Lessons from Chesapeake Bay Restoration Efforts:

Understanding the role of nutrient reduction activities in improving water quality

Chesapeake Bay Program
A Watershed Partnership

Scientific, Technical Assessment and Reporting (STAR) Team Meeting
April 25, 2013

Liza Hernandez and Christina Lyerly
University of Maryland Center for Environmental Science at the Chesapeake Bay Program

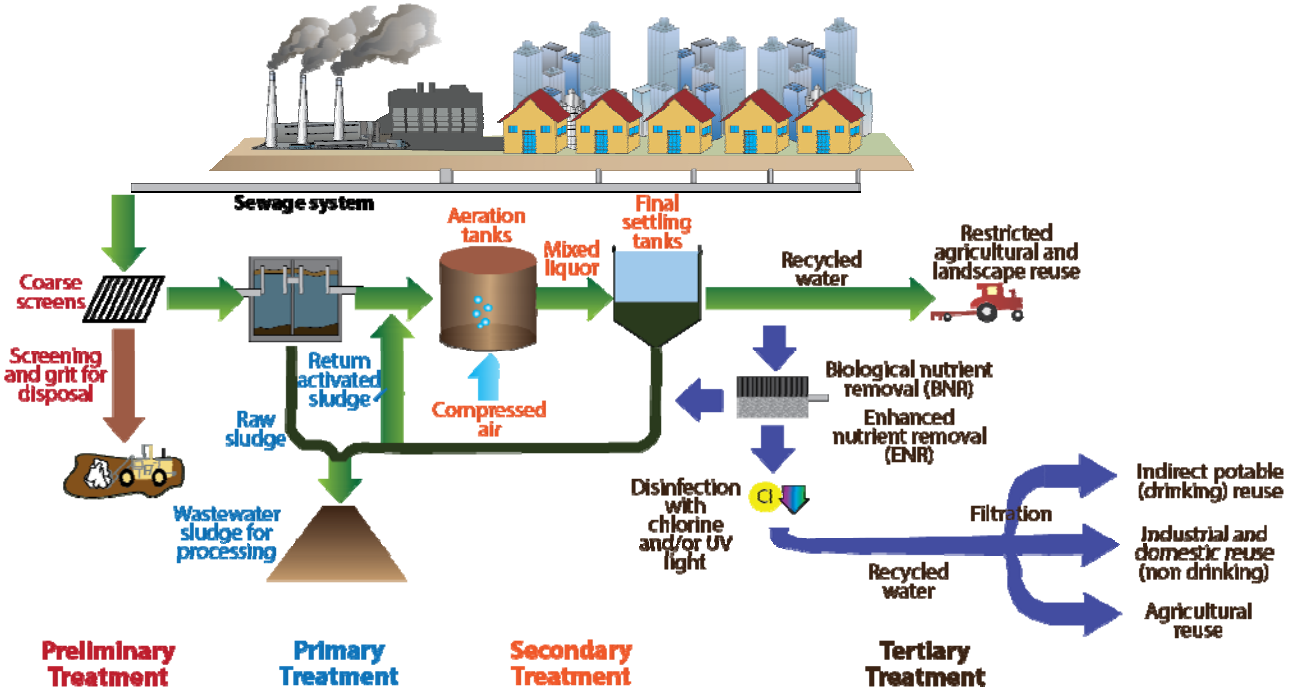
Graphics by Brianne Walsh

Lesson Categories

Contents

Lesson 1

- Upgrades in both nitrogen and phosphorus waste water treatment result in rapid local water quality improvements



Case Studies

- Back River Estuary
- Gunston Cove
- Potomac River
- Mattawoman Creek
- Patuxent River

