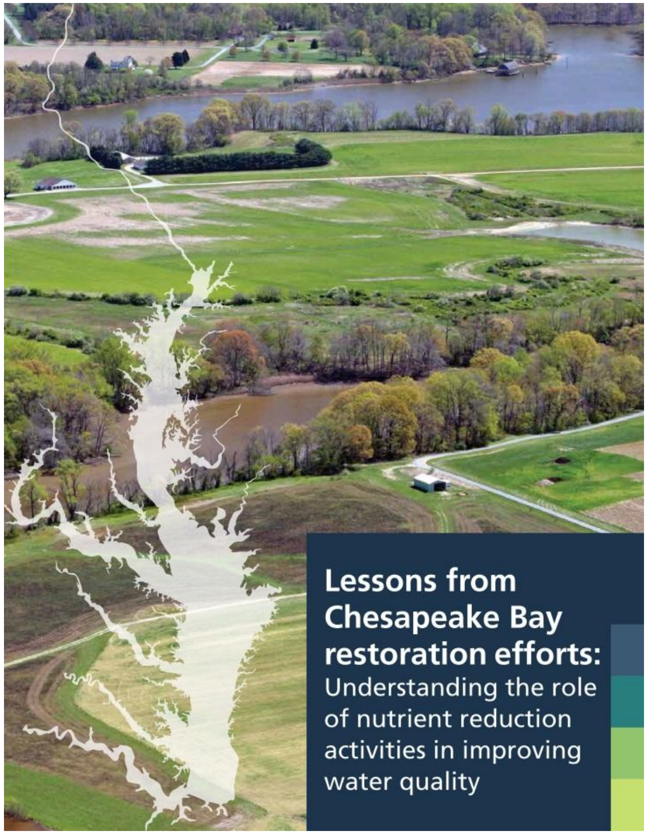

Lessons from Chesapeake Bay restoration efforts:
Understanding the role of nutrient reduction activities in improving water quality

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Nontidal Water Quality Workgroup Meeting
November 20, 2013

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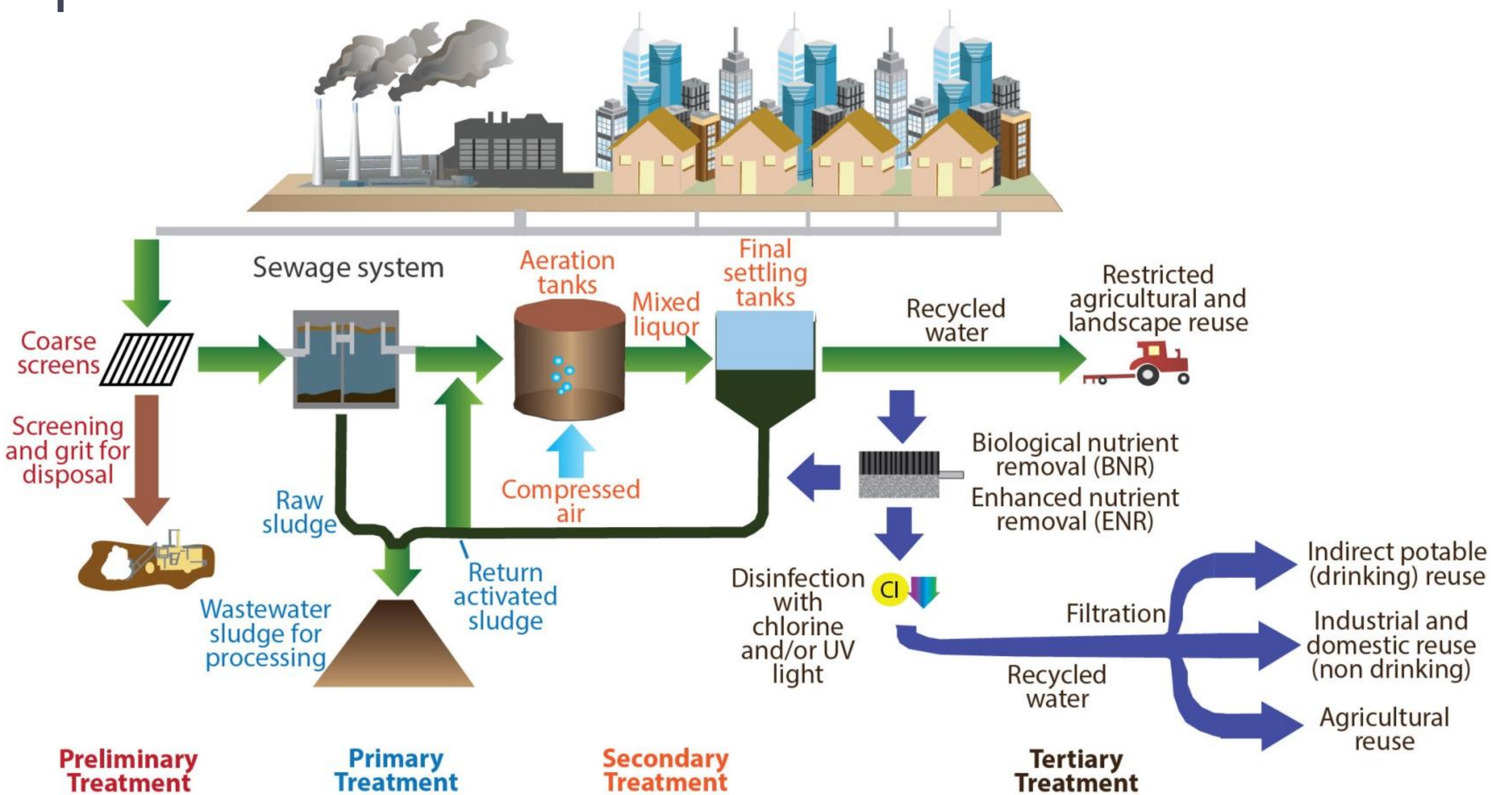
Lessons from Chesapeake Bay Restoration Efforts

- Seven lessons under three broad categories:
  1. **What Works**
  2. **Challenges**
  3. **What We Need**
- Presented at the Coastal and Estuarine Research Federation conference (November 5th)
- Accepted as a poster presentation at the December 2013 Maryland Water Monitoring Council conference
- Scheduled for release January 2014

