Constructed Wetlands and Carbon Bioreactors for Controlling Offsite Nitrogen Losses

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Workshop at the 2012 Land Grant and Sea Grant National Water Conference

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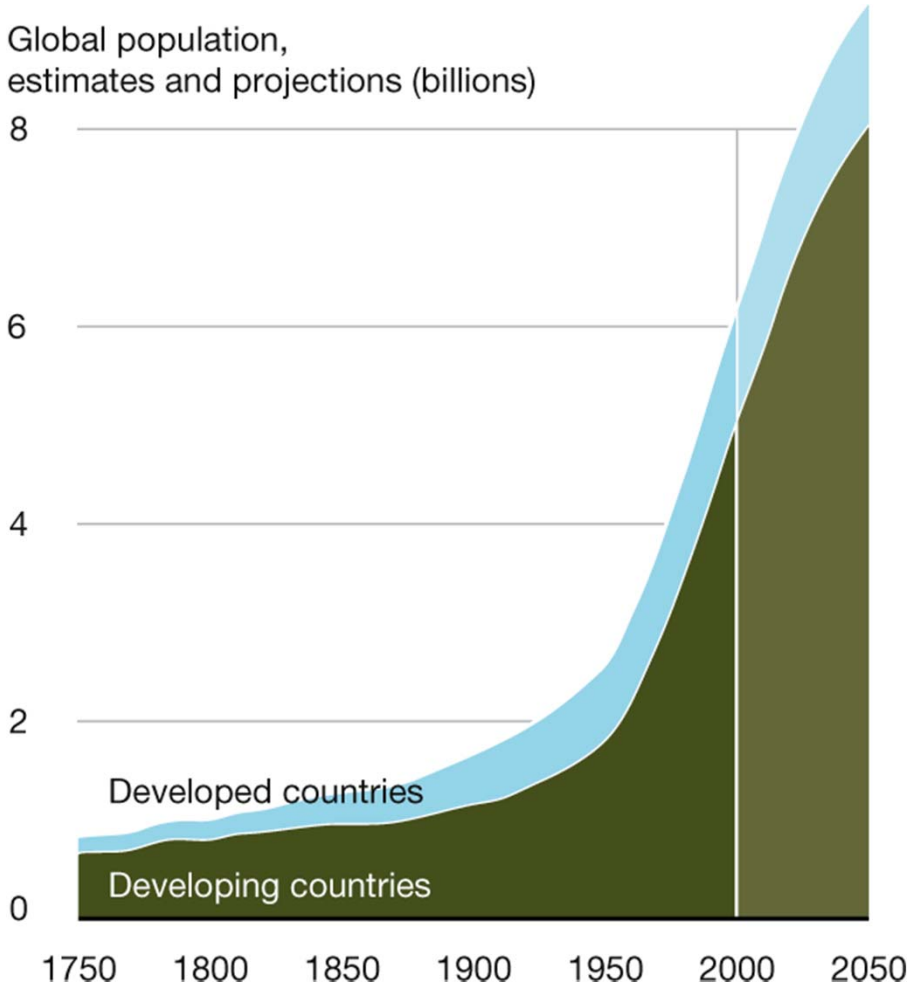
THE UNIVERSITY OF RHODE ISLAND

