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Watershed and stream network structure influences on physical and biological nutrient retention and stream water sources

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Stream network nutrient retention is a function of both physical processes and biological processes. To date our ability to measure and model these processes at the reach and network scales has been limited. However, watershed and stream network scale assessment of where and to what degree groundwater surface water exchange and biological retention modify stream water signatures is critical for understanding basic watershed hydrology and biogeochemistry and for aiding and improving management decisions made at watershed or regional scales. To address this challenge, we developed an empirically based network scale model to simulate hydrologic turnover, concentration-dependent nutrient uptake kinetics, and total nutrient retention across stream networks. Exchange and uptake parameters were constrained by conservative and nonconservative tracer addition experiments in the Bull Trout Watershed, central Idaho, USA. We simulate physical exchange of stream water and dissolved nutrients with groundwater (hydrologic turnover) and concentration-dependent biological uptake. Our model allowed us to estimate total nutrient retention across the stream network, examine the effects of serial processing, and separate nutrient retention into constituent physical and biological components. Analyses of six adjacent watersheds (including Bull Trout) with variable geometries indicated that hydrologic turnover is strongly influenced by watershed and stream network structure. Biological retention and serial processing are also strongly influenced by network and watershed geometry. These physical and biological processes are not simply additive: rather they exhibit complex but discernable feedback behavior that can strongly influence watershed hydrology and biogeochemistry.