Hydrologic connectivity, climate change, and nutrient delivery to receiving waters

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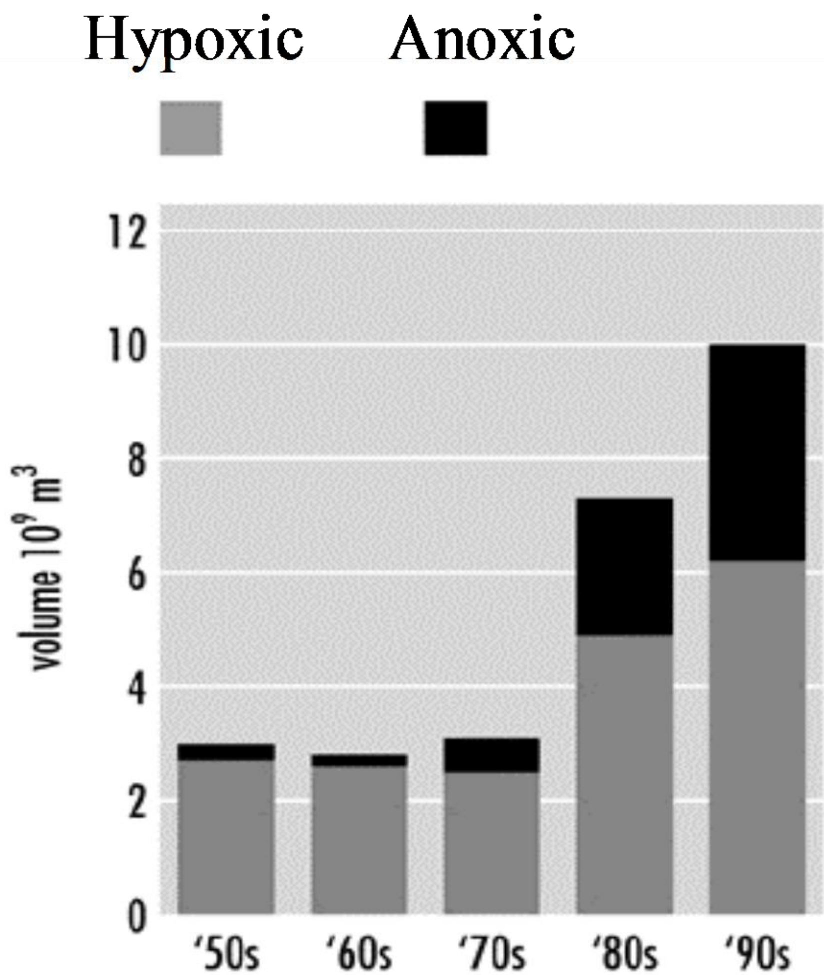
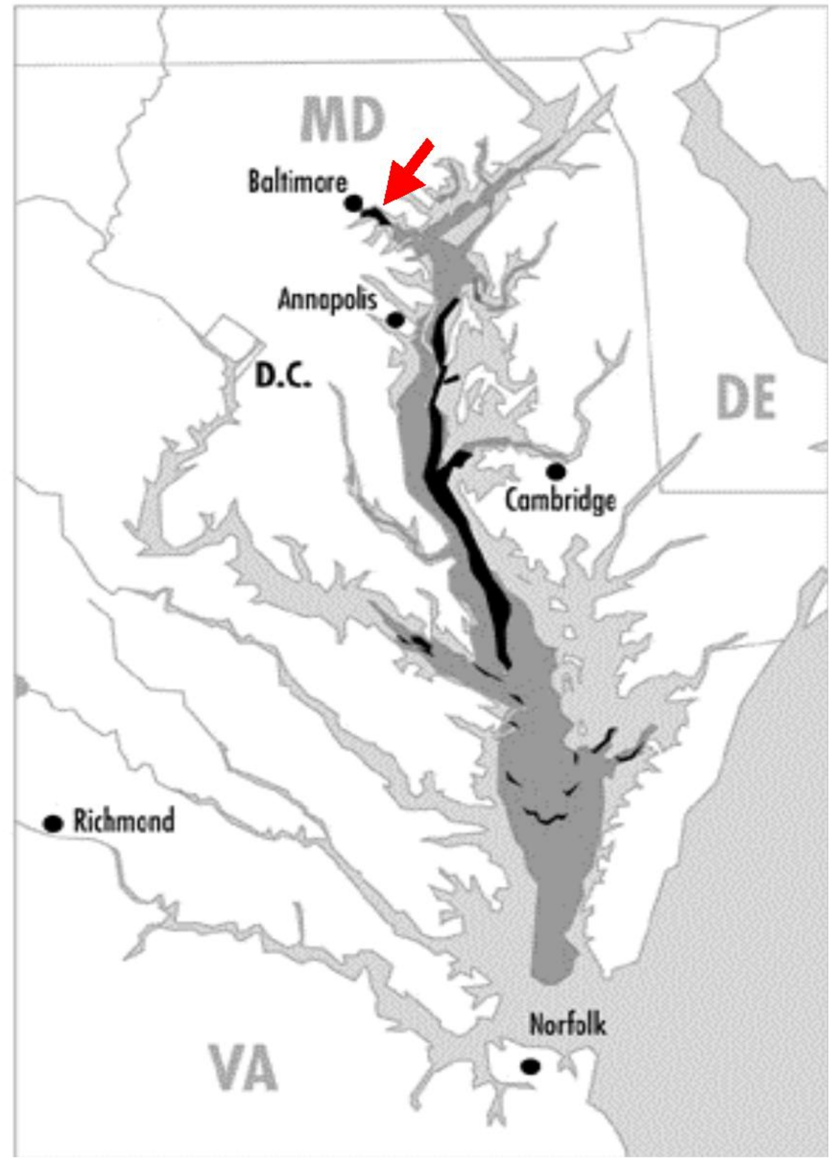
Rationale

- Nitrogen transport from river basins has doubled globally
- Increasing land use change and climate variability
- Contamination of drinking water supplies
- Currently 150 dead zones along coasts and the number is growing



Typical dead zone in summer, '90s



Outline

I. Urbanization alters hydrologic “connectivity”

II. Urbanization and climate variability amplify nitrogen loads

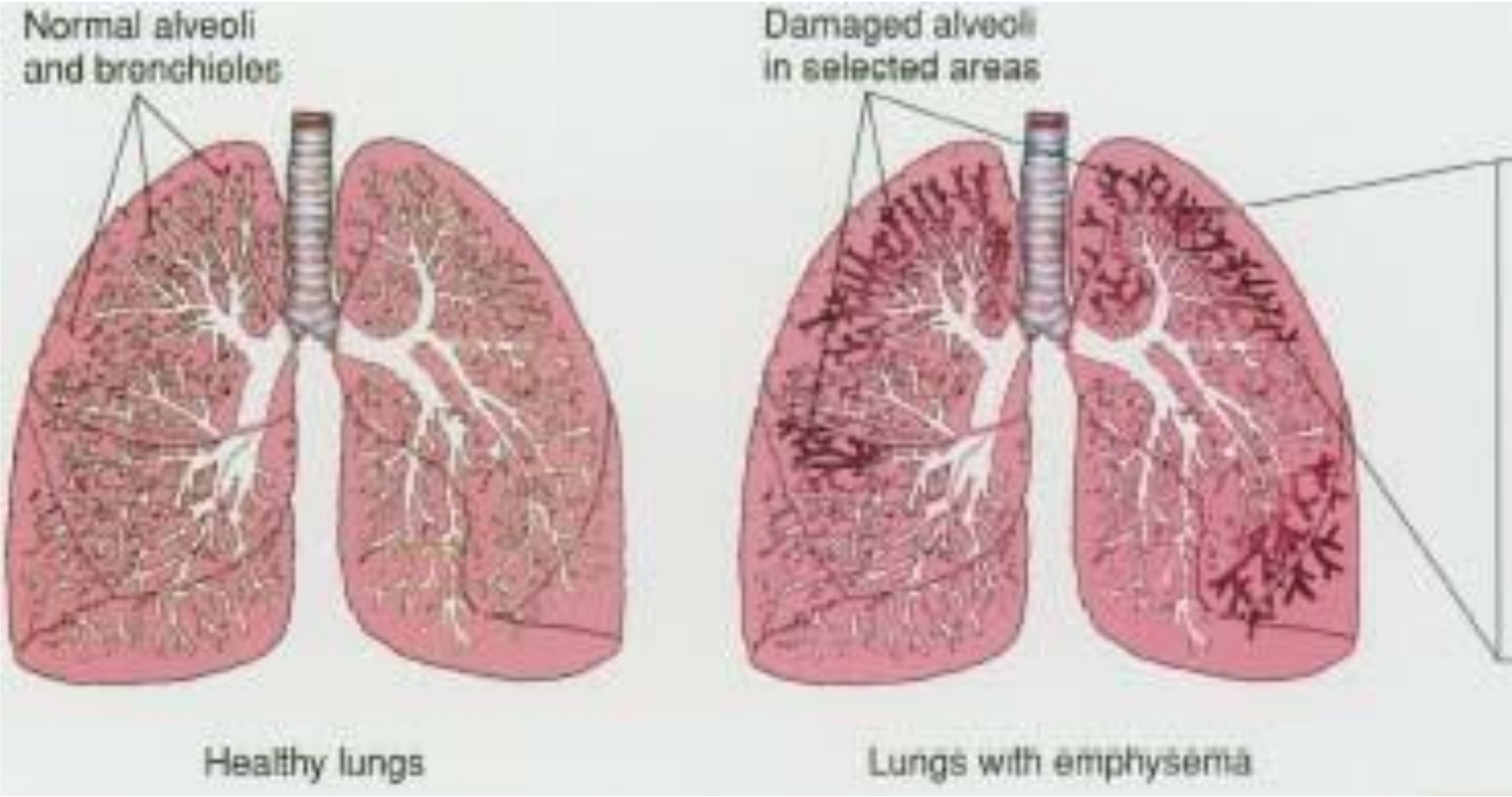
III. Can we engineer "connectivity" with biogeochemical “hot spots” to reduce future nitrogen loads?

