Non-Point Nitrogen Sources and Transport in the Great Bay Watershed

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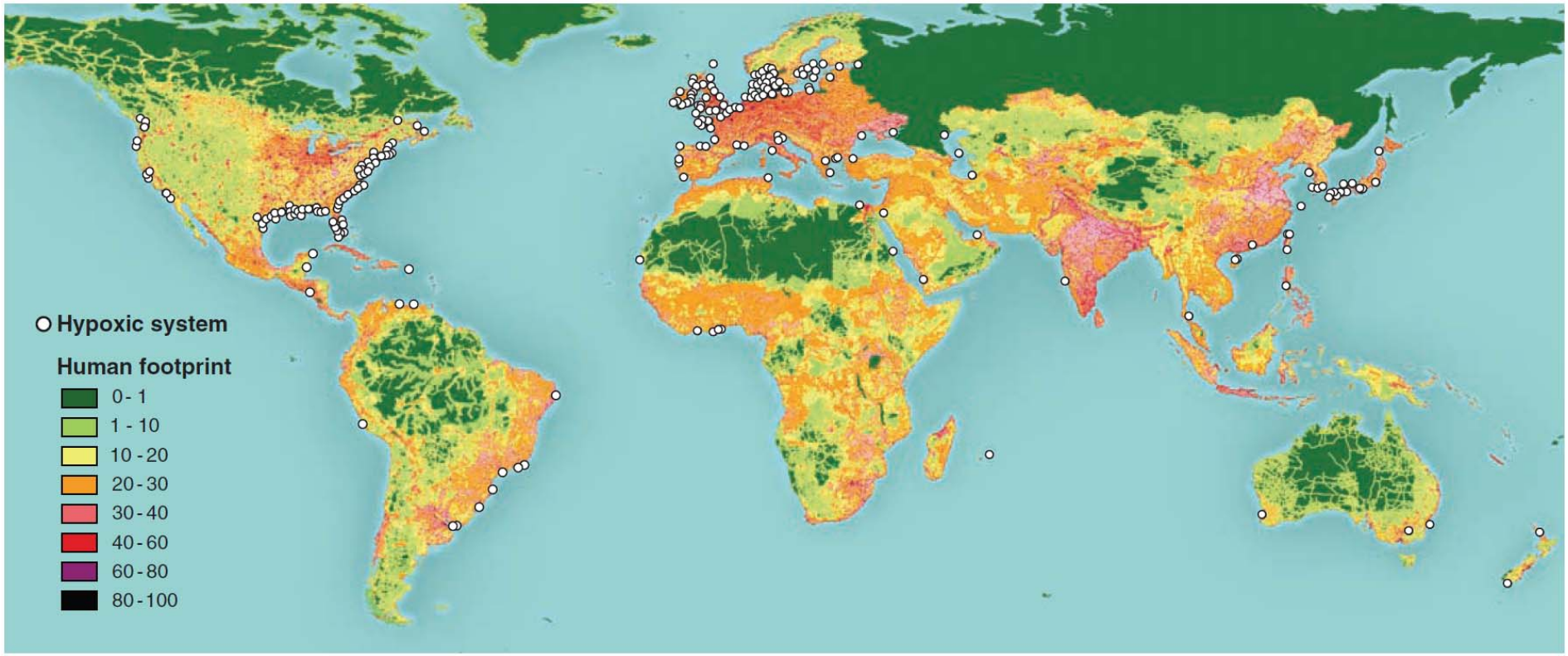
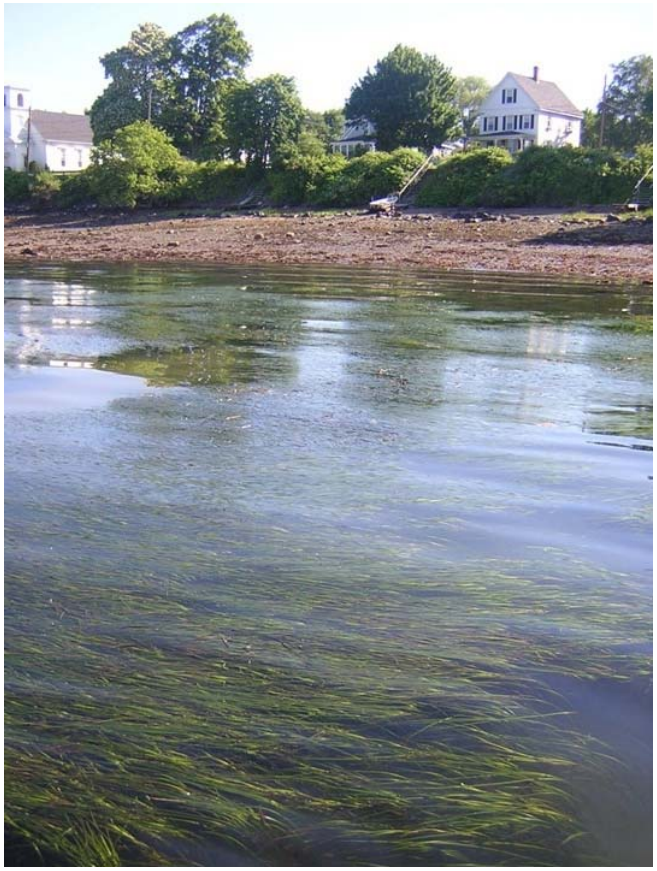
Eutrophication-associated dead zones and the human footprint



Diaz and Rosenberg. 2008. Spreading dead zones and consequences for marine ecosystems. Science 321:926-929.

