Terrestrial sources of urea to water in a mixed land use watershed: Implications for nitrogen management

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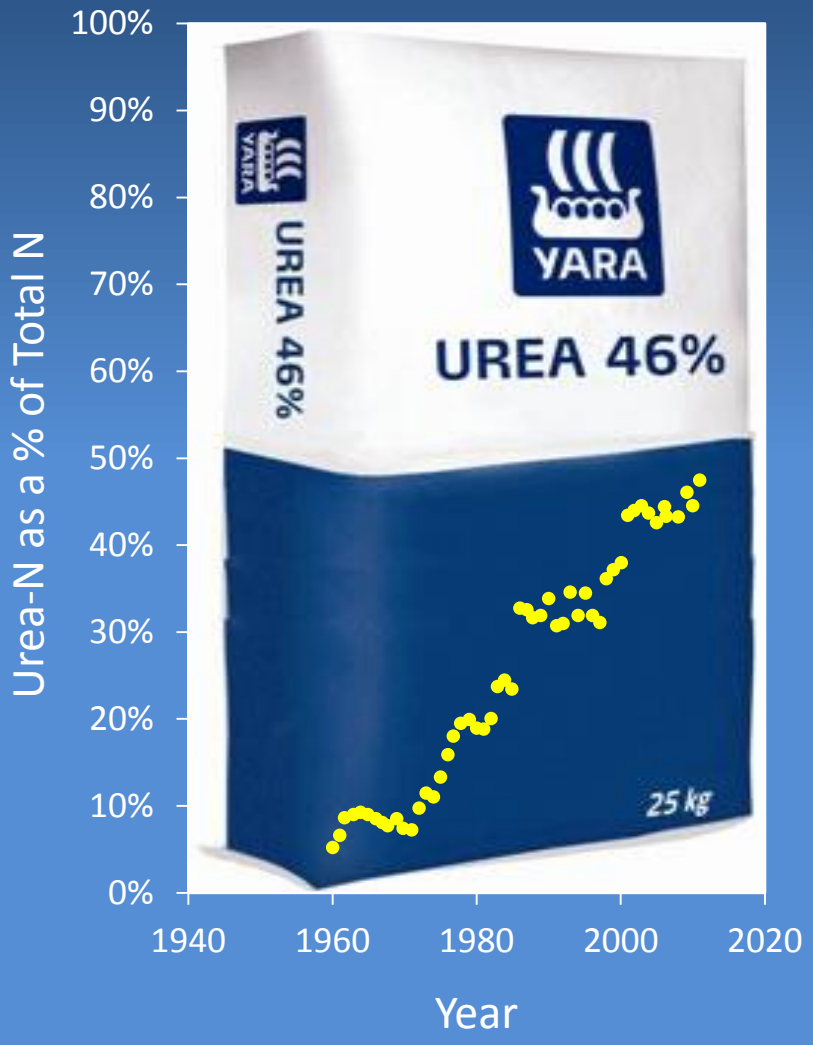
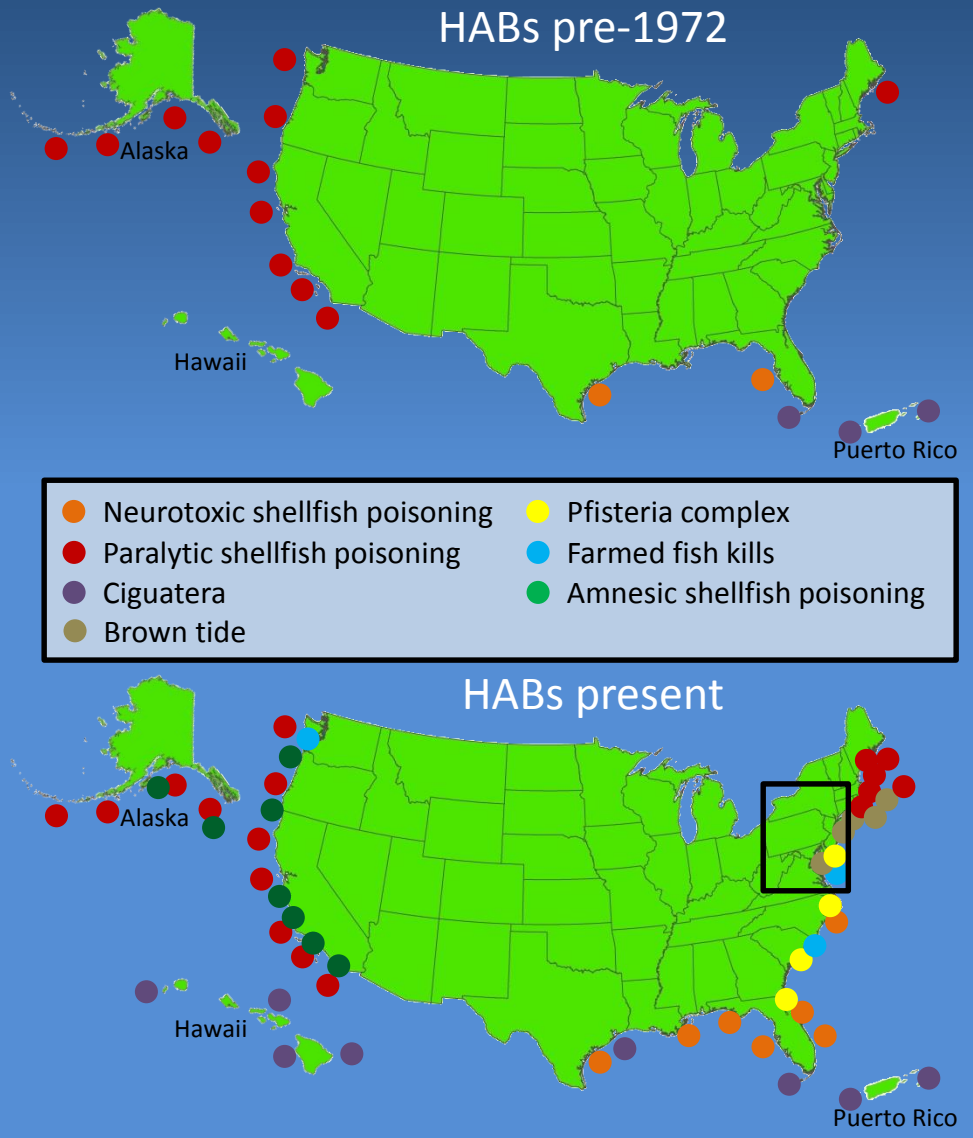
Increasing urea fertilizer use has been tied to more frequent harmful algal blooms