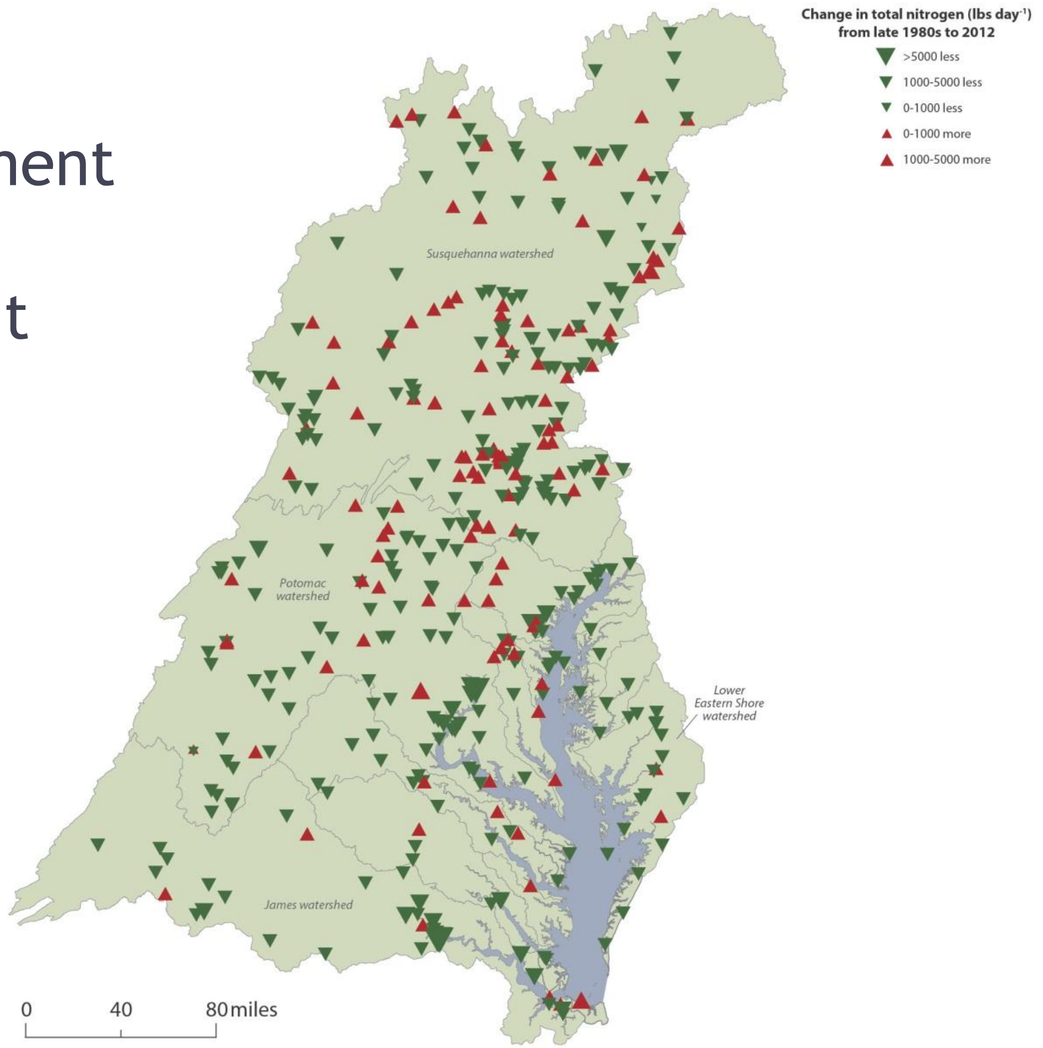
Lesson 1

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



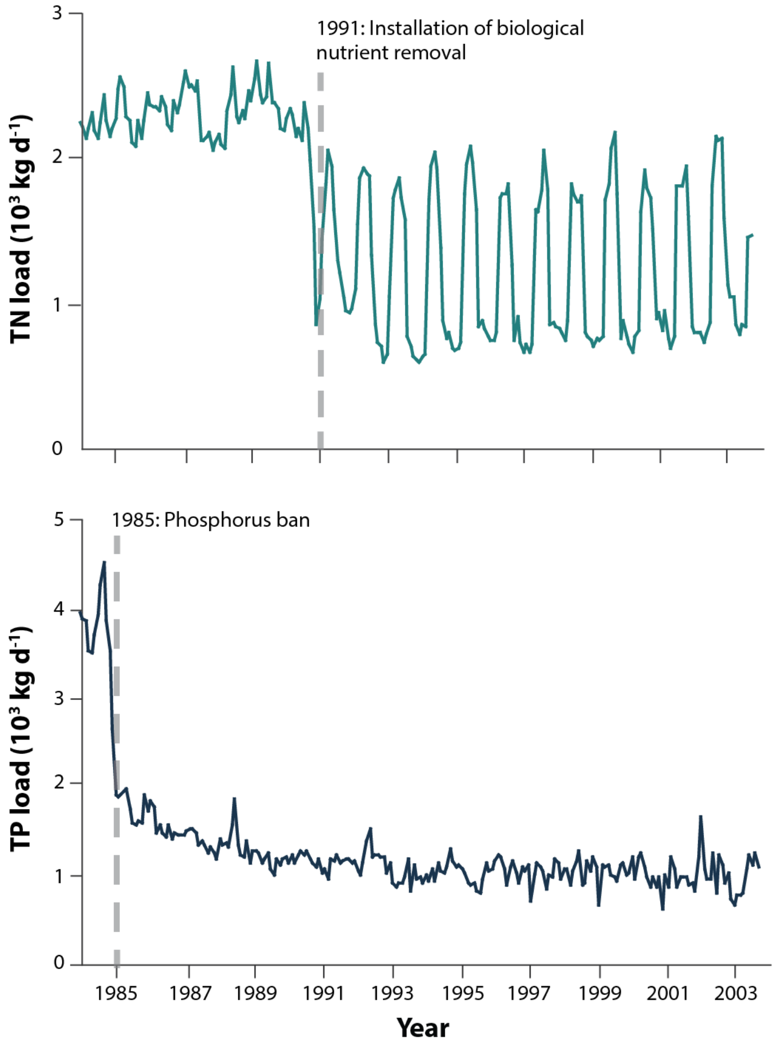
Trends in Wastewater Treatment Plant Loads

- Wastewater treatment plants yet to be upgraded represent opportunities for continued improvement



Upper Patuxent River

- Upgrades to a wastewater treatment plant reduced nitrogen loads to the Upper Patuxent River



Changes in TN and TP loads (1984-2004)

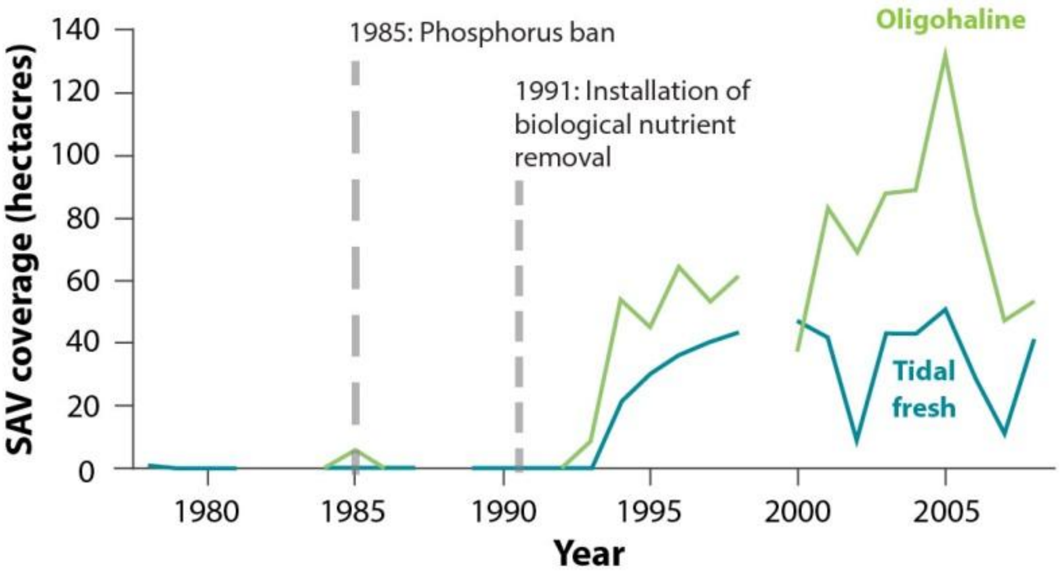
Data from Testa et al., 2008

Upper Patuxent River

- Decreased wastewater treatment plant nutrient loads contributed to a resurgence of submerged aquatic vegetation

Vallisneria americana *(wild celery). Photo © Cassie Gurbisz*

Changes in SAV (1978-2008)

