USE OF NITROGEN BUDGETS AND N_2 FLUX MEASUREMENTS TO ESTIMATE THE ROLE OF DENITRIFICATION IN BROWNFIELD STORMWATER WETLANDS

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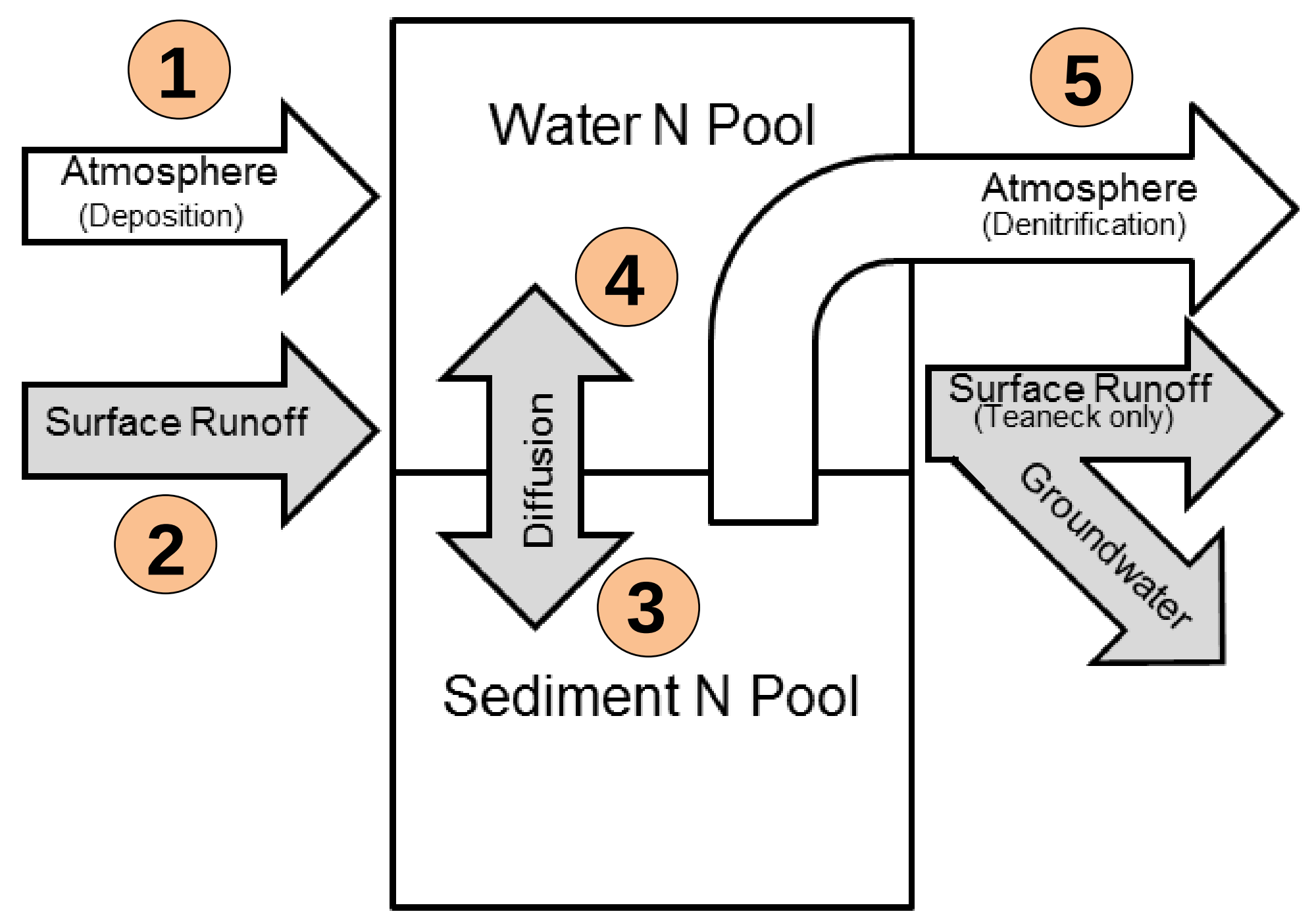
INTRODUCTION

