Artificial Sinks: Opportunities and Challenges for Managing Offsite Nitrogen Losses.

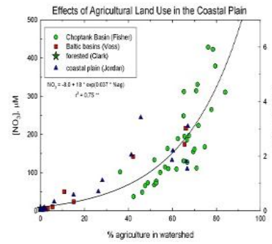
Art Gold, Univ. of RI

SSSA Symposium: Agronomic Systems to Reduce Nitrate Loss: Methods, Unknowns, and Limits to Adoption

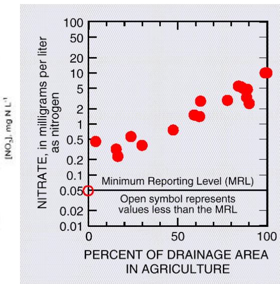
October 23, 2012

THE UNIVERSITY OF RHODE ISLAND | USDA United States Department of Agriculture | National Institute of Food and Agriculture | National Water Program

Streams draining croplands carry high concentrations of nitrate-N



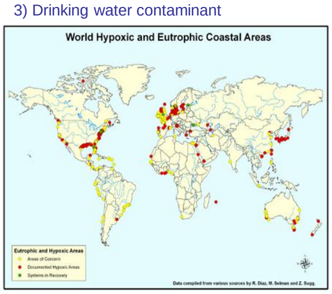
Chesapeake Bay Action Plan. 2010



Willamette River Basin, OR. USGS Circular 1161. 1998

Engineering Grand Challenge:
Excess nitrogen (N)

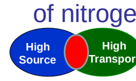
1) Stimulates algal growth: consumes O_2 and degrades coastal habitats
2) Generates a potent greenhouse gas, nitrous oxide (N_2O =300 CO_2 equivalents)
3) Drinking water contaminant



Degraded eelgrass

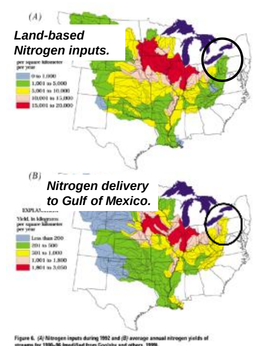
Fish Kill, Greenwich Bay, RI

Settings with high risk of nitrogen delivery



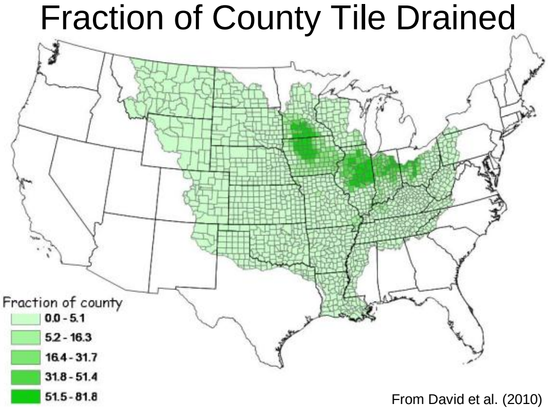
Critical Source Area
Beegle, PSU

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



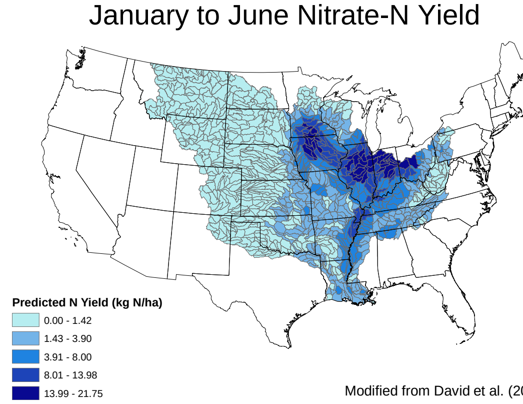
Locations of high nitrogen outputs to Gulf of Mexico are not identical to high input locations. (USGS Sparrow model)

Fraction of County Tile Drained



From David et al. (2010)

January to June Nitrate-N Yield



Modified from David et al. (2010)

Controlling N losses from croplands

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

Schultz, Iowa St. Univ.

