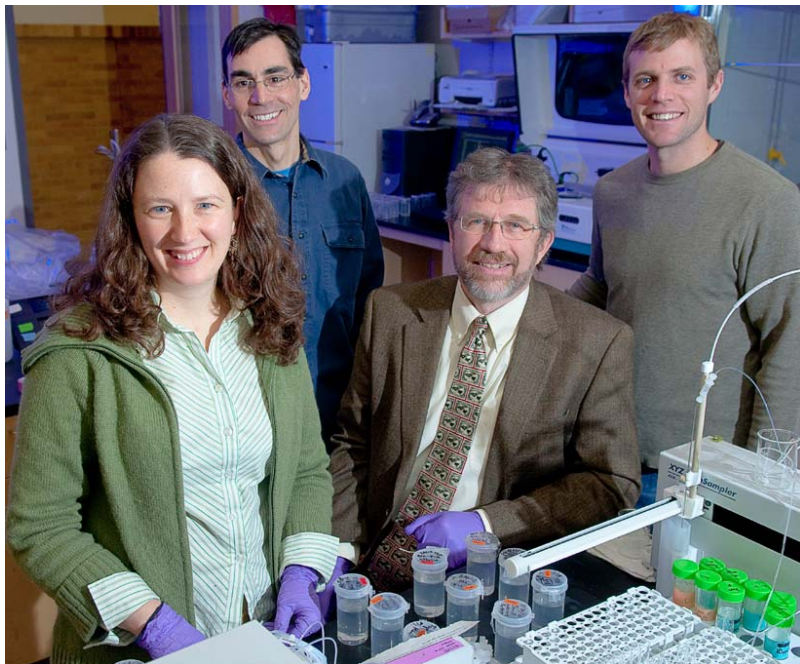




NERRS Science Collaborative Project



Detecting non-point nitrogen sources and transport pathways in the Great Bay watershed and engaging decision makers in the science



Investigators: Dr. William H. McDowell, Dr. John Bucci, Dr. Erik Hobbie, Dr. Charlie French, Michelle Daley, Jody Potter and Steve Miller

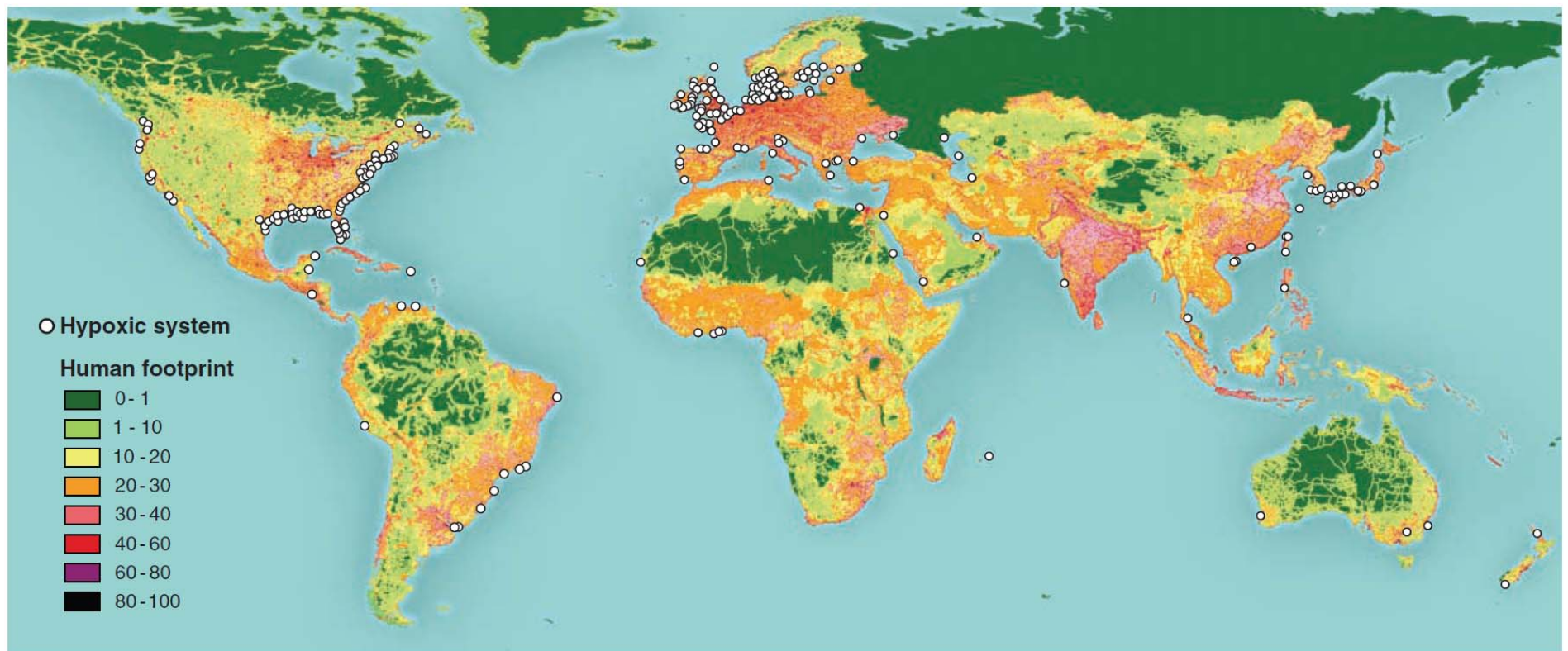


Outline

- Brief overview of N impairment and proposed TN reductions
- Existing nitrogen data from the Lamprey and Oyster watersheds
- Introduction of recent project “*Nitrogen Sources and Transport Pathways: Science and Management Collaboration to Reduce Nitrogen Loads in the Great Bay Estuarine Ecosystem*”