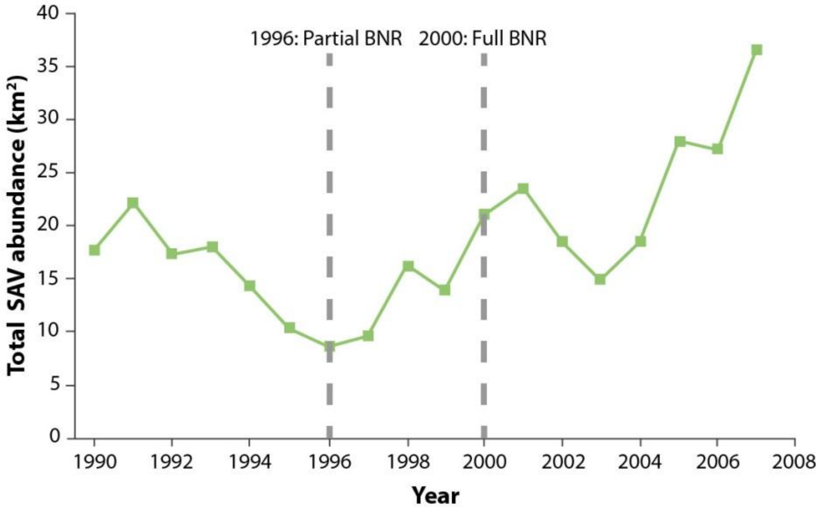


Data from Boynton et al., 2008

Upper Potomac River

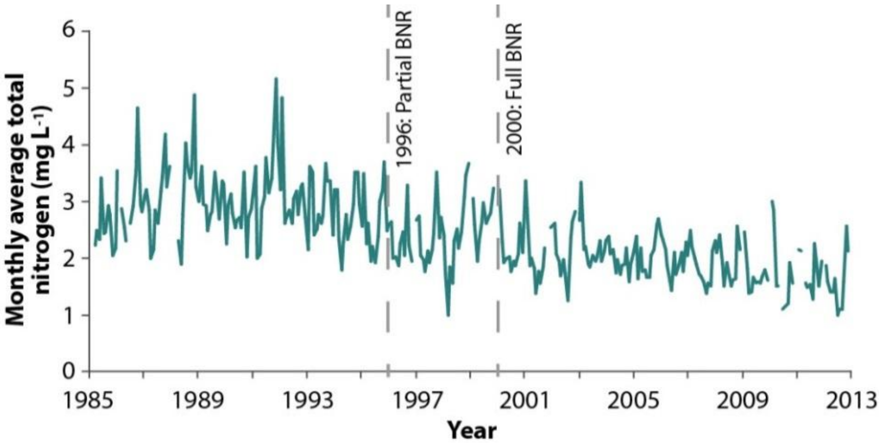
- Submerged aquatic vegetation abundance increased
- Total nitrogen concentrations decreased at the Piscataway Creek monitoring station

Changes in total SAV abundance in the Upper Potomac River (1990–2008)



Data from Ruhl and Rybicki, 2010

Changes in mean monthly surface TN concentrations at a monitoring station near Piscataway Creek (1985–2013)

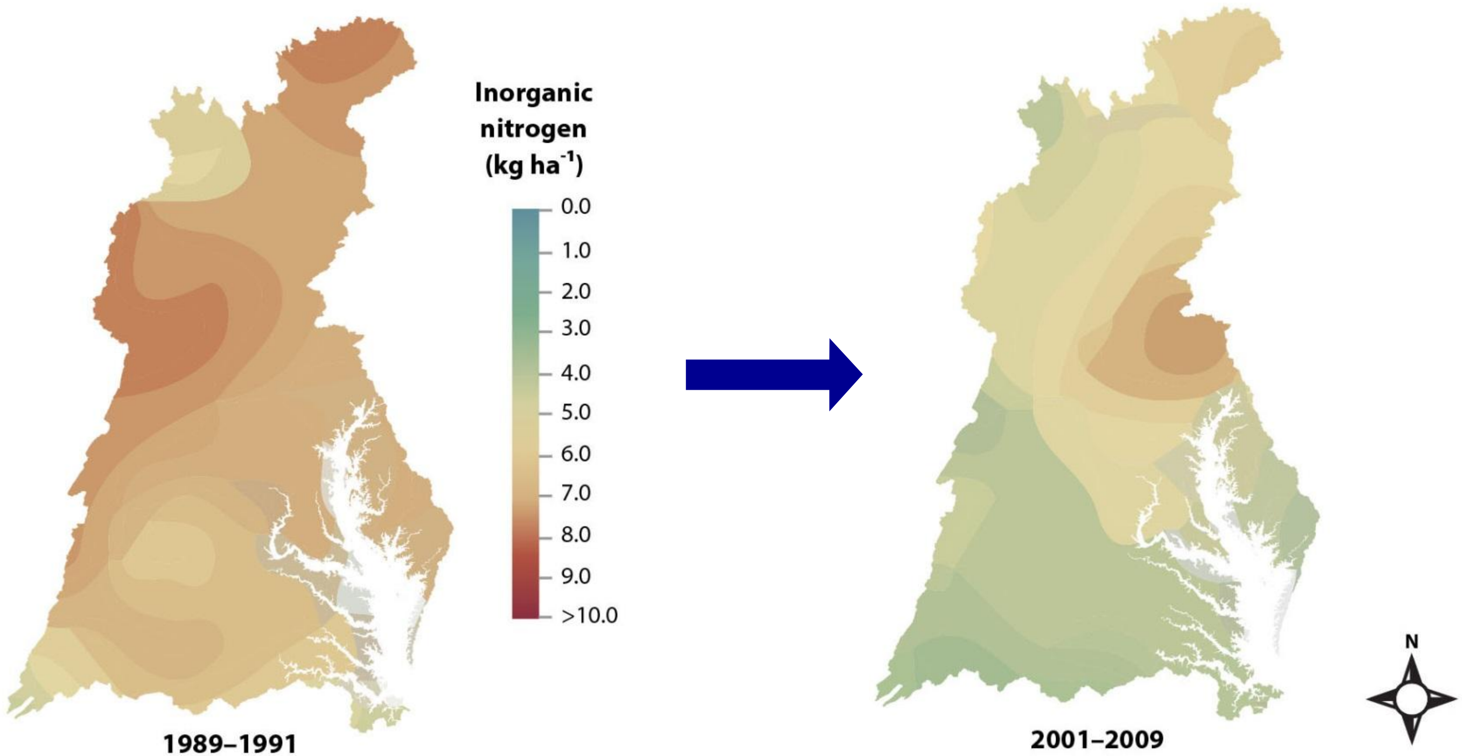


Data from Romano and Buchanan, 2011

Lesson 2

- Improvements in air quality lead to reductions in atmospheric nitrogen deposition

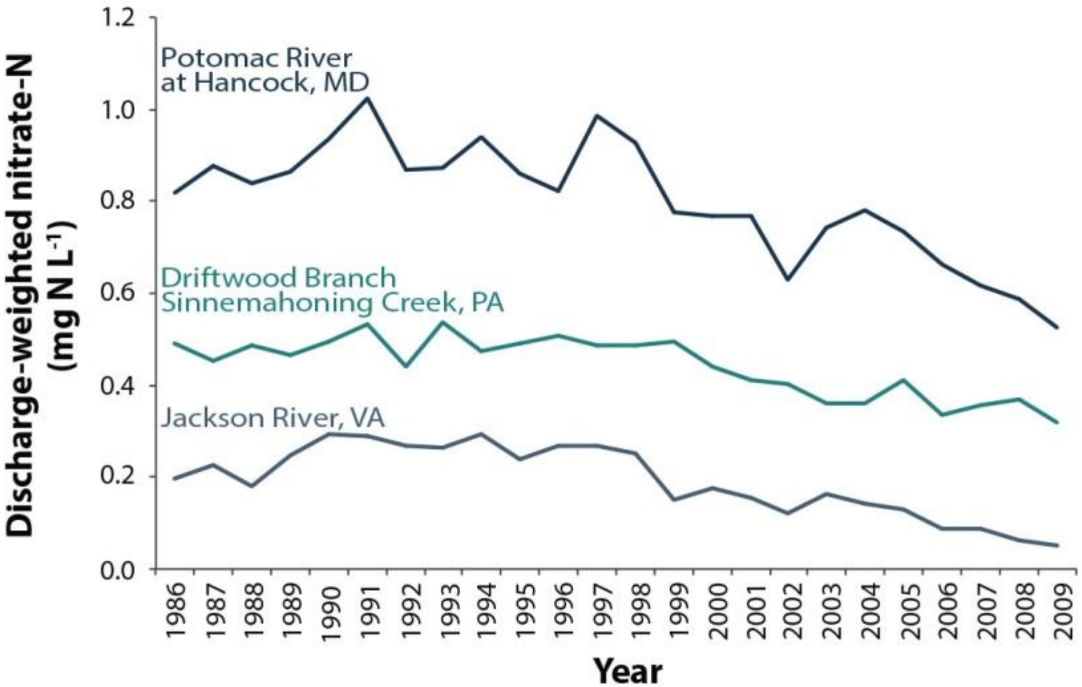
Annual mean wet inorganic nitrogen deposition



US EPA Clean Air Markets: 2009 Results

Point Source Emissions and Surface Water Quality

- Decreases in atmospheric point source emissions and nitrogen deposition are linked to increased surface water quality in 9 mostly-forested subwatersheds



