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Persistent Effects of Forest Harvest on Dissolved Organic Matter Composition in Subsurface Hillslope Runoff

Tim Fegel[1], Banning Starr[1], Kelly Elder[1], Tim Covino[1*], Ed Hall[1], Claudia Boot[1], and Charles Rhoades[1]

[1] Colorado State University, Fort Collins, CO

Contact: tim.covino@colostate.edu

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Timber harvesting commonly alters soil nitrogen (N) and carbon (C) inventory and associated biogeochemical processes the initial years after treatment, yet changes in critical zone processes as forests recover from harvesting remain poorly understood. In high-elevation conifer forests of the Rocky Mountains, slow tree growth and short growing season prolong post-harvest ecosystem responses. Here we analyze hillslope-scale subsurface flow at the Fraser Experimental Forest to evaluate differences in nutrient export and dissolved organic matter (DOM) composition between old-growth and second-growth forest more than three decades after clear cut harvesting. Runoff passing through the upper 3 m of the soil profile was collected before, during, and after peak subsurface discharge during 2017 and 2018. In the second-growth stand, runoff nitrate concentrations were significantly higher and dissolved organic C concentrations were lower relative to the old-growth forest. Dissolved organic N was an order of magnitude higher than dissolved inorganic N concentrations in both forest conditions. Fluorescence spectroscopy of subsurface flow showed contrasting DOM composition from the old- and second-growth forests. The old-growth forest was composed of more complex, aromatic DOM and microbial-like DOM was more prevalent in the second-growth forest. Subsurface flow C:N ratios were twice as high in the old-growth forest and correlated with DOM characterization indices based on fluorescence spectroscopy. Further, biological oxygen demand assays showed that DOM exported from the second-growth forest was consumed 50% more rapidly than that from the old-growth forest. Old-growth and second-growth forests are common within managed landscapes and this hillslope scale comparison will advance understanding of long-term changes in critical zone processes that regulate watershed C and N export and downstream water quality.