Preliminary findings from an atmospheric nitrogen deposition monitoring network on Long Island, NY

Presented by

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with support from

- Long Island Regional Planning Council
- NYS Department of Environmental Conservation
- Hofstra University

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… the students at Hofstra University and employees at Town of Hempstead C&W who do much of the real work!

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Nitrogen Pollution

- *Reactive* Nitrogen
  - Often a limiting nutrient for plant/algal growth
  - Nitrate (NO_3^-), ammonium (NH_4^+), nitrous oxides (NO_x), and organic forms.

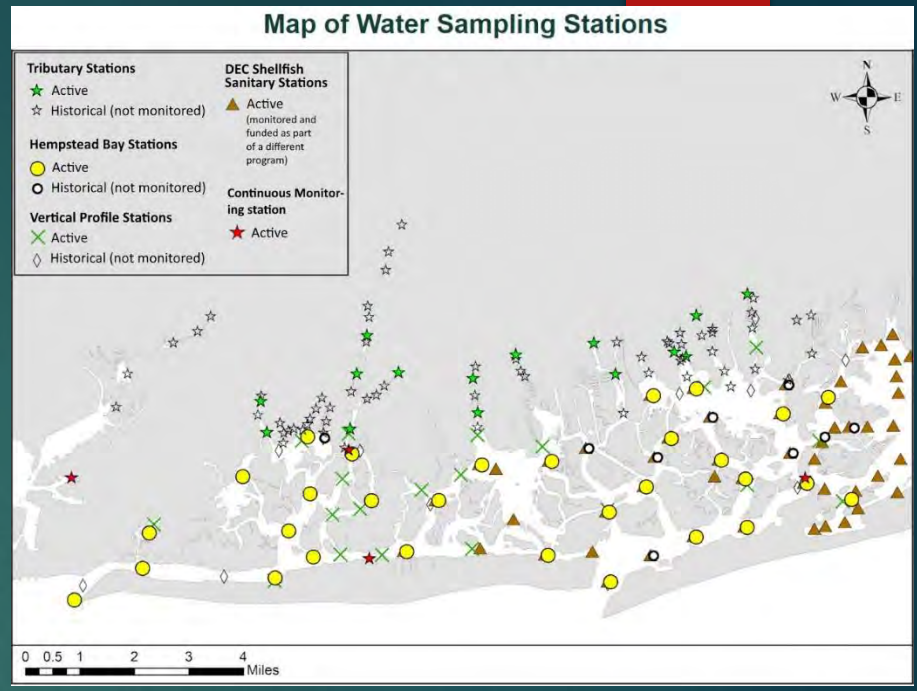
- Too much of a good thing
  - Acid rain, smog, drinking water contamination
  - Coastal eutrophication ("dead zones")
  - Loss and degradation of wetlands, seagrass beds, and benthic communities

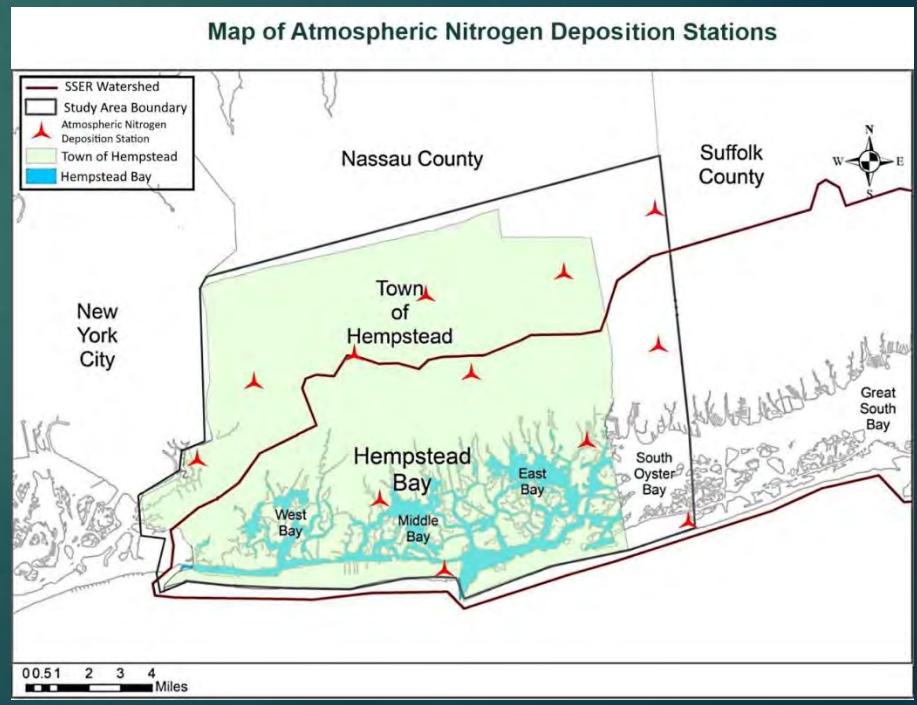
- Urban and suburban contributions
  - Stormwater runoff
  - Wastewater treatment plant (WWTP) discharges
  - Septic systems and leaking sewage infrastructure
  - Lawn and garden fertilizer
  - Vehicles, heating systems, and fossil fuel power plants → Atmospheric nitrogen deposition

Photo credit: Stefan Beaumont
https://www.danspapers.com/2015/06/fish-kill-stinks-up-peconic-river/

A Renewed Water Quality Monitoring Program in Hempstead Bay (i.e., SSER Western Bays)

- TOH C&W Marine Lab: 50 years of water quality monitoring
  - Started in partnership with Hofstra University in 1968
- Summer 2017: Marine lab closure
- Fall 2019: Renewed monitoring in partnership with Hofstra University with funding from LIRPC
- Just in time for major changes:
  - WWTP upgrades, sewering of Pt Lookout, bioextraction projects, Living with the Bay stormwater upgrades (GOSR)
  - Bay Park Conveyance Project
- Atmospheric Nitrogen Deposition Monitoring
  - New addition to monitoring parameters
  - Non-point sources will dominate nitrogen pollution in Hempstead Bay after WWTP effluent is rerouted