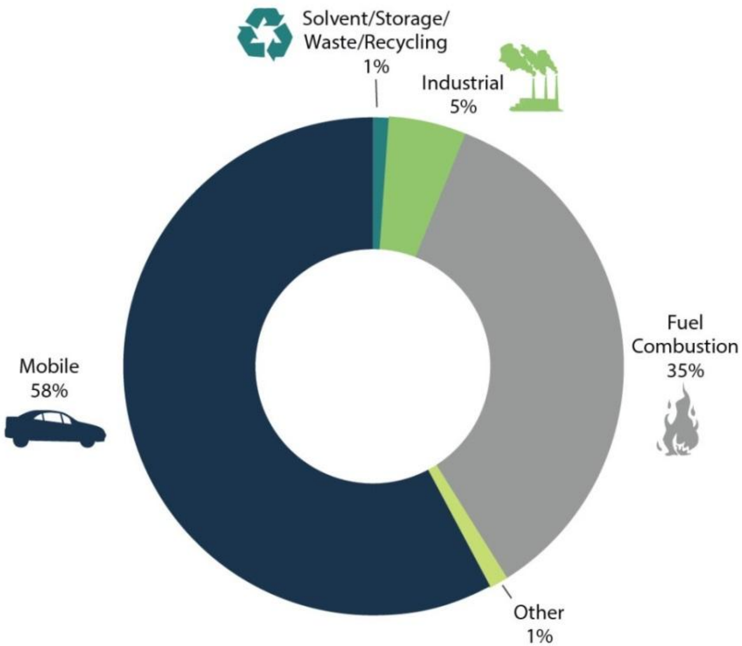
Changes in nitrate-N concentrations at 3 water quality monitoring stations (1986-2009)

Data from Eshleman et al., 2013

Nonpoint Source Emissions

- Mobile sources represent the majority of NO_x air emissions

U.S. NO_x emissions by category (2006)



Adapted from US EPA 2007 Progress Report: Vehicle and Engine Compliance Activities

Pre 1970s. Over concern from early smog studies in Los Angeles, CA, the catalytic converter was invented in the 1950s by Eugene Houndry, a French mechanical engineer living in the United States. Catalytic converters were further developed by John J. Mooney and Carl D. Keith, creating the first production catalytic converter in 1973.

1975. The U.S. EPA requires that all new cars be equipped with catalytic converters. These two-way converters combine carbon monoxide (CO) and unburned hydrocarbons (HC) to produce carbon dioxide (CO_2) and water (H_2O).

1981. To keep up with the Clean Air Act of 1970, a new generation of catalytic converters act as a three-way catalyst, converting carbon dioxide (CO_2) and hydrocarbons (HC) to water (H_2O), and reducing nitrogen oxides (NO_x) to elemental nitrogen (N) and oxygen (O).

Lesson 3

- Reductions of agricultural nutrient sources result in improved stream quality

Cover crops

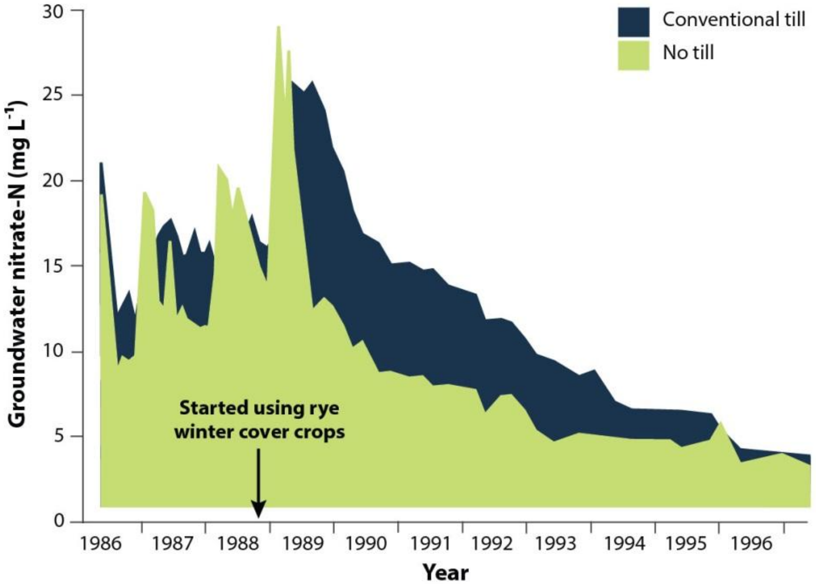
Livestock exclusion

Waste management

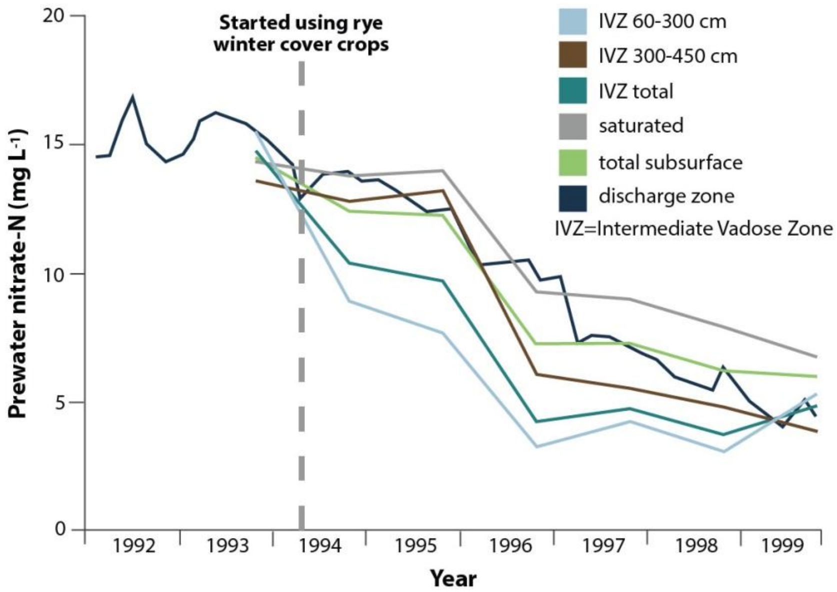
Photo © top left: Nicholas Tonelli, Flickr; top right: Jeff Vanuga, USDA NRCS; bottom: USDA.

Wye River Drainage Basin

- Winter cover crops planted in the Wye River drainage basin improved water quality



Changes in groundwater nitrate-N concentrations in 2 agricultural fields (1986–1998)



Changes in nitrate-N concentrations in different subsurface zones on an agricultural field (1992–1999)