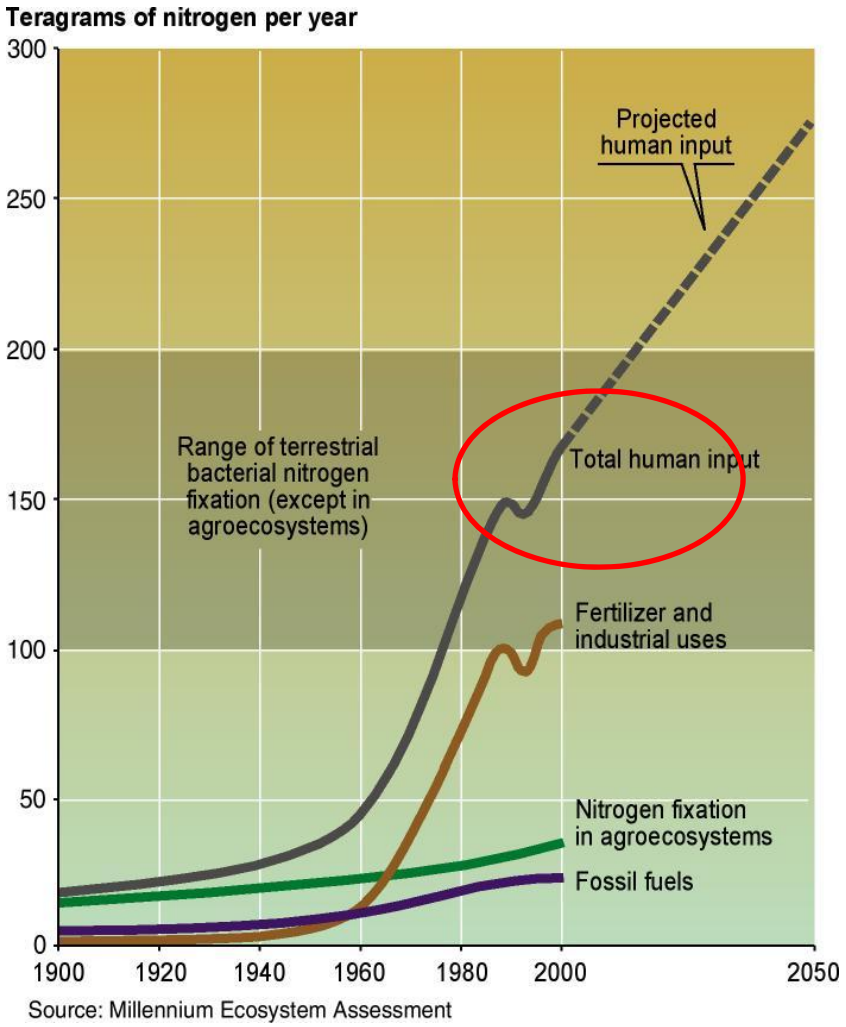
Applying knowledge to improve water quality

National Water Program

A Partnership of USDA NIFA & Land Grant Colleges and Universities

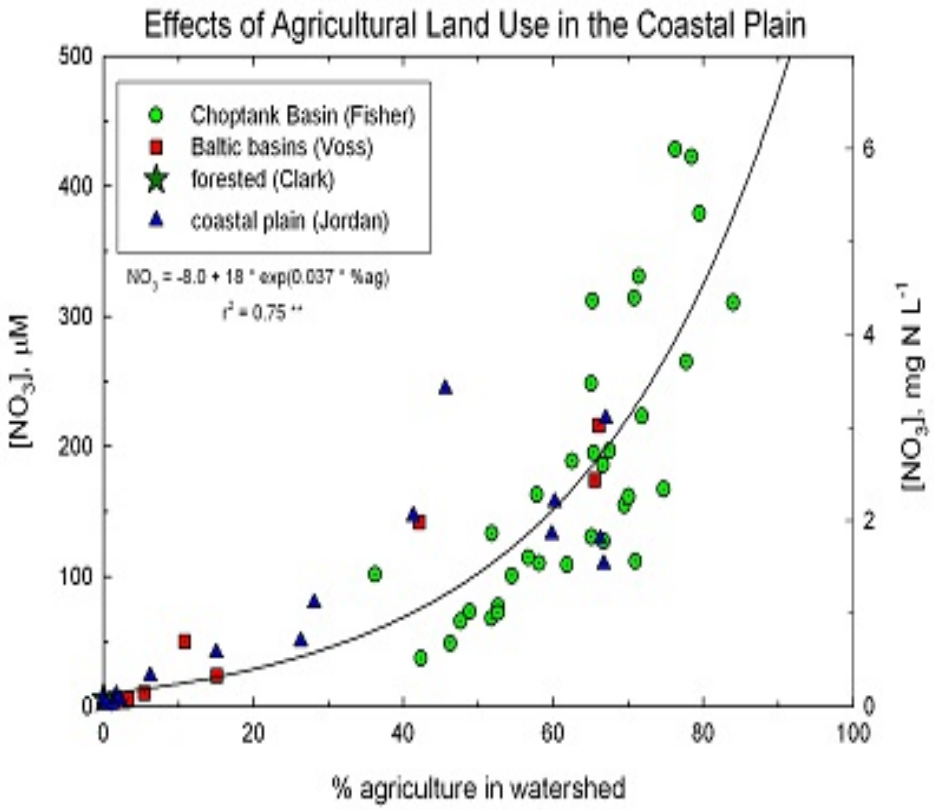
Increased N inputs are projected in response to increased global population