- Urban areas are net sources of excess inorganic nitrogen in waterways
- Wetlands provide desirable ecosystem services such as NO_3^- removal via denitrification (microbial conversion of NO_3^- to N_2)
- Despite a broad understanding of environmental factors controlling rates of denitrification, few robust & predictive models have been constructed and validated for wetlands
- N_2 flux is difficult to measure, resulting in primarily measurements of potential or incomplete denitrification rates

STUDY OBJECTIVES

(1) Utilize **in situ measurements of N_2 gas production and NO_3^- loss** in sediment profiles to calculate denitrification rates

(2) Examine the **role and importance of denitrification** in inorganic nitrogen cycling and removal in urban brownfield wetlands

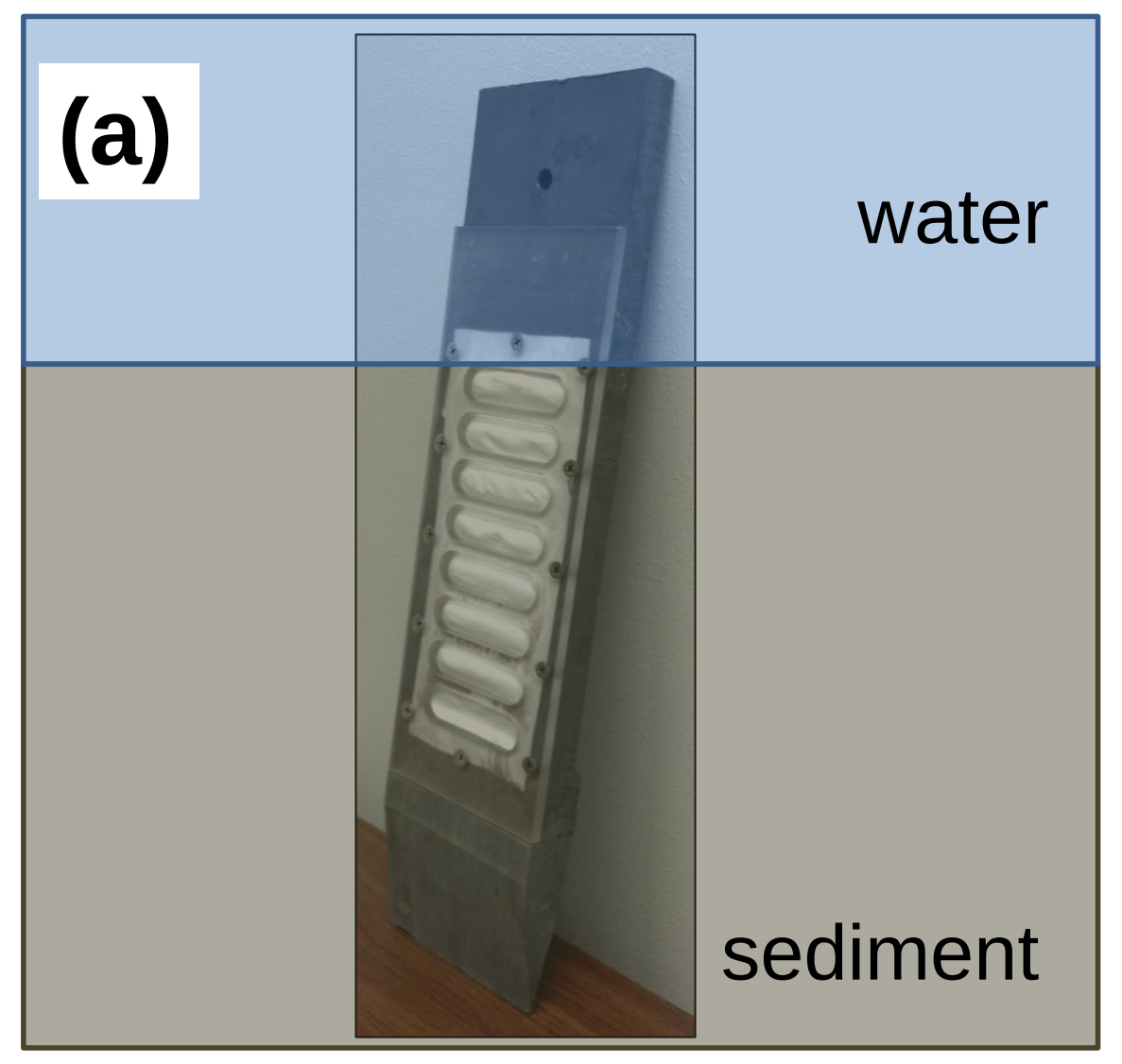


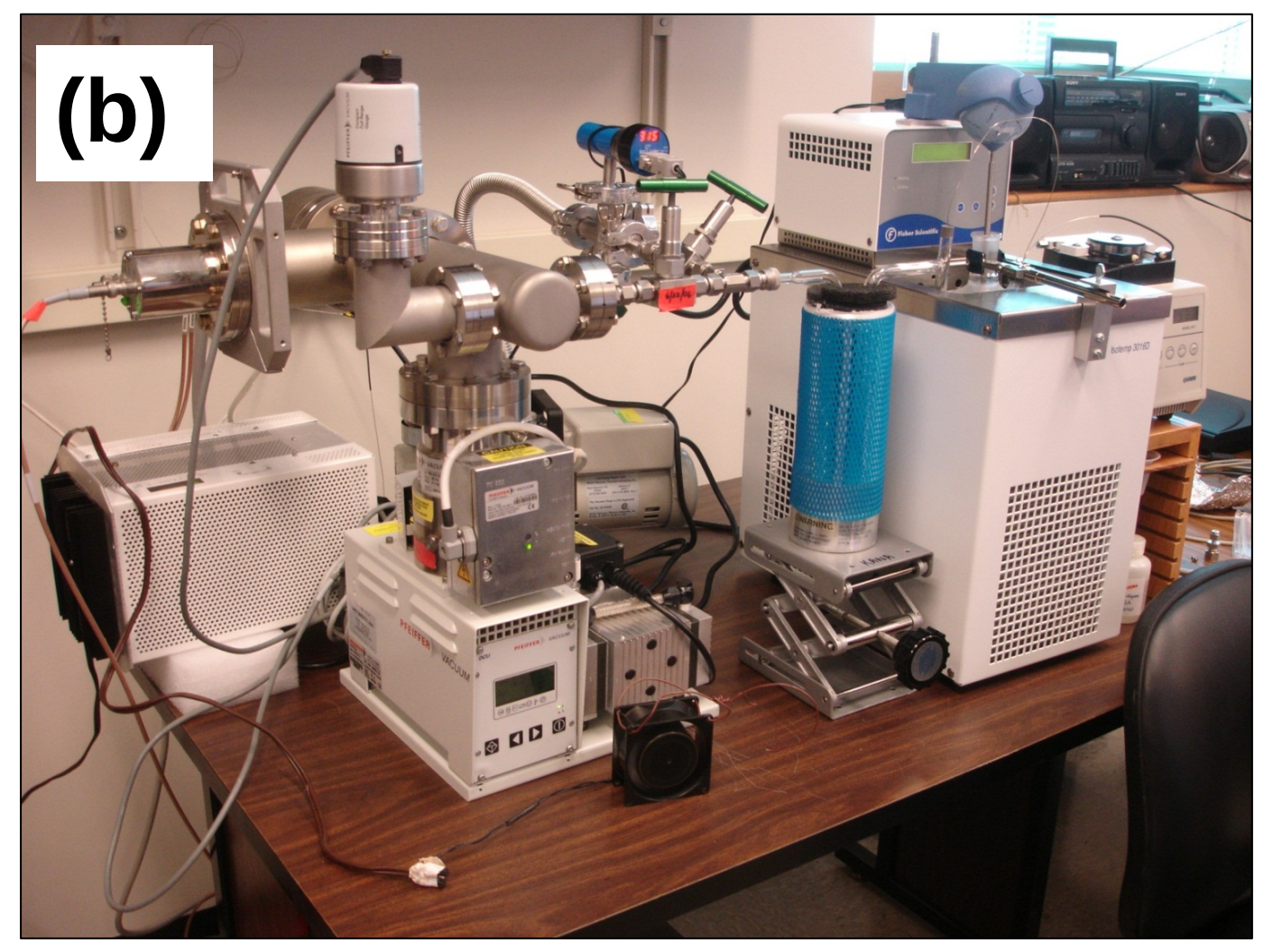
POOLS AND FLUXES OF INORGANIC N.

