Nitrogen Along the Urban Watershed Continuum: *Riparian Zones to Rivers*

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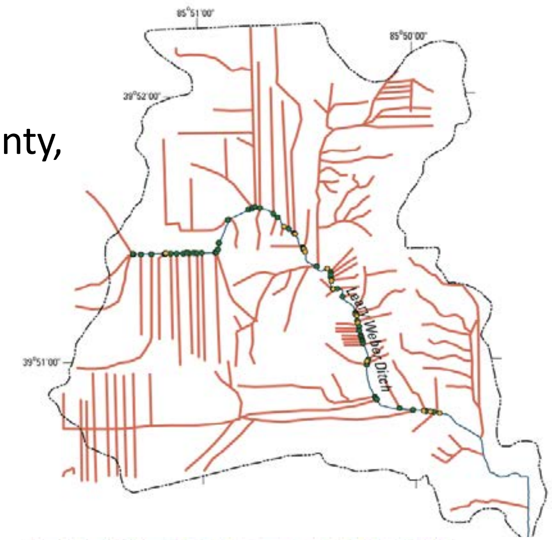
Alteration of the Watershed Continuum

- Land development replaces natural drainage with infrastructure
  - Tile drain systems
  - Storm drain systems
  - Impervious surfaces
- Impacts on material and energy transport downstream and over time

Tile drains in Hancock County, Indiana



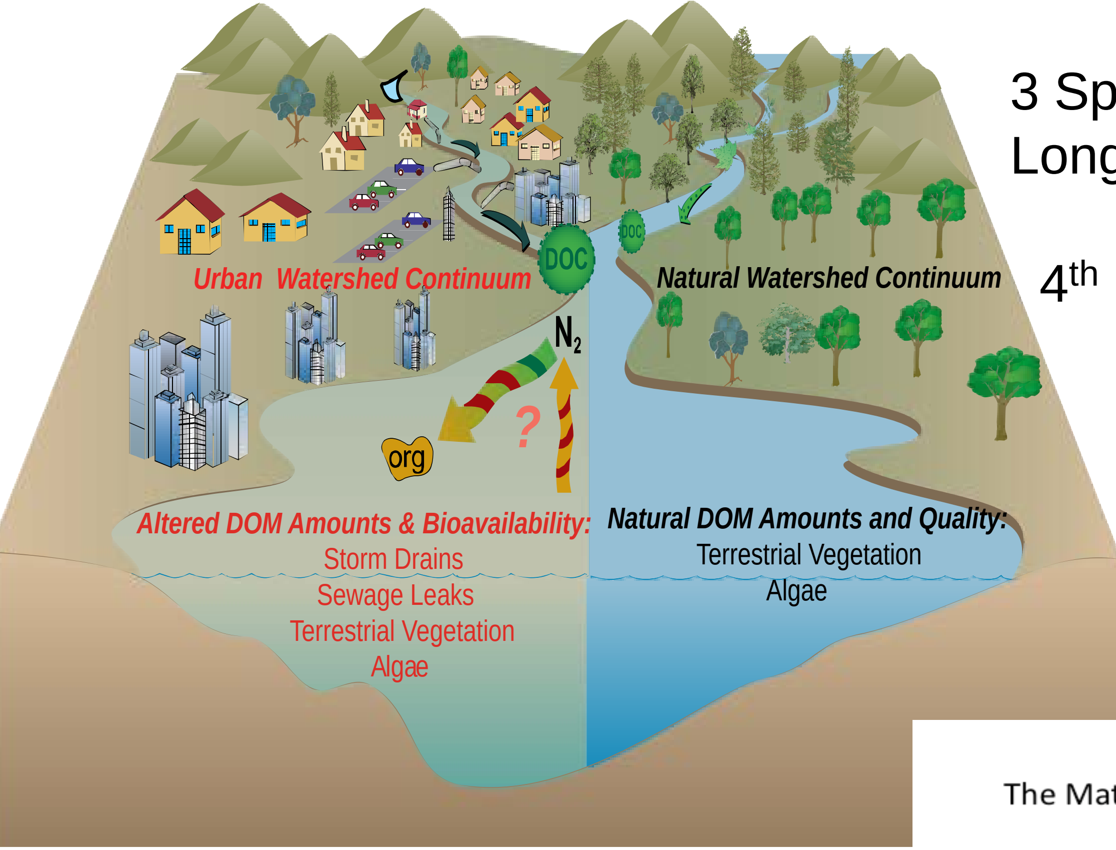
Storm drains in Baltimore, Maryland (Courtesy Bill Stack)