I. Urbanization alters hydrologic "connectivity"

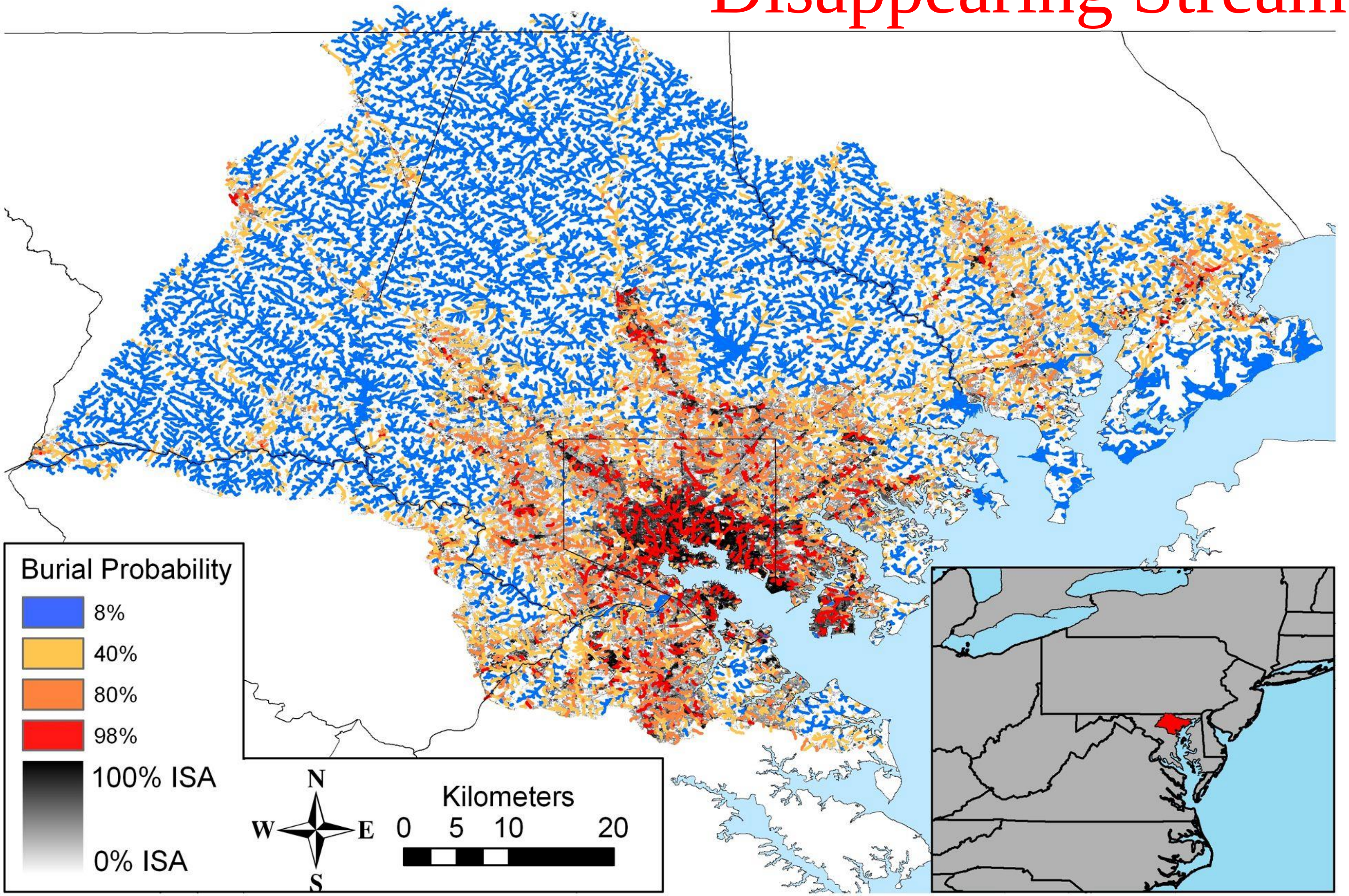




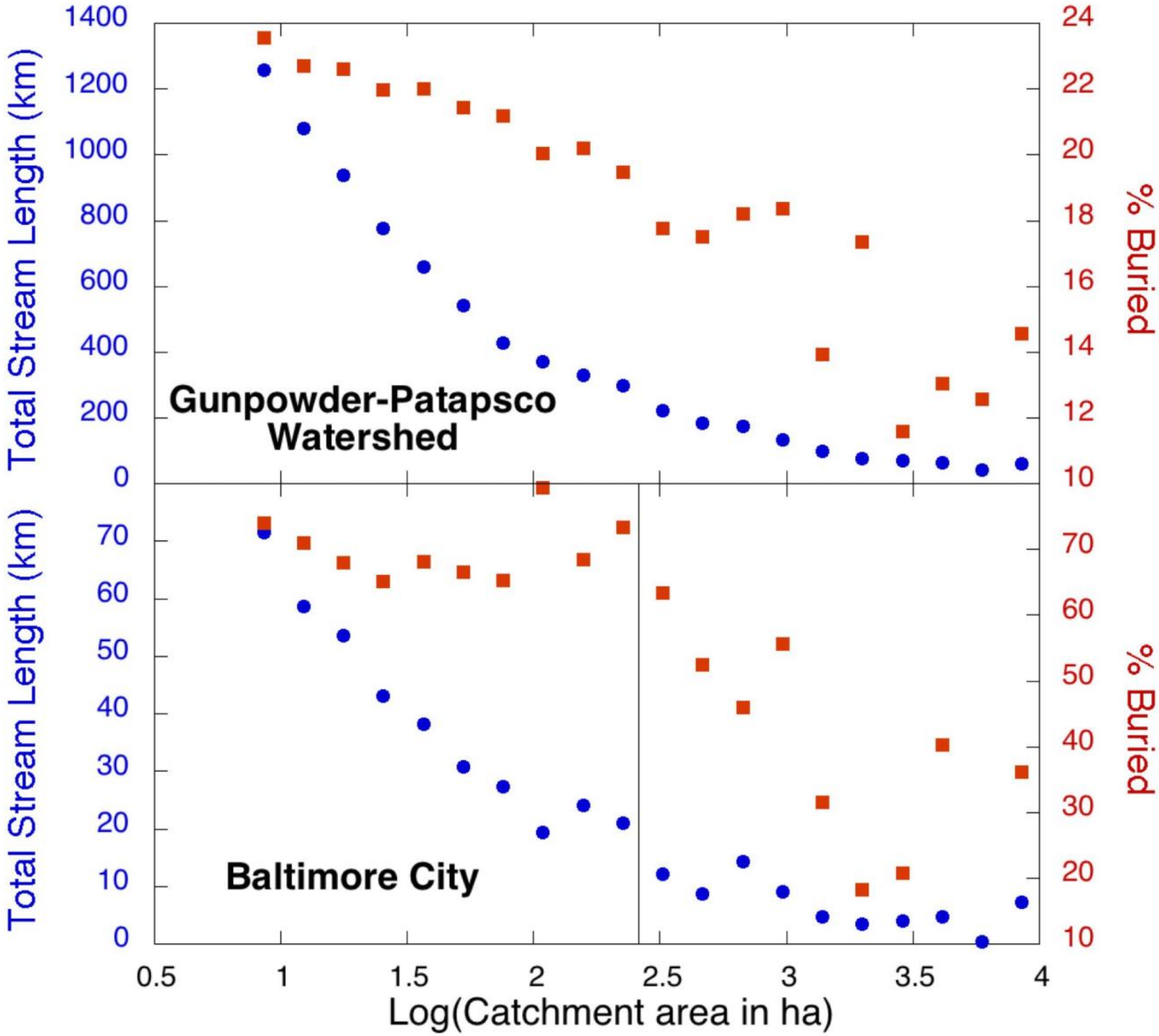
Emphysema


Normal alveoli
and bronchioles
Damaged alveoli
in selected areas
Healthy lungs
Lungs with emphysema

Disappearing Streams?



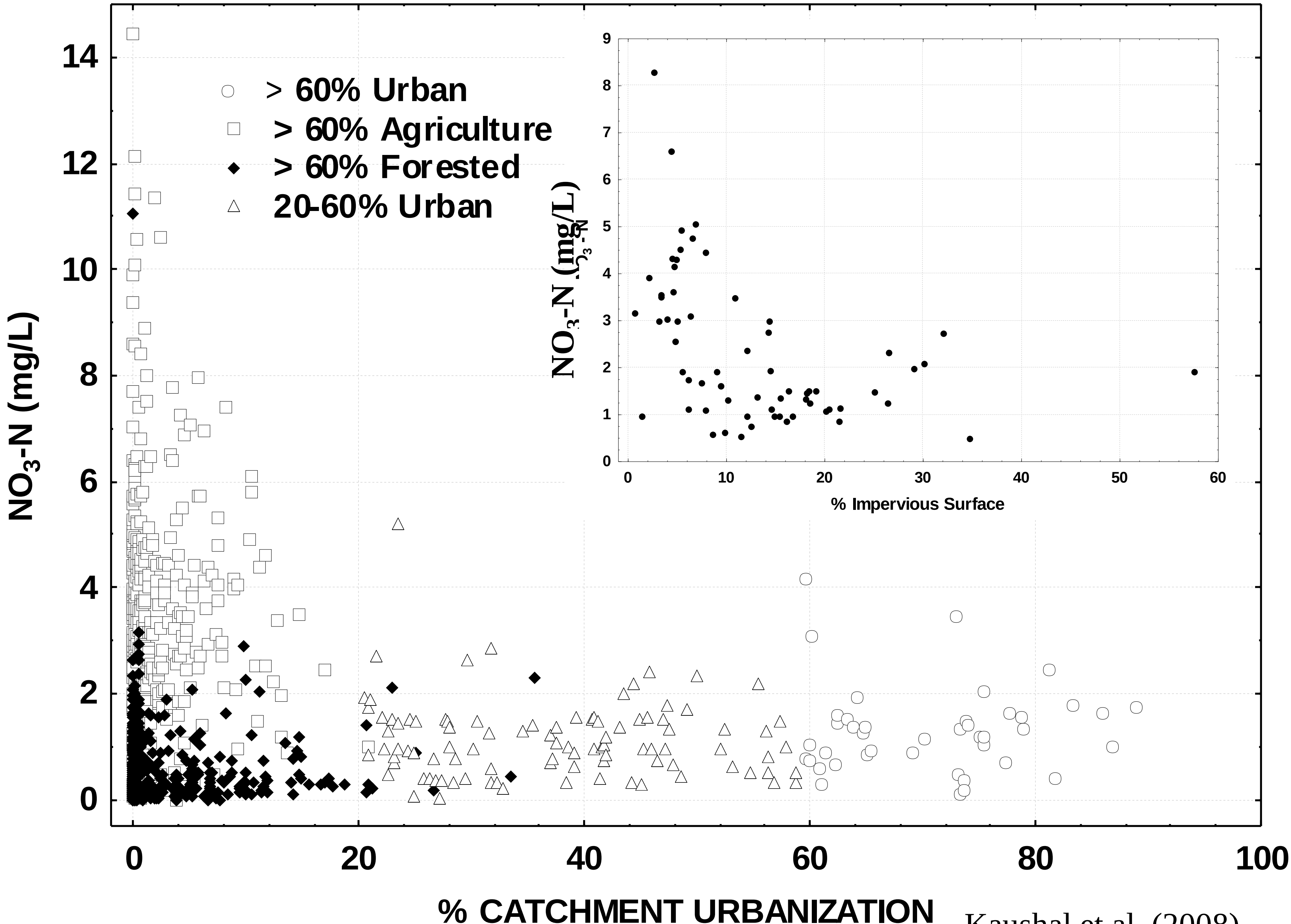
Elmore and Kaushal (2008)



