Beaver Ponds and Transient Headwater Streams: Hidden Hotspots of Biogeochemical Cycling

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Introduction

Background

Soil microbial biomass, an indicator for biogeochemical cycling, is defined as "the living portion of the soil organic matter, excluding plant roots and soil animals larger than 5 x 10^{-3} um^3" (Dick 2011). Soil microbial biomass accounts for less than 5% of the total organic matter in soil, yet is the center of biological activity. Areas high in soil microbial biomass are deemed "hotspots" for nutrient cycling (Figure 1) and chemical degradation. They serve as both a source and sink for carbon, nitrogen, phosphorous and sulfur. They also aid in the degradation of pesticides and other pollutants. Microbial biomass provides an idea of the rates of turnover, productivity of the soil, and quality of the environment.

Hypothesis

Since beaver ponds and impoundment pools in transient headwater streams are areas with high retention times and an accumulation of organic matter, we hypothesized that they would be "hotspots" of biogeochemical cycling.

Approach

We analyzed microbial biomass carbon levels in sediments from three beaver ponds (Figures 2a and b) and nine impoundment pools (Figures 3a and b) in three headwater streams in Rhode Island. Cores were brought back to the lab, where the chloroform fumigation extraction method was performed.

Research Sites

Figures 2a and 2b. Beaver Pond
Organic sediments accumulate over the year and exhibit signs of advanced decay

Figures 3a and 3b. Stream Impoundment Pools
Sediments derived from annual pulses of leaf litter and plant growth and are periodically flushed out during flood events

Methods

Sampling

-Subaqueous soil samples were collected using a soil coring device. Three locations were sampled in each beaver pond (Figure 4) and three impoundment pools were sampled in each stream (Figure 5)

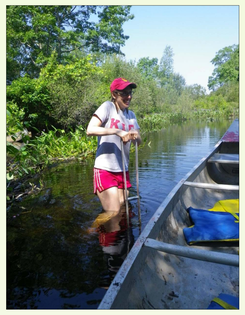


Figure 4: Sampling beaver pond sediment

Figure 5: Sampling stream sediment

Fumigation (Witt, et al. 2000)

- A 10 gram subsample from each core was dried at 60°C for 2 days to obtain the percent moisture.
-An equivalent mass of 35 grams of dry weight was transferred to 250 mL bottles.
-Under a fume hood, 2 mL ethanol-free chloroform was added to each sample.
-Samples were shaken by hand to spread the chloroform over the sediment
-Samples were incubated at 25˚C for 24 hours
-Samples were opened in fume hood and left to sit for 30 minutes for the chloroform to evaporate
-140 mL of 0.5 M K_2SO_4 was added to each bottle
-Bottles were put on the shaker for 60 minutes
-Extract was filtered and refrigerated until analysis
-Controls for each sample were also prepared, using the same method without addition of chloroform

Analysis

-Samples were run on a Shimadzu Total Organic Carbon analyzer to determine the dissolved organic carbon in the extract
-Controls were subtracted from the samples to determine carbon generated by the lysing of microbial cell walls

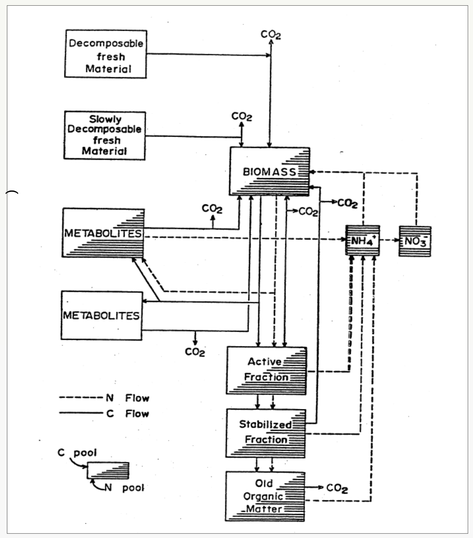
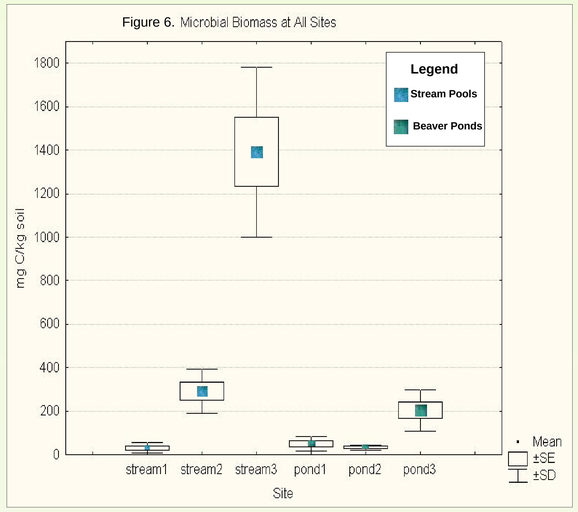