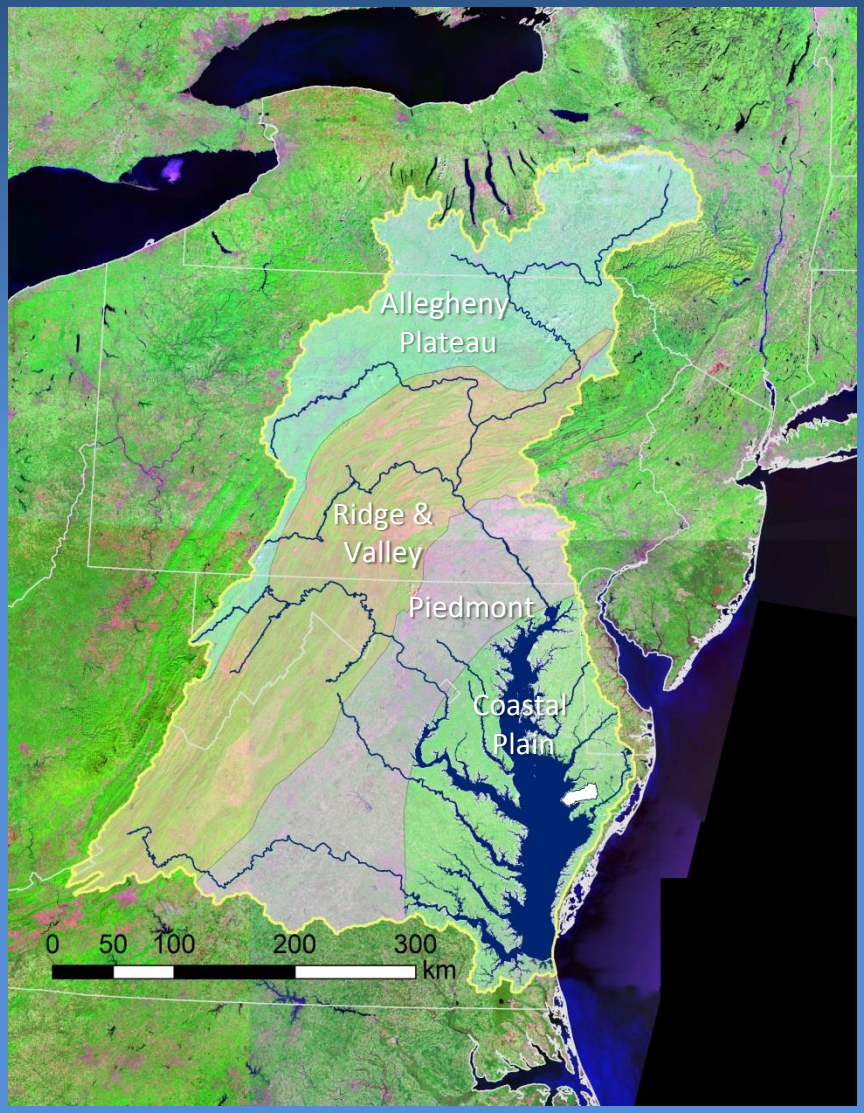


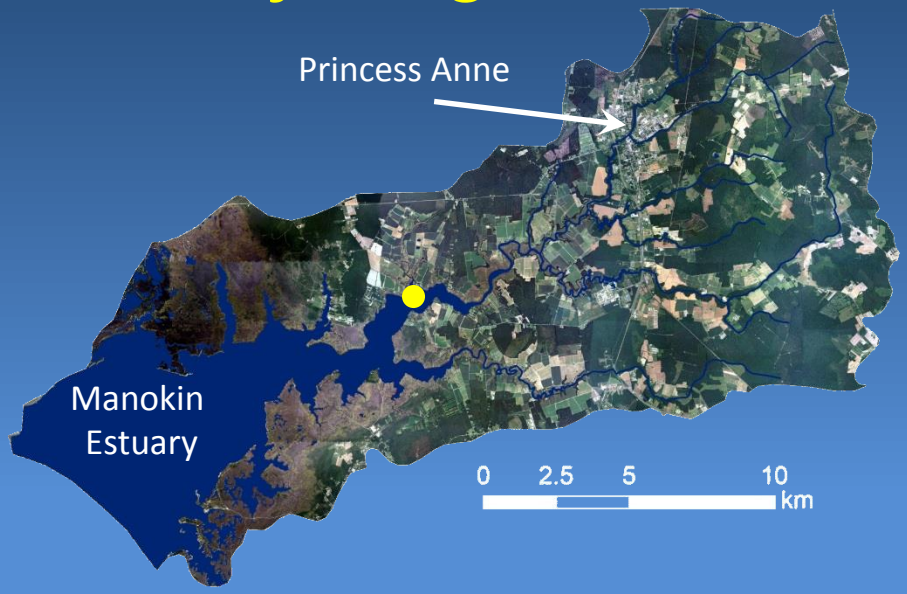
Data source: USDA Economic Research Service

Image source: Adapted from WHOI Harmful Algal Bloom website

The Manokin River watershed

A history of urea-induced harmful algal blooms





THE BALTIMORE SUN
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Pfiesteria casts shadow over Md.'s fish farms. Somerset fish farmer warily searches his ponds for deadly microbe

PRINCESS ANNE -- Tony Mazzaccaro last week peered through a microscope lens, searching for an elusive killer. "I just don't see it," he said. "Looks like I won't have to nuke the pond after all."

This time.

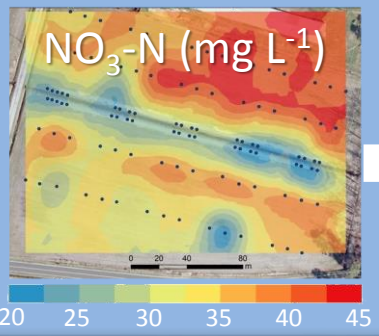
Mazzaccaro, owner of the Hyrock fish farm by the Manokin River in Somerset County, was looking for a microorganism that might have been responsible for killing 8,000 of his hybrid striped bass in early August. A year earlier, a microbe may have killed 23,000 of his farm's adult bass.

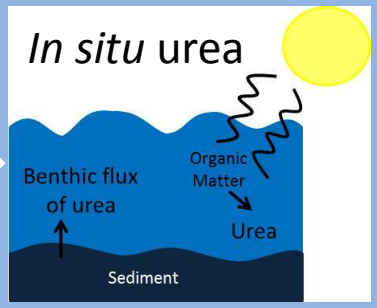
Today's presentation

1. Transfers of recently applied urea to overland flow and leachate.

2. Urea mobilization and transport patterns in surface waters.

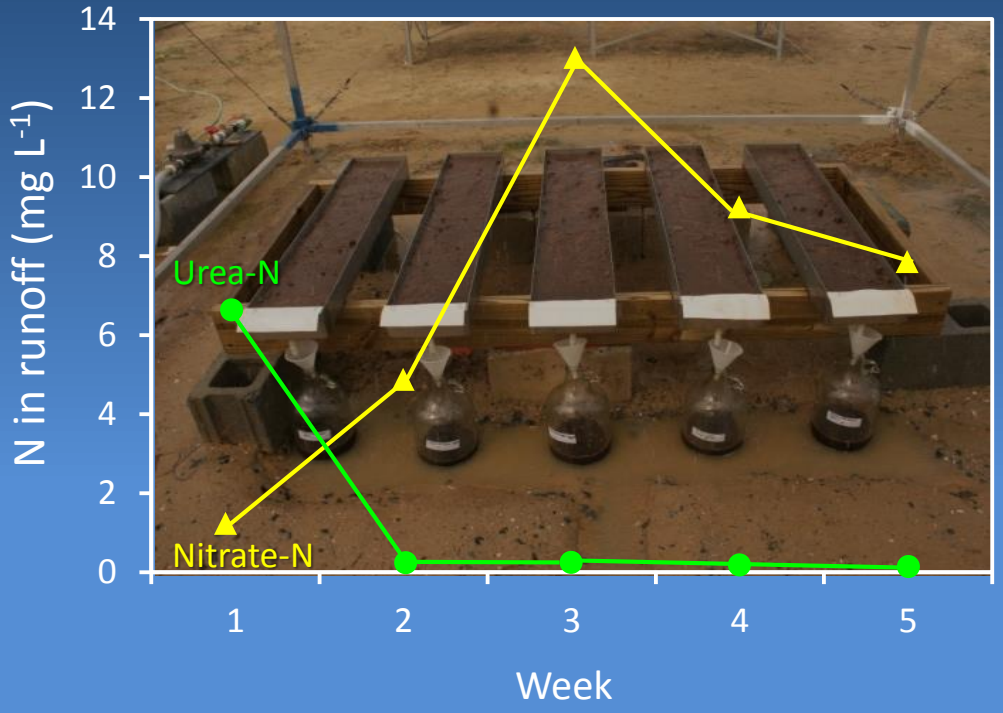
3. Postulating an influence of legacy nitrate on *in situ* urea generation.