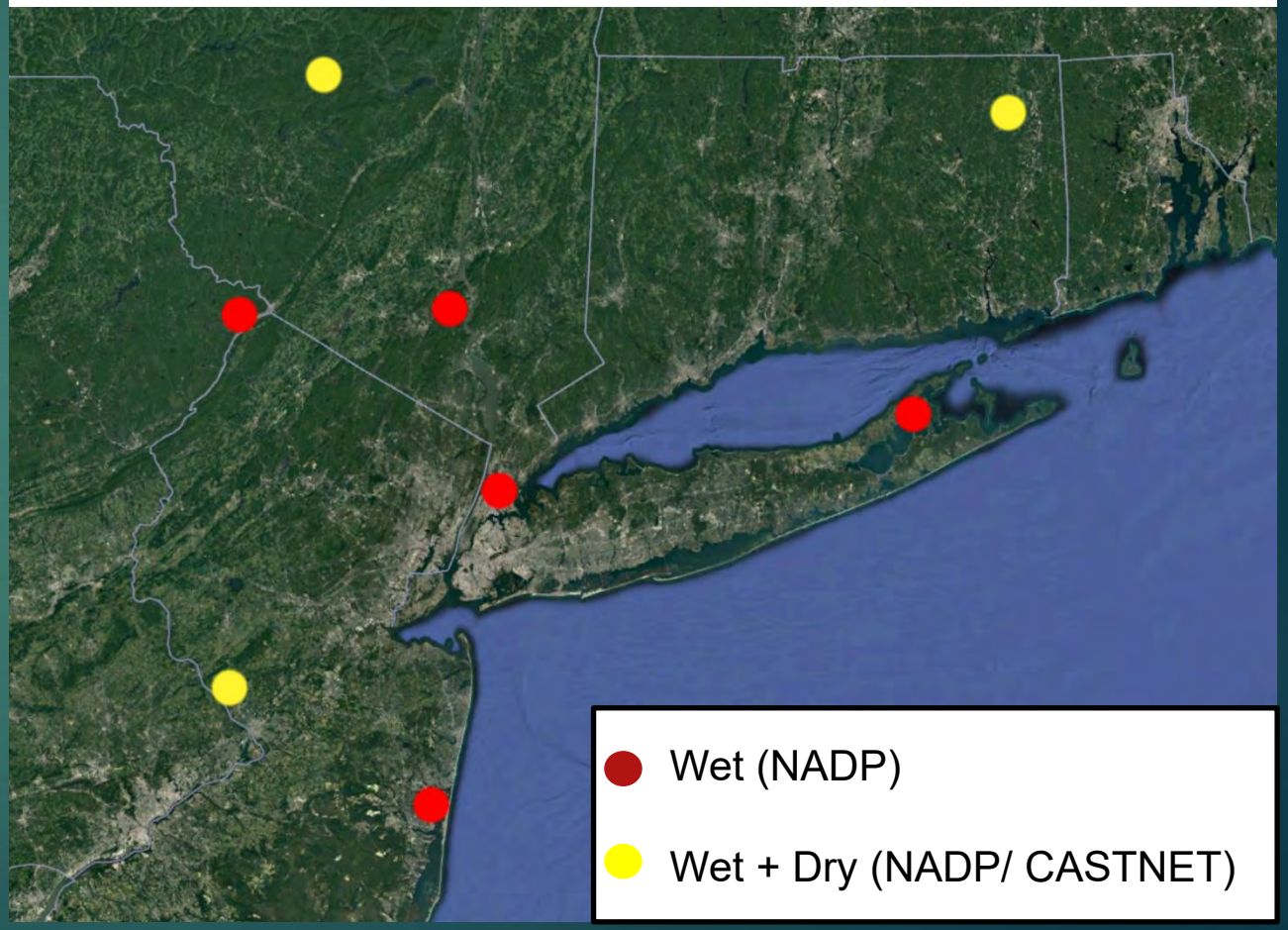
Estimates of Atmospheric N Loads to LI's Coastal Waters

- Hempstead Bay (i.e., SSER Western Bays):
  - West Bay: <1% (99% WWTPs; Gobler et al. 2020)
  - Middle Bay: ~25% (Gobler et al. 2020)
  - East Bay: ~30% (Gobler et al. 2020)
- Eastern Bays: 33% of total N loads (Gobler et al. 2016)
  - 21% direct-to-water and 12% indirect
- Long Island Sound: 38% of total N loads (Vaudrey et al. 2016)
  - 14% direct to water and 24% indirect
- Great South Bay: 42% of total N loads (Fisher et al. 2018)
  - 26% direct-to-water and 16% indirect
- Peconic Bay:
  - 56% of total N loads? (Peconic Estuary Program TMDL Review, 2013)
    - Dry deposition not recorded in the region. Estimated at 1/3 of total.
  - Direct-to-water deposition is high and requires better quantification (Lloyd 2014);

A Key Area of Uncertainty

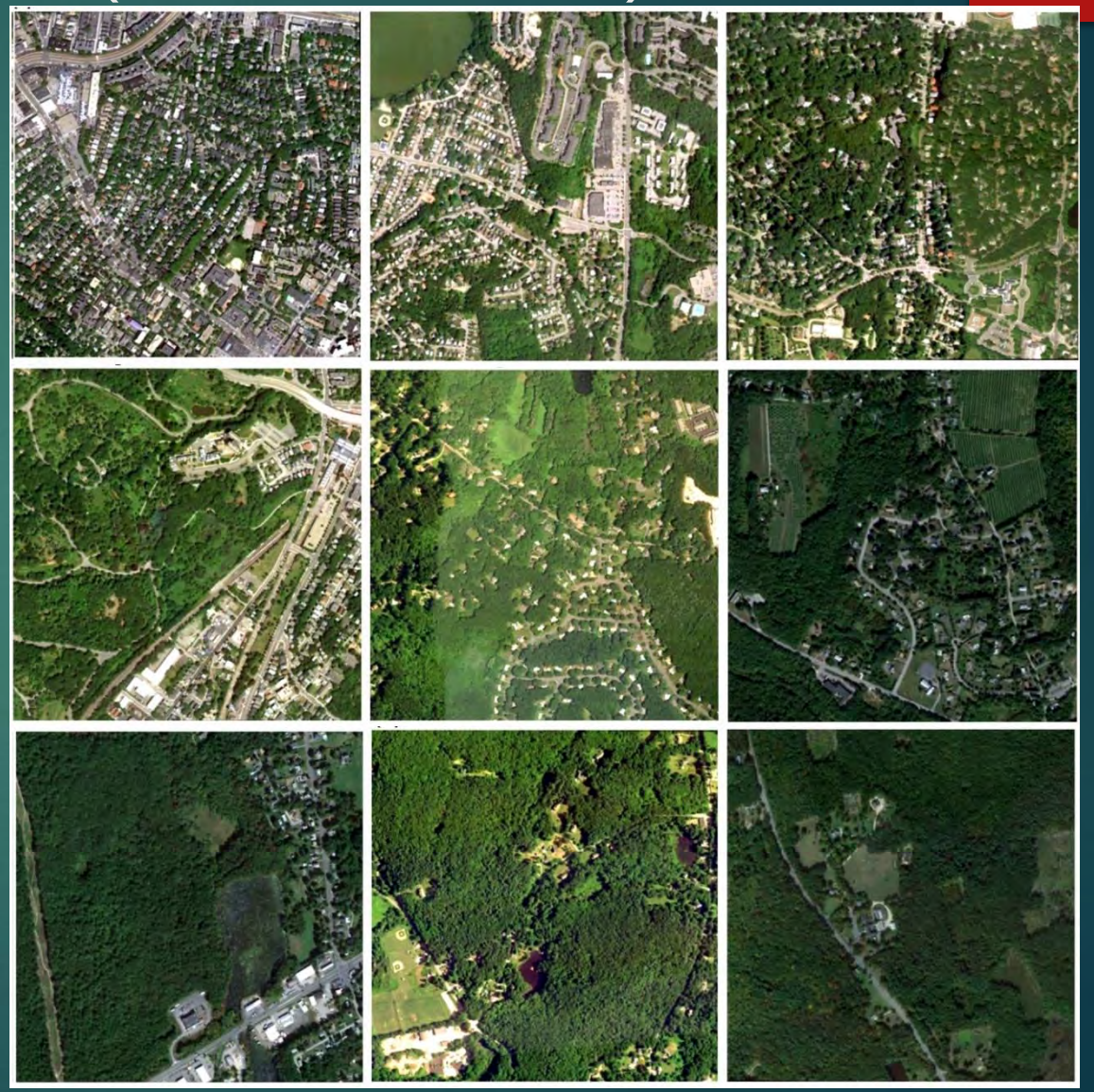
- N deposition is a large proportion of the total N loads to Long Island coastal waters
- Current estimates are based on National Trends Network (NTN) sites (e.g., CASTNET/NADP)
  - Network designed to measure continental-scale patterns of N deposition; Sites intentionally located far from urban areas
  - Wet Deposition: 1 NADP station in rural area of Long Island (Cedar Beach, Southold, NY)
  - Dry Deposition: 0 CASTNET sites on LI; Current estimates are based on rural sites near the Catskills, NE Connecticut, and western New Jersey