- Gray arrows indicate hydrologic fluxes, white arrows indicate fluxes into or out of the atmosphere.
- Atmospheric fluxes into the water and soil N pools include both wet and dry deposition.

METHODS

- Denitrification measurements:
  - Peepers (a) to collect pore water in sediment (2009–2010)
  - Membrane Inlet Mass Spectrometry (MIMS) to analyze pore water for N_2, Ar, and O_2 (b)
- Nitrogen loading to wetlands:
  - Atmospheric dry and wet deposition concentrations determined using literature values (Liberty) and a 2005–2006 field monitoring study (Teaneck)
  - Stormwater concentrations monitored at Liberty in 2008 and at Teaneck in 2005–2006
  - Volumes of stormwater entering and exiting wetlands estimated using SWMM and Mike SHE/Mike 11 models
  - Volumes of precipitation calculated from NOAA gages
- Calculations:
  - Saturation normalized N_2/Ar ratio calculated using the following equation: $(N_2/Ar)_{sat}=(N_2/Ar)_{molar\ ratio}/(N_2/Ar)_{saturation\ equilibrium\ ratio}$
  - Diffusive N_2, NO_3^- and NH_4^+ fluxes in sediments calculated at the point of maximum slope of all dissolved constituents in the profile and where $(N_2/Ar)_{sat} > 1.0$