Eutrophication-associated dead zones and the human footprint

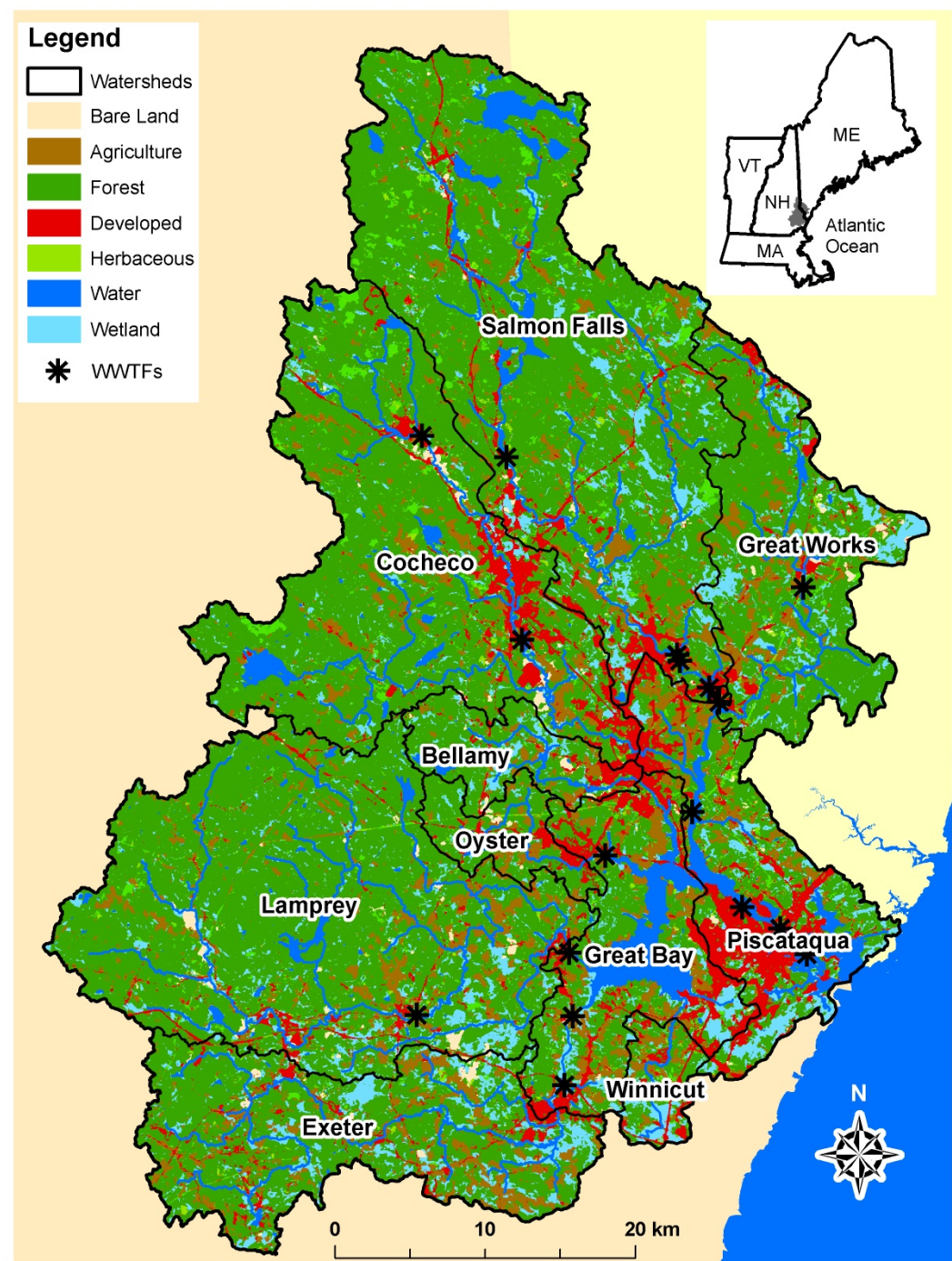


Diaz and Rosenberg. 2008. Spreading dead zones and consequences for marine ecosystems. *Science* 321:926-929.



Great Bay Estuary

- Moderately impaired, but in violation of the clean water act
- Mostly forested
- No big agriculture
- Some people
- Both point and non-point sources of N





Great Bay Nitrogen (N) Impairment

- In the bay, all forms of N can directly or indirectly result in oxygen depletion - TN criteria established
- Total N must be reduced by 31% to protect dissolved oxygen in the tidal rivers and restore eelgrass in the bay
- Current N load to Great Bay
 - 27% Sources (WWTFs)
 - 73% nonpoint n-point sources
 - Septic systems and leaky sewer lines
 - Fertilizers
 - Pets and livestock
 - Atmospheric deposition
 - Wetlands, forests and soils

**Not all non-point N
relates to human
activity and can be
managed**



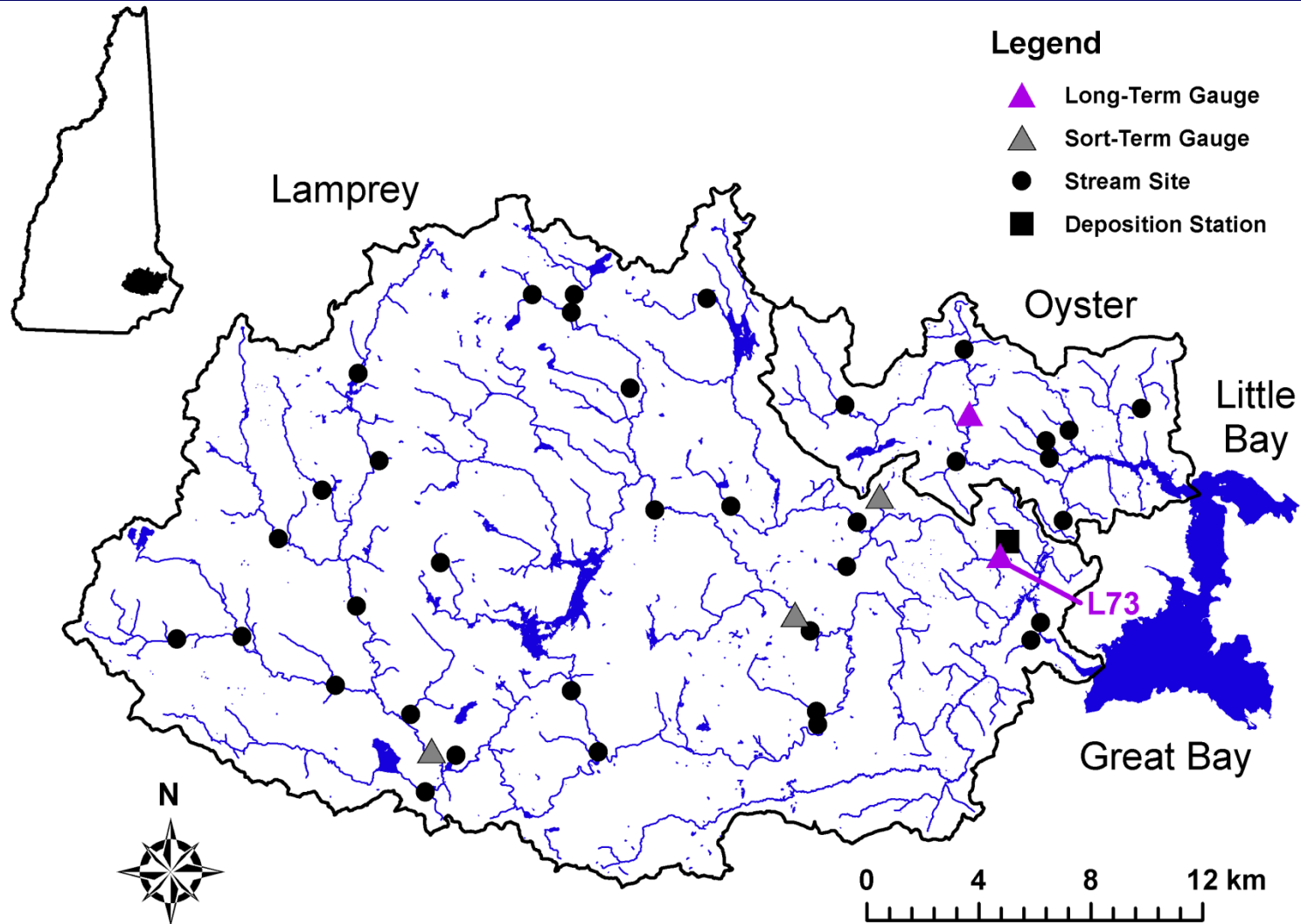
The Lamprey River is the Largest Tributary to Great Bay