NTN Sites in NYC/Long Island Metro Area



Past Work: N Deposition Across Urban to Rural Gradient in the Boston Metropolitan Area (Rao et al. 2014)

Mixed ion-exchange (IER) resin columns

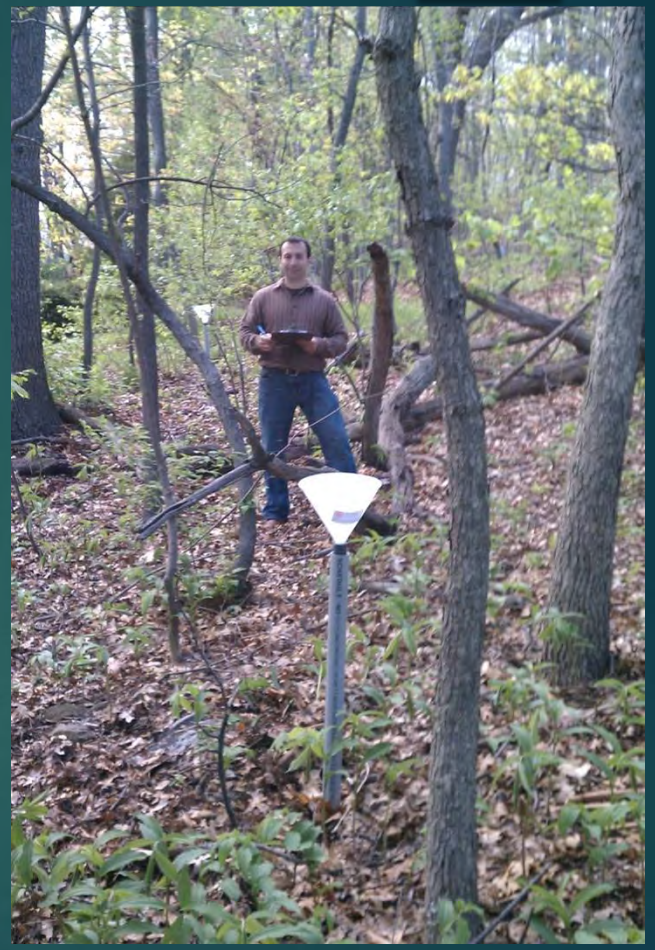


- Continuous capture of inorganic nitrogen ions as water filters through IER columns
- Chemically stable until processed
- Cost-effective method that allows for high density of measurement sites

Bulk vs Throughfall Nitrogen Deposition Measurements

- Bulk deposition
  - Rainfall captured under open sky
  - Mostly wet deposition
    - Estimates from bulk samplers are typically within 10-20% of estimates from wet only samplers like those used by NADP (Ellerman et al. 2018)

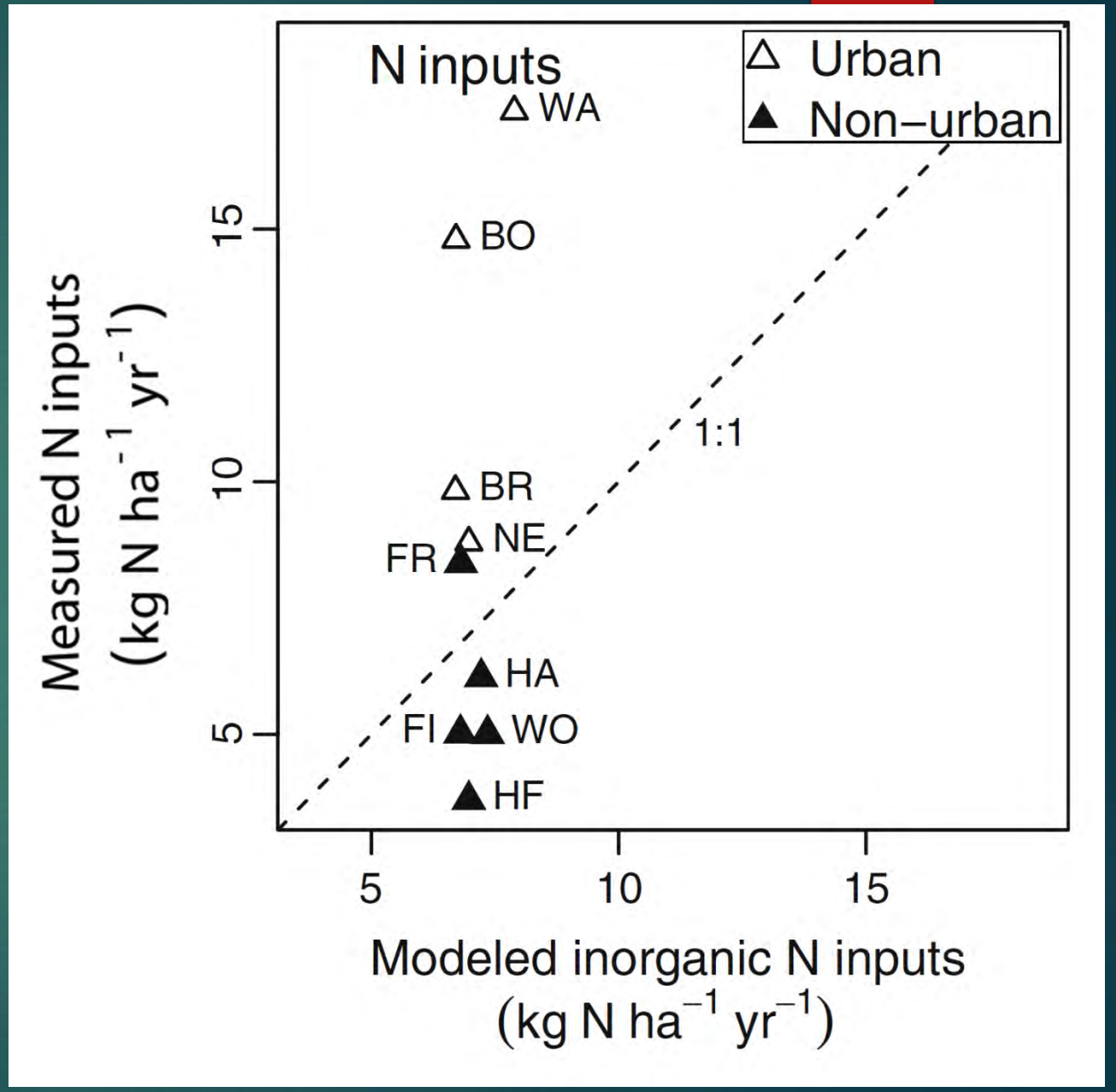
- Throughfall deposition
  - Tree canopy as a collecting surface for dry, fog, and cloudwater deposited pollutants
  - Wet + dry deposition