Decline in water quality and aquatic life in Great Bay

- New Hampshire's most significant estuary
- Watershed is home to almost 25% of NH's population
- Watershed intersects 52 communities
- Deterioration of water quality and aquatic life
  - Low dissolved oxygen (DO)
  - Increased suspended sediment and nitrogen
  - Loss of eelgrass
  - Loss of oysters and clams
  - Nitrogen impaired



Eelgrass Photo Credit:
Fred Short

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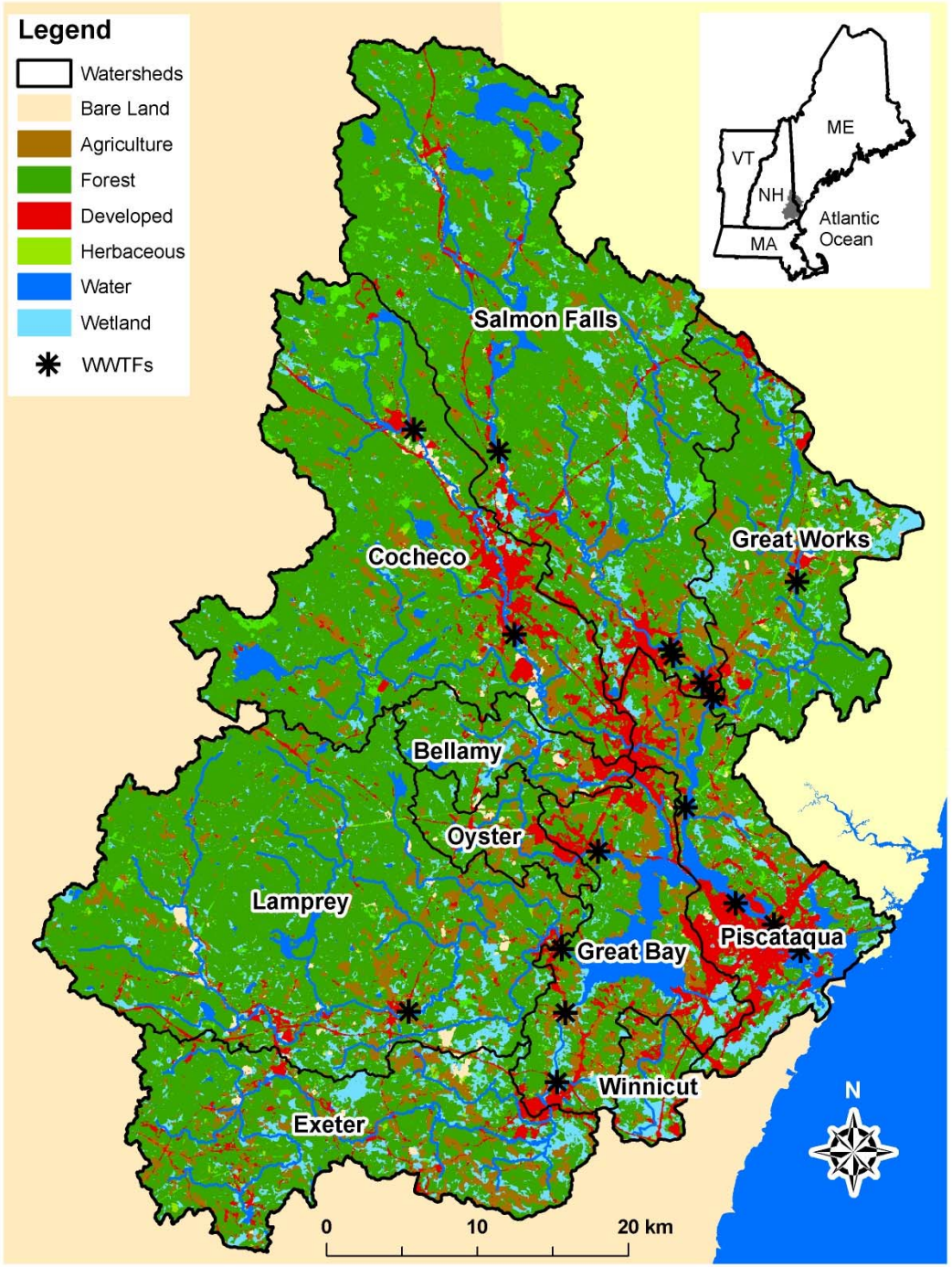
N loading to Great Bay

- 32% Point Sources
- 68% non-point sources



Objectives

- Integrate research with stakeholders to ensure results are useful and accessible

Address these questions:

1. How do surface water nitrogen concentrations respond to varying watershed landscape characteristics and N inputs?
2. What non-point sources of N reach surface waters?