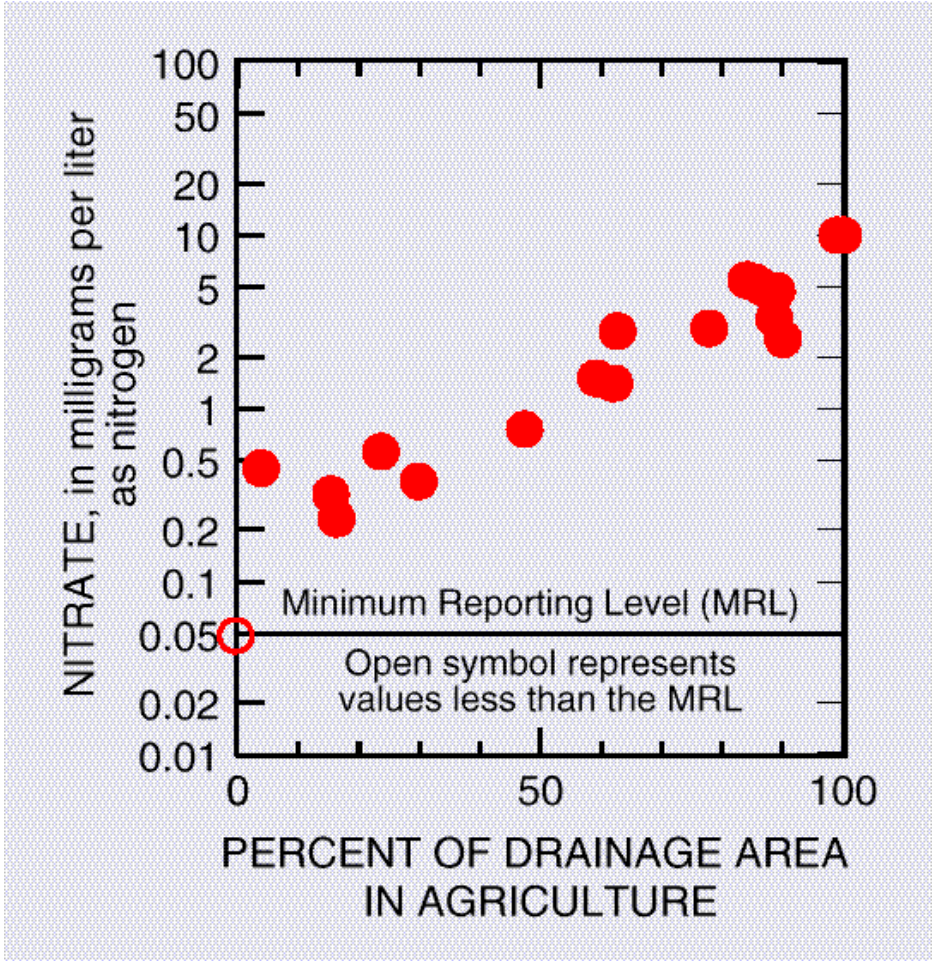


UNEP, 2009

Streams draining croplands carry high concentrations of nitrate-N



Chesapeake Bay Action Plan. 2010

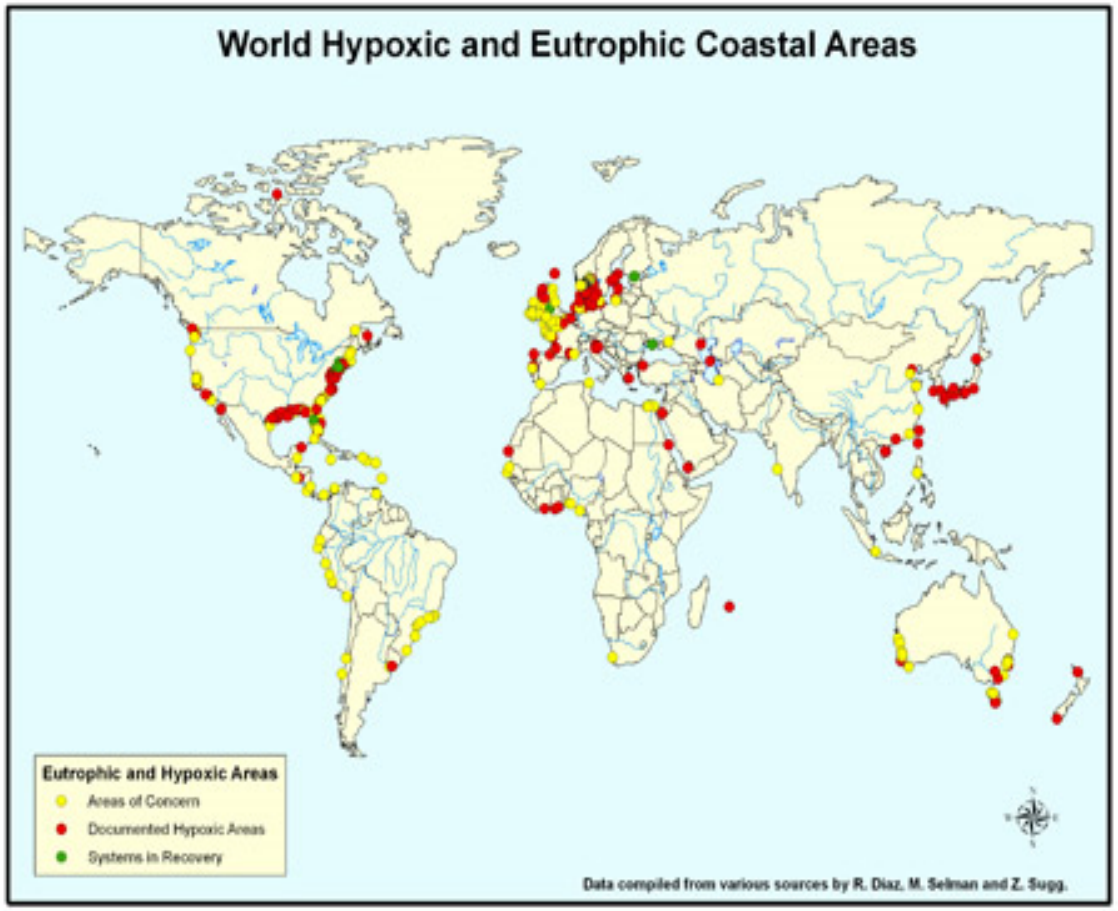


Willamette River Basin, OR.
USGS Circular 1161. 1998

Engineering Grand Challenge:
Excess nitrogen (N)

1) Stimulates algal growth: consumes O_2 and degrades coastal habitats
2) Generates a potent greenhouse gas, nitrous oxide (N_2O =300 CO_2 equivalents)
3) Drinking water contaminant

Degraded eelgrass



Fish Kill, Greenwich Bay, RI

Settings with high risk of nitrogen delivery

- Well-drained sandy soils
- Limestone areas
- Drained croplands
- Flow paths don't interact with organic soils and wetlands
- Adjacent to larger rivers