Urea and nitrate losses in overland flow

Urea-N and nitrate-N in overland flow



150 kg ha^{-1} of 45-0-0 applied to each box

99 % of applied urea was either retained or hydrolyzed and mineralized

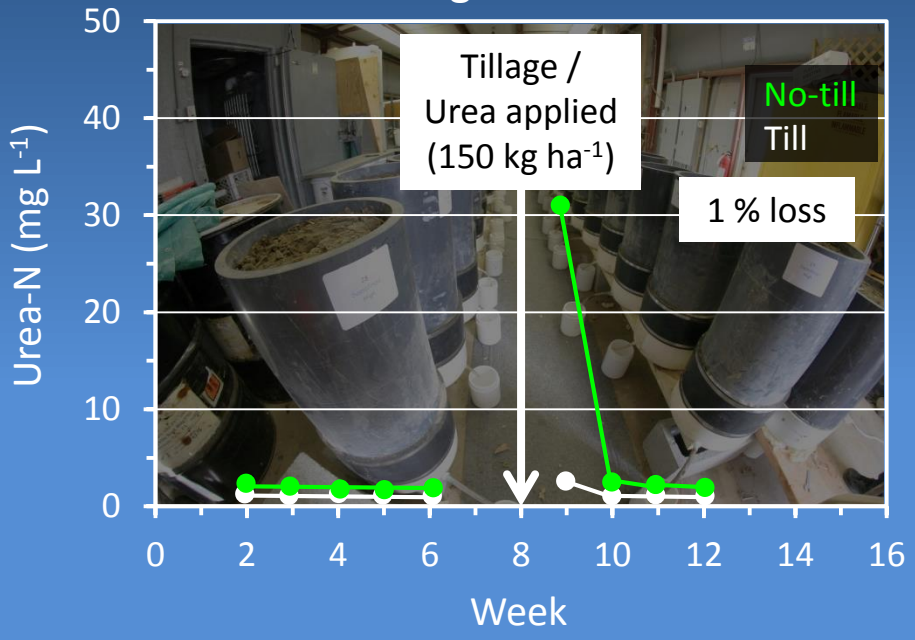
1 % lost as urea-N in runoff

The greatest risk for urea-N loss in overland flow occurs within one week of application, while nitrate-N losses persist for several weeks.

Runoff data courtesy of Leonard Kibet

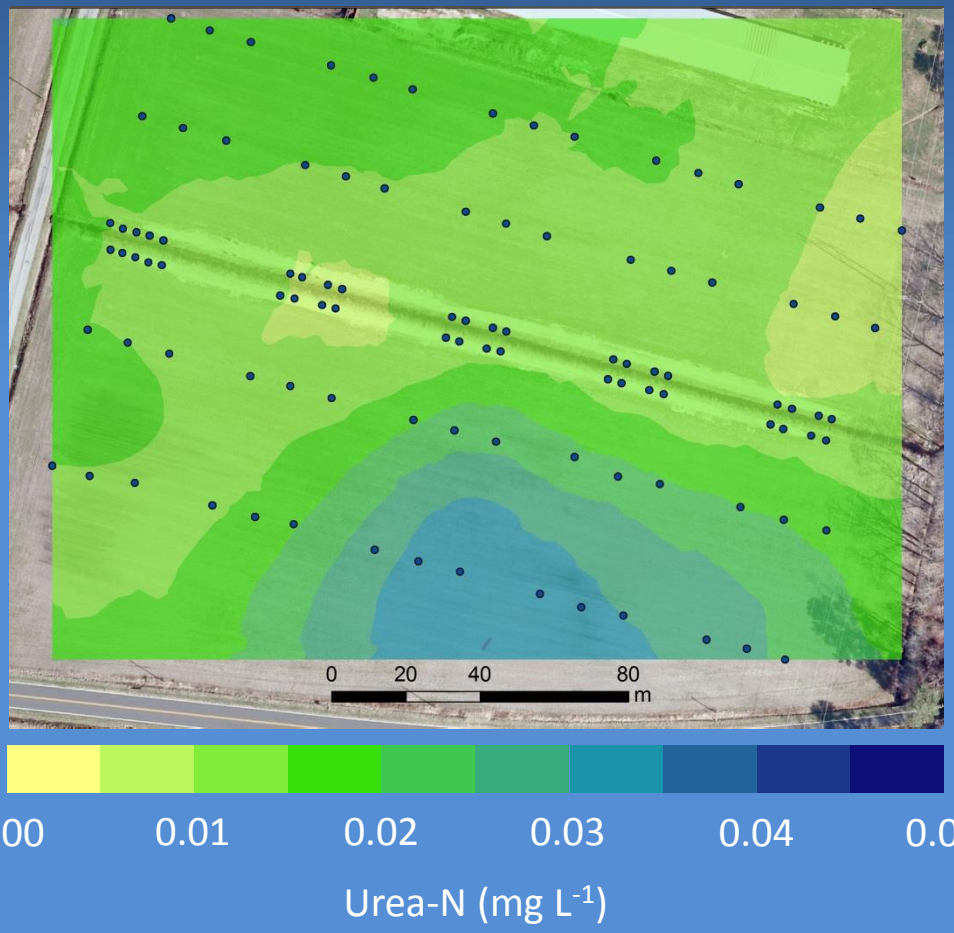
Urea levels in leachate and in shallow groundwater

Urea-N leaching in intact soil columns



Urea-N leaching is brief and does not appear to yield comparably high urea concentrations in shallow groundwater.

