Spatiotemporal trends in solute export and concentration-discharge relationships determined by a high-frequency in situ optical sensor network

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Water Quality
Analysis Lab

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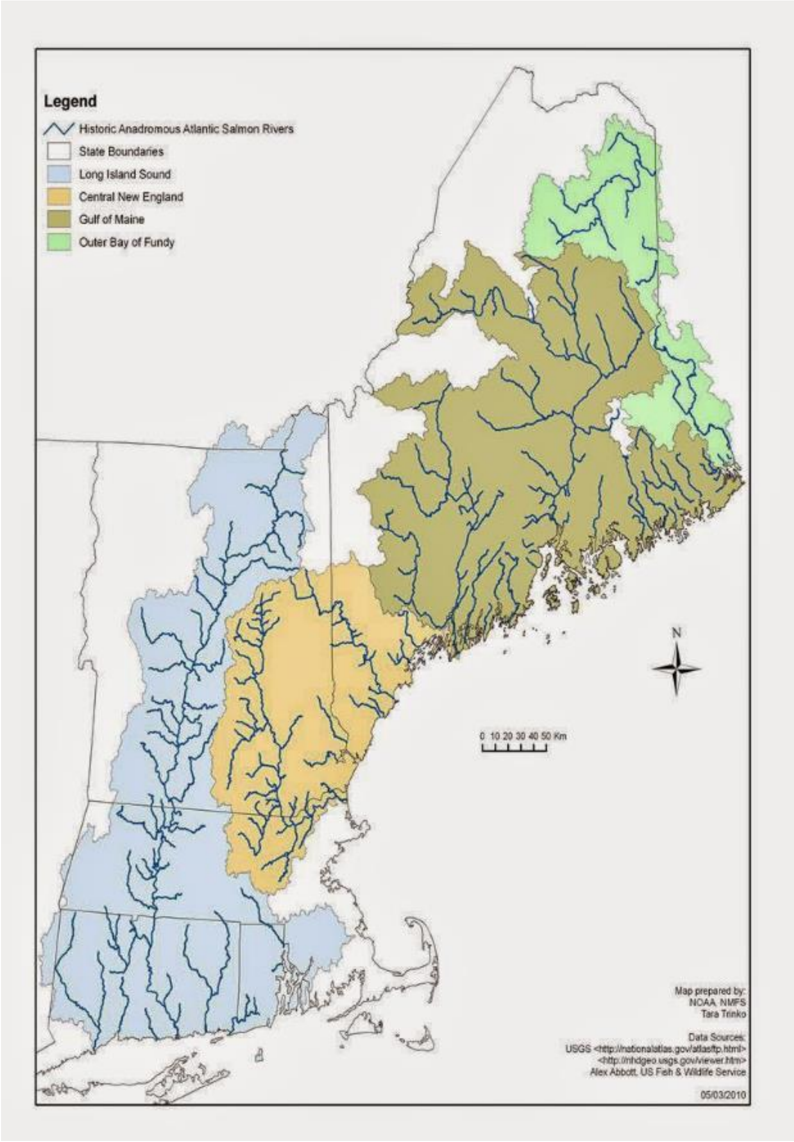
NH WRRC

River systems integrate the spatiotemporal variability in catchment properties



Water quality conditions in streams and rivers can change rapidly

- 15-minute resolution
  - Q
  - fDOM
  - NO_3
  - DO
  - Temperature
  - Turbidity
  - pH
  - Conductivity

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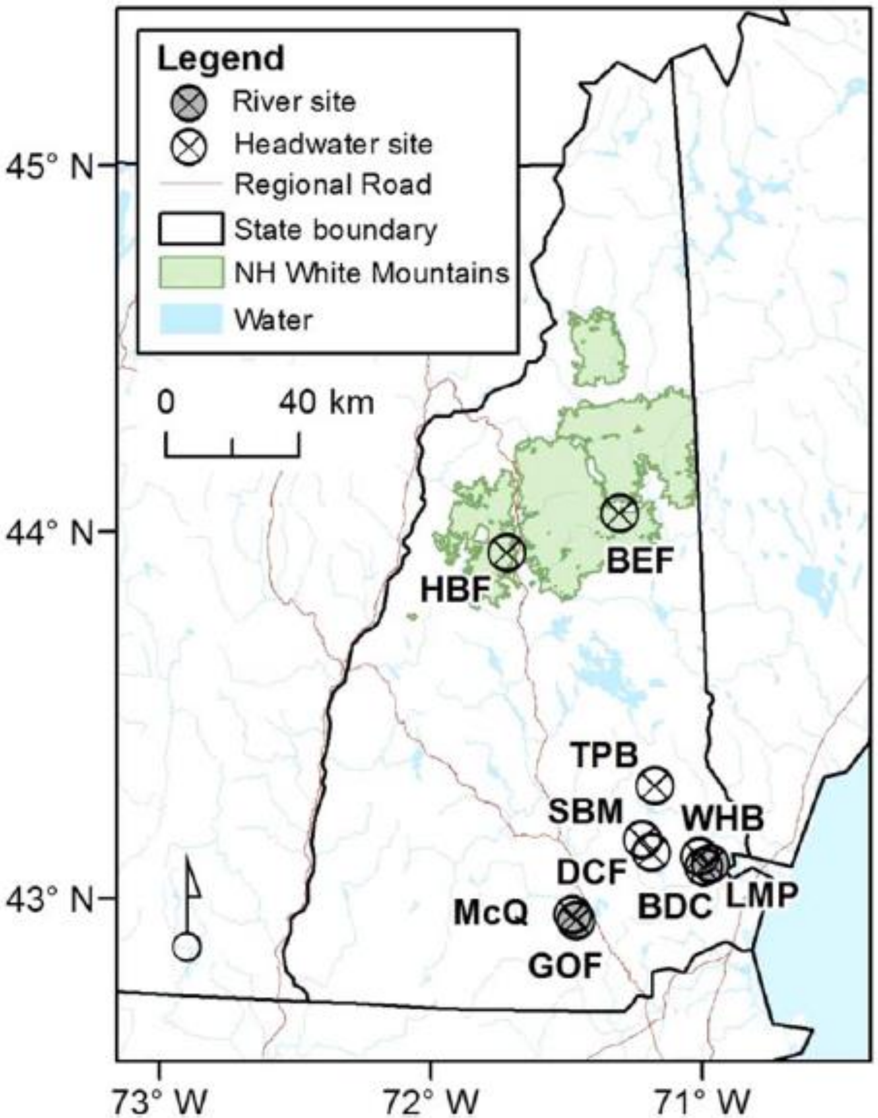
Sensor network includes ten streams in New Hampshire



Wymore et al. 2018

- Sites span a gradient
  - DOM
  - NO_3
  - Land use
  - Size
- Sensor dataset: 10 streams
  - 3-5 years of data (2012-2017)
- Grab sample dataset

