Stormwater management impacts on urban stream water quality and quantity during and after development in Clarksburg, MD

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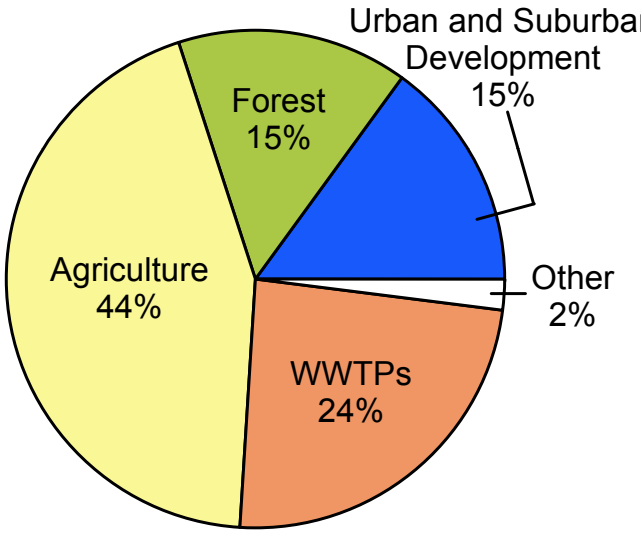
U.S. Department of the Interior
U.S. Geological Survey

Background

- Problem: Chesapeake Bay eutrophication and hypoxia

- Urban and Suburban contributions to the Bay[1]:
  - 15% of total phosphorus
  - 8% of total nitrogen
  - 16% of sediment

- Variety of sources requires many solutions to achieve Chesapeake Bay TMDL goals
  - 24% P reduction
  - 25% N reduction
  - 20% Sediment reduction



Phosphorus loading to the Cheseapeake Bay[1]

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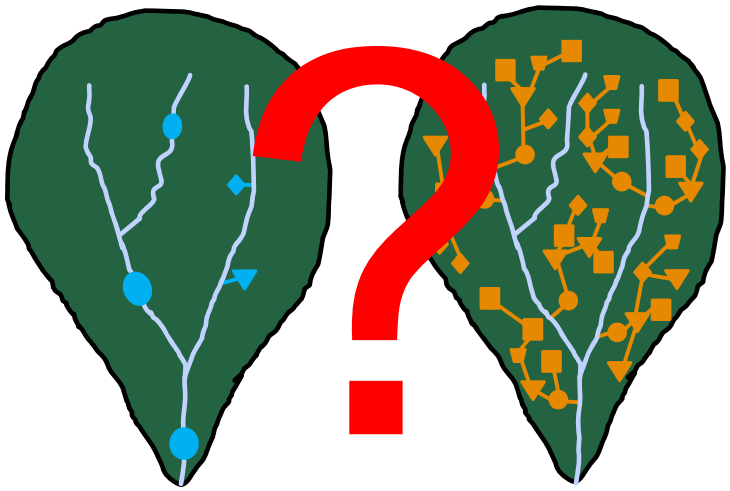
[1]Based on data from US EPA, *Chesapeake Bay TMDL for Nitrogen, Phosphorus and Sediment,* 2010

Background

- Stormwater Best Management Practices (BMPs) are used to address urban stormwater runoff:
  - Detention/retention Ponds
  - Infiltration trenches/Grassed swales
  - Filters/Bioretention cells
- BMPs have traditionally been constructed in a centralized manner to address urban stormwater runoff
- Recently, distributed BMPs have been used to achieve low impact development by providing treatment operations in series and on the landscape



Centralized BMPs

Distributed BMPs

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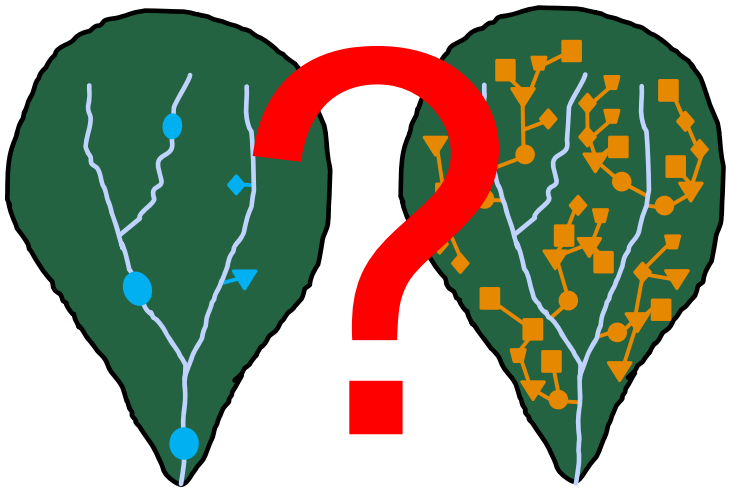
Research Objectives

