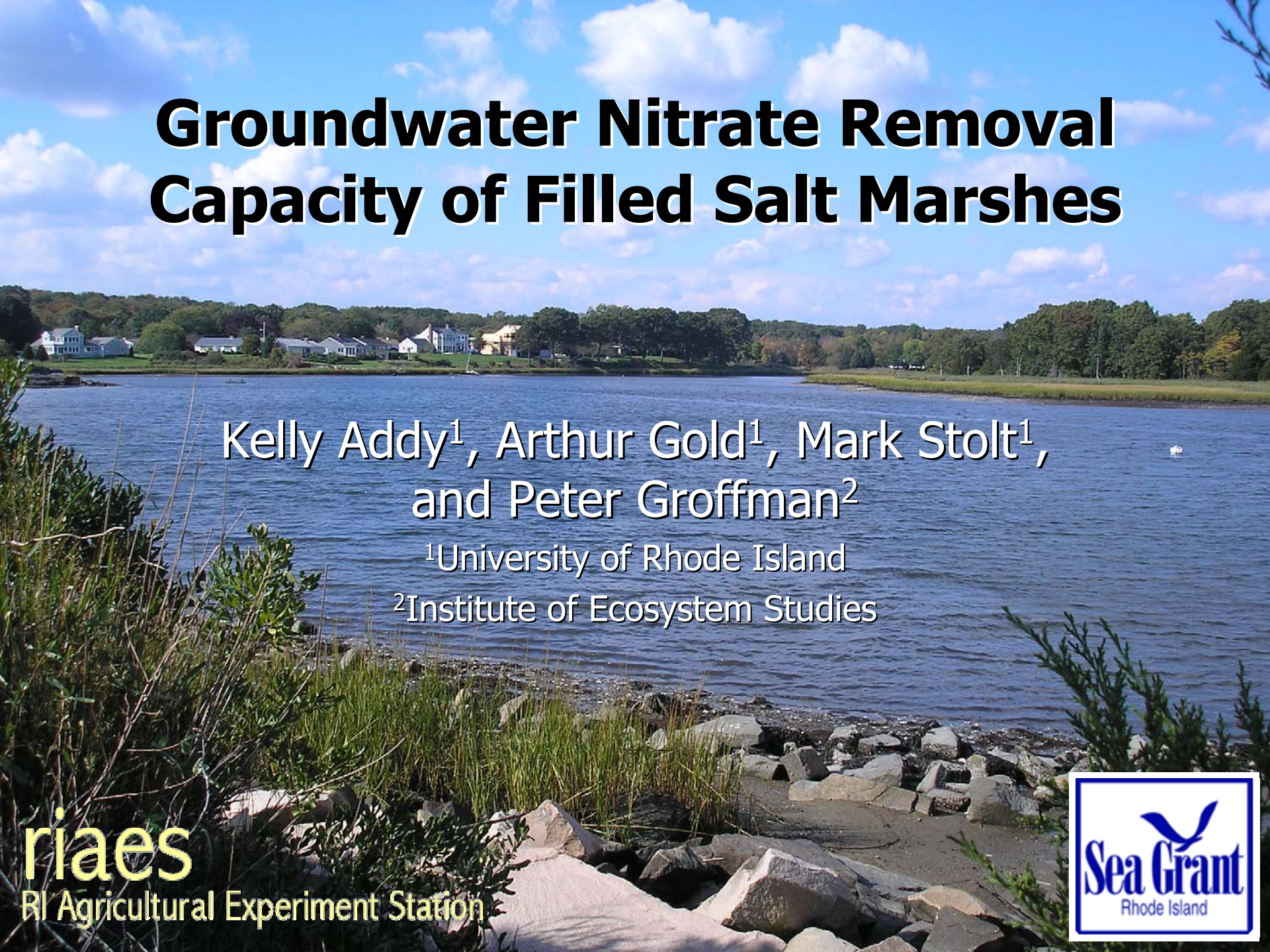
Groundwater Nitrate Removal Capacity of Filled Salt Marshes



Kelly Addy[1], Arthur Gold[1], Mark Stolt[1], and Peter Groffman[2]

[1]University of Rhode Island

[2]Institute of Ecosystem Studies

riaes
RI Agricultural Experiment Station

Sea Grant
Rhode Island

Undisturbed Salt Marshes in Northeastern U.S.

- Salt marshes in the northeast characterized by peat at the marsh surface overlying sands or gravels
- What is the fate of groundwater nitrate through these sands with high K?
  - Early studies: Minimal nitrate processing in these sandy aquifers (Giblin & Gaines 1990; Valiela et al. 1990 & 1992).
  - Recent studies: Groundwater denitrification can be substantial as approach coast (Tobias et al. 2001, Talbot et al. 2003, Ueda et al. 2003, Addy et al. 2005).