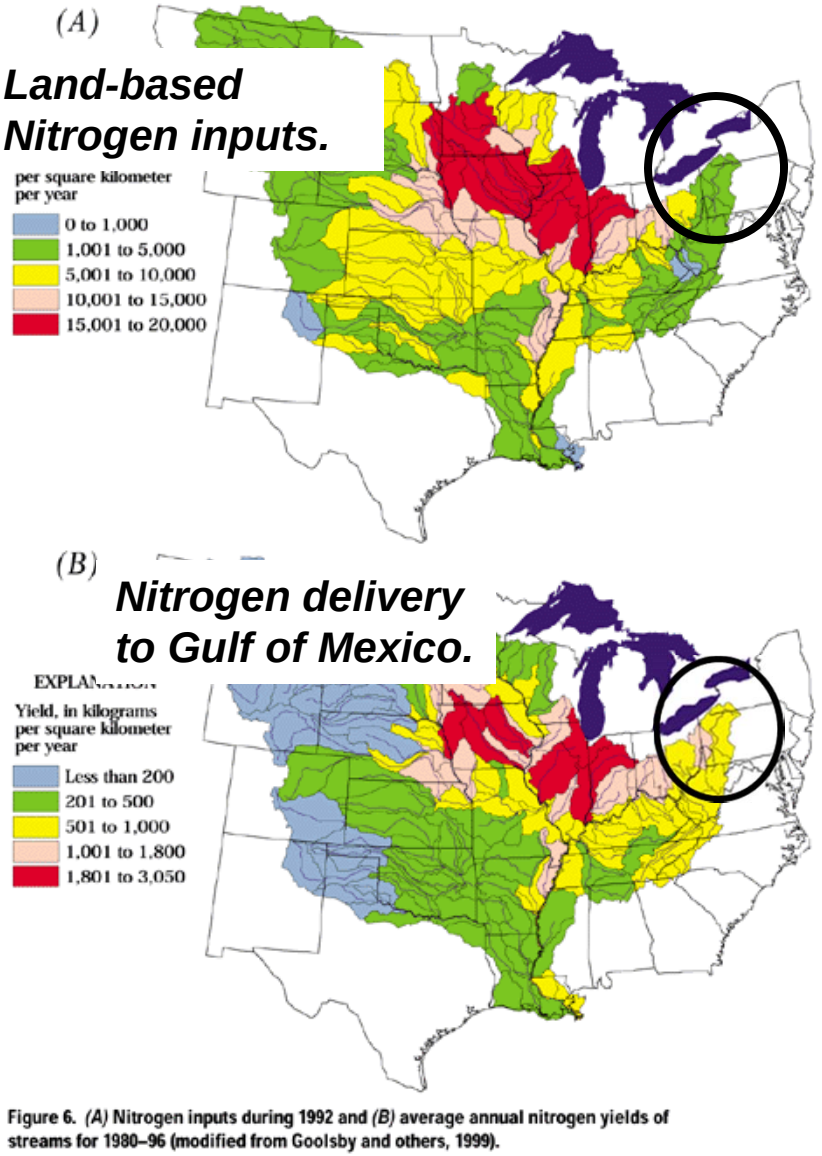


Figure 6. *(A)* Nitrogen inputs during 1992 and *(B)* average annual nitrogen yields of streams for 1980–96 (modified from Goolsby and others, 1999).

Locations of high nitrogen outputs to Gulf of Mexico are not identical to high input locations. (USGS Sparrow model)

Tools available for controlling N losses from croplands

- Catchment scale: Strategic targeting of high risk locations
- Field scale: Crop nutrient mgmt
- Field scale: Cropping systems
- Edge-of-field and landscape scale: Buffers/riparian zones
- **Edge-of-field: Artificial N sinks (bioreactors and constructed wetlands)**

Schultz, Iowa St. Univ.