Elmore and Kaushal (2008)


How will a highly “connected” landscape
respond to climate variability?

II. Urbanization and climate variability amplify nitrogen loads

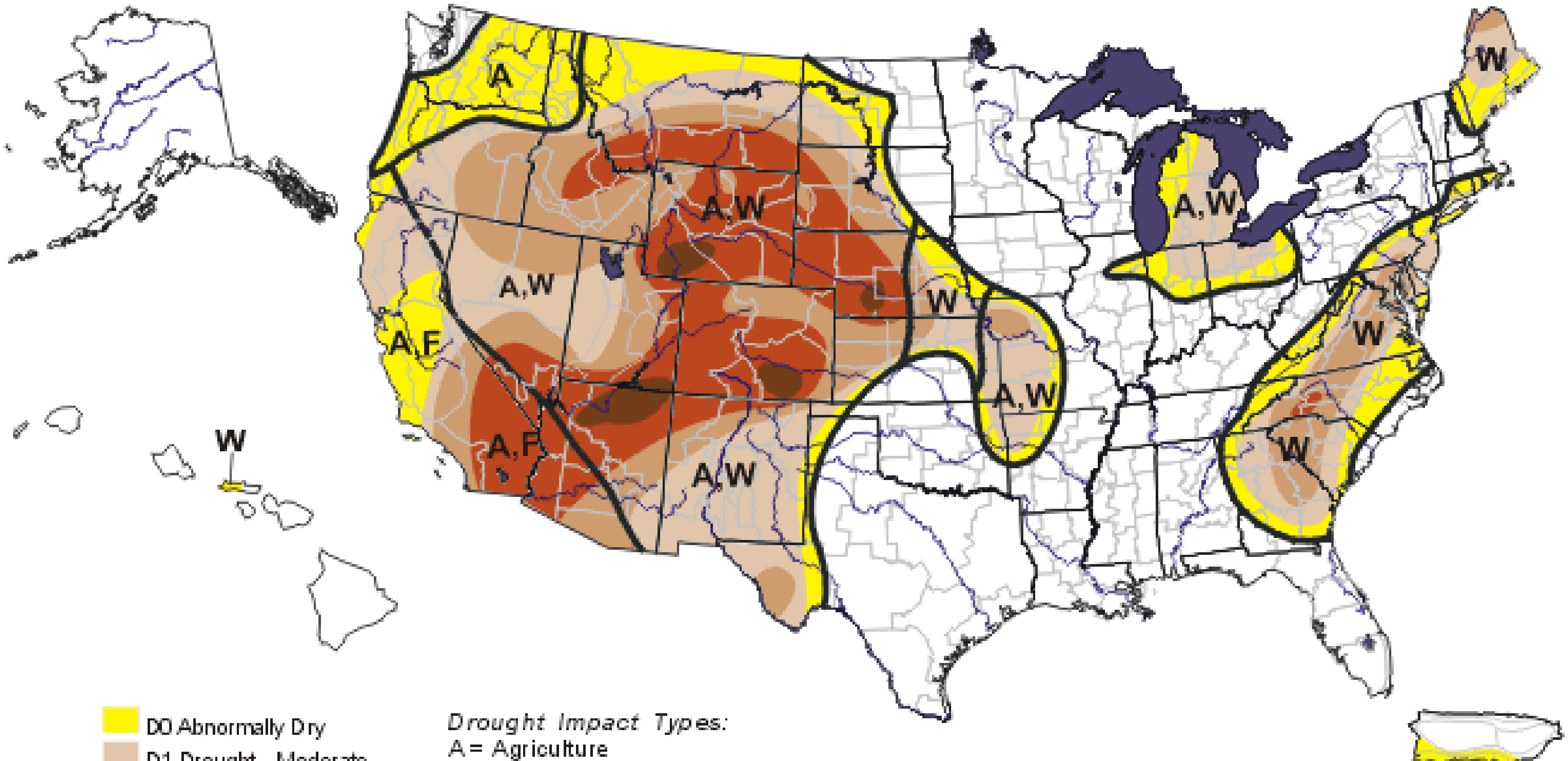


Kaushal et al. (2008)

U.S. Drought Monitor

October 29, 2002

Valid 7 a.m. EST



- D0 Abnormally Dry
- D1 Drought—Moderate
- D2 Drought—Severe
- D3 Drought—Extreme
- D4 Drought—Exceptional

Drought Impact Types:

A = Agriculture

W = Water (Hydrological)

F = Fire danger (Wildfires)

Delineates dominant impacts

(No type = All 3 impacts)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://drought.unl.edu/dm