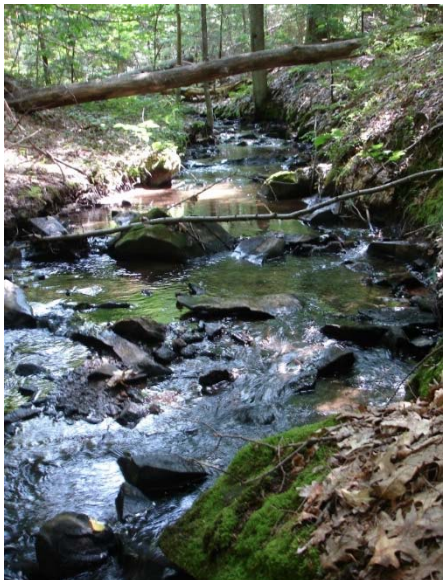
Integrate research with stakeholders

- Nitrogen sources collaborative advisory board (NSCAB)
  - 15 members
  - Approximately quarterly meetings
- Nitrogen Sources Newsbites – 150 diverse stakeholders
- NSCAB trust the science and advocate for improved management

Characterizing nitrogen concentrations…

- 5 extensive sampling campaigns (2010-2012)
- 236 stream sites
  - Urban, suburban and agricultural land use
- Median N concentrations:
  - Dissolved inorganic N (DIN)
    - Nitrate (NO_3)
    - Ammonium (NH_4)
  - Dissolved organic N (DON)
  - Total dissolved N (TDN)

Urban



Suburban

...and watershed landscape features

Human impact

- Human population density (0-2,017/km^2)
  - Septic
  - Sewer
- % Impervious (0-68%)
- % Developed (0-100%)
  - High intensity
  - Medium intensity
  - Low intensity
  - Open space

Agriculture

- Cultivated crops (0-17%)
- Pasture or hay (0-68%)

Natural features

- % Forest (0-91%)
- % Scrub shrub
- % Water (0-15%)
- % Wetland (0-37%)

Data Sources:

- Land Cover – NOAA Coastal Change Analysis Program (CCAP) 2006
- Population density – Census 2010 and NHDES GBNNPSS 2014
- Impervious cover – NH GRANIT 2010

DIN controlled by human impact and natural features

	Coefficient	VIP
Population density	0.16	0.92
% Developed	0.08	1.09
Medium intensity	0.06	0.93
Low intensity	0.07	1.06
Open space	0.08	0.90
% Impervious cover	0.06	0.98
% Forest	-0.04	0.82
% Wetland	-0.26	1.24

Human 24%

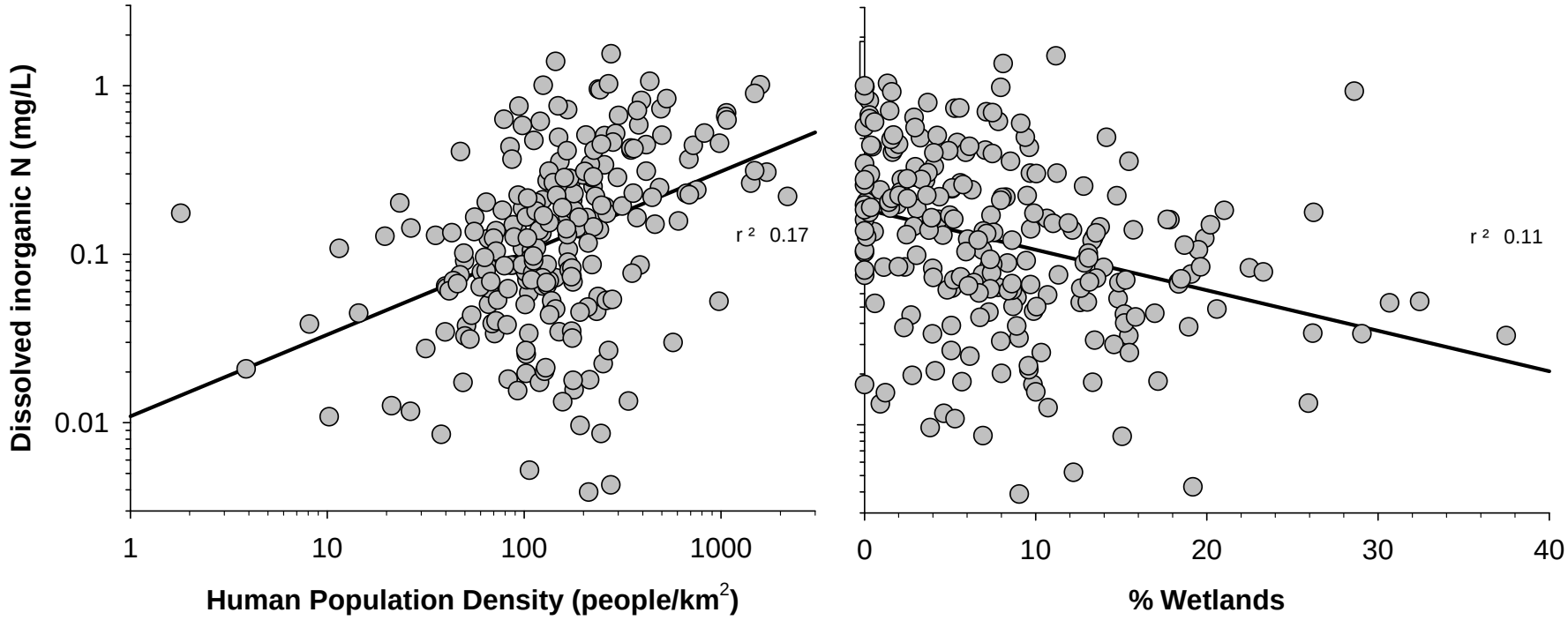
Natural 5%

Together explain 29% of the spatial variability in DIN

High intensity development, agriculture, scrub shrub, and water not important predictors