Watersheds contain natural "sinks" for denitrification [Soluble nitrate (NO_3^-) **transformed to gaseous products]**

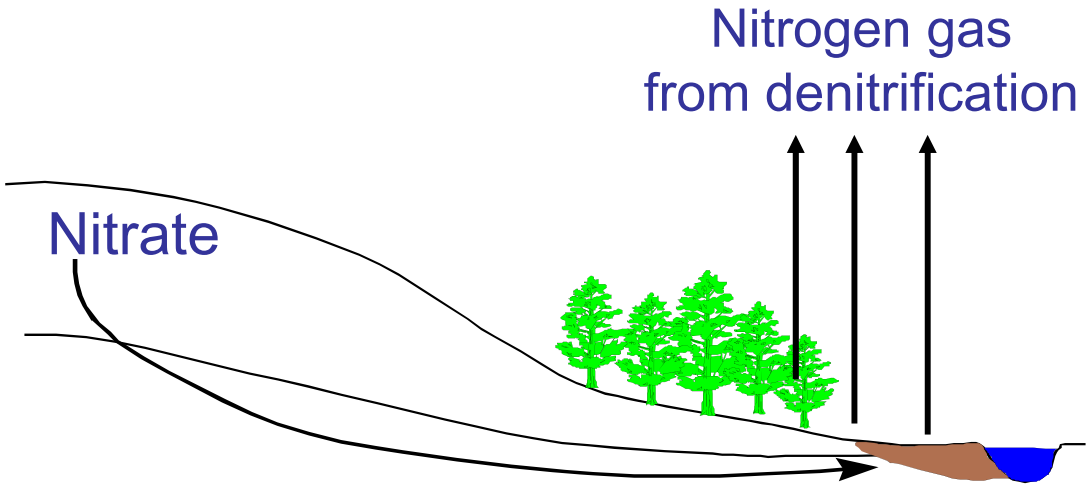
$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$$

Requirements for denitrification:

- Electron donor (labile carbon; pyrite)
- Anaerobic conditions
- Extended interaction with nitrate-laden waters
- Appropriate temperatures

Natural denitrification sinks

- Anaerobic, pyrite-rich aquifers
- Riparian and in-stream wetlands
- Small, headwater streams
- Reservoirs and lakes