Throughfall sampling site from our Boston area urban-to-rural gradient (Rao et al. 2014)

Boston Results: National Trends Network (NTN) underpredicts N deposition in urban & suburban areas

- Modeled N deposition based on NTN data does not reflect changes in urbanization intensity
- All sites predicted at ~7 kg N ha^{-1} yr^{-1}
- Deposition to urban/suburban regions was twice as high as modeled from NADP/CASTNET data
- Strong correlations between N deposition and anthropogenic factors:
  - On-Road CO_2 Emissions and NO_3^- Deposition (R^2 = 0.74)
  - NH_4^+ and proximity to urban core (R^2 = 0.57)



State of the Science: "*Toward the improvement of total nitrogen deposition budgets in the United States*"

Review by scientists at thirty governmental and academic institutions (Walker et al. 2019)

- Key Findings and Recommendations
  - NTN underestimates urban and suburban N deposition
  - Dense networks of ion exchange resin (IER) samplers are recommended (cost-effective)
  - Results of high-density IER sampling can help direct locations of future NTN sites

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Toward the improvement of total nitrogen deposition budgets in the United States

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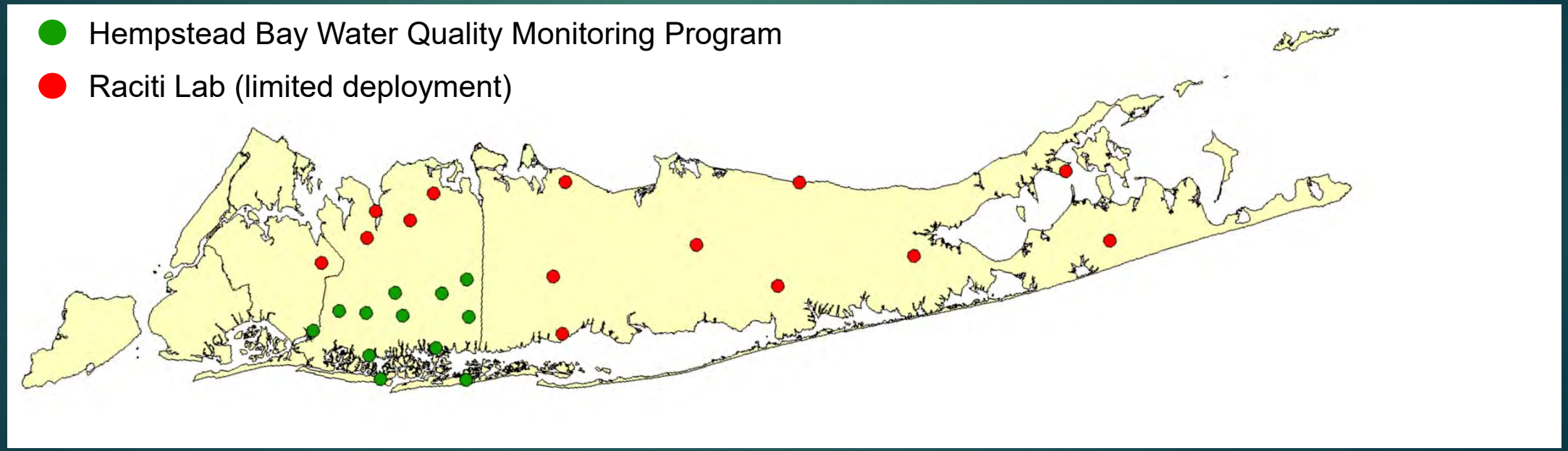
A Long Island-Wide N Deposition Monitoring Network?

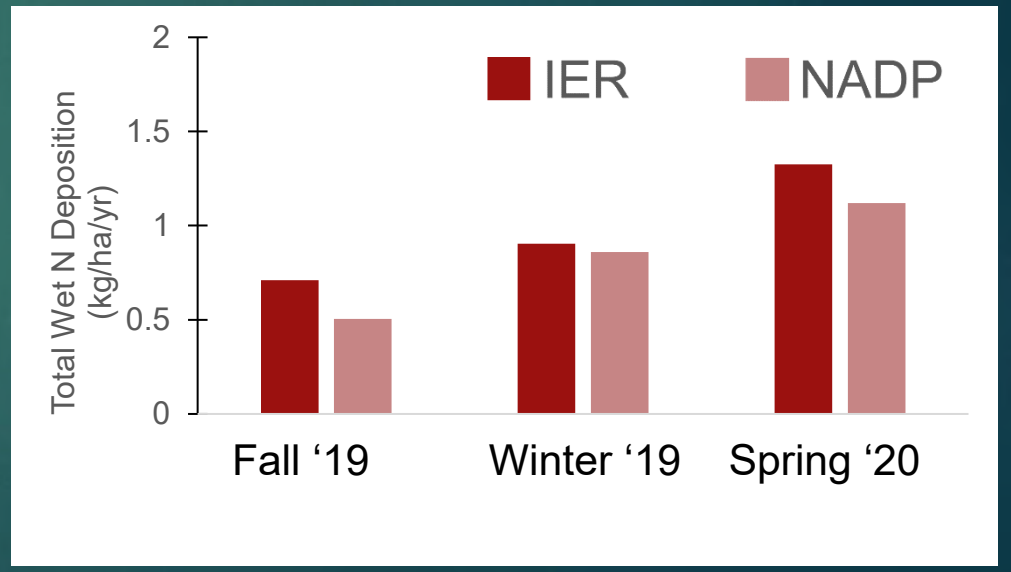
- Southern Nassau County (Funded for 2 years)
  - 12 monitoring sites
  - 3 x throughfall/site (wet + dry dep)
  - 3 x bulk/site (wet deposition)
  - 6-week integration periods
- Raciti lab (unfunded)
  - Short-term, low-density network: 14 sites in Suffolk and northern Nassau
  - Reduced temporal, spatial, and parameter resolution
    - 3 x throughfall/site
    - 0 x bulk/site
    - 12-week integration periods



Are Our Measurements Reasonable?

