

## **Title: Understanding the Relative Importance of Nitrogen Versus Phosphorus Cycling in an Undisturbed Ombrotrophic Bog: Insight into Ecosystem Response to SPRUCE Manipulations**

Verity G. Salmon<sup>1,\*</sup>, Randy Kolka,<sup>2</sup> Colleen M. Iversen,<sup>1</sup> Natalie Griffiths,<sup>1</sup> Steve Sebestyen,<sup>3</sup> Richard J. Norby,<sup>1</sup> Xiaojuan Yang,<sup>1</sup> Deanne J. Brice,<sup>1</sup> Joanne Childs,<sup>1</sup> Holly M. Vander Stel,<sup>3</sup> Avni Malhotra,<sup>4</sup> Jake Graham,<sup>5</sup> Jana Phillips,<sup>1</sup> Paul J. Hanson<sup>1</sup>

<sup>1</sup>Environmental Sciences Division and Climate Change Science Institute, Oak Ridge National Laboratory, Oak Ridge, TN;

<sup>2</sup>Northern Research Station, USDA Forest Service, Grand Rapids, MN;

<sup>3</sup>Kellogg Biological Station, Michigan State University, Hickory Corners, MI;

<sup>4</sup>Stanford University, Stanford, CA;

<sup>5</sup>Department of Geosciences, Boise State University, Boise, ID

**Contact:** ([salmonvg@ornl.gov](mailto:salmonvg@ornl.gov))

**Project Lead Principal Investigator (PI):** Paul J. Hanson

**BER Program:** TES

**Project:** TES SFA at Oak Ridge National Laboratory

**Project Website:** <https://mnspruce.ornl.gov/>

**Project Abstract:** Peatlands store one third of global soil C and this large pool of C has accumulated due to productivity outpacing decomposition. In northern peatlands, however, rapid warming threatens to accelerate peat decomposition, potentially causing a net release of C to the atmosphere. The future C balance of peatland systems will likely be mediated in part by the availability of nutrients, especially in ombrotrophic bogs where plant productivity hinges on deposition of nitrogen (N) and phosphorus (P) due to slow decomposition and nutrient recycling under cold, wet, and acidic conditions. To better understand the relative importance of these two nutrients in an ombrotrophic bog, we combined field observations and literature data to build comprehensive N and P budgets for the S1 bog at Marcell Experimental Forest. The S1 bog is a well-studied ecosystem and the site of the Spruce and Peatlands Under Changing Environments (SPRUCE) experiment where warming and elevated CO<sub>2</sub> treatments are applied in a regression-based design. While peatlands are known to be strongly nutrient-limited, our results show that both N and P are lost from the S1 bog ecosystem prior to treatment application. N losses are over four times higher than P losses (6.05 gN/ha/yr versus 1.27 gP/ha/yr), but both N and P losses are driven primarily by lateral outflow from the bog surface. Annual net primary productivity (NPP) of plants requires  $101.80 \pm 165.25$  gN/ha/yr ( $N_{\text{req}}$ ) and  $8.28 \pm 16.80$  gP/ha/yr ( $P_{\text{req}}$ ). NPP of *Sphagnum* moss is the strongest driver of both  $N_{\text{req}}$  and  $P_{\text{req}}$  at the ecosystem scale, making up 46% and 42% of the total nutrient requirements.  $N_{\text{req}}$  and  $P_{\text{req}}$  are met predominantly through recycling of N and P, with new inputs meeting only 5% and 0.8% of the demand for N and P respectively. Together, the smaller P losses and smaller proportion of  $P_{\text{req}}$  met by inputs indicate that P cycle is more tightly constrained than the N cycle at the S1 bog. Low P availability may be particularly limiting for growth of the trees (*Picea mariana* and *Larix laricina*) since  $N_{\text{req}}:P_{\text{req}}$  is lower for trees than *Sphagnum* or understory plants (9 vs 13 & 15). Our results show that the response of the S1 bog to SPRUCE manipulations will likely depend on internal cycling of N versus P through plants and soils and accurate modeling of nutrient dynamics will be crucial to projecting the future C balance of the ombrotrophic bogs.