Photo credit: Alexandra Fries, IAN Image Library

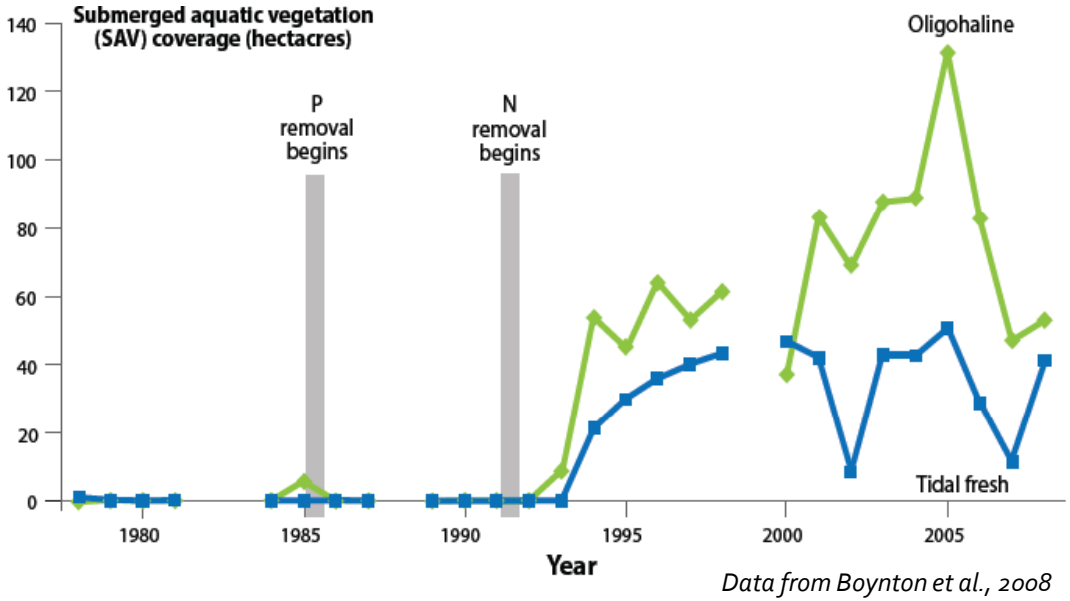
Photo credit: Cassie Gurbisz , UMCES

Lesson 1

Upper Patuxent River

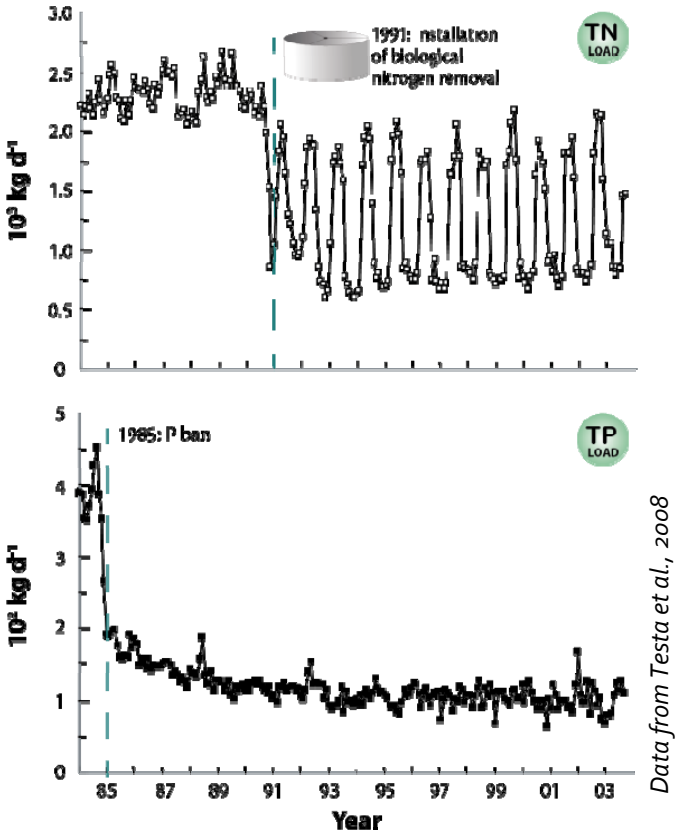
- Nutrient removal upgrades at WWTPs
- Decreases in phytoplankton, N and P
- Increases in SAV

Changes in SAV (1978-2008)



Data from Boynton et al., 2008

Changes in TN and TP Concentrations (1984-2004)



Data from Testa et al., 2008

Lesson 2

- Reductions of agricultural nutrient sources result in improved stream quality

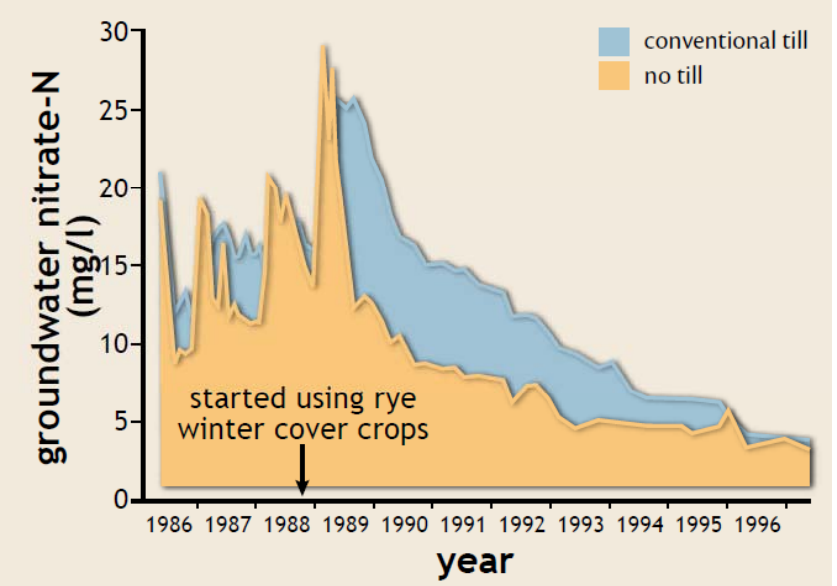
Pre-treatment photo, May 1996

Post-treatment photo, May 1998

Big Spring Run: Riparian areas pre- and post-cattle stream exclusion and riparian replanting (Galeone et al. 2006).