*All variables except % forest and % wetland were log transformed

DIN increases with human population density and decreases with wetlands



DON controlled by natural features and agriculture

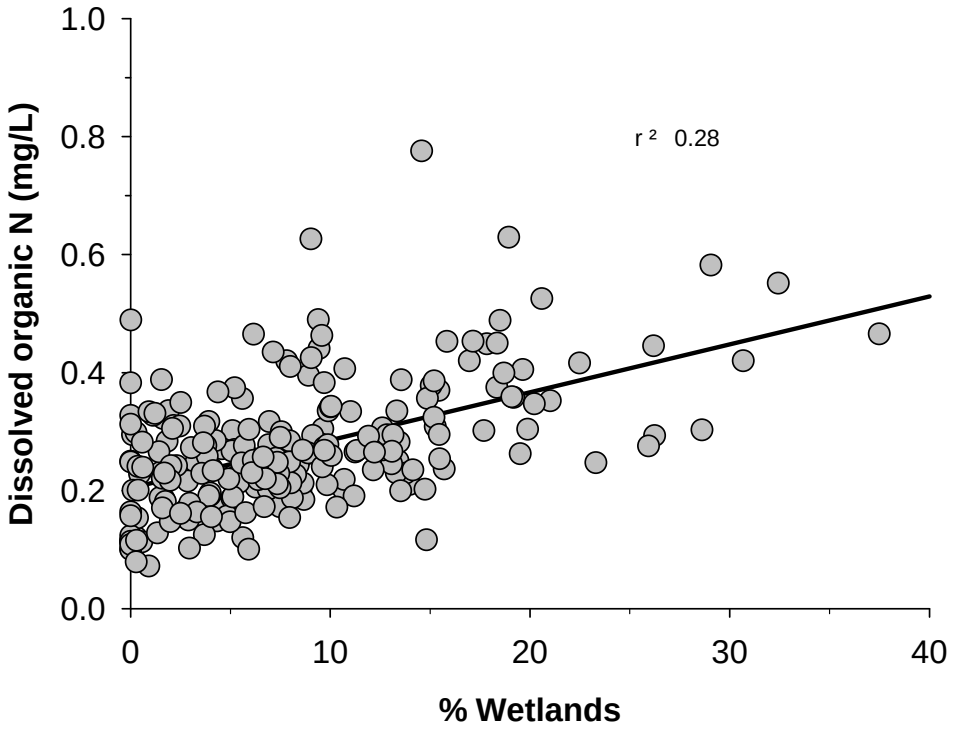
	Coefficient	VIP
% Wetland	0.56	1.56
% Cultivated Crops	0.10	0.52
% Pasture and Hay	0.26	0.54

35%

1%

Together explain 36%

Human population density, development, impervious cover, forest, scrub shrub and water were not important predictors