LR Watershed = 550 km²





Sites in the Lamprey and Oyster watersheds





Forms of Nitrogen (N)

Particulate N

(Measured Since Oct 2002 - 0.07 mg/L)

Attached to sediment and increases with flow; no data on land use

“Reactive” Nitrogen

Associated with Human Activity

Dissolved Inorganic Nitrogen (DIN; 0.12 mg/L)

Nitrate
(NO_3^-)

Ammonium
(NH_4^+)

Dissolved N

(Measured since Sept. 1999)

Dissolved Organic Nitrogen (DON; 0.21 mg/L)

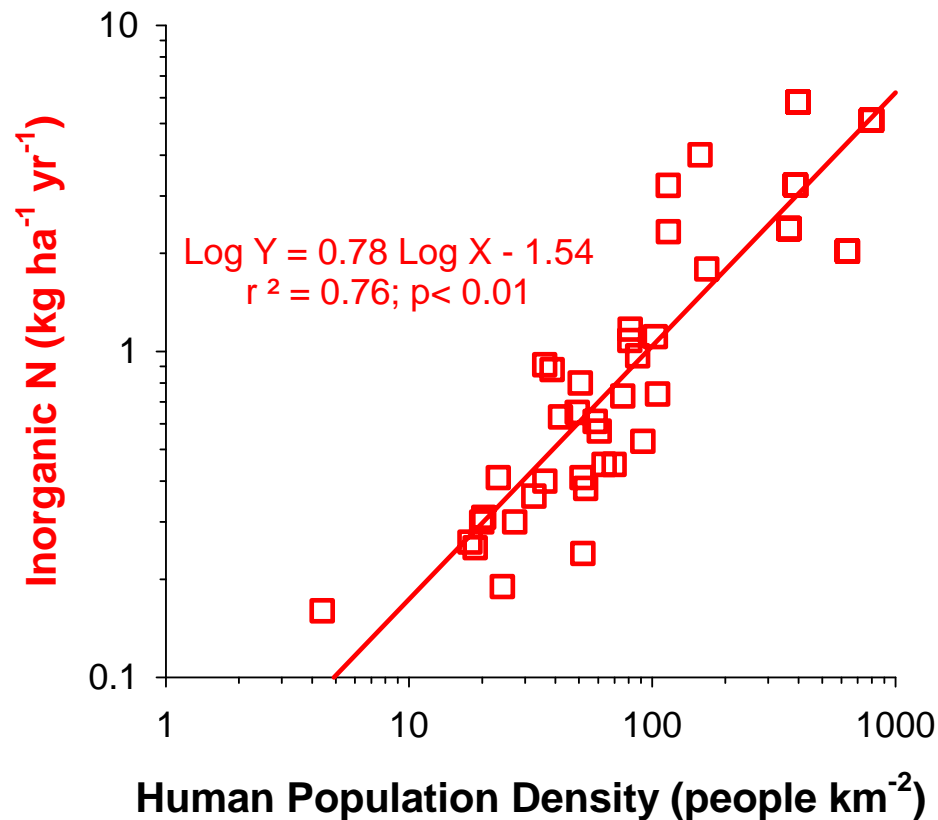


Use 10+ years of data to examine trends in dissolved N at L73



Non-point inorganic N responds to the human footprint – **MANAGEABLE**

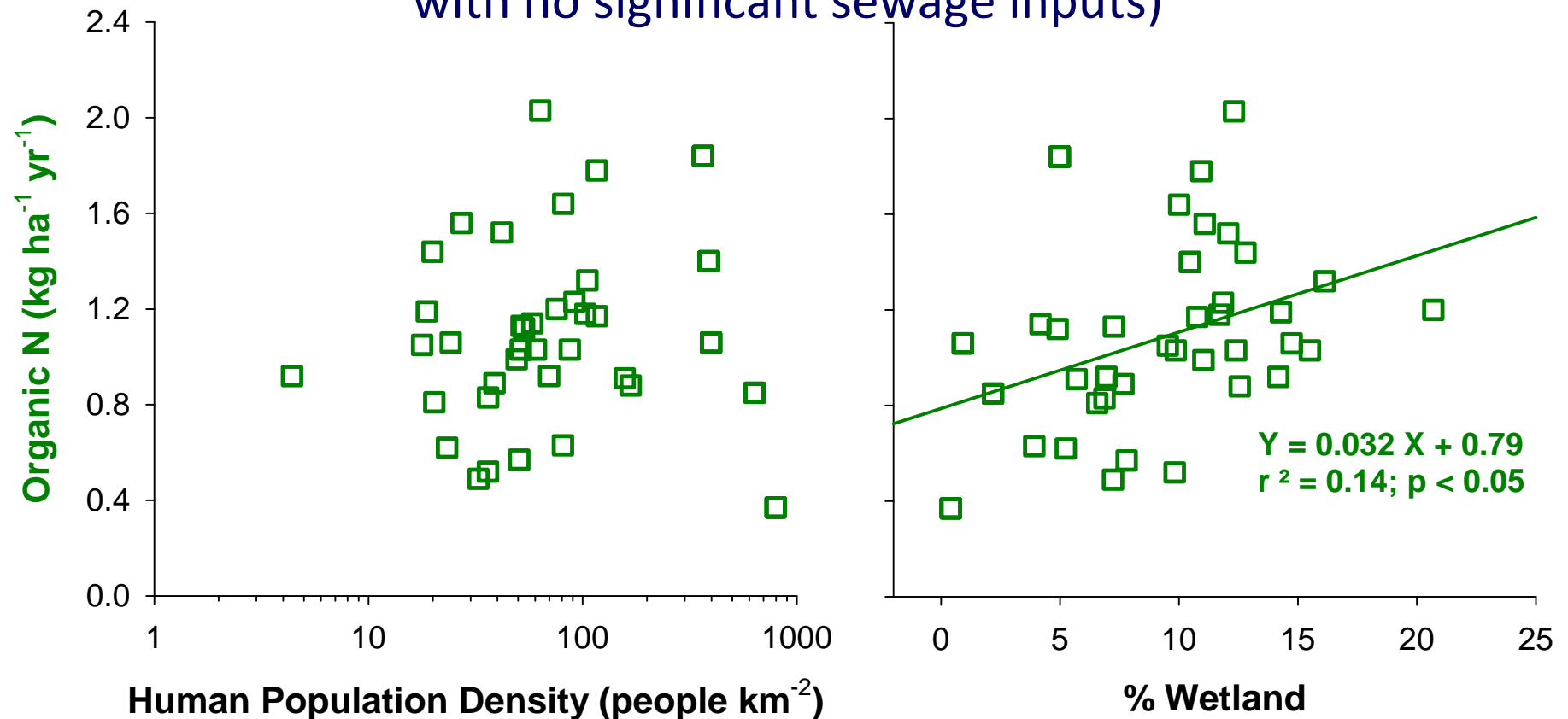
(Nitrate + ammonium in individual Lamprey and Oyster sub-basins with no significant sewage inputs)





