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Spatial and Temporal Dynamics of Nitrogen within a Mountainous Watershed

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A widely held conceptual model of pristine mountainous watersheds maintains that ecosystem productivity is limited by nitrogen availability. Work within the current phase of the SFA supports and contradicts this paradigm, indicative of a temporally heterogeneous ecosystem. For example, our recent efforts have demonstrated that hydrological export of dissolved inorganic and organic nitrogen during the most intense periods of nitrogen demand (i.e., the growing season) can be high (indicative of no limitation), and extremely low (indicative of nitrogen limitation). Given the importance of headwater streams for downstream nitrogen dynamics, a more nuanced characterization and quantification of the main sources and sinks for nitrogen within the watershed can improve understanding of the fate of nitrogen.

Efforts within the first phase of this SFA have focused on identifying the ecosystem traits (e.g., geology, geomorphology, vegetation, microbial activity) controlling the fate of nitrogen. First phase studies have shown that shale bedrock (~ 4.2 kg ha yr^{-1} and 3.3 kg ha yr^{-1} in 2017 and 2018), alongside atmospheric deposition (~ 2 kg ha yr^{-1}), is a significant source of both NH^{4+} (through weathering and cation exchange), and NO^{3-}, via *in situ* nitrification, at the East river. This input can be several-fold larger than the hydrological export of NO^{3-} from the East River watershed, indicating significant retention and storage of nitrogen within watershed vegetation, soils, or aquifer. Indeed, a coarse scale model (HAN-SoMo) informed by PARFLOW, emphasizes the importance of plant processes as critical controls on the retention and release of nitrogen, and denitrification as a critical watershed loss term for nitrogen, up to four times larger than hydrological export. The timing of snowpack formation, the depth of that snowpack, and snowmelt are important factors in determining this retention and release of nitrogen. First phase observations demonstrate that a deep snowpack thermally insulates the soil, maintaining soil temperatures above freezing and facilitating soil microbial growth and activity. The subsequent snowmelt period can induce a crash in microbial biomass and a significant pulse of nitrogen release. However, a late accumulating and shallow snowpack, with a persistent layer of frozen soil (during the winter of 2017-2018), showed no overwinter immobilization of nitrogen in microbial biomass and no appreciable release of nitrogen. Understanding gleaned from measurements and modeling efforts performed in the first phase of this program will contribute towards our second phase goal of using historical nitrogen records to better predict the future watershed nitrogen cycle.