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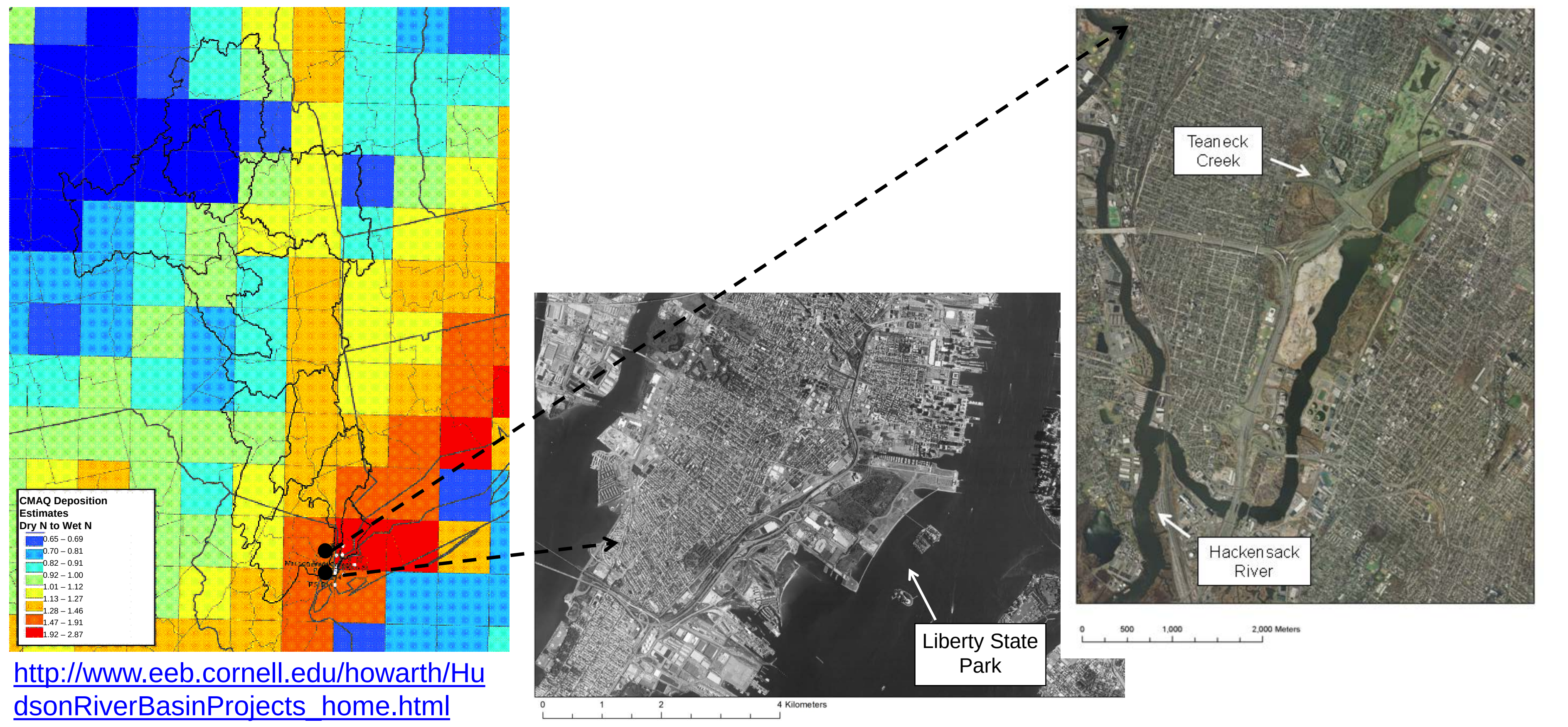