Kaushal and Belt (2012), Kaushal et al. (In Press)

Why explore a new concept?

- Expanded hydrologic connectivity
- Evolution of urban watersheds over time
- Need to consider infrastructure as part of ecosystems
- No concepts to compare the ecological and biogeochemical functions between natural *vs.* urban watersheds across hydrologic flow paths

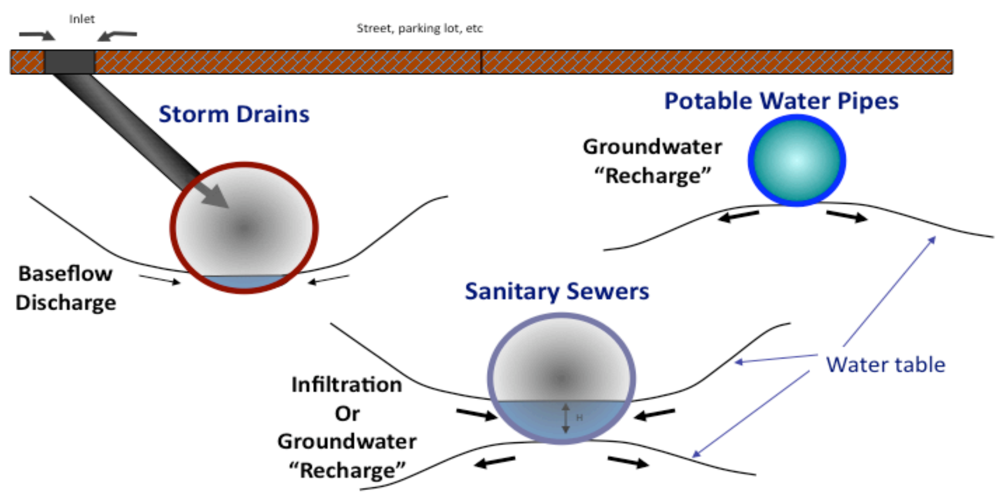
Kaushal and Belt (2012), *Urban Ecosystems*



3 Spatial Dimensions:
Longitudinal, Horizontal, and Vertical

4th Dimension: Evolving over time

The Matrix: A dense, landscape-wide systems of pipes…
an urban "Karst"



Urban Watershed Continuum
Kaushal and Belt (2012) *Urban Ecosystems*

Nitrogen Along the Watershed Continuum

How does hydrologic connectivity influence:

