THE WATERSHED APPROACH IN THE BALTIMORE ECOSYSTEM STUDY

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Introduction

Every piece of land is part of a watershed (the land water travels through to reach a particular stream or other waterbody). The watershed approach (monitoring watershed inputs and outputs of) is like urinalysis, where doctors monitor chemicals in the urine to assess patient health. In BES, we are conducting long-term watershed studies of nutrients like nitrogen and phosphorus to help understand how urban watersheds respond to changes like new sewage systems and climate change. Studies of riparian (streamside) zones are an important part of these studies, because their position in the watershed allows them to function as a "buffer zone" that can prevent pollutants from washing into streams, and into the Chesapeake Bay.

Materials and methods

Every week, BES scientists sample a network of stream sites in streams that flow through different types of land - agricultural, forest, rural/suburban, new suburban, even right in the core of the city. Stream gauging stations were built and maintained by the US Geological Survey. No attempt is made to avoid wet weather, so as to retain a random component to the sampling scheme. Both filtered (nitrate, phosphate, chloride, sulfate by ion chromatography) and unfiltered (total nitrogen, total phosphorus by persulfate digestion followed by analysis of nitrate and phosphate) samples are analyzed.

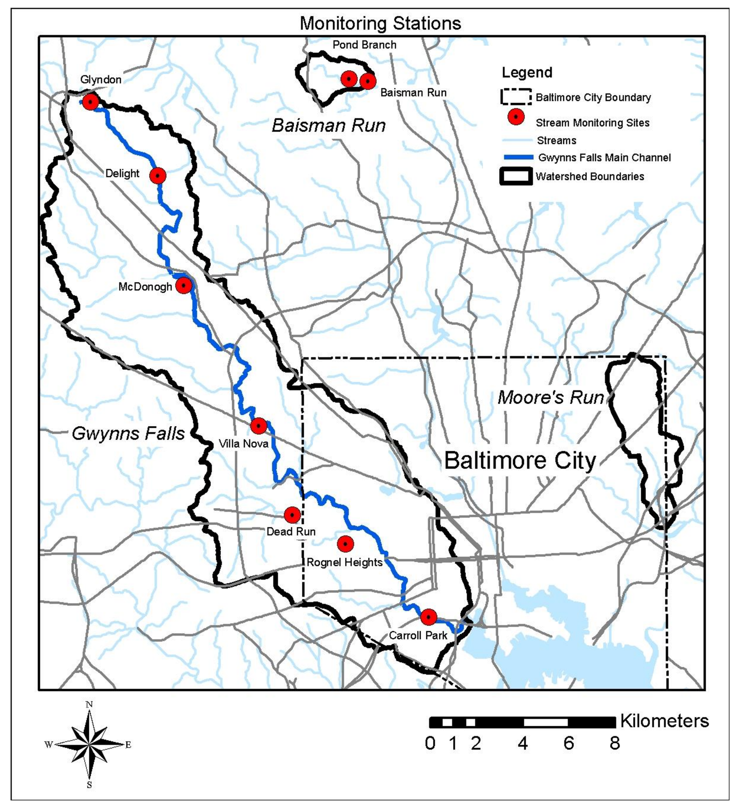

Figure 1. BES long-term watershed sampling sites.

Results

Urban and suburban watersheds consistently have nitrate concentrations that are higher than forested watersheds, but lower than agricultural watersheds (Figure 1). Nitrate is of great concern as a cause of eutrophication in Chesapeake Bay.