Figure 1: The role of microbial biomass in nitrogen and carbon cycling (Dick, 2011)

Results



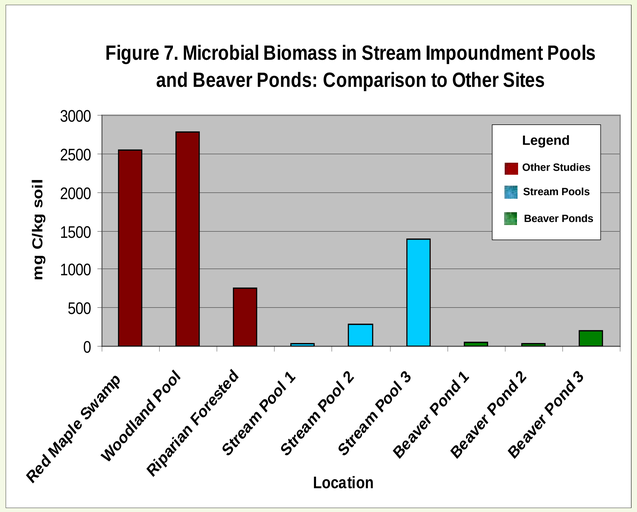
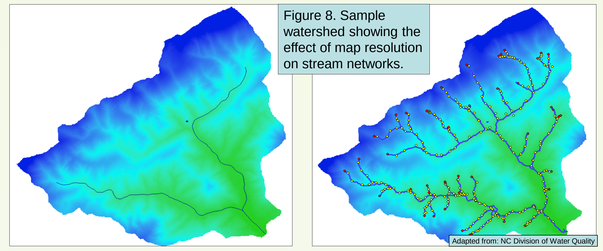


Figure 6: Comparison of microbial biomass values at all sites. Values ranged from 30 mg C/kg soil to 1,390 mg C/ kg soil. Stream 3 had the highest values. Reported site values reflect the average of the three samples per site in ponds and three impoundment pools per site in streams.

Figure 7: Comparison of microbial biomass in streams and beaver ponds to microbial biomass in other areas of the landscape reported in Groffman's studies. Stream 3 microbial biomass is higher than values for poorly drained riparian forested areas (Groffman 1996 and 1992).

Figure 8: Example watershed mapped with low resolution data (left) and mapped with field data (right). With higher resolution data, you see more transient headwater streams and their significance as a hotspot increases.



Discussion

- **Elevated microbial biomass values were observed in impoundment pools in 2 out of 3 streams and 1 out of 3 beaver ponds.** Significant microbial biomass values ranged from 205 to 1,390 mg C/kg soil, exhibiting considerable variation between sites
- **All impoundments from stream 3 had high microbial biomass values, indicative of a sequence of biogeochemical hotspots within that stream reach.** More research should be conducted in headwater streams to investigate the source of variation, nature and rate of nutrient cycling.
- **Microbial biomass in stream 3 was substantially higher than microbial biomass at all of the beaver ponds**

The routine addition of organic matter from forested riparian zones may contribute to this higher microbial biomass. Leaf litter and plant growth are continuously added and flushed out during rainfall events, leading to dynamic formation of debris dams. Organic matter in beaver ponds accumulates more slowly with less turnover. However, the longer water retention times in beaver ponds may be of future interest, for even though microbial biomass values were lower in these streams, long retention times indicate there is greater potential for nutrient cycling to occur.

- **The presence of hotspots in beaver ponds and headwater streams has research and management implications**

While we observed variability, beaver ponds and impoundment pools in streams can be substantial hotspots for biogeochemical cycling – and more research is warranted to investigate their pollutant removal potential and their capacity for greenhouse gas generation. Significance of beaver ponds as hotspots may increase as beaver populations rise. Significance of transient streams as hotspots may increase as mapping resolution improves identifying more such reaches on the landscape (Figure 8).

References

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