- Assess how urban stormwater management strategies utilizing either centralized or distributed BMPs affect:
  - Water quantity: Magnitude and timing of water export
  - Water quality: Magnitude and form of phosphorus, nitrogen, and sediment export



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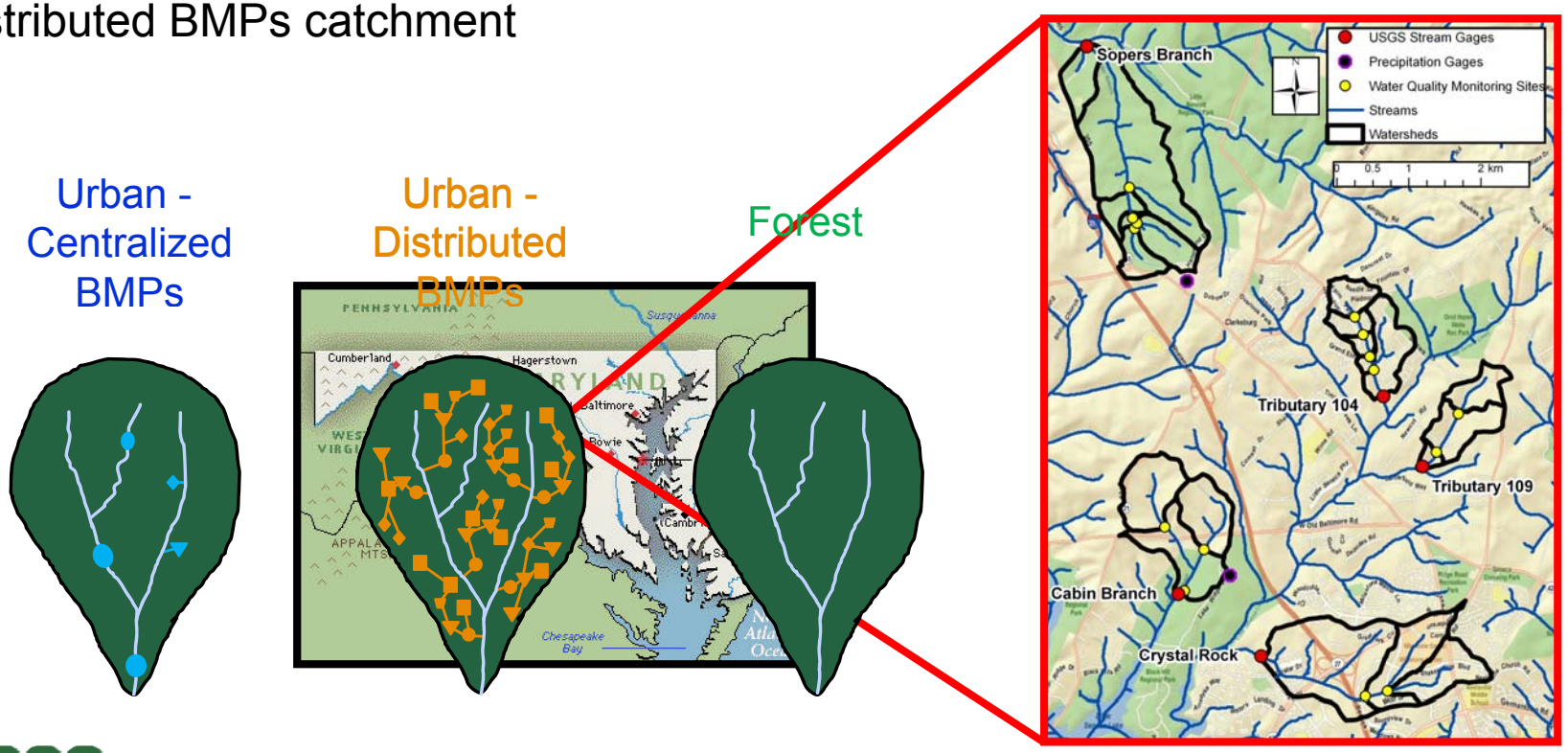
Study location and design