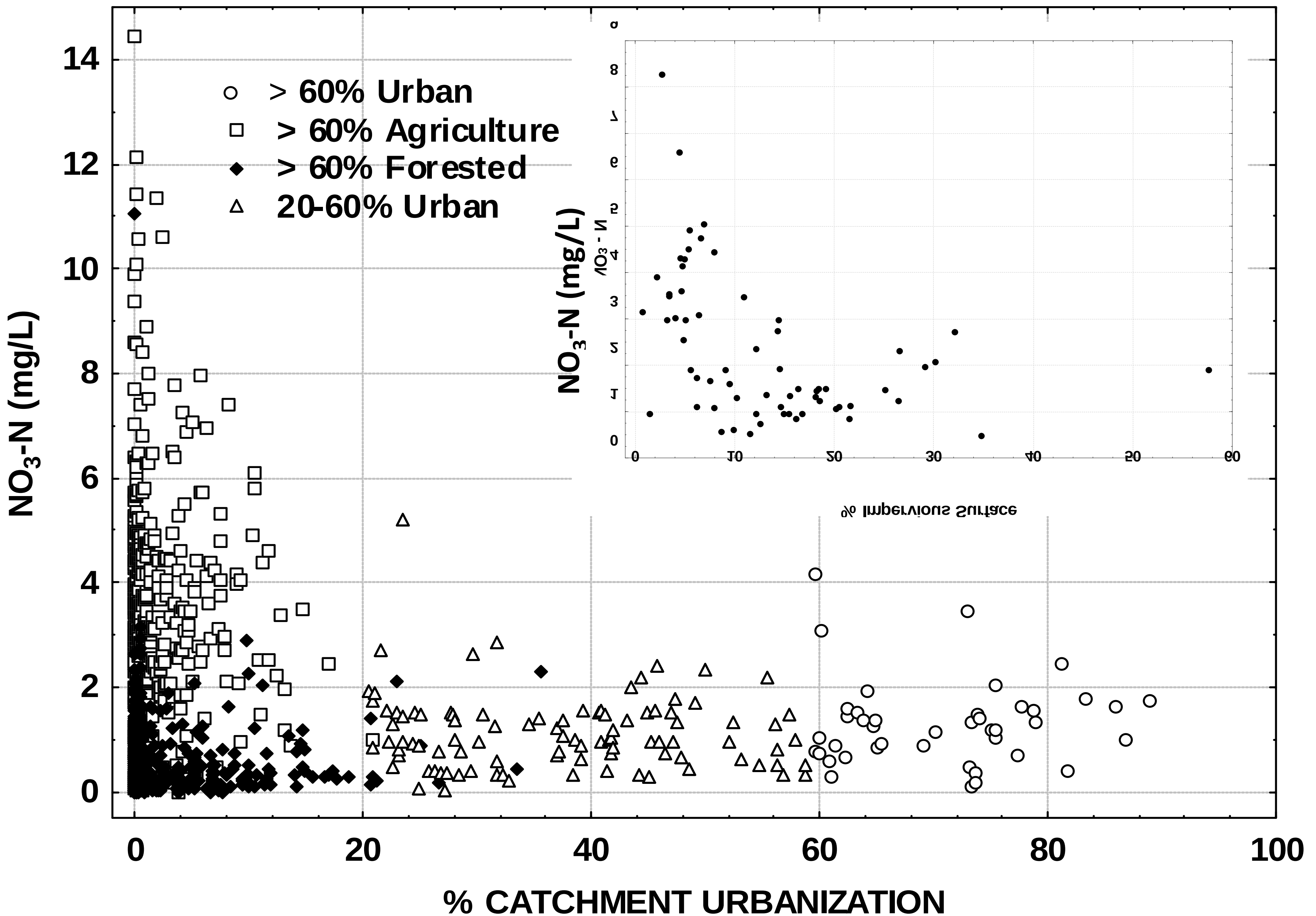
1. *fluxes* of N exported from watersheds?

2. *sources* of N exported from watersheds?

3. *transformations* of N in urban streams?