Cover Crops

- Wye River drainage basin
- Decreased nitrate concentrations in shallow groundwater and deeper subsurface flow
- Decreased subsurface nitrate discharge into the river



Average groundwater nitrate-nitrogen (N) concentrations under two adjacent corn fields. Rye cover crops were planted after corn harvest starting in 1988 (Staver, 1995)

Lesson 2

Fertilizer & Manure Management

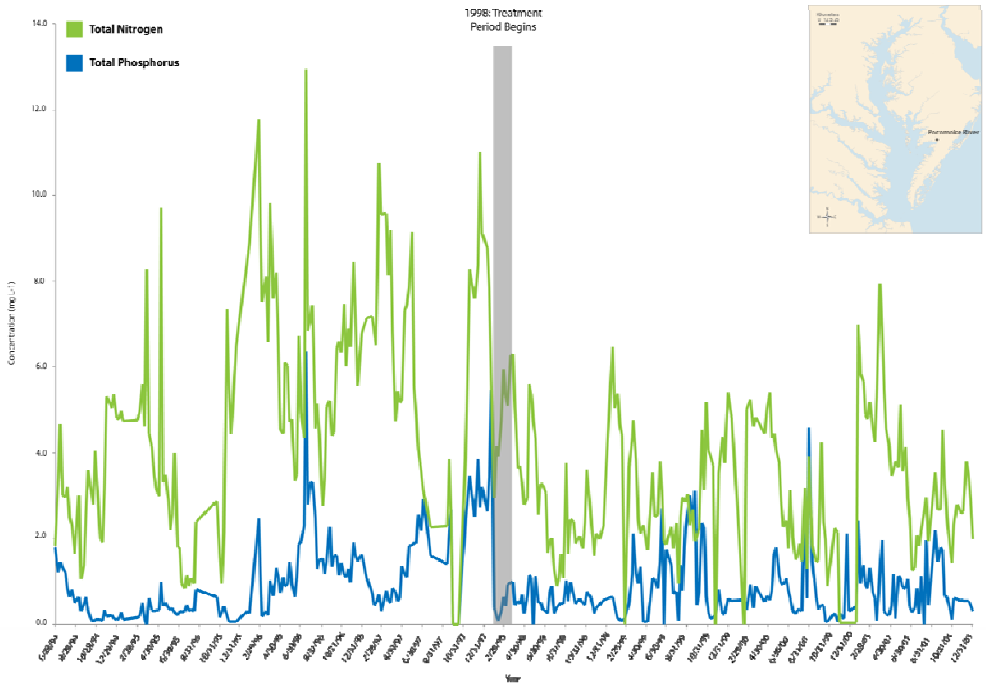
- Brush Run Creek (lower Susquehanna River)
- Reduced application of P in commercial and manure fertilizer
- Decreased P concentrations at three water quality gauges

Photo credit: Ben Fertig, IAN Image Library

Fertilizer & Manure Management

- Upper Pocomoke River watershed
- Exported all poultry litter
- Planted cover crops on all available cropland
- Significantly reduced total N concentrations, but not P concentrations

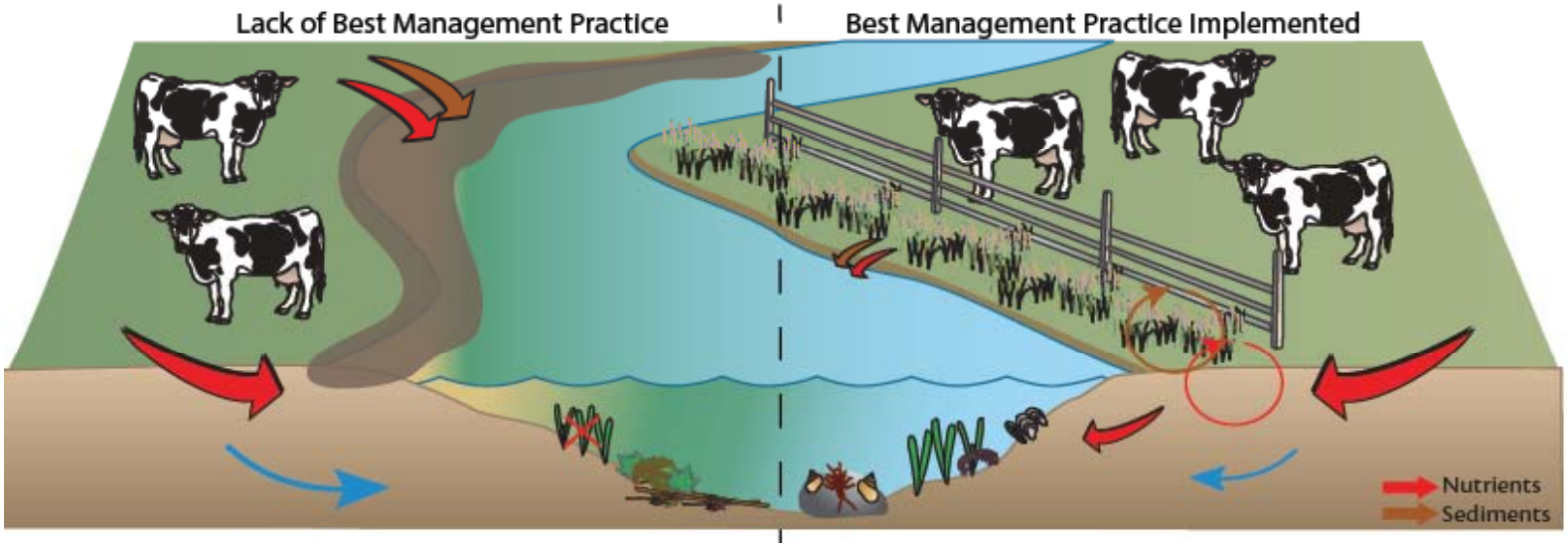
TN and TP Concentrations (1994-2002)