Urea-N in shallow groundwater

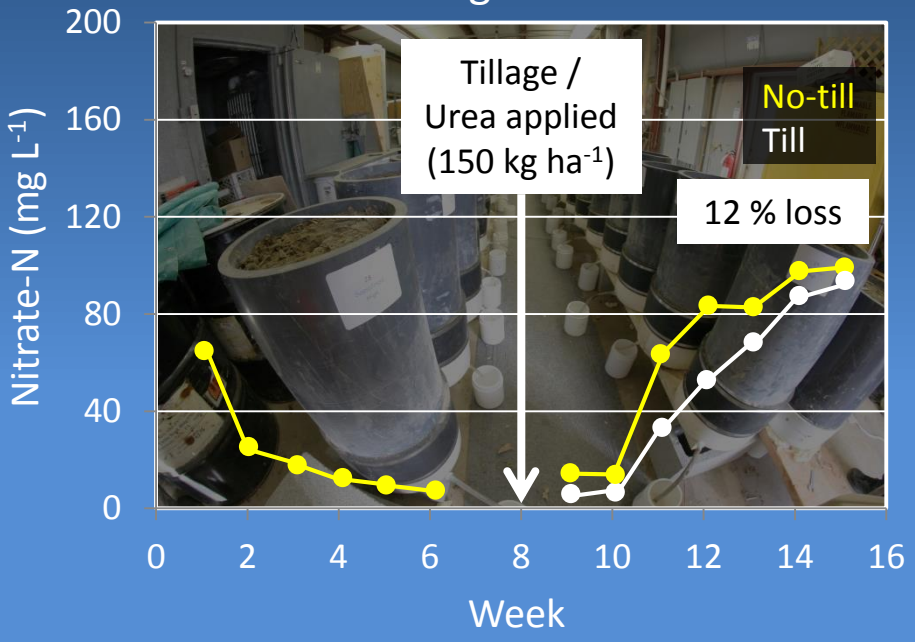


Leaching data courtesy of Han Kun

Groundwater data courtesy of Leonard Kibet

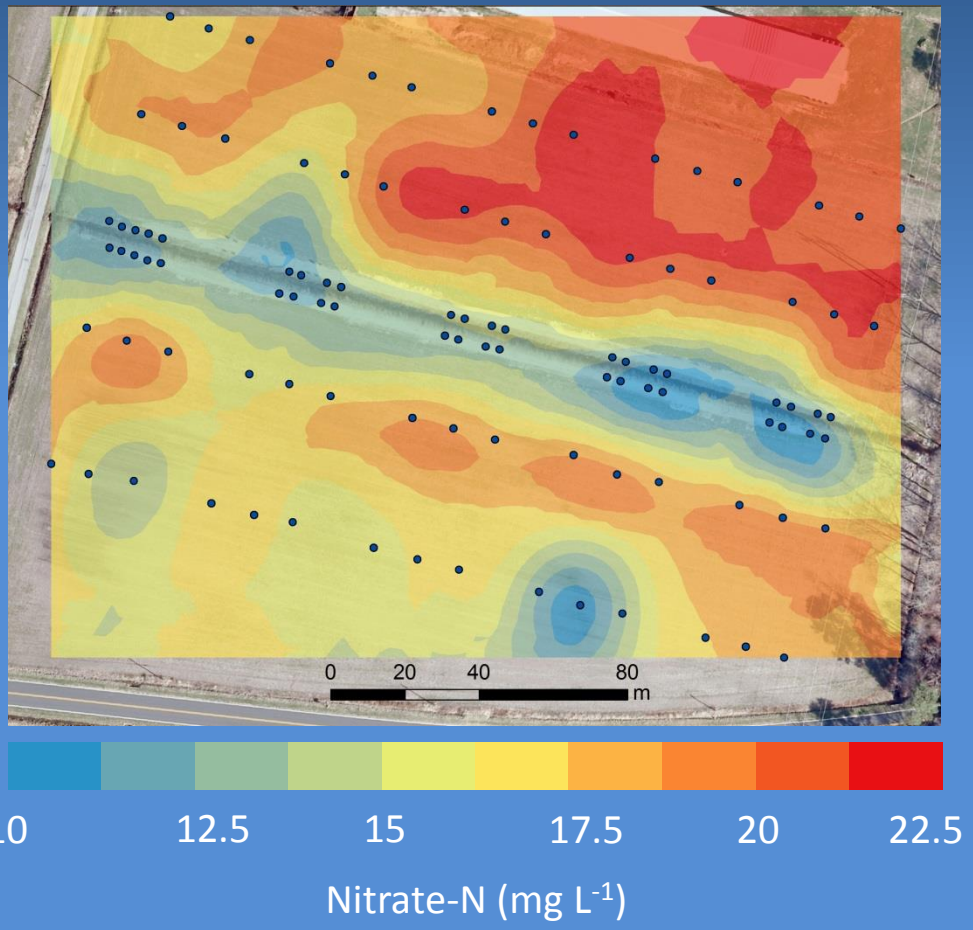
Nitrate levels in leachate and in shallow groundwater

Nitrate-N leaching in intact soil columns



Nitrate-N leaching is prolonged and clearly contributes to and exacerbates groundwater nitrogen legacies.