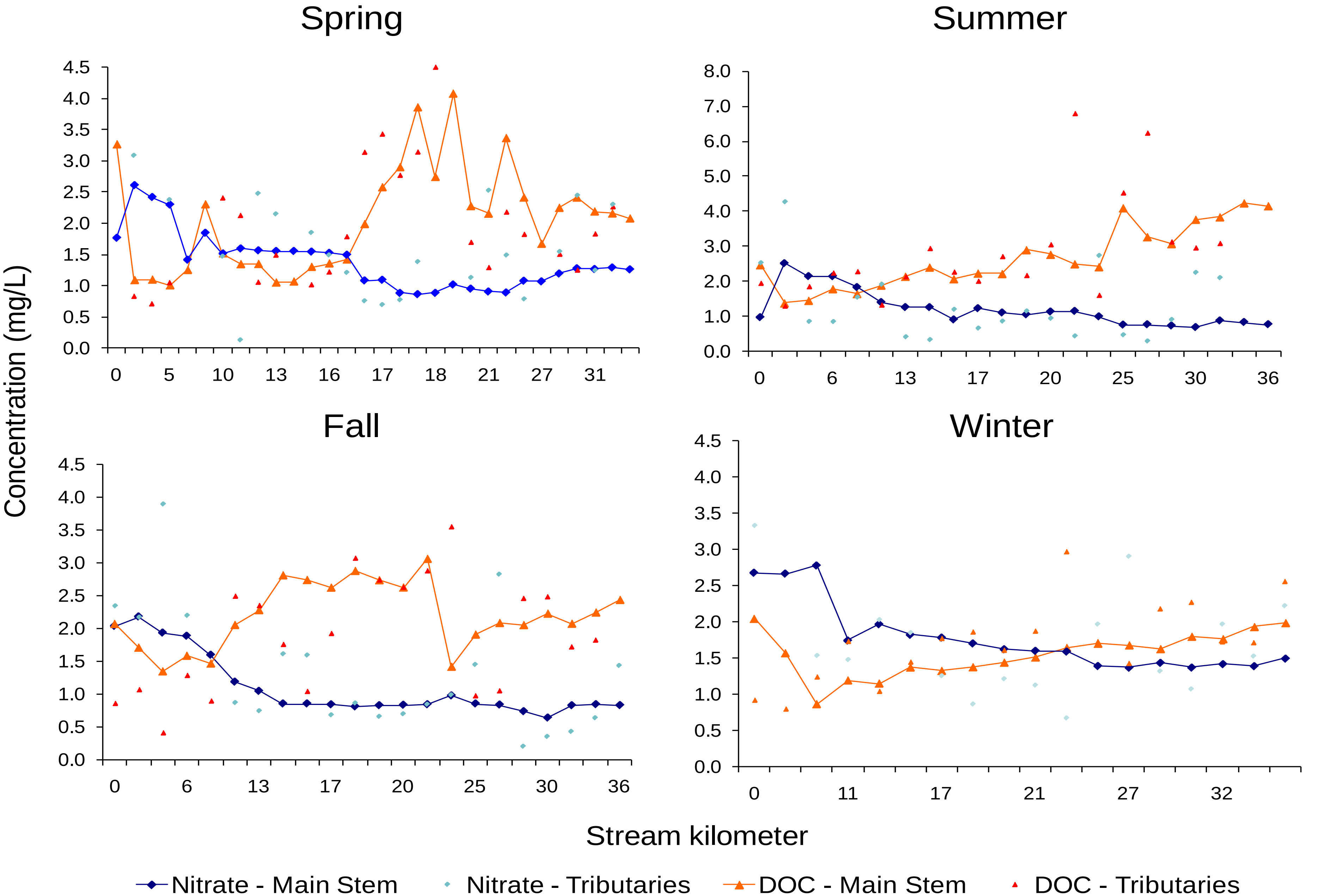
1. Fluxes of Watershed N Export?

Newcomer et al. (2012)

