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Landscape heterogeneity and hydrologic losses of inorganic nitrogen from boreal catchments

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Boreal forest ecosystems of northern Sweden are highly retentive of inorganic nitrogen (N), which limits terrestrial productivity. Given strong biotic demand and tight internal cycling within the plant-soil system, understanding how landscape configuration and hydrologic forcing influence the export of bioavailable forms of N from boreal catchments is a current research challenge. Here we ask how heterogeneity in inorganic N availability and demand associated with the mosaic of forest and wetland (mire) patches influences the hydrologic losses of limiting nutrients from these landscapes. We surveyed nutrient chemistry and the isotopic signature of water from surface streams and groundwater wells within a boreal catchment to explore: 1) vertical patterns of resource accumulation and export from a mire ecosystem, 2) the fate of mire-derived N in outlet streams, and 3) the importance of mires for broader-scale patterns of nutrient concentrations throughout the channel network. Results document the accumulation of ammonium during the winter season within deep (2-3 meters), yet hydrologically active, soil layers of the mire. The isotopic signature of water from mire wells suggests that preferential flowpaths through these deeper layers are persistent over time, and nutrients accumulated in these zones are delivered to surface streams during the spring snow melt and throughout the growing season. Longitudinal surveys of surface water chemistry in outlet streams indicate rapid processing of mire-derived ammonium, with concomitant production of nitrate consistent with in situ nitrification. Finally, at broader spatial scales, differences in the average concentrations of ammonium and total inorganic N among streams are positively correlated with the areal coverage of mires within the sub-catchments. Results illustrate how landscape heterogeneity interacts with hydrologic flowpaths to govern the accumulation and export of resources from zones that are not readily accessible by terrestrial vegetation, providing a mechanism by which limiting nutrients may be lost from boreal landscapes.