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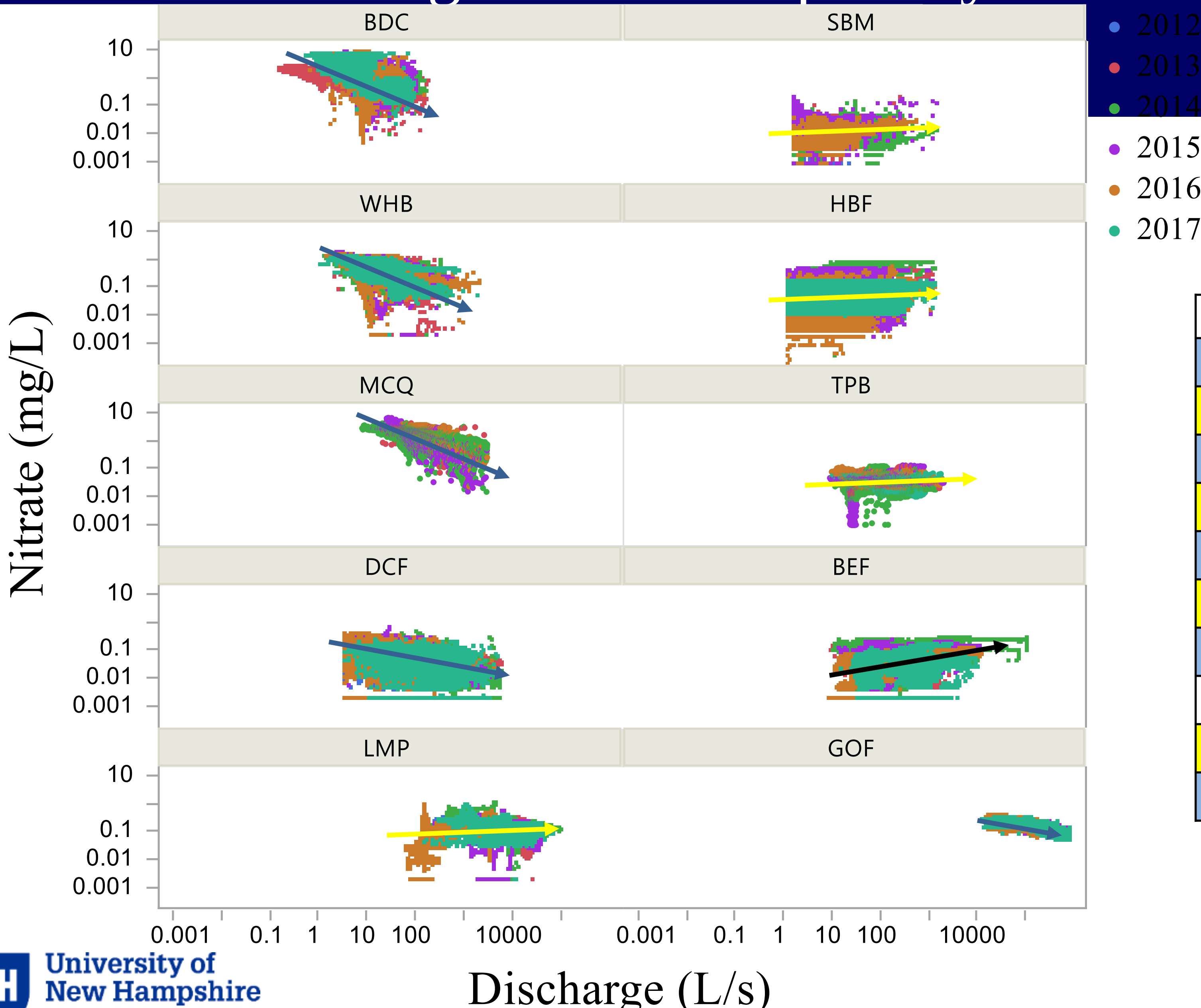
Main Questions

- What is the spatiotemporal variability in nitrate yield calculated from sensor data?
- What sampling resolution produces the closest estimates to ‘true’ nitrate load?
- What is the intra-annual variability in solute-discharge behavior

Nitrate-Discharge relationships vary across streams



Site	c-Q slope
BDC	-0.61
SBM	0.13
WHB	-0.34
HBF	0.13
MCQ	-0.26
TPB	-0.11
DCF	-0.58
BEF	0.23
LMP	0.03
GOF	-0.36

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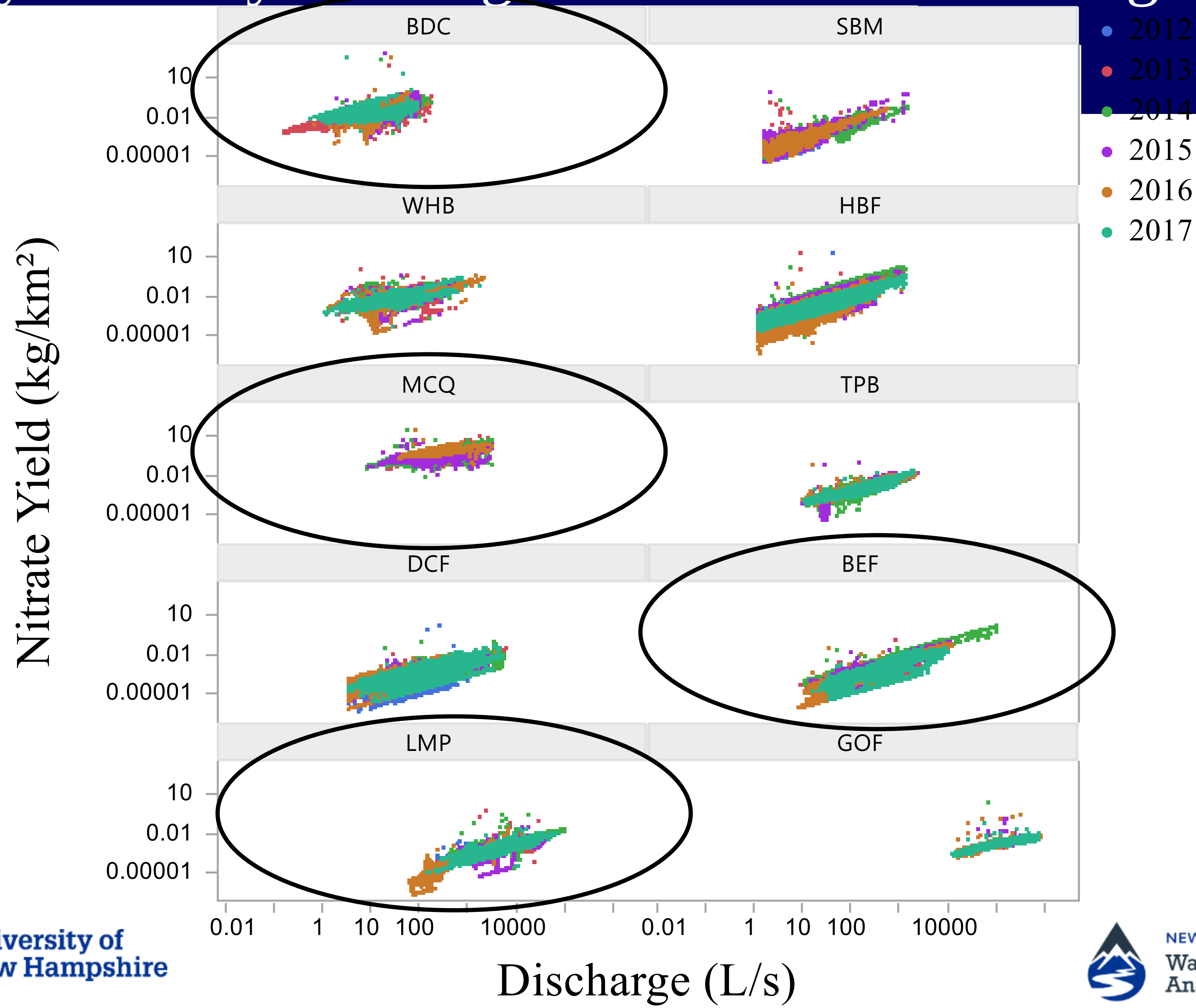
Daily Nitrate yield ranges several orders of magnitude



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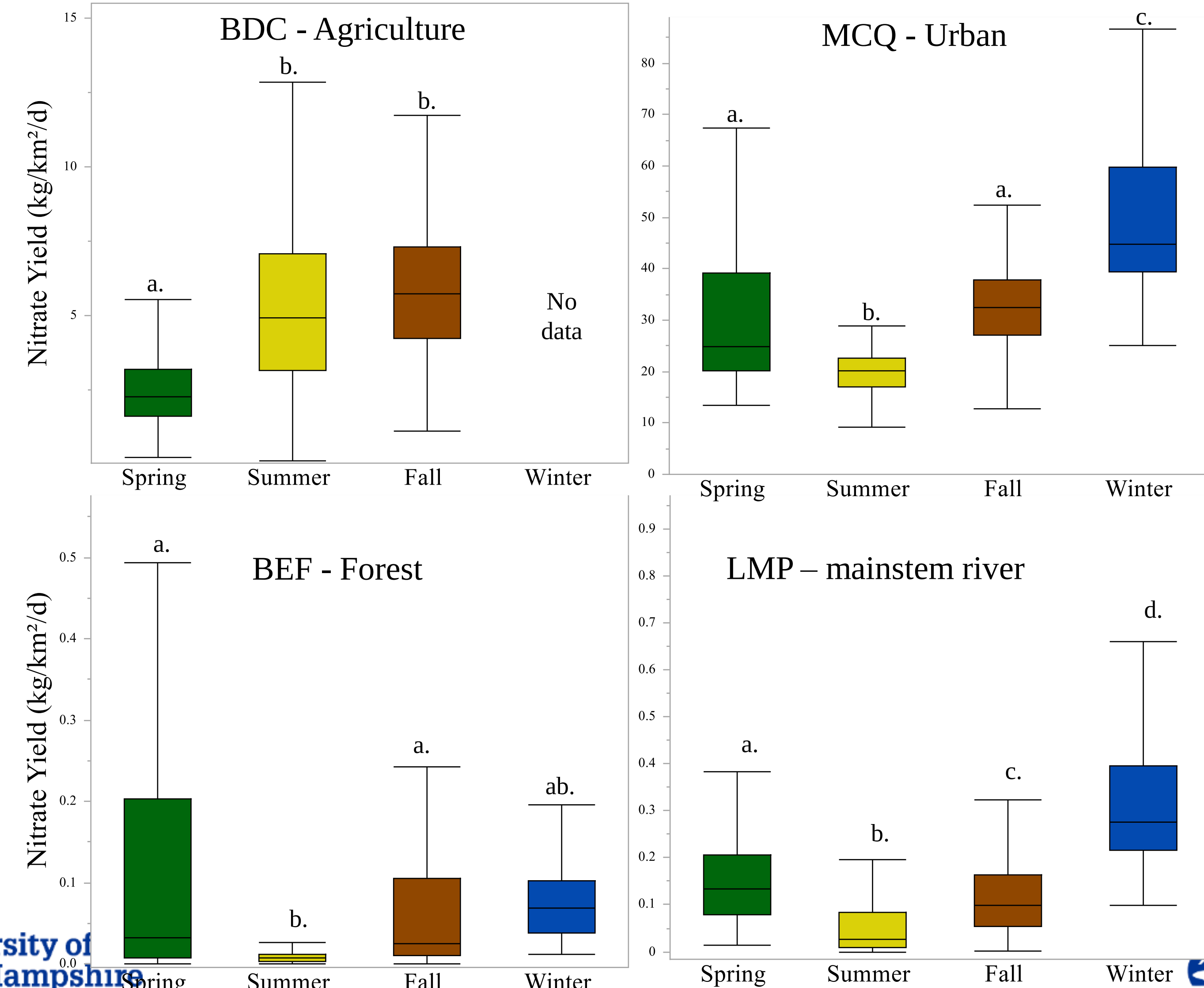
Summer had lower daily yield than other seasons except for agricultural streams