Non-point organic N does NOT respond to the human footprint – **NOT MANAGEABLE**

(Dissolved organic N in individual Lamprey and Oyster sub-basins
with no significant sewage inputs)

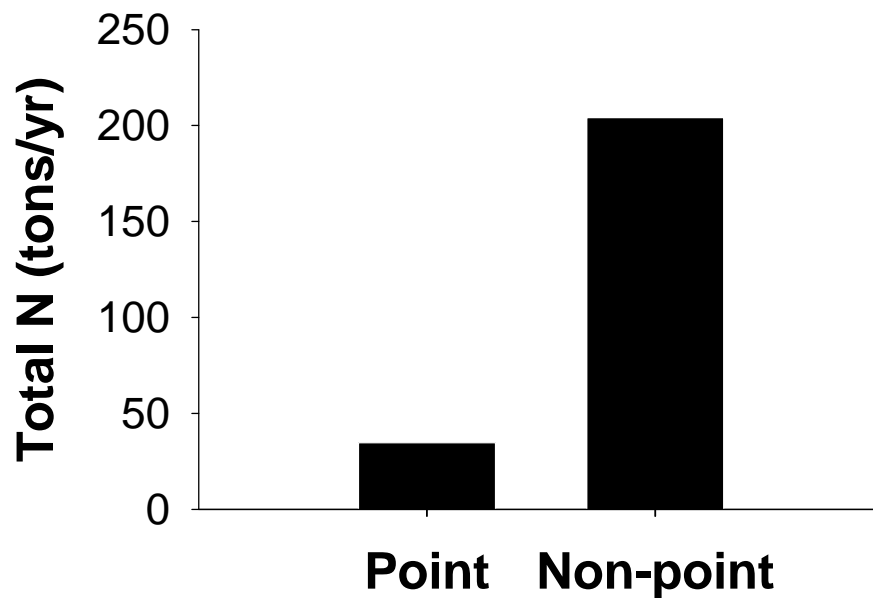




Total and Manageable N in the Lamprey

Total N

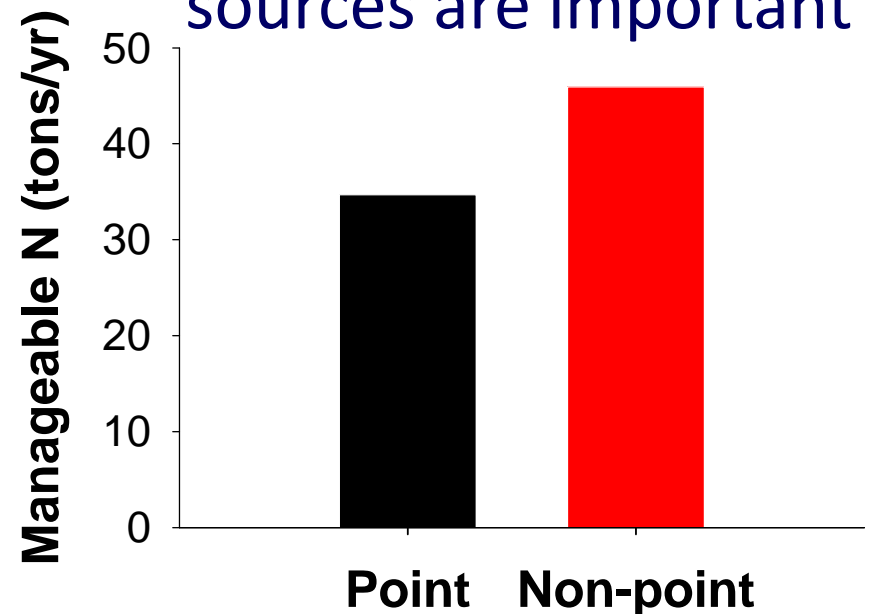
Non-point sources
dominate the problem



Manageable N

(fraction that responds to
human footprint)