USDA

National Drought Mitigation Center

NOAA

Released Thursday, October 31, 2002

Author: *Brad Rippey, USDA*

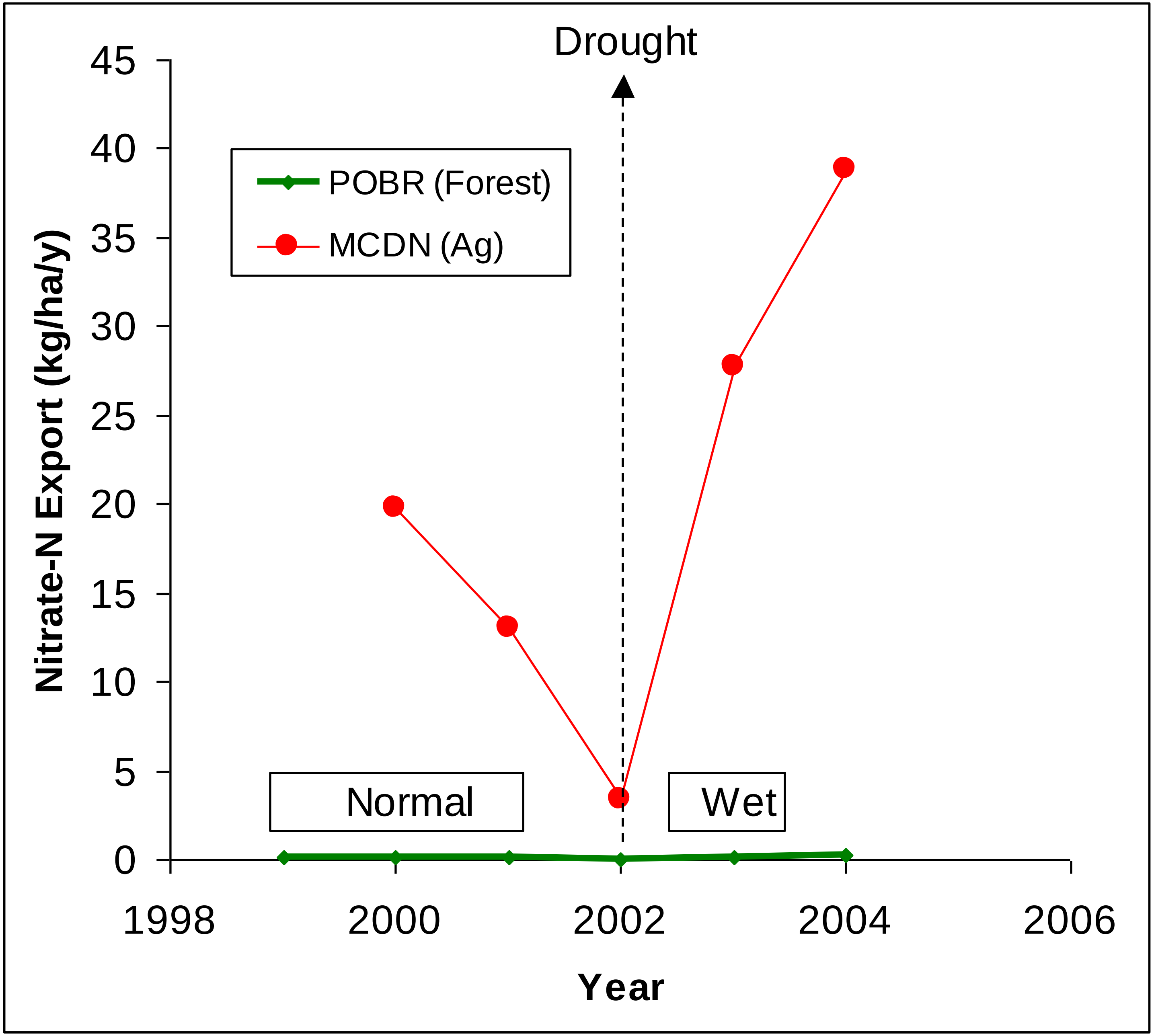
2003 Wet Year

2003

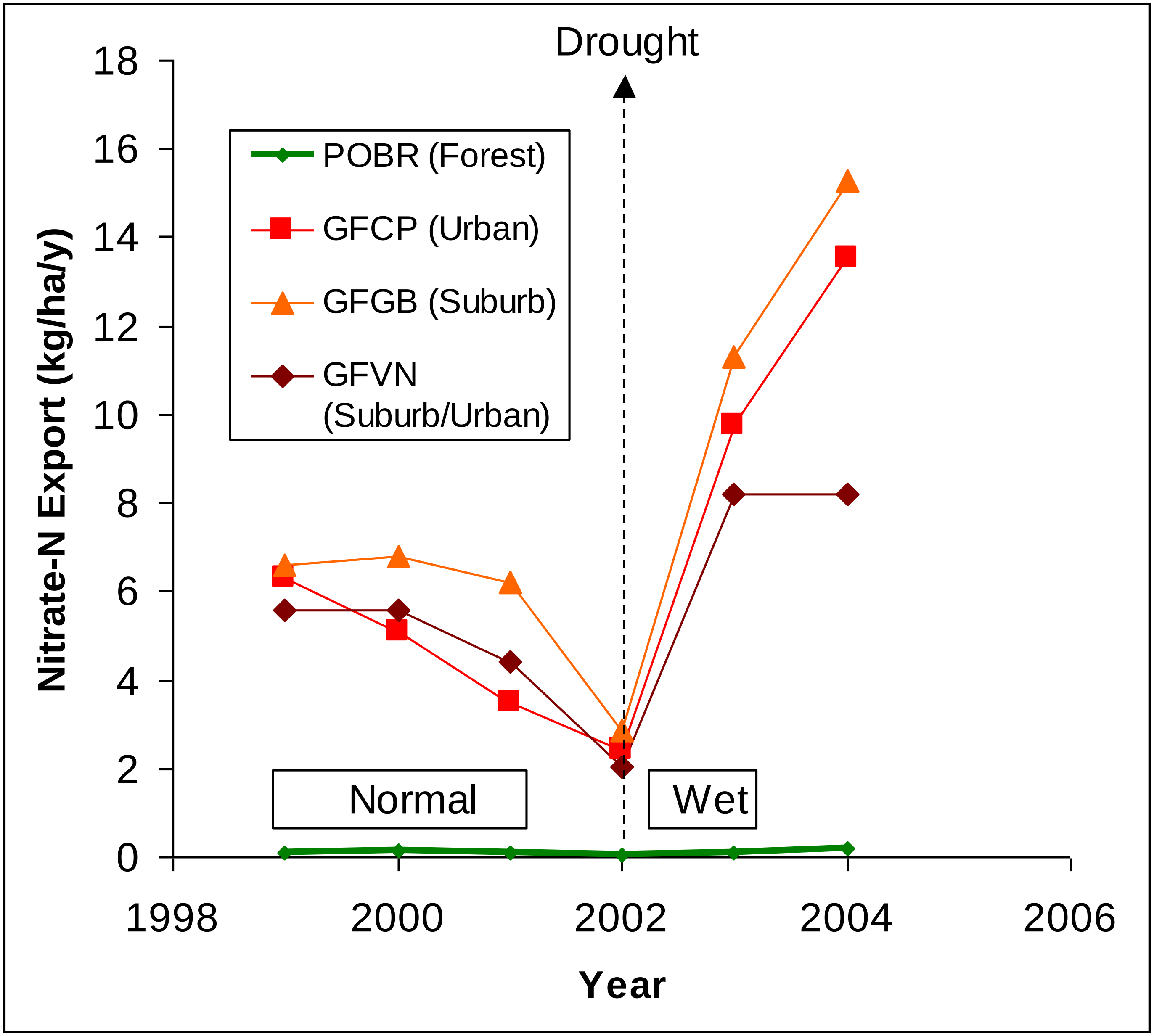

Germantown, MD


Seneca Creek, Baltimore County

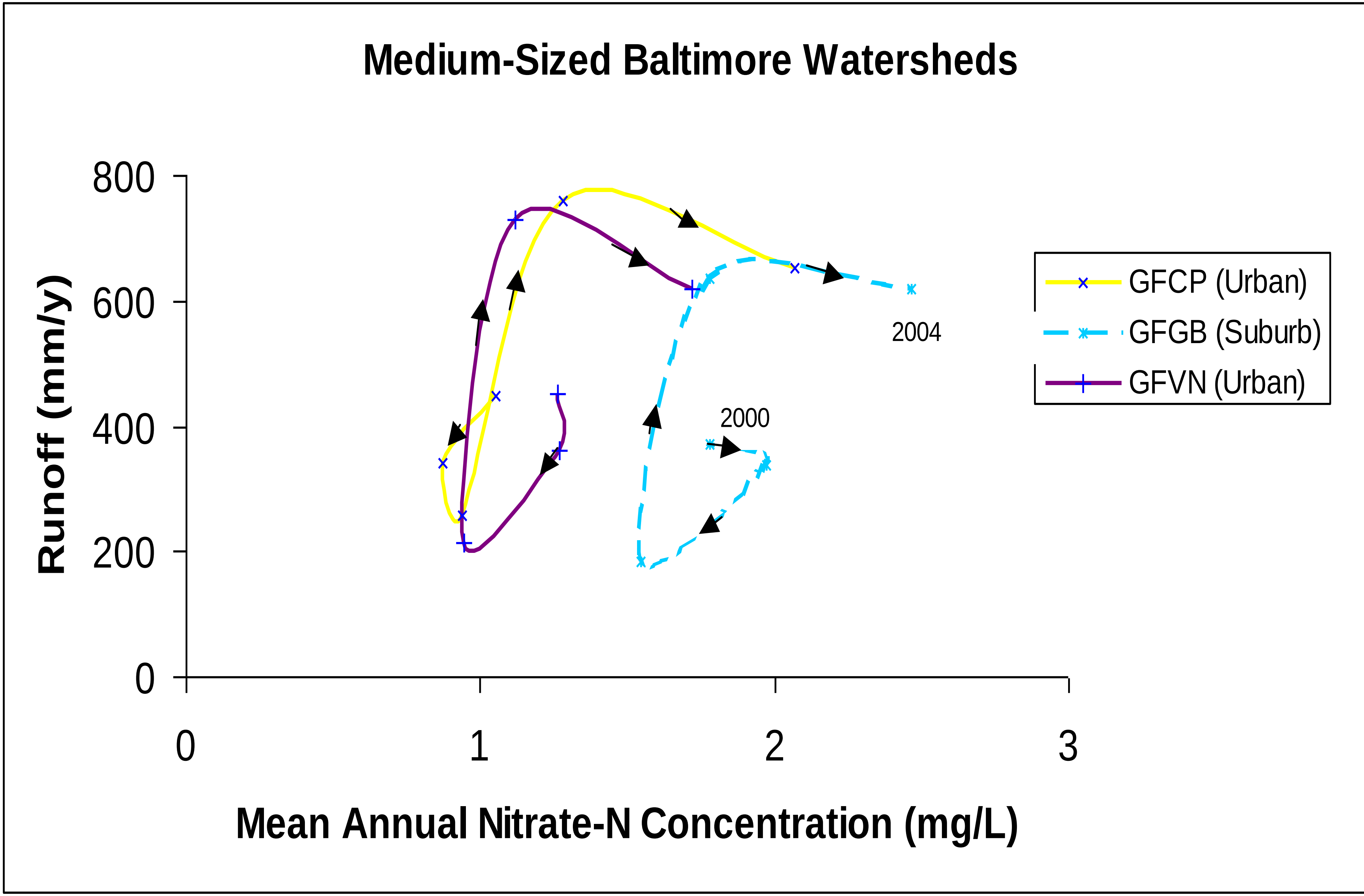
Baltimore City



Kaushal et al. (2008)

