Soil Frost Modeling in a Northern Hardwood Forest: Past and Present

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ABSTRACT

The insulating properties of a continuous snow cover are known to protect soil from extensive freezing in a normal winter. One of the more dramatic effects of climate change in the temperate forest may be less snow cover and more extensive soil freezing resulting in changes to soil biogeochemical processes and the delivery of solutes to streams. Increases in freeze events may affect the cycling and loss of nutrients and the chemistry of drainage waters. Our field investigation took place at the Hubbard Brook Experimental Forest (HBEF) near N. Woodstock, New Hampshire. HBEF was established in 1955 and contains a long-term database of meteorological, snow depth, stream flow, and stream water chemistry data. We established four experimental sites, two in sugar maple stands and two in yellow birch stands. Each site contained a designated "reference" plot and a "treatment" plot. The treated plots were shoveled to keep snow-free until early February to mimic a late arriving snow cover and induce soil freezing. Snow on the reference plot was unaltered. Soil thermistors recorded hourly temperatures at five depths in all plots. We made periodic measurements of snow properties, soil water content, and soil water chemistry. Results show increases in soil freezing depth, fine root mortality, and leaching of N and P, Ca, and Mg, in all treated plots compared to reference plots. Analysis of the historical HBEF data of soil freezing depth showed that the winter of 1988-89 had an unusually severe soil-freezing event. We then used meteorological data from 1988-89 winter to "hindcast" the extent of frozen soil in Watershed 6 at HBEF. Regression analysis examines the relationships between soil freezing variables and Watershed 6 stream chemistry. SLTHERM's predictions of soil temperature and moisture are incorporated into a model predicting stream water chemistry. A simple linear regression model indicated that soil freezing explained ~ 50% of the short-term (5 year) variability in stream nitrate and potassium concentrations and ~ 30 % of the short-term variability in stream calcium and magnesium concentrations between 1970 and 1989.

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