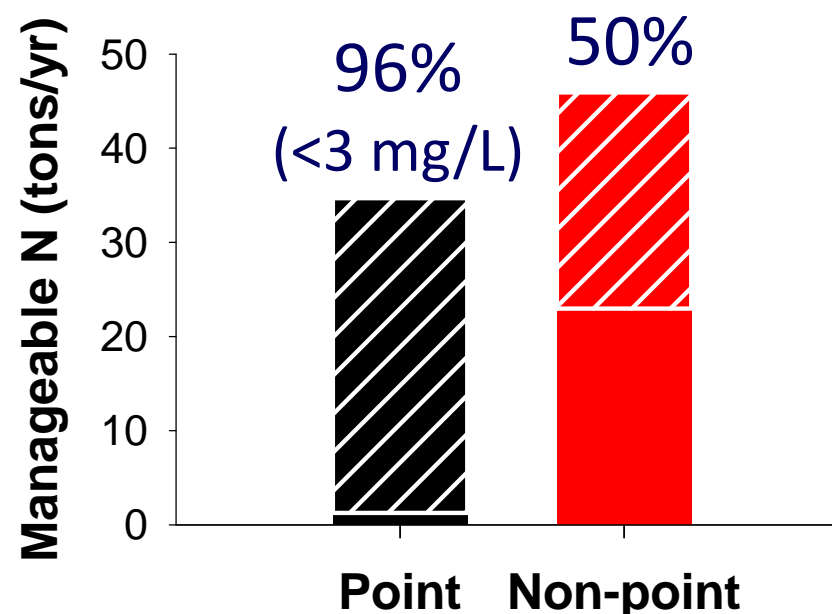
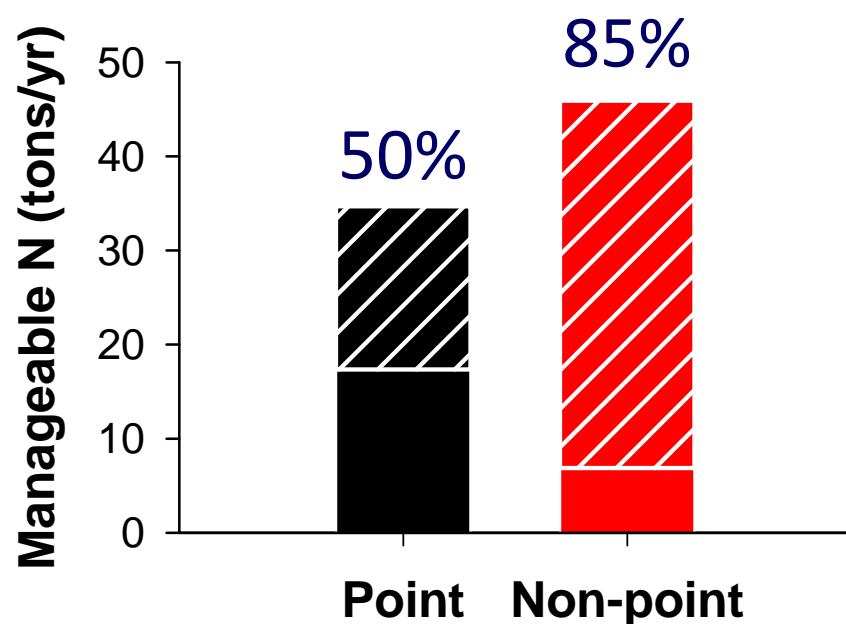
Both point and non-point
sources are important





Lamprey manageable N reduction scenarios

% Reduction to protect DO in tidal river and eelgrass in the bay



More than 50% reduction in manageable non-point N is unlikely; must use available technology to reduce point sources.



*Nitrogen Sources and Transport
Pathways: Science and
Management Collaboration to
Reduce Nitrogen Loads in the
Great Bay Estuarine Ecosystem*



Non-Point N Questions for Great Bay watershed

- What forms of N respond to human activity?
 - Does organic N or particulate N respond to the human footprint in other Great Bay sub-watersheds?
- Are there “hot spots” of N throughout the watershed?
 - How high are N concentrations?
 - Are concentrations higher than expected?
- What N sources are delivered to the stream? What is the delivery pathway?
 - In the Lamprey, only 19% of the N imported to the watershed makes it to the stream
- How efficient is the stream network at removing N?



Nitrogen Sources and Transport Pathways Objectives

Objectives:

1. Integrate scientific investigations with stakeholders to ensure results are useful and accessible to environmental managers and other stakeholders
2. Identify, model and map N concentrations in surface waters throughout the Great Bay Watershed to identify “hot spots”
3. Identify non-point sources of N that reach surface waters and the delivery pathway (e.g. groundwater vs. stormwater) using tracers.
4. Quantify N attenuation in large river reaches by modeling N inputs and outputs and inferring N attenuation

Project Duration: Fall 2010 to Summer 2013



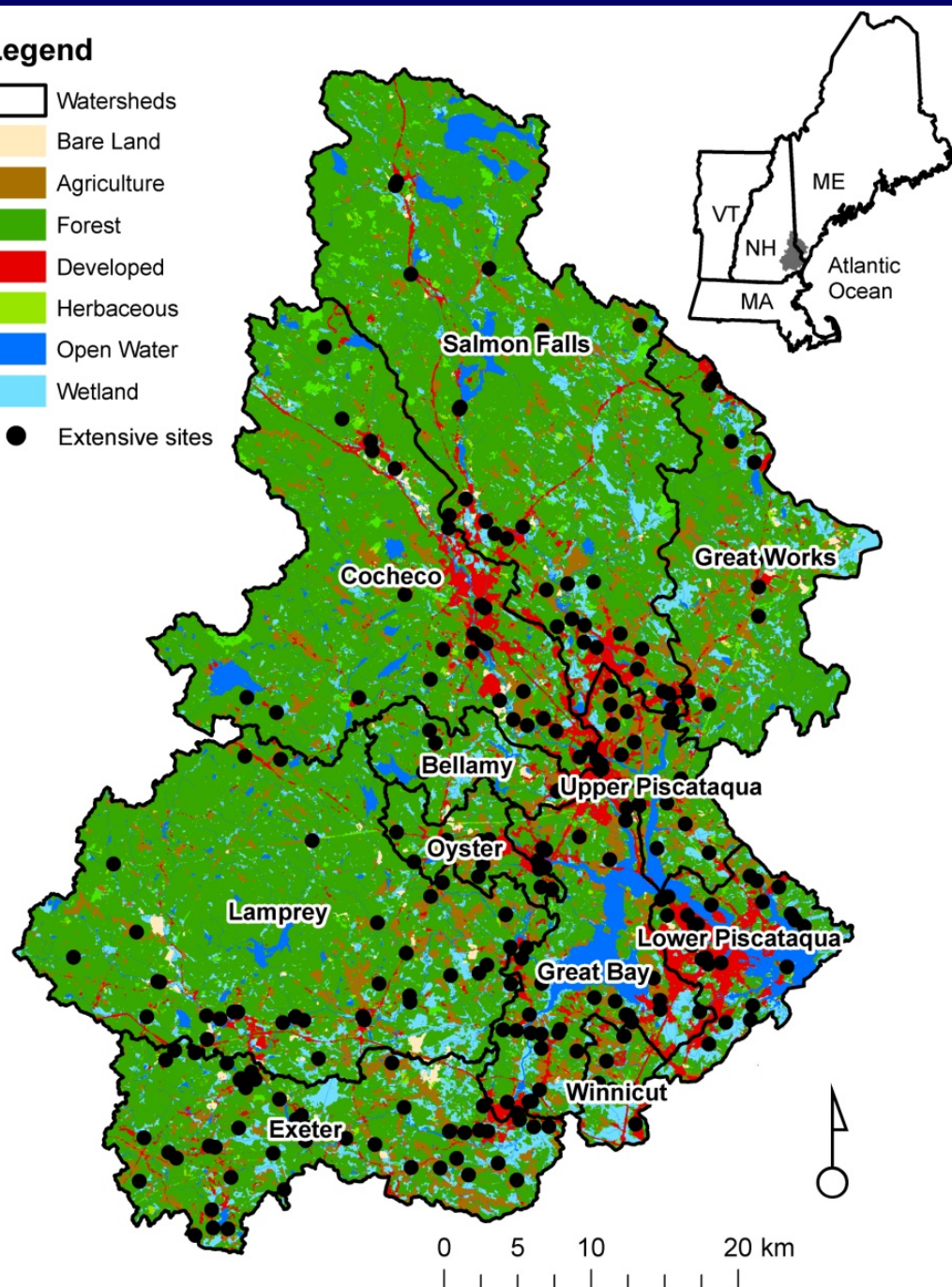
Identify N Concentrations at ~250 “Extensive” sites