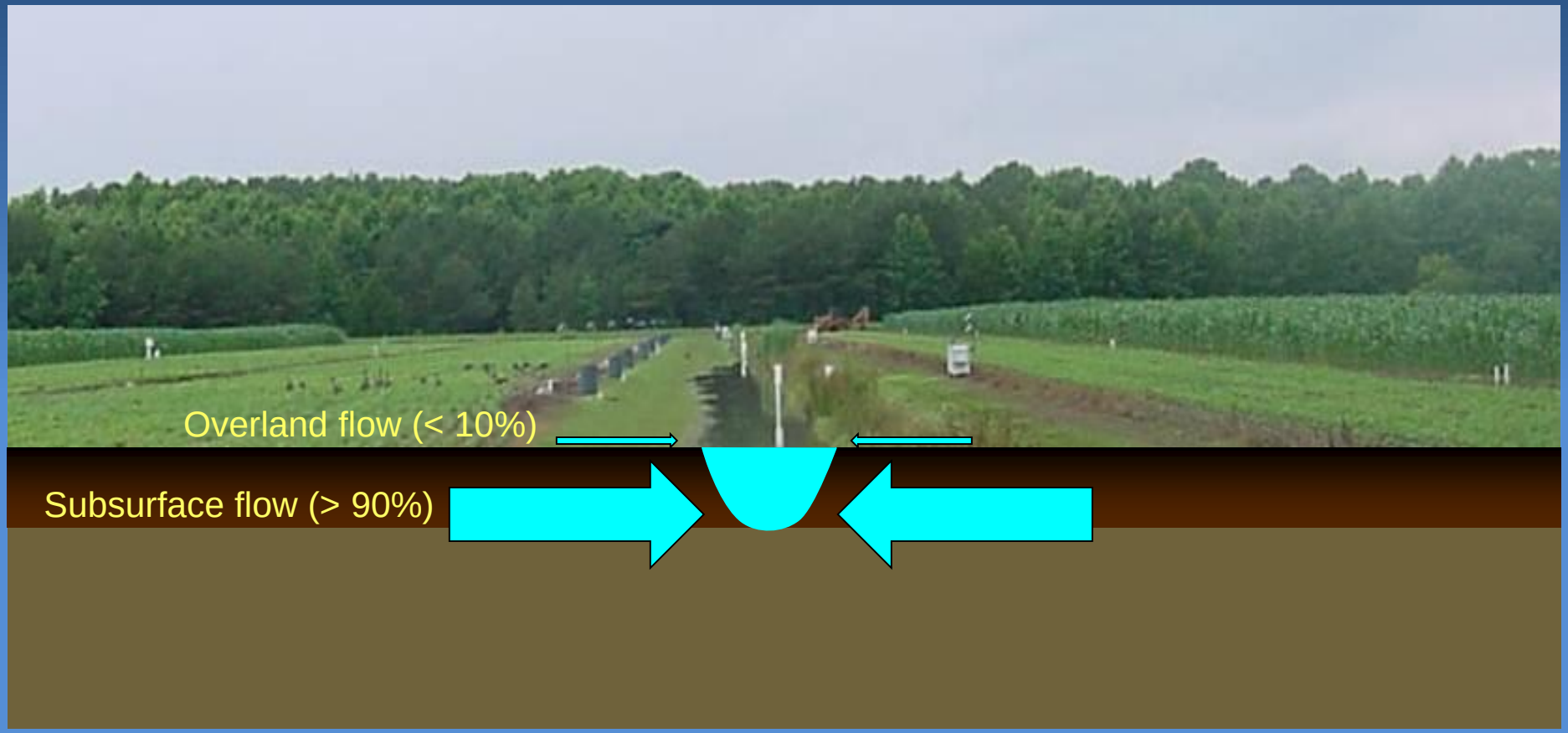
Nitrate-N in shallow groundwater



Leaching data courtesy of Han Kun

Groundwater data courtesy of Leonard Kibet

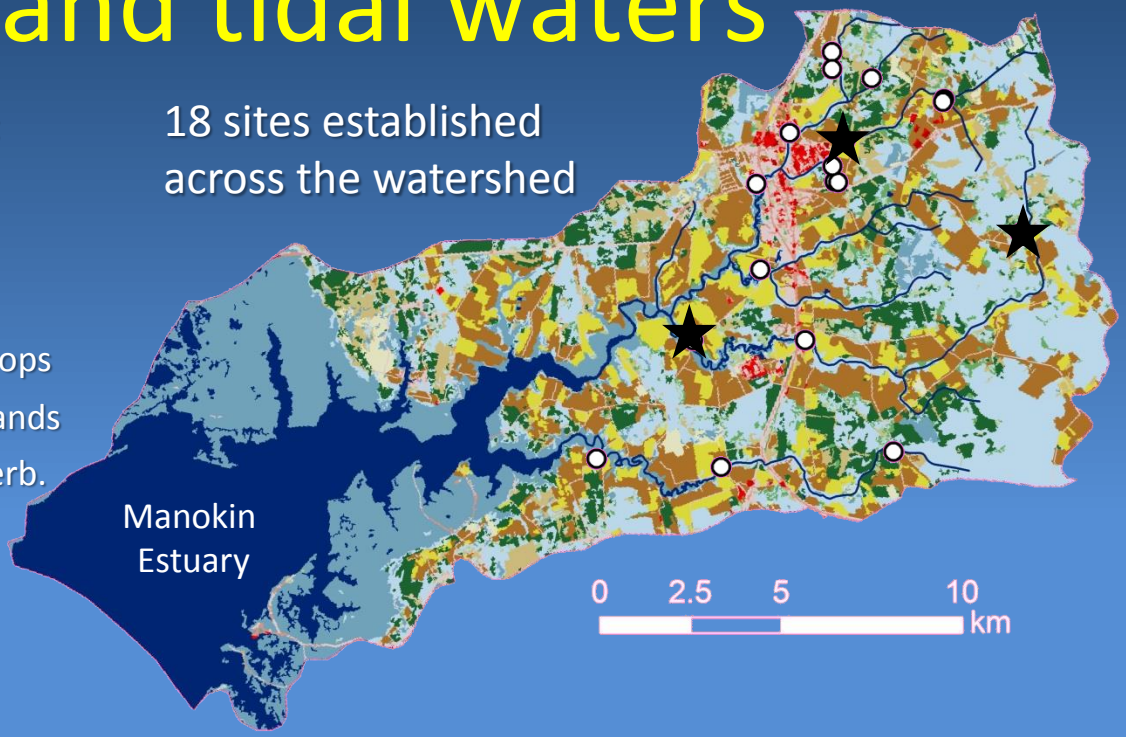
Majority of nutrients are transported by subsurface flow pathways



Adapted from Kleinman et al., 2007 (J. Soil Water Conserv.)

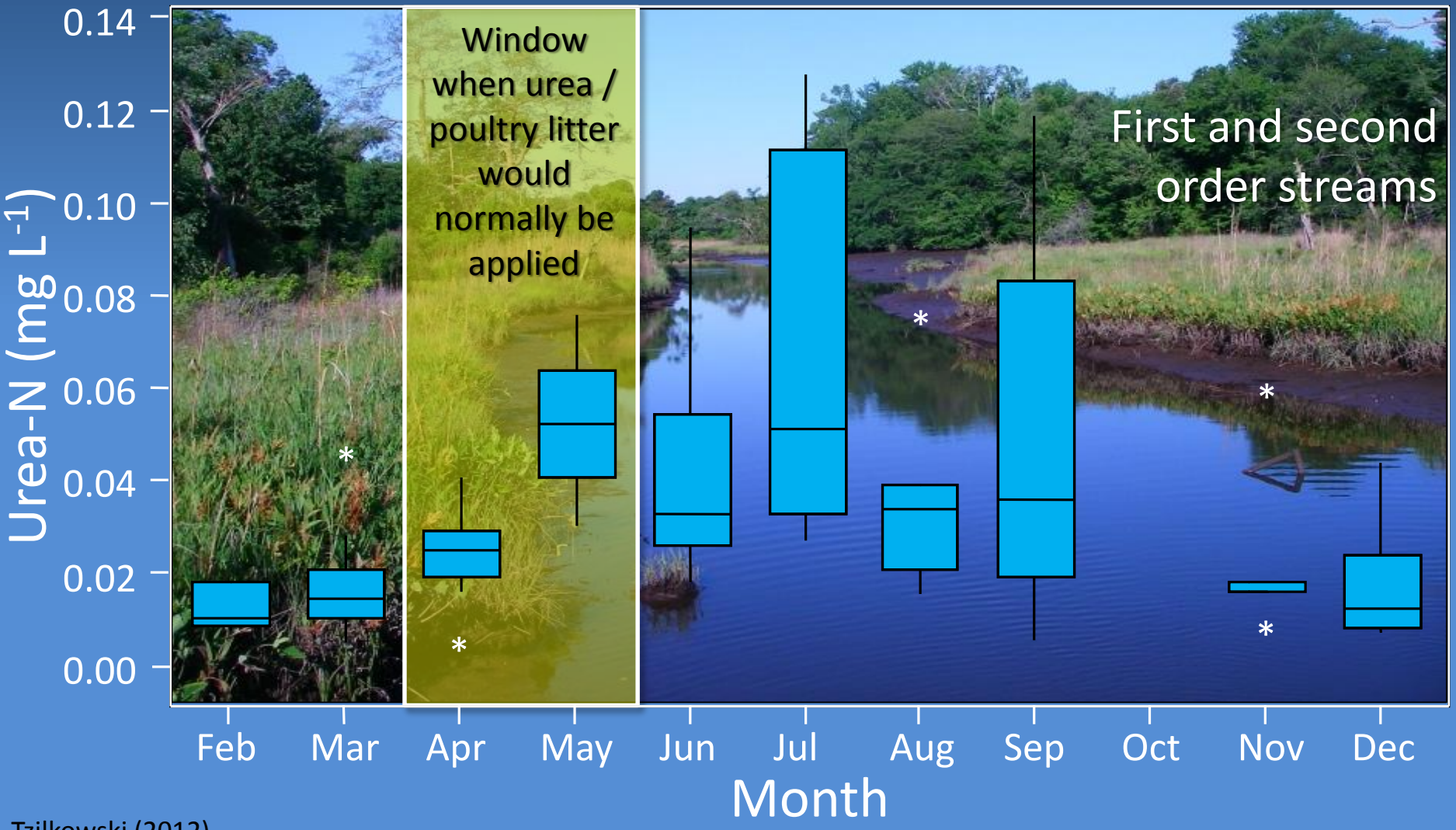
Monitoring urea in field ditches, streams, and tidal waters