Data from Staver and Brinsfield, 1995 & 2000

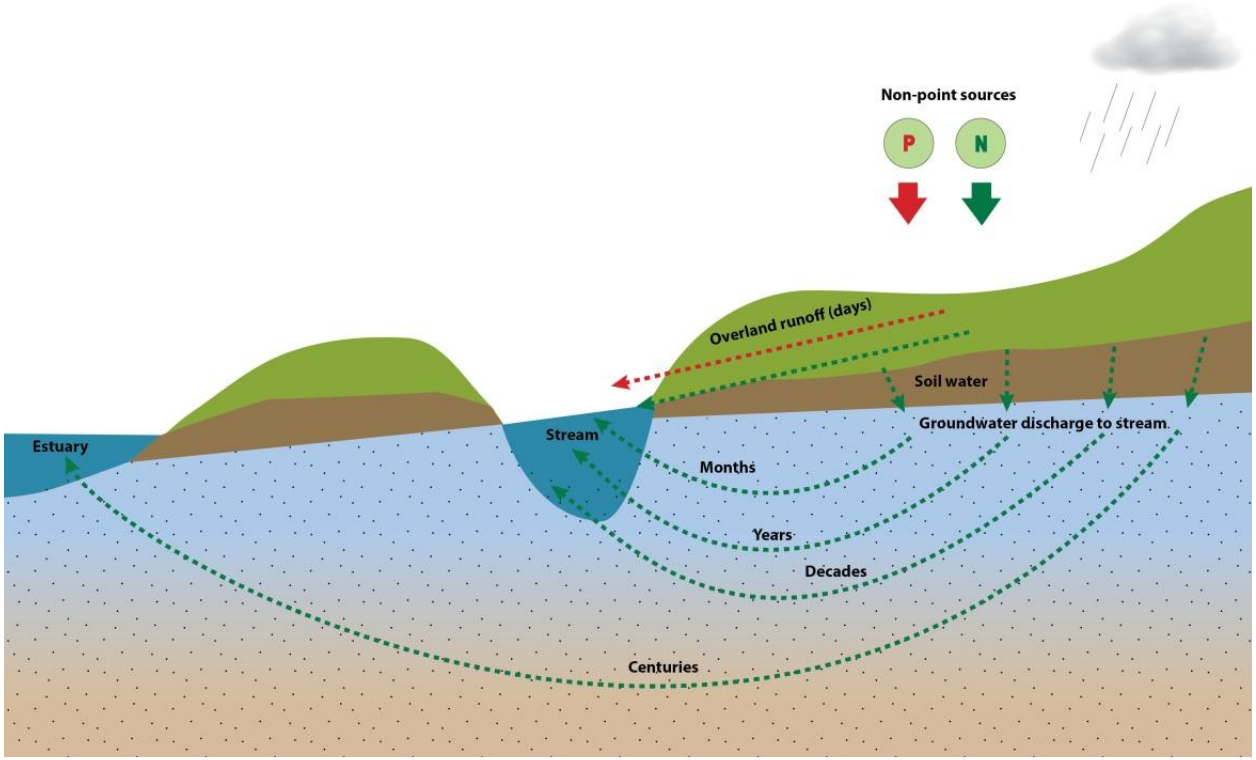
Practices for Further Study

- Rotational grazing may provide some benefits but has shown mixed results
- Cattle feed composition may influence the volatilization of ammonia from animal waste
- Ventilation construction may affect ammonia emitted from poultry houses

Photo © jlastras

Lesson 4

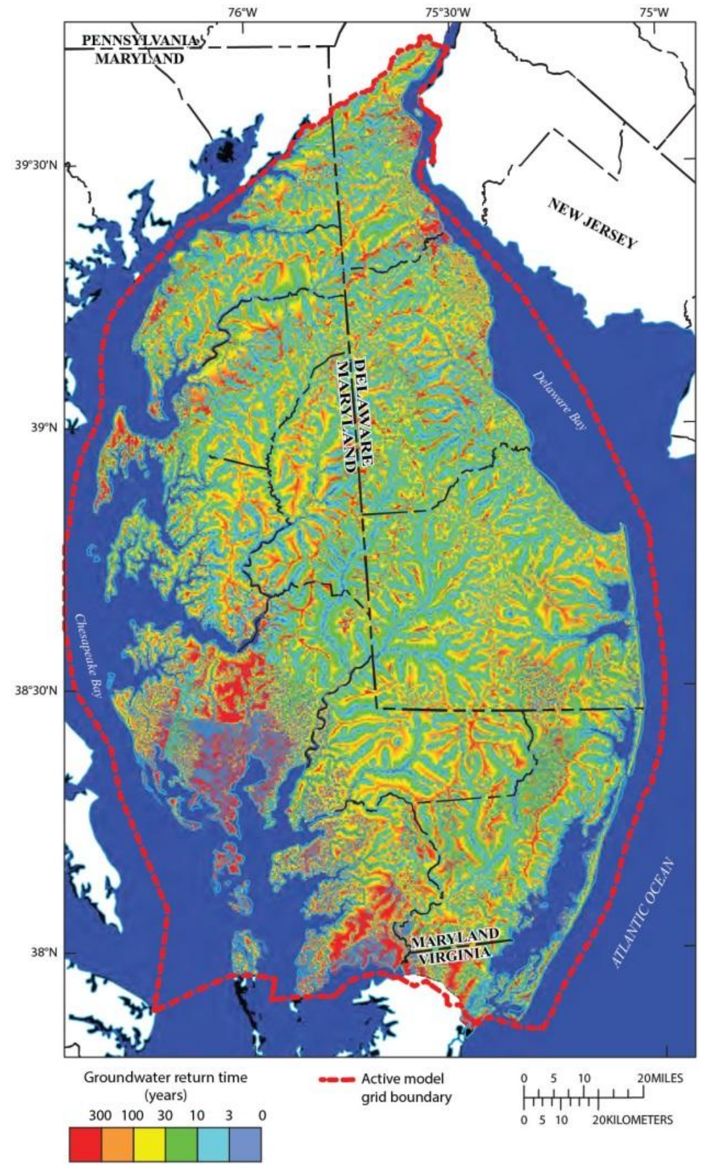
- Many practices provide initial water quality improvements in runoff; however, full benefits to stream conditions can be delayed



Sanford et al., 2012

Delmarva Peninsula

- Groundwater ages can range from less than a year to more than 100 years

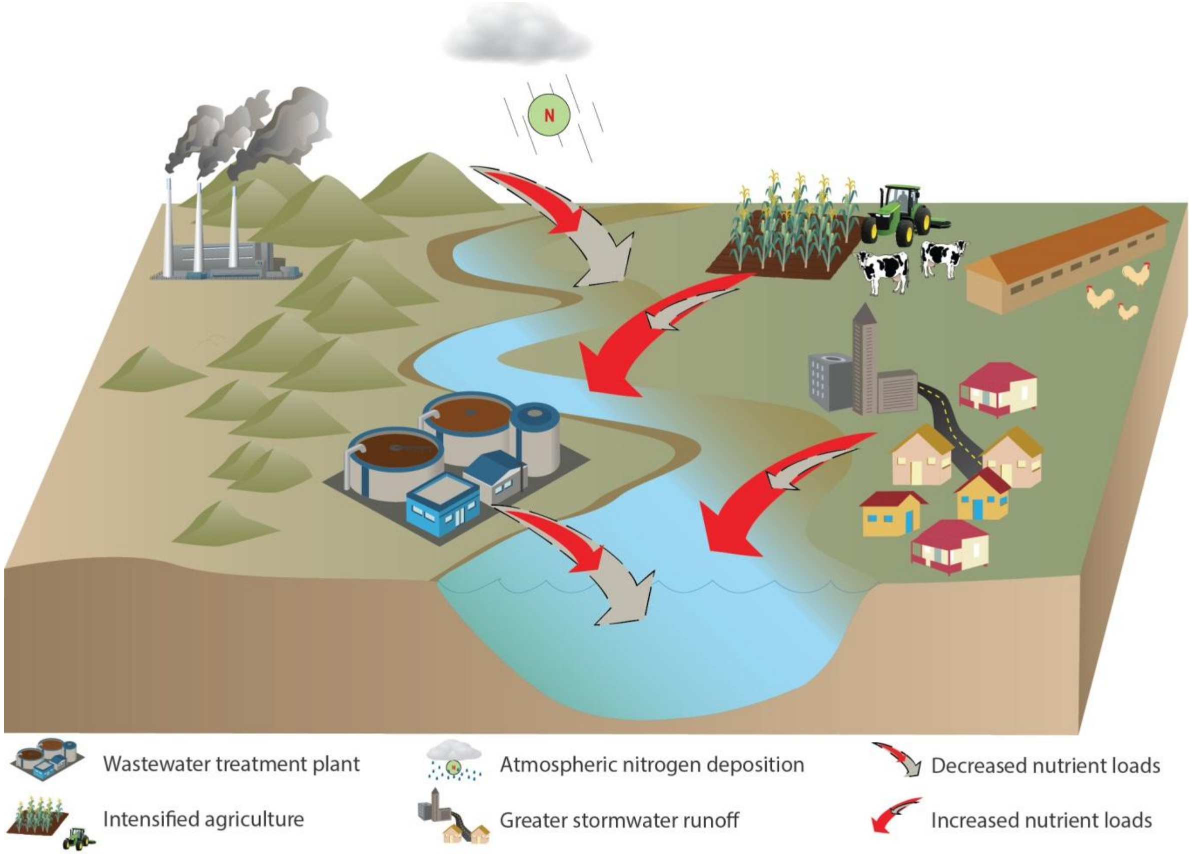


Simulated return time of groundwater traveling from the water table to its discharge location