N fractions

- Dissolved inorganic N (DIN)
- Dissolved organic N (DON)
- Particulate N

Legend

- Watersheds
- Bare Land
- Agriculture
- Forest
- Developed
- Herbaceous
- Open Water
- Wetland
- Extensive sites





Extensive Sampling May 2011

Inorganic N (Nitrate)

mg N/L

○ 0.00 - 0.30

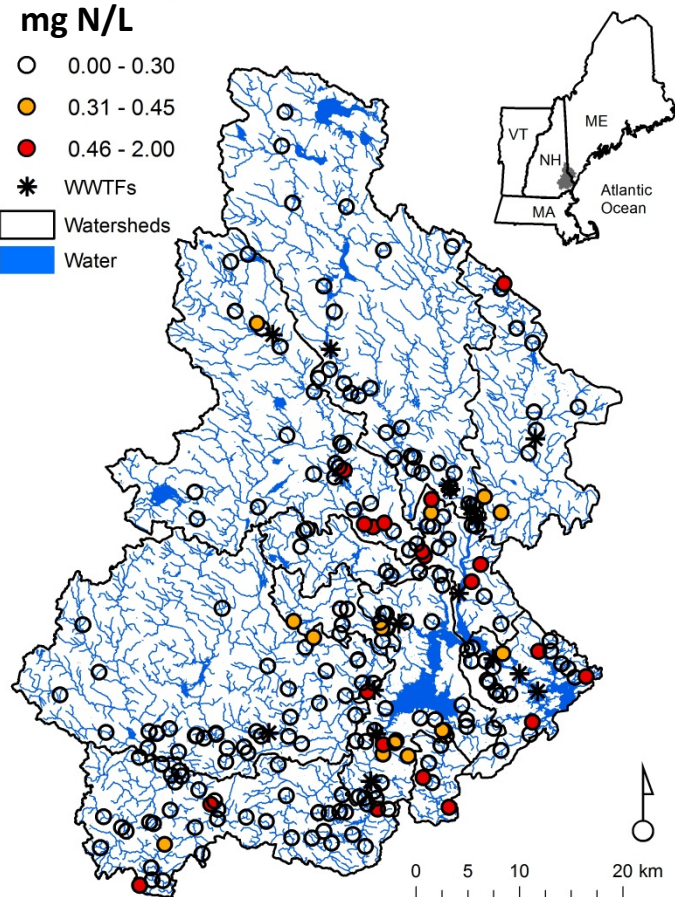
● 0.31 - 0.45

● 0.46 - 2.00

* WWTFs

□ Watersheds

■ Water



Dissolved Organic N (DON)