- Study Sites: Montgomery County, Maryland
- Located in Chesapeake Bay Watershed
- Paired watershed study
- Study period spans development process and BMP implementation in distributed BMPs catchment
- catchments comprise Clarksburg Special Protection Area

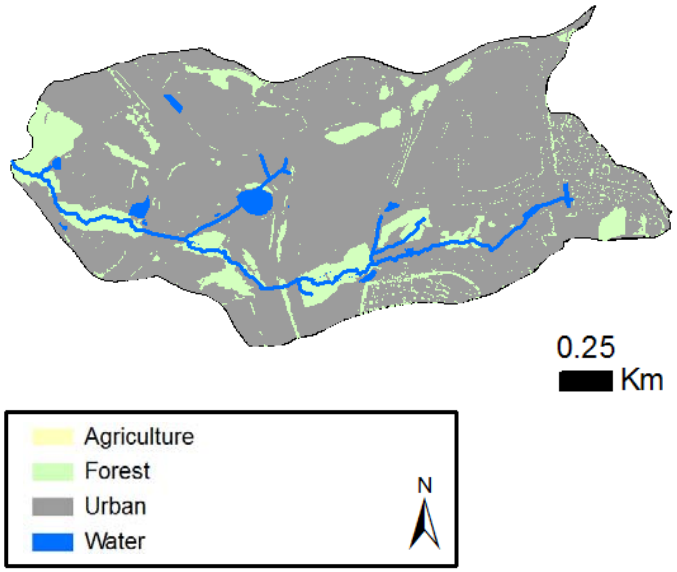


Figures modified from Loperfido and Hogan (2012), USGS Fact Sheet 2012-3079

Centralized versus distributed BMPs

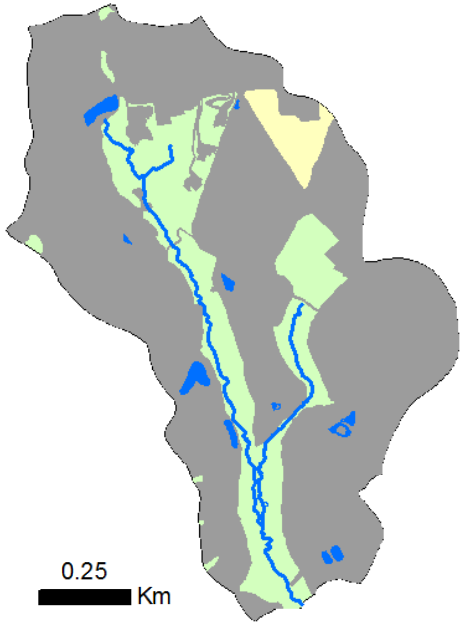
Centralized BMPs

-located instream or directly adjacent to stream
-treat larger areas



Distributed BMPs

-located on the landscape
-often connected in series
-protected riparian zone



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Figures modified from Loperfido et al. (in review), submitted to *Journal of Hydrology* Jul 5, 2012; data from 2011

Development effects on water quality and quantity

- Best available sediment & erosion control (S&EC) BMPs used during development of Distributed BMPs catchment
- Depressed IBI scores during peak development indicate distributed S&EC BMPs did not prevent stream impacts from urbanization
- Distributed BMPs resulted in increased streamflow during development