Sanford et al., 2012

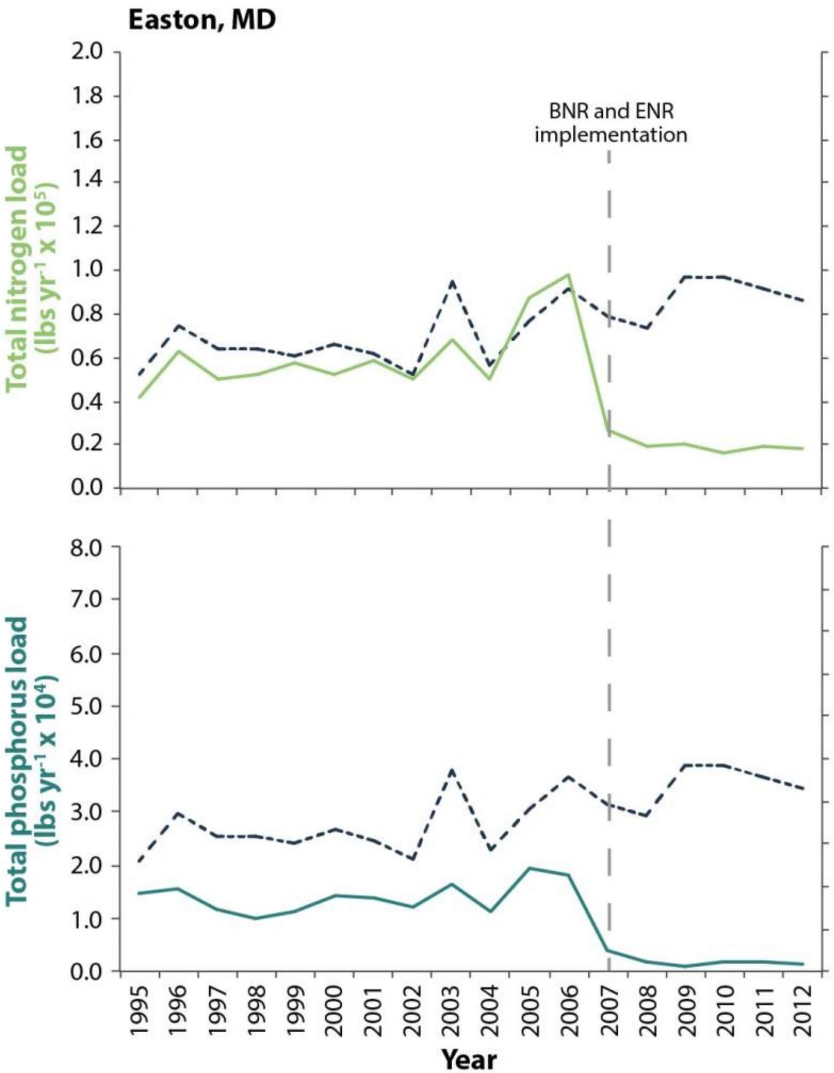
Lesson 5

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



Choptank River

- Wastewater treatment plant flow has increased in some locations, but WWTP upgrades have decreased nutrient loads



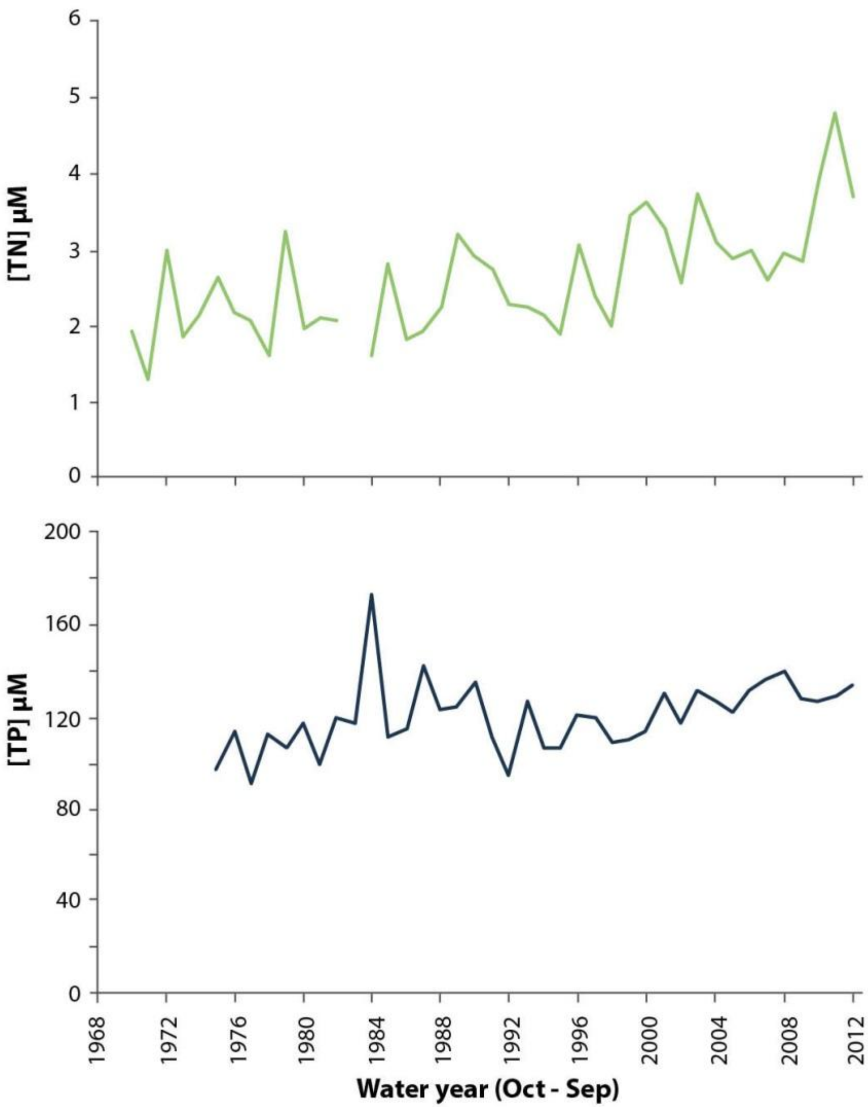
Changes in flow, N and P loads from the Easton wastewater treatment plant (1995-2012)

Data from Karrh, 2012

Choptank River

- Agricultural nutrient sources have counteracted reductions in wastewater treatment plant nutrient loads

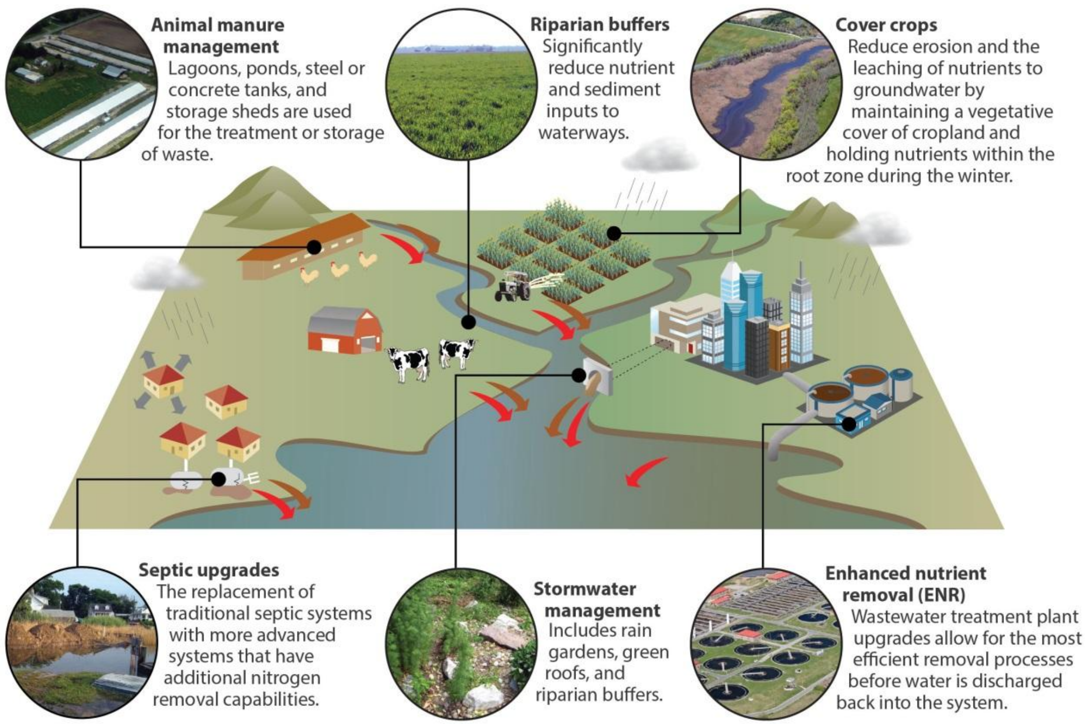
Increases in TN and TP at Greensboro water quality monitoring station (1968-2012)