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

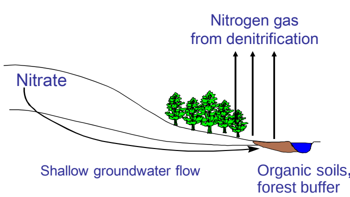
$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$$

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

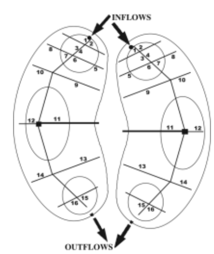


Schipper, U. of Waikato

Augmenting denitrification: Artificial N Sinks

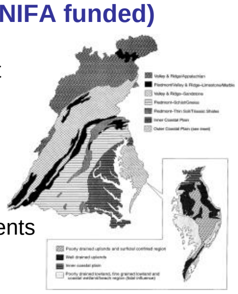
Wood Chip Bioreactors

Constructed Wetlands



New national initiative to promote artificial N sinks (NIFA funded)

- 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

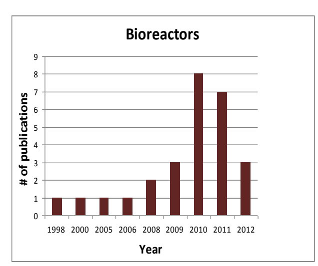
Refereed papers for meta-analyses: Bioreactors (17 field; 9 lab studies)

Data collected (of 26 papers):

- Temperature: 19
- Retention time: 22
- Inflow nitrate conc: 21

Field Settings

- In-stream locations: 2
- Tile lines: 8
- Groundwater: 7



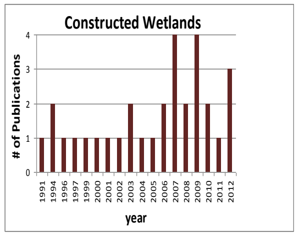
Refereed papers for meta-analyses: Constructed wetlands (26 field; 3 lab studies)

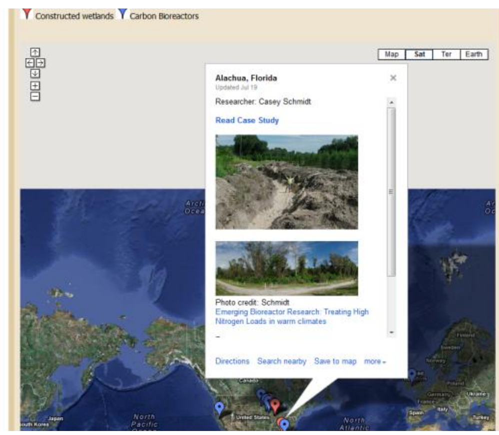
Data collected:

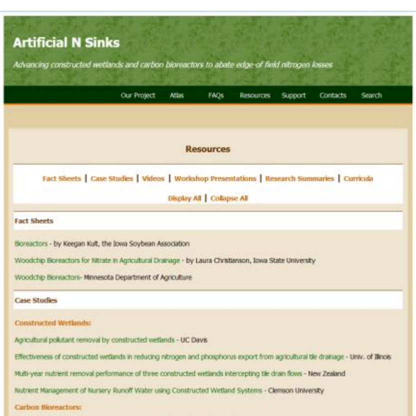
- Temperature: 16
- Retention time: 21
- Inflow nitrate conc: 24

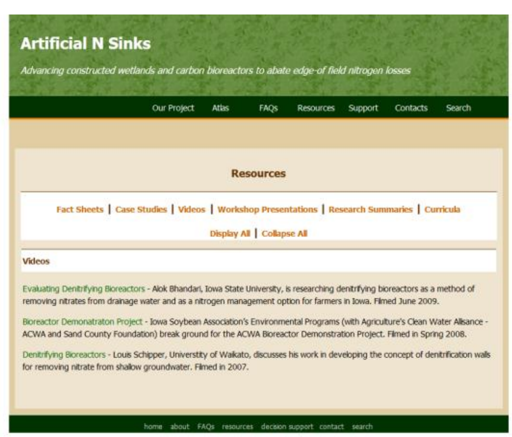
Source Water

- Ag surface runoff: 5
- Tile lines: 8
- Irrig. return flows: 7
- Agricultural streams:5









Next Steps

- Build a community of practioners, researchers and technology transfer experts who contribute expertise and guidance to the project
- Create additional resources for researchers, NRCS, farmers, installers and other interested parties.

In-stream bioreactor
Robertson, U. of Waterloo.

Funding: USDA-NIFA Agreement No. 2011-51130-31120. Co-PIs, Gold, Schipper, David, Needelman and Addy.