McCoy, 2010

Stream Bank Fencing

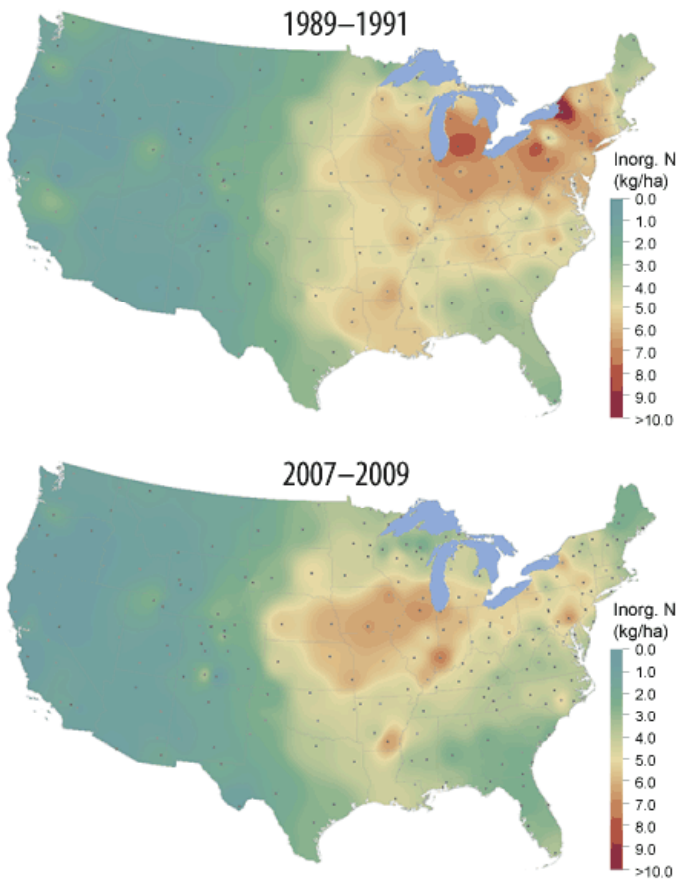
- Excluded cattle
- Riparian vegetation growth
- Reduced suspended sediment loads
- Improved instream habitat
- Reduced nutrients and improved aquatic life



Lesson 3

- Improvements in air quality have led to reductions in atmospheric nitrogen deposition

Annual Mean Wet Inorganic Nitrogen Deposition



EPA Clean Air Markets: 2009 Results

Point Source Air Emissions

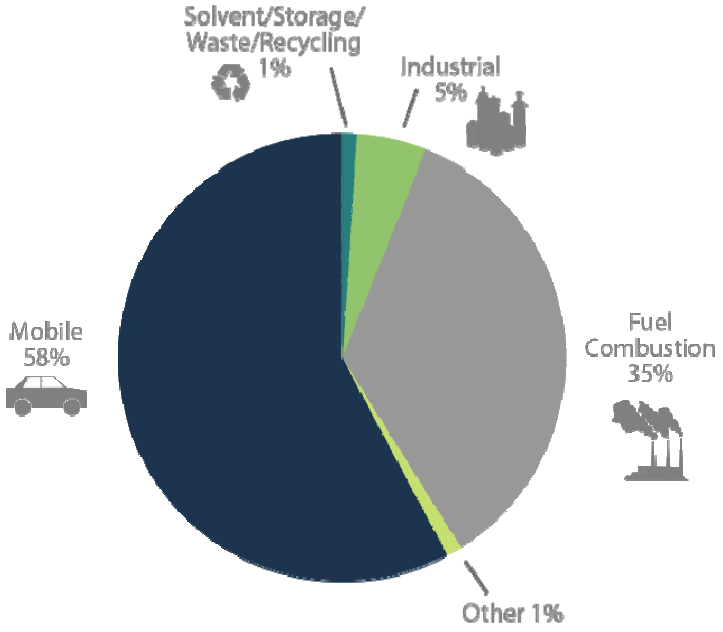
- 20 years of point source air emission reductions
- 30% decrease in nitrate loads from atmospheric deposition to the Bay watershed
- Electric generating units of particular importance

