Michael Weintraub, Ph.D.
Department of Environmental Sciences
University of Toledo
Toledo, Ohio

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Contact: Christopher Schadt, 576-3982

The changing seasonality of soil processes in the Arctic tundra of Alaska

Tundra soils are key regulators of many aspects of the Arctic System. Arctic soils have large stores of carbon (C) and may act as a significant CO_2 source with warming. However, the key to understanding tundra soil processes is nitrogen (N), as both plant growth and decomposition are severely N limited. However, current models of tundra ecosystems and their responses to climate change assume that while N limits plant growth, C limits decomposition. In addition, N availability is strongly seasonal with relatively high availability early in the growing season followed by a pronounced crash. This pattern suggests that low N concentrations in tundra soils at the height of the growing season are likely the result of an increase in soil N uptake associated with the peak in plant growth, either directly by roots or indirectly by microbes fueled by increased root C inputs in mid-July. However, there are multiple questions that still need answers: 1) What causes the seasonal nutrient crash? 2) Does microbial activity switch seasonally between C and N limitation? 3) How will a lengthening of the growing season alter overall ecosystem C and N dynamics, as a result of differential extension of the periods before and after the nutrient crash? 4) What will be the larger impacts of these patterns on the Arctic system? Our current research addresses these questions by: 1) Varying the length and timing of the growing season in the field by advancing snow melt and warming the ecosystem; 2) Establishing the fine scale seasonal time-courses of soil N availability, plant N content, leaf expansion, root growth and rhizodeposition, ecosystem respiration, microbial biomass and enzyme activity; 3) Conducting lab experiments to determine the extent to which microbial activity is limited by temperature, and C and N availability before and after the crash; 4) Determining how the timing of the nutrient crash and plant growth vary across a latitudinal transect; 5) Refining models developed for arctic ecosystems to better handle how plant and microbial systems respond to N limitation; and 6) Testing the large-scale spatial and temporal effects of the seasonality of nutrient availability and how it may change in a warming Arctic with a lengthening growing season.