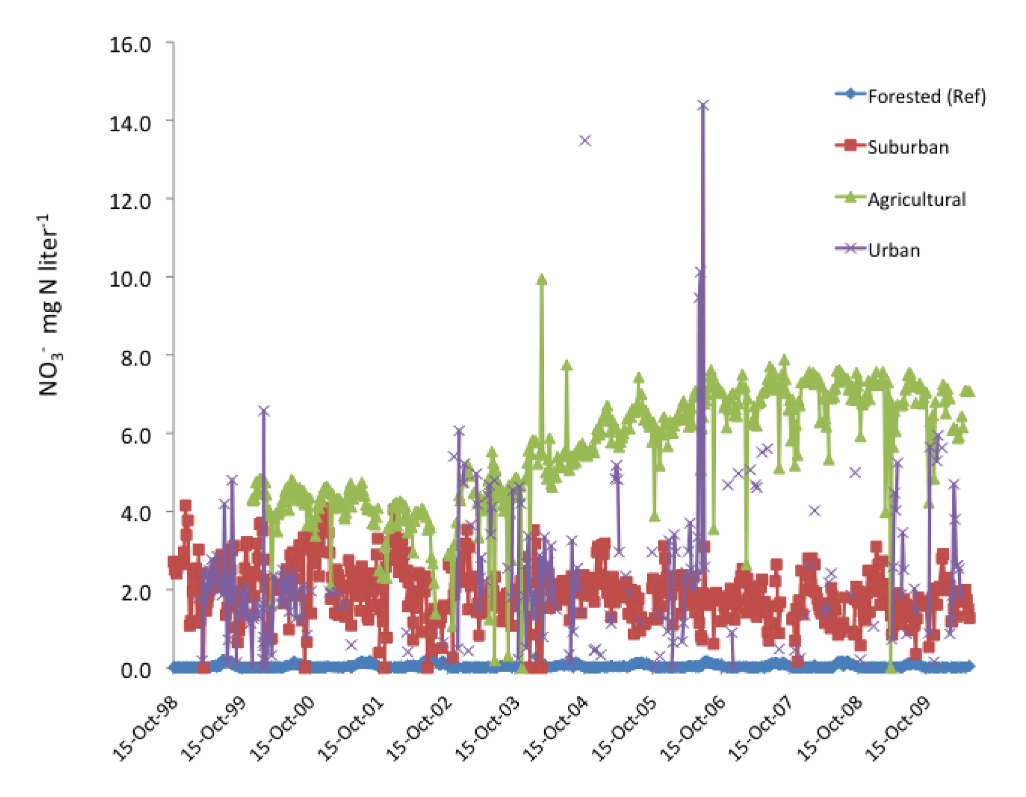

Figure 2. Nitrate concentrations in streams draining rural forested (Pond Branch), suburban (Glyndon) and agricultural (McDonogh), urban (Rognel Heights) watersheds near Baltimore, MD from October 1998 - Jun 2010.

Suburban watershed input/output budgets for nitrogen (Figure 3) have shown surprisingly high retention which has led to detailed analysis of sources and sinks in these watersheds:

- Home lawns, thought to be major sources of N in suburban watersheds, have more complex coupled carbon and N dynamics than previously thought, and are likely the site of much N retention.
- Riparian zones, thought to be an important sink for N in many watersheds, have turned out be N sources in urban watersheds due to hydrologic changes that disconnect streams from their surrounding landscape (Figure 4).
- In-stream retention, thought to be an important sink for N in forested watersheds is reduced by structural degradation caused by urban runoff.

Figure 3. N BUDGETS 1999 – 2001. From Groffman et al. 2004

	Suburban	Forested	Agriculture
	---------------------- kg N ha^{-1} y^{-1}	----------------------	
Inputs			
Atmosphere	8.7	8.7	8.7
Fertilizer	13.9	0	100
TOTAL	22.6	8.7	108.7
Outputs			
Streamflow	6.5	0.52	16.4
Retention			
Mass	16.1	8.2	92.3
Percent	71	94	85