Photo Credit: Adrian Jones, IAN Image Library

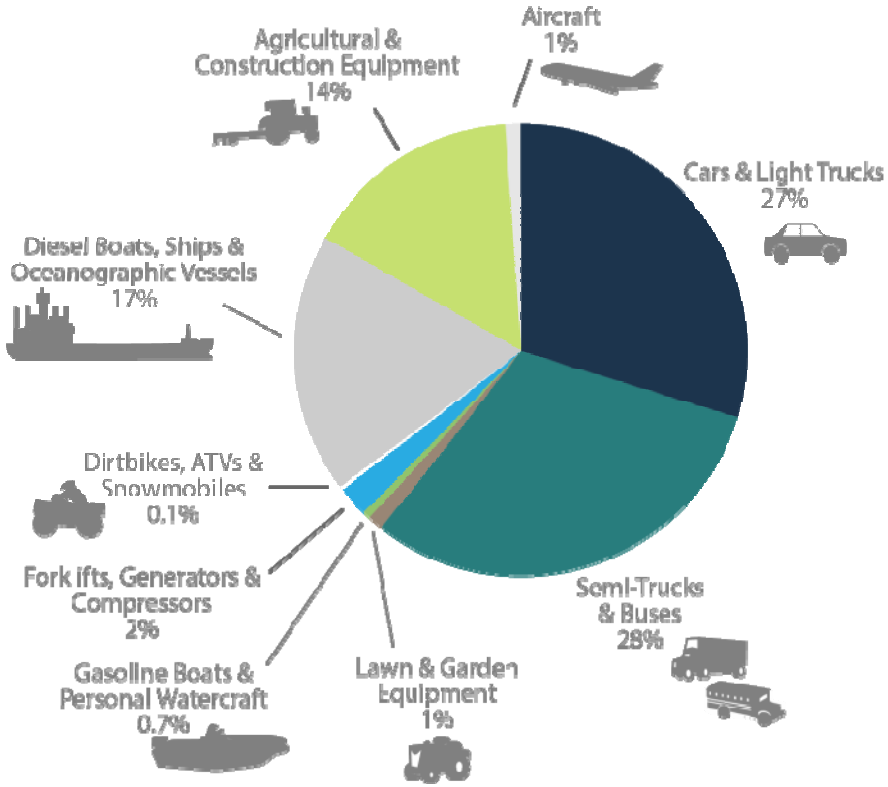
Diffuse Air Emissions

Mobile sources – 58% of NOx emissions

U.S. NOx Emissions by Category (2006)



Mobile Sources of NOx Emissions by Sector (2007)