- Water
- Open space
- Dev., low intensity
- Dev., med intensity
- Dev., high intensity
- Barren land
- Deciduous forest
- Evergreen forest
- Mixed forest
- Scrub/shrub
- Herbaceous
- Hay/pasture
- Cultivated crops
- Woody wetlands
- Emergent Herb. Wetlands



Urea concentrations in baseflow

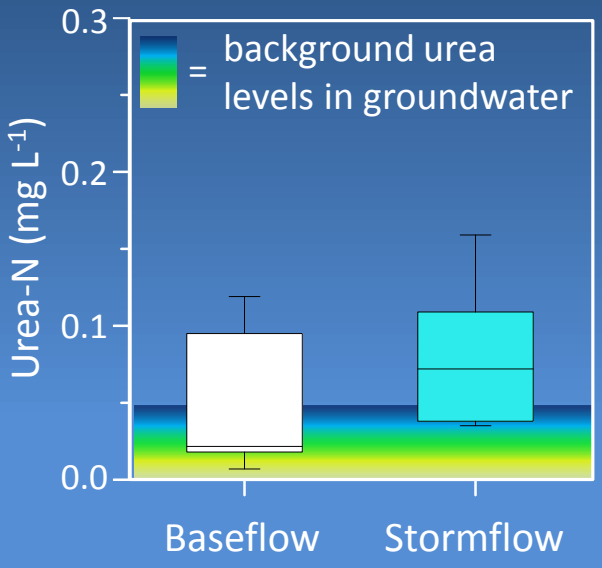
Highest in summer months and again in early fall

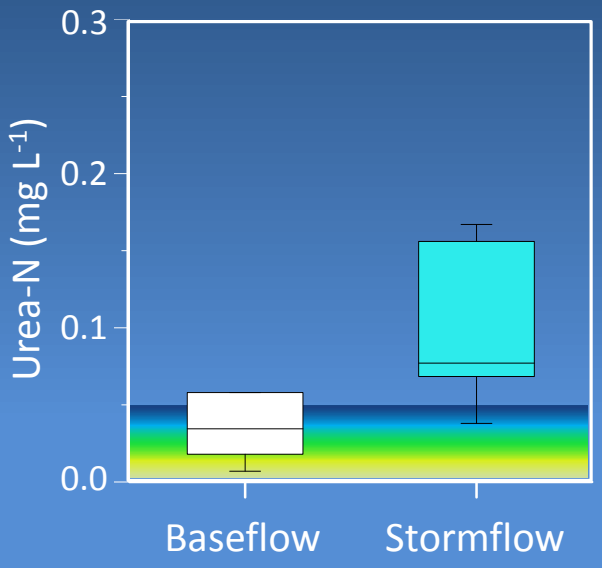


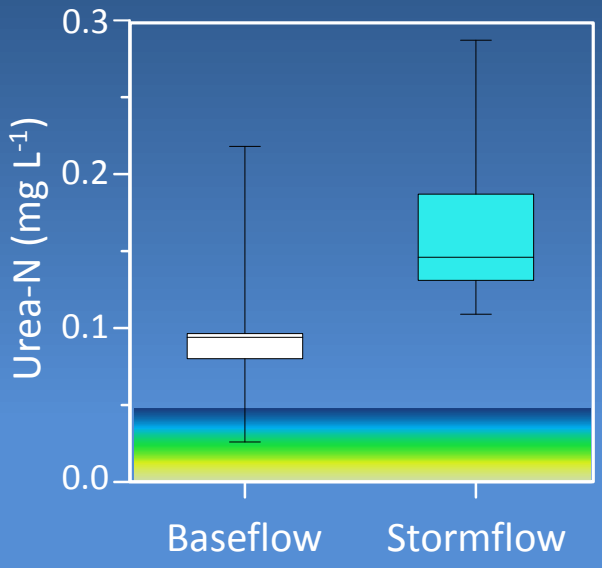
Tzilkowski (2012)

Urea levels increase during storms

Especially in field drainage ditches

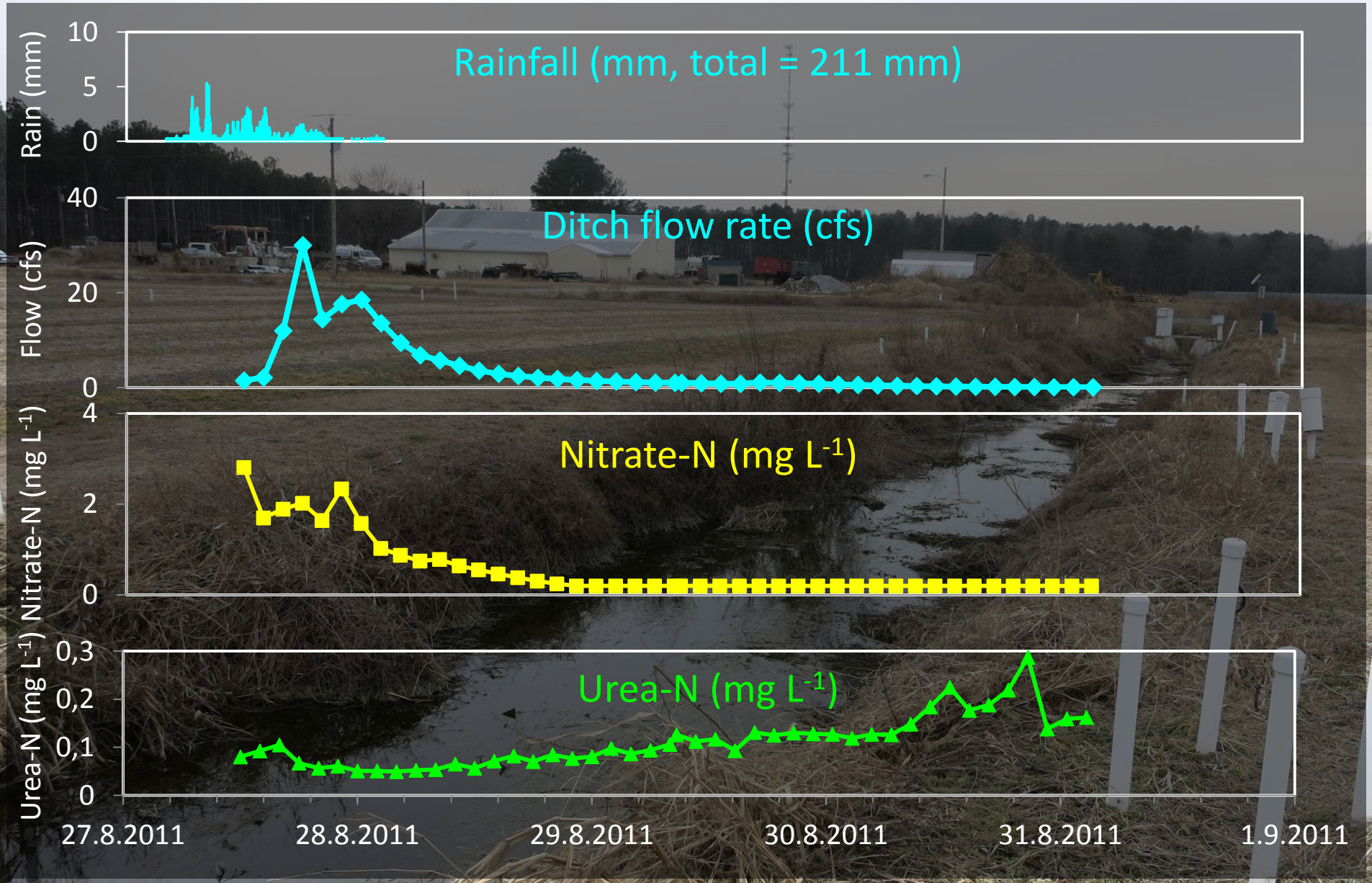






Tzilkowski (2012)

Urea and nitrate patterns during a large storm



Tzilkowski (2012)

Role of legacy N in urea generation?