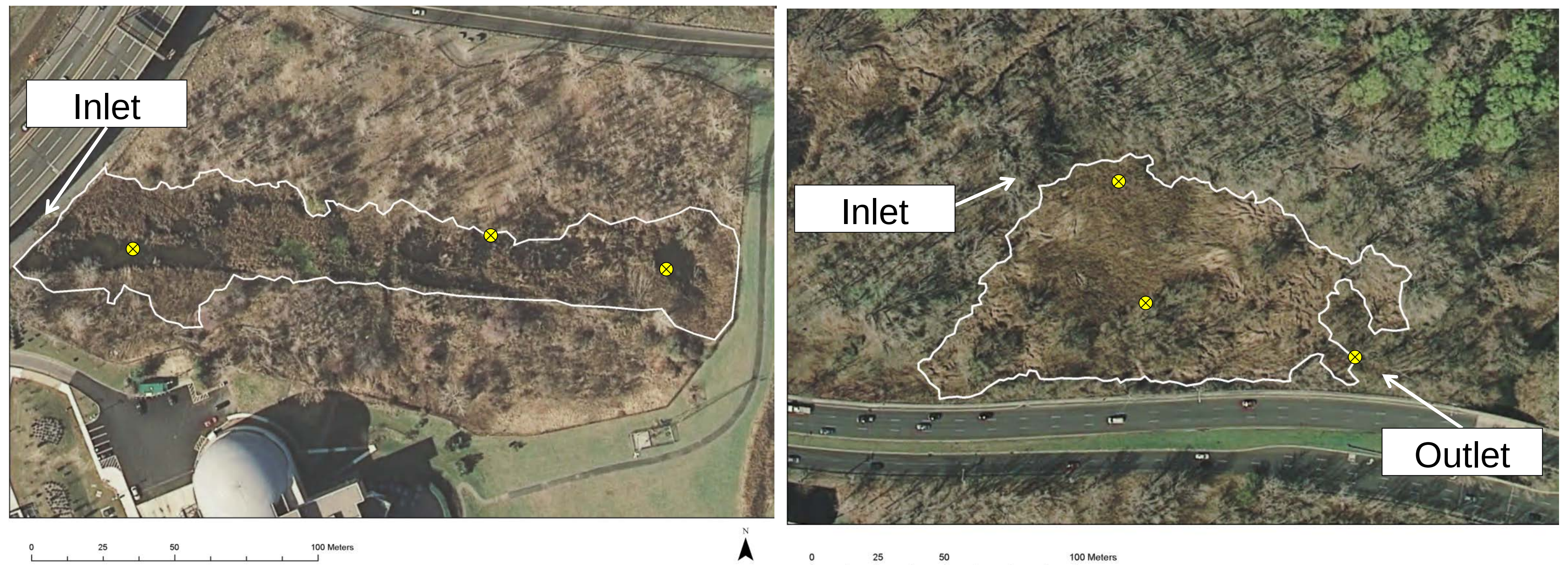
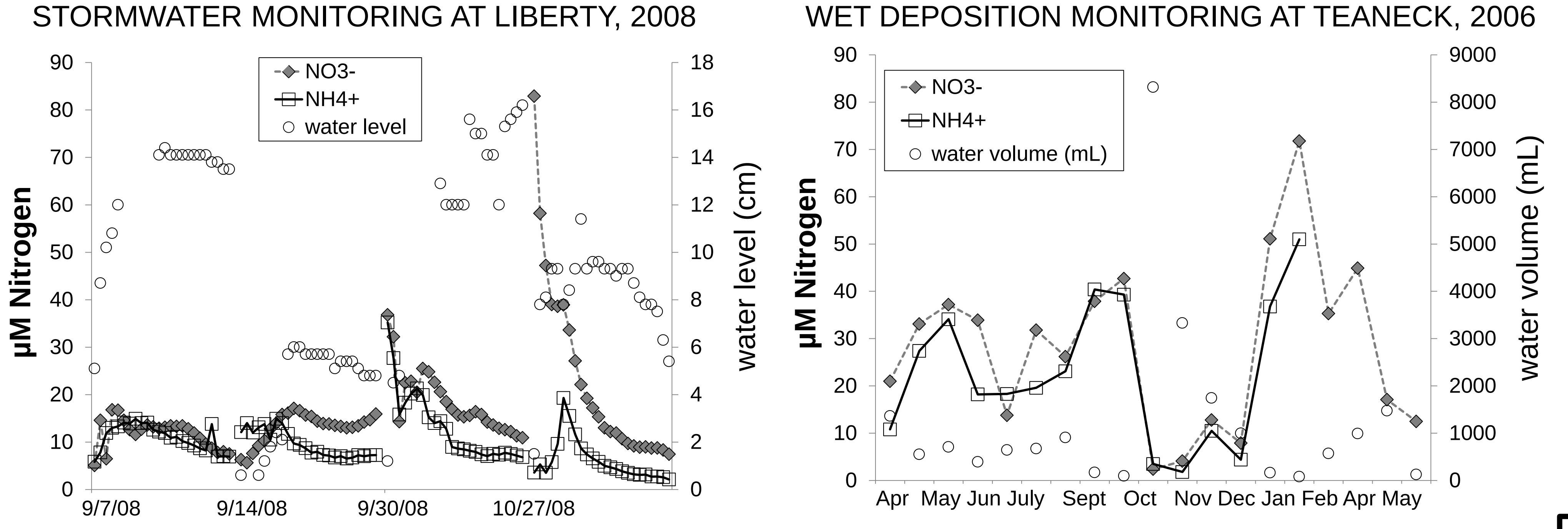