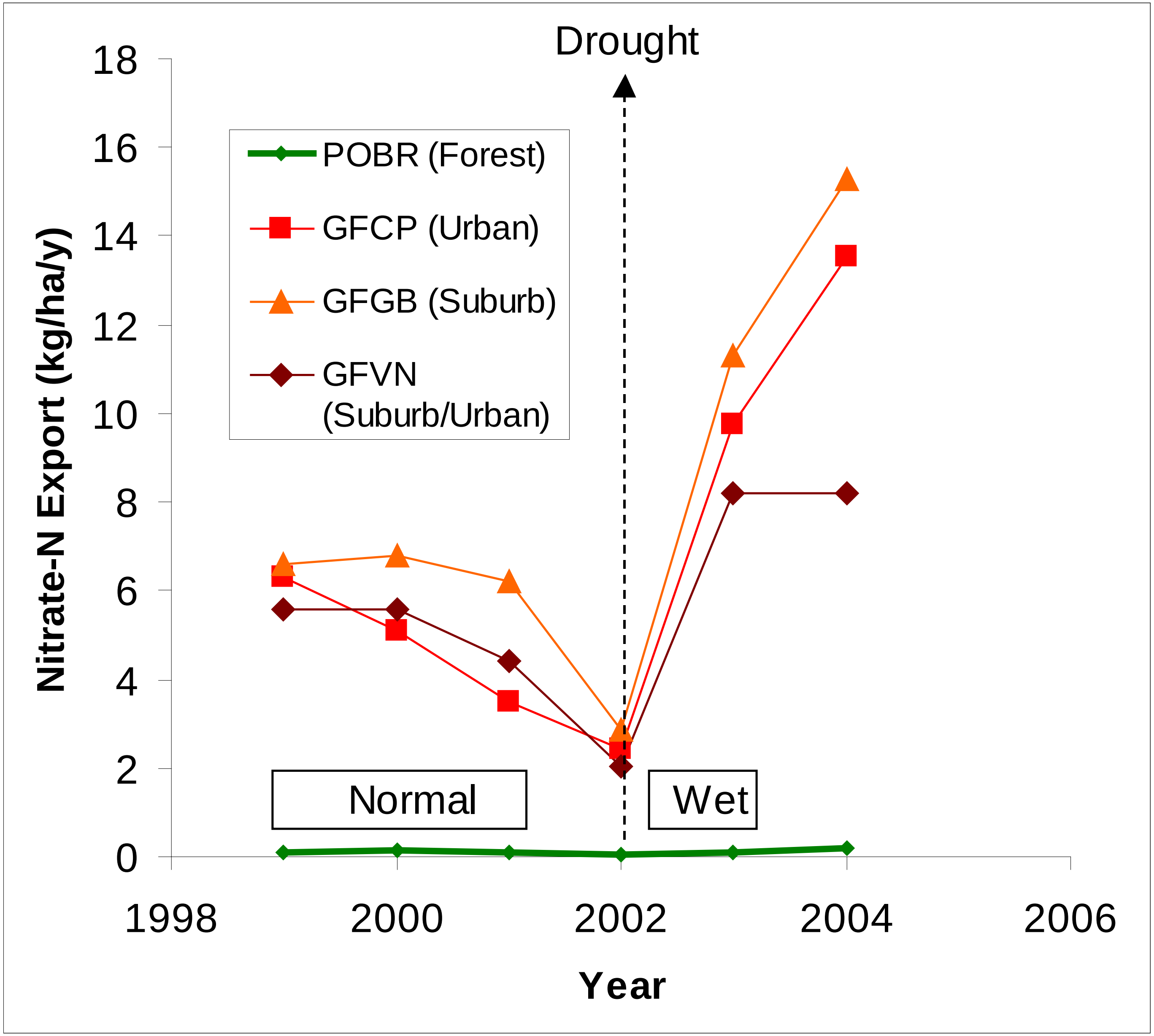


Kaushal et al. (2008), *Envir. Sci. &Tech.*

20-30% Nitrogen Retention Along Gwynns Falls Mainstem

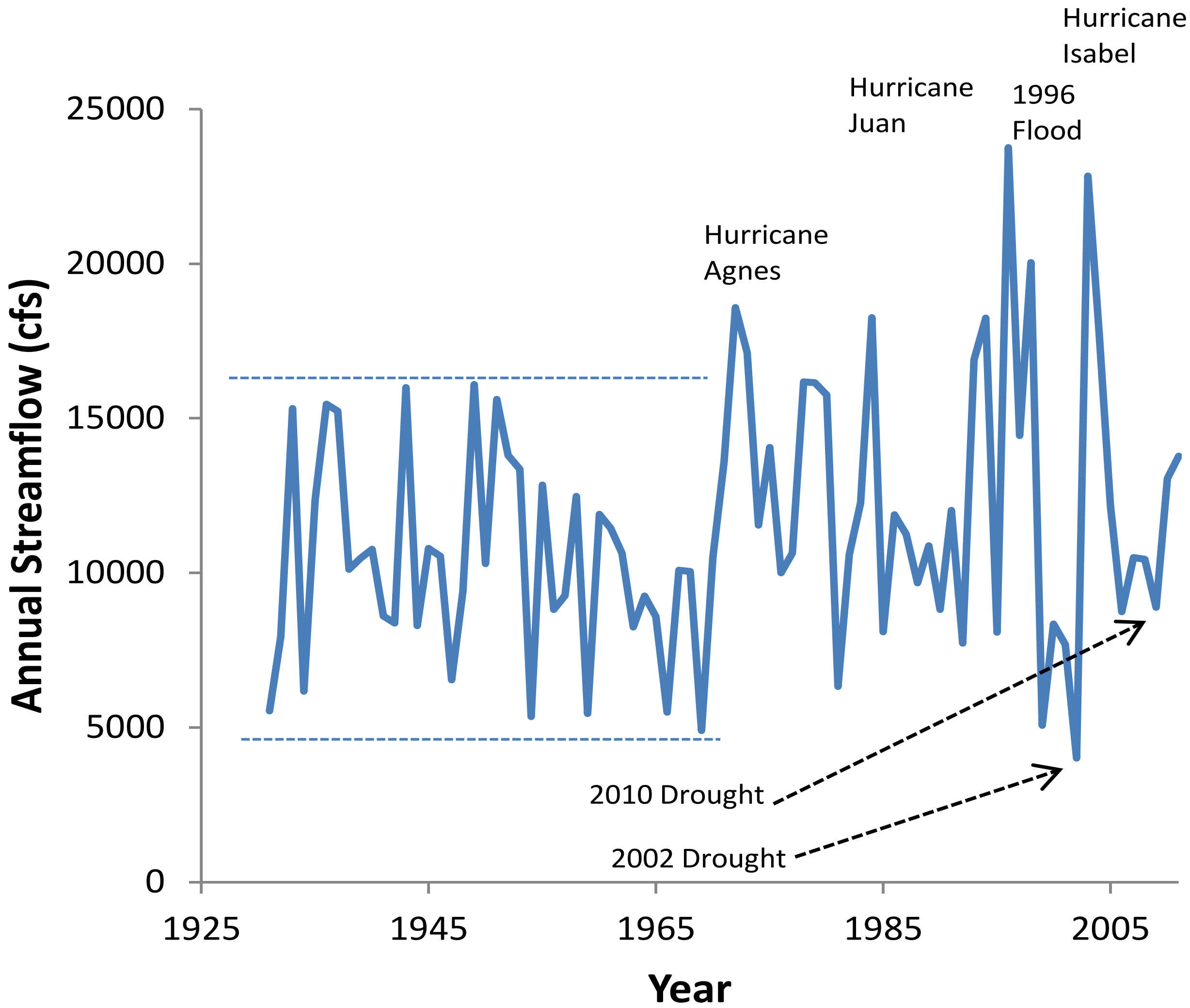


Kaushal et al. (2014), *Biogeochemistry*



Kaushal et al. (2008), *Envir. Sci. &Tech.*

Potomac River



USGS monitoring allows us to put research into context regarding hydrologic variability.

