Nutrient budgets calculated in floodwaters using a whole-ecosystem experimental manipulation

Ceara J. Talbot[1], Michael J. Paterson[2] and Marguerite A. Xenopoulos[3]

[1]Environmental and Life Sciences Graduate Program, Trent University, Peterborough, ON, Canada

[2]IISD-ELA, Winnipeg, MB, Canada

[3]Department of Biology, Trent University, Peterborough, ON, Canada

Introduction

Hydrology affects aquatic ecosystem characteristics and processes. Although the links between hydrology and ecology are well-known, research linking aquatic ecosystem condition with flooding is scarce. Here, we quantify nutrient variation caused by flooding which should provide a better understanding of how aquatic ecosystems will respond to flooding.

Site description

- Three upland forest sites were flooded from June to September in 1999 to 2003 during the Flooded Upland Dynamics Experiment (FLUDEX) at the Experimental Lakes Area (ELA) in northwestern Ontario
- Sites had different amounts of stored organic carbon
  - **Low carbon:** 30, 900 kg C ha^{-1}
  - **Medium carbon:** 34, 900 kg C ha^{-1}
  - **High carbon:** 45, 860 kg ha^{-1}

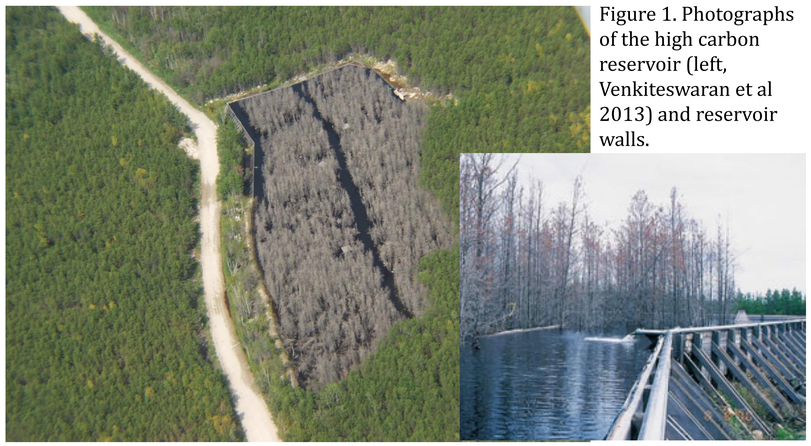

Figure 1. Photographs of the high carbon reservoir (left, Venkiteswaran et al 2013) and reservoir walls.

Reservoir hydrology

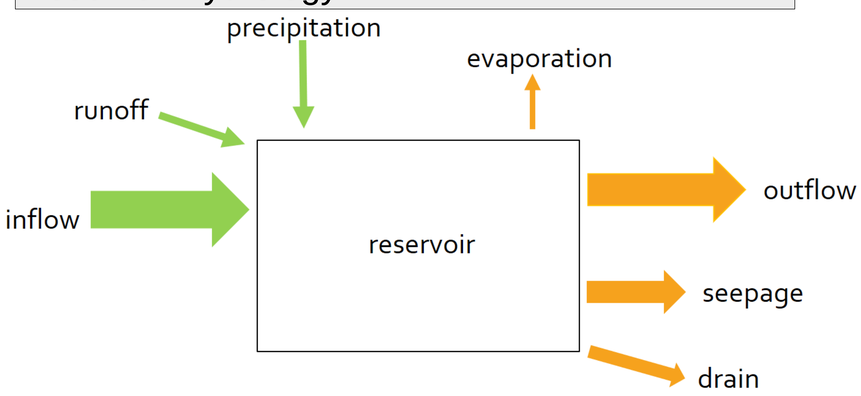

Figure 2. Diagram of reservoir hydrology with the main inputs in green and the outputs in orange. The relative size of the arrows corresponds to the relative volume contributed to the water budget by that component.

Calculating nutrient budgets

- Nutrient budgets were calculated using the same components in the water budget except for evaporation (Fig. 2)
- Volume weighted concentrations were calculated by multiplying the average nutrient concentration between two chemistry sampling dates by the volume of water moving through each component during that time interval
- TN and TP fluxes were calculated by subtracting the mass at inflows from the mass at outflows