http://www.eeb.cornell.edu/howarth/HudsonRiverBasinProjects_home.html

INORGANIC N INPUTS IN THE NORTHEASTERN US ARE HIGH DUE TO URBAN STORMWATER AND ATMOSPHERIC DEPOSITION. Rivers and estuaries in the region are subject to associated eutrophication problems; public parks are often an intermediary between urban stormwater from upland areas and adjacent waterbodies.

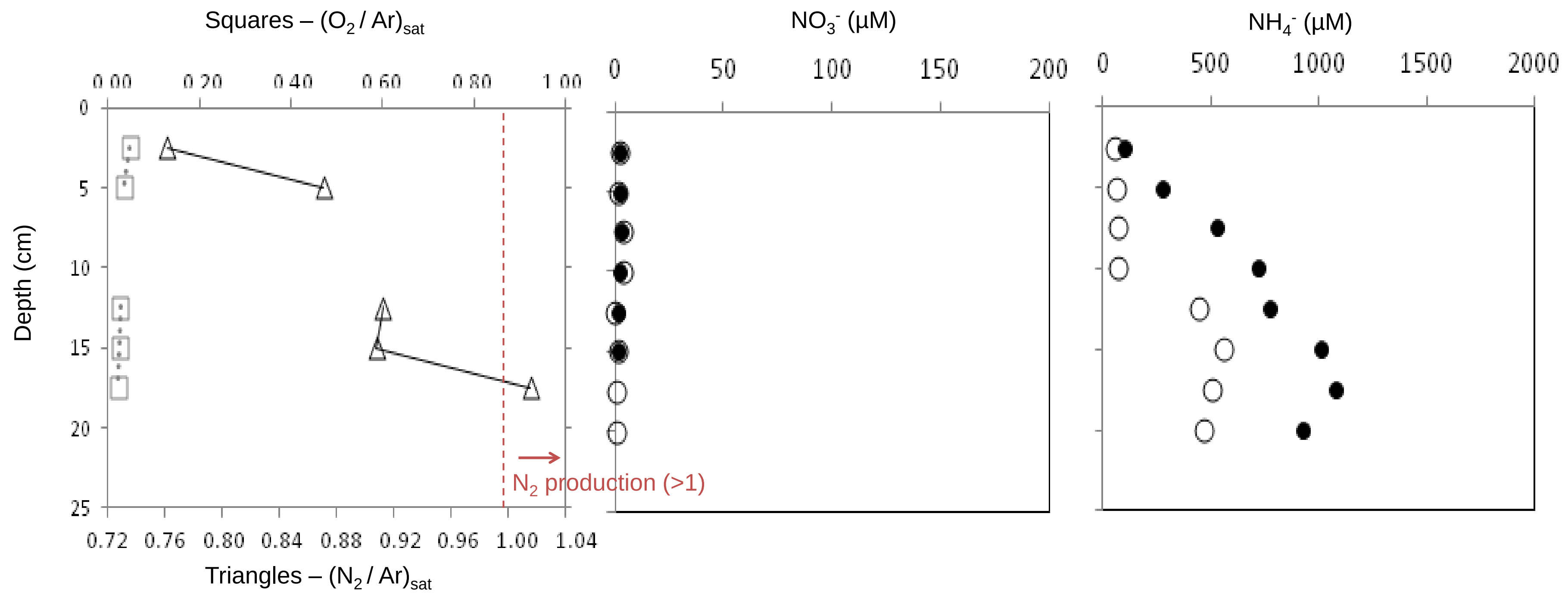


LIBERTY STATE PARK AND TEANECK CREEK CONSERVANCY ARE URBAN BROWNFIELD SITES SUPPORTING SEMI-PERMANENTLY FLOODED WETLANDS. White outlines delineate low-lying semi-permanently flooded areas. Flow in both wetlands moves west to east—surface water at the far left side of each photograph.