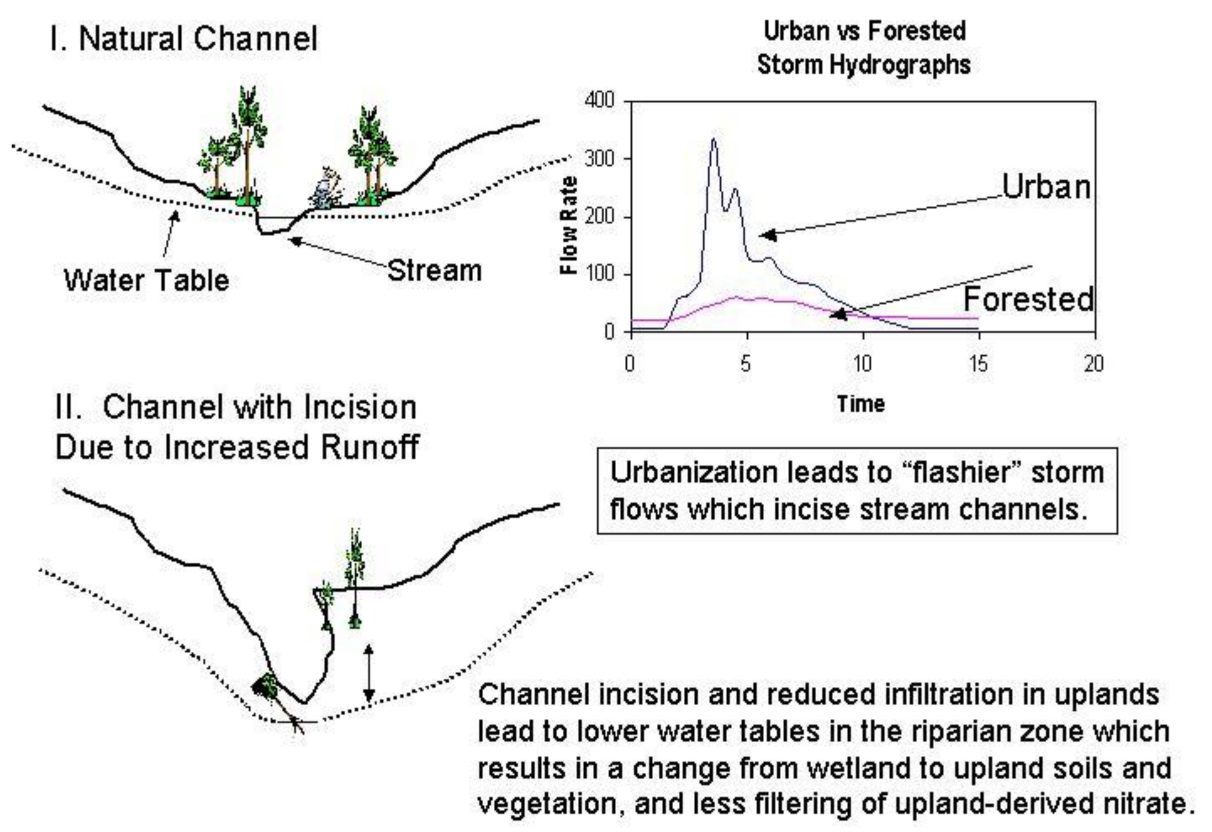

Figure 4. Conceptual diagram showing streams and associated riparian zones in forested and urban watersheds. High runoff during storm events leads to incised stream channels in urban watersheds, which in combination with reduced infiltration in impervious urban uplands, can lead to reduced riparian groundwater levels.

Improvements to sanitary sewer infrastructure appear to result in major improvements in water quality (Figure 5). The City of Baltimore is spending $900 million on improvements of this sort.