Co-location with NADP equipment at Cedar Beach, Southold, NY

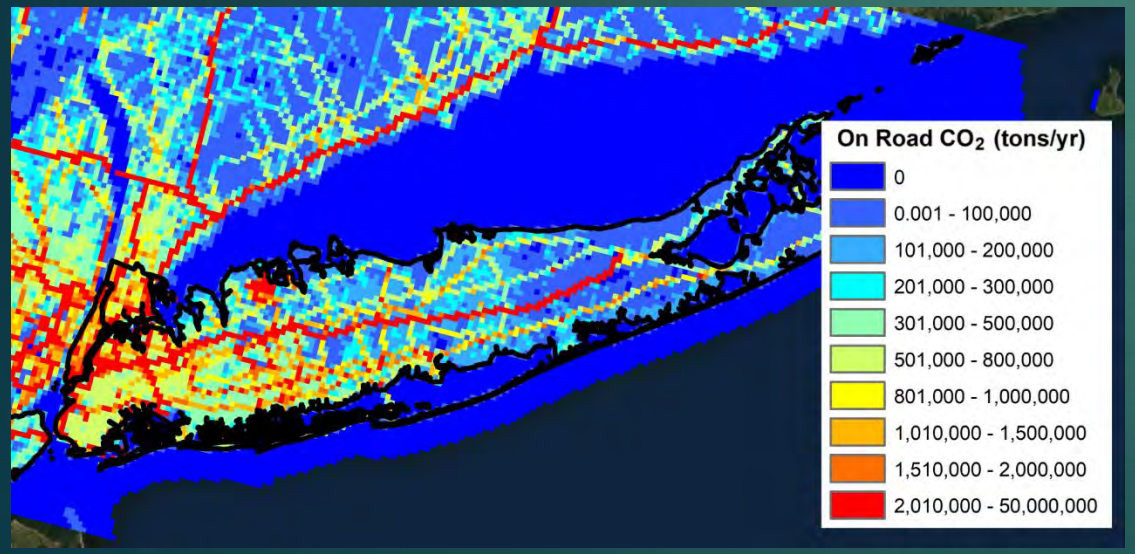
- NADP measures wet deposition (only)
- Good match between IER data and NADP data for wet deposition
- Spring 2020: NADP is missing data for 6 weeks due to COVID-related shutdown
  - IER method was uninterrupted (continuous, passive sample collection)



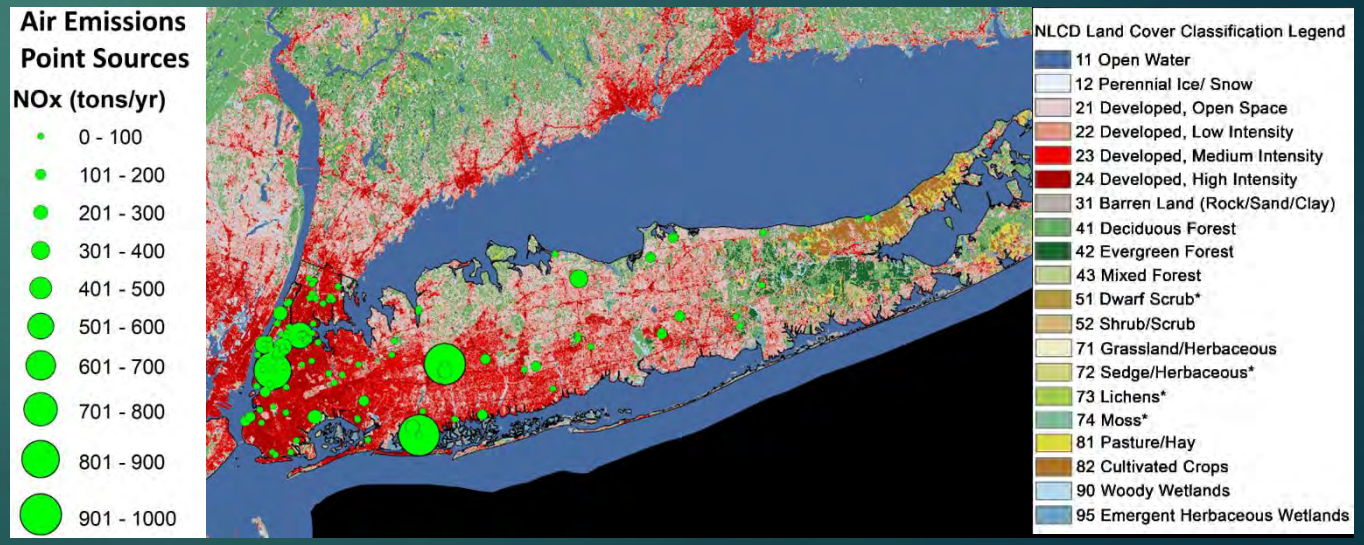
Oct 2019 - May 2020 (in kg N ha^{-1} yr^{-1})

Hypotheses for Eastern Long Island?

- NTN provides reasonable estimates (?)
  - Less developed than western LI
  - Direct-to-water deposition might approximate rural background, particularly away from highly-developed coastal areas
- NTN underestimates deposition (?)
  - Considerable suburban development
  - Substantial transportation emissions
  - Dry deposition measurements derived from rural sites far from Long Island



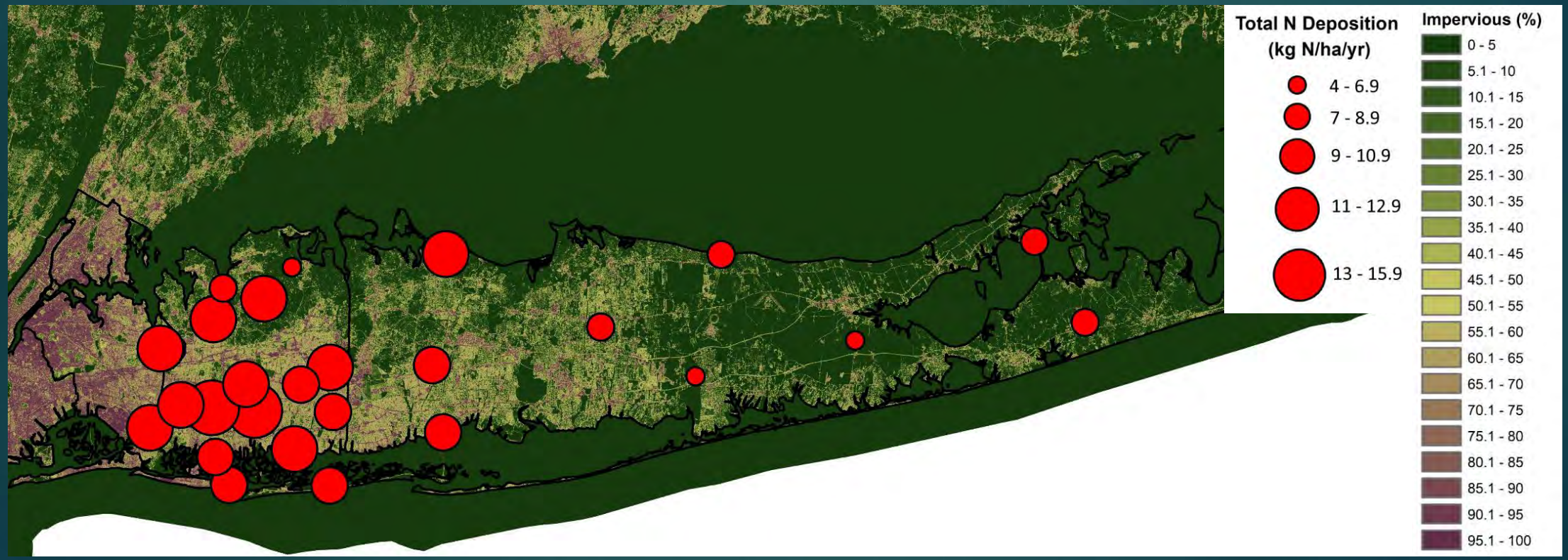
DARTE on-road CO_2 emissions (Gately et al. 2015)