Note: y-axis range varies

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When do sensors matter most?

What sampling resolution can best estimate “’true” nitrate loading?

a. monthly grab samples
b. monthly subsample of sensor data
c. weekly subsample of sensor data

Loadflex package in R

Linear Regression model 5

$\ln(\text{load}) = a_0 + a_1 \ln(\text{discharge}) + a_2 \ln(\text{discharge})^2 + a_3 \Delta\text{time}$

Linear Regression model 7

$\ln(\text{load}) = a_0 + a_1 \ln(\text{discharge}) + a_2 \sin(2\pi\Delta\text{time}) + a_3 \cos(2\pi\Delta\text{time})\ a_4\Delta\text{time}$

Interpolation model

Rectangular interpolation

Composite model

Combines regression estimation with interpolation

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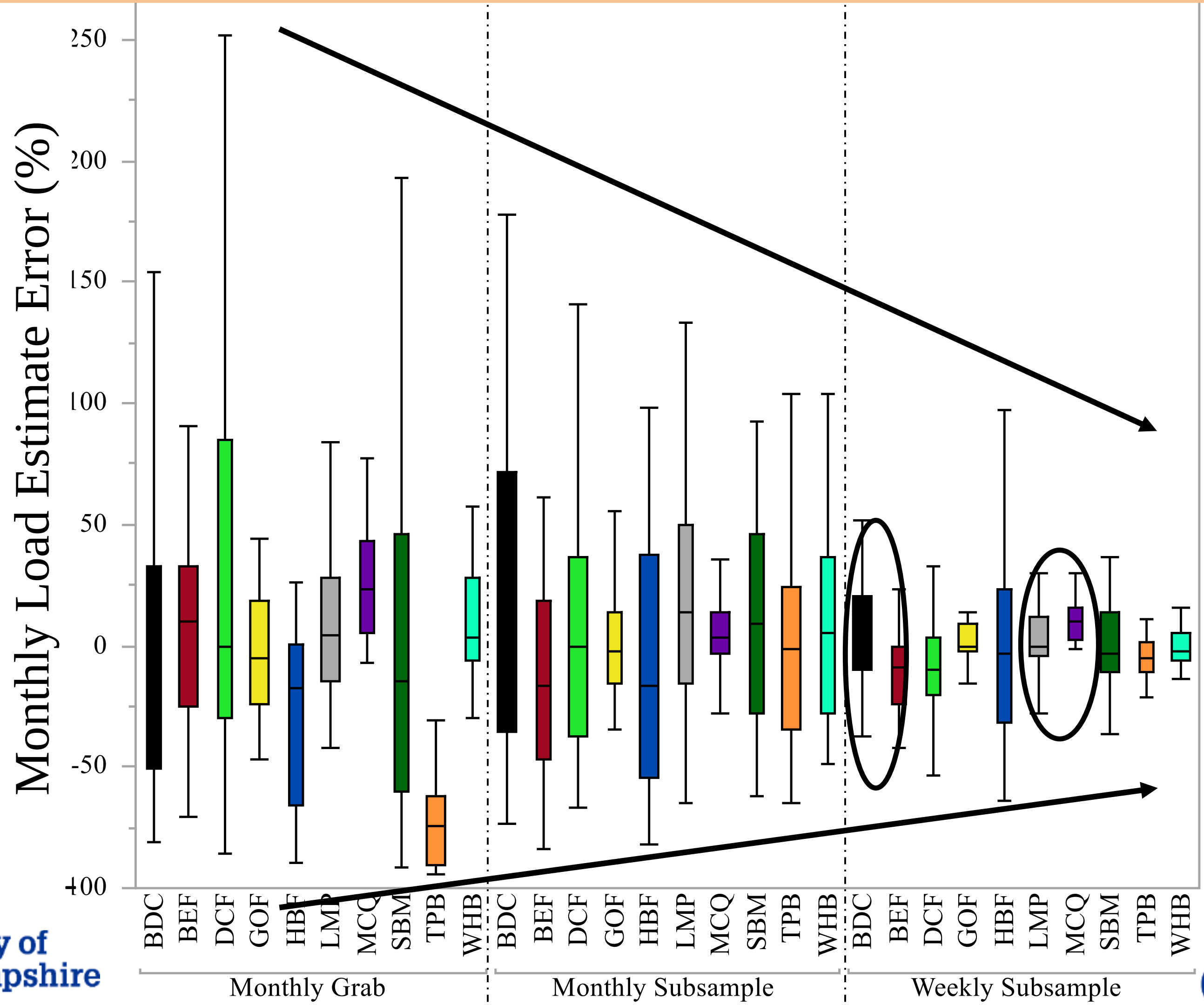
Nitrate load estimation was more accurate at low sample resolution