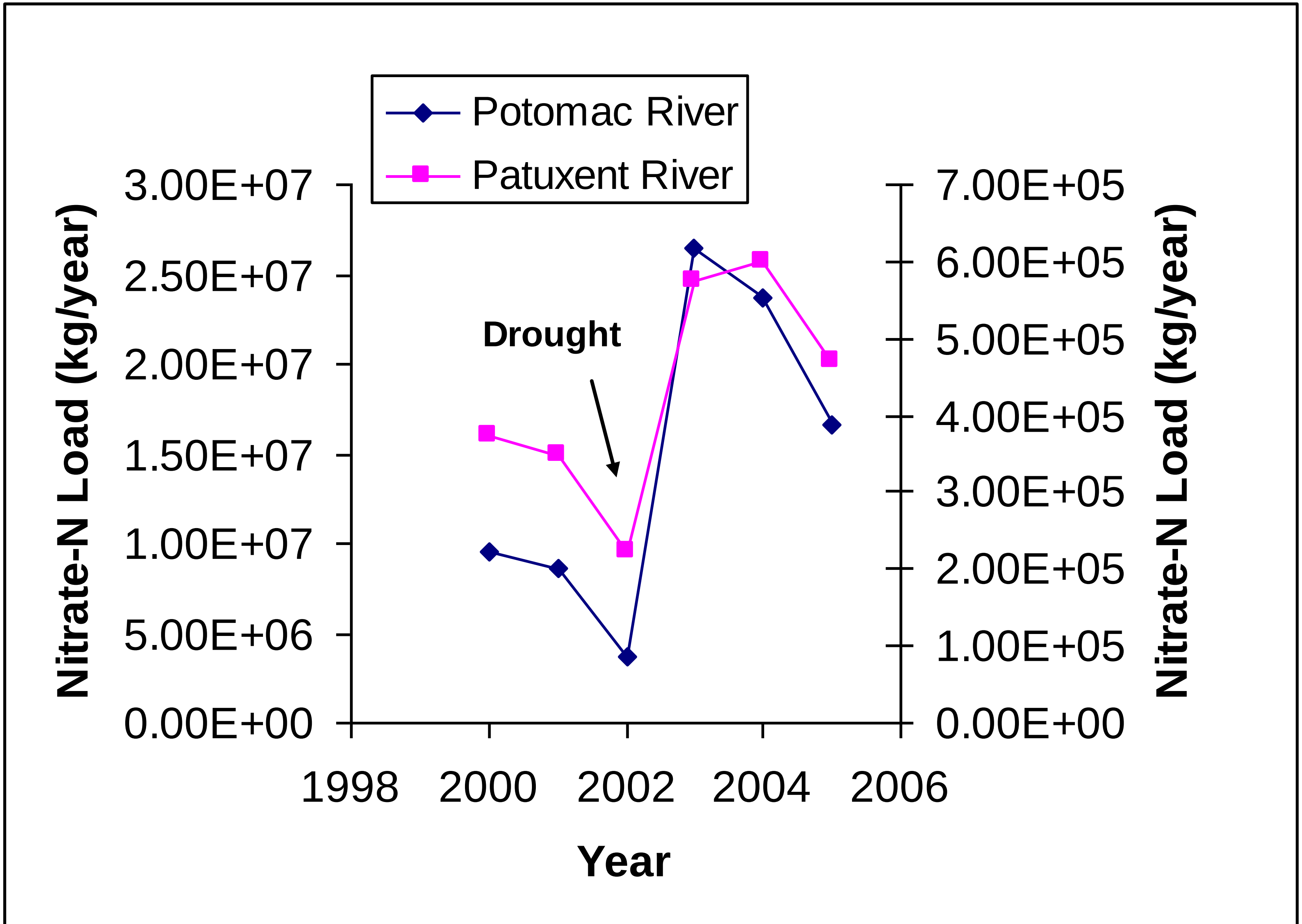


Kaushal et al. (2008)

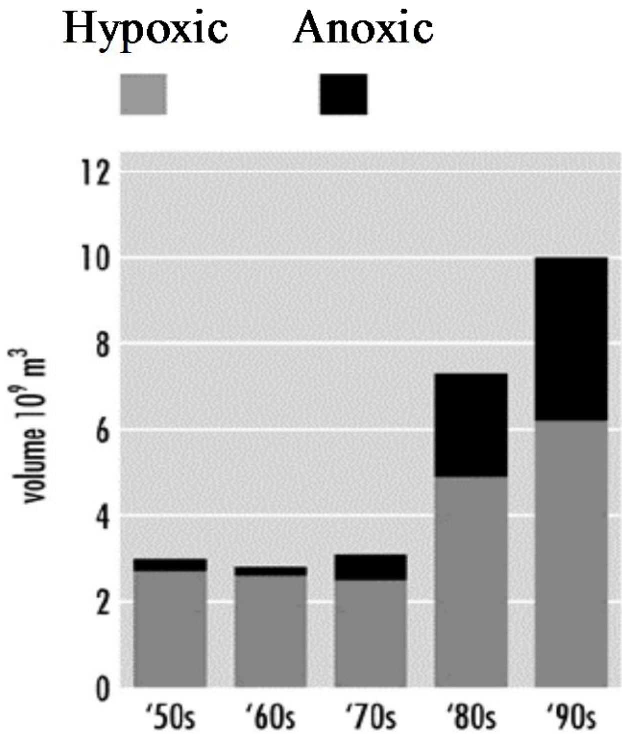


Kaushal et al. (2008)

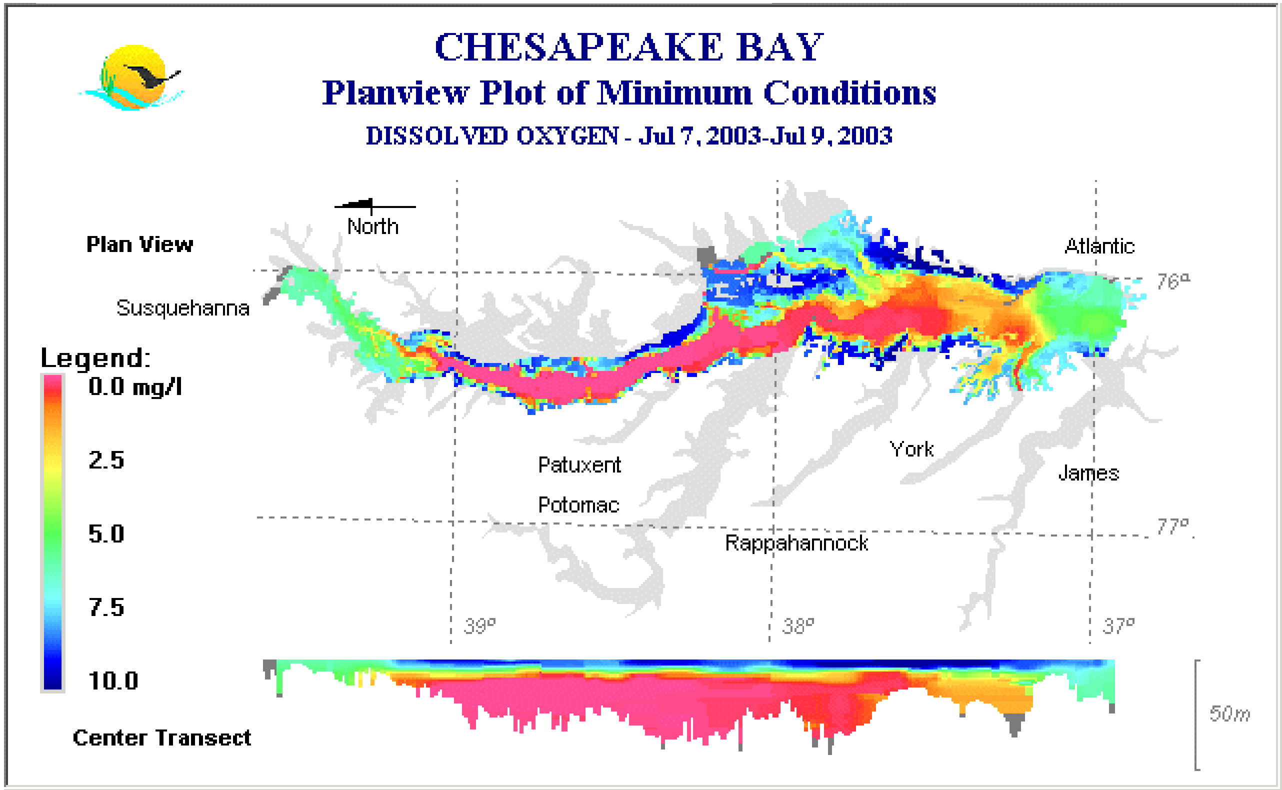
Large Rivers of the Chesapeake Bay



Kaushal et al. (2008) from USGS RIM



- **Human land use amplifies effects of climate**
- **Developed land less resilient to climate**
- **Record coastal hypoxia**



III. Can we engineer "connectivity" with biogeochemical “hot spots” to reduce future nitrogen loads?

Stream restoration

Riparian “reconnection”

?

Increased denitrification and improved water quality

Urban Stream Degradation

Engineering Riparian "Connectivity"

Hypotheses

- Stream restoration increases rates of hyporheic denitrification

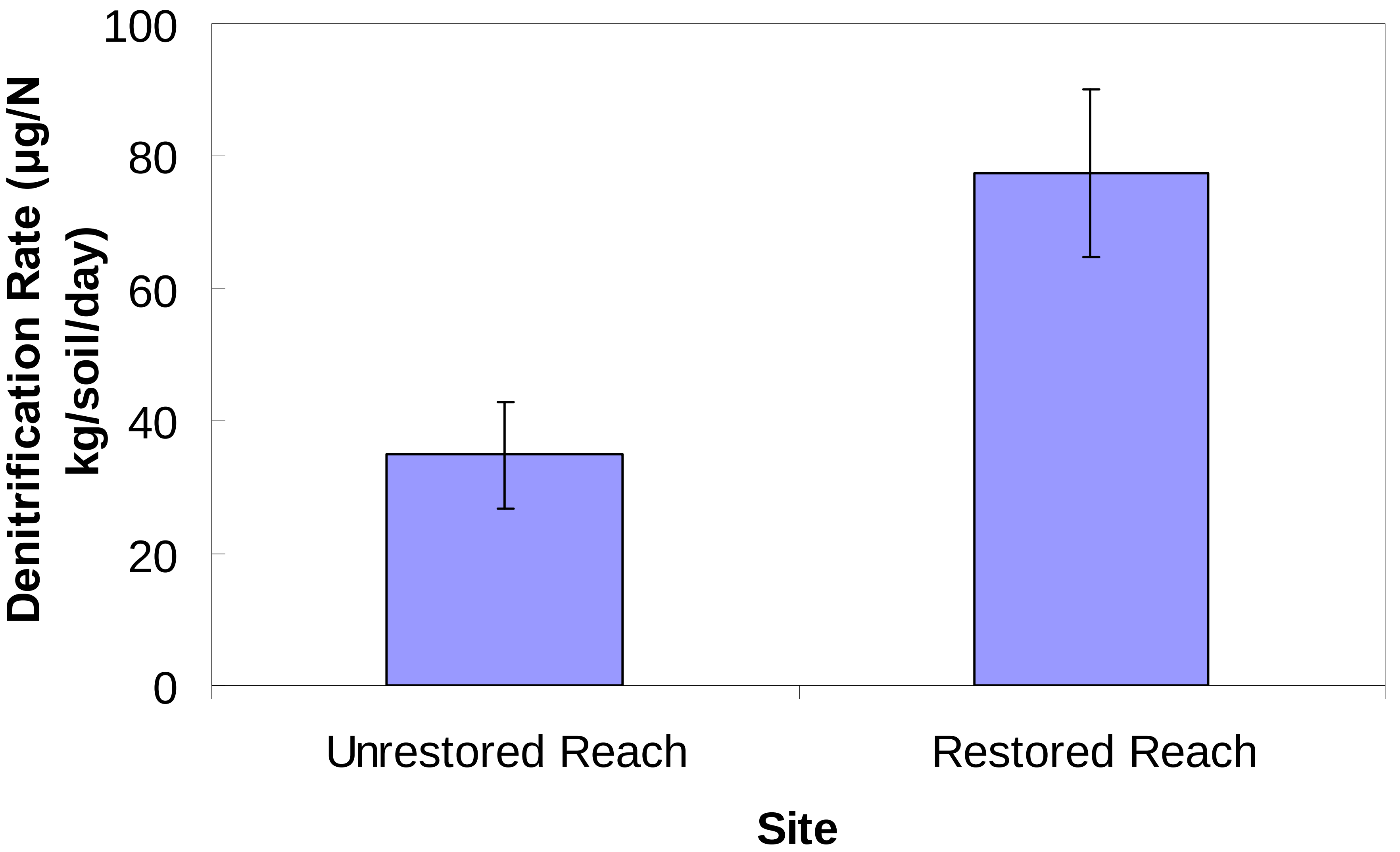
- Denitrification is stimulated by *riparian* hydrologic “connectivity”