In situ groundwater denitrification capacity in an undisturbed salt marsh

(Addy et al. 2005; Tracking ^{15}N-enriched nitrate additions)

In situ groundwater denitrification capacity in an undisturbed salt marsh

(Addy et al. 2005; Tracking ^{15}N-enriched nitrate additions)

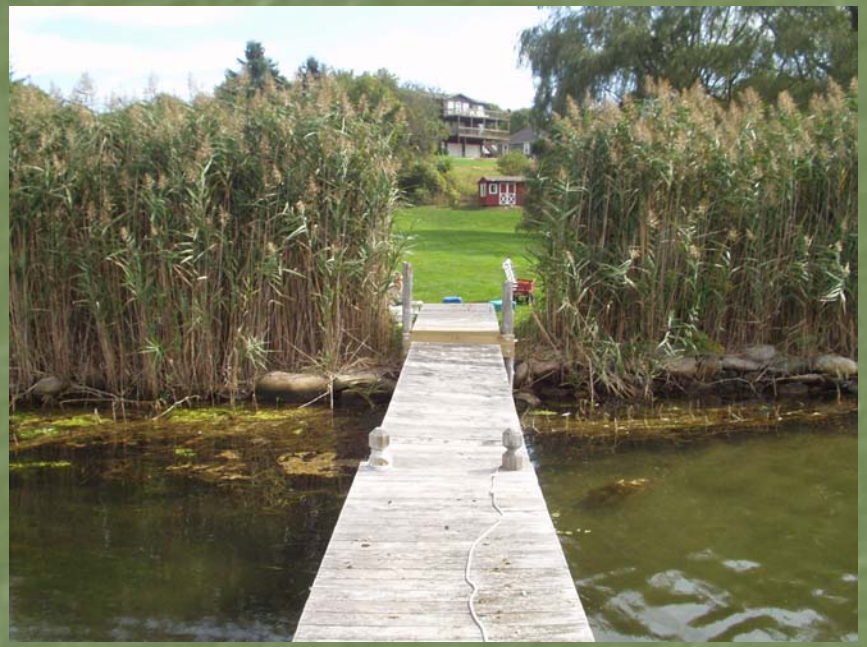
Zone	Depth (cm)	Summer/Fall Rate ($\mu g\ N\ kg^{-1}\ soil\ d^{-1}$)	Spring Rate ($\mu g\ N\ kg^{-1}\ soil\ d^{-1}$)
Low marsh	125	123	60
High marsh	125	49	2
High marsh	200	37	

Low Marsh = substantial annual sink for N

Extensive shoreline alteration

- Coastal areas often drained, filled and/or bulkheaded for development to proceed

- Nowicki et al. field survey (unpublished data): roughly 33 - 50% of the shorelines of 3 RI coastal ponds altered



- Does this extensive shoreline alteration eliminate the capacity for groundwater denitrification?

Situation

- In most cases, fill material (human transported materials – HTM) added on top of existing salt marsh
- Surface ecosystem completely altered – surface flooding will NOT occur
- Unless pipes installed for drainage, water table will remain at historic levels at or near the buried salt marsh horizon; tidal cycle will still create diurnal water table fluctuations
- **Hypothesis: Buried salt marsh horizons will continue to foster substantial groundwater denitrification rates**

Objectives

- Characterize shoreline alteration that dominates RI's coast
  - Describe fill material
  - Assess hydrology
- Measure in situ groundwater denitrification capacity in filled salt marshes

Site Selection

- From review of 1939 and 1997 aerial photography and GIS databases on disturbed and degraded salt marshes, selected initial 76 sites for field visits
- Based on site visits and landowner permission – 11 filled salt marsh sites and 4 undisturbed sites selected for soil & hydrological assessment

Initial Soil & Hydrology Assessment

- Auger transects & soil pits
- Two water table wells per site monitored biweekly

In Situ Groundwater Denitrification Capacity

- Former salt marsh sites covered with fill material
  - 3 grassy areas
  - 1 parking lot

- Denitrification, Flowpath & K assessment
  - 5 replicate mini-piezometers per site
  - sandy soil 40-90 cm below the former salt marsh surface