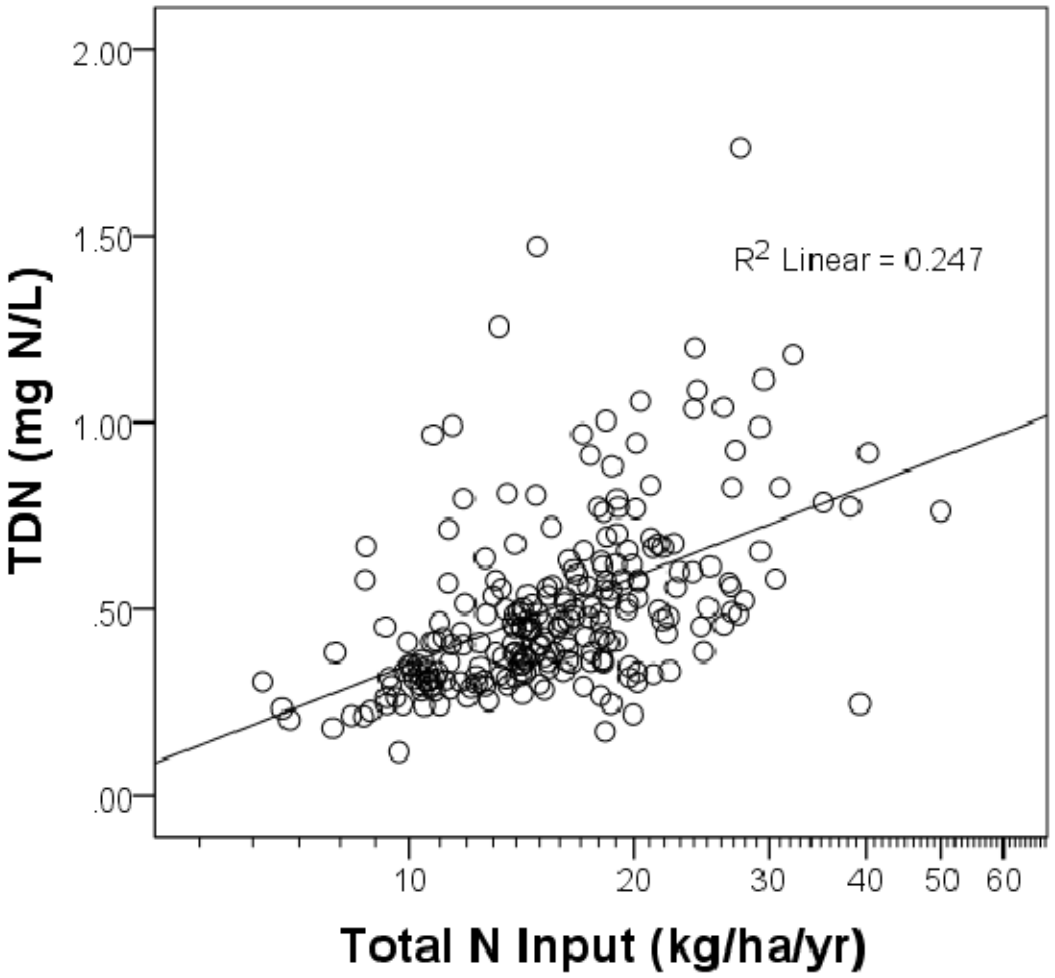


Characterizing watershed nitrogen inputs

- Used methodology from Great Bay Nitrogen Non-Point Source Study (Trowbridge et al. 2014)
- Atmospheric deposition
- Inputs associated with development
  - Human waste
  - Residential Fertilizer
  - Managed Turf Fertilizer
  - Pet waste (dogs and cats)
- Inputs associated with agriculture
  - Cropland Fertilizer
  - Animal waste (cattle and horses)

Total N Inputs

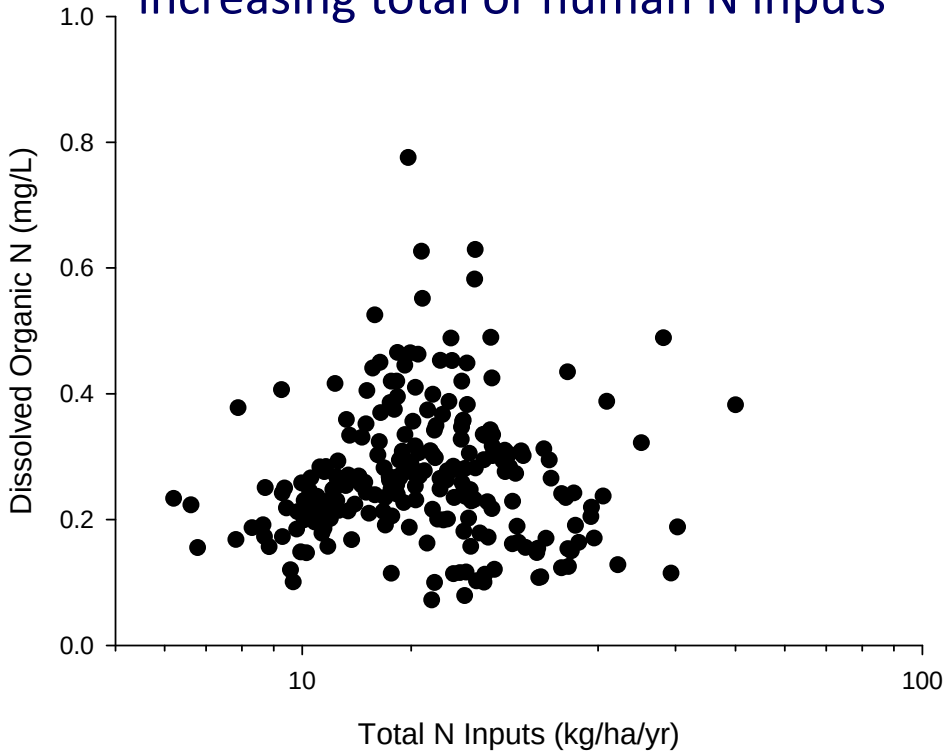
TDN and DIN increase with increasing N inputs



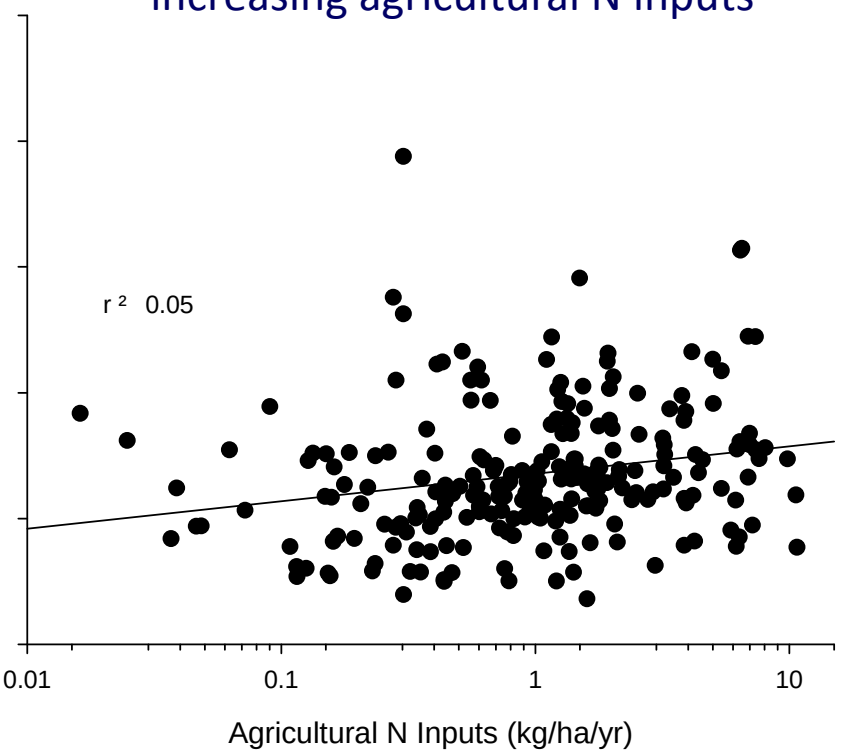
- Mainly from N inputs from developed areas
- TDN and DIN are not related to agricultural inputs