Average Absolute Value % Error:	42%	41%	20%



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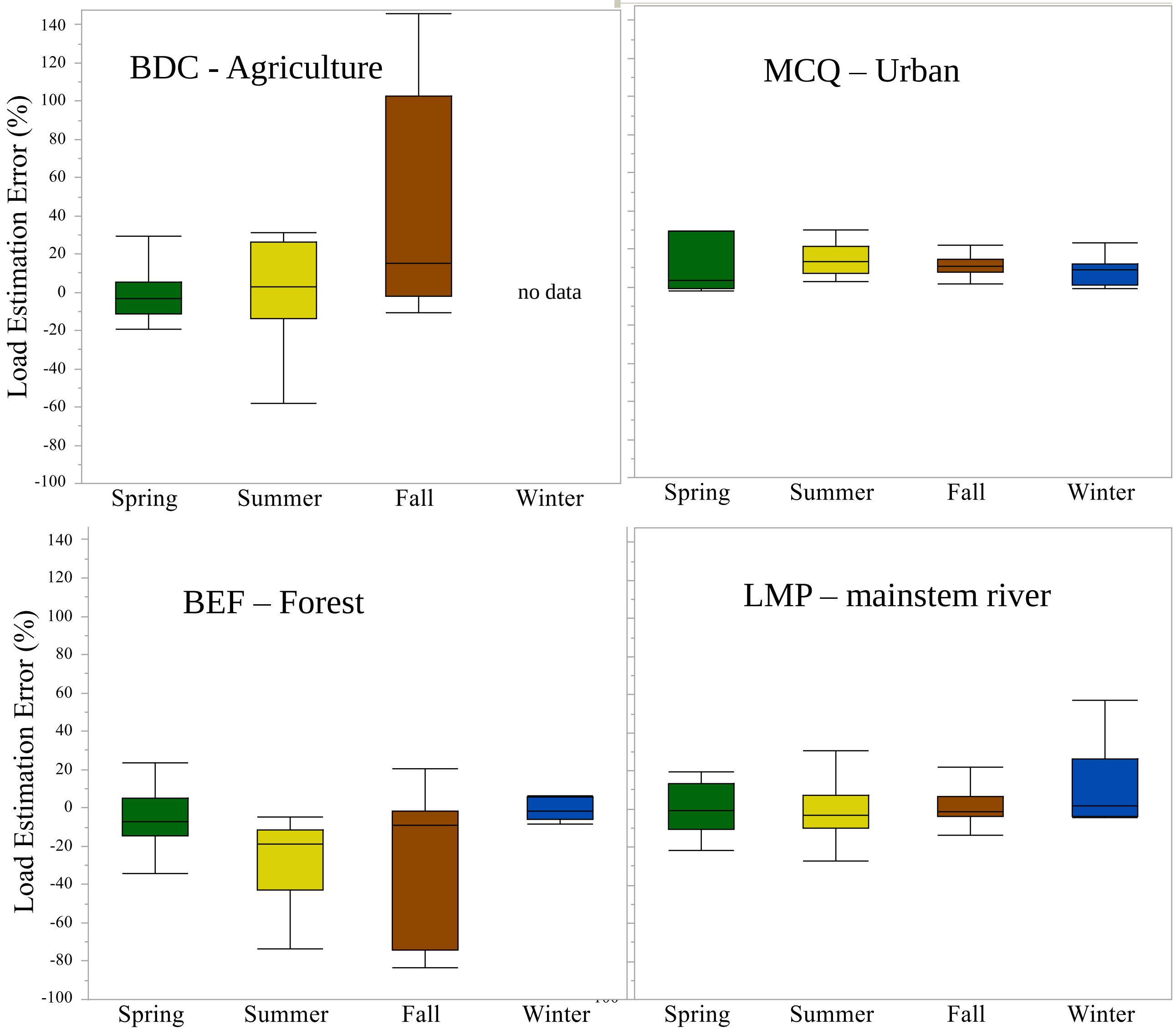
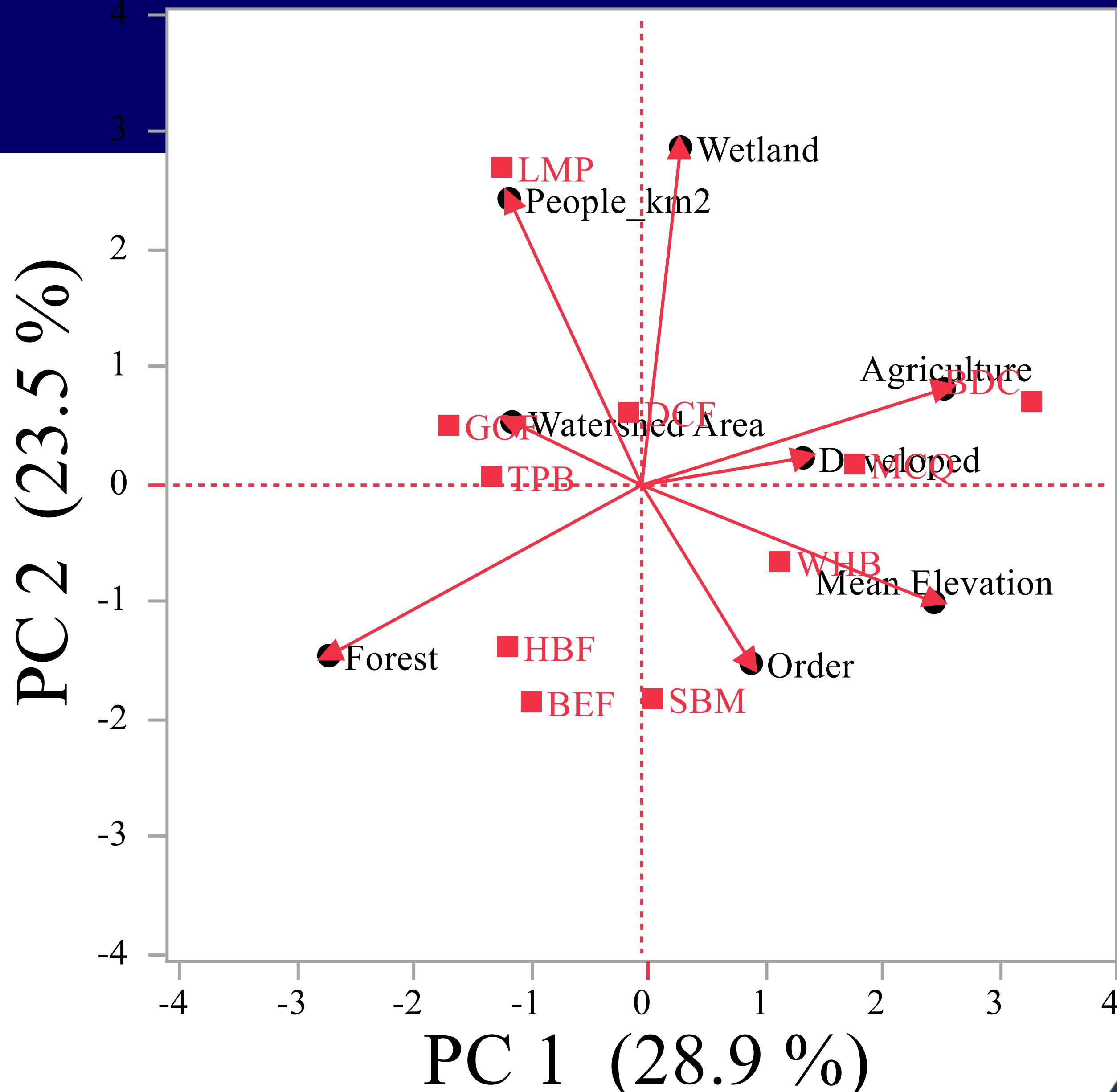
Accuracy of load estimates does not depend on season