Adapted from EPA Vehicle Compliance Report, 2007

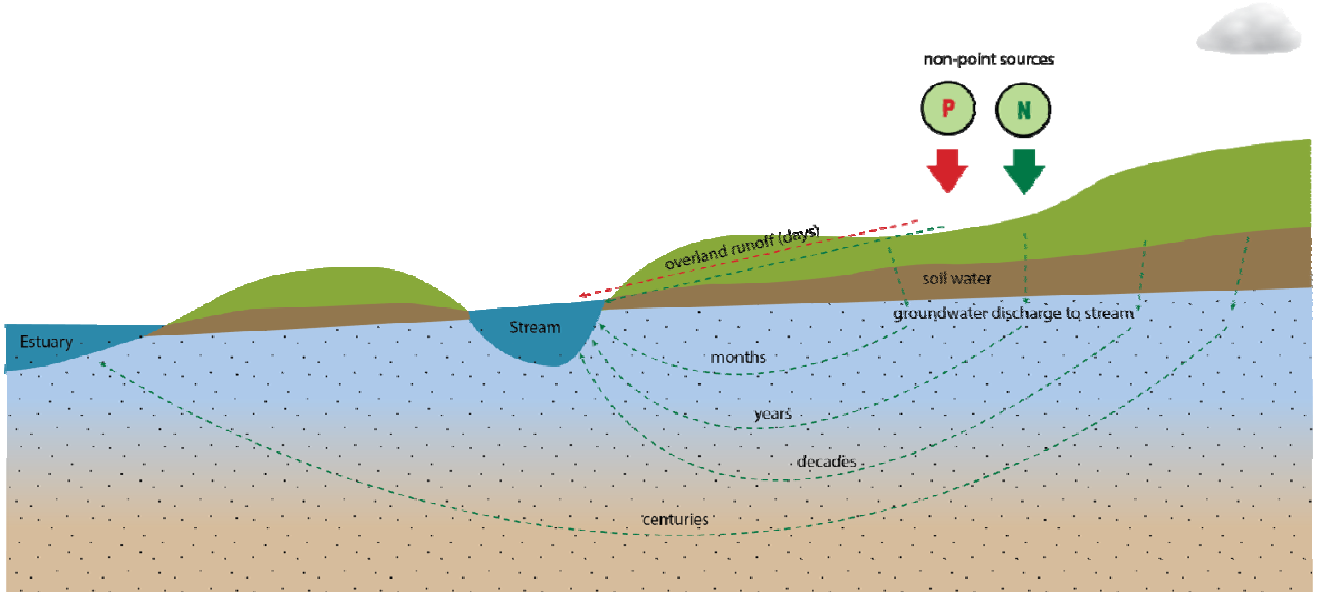
Diffuse Air Emissions

- Gas emissions from the volatilization of animal waste

Photo Credit: Ben Furtig, IAN Image Library

Lesson 4

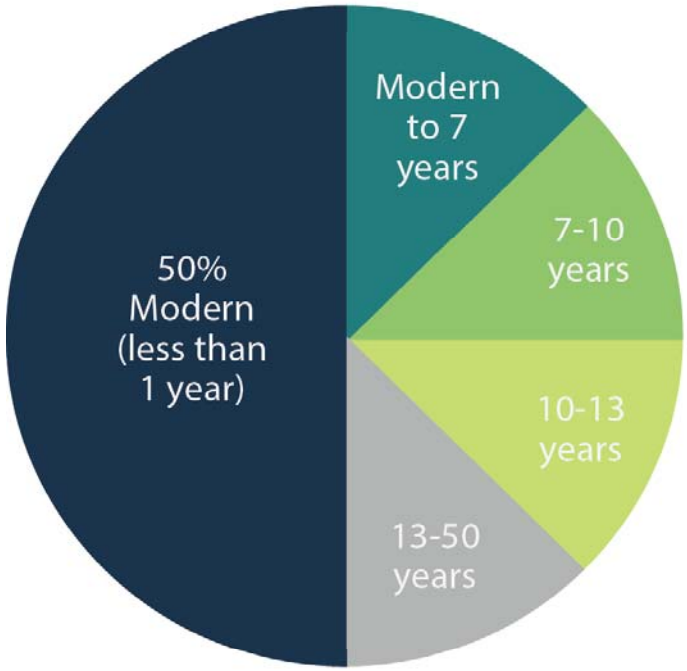
- Many practices provide initial water quality improvements in runoff; however, full benefits to stream conditions can be delayed



Groundwater Return Time

- Groundwater age will affect the timing of water quality improvements after N loads are reduced
- Practice: Reduce the amount of N reaching groundwater (cover crops)
- Practice: Consider lag times when prioritizing BMP locations
- Goal: Shorter lag times → achieve TMDL benchmarks on time

Ages of Water Discharged to a Stream



Adapted from Phillips and Lindsey, 2003

Nutrient Storage in Sediments

- Sediments can store P and gradually release it
- Practice: Reduce P and sediment runoff (riparian buffers)
- Goal: Avoid lag times associated with long-term P storage in sediments

Photo Credit: Ben Furtig, IAN Image Library

Little Conestoga Creek

- Manure and fertilizer management was implemented
- Nutrient concentrations remained constant
- Nutrient concentrations in surrounding non-managed areas increased
- Full benefits of BMPs may not be achieved for several years after implementation

Lesson 5

- Improvements in water quality can be counteracted by other nutrient sources and changes in land-use practices

Photo credit: Alexandra Fries, IAN Image Library

Increases in Stormwater

- Choptank River
- Large reductions in WWTP loads

Photo credit: Allison Dungan, IAN Image Library

- Expanding population on Maryland's Eastern Shore
- Increased agricultural nutrient inputs
- Increased stormwater runoff
- No improvement in water quality