Slight increase in DON with increasing agricultural inputs

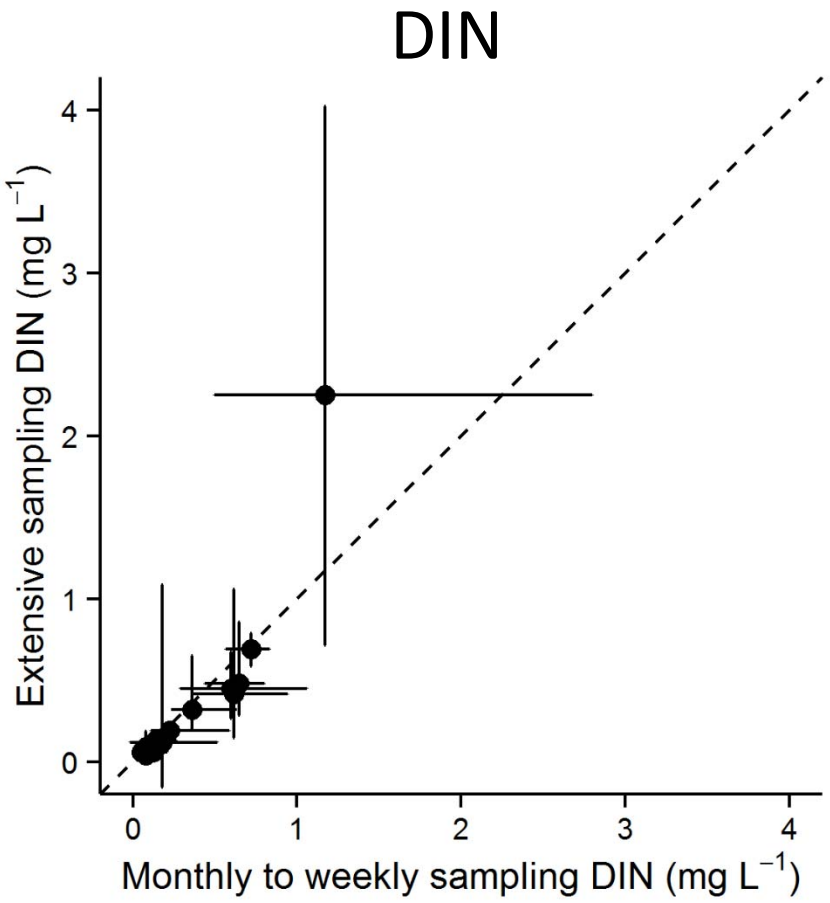
DON does not respond to increasing total or human N inputs

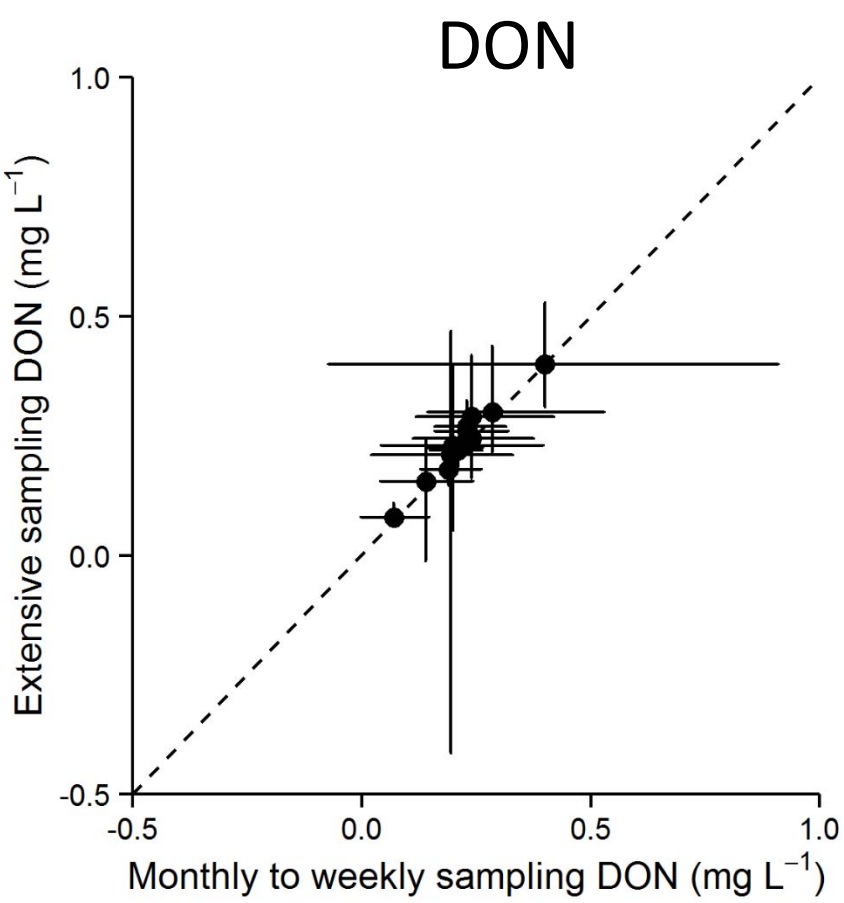


Slight increase in DON with increasing agricultural N inputs



Are 5 samples adequate?