Data from Fisher, 2006

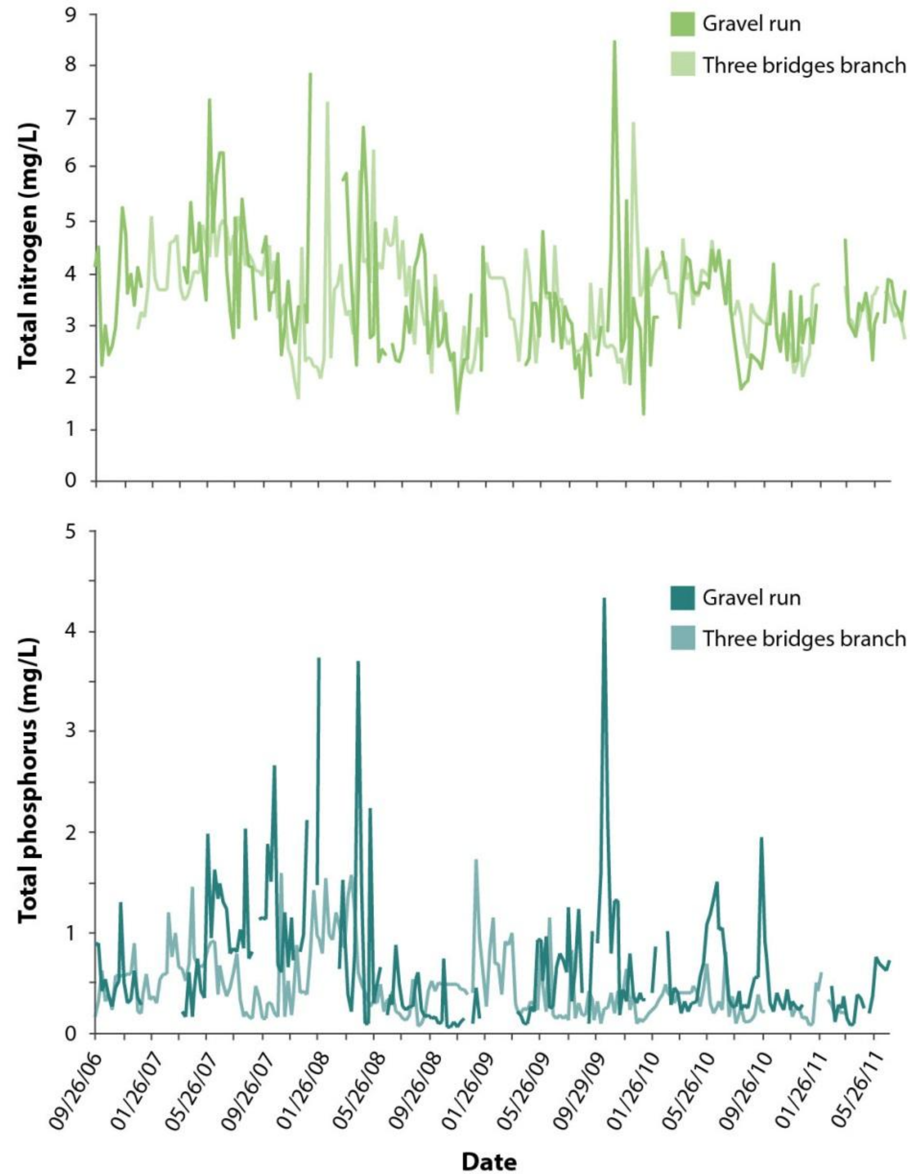
Lesson 6

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



Corsica River

- Improvements in nontidal water quality in the Corsica River were observed after aggressive implementation of multiple nutrient reduction practices

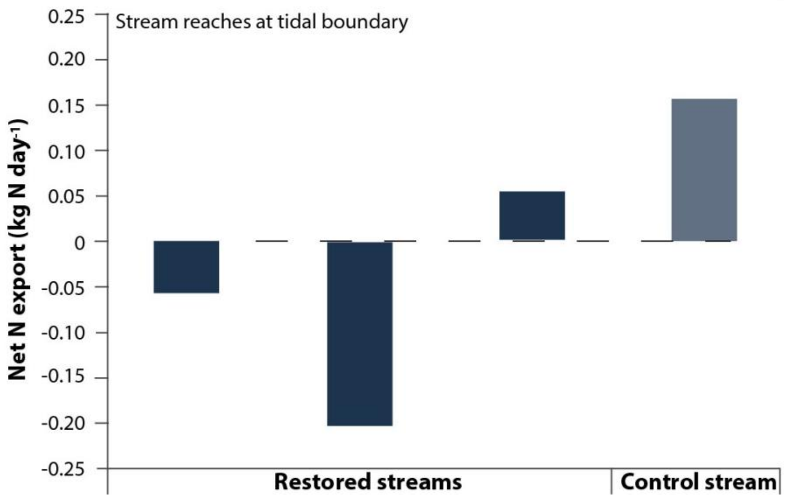


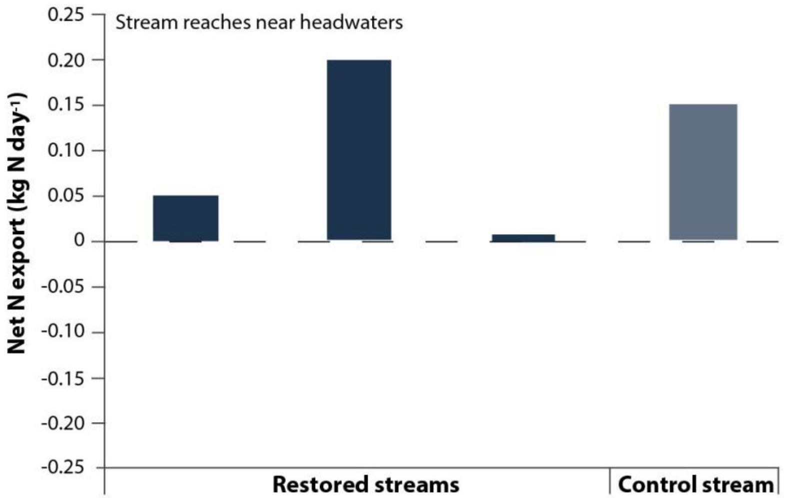
Changes in TN and TP concentrations in Three Bridges Branch and Gravel Run (2006-2011)

Data from Batchelor et al., 2011

Anne Arundel County

- Location matters





Tidal Boundary Streams: 2 out of 3 restored streams retained nitrogen…Partial success

Headwaters Streams: 0 out of 3 restored streams retained nitrogen…No success

Positive Export Values = No Nitrogen Retention = Restored Streams Not Doing Their Jobs!