USGS River Input Monitoring
Kaushal et al. (2010), Kaushal et al. In Press

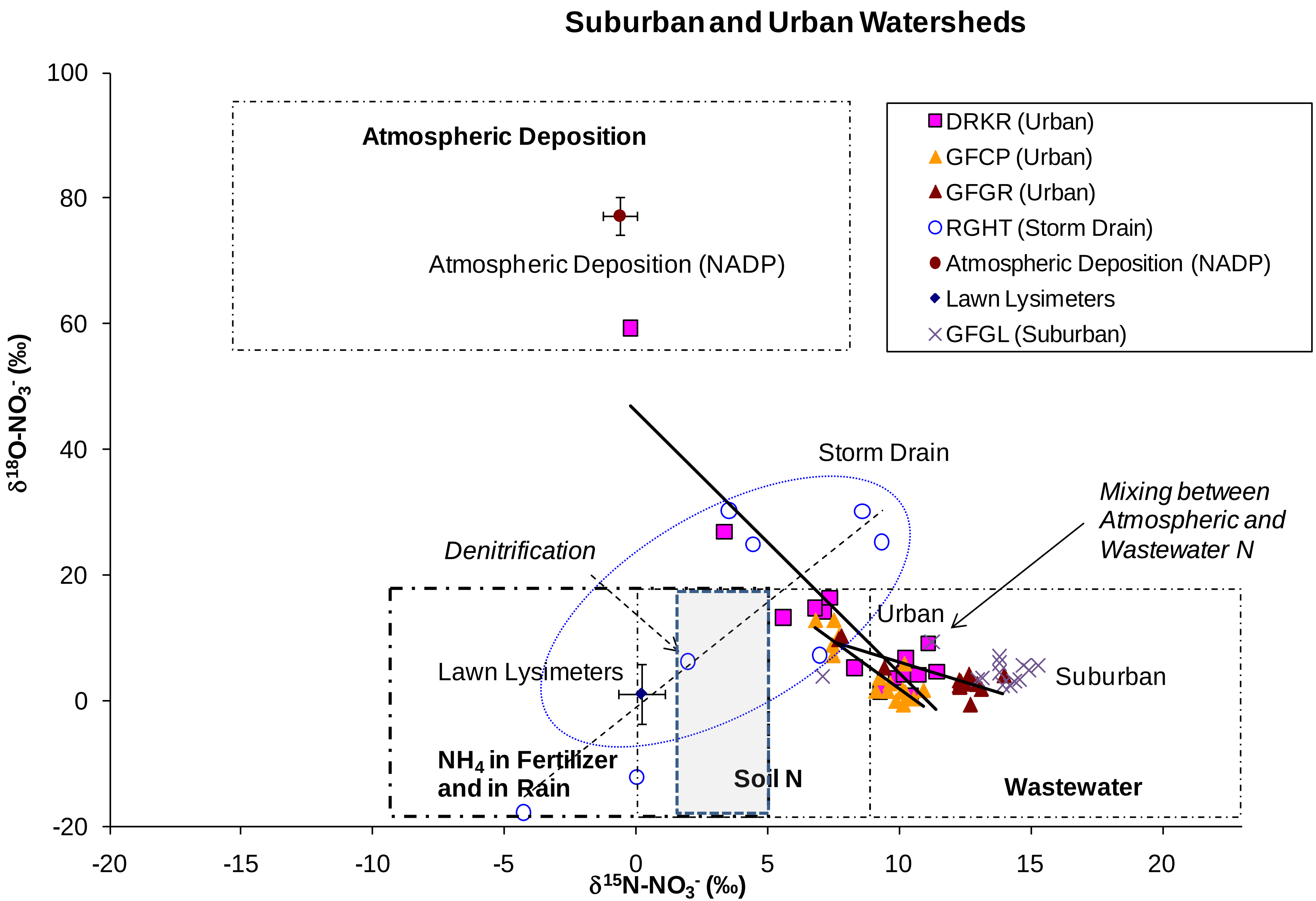
Part 1: Key Points

- Imperviousness is related to stream N concentrations
- Watershed N fluxes are related to runoff variability
- Magnitude of response can differ across land use