NLCD Land Use (2011) and EPA NOx Point Sources (2019)

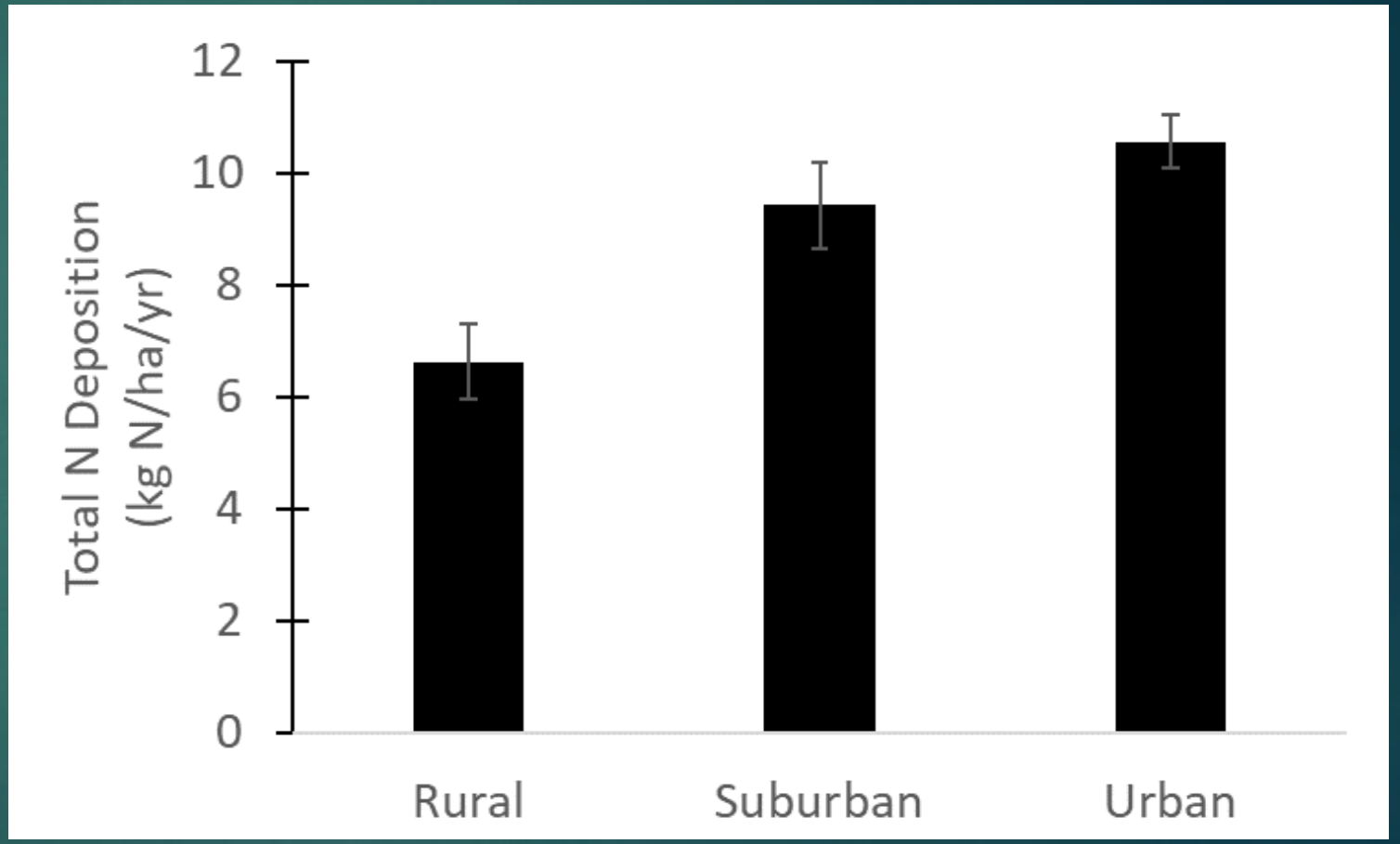
Preliminary Results

- Mapping Nitrogen Deposition
  - Rural forested areas: lower N deposition?
  - Urban and dense suburban: higher N deposition?