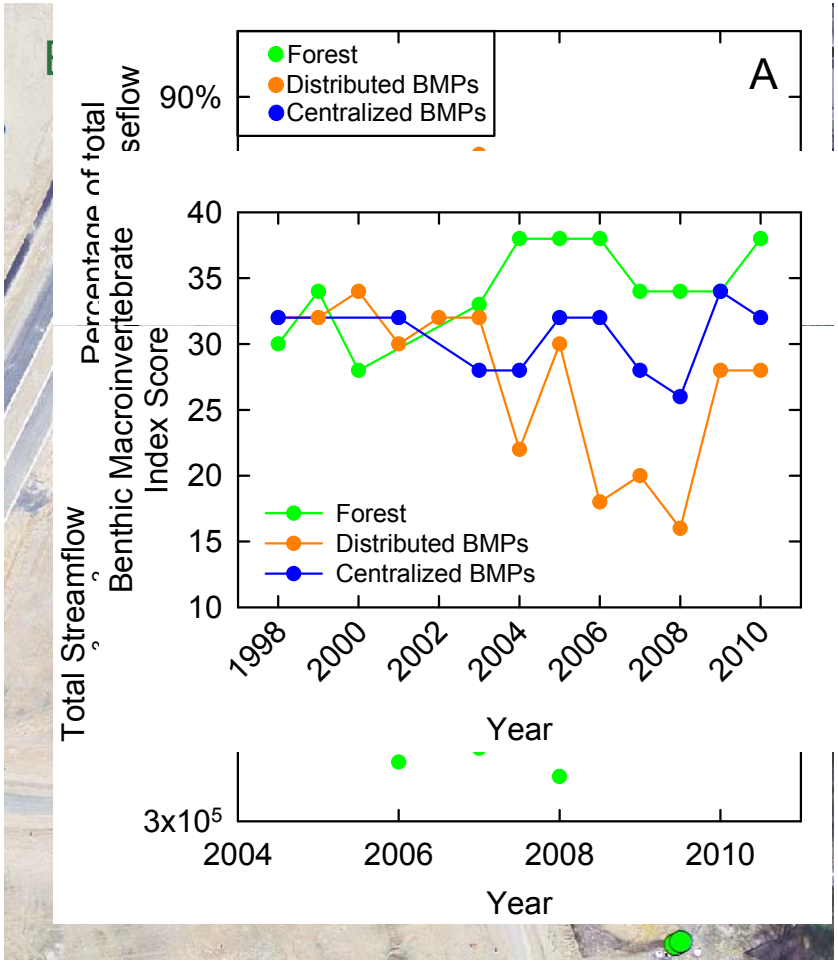

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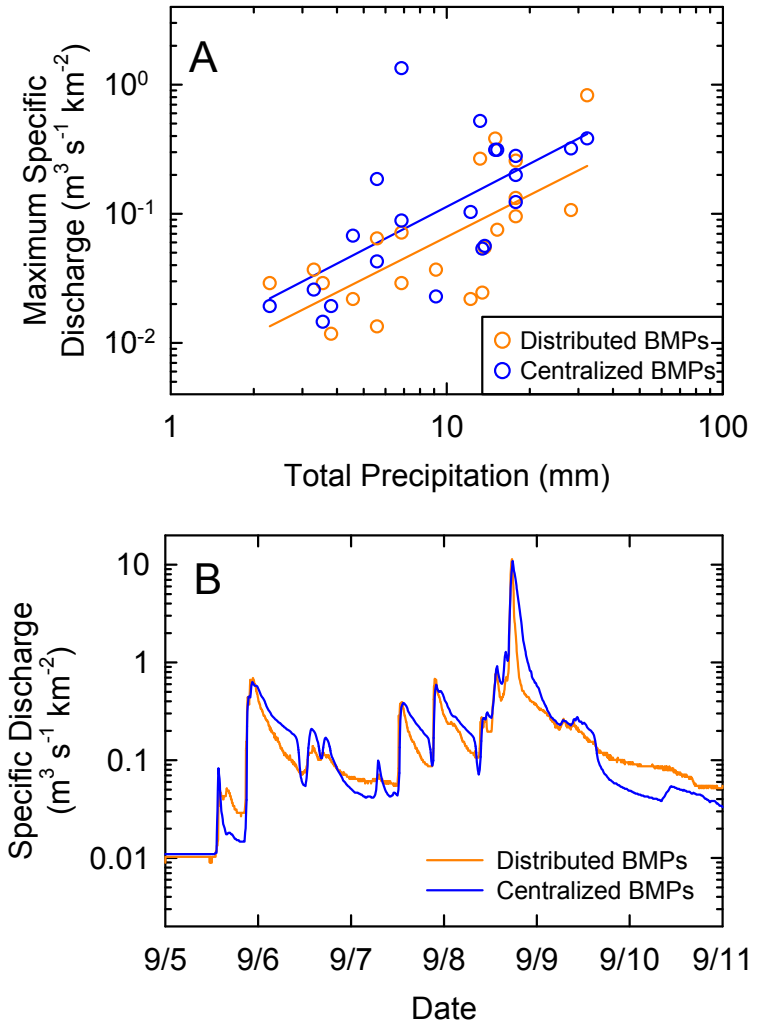
Figure modified from Hogan et al. (in review), submitted to *Journal of the American Water Resources Association*.