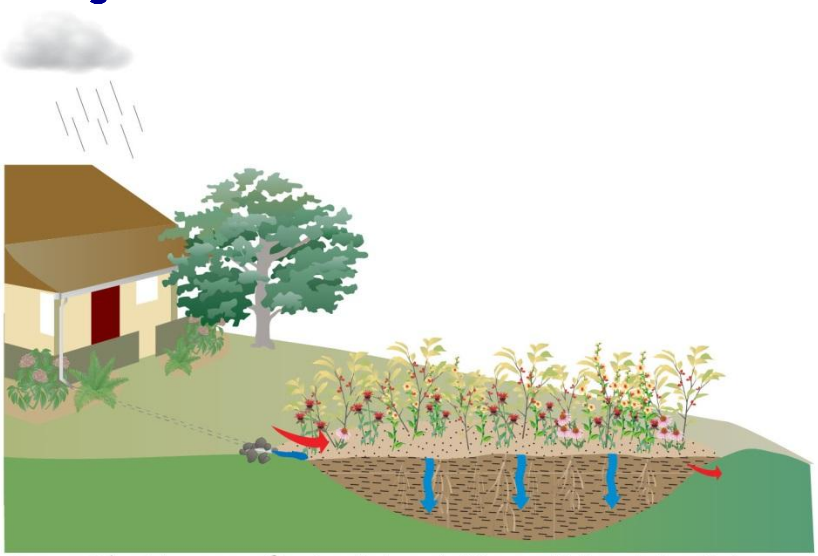
Data from Filoso and Palmer, 2009

What We Need

Lesson 7

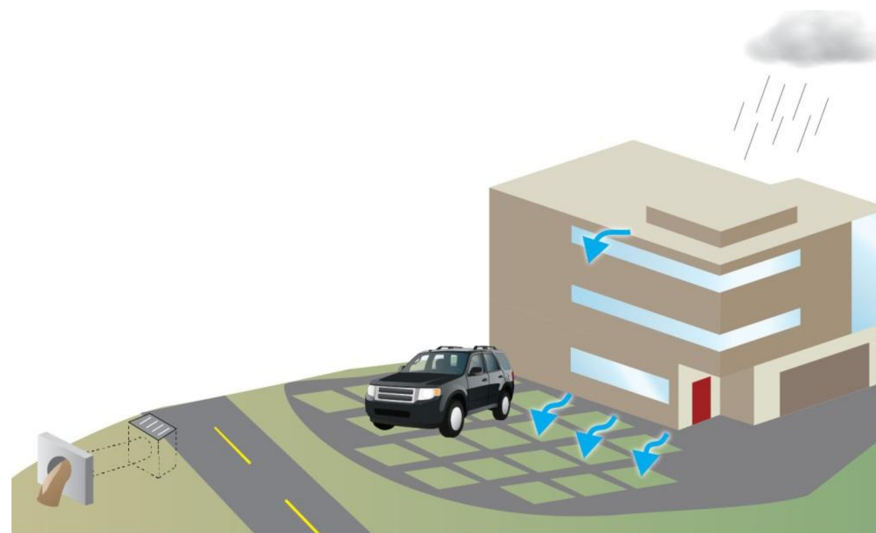
- An array of practices to promote stormwater infiltration and retention are needed in urban and suburban areas

Rain gardens



Gutters and downspouts installed onto buildings and in lawns help assist in directing rain water from the roof to the garden. A landscape of native, drought resistant plants is well adapted to local conditions and easily maintained. Plants with deep root systems encourage stormwater infiltration and help absorb excess nutrient runoff . Additionally, a berm on the downward slope of a rain garden will help hold water in the garden during heavy rains, further improving its filtering capacity.

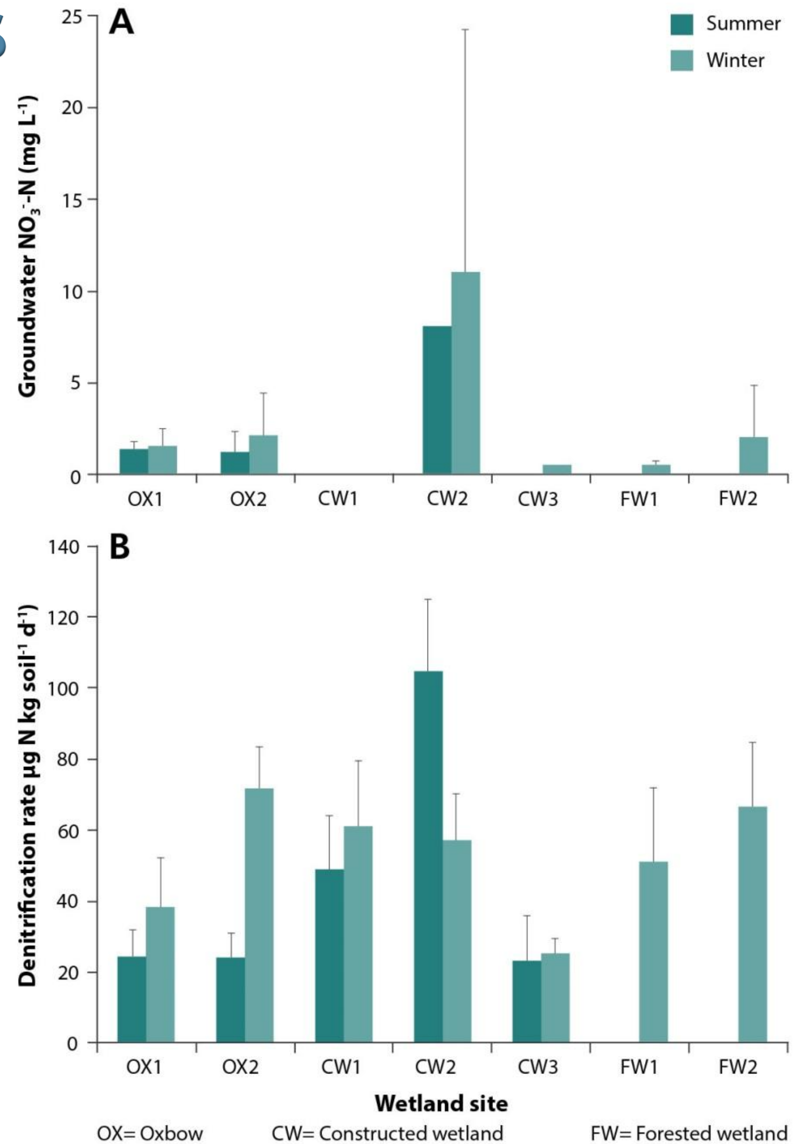
Pervious surfaces



Impervious surfaces such as cement, asphalt and roofing prevent the infiltration of stormwater, increasing the volume and velocity of surface runoff which carries nutrients and sediments with it. Pervious surfaces, such as pervious pavement or pavers , allow for stormwater to filter through the surface and into the ground , rather than into nearby streams and storm drains .

Constructed Wetlands

- Constructed wetlands in Baltimore, MD demonstrated the potential to reduce nitrate entering streams through stormwater runoff

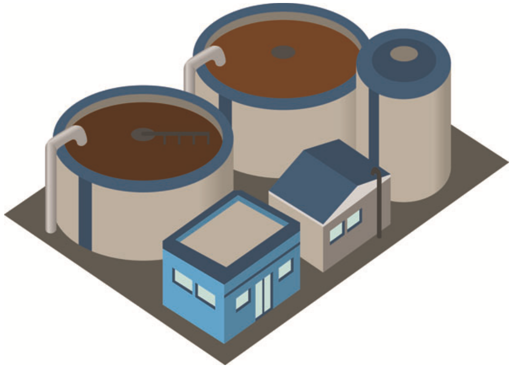


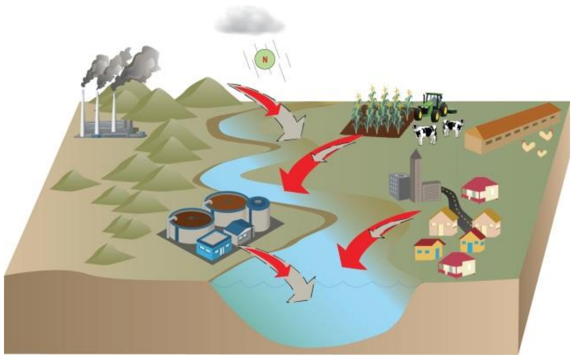
Mean groundwater nitrate-N concentrations (A) and denitrification rates (B) in oxbow, forested, and constructed wetlands in Baltimore, MD

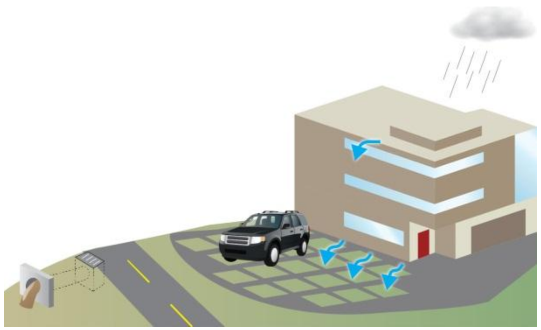
Harrison et al., 2011

Conclusions

1. What Works
   - The Clean Water Act works
   - The Clean Air Act works
   - Multiple practices that reduce agricultural nutrient loads work
2. Challenges
   - Delays in improvements necessitates patience, persistence and perspiration
   - We are not trying hard enough
3. What We Need
   - Location, location, location should guide restoration efforts
   - Innovative practices are needed to up our game







Questions?

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