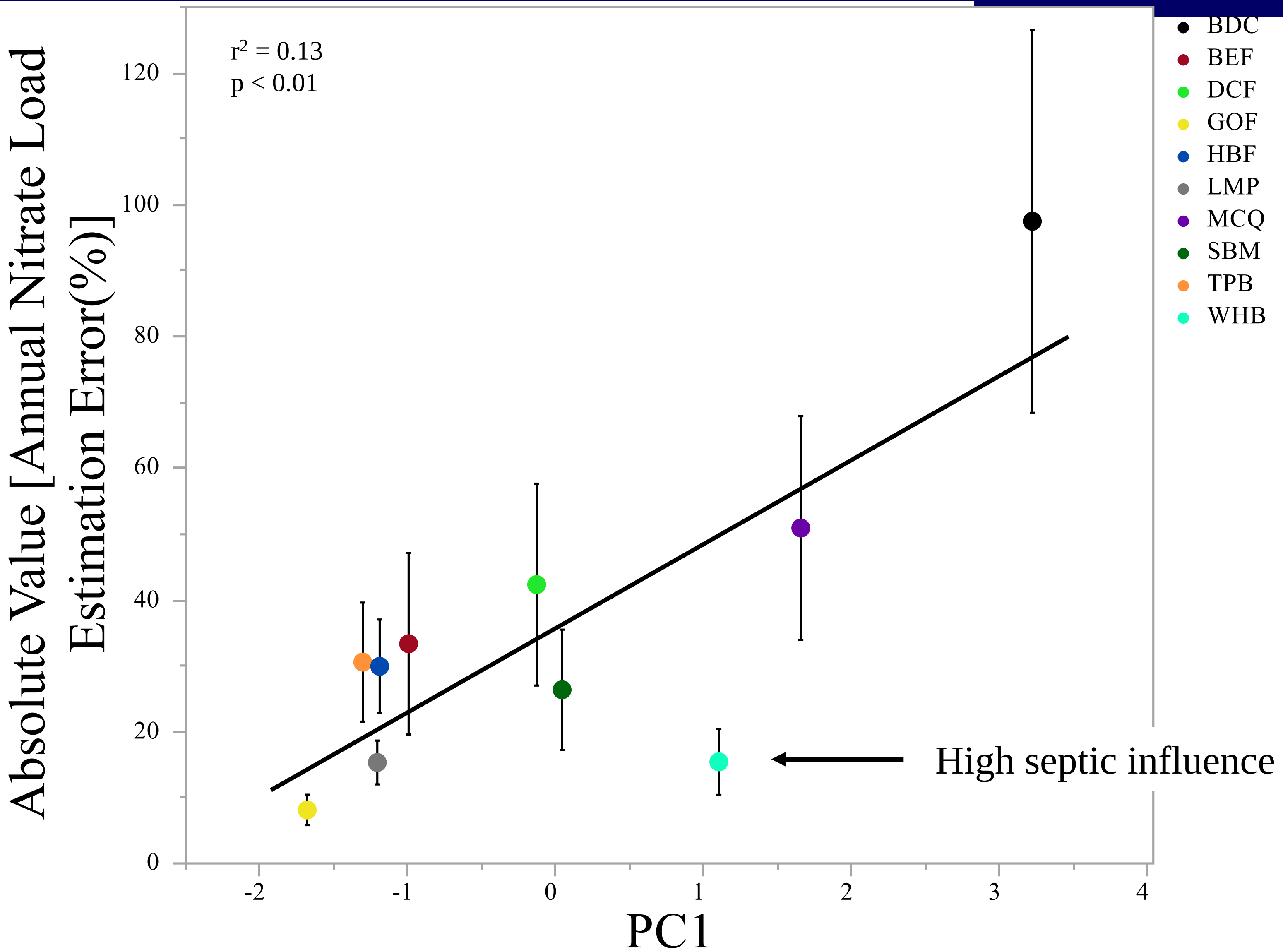


Weekly subsample of sensor dataset

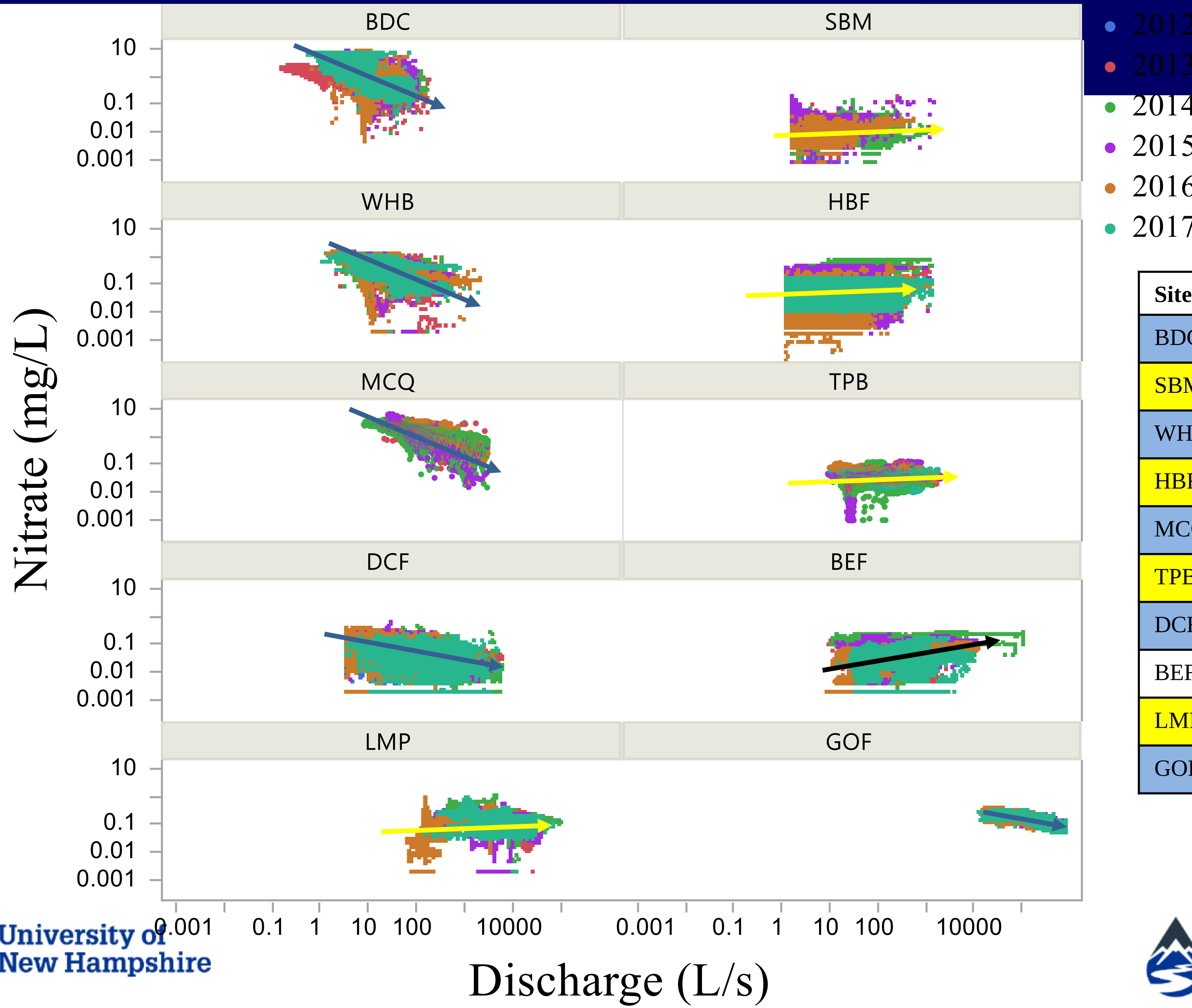


PC 2 (23.5 %)
PC 1 (28.9 %)
4
3
2
1
0
-1
-2
-3
-4
-4
-3
-2
-1
0
1
2
3
4
Wetland
LMP
People_km2
Agriculture
BDC
DCF
GOF
Watershed Area
Developed
MCQ
TPB
WHB
Mean Elevation
HBF
Forest
Order
BEF
SBM