Water quantity effects of stormwater BMPs – post development

- Water quantity improvements provided by Distributed BMPs as compared to Centralized BMPs
  - A. Decreased maximum discharge during typical precipitation events
  - B. Reduced water export as peak discharge during extreme precipitation (Tropical Storm Lee, 2011)
  - Overall more 'consistent' discharge



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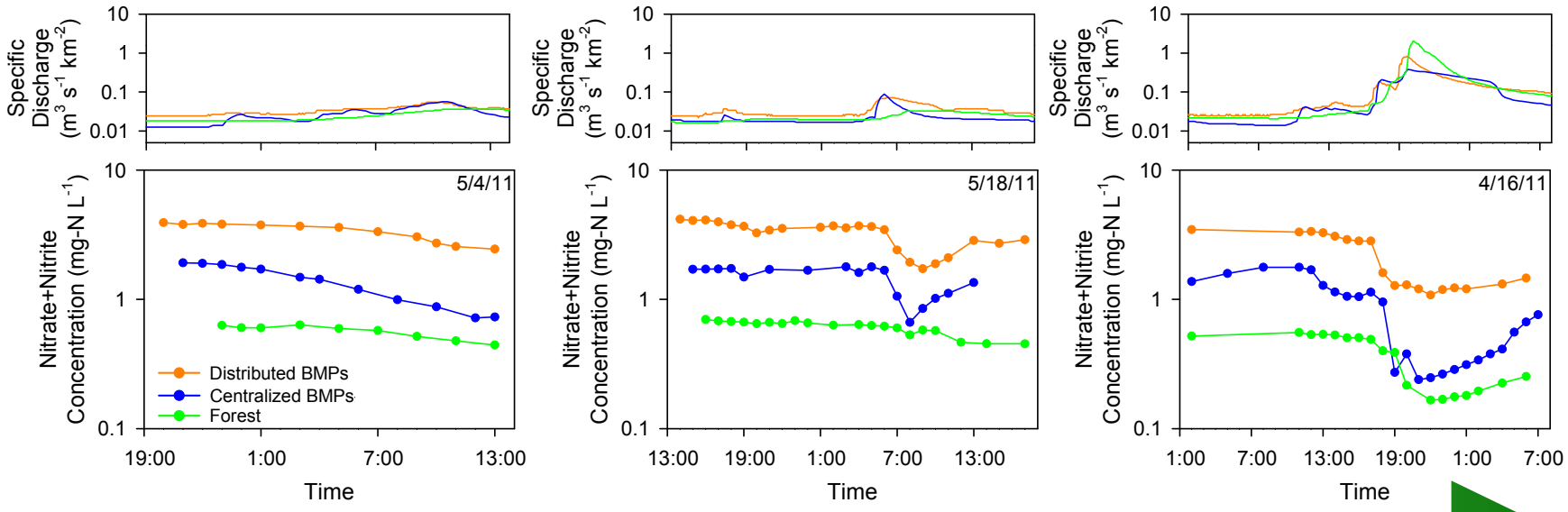
Catchment-scale water quality effects of stormwater BMPs