Lesson 5

Changes in Farming Practices

- Fertilizer rates
- Types of farming
- Ditch management

Photo credit: Ben Fertig, IAN Image Library

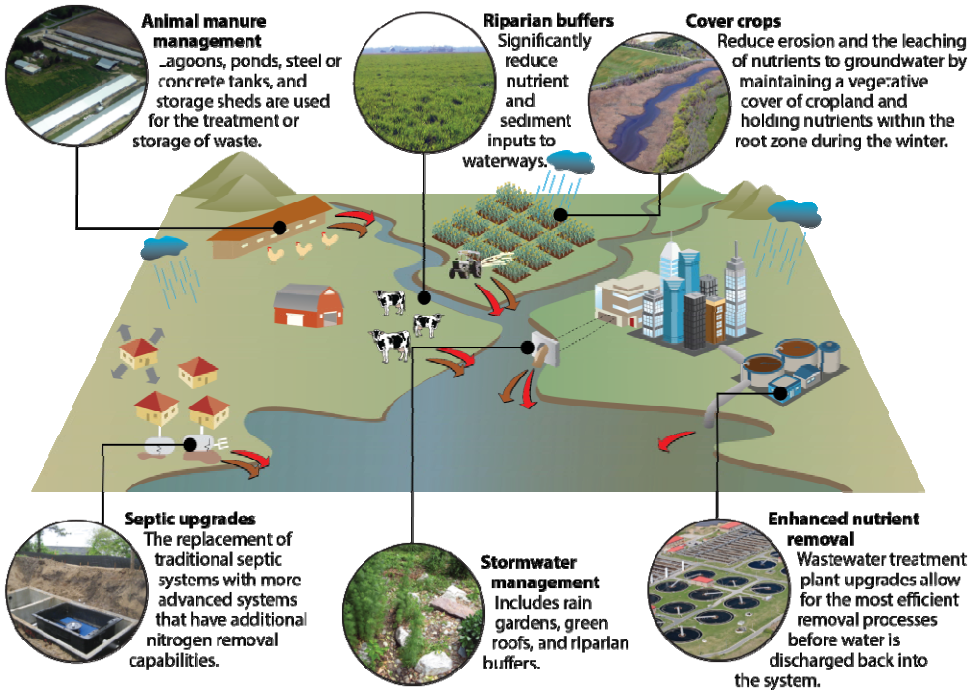
Patuxent River

- WWTP upgrades
- Limited improvements in the mesohaline region
- Decreases in water quality in the lower polyhaline region
- Nonpoint sources from cropland is the most important contributing factor

Photo credit: Jane Thomas, IAN Image Library

Lesson 6

- Observable water quality responses are more likely to occur if A) location specific sources of pollution are **identified** and B) **targeted** practices are implemented.



Targeted Practices

- Corsica River Watershed
- Aggressive implementation of multiple nutrient reduction practices – point sources and nonpoint sources
- Improvements in water quality in the nontidal streams

Photo credit: Corsica Targeted Watershed Initiative Progress Report: 2005-2011

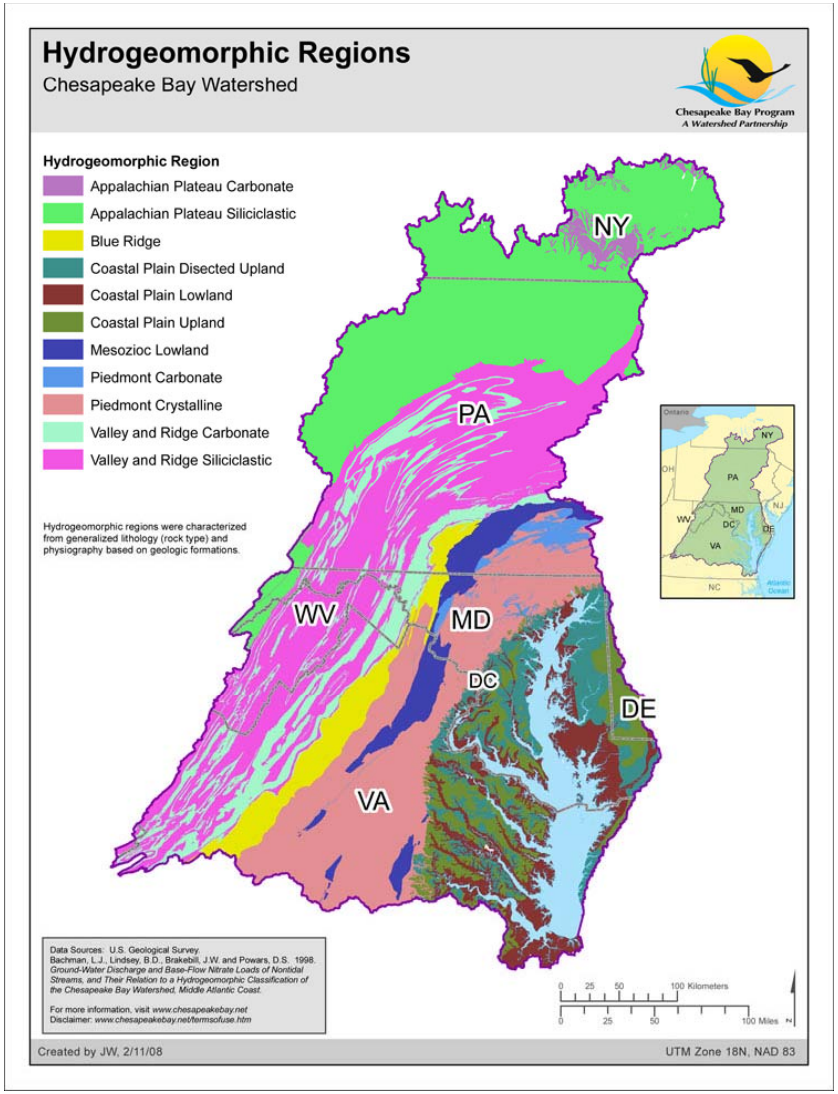
Stream Location

- Anne Arundel County, MD
- Mixed results
  - Upland vs. lowland
  - Flow dependent

