The S1-Bog Carbon Cycle and Projected Warming Responses for the SPRUCE Experiment

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The S1-Bog is a Picea-Sphagnum peatland located on the Marcell Experimental Forest in northern Minnesota that is being characterized and prepared for experimental manipulations to evaluate organismal and ecosystem carbon cycle responses to warming and elevated CO_2. These saturated wetlands are characterized by deep histosol soils (2-3 meters). S1-Bog belowground C stocks equal 2200 MgC ha-1. Similar ecosystems occupy ~1 percent of global ice-free land area, but contain 300 to 700 Pg of global soil C (atmospheric C = 589 Pg C).

Calibrated peat ages and carbon stocks below -40 cm (1500 to 12000 yBP) show a post-glacial, millennial C accumulation rate of 21 gC m-2 y-1 for stable peat with a C:N ratio around 20. In the surface peat (-40 to 0 cm) C:N ratios rise to values near 50 reflecting freshly deposited plant material (Sphagnum and various woody species). Net ecosystem production within the bog ranges from 100 to 300 gC m-2 y-1 and is considerably higher than the millennial accumulation rate. Labile carbon losses during surface aerobic decomposition account for the difference. The SPRUCE experiment is designed to provide data on the susceptibility of both the current C cycle and millennial carbon stocks to potential future warming. Detailed characterization of biogeochemical cycles for limiting elements with the bog (N, P, Ca, Mg, etc) will be conducted to characterize mineralization rates of such elements from accumulated peat. Mineralization may effectively fertilize the bog vegetation and compensate for decomposition losses through enhancement of annual production.

Models are being structured to better represent bog biogeochemistry and hydrology. ORNL efforts are focused on extending the Community Land Model (CLM) version 4.5 for the S1-Bog and vegetated wetland systems in general. Initial simulations use a 2-column structure to represent hummock-hollow topography with lateral flows and vertically resolved soil carbon and nitrogen. CLM4.5 is also being updated to include a microbial decomposition model, which is producing more realistic predictions of observed pre-treatment CO_2 and CH4 fluxes. Model simulations with warming suggest a substantial drop in water table. Initial hypotheses suggest that peat and C accumulation may be sustained for low levels of warming, but shift to a pattern of net carbon release in the forms of CO_2 and CH4 for greater levels of warming. Model projections for various processes will be discussed in the context of planned warming manipulations: belowground-only (2014) and whole-ecosystem (2015 and beyond).