mg N/L

○ 0.00 - 0.30

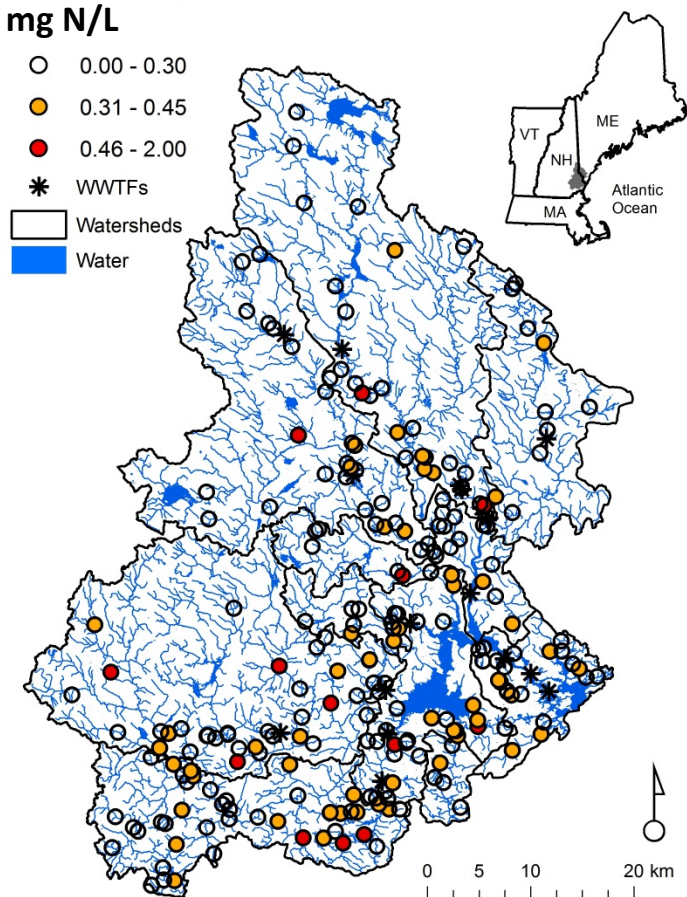
● 0.31 - 0.45

● 0.46 - 2.00

* WWTFs

□ Watersheds

■ Water



Also sampled October 2010; Will sample several more times in 2012

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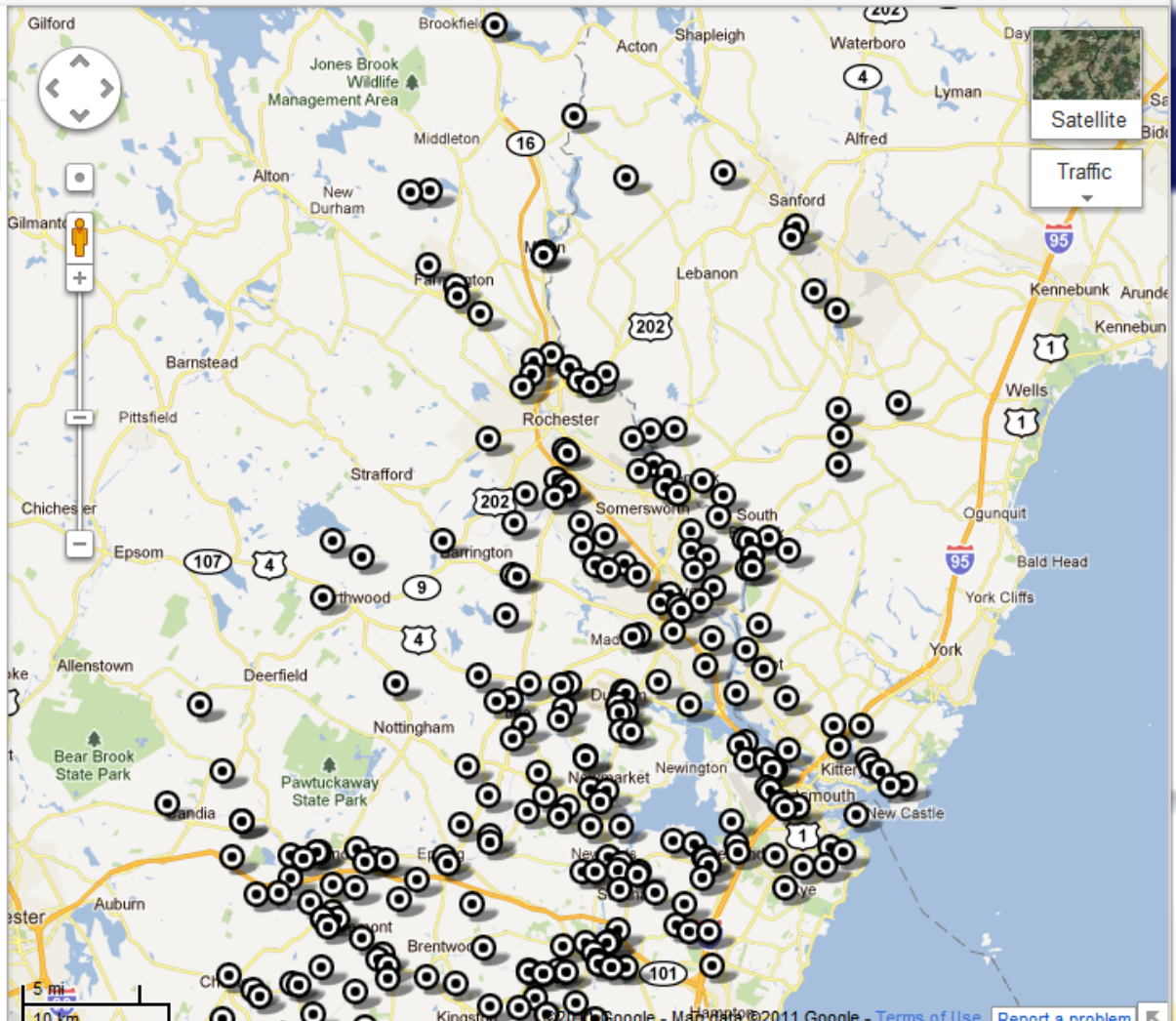
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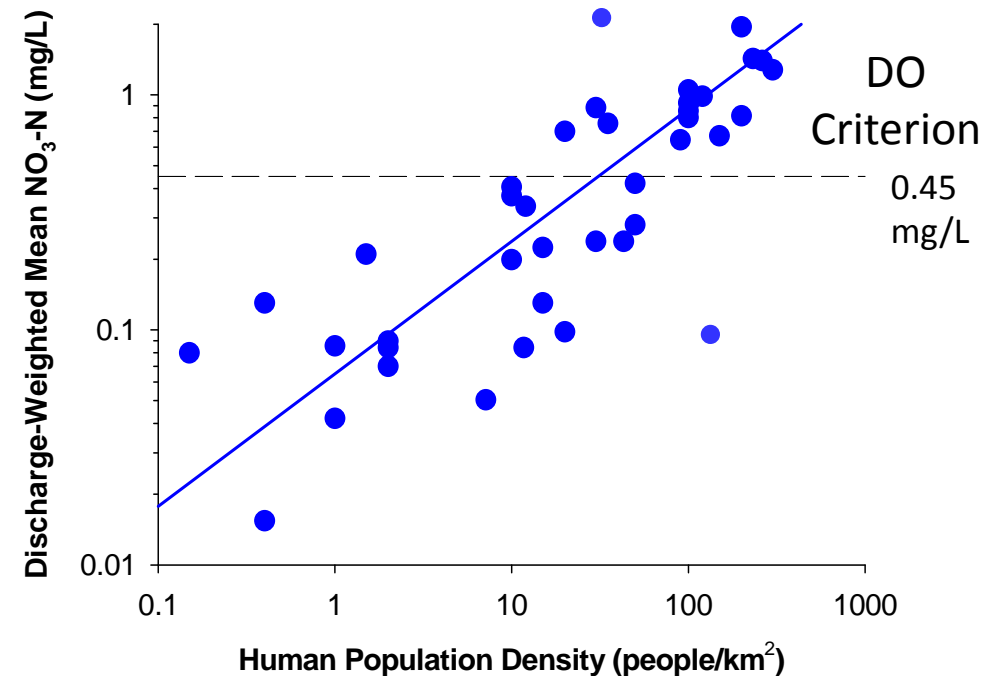
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Generate Great Bay Landscape Models

- Relate stream N concentration to landscape characteristics (e.g. population density, impervious surfaces and land use)
 - Do Lamprey/Oyster relationships hold at the Great Bay scale?
 - Does Organic N respond to human activity at the Great Bay scale?
 - Are other features important for Inorganic N? e.g. Agriculture?
- Identify N “hot spots”
 - Sites with high N
 - “Outlier” sites with higher (or lower) than expected N