Photo credit: Jane Hawkey, IAN Image Library

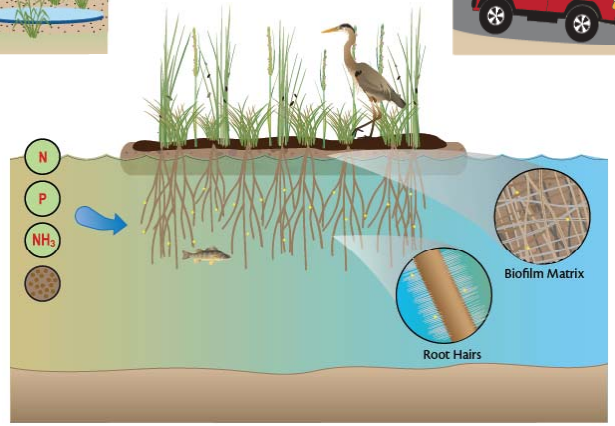
Physiographic Provinces

- Broad regional differences
  - Coastal Plain
  - Piedmont
  - Appalachian Mountain



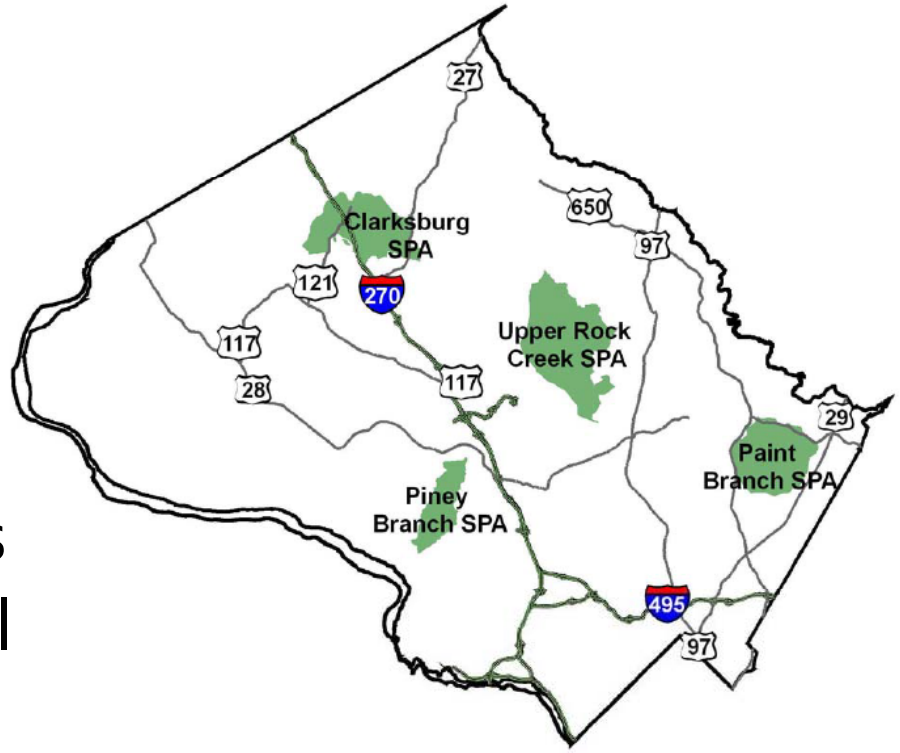
Lesson 7

- An array of practices to promote stormwater infiltration and retention are needed in urban and suburban areas



Montgomery County

- Combinations of different stormwater BMPs
- Multiple redundant BMPs
- Reduced stormwater runoff and nutrient loads
- No response in biological communities



Source: Montgomery County Special Protection Area Annual Report 2009

Fairfax County

- Comparison:
  - Sophisticated stormwater BMPs
  - Traditional stormwater basins
- Sophisticated stormwater BMPs removed and retained greater soil P and sediments

Fairfax County Watersheds

Source: www.fairfaxcounty.gov

Recommendations

1. **Monitoring and assessment** should accompany management implementation of nutrient and sediment controls. Quantitative monitoring is crucial for rigorous assessment of effectiveness of various management practices

Recommendations

2. **Evaluate management practice effectiveness** in a variety of settings to develop recommendations on best practices
3. **Use adaptive management** by incorporating the findings of monitoring and evaluation in which the results inform the planning and protocols for future management practices

Thank You

- Questions?
- Comments?
- Suggestions?