HTM Effects on Groundwater Denitrification along RI's Coast

Kelly Addy, Arthur Gold,
Mark Stolt, and Sean Donohue

University of Rhode Island

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)

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Zone	Depth (cm)	Summer/Fall Rate (μg N kg^{-1} soil d^{-1})	Spring Rate (μg 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

Urbanization alters salt marshes

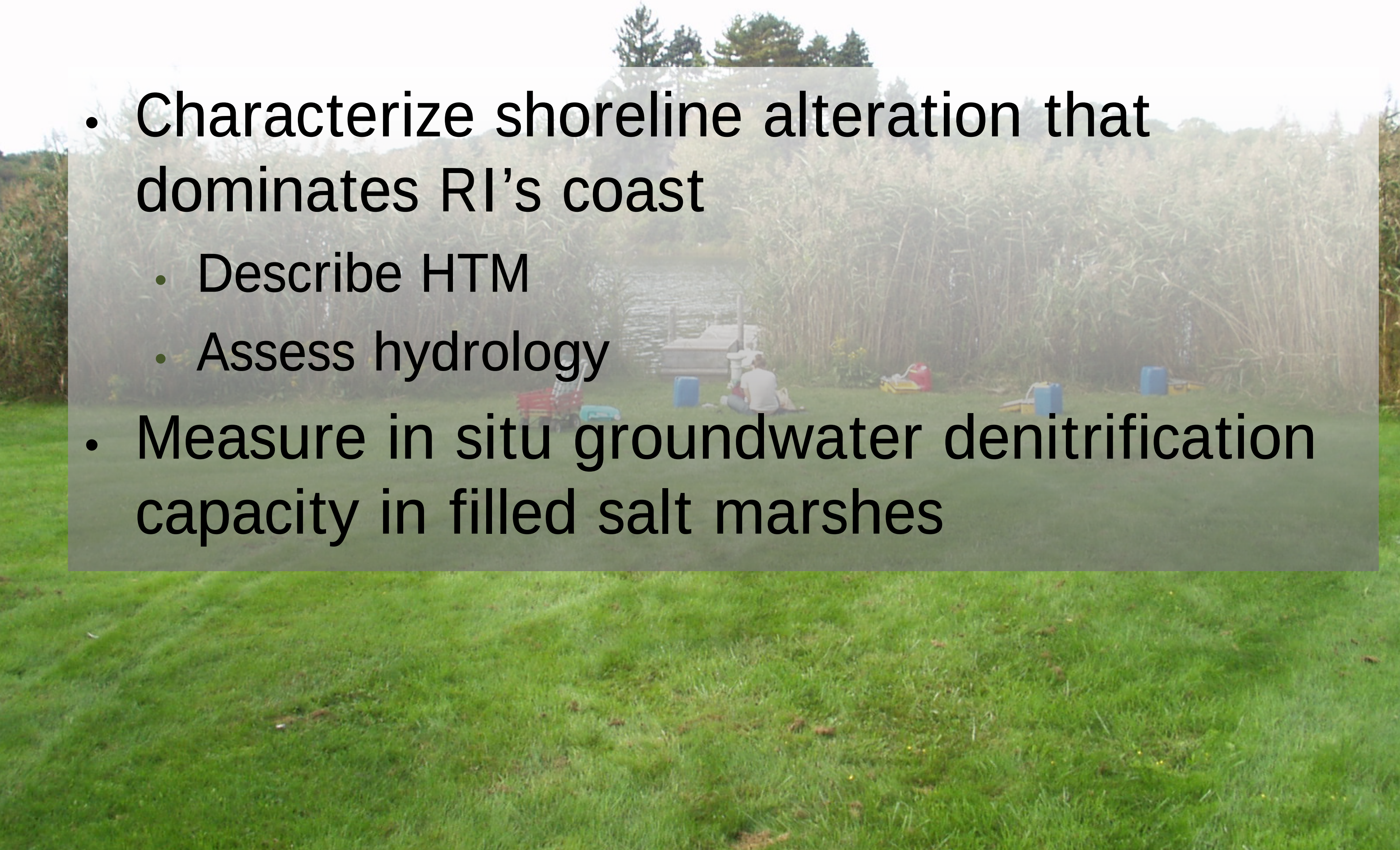
- Estimated that 37% of original salt marsh in New England has been lost - 53% in RI (Bromberg & Bertness, 2005)
- Coastal areas often drained, filled and/or bulkheaded for development to proceed

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

Situation

- In most cases, 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 HTM
  - 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