TN and TP within flooding seasons

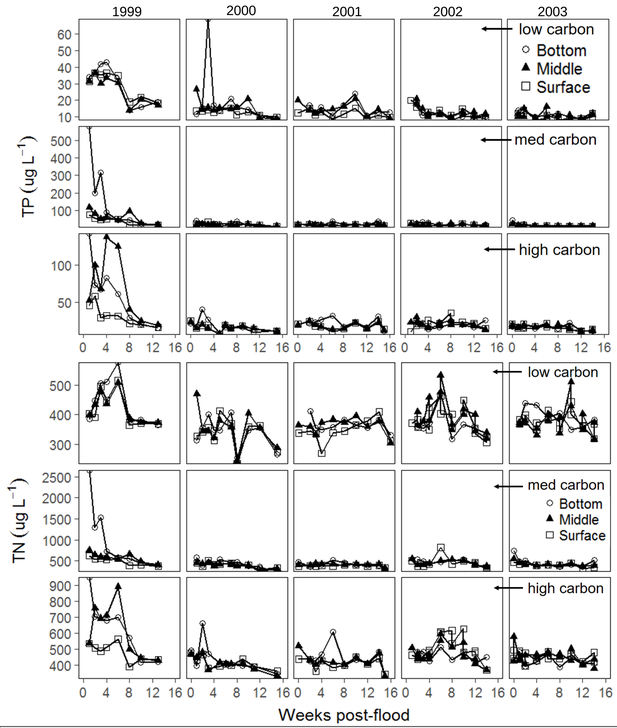

Figure 3. TP (top) and TN (bottom) concentrations in reservoirs measured at the top, middle, and bottom of each reservoir during flooding from 1999 to 2003. Generally, TN and TP concentrations were highest in the beginning of the first flooding season but the magnitude and timing of the increase was reservoir dependent.

Annual nitrogen and phosphorus

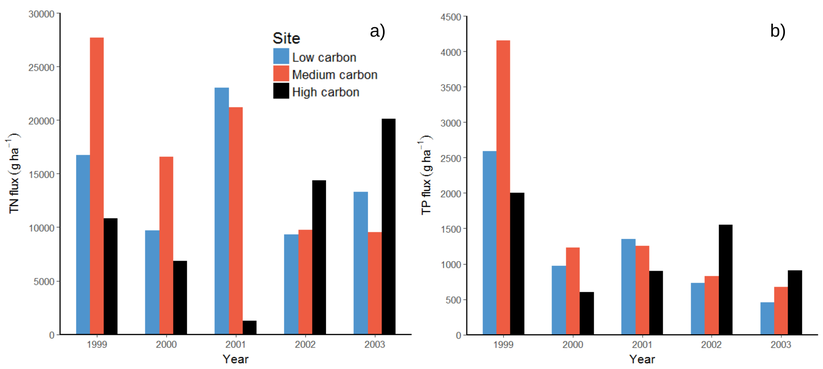

Figure 4. Calculated annual a) TN and b) TP fluxes in low, medium, and high carbon reservoirs from 1999 to 2003. TP fluxes decreased with each flooding season, but TN fluxes remained high for all flooding seasons.

Annual nitrogen and phosphorus (continued)

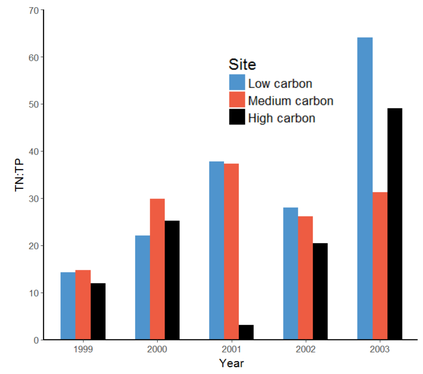

Figure 5. Molar annual flux TN:TP ratios calculated for each reservoir from 1999 to 2003. TN:TP ratios are generally lowest during the first flooding season but trends in the following seasons are site-dependent.

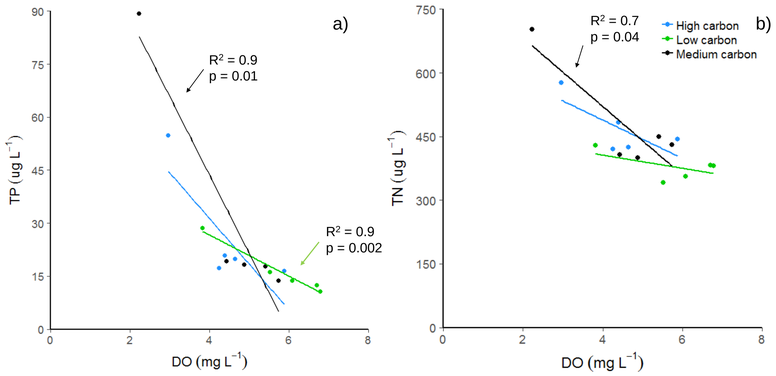

Figure 6. Annual average a) TP and dissolved oxygen (DO) and b) TN and DO concentrations in the low, medium, and high carbon reservoirs in each year of flooding with linear regression lines. In general, TN and TP were both related to DO concentration but the relationships between TP and DO were strongest.

Conclusions

- Flooding causes significant amounts of N and P to be released into aquatic ecosystems
- Organic matter decomposition is likely the major mechanism driving N and P concentrations
- Although more nutrients are released during long periods of flooding, large amounts of N and P can be released within one week
- P fluxes decline after each flooding season, but nitrogen fluxes remain high after repeated flooding

Citations

Venkiteswaran, J. J., S. L. Schiff, V. L. St. Louis, C. J. D. Matthews, N. M. Boudreau, E. M. Joyce, K. G. Beaty, and R. A. Bodaly. 2013. Processes affecting greenhouse gas production in experimental boreal reservoirs. Global Biogeochemical Cycles 27:567–577.