Storm events

Groundwater is hydraulically connected to ditch.

Nitrate-N delivery to ditch waters from groundwater.

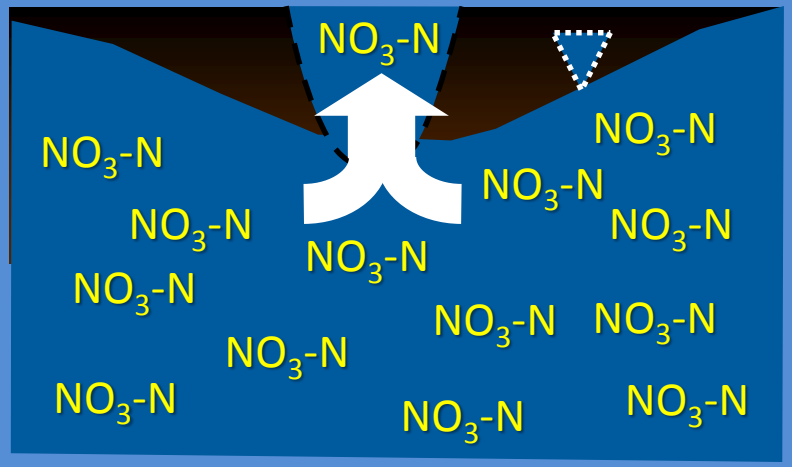
Uptake of nitrate-N by microbiota in ditch water?

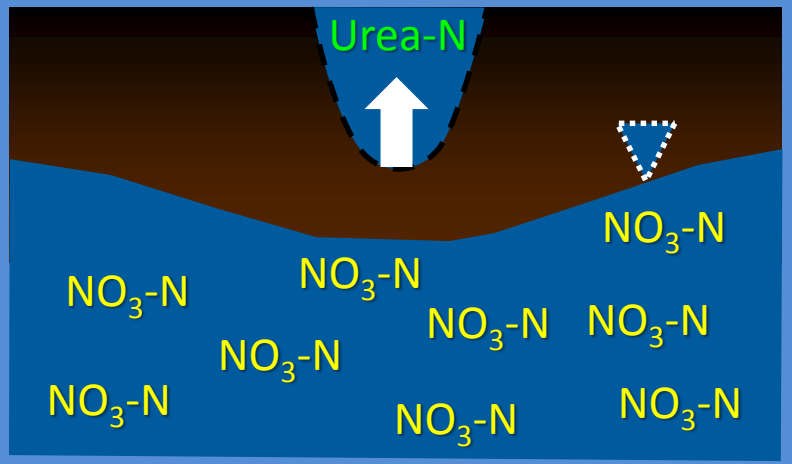
Post-storm recession

Groundwater is hydraulically disconnected from ditch.

Denitrification as ditch water becomes stagnant.

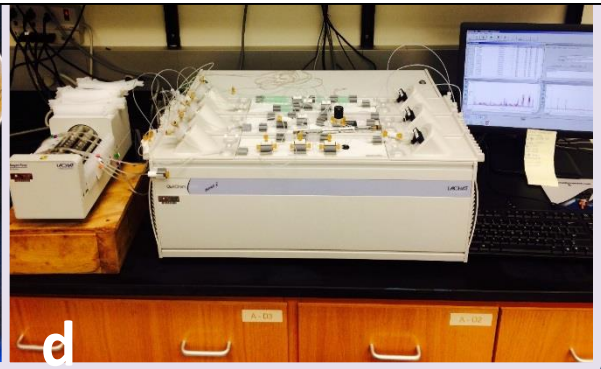
Urea release from sediments and/or biota?





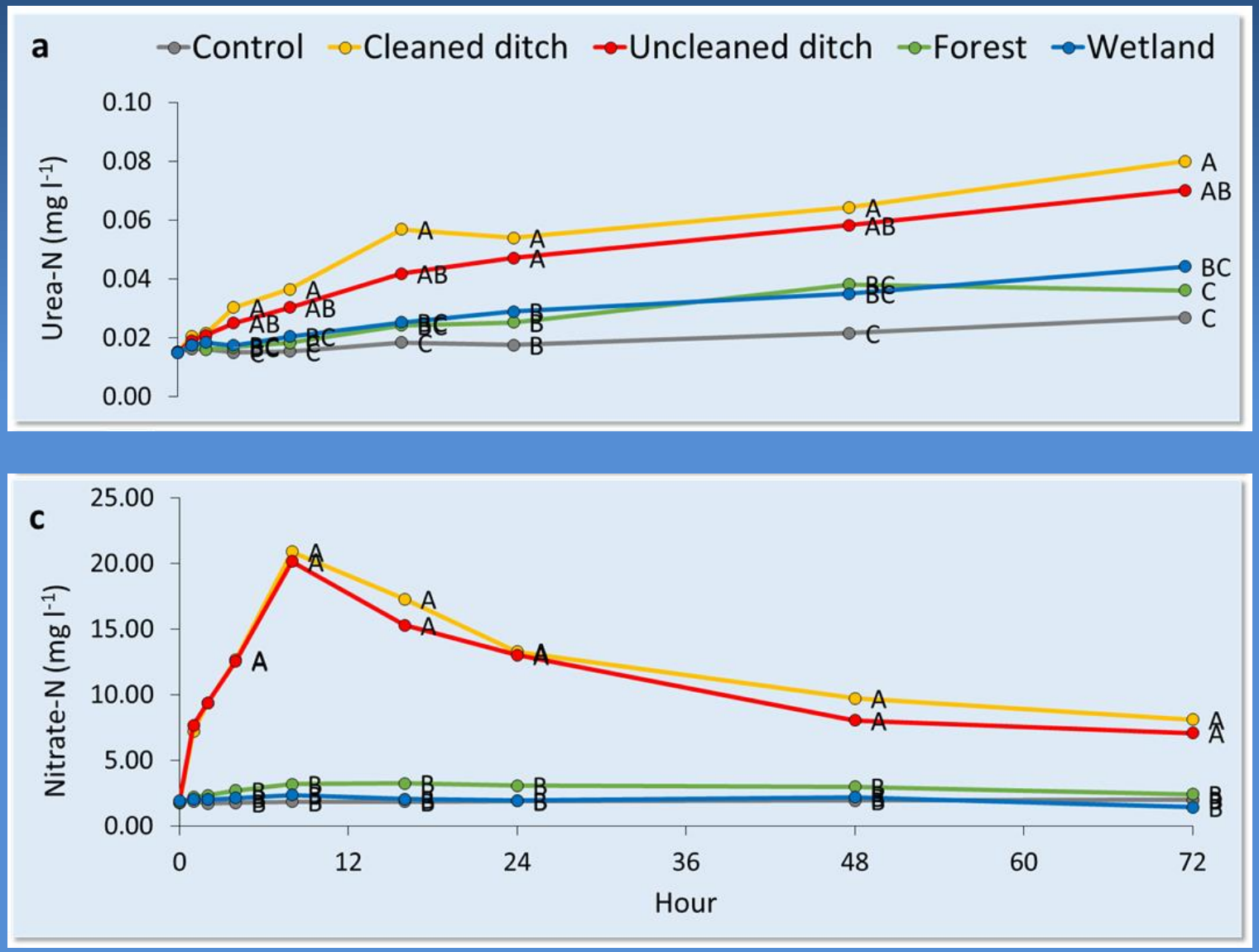
Mesocosm Studies

5 sites	x	3 temperature treatments	x	5 solution types	=	75 conditions
Agriculture ditch		15.0 °C		H_2O		
Cleaned agriculture ditch		22.5 °C		5 mg NH_4^+-N l^{-1}		
Forest ditch		30.0 °C		10 mg NH_4^+-N l^{-1}		
Wetland				5 mg NO_3^--N l^{-1}		
Control				10 mg NO_3^--N l^{-1}		