Hypothetical

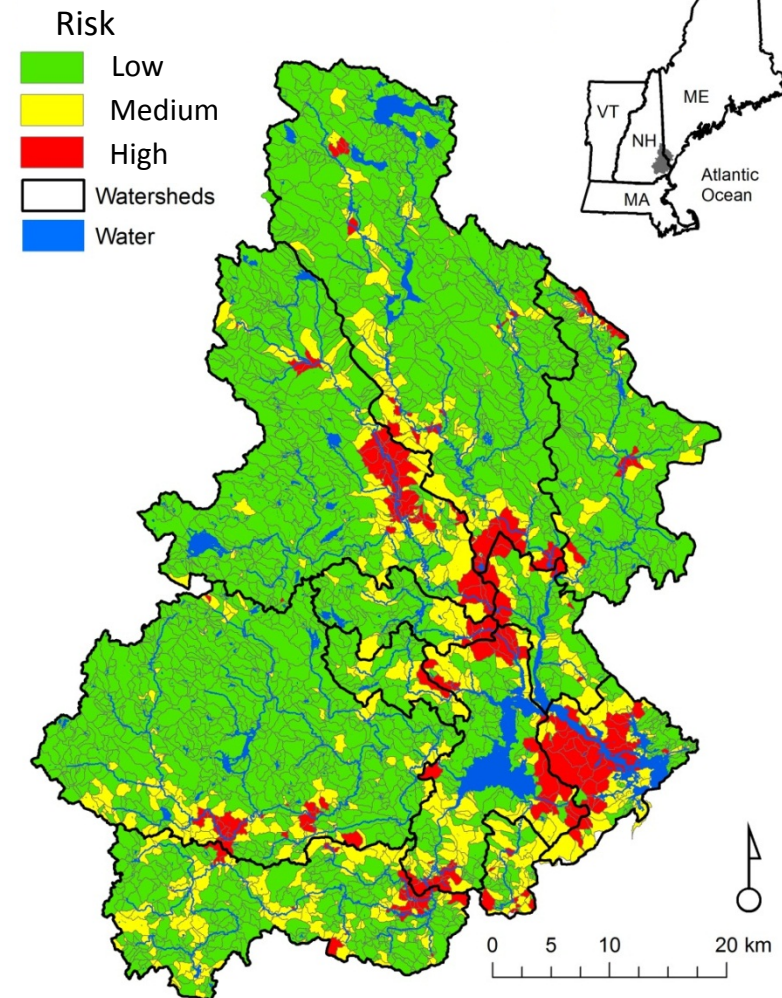




Risk Assessment Maps

- Use Great Bay landscape models to profile catchments at risk for elevated non-point N
- Assess risk at ~3000 NHGS catchments (<0.002 to 7 mi²)
- Generate risk assessment maps for each sub-watershed (~40 HUC 12s) and each town

1st Generation Assessment





Multi tracer approach to identify the dominant non-point N sources delivered to surface waters

- Stable Isotopes
 - Nitrate (NO_3^-) isotopes – $\delta^{15}\text{N}$ and $\delta^{18}\text{O}$ to distinguish between atmospheric, fertilizer and animal waste
 - Sediment isotopes – $\delta^{15}\text{N}$ of surficial sediment (2 cm) to distinguish between fertilizer and animal waste
- Chemical
 - Caffeine – human waste signal
 - Optical brighteners – laundry detergents, human waste signal
- Microbiological source tracing – mitochondrial (mt) DNA to identify animal waste sources – Human, Bovine or Dog
- Pharmaceuticals in collaboration with EPA on some intensive sites



Tracer Testing and Application at Intensive study sites (n = 20-30)

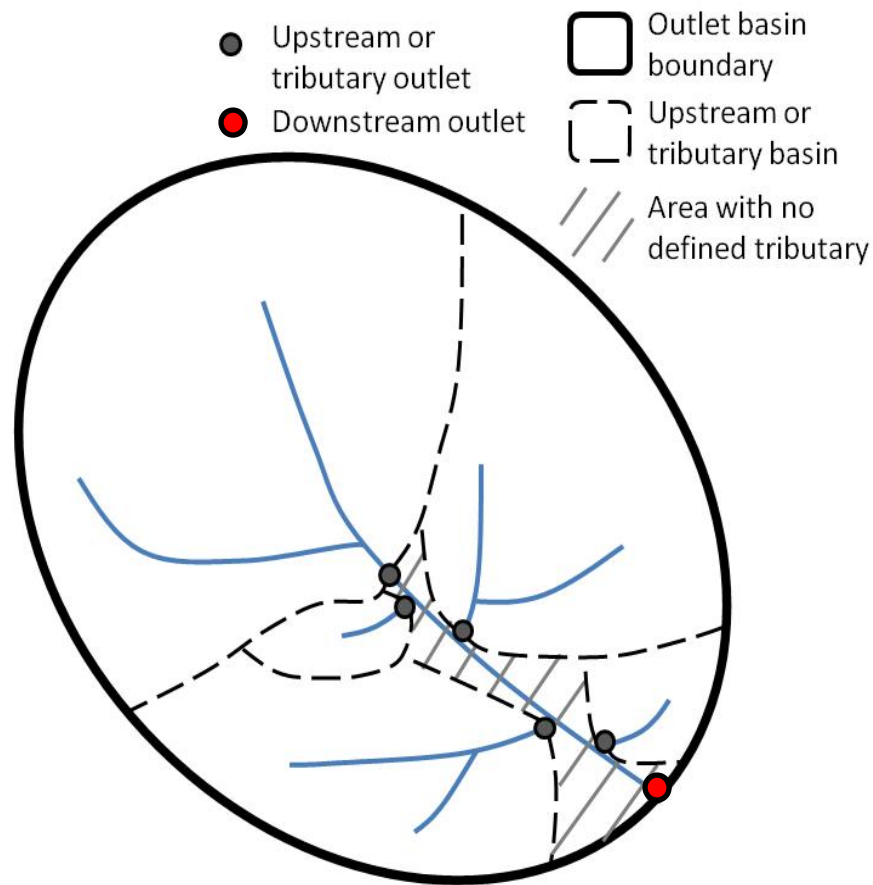
1. Test known sources to build our tracer toolbox
 - Small watersheds with uniform land-use
 - Forested as a control site
 - Agricultural to identify livestock waste
 - All septic and all sewerred
 - Golf course site to identify fertilizers
 - Parking lot drainage
2. Apply tracer methods in combination to mixed land-use sites to identify dominant source of Non-point N
 - Sample streams, shallow groundwater, storm events to characterize transport pathway

“Fingerprinting” Sources

Tracer	Septic	Sanitary Sewer	Fertilizer	Pet waste	Livestock waste	Deposition or Pavement Drainage
Nitrate Isotopes	Animal waste	Animal waste	Fertilizer	Animal waste	Animal waste	Atmospheric Deposition or parking lot signal
Sediment ¹⁵ N	High	High	Low	High	High	Low
Caffeine	Present	Present	Absent	Absent	Absent	Absent
Optical Brighteners	Present	Present	Absent	Absent	Absent	Absent
mtDNA	Absent	Human	Absent	Dog	Bovine	Absent
E coli	Absent	Present	Absent	Present	Present	Absent



N attenuation in large freshwater river reaches



- Quantify N attenuation in large river reaches by modeling N inputs and outputs and inferring N attenuation
- N attenuation = N load at outlet
 - upstream N load
 - tributary N loads
 - N load for riparian area not drained by defined tributary



Stakeholder Integration

Great Bay Nitrogen Sources Newsletter

To subscribe, email:

charlie.french@unh.edu



Nitrogen Sources Collaborative Advisory Board (NSCAB)



A River, Estuary or Lake is a Reflection of its Watershed

Questions?

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603-862-1794