand- and silt-stones and igneous rock types. The 86 km^2 main stem East River is oriented in a northwest-southeast direction, has 26% coverage by conifer species, and is largely underlain by Cretaceous Mancos shale bedrock, which is entirely absent in Coal Creek. Runoff characteristics for both catchments are similar in terms of the timing of peak discharge in early June and the transition to baseflow in late September-early October, where groundwater represents a significant fraction of streamflow.

These distinguishing characteristics manifest themselves in terms of the concentration magnitude and isotopically inferred source of nitrogen exported from each catchment. For example, the nitrate exported from Coal Creek is sourced primarily from new, atmospherically deposited nitrate, which makes up ~54 % of riverine nitrate. By contrast, nitrate is retained longer in the East River

watershed, where it is cycled multiple times, and when exported, is primarily (~64 %) derived from terrestrial sources. Taken collectively, our multi-year results provide a unique insight into the primary controls on the provenance of nitrogen loading and its riverine export when considered over scales that functionally aggregate to a collective, integrated watershed response.

Finally, using a coarse-resolution model representing the interacting nitrogen and water cycles, we extend our observations to further address how the nitrogen cycle, and, by extension, the availability of nitrogen to plants and microbes, is impacted by climate extremes. Specifically, we perturb the different catchments feeding into the East River watershed by increasing annual temperature and lengthening the summer dry period. These perturbations show a strong impact on nitrogen export, with higher inorganic nitrogen exported under warming conditions. We further demonstrate the important role vegetation plays in the ecosystem retention of nitrogen, and emphasizes the need to improve our understanding of when plants acquire different organic and inorganic nitrogen compounds within mountainous ecosystems.