High Bank
(Unrestored)

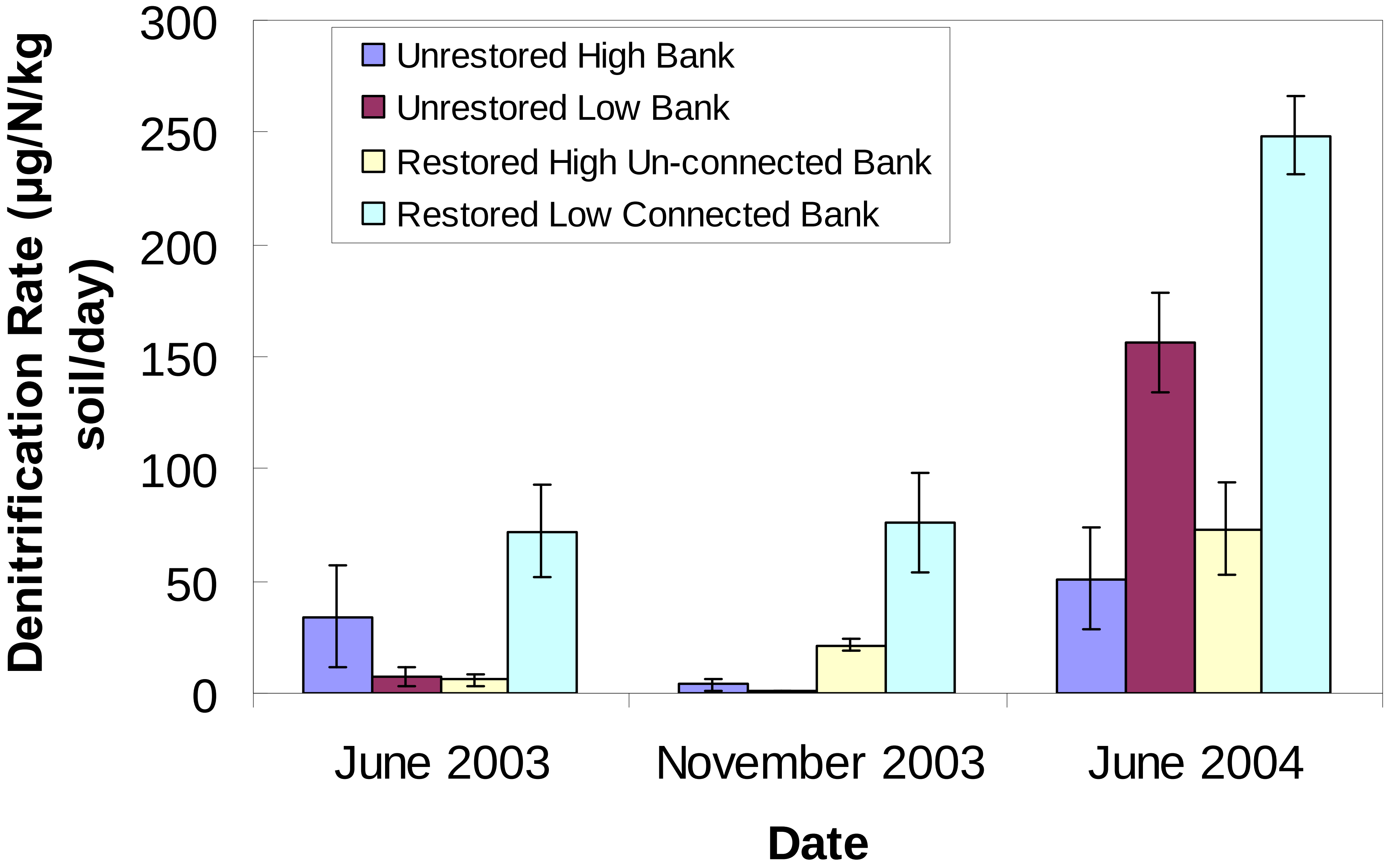

Low Bank
(Unrestored)


High non-connected bank
(Restored)


Low “Connected” Bank
(Restored)

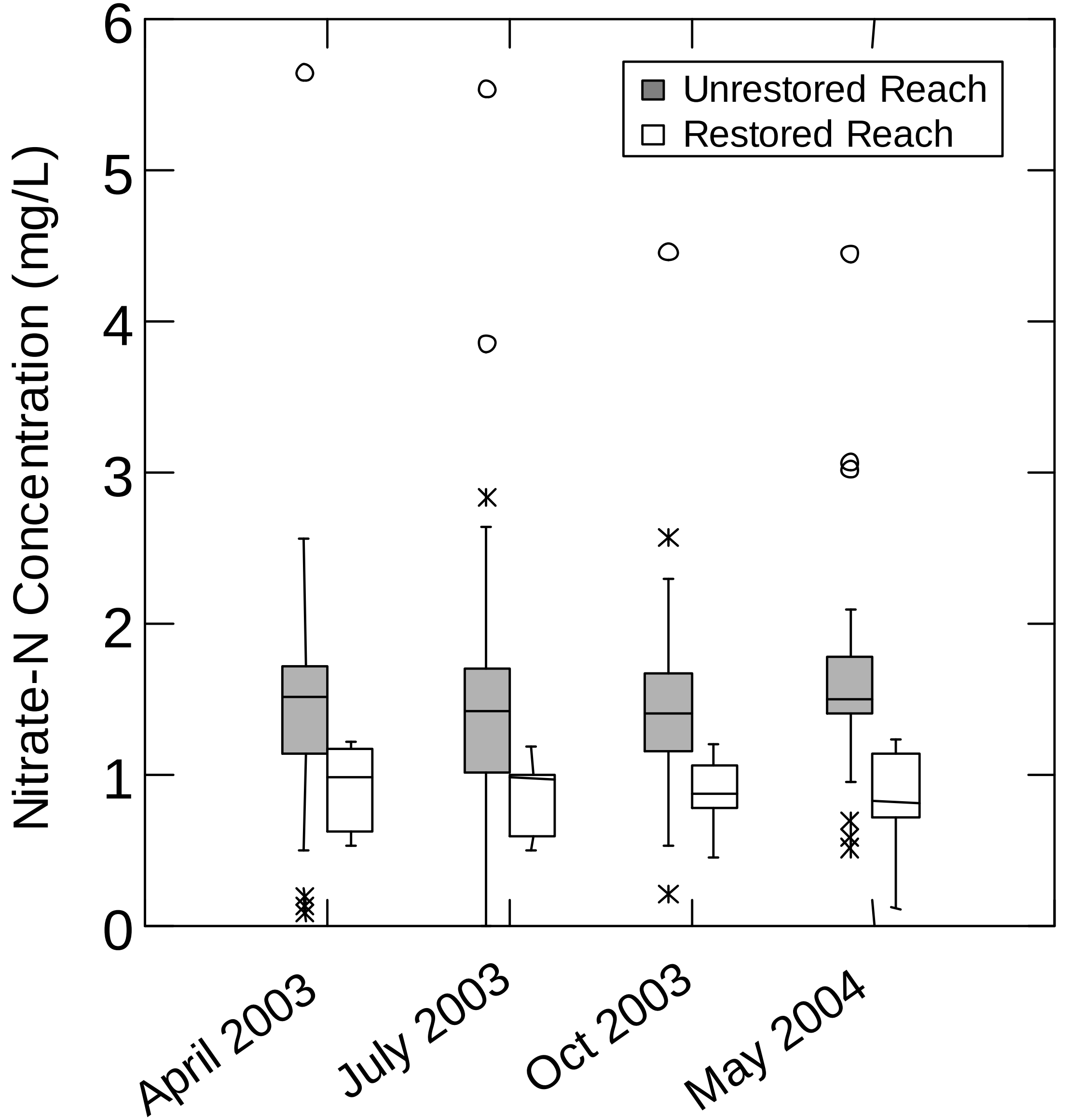


Kaushal et al. (2008)



Kaushal et al. (2008)