Nitrate load error at annual scale is greater for more impacted sites



Intra-annual variability in nitrate-discharge behavior



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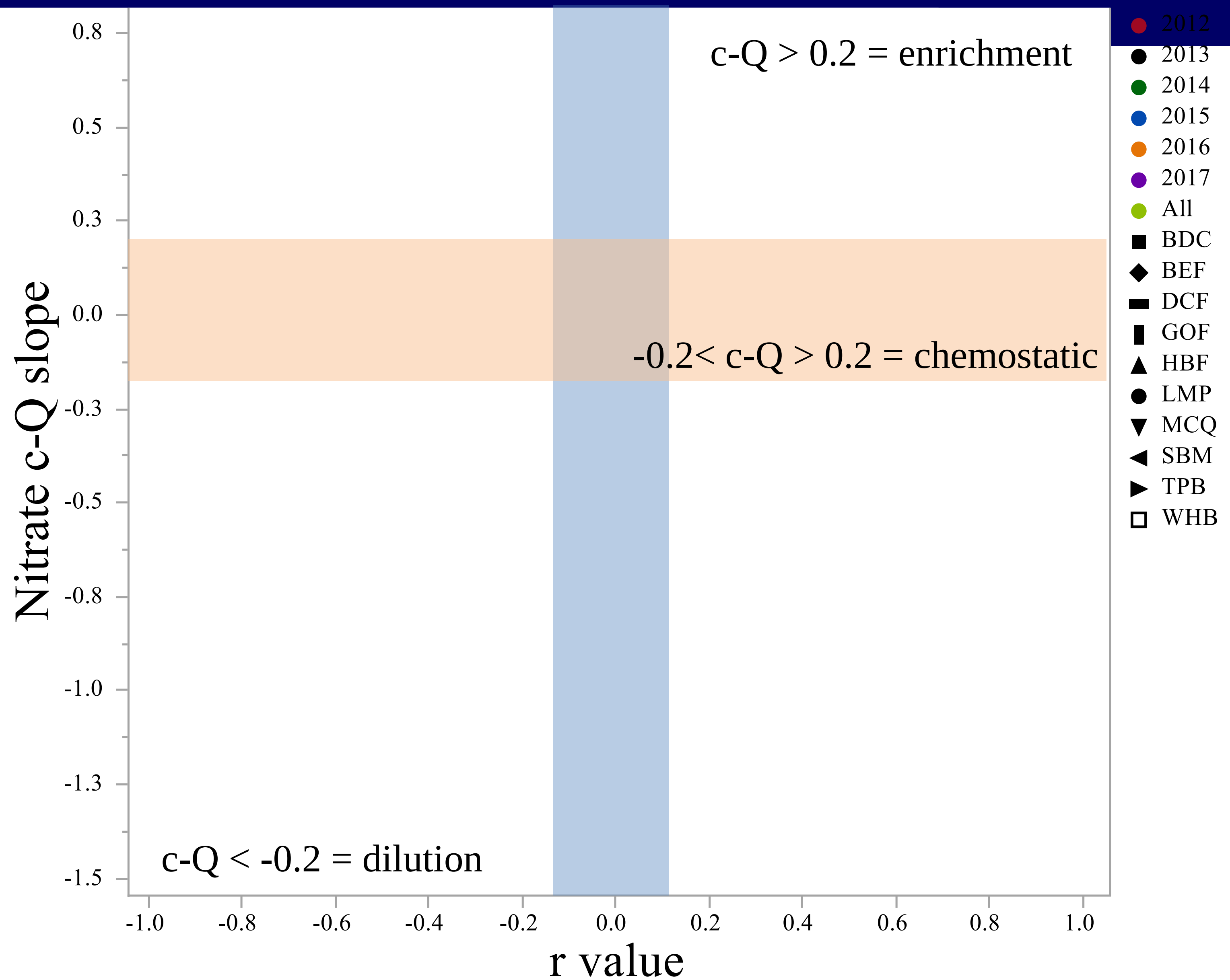
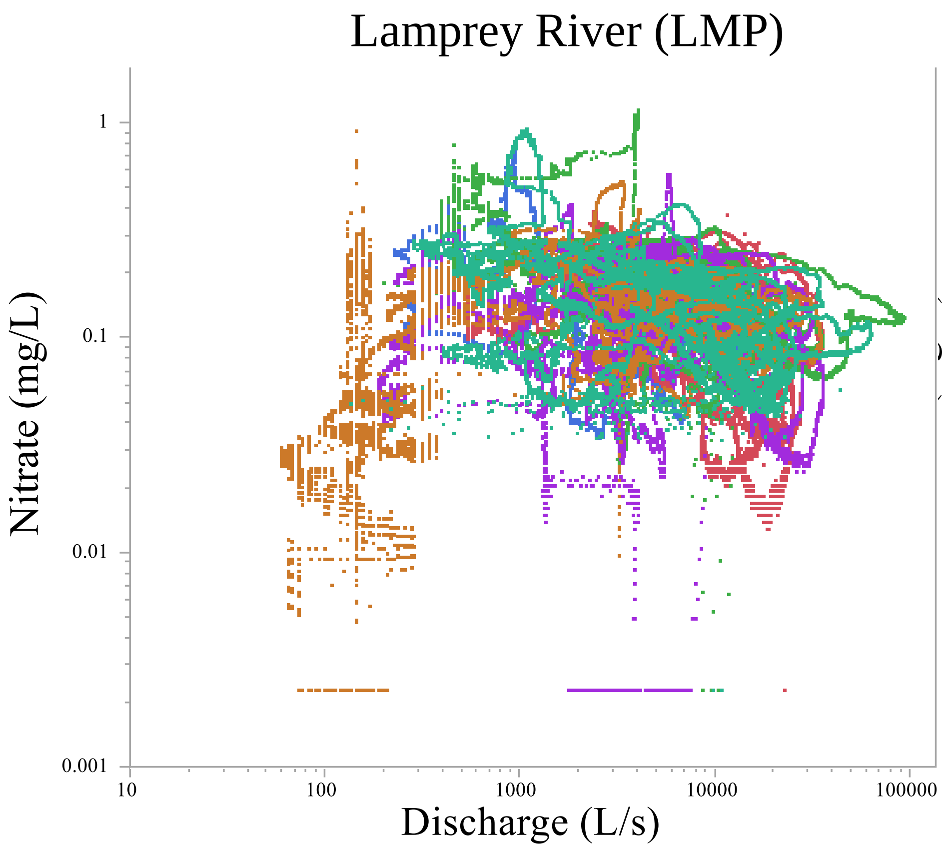
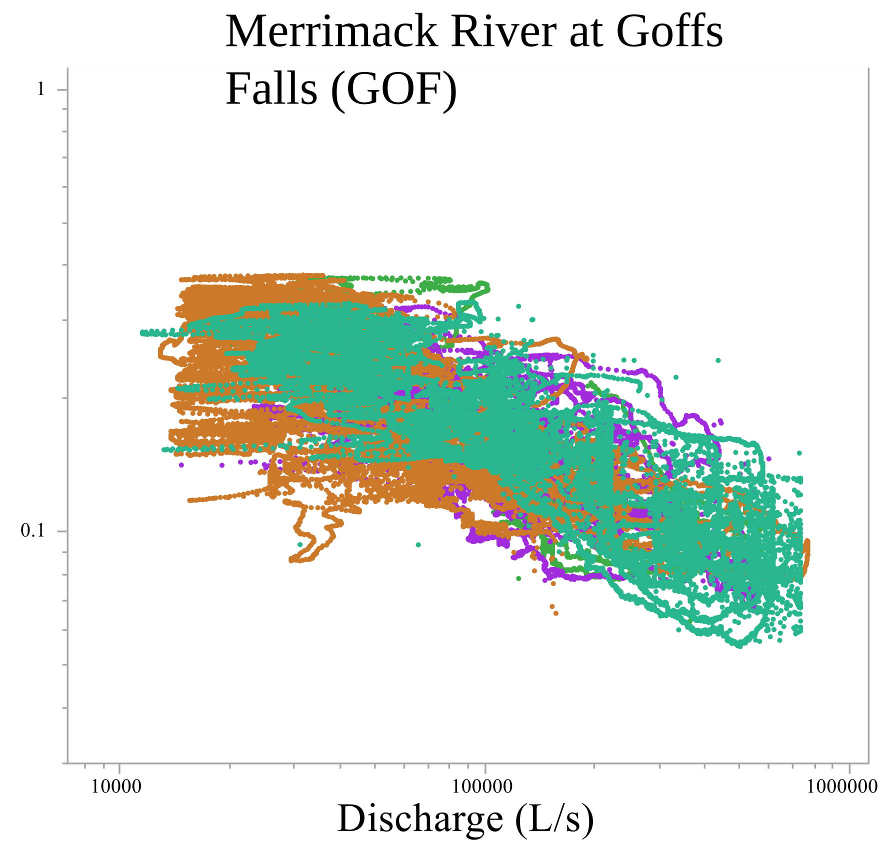
Annual Nitrate-Discharge behavior