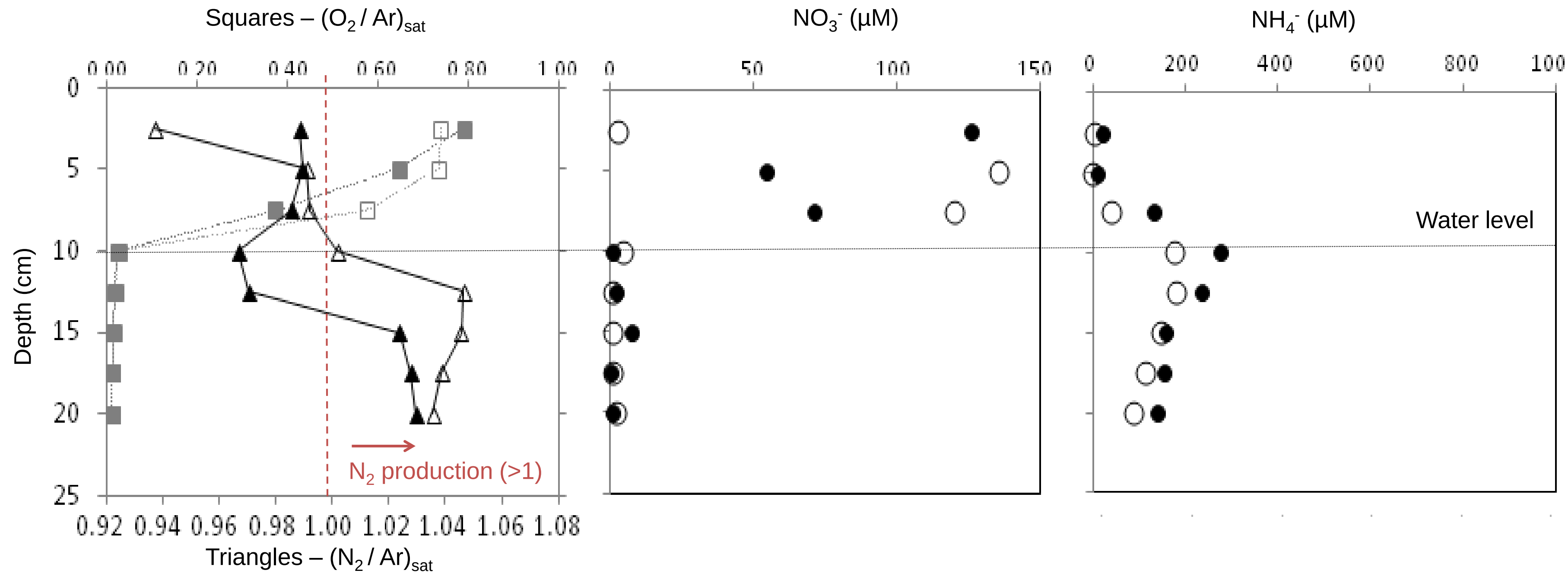

STORMWATER MONITORING AT LIBERTY, 2008

WET DEPOSITION MONITORING AT TEANECK, 2006

NH_4^+ AND NO_3^- LOADING IS HIGH DURING STORM EVENTS, AND EXHIBIT SIMILAR CONCENTRATIONS IN STORM AND RAINWATER ENTERING THE WETLANDS.



FLOODED CONDITIONS RESULT IN LOW NO_3^-, LOW N_2, AND HIGH NH_4^+ PRODUCTION. Peepers under flooded conditions demonstrated low dissolved O_2 , which appeared to promote NH_4^+ production via mineralization of plant material, but little denitrification due to low NO_3^- availability (example from Liberty shown).



DRY-DOWN CONDITIONS RESULT IN HIGH NO_3^- PRODUCTION ABOVE THE SEDIMENT-WATER INTERFACE, AND HIGH N_2 PRODUCTION BELOW THE SEDIMENT-WATER INTERFACE. Peepers under dry-down conditions demonstrated lower overall NH_4^+ production. N_2 production was much higher than under flooded conditions, and coincided with a drop in dissolved O_2 and NO_3^- at the sediment-water interface (example from Teaneck shown).

		Dry Conditions	Wet Conditions
Surface Water N Fluxes (IN)			
Dry Deposition			
N-NO_3^-	①	3,090	3,090
N-NH_4^+		4,511	4,511
Wet Deposition		[Vol: 36.0 L]	[Vol: 57.3 L]
N-NO_3^-	①	2,592–34,380	4,125–54,722
N-NH_4^+		576–48,456	917–77,125
Overland flow		[Vol: 35.2 L]	[Vol: 237.9 L]
N-NO_3^-	②	2,498–40,853	16,886–276,107
N-NH_4^+		1,045–17,347	7,061–117,237
Fluxes Between Water and Sediment			
N-NO_3^- (OUT water pool, IN sediment pool)	③	640–1,900	590–630
DenitrificationN-N_2 (IN atmosphere, OUT sediment pool)	⑤	1,000–2,580	620
N-NH_4^+ (IN water, OUT sediment)	④	3,740–8,160	3,050–6,530

**Rates are in µg/m²/day. Volumes are on a per m² basis (total wetland area = 11,000 m²) over 2 weeks (period of peeper deployment)

NH_4^+ produced in sediment dissolves into porewater and exits wetland via groundwater

NITROGEN BUDGETS REVEALED THAT WETLANDS ARE A SINK FOR NO_3^- AND A SOURCE OF NH_4^+. Budget from Liberty shown here. Denitrification did not account for a large amount of nitrogen loss from the wetlands, likely because denitrification is limited by NO_3^- availability

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