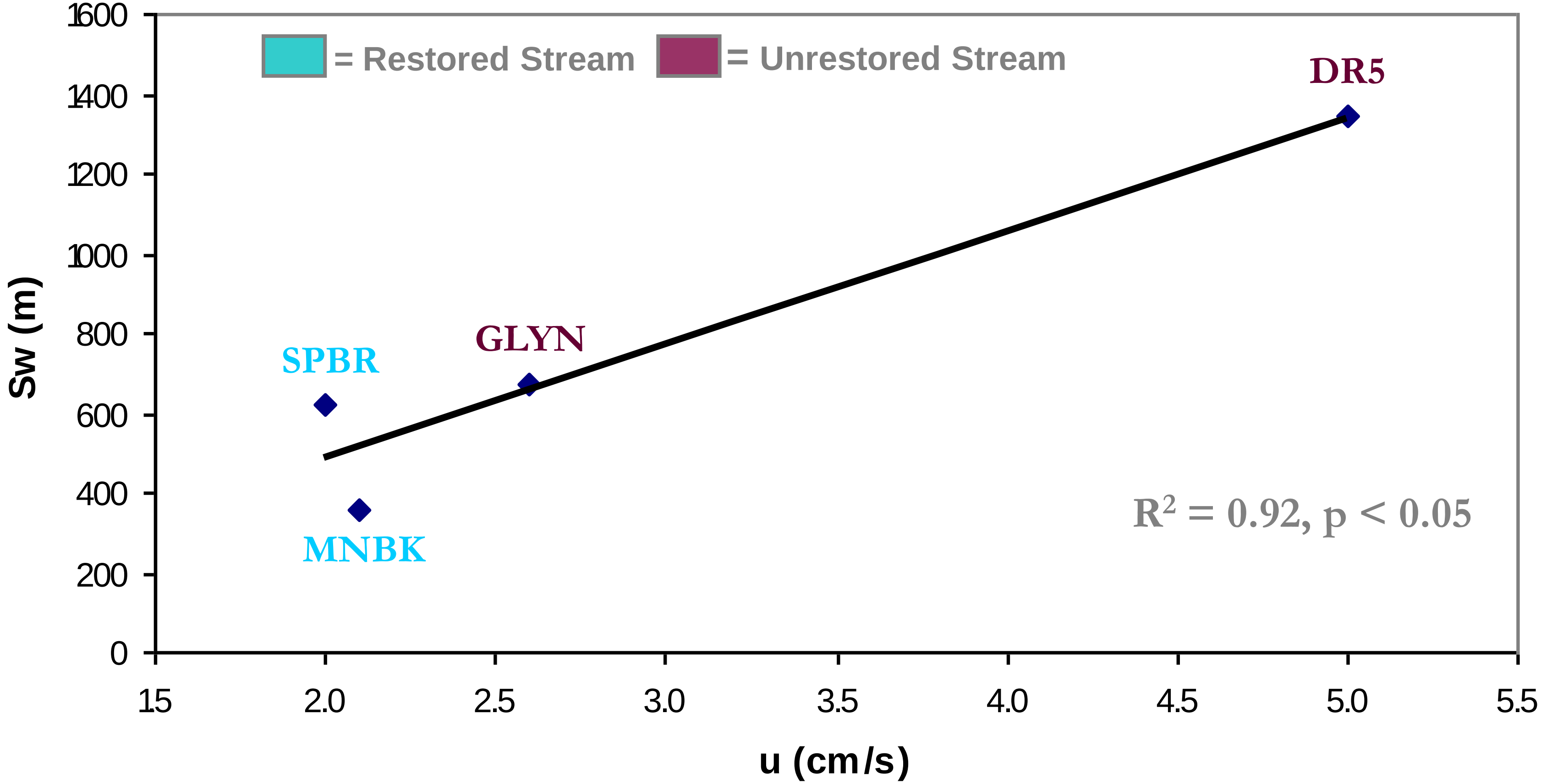
Groundwater Nitrate Concentrations



Kaushal et al. (2008)

Nitrogen removal in “engineered” streams?

Surface Water Velocity (u) and NO_3^- Uptake Length (S_w)



Klocker et al. (In Press)

NO_3^- flux =

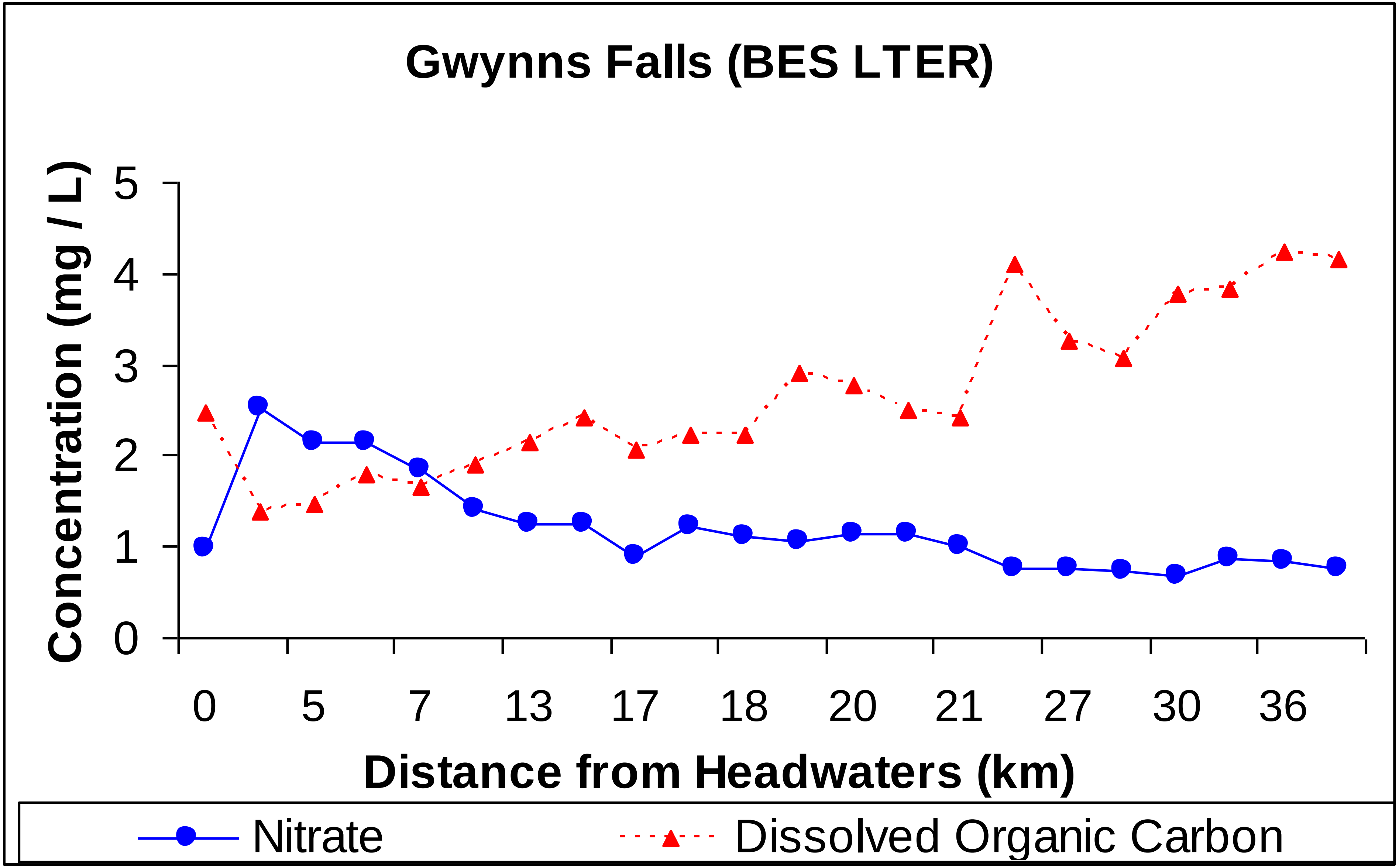
182,000 mg-N d^{-1}

~ 40%

of the daily load was removed by denitrification over a 220.5 m reach

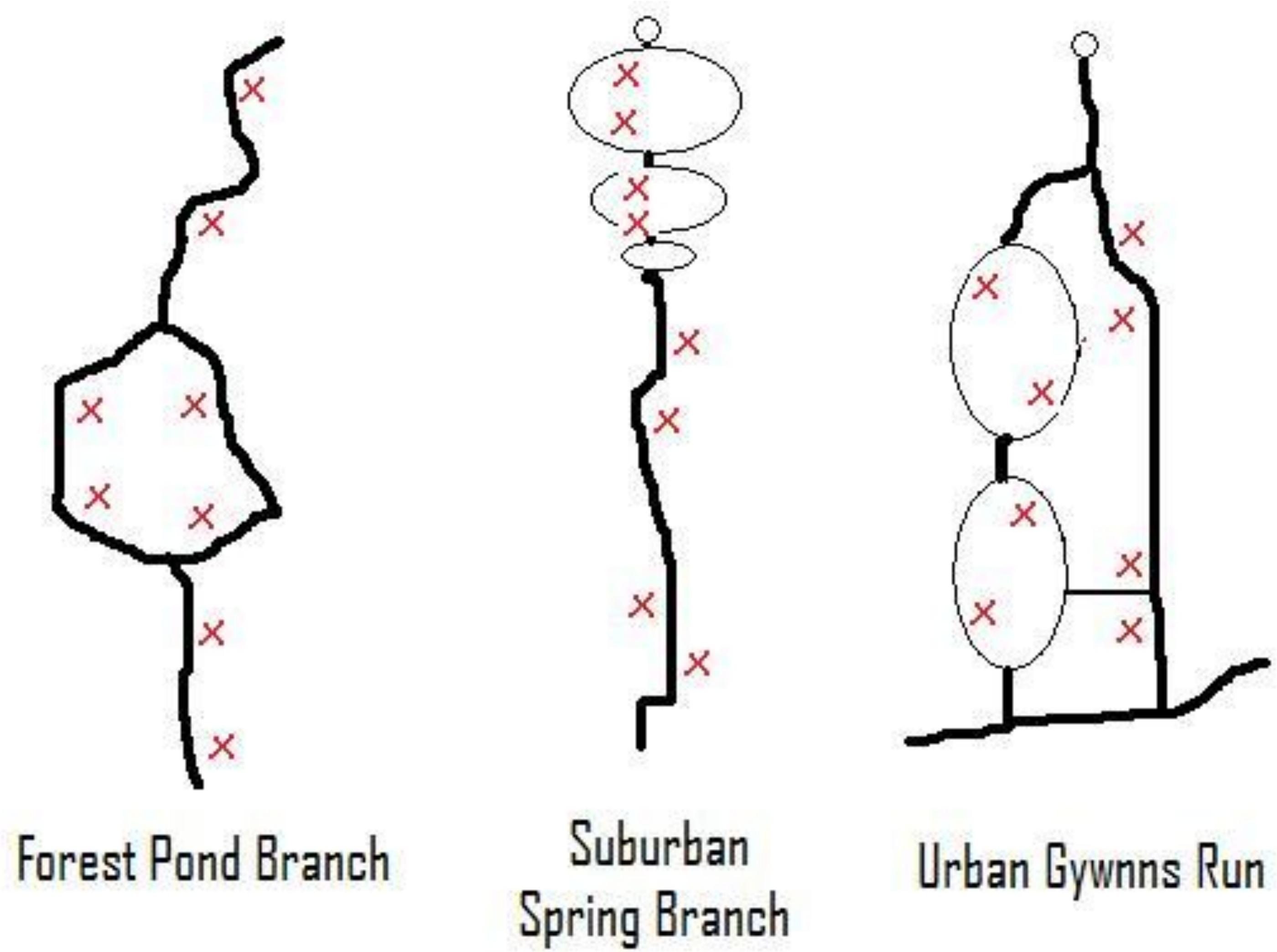
Klocker et al. (In Press)