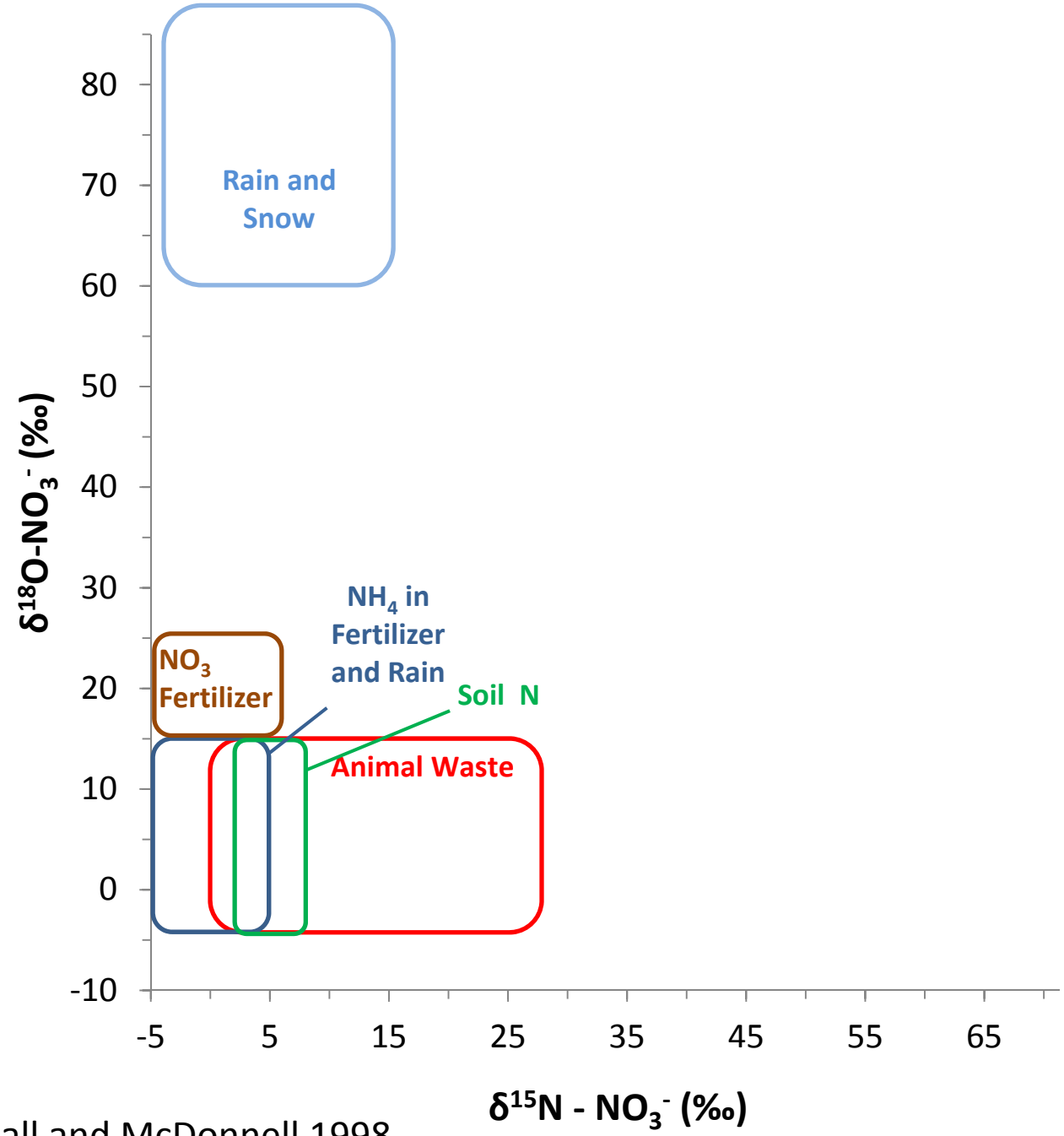
Summary of N concentrations, landscape characteristics and N inputs

- Human development increases DIN in streams, forests and wetlands remove or retain DIN
  - Agriculture not a significant predictor of spatial variability at watershed scale
- Wetlands are the main source of DON, not human development
  - Slight influence from agriculture
- Models explained 29% of DIN and 36% of DON spatial variability (fair amount unexplained)

Watershed N inputs >> N outputs

What non-point sources of N reach surface waters?