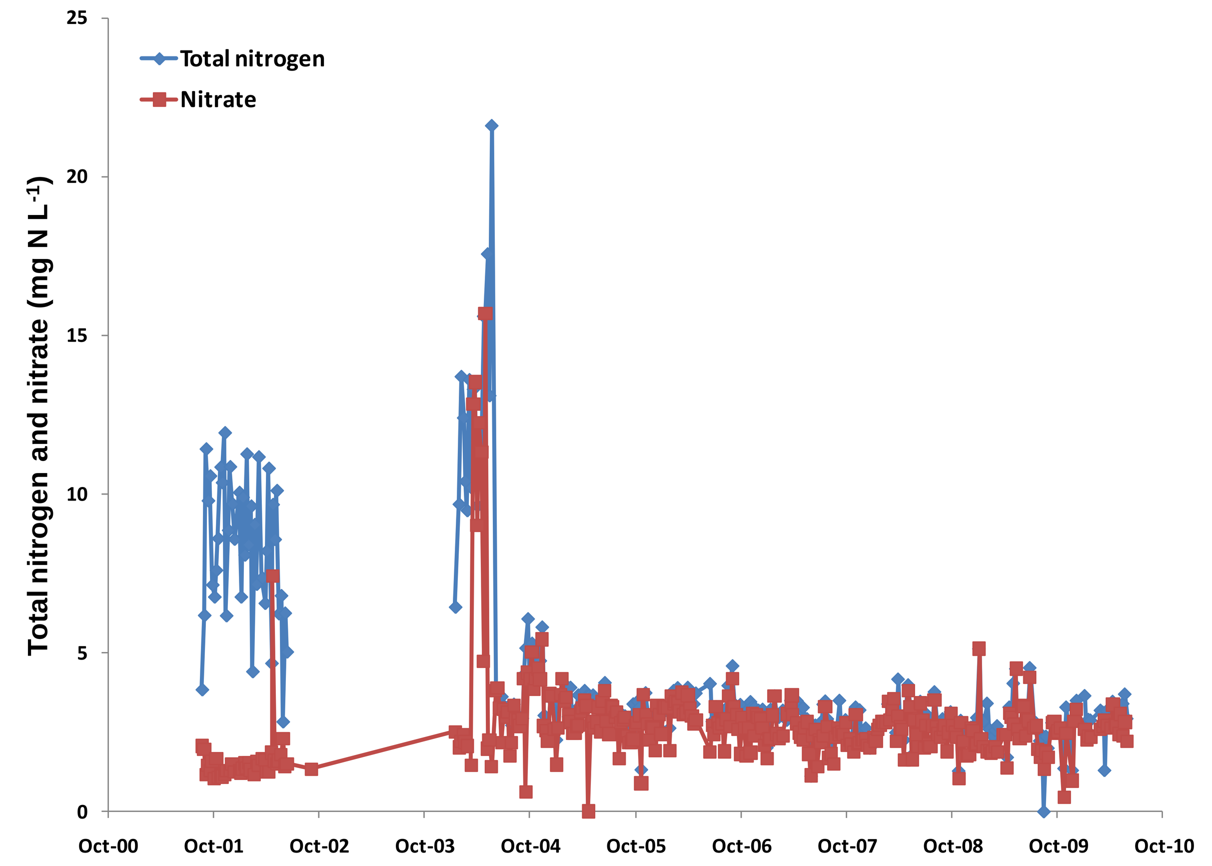

Figure 5. Total nitrogen and nitrate in Gwynns Run before and after repair of a sewer leak in April 2004.

BES streamflow and chemistry data are freely available for download on the internet: http://www.beslter.org/. Go to "data", then "BES data for download" and search under "stream" for a listing of all datasets.

Conclusions

Urban watersheds are significant sources of nitrogen and phosphorus to Chesapeake Bay, but are not as high as agricultural watersheds.

There is significant potential for nitrogen retention in urban watersheds that needs to be understood and managed to improve the environmental performance of these watersheds.

There are some surprising "sinks" (e.g., lawns) and "sources" (e.g. riparian zones) of nitrogen in urban watersheds

Selected publications:

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Acknowledgments

This work was funded by National Science Foundation Long Term Ecological Research Program. Special thanks to Dan Dillon, Lisa Martel and many other field and laboratory technicans who have carried out these measurements.

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