Re-inventing the Urban River Continuum

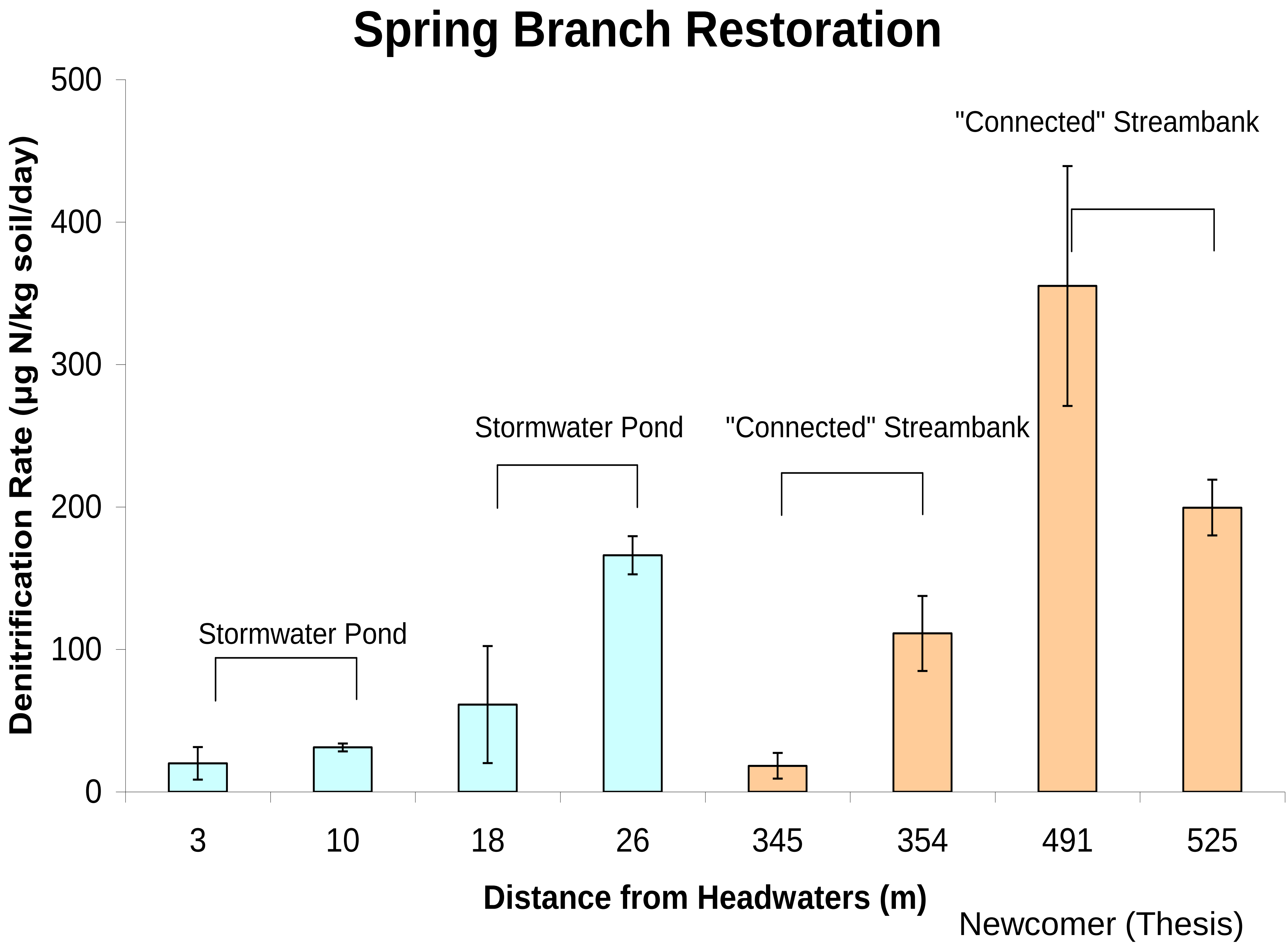


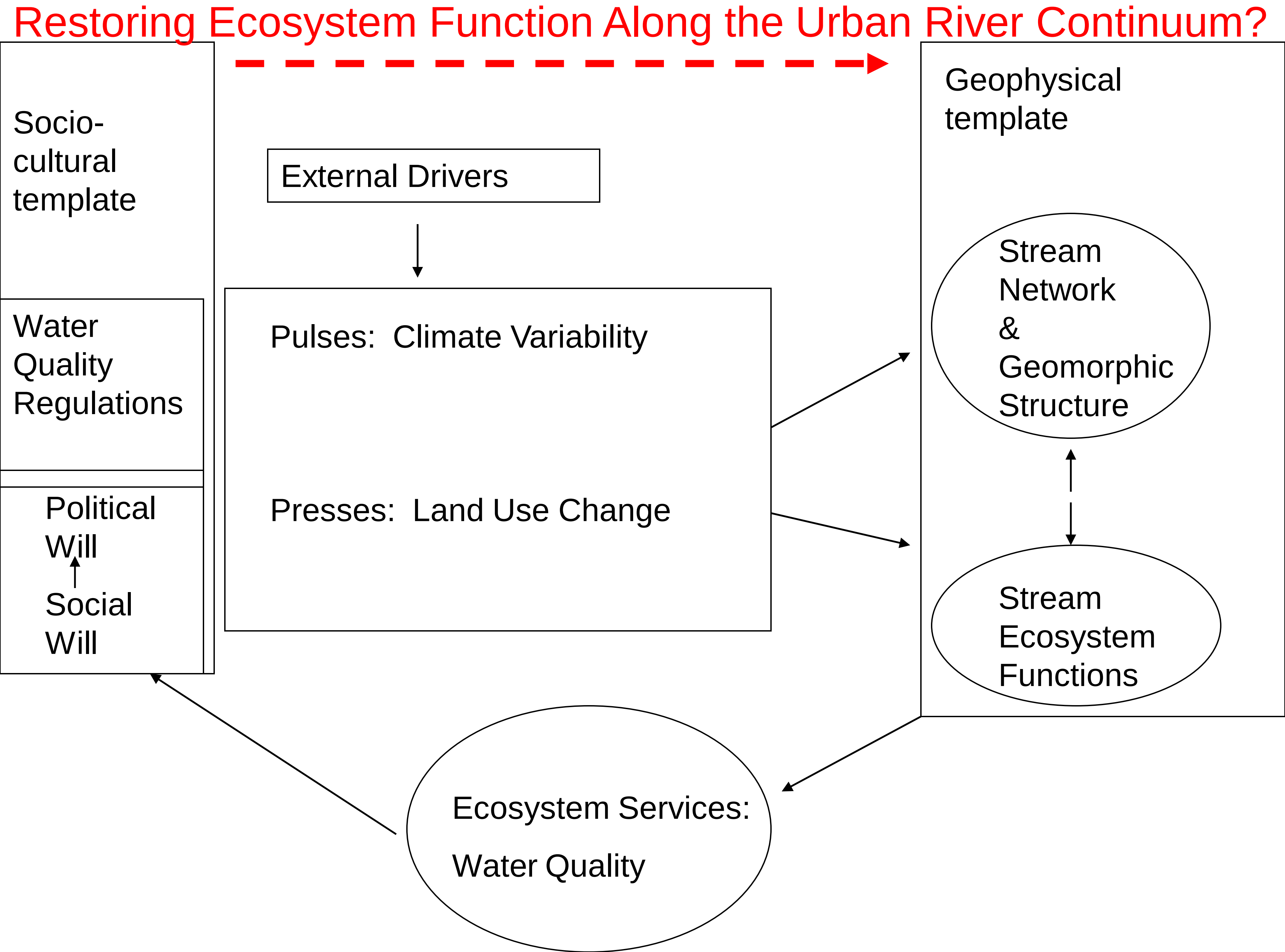
Delaney et al. (In Prep)

Re-inventing the Urban River Continuum



Newcomer (Thesis)


Spring Branch Restoration
Denitrification Rate (µg N/kg soil/day)
500
400
300
200
100
0
Stormwater Pond
Stormwater Pond
"Connected" Streambank
"Connected" Streambank
3
10
18
26
345
354
491
525
Distance from Headwaters (m)
Newcomer (Thesis)


Restoring Ecosystem Function Along the Urban River Continuum?
Socio-cultural template
Water Quality Regulations
Political Will
Social Will
External Drivers
Pulses: Climate Variability
Presses: Land Use Change
Geophysical template
Stream Network & Geomorphic Structure
Stream Ecosystem Functions
Ecosystem Services:
Water Quality

Conclusion

- Urbanization has altered hydrologic "connectivity" to coastal waters

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- Hydrologic "connectivity" has decreased nitrogen retention

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- Can engineering "connectivity" with biogeochemical “hot spots” increase resilience to climate variability?

Acknowledgements

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