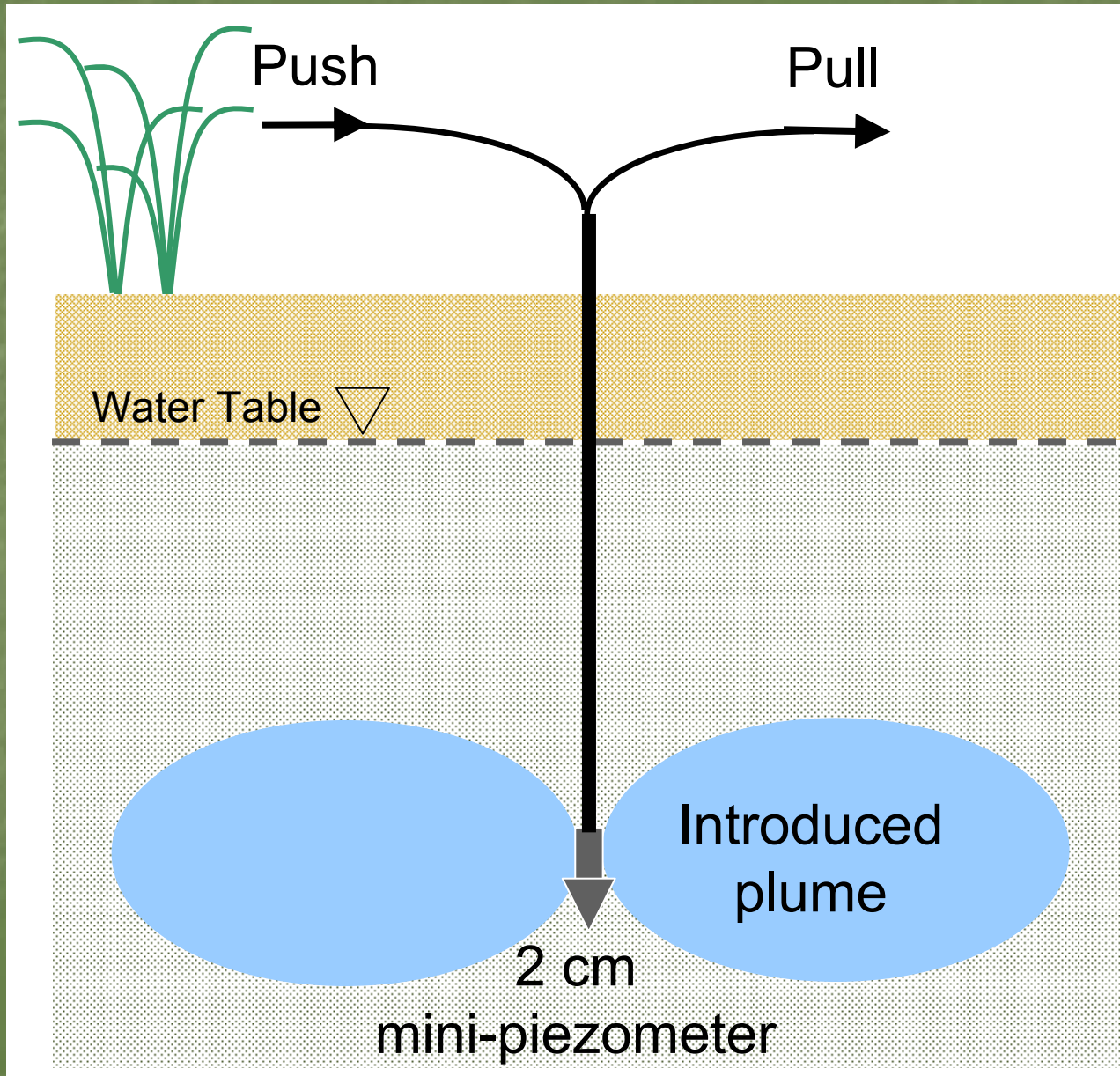
Fill Characteristics

Site	1	2	3	4
Latest Year Filled	1962	1976	1976	1952
Fill Thickness (cm)	80	63	150	120
Fill composition	silt loam, gr sandy loam	loamy sand, gr loamy sand	sandy loam, sand	sand, v gr sand