Soil & Hydrology Assessment

Soil Assessment

- Auger transects and soil pits
- Lots of variability in HTM
- Assessed particle size, bulk density and SOC of fill material and buried marsh soil

Water Tables

- Rose into HTM deposits at all sites
- Fluctuations within HTM were influenced by tide and other factors

Former Marsh Surface

In Situ Groundwater Denitrification Capacity

- Former salt marsh sites covered with HTM
  - 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

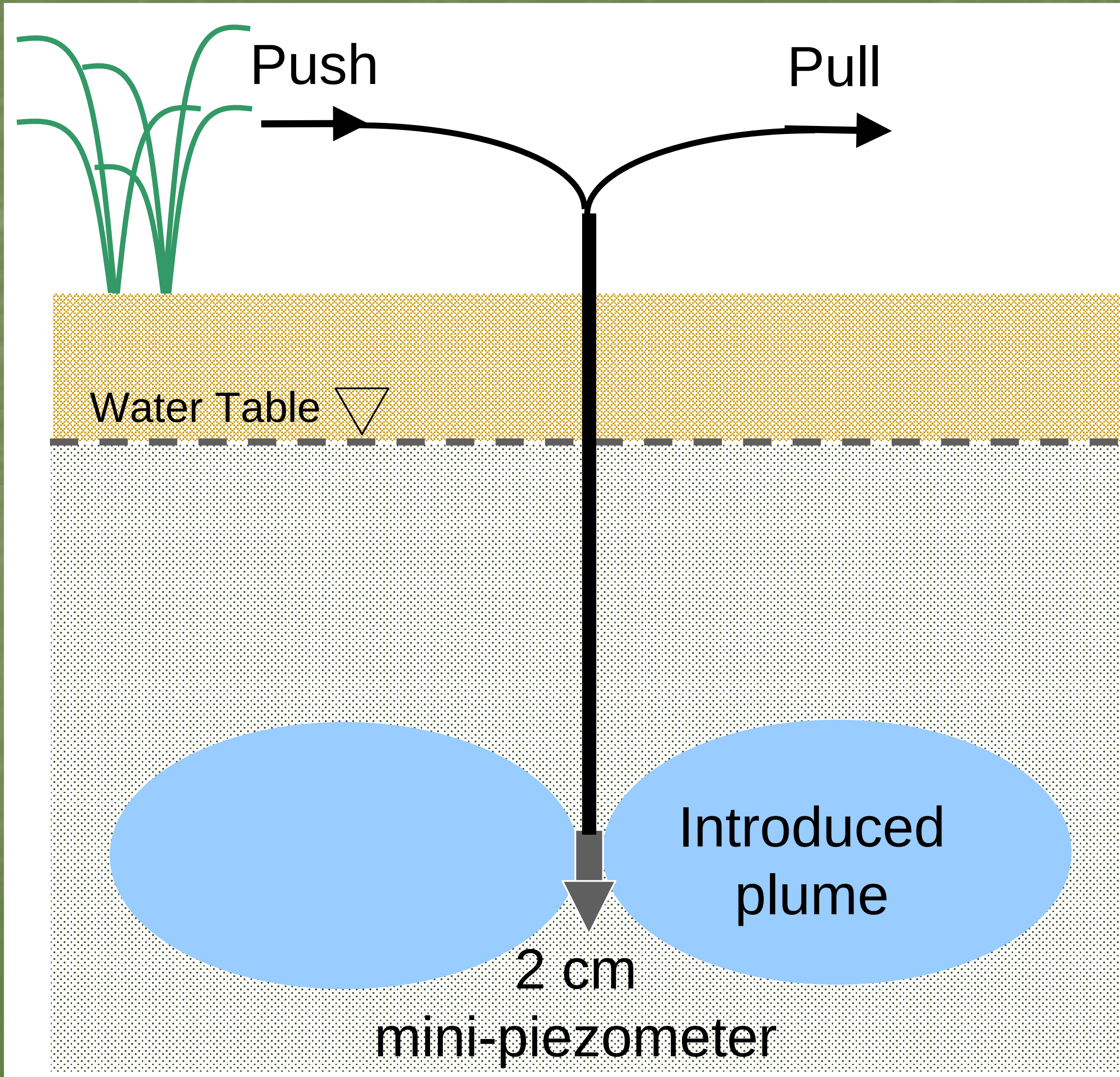
HTM Characteristics

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

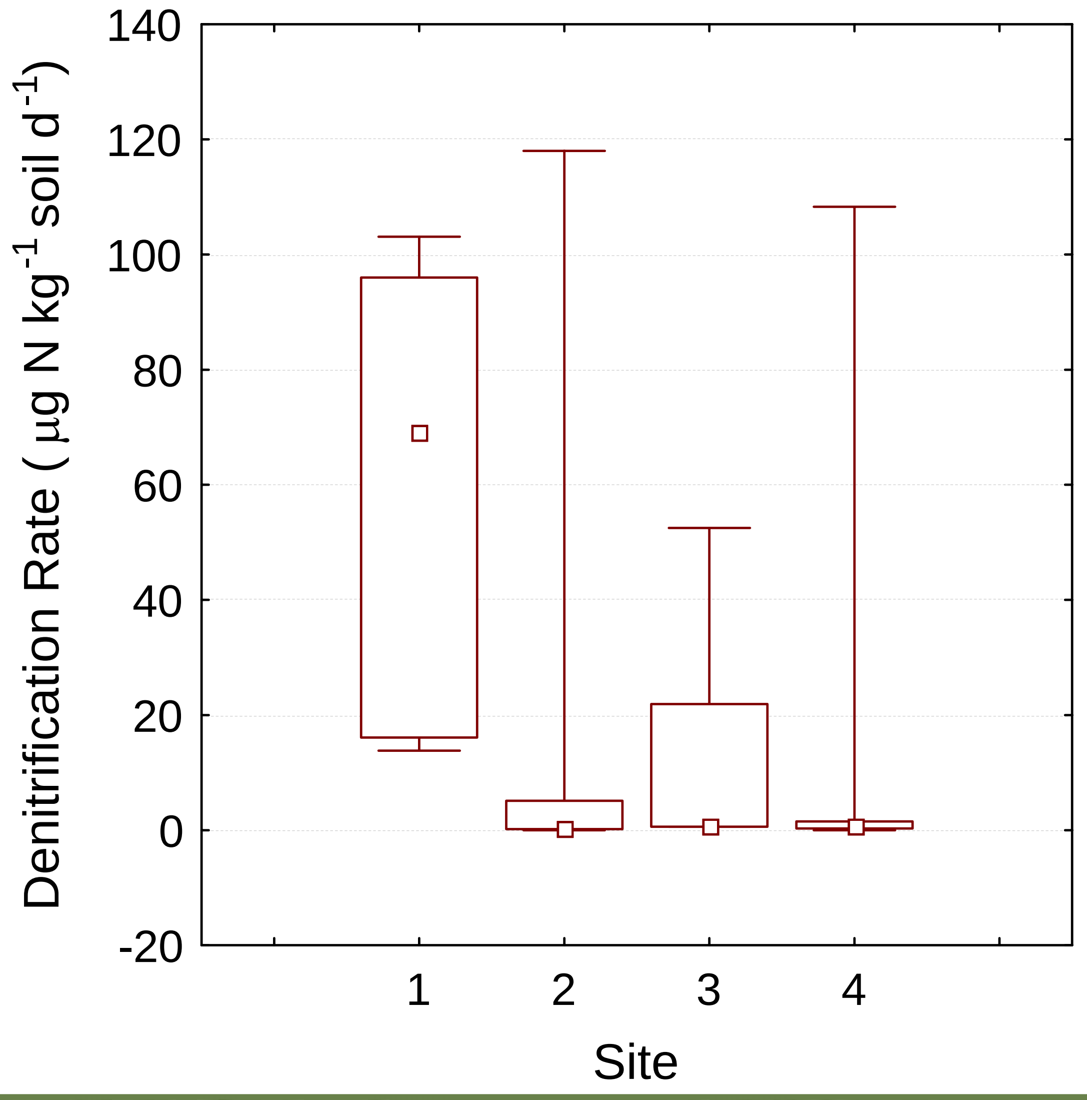
Push-Pull Method: In situ denitrification capacity

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:



Why?

- No significant correlation with groundwater DO, DOC, temperature, pH, ambient nitrate, depth below water table, HTM thickness, HTM age, or depth below former marsh
- Groundwater at all sites fresh (did HTM cut off sulfide connections?)

- HTM at Site 1 had the finest texture and highest SOC (look at HTM characteristics more closely)

Discussion

- Human disturbance likely to generate non-uniform physical characteristics
  - All sites were HTM over organic material

    - bulk density measurements indicate that the marsh soils were NOT compacted prior to filling
    - source of the HTM was variable
  - Extreme intrasite variability of in situ groundwater denitrification capacity contrasts with our observations at undisturbed salt marshes

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 HTM contribute labile C?
- Are other electron donor sources, i.e., sulfide, contributing to denitrification in salt marshes


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