Isotopic signature of Nitrate ($^{15}N^{18}O_3$) can be used to identify sources



Kendall and McDonnell 1998

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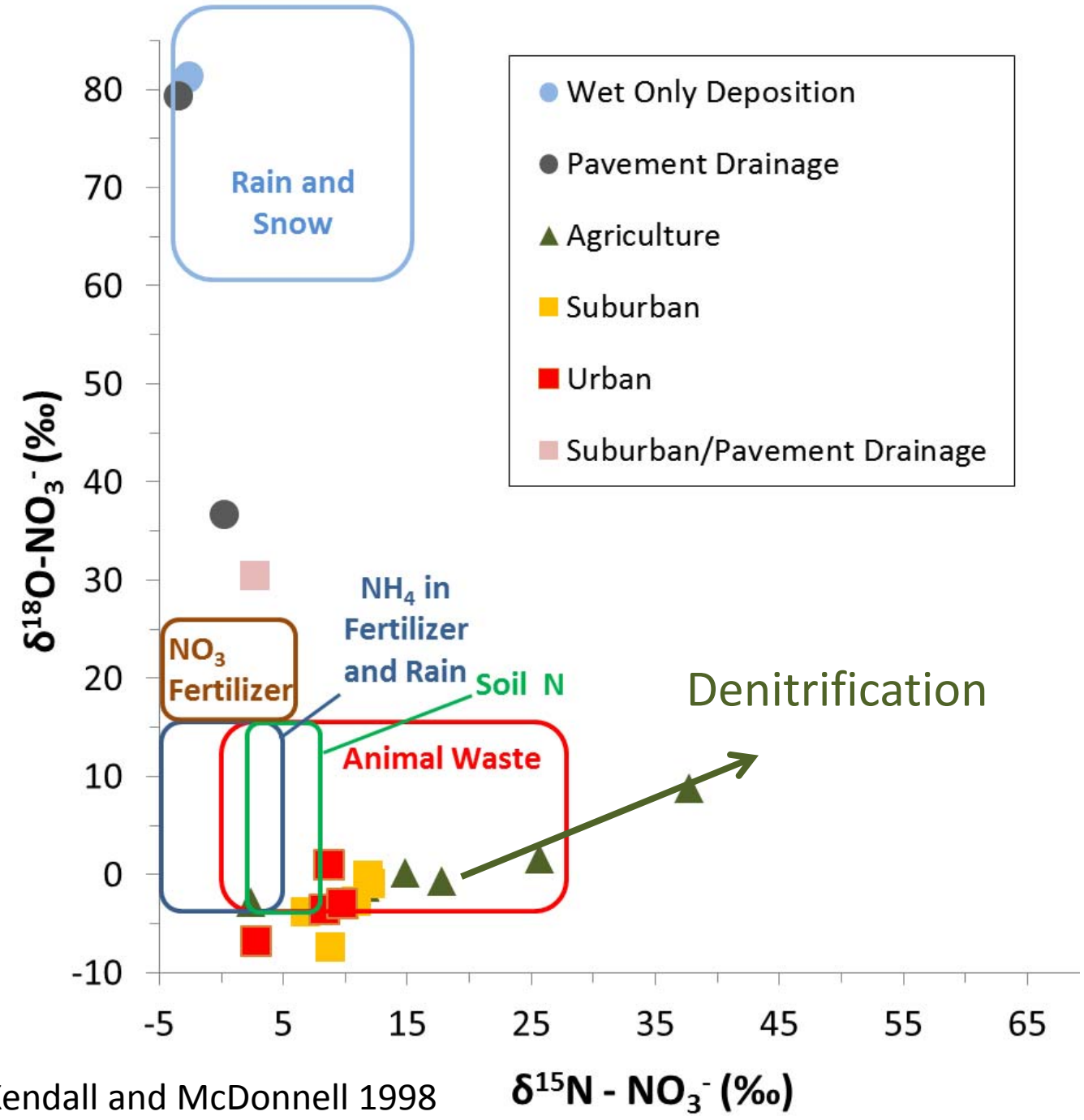
Nitrate isotopes in streams and groundwater

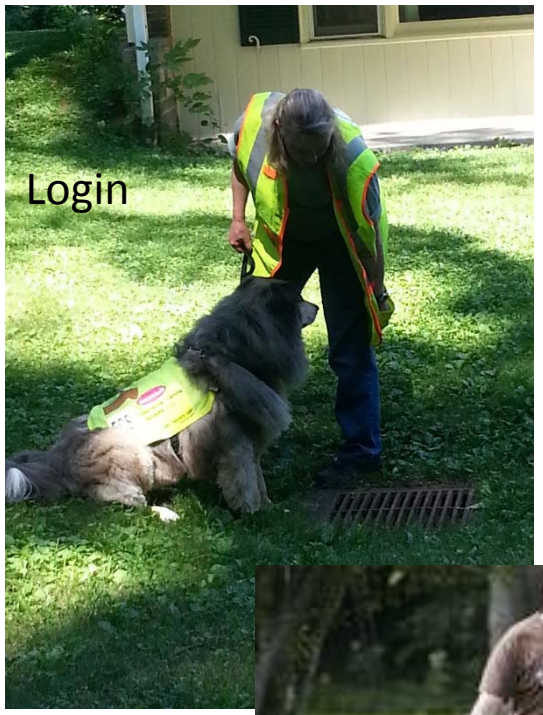


Kendall and McDonnell 1998

Mitochondrial DNA (J. Bucci)

Stream sites	Human	Cow	Dog
Urban human waste removed (9 sites, 26 samples)	✓	✓	✓
Suburban human waste treated on-site (4 sites, 13 samples)	✓	✓	✓
Agricultural (1 site, 5 samples)	X	✓	X
Reference (1 site, 5 samples)	✓	X	X

Scent-trained canines to "sniff out" human waste



Environmental Canine Services (ECS)

EPA approved method

- Detect human waste in streams, culverts, storm drains etc.
- Dogs have different detection limits
- Human waste detected at 6 of 7 urban steams
- Human waste detected at 2 of 3 suburban streams
- Not detected at reference site

Conclusions

- Improvements in land management may reduce DIN, but unlikely to significantly reduce DON
- No silver bullet – all types of development matter
- Isotopic signatures of nitrate suggests that most of the nitrate in streams is processed (does not reflect unaltered atmospheric deposition)
- Leaky sewer lines and illicit connections may be an overlooked source of non-point nitrogen

Acknowledgements

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NSCAB

McDowell lab

Coastal Science for the Granite State

Sea Grant
New Hampshire

Spatial variability is more predictable within the Lamprey