- Preliminary analyses indicate impacts of *stormwater BMP configuration*



9.1 mm hr^{-1}
Maximum Precipitation Intensity

28 mm hr^{-1}

61 mm hr^{-1}

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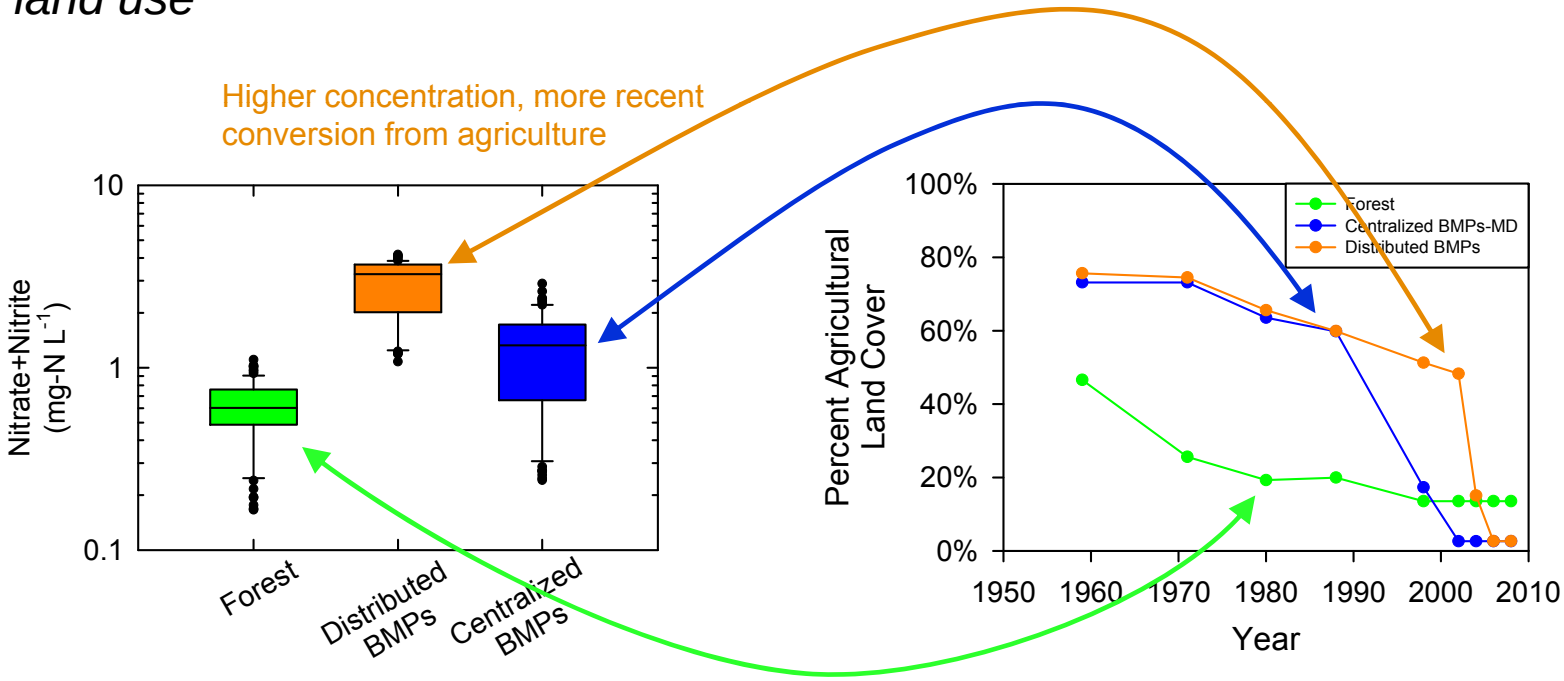
Catchment-scale water quality effects of stormwater BMPs

- Preliminary analyses indicate impacts of stormwater BMP configuration and *historical land use*



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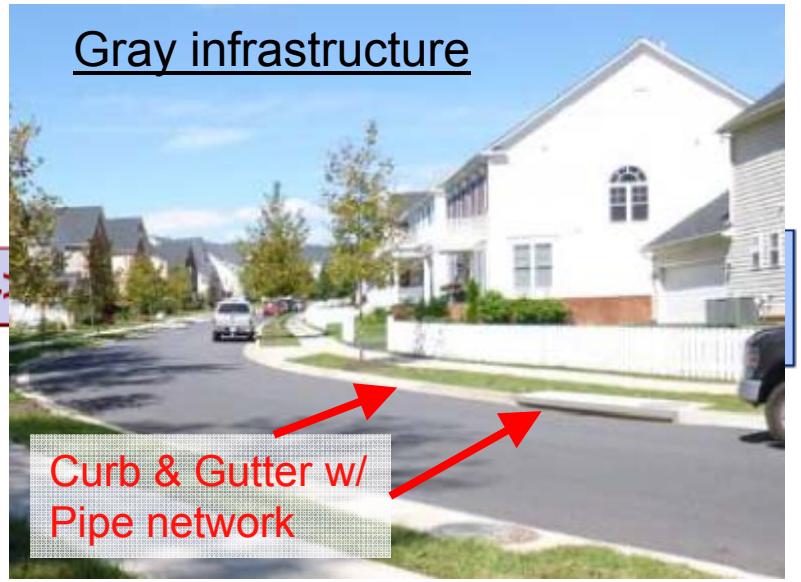
Distributed BMP treatment train monitoring

- Monitoring is underway to examine the effect of gray infrastructure vs. green infrastructure on distributed BMP treatment train performance

Green infrastructure

Gray infrastructure



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Research led by Taylor Jarnagin and Yusuf Mohamoud – US EPA

Preliminary Stormwater Management Implications

- Discharge from Distributed BMPs more consistent
  - Increased baseflow and reduced peak discharge (duration and water yield) → more favorable ecological conditions or more stable stream banks
  - Reduced discharge during extreme events could reduce flooding that may be associated with future shifts in climate

- Water Quality
  - Historical land use should be considered when selecting watersheds for urban development due to legacy nutrients from fertilizer application on agricultural lands

- Distributed sediment and erosion control BMPs
  - Did not appear to eliminate stream impacts due to urbanization (i.e. declining IBI scores)

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Questions

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