Nitrate-discharge relationships are stream specific





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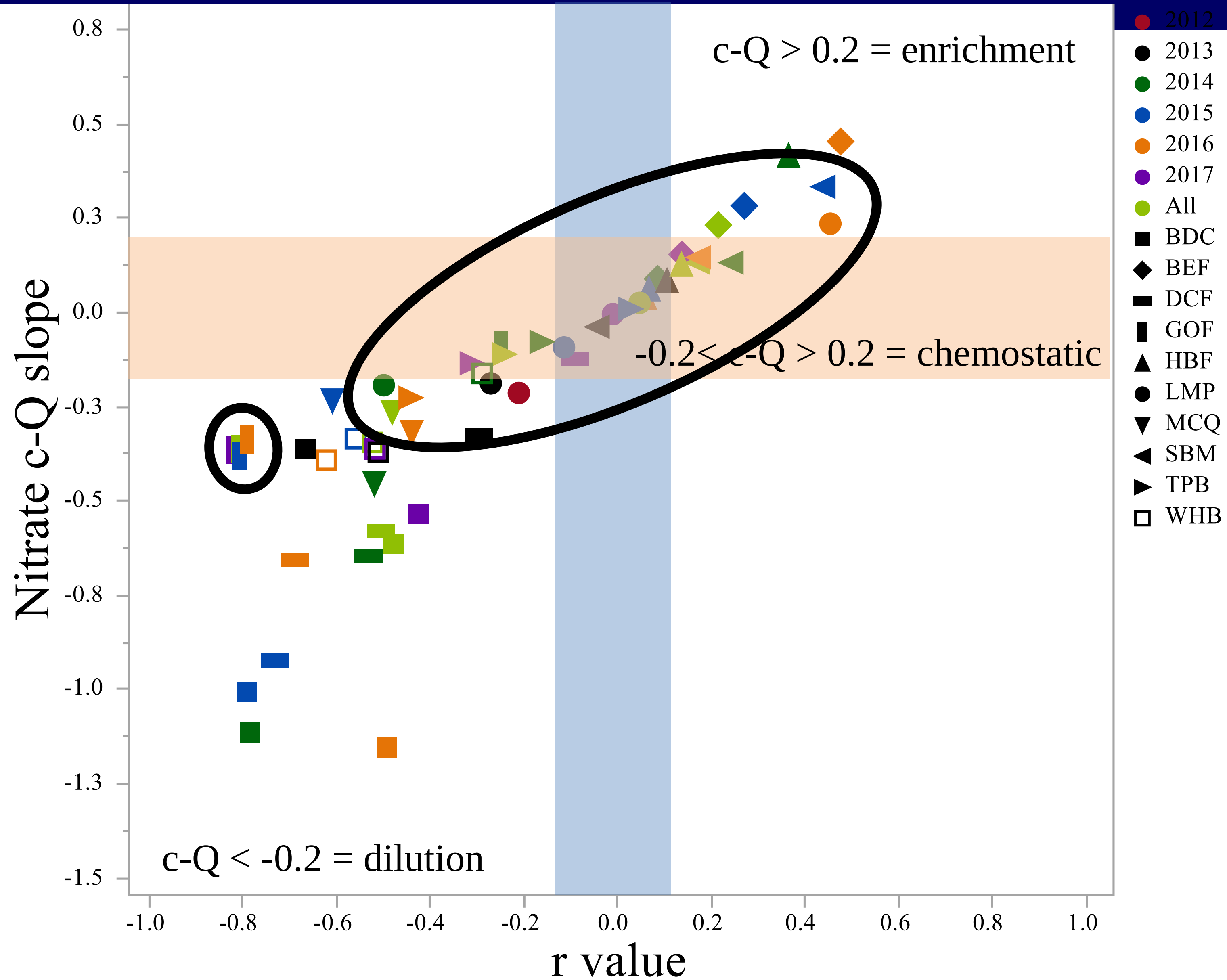
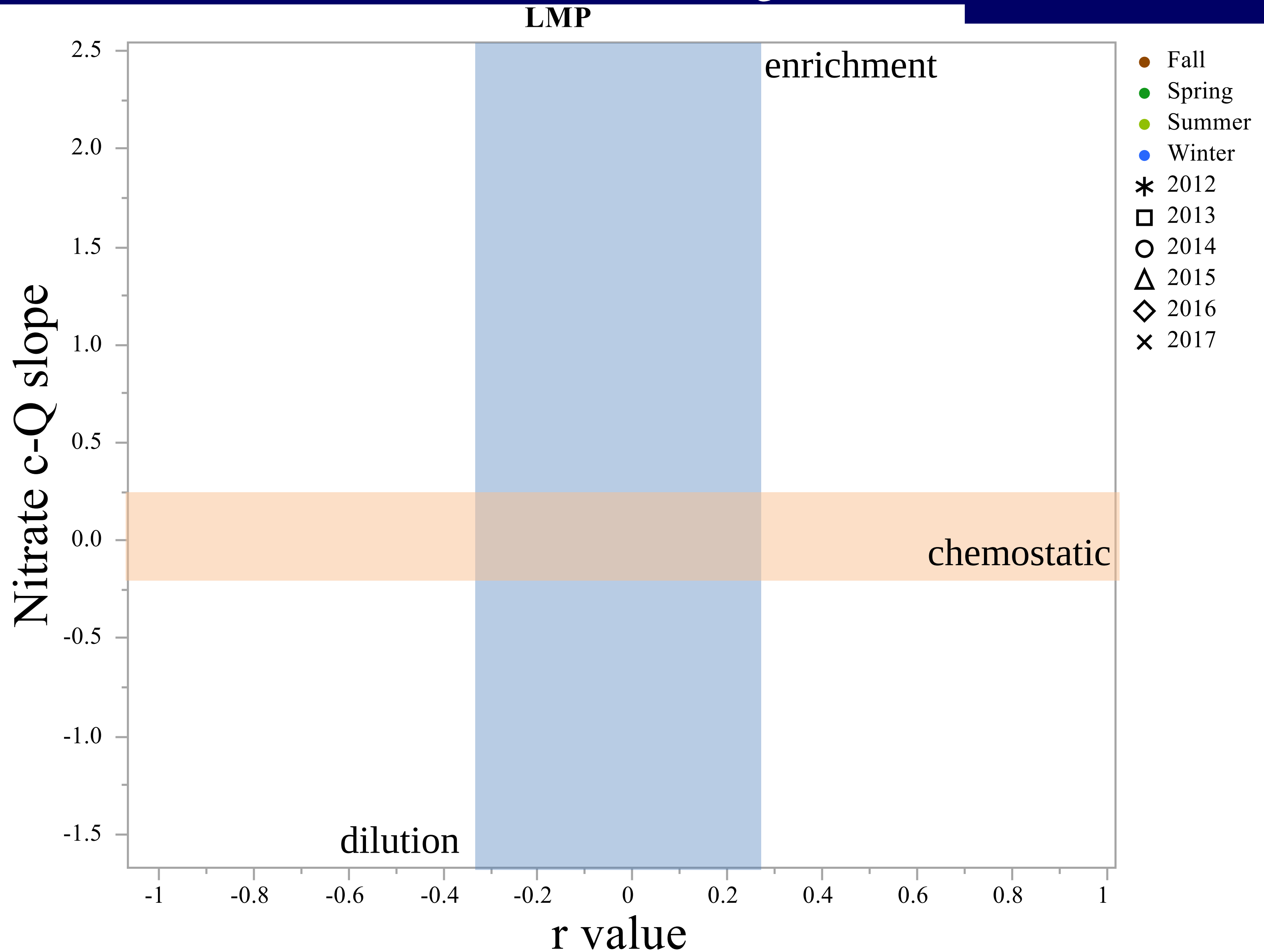
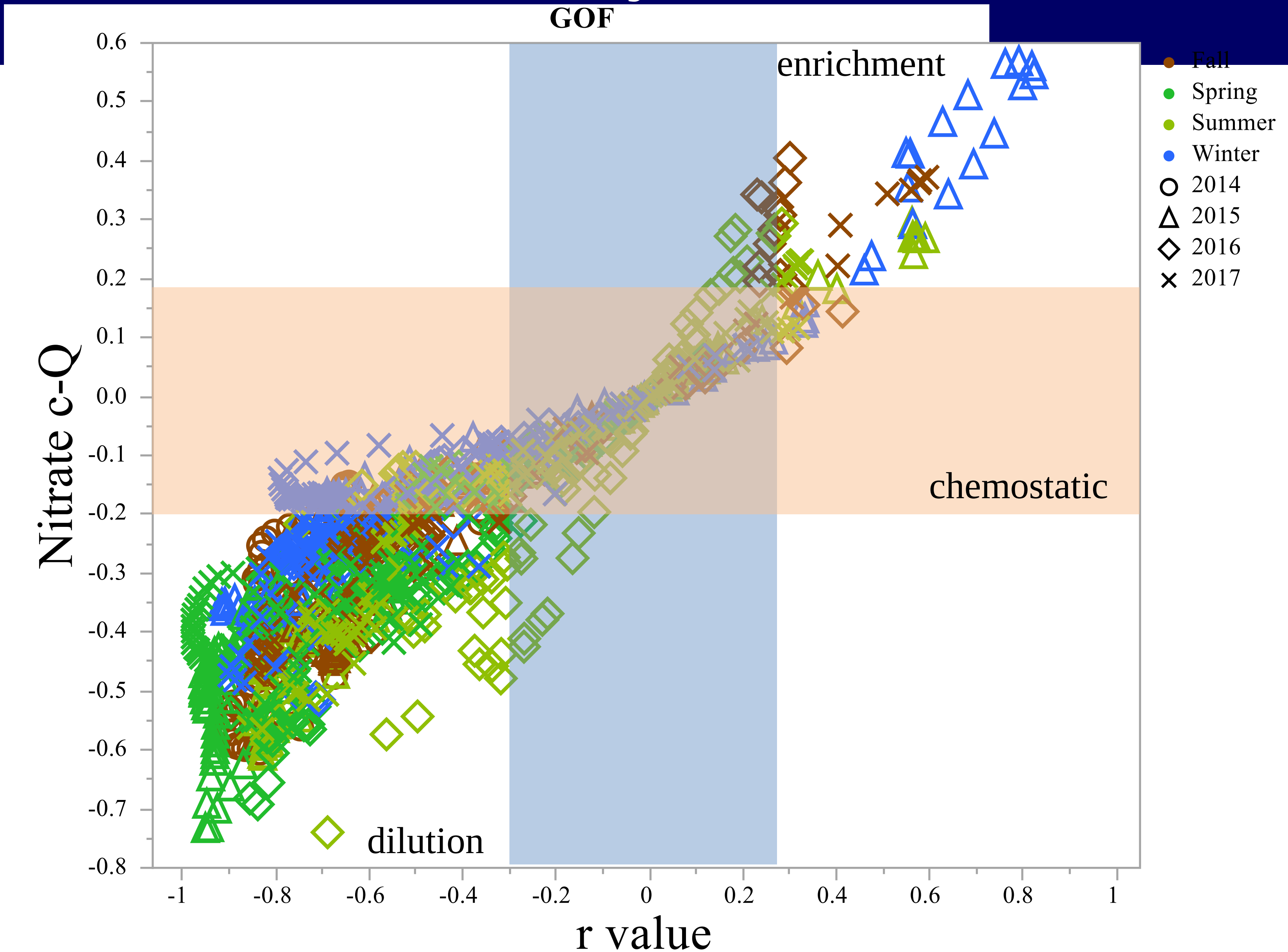