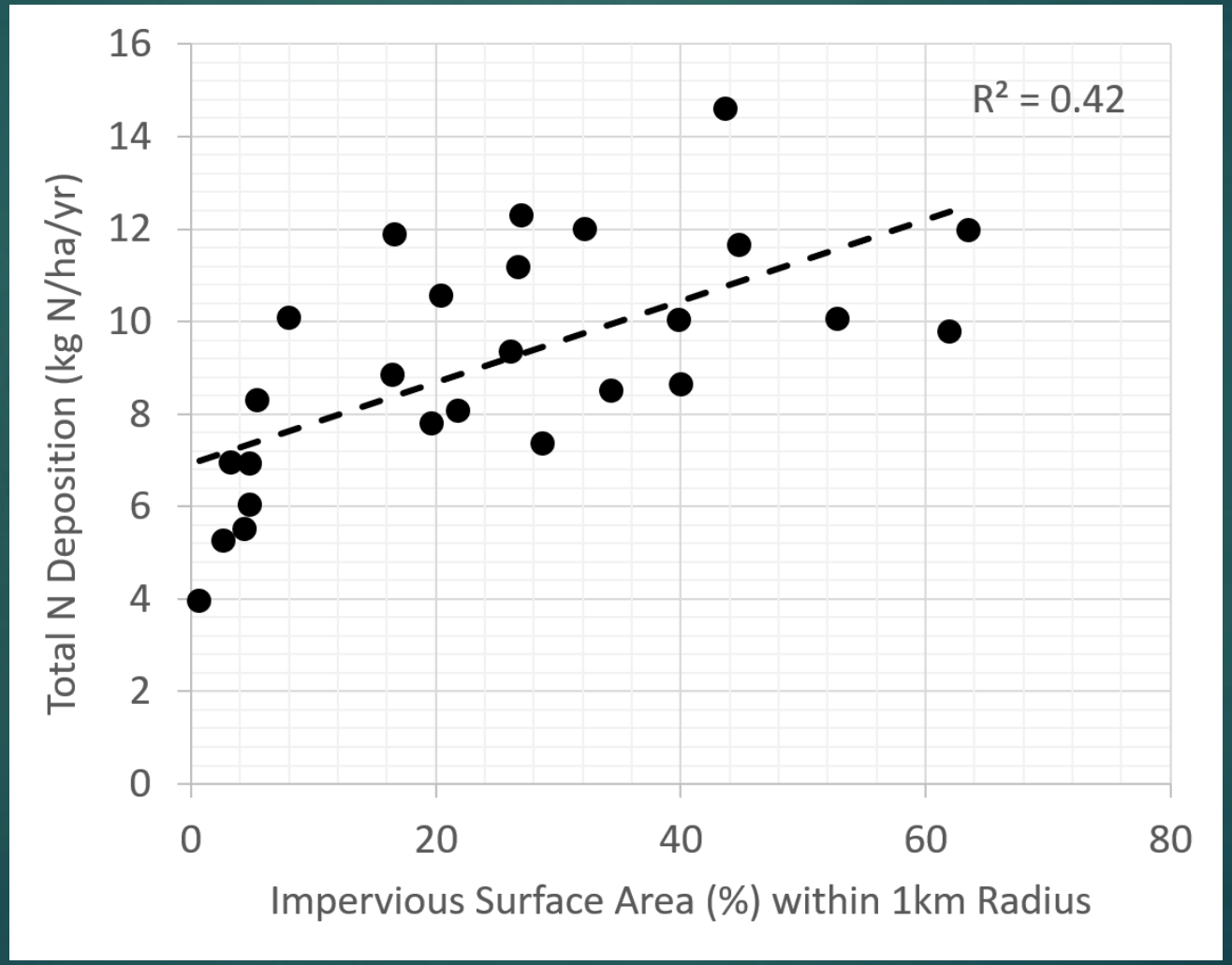
Preliminary Results

- Rural: <10% impervious area within 1 km radius
- Suburban: 10 – 25% impervious area within 1 km radius
- Urban: >25% impervious area within 1 km radius

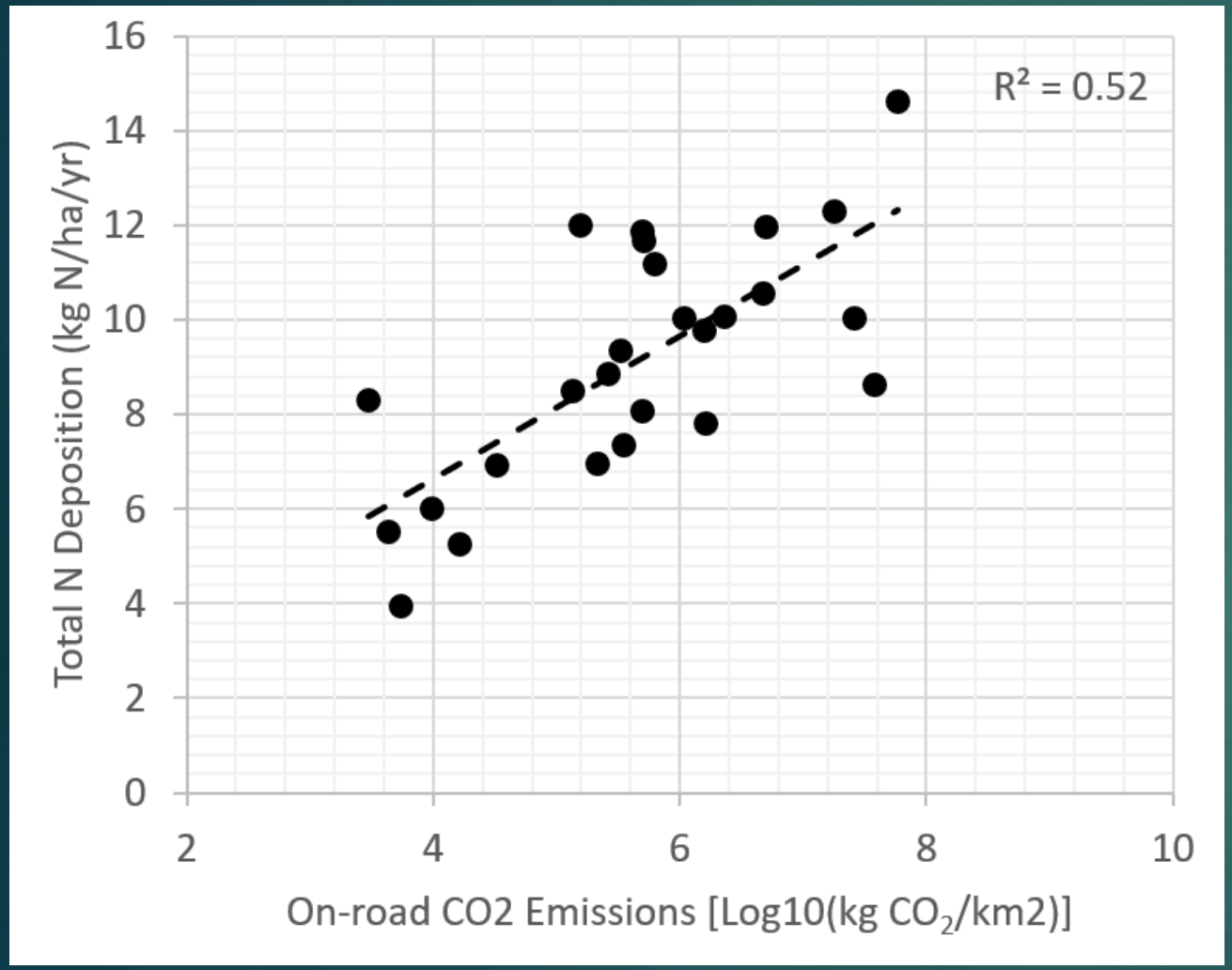


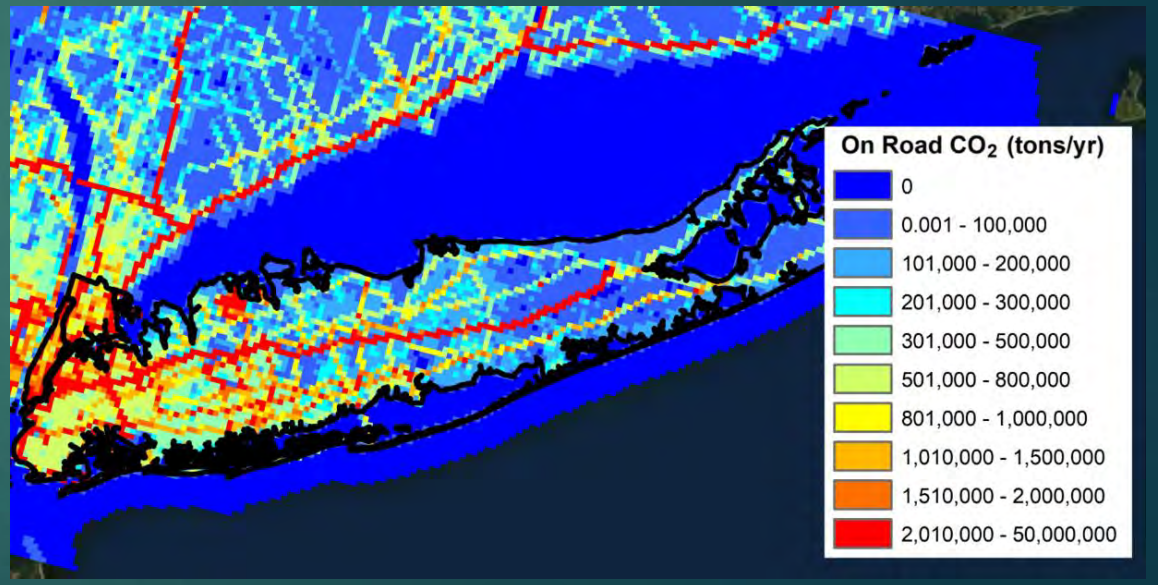
Error bars are SE of the mean (n = 8, 5, and 13, respectively)

Urbanization and nitrogen deposition



Vehicle emissions and nitrogen deposition





DARTE on-road CO_2 emissions (Gately et al. 2015)

Did COVID-19 shutdowns decrease N deposition?