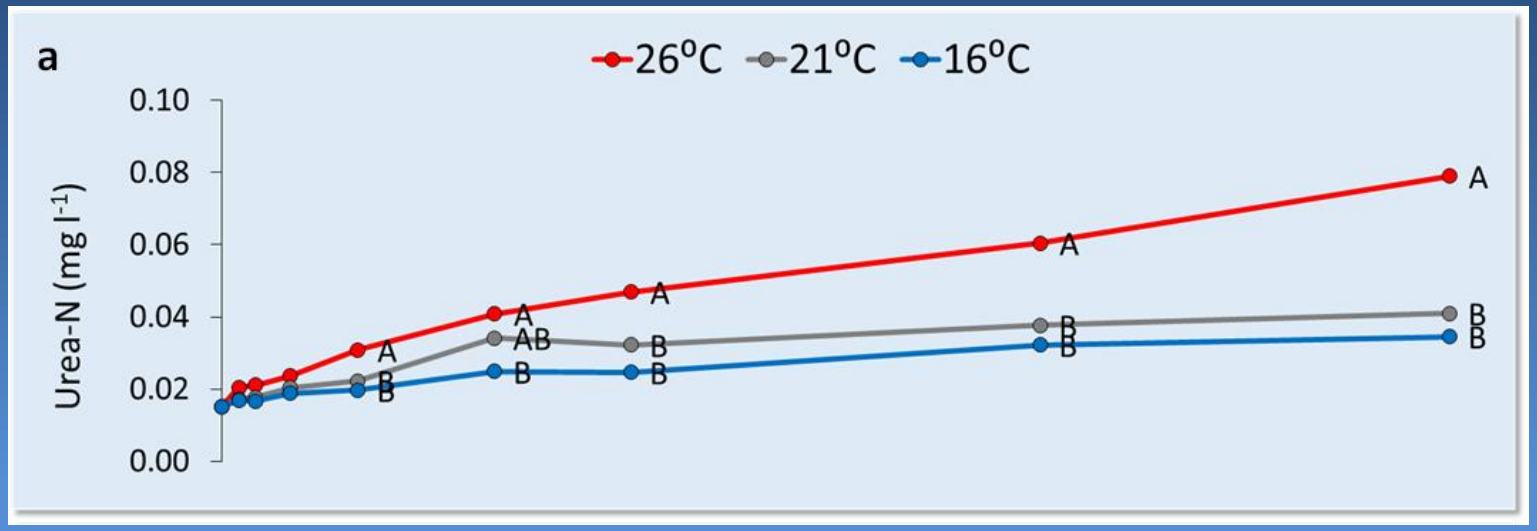


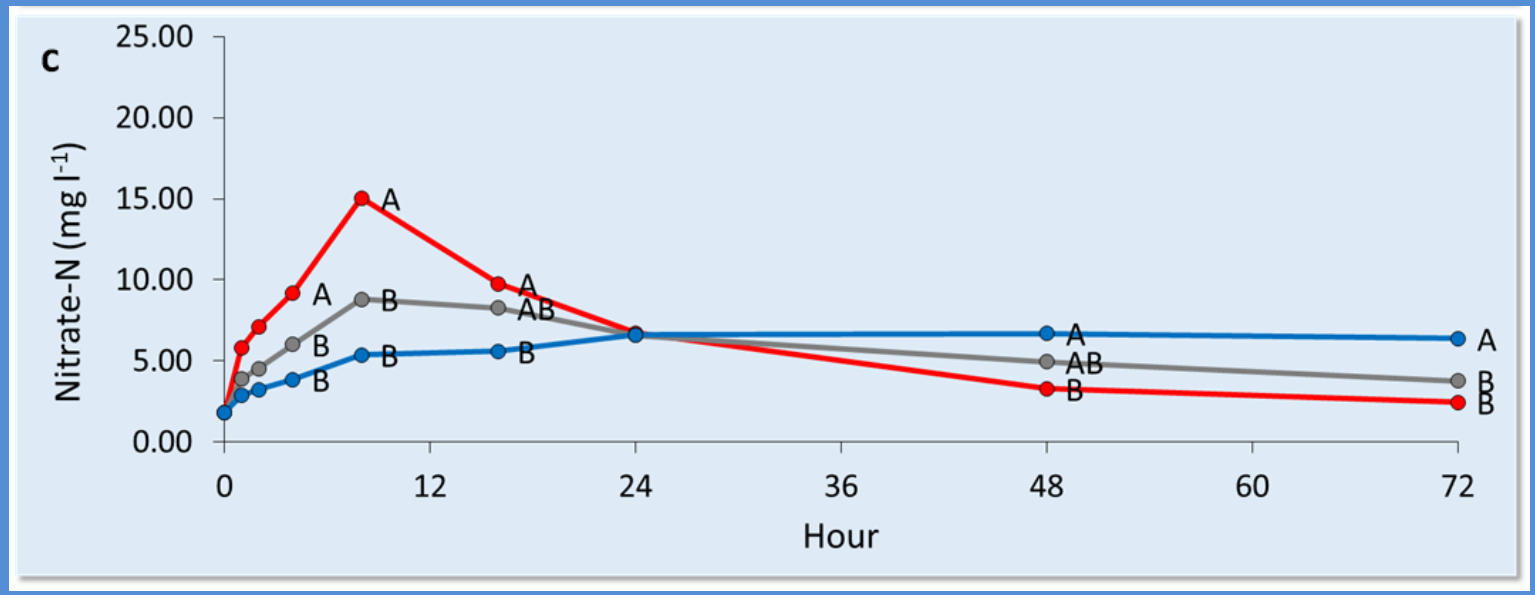
Sterile Sand Control

Treatment Response



Temperature Response





Conclusions

Transfers of recently applied urea to water are unlikely under normal climate conditions and management.

Evidence suggests that N-rich groundwater delivered to field ditches may be converted to urea as flows recede.

Urea that is generated *in situ* would be available for hydrologic transport in subsequent storm events.

We hypothesize that legacy nitrogen in groundwater may play a key role in urea cycling and movement.

Implications

Switching away from urea-N fertilizers is unlikely to result in decreased urea loads to coastal waters.

Ditch management to prevent stagnant pools of water in ditches may reduce *in situ* urea formation.

Reduced nitrate concentrations in groundwater through improved N use efficiency may reduce in situ urea formation.