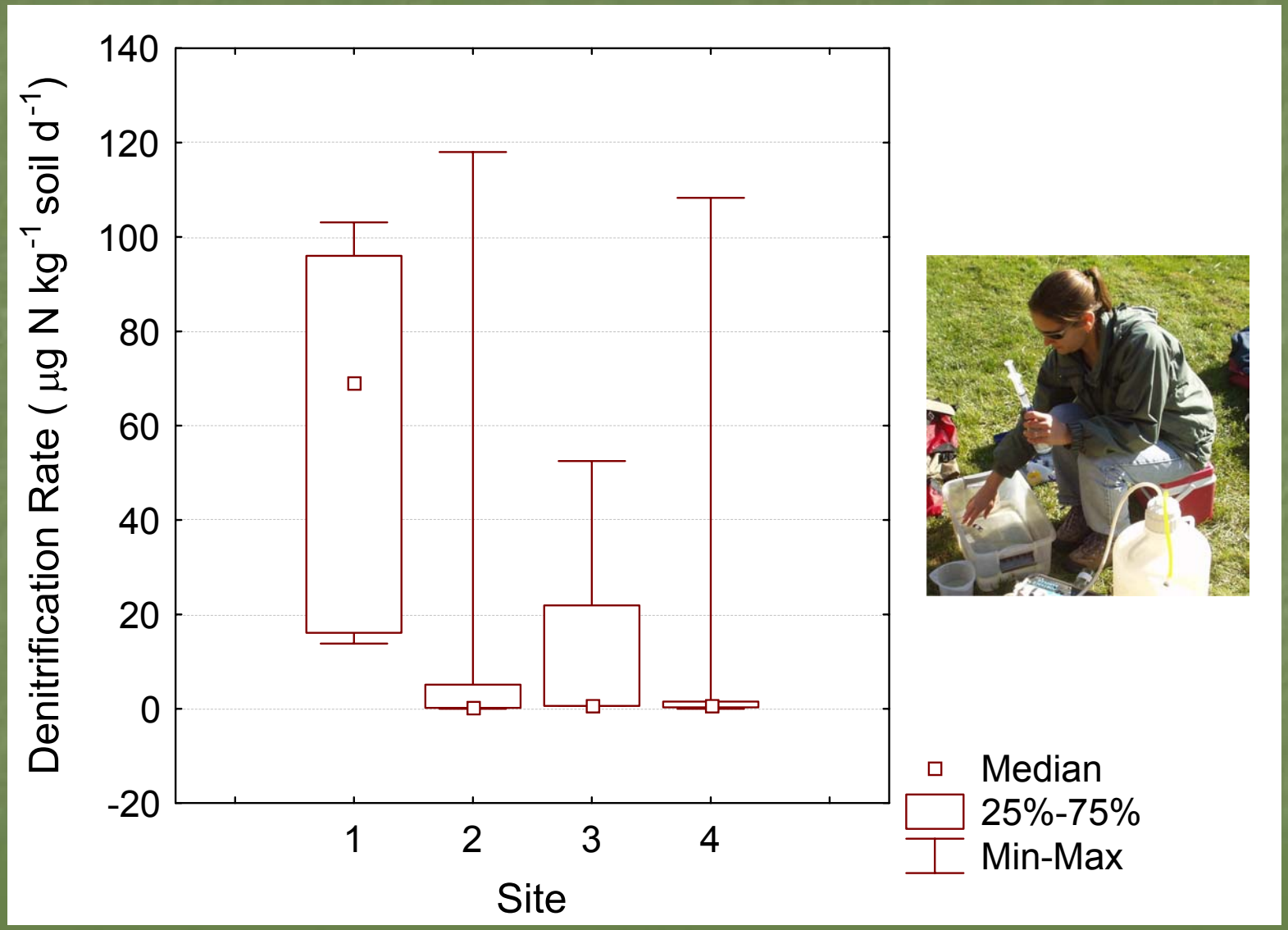
Push-Pull Method: In situ denitrification capacity

1. Pump groundwater
2. Amend with $^{15}NO_3^-$ and Br^-
3. Lower DO to ambient levels with gaseous SF_6
4. Push (inject) into well
5. Incubate
6. Pull (pump) from well
7. Analyze samples for $^{15}N_2$ and $^{15}N_2O$ (products of microbial denitrification)

(Addy et al. 2002)



Fall 2005 Denitrification Capacity Results:



Lack of correlation of site characteristics to groundwater denitrification capacity

- No significant correlation with groundwater DO, DOC, temperature, salinity, pH, ambient nitrate, depth below water table, fill thickness, fill age, or depth below former marsh
- Fill at Site 1 had the finest texture (and highest organic matter content)

Discussion

- Human disturbance likely to generate non-uniform physical characteristics
  - All sites were fill over organic material, but we do not know:
    - the extent or nature of the disturbance to the marsh before filling
    - the source of the fill material
  - Extreme intrasite variability of in situ groundwater denitrification capacity contrasts with our observations at undisturbed salt marshes

Discussion

- Rates, flowpaths & K indicate that Site 1 can be substantial N sink
- Remaining sites displayed patchy N removal capacity
- Questions:
  - Are buried salt marsh horizons the source of labile C for groundwater denitrification?
  - If so, how much buried labile C is available?
  - Can certain fill materials contribute labile C?
  - Are other electron donor sources contributing to denitrification

Thank You!!

Special thanks to: Sean Donohue, Tara Watson, Alison Milliman, Dave Millar, Sophia Narkiewicz, Josh Klement, Yemi Odewale, Linda Green, Q Kellogg, and David Lewis

riaes
RI Agricultural Experiment Station

Sea Grant
Rhode Island