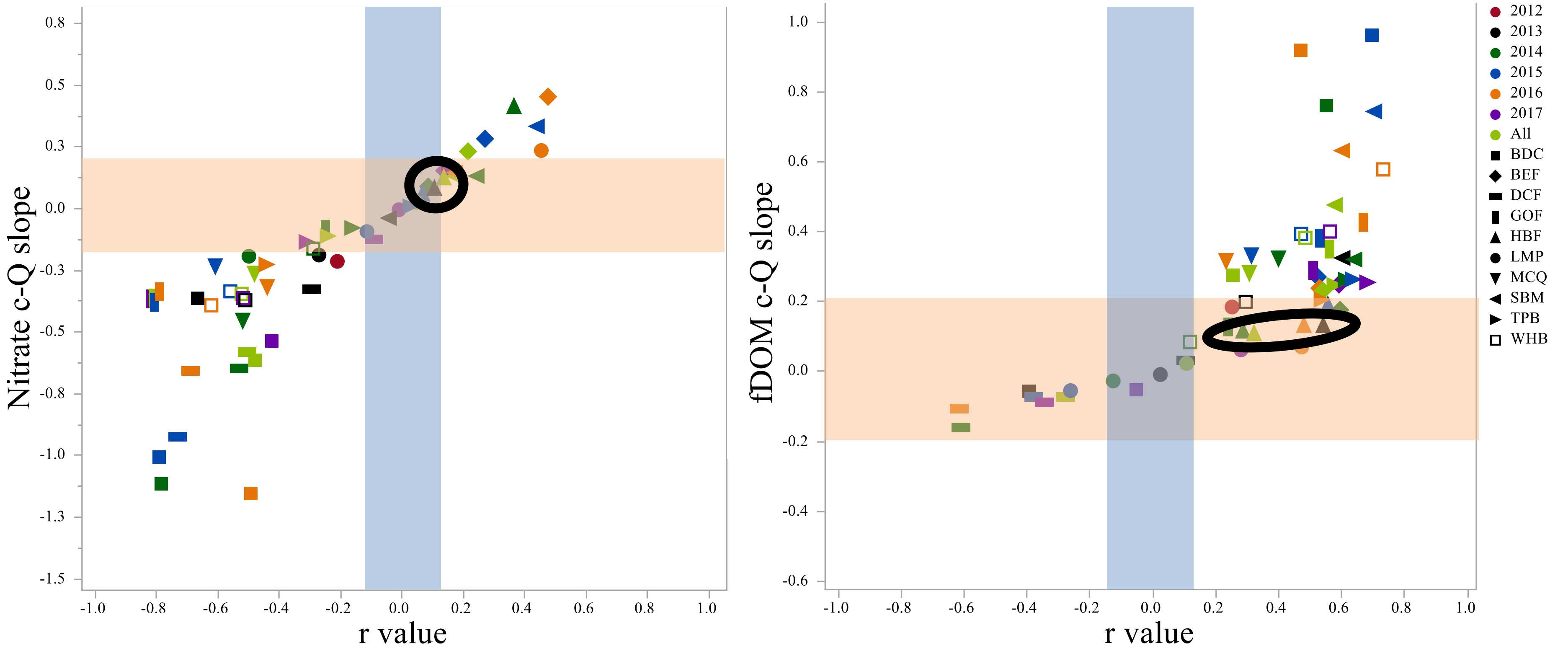
Lamprey River intra-annual variability mirrors inter-annual c-Q



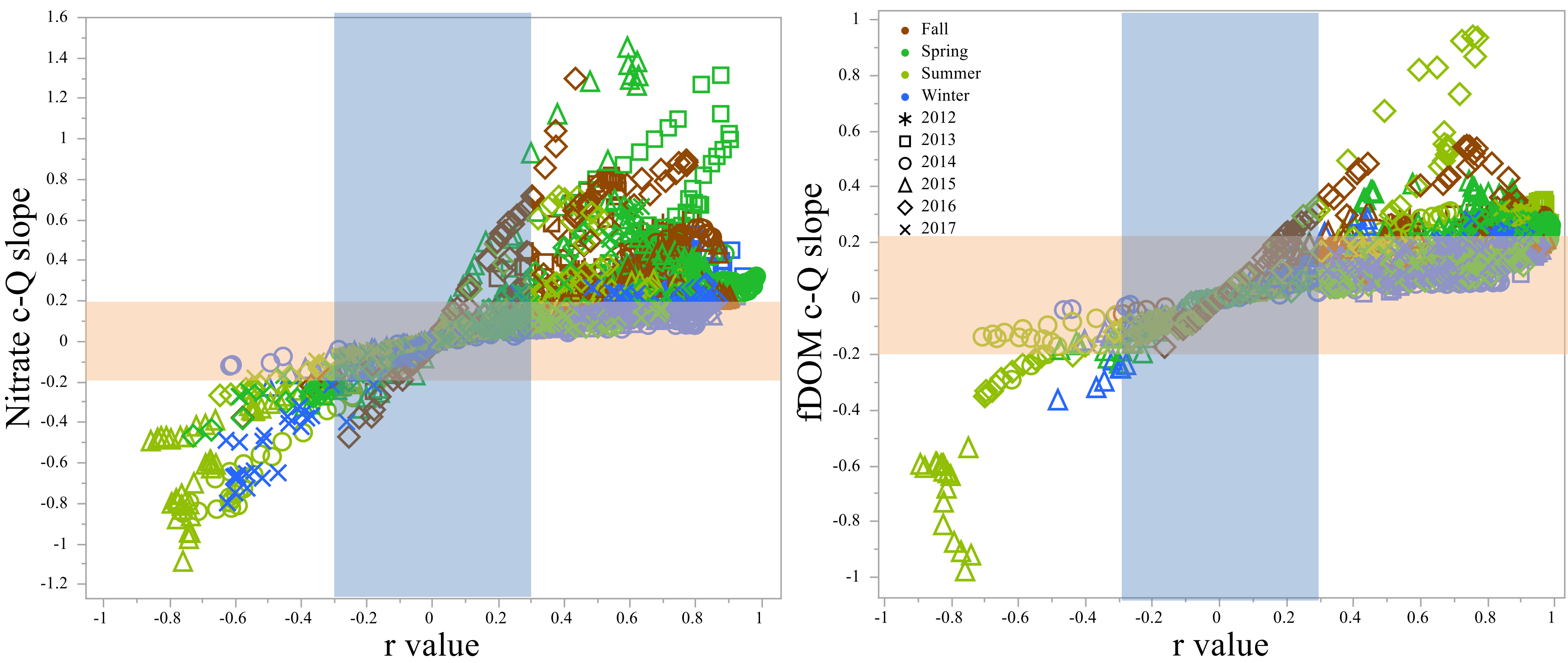
GOF is not always source-limited



c-Q behavior is constituent specific – C and N are decoupled



HBF is not chemostatic most of the year

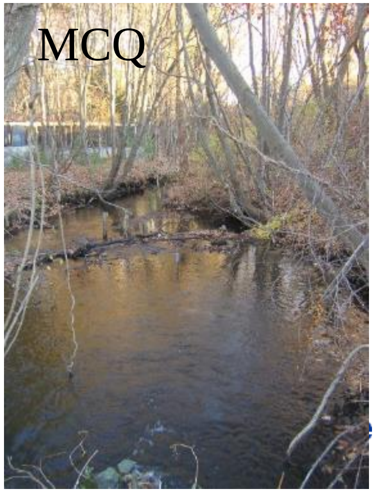


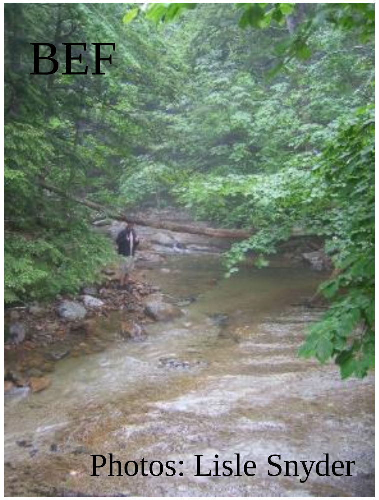
Summary

1. Estimates of nitrate yield varied across sites and seasons
    1. Highest yield at larger streams sites and more impacted stream sites
    2. Lowest yield in summer except for at agricultural site

2. Methods for estimating constituent loads often overestimate or underestimate true nutrient loads
    1. sampling resolution and timing matters

3. Solute-discharge relationships are variable within and among streams
    1. Event-induced shifts in c-Q from typical behavior – climate variability





Photos: Lisle Snyder

Acknowledgements:
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