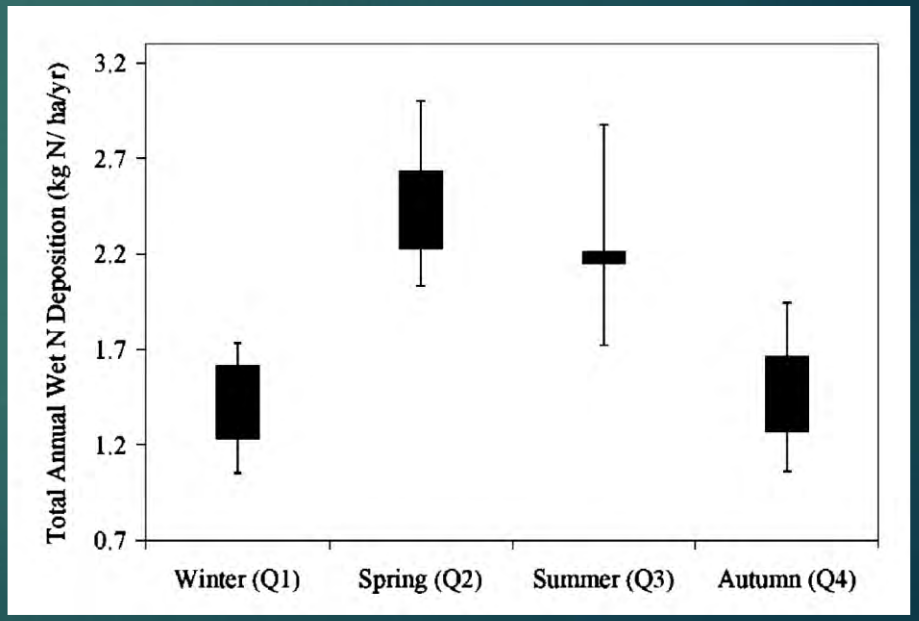
- We need long term data to answer questions like this
  - No baseline for comparison
  - N deposition typically rises in the spring (we saw this pattern)
  - Was this year below past years? By how much?

The New York Times

Traffic and Pollution Plummet as U.S. Cities Shut Down for Coronavirus

By Brad Plumer and Nadja Popovich March 22, 2020

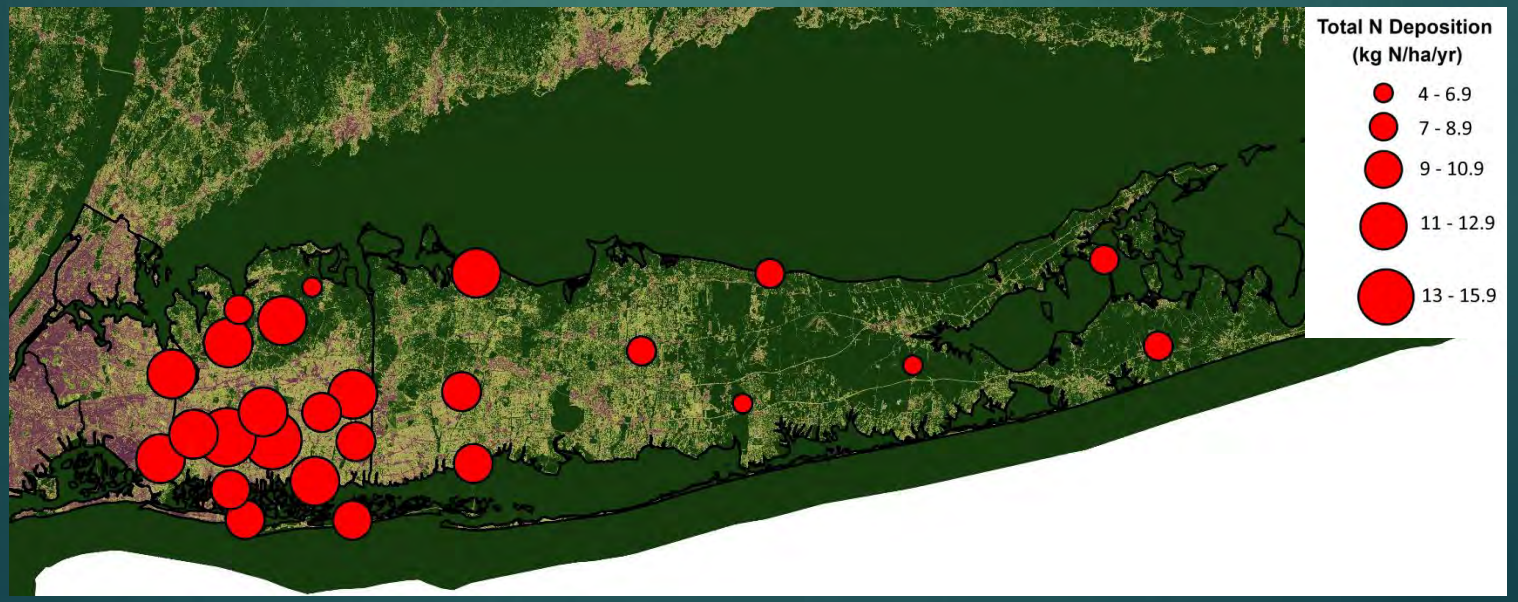
In cities across the United States, traffic on roads and highways has fallen dramatically over the past week as the coronavirus outbreak forces people to stay at home and everyday life grinds to a halt.



Seasonal patterns of N deposition north of NYC metro area (Golden and Boyer 2008)

Preliminary Conclusions

- Atmospheric deposition is a major source of N pollution to LI coastal waters
- Variable in space and time, but not random
  - Correlated with on-road emissions, development, and likely other factors
- NTN sites (e.g., Cedar Beach) represent rural background
  - Probably not representative of greater Long Island region
  - Likely underestimates urban and suburban sources



Future Research Needs

- Long-term measurements to quantify N deposition on LI
  - Major source of uncertainty in N loading models
  - No formal monitoring network outside of southern Nassau
- Capture N deposition trends related to:
  - On-road emissions, point sources (e.g., power plants), land use/land cover, proximity to urban areas
- NYS and Long Island can take a leadership role
  - Establish urban and suburban deposition monitoring network
  - Lay groundwork for locating permanent, federally-supported monitoring sites (e.g., NADP and CASTNET)
- Data can guide conservation management plans for LIS, Peconic, and SSER regions
  - Inform realistic targets for what can be achieved by attenuating other sources (e.g., WWTPs)
- Advance LINAP goals: 1) improve understanding of nitrogen pollution, 2) determine N reduction strategies and targets, 3) enact policies to alleviate N pollution


Mixed ion-exchange resin column for measuring N deposition

Questions?