Iron-phosphorus interactions across redox transitions in tundra and boreal wetlands

ELIZABETH HERNDON[1], KIERSTEN DUROE[1], JONATHAN MILLS[1], LAUREN KINSMAN-COSTELLO[2], STAN WULLSCHLEGER[3], STEPHEN SEBESTYEN[4], EVAN KANE[5]

[1]Department of Geology, Kent State University, Kent, OH, USA 44242 (eherndo1@kent.edu)
[2]Department of Biological Sciences, Kent State University, Kent, OH, USA 44242
[3]Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN, USA 37831
[4]USDA Forest Service, Northern Research Station, Grand Rapids, MN, USA 55744
[5]School of Forest Resources and Environmental Science, Michigan Technical U., Houghton, MI, USA 49931

Rapidly changing climate at northern high-latitudes is altering biogeochemical cycles and potentially shifting terrestrial ecosystems from sinks to sources of atmospheric carbon. Plant growth may mitigate greenhouse gas emissions to the atmosphere, but the ability of increased plant growth to offset soil C losses is limited by soil nutrients. In particular, phosphorus availability to plants is strongly regulated by hydrologic conditions due to redox-dependent interactions with iron oxyhydroxide minerals.

Our objective was to evaluate how changes in Fe geochemistry across redox boundaries impact P solubility and storage in northern wetlands. We examined iron geochemistry and phosphate sorption capacity in peat soils obtained from tundra and boreal ecosystems across North America. Soils at each site were collected from wet and dry landscape positions that span redox gradients. Spectroscopic and sequential extraction techniques were used to identify dominant Fe phases, while sorption assays were used to measure the phosphate binding capacity of each soil.

Saturated soils in topographic depressions exhibited large accumulations of Fe oxides and an increased capacity to sorb phosphate relative to higher and drier soils. These observations are explained by redox boundaries that form at distinct positions on the landscape. In well-drained soils, high acidity drives leaching of dissolved Fe and prevents oxide accumulation. In poorly drained soils, dissolved Fe migrates upwards from deep, anoxic zones and is oxidized near the soil surface. The Fe oxides that accumulate at these redox boundaries potentially sequester phosphate that is released into solution from decomposition. Thus, Fe oxide barriers that form in depressional areas may impact the solubility and transport of nutrient P in arctic and subarctic regions.