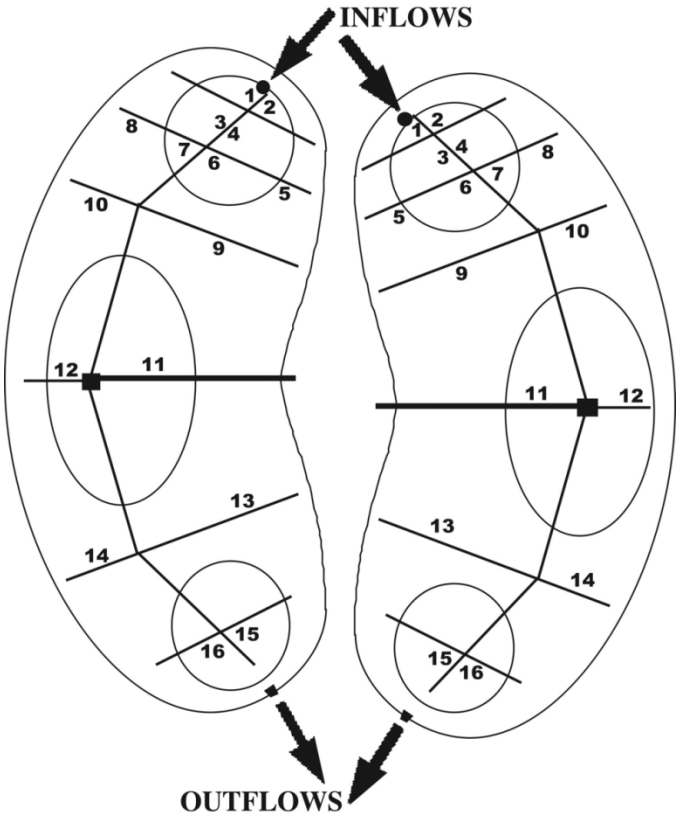


Schipper,
U. of Waikato

Augmenting denitrification: Artificial N Sinks

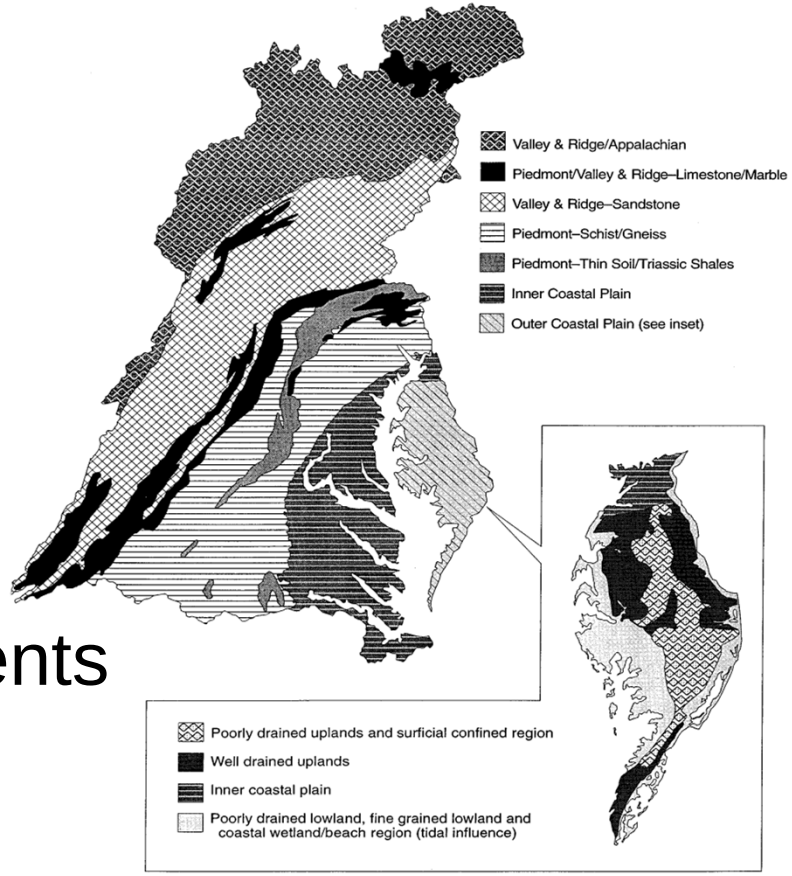
Wood Chip Bioreactors

Constructed Wetlands



New national initiative to promote artificial N sinks

- Design options for different sites
- Regional differences in performance
- Seasonal and long term performance
- Place-based site assessments
- Knowledge gaps
- Building a database for evaluating and promoting artificial sinks



Lowrance et al. 1997 for guidance

Workshop Speakers

- Louis Schipper, Overview of Carbon Bioreactors
- Richard Cooke, Protocol and Interactive Routine for the Design of Subsurface Bioreactors in the Midwest
- Mark David, Overview of Constructed Wetlands
- William Crumpton, Constructed Wetland Case Studies
- Brian Needelman, Geospatial Data and Soil Survey Interpretations for Siting Artificial Sinks
- Kelly Addy, Online Atlas and Web Resources

Panel discussion and meeting will follow formal presentations

- Location: Salon H
- Time: 10:15 to noon
- Purpose: To build a community of practioners, researchers and technology transfer experts who contribute expertise and guidance to the project
- Panel includes:
  - Laura Christianson, Iowa State University
  - Casey Schmidt, University of Florida
  - Pat Willey, NRCS West National Technical Center
  - Keegan Kult, Iowa Soybean Association
  - Jeppe Kjaersgaard, South Dakota State University