I. Land Use and Sources of Nitrogen Export

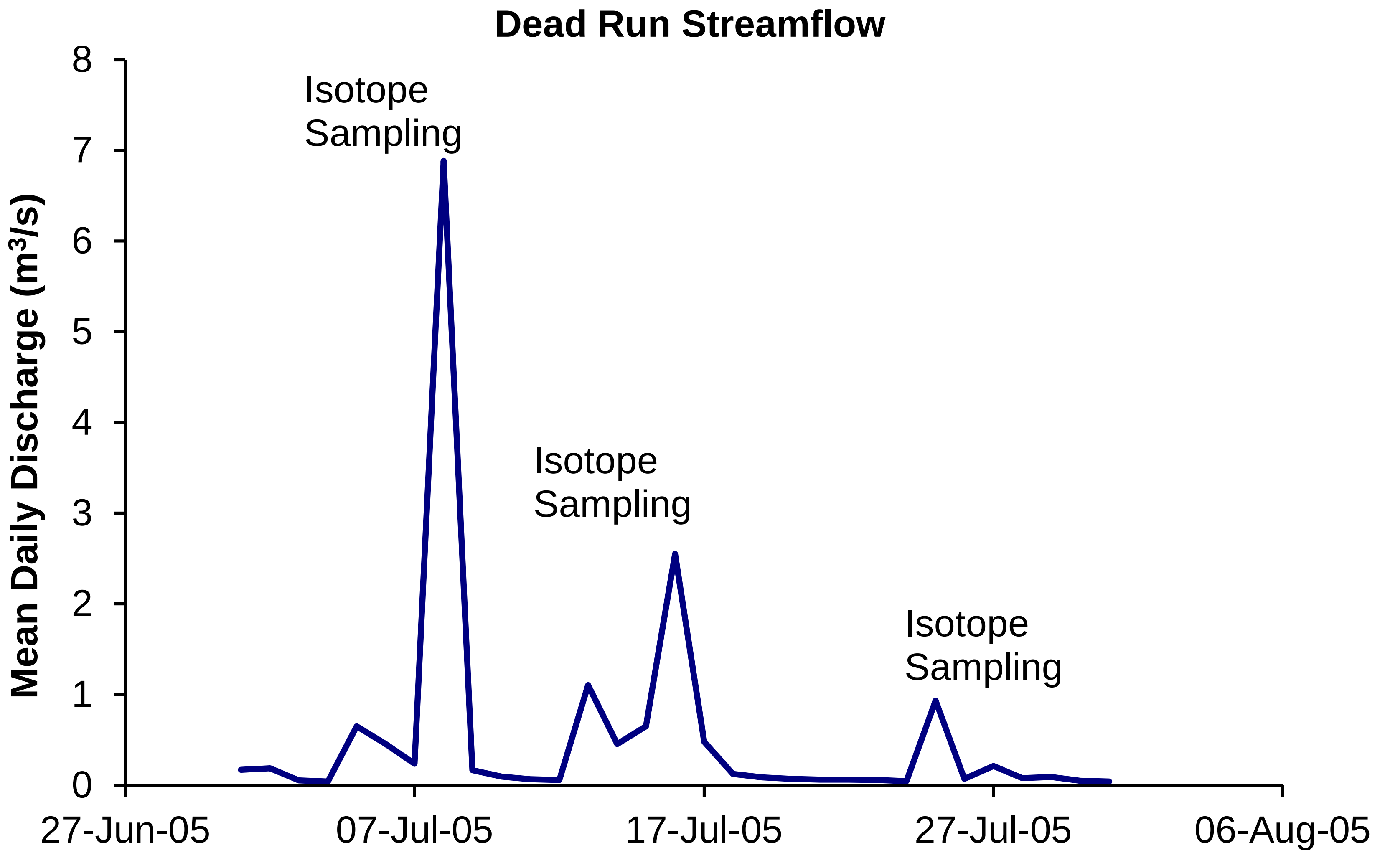
Nitrogen and Oxygen Isotopes

- Atmospheric Sources: d^{15}N of nitrate decreases while d^{18}O increases
- Fertilizer: d^{15}N of nitrate is low and d^{18}O is low
- Wastewater: d^{15}N of nitrate is +10 to 20, and d^{18}O is low
- Denitrification: d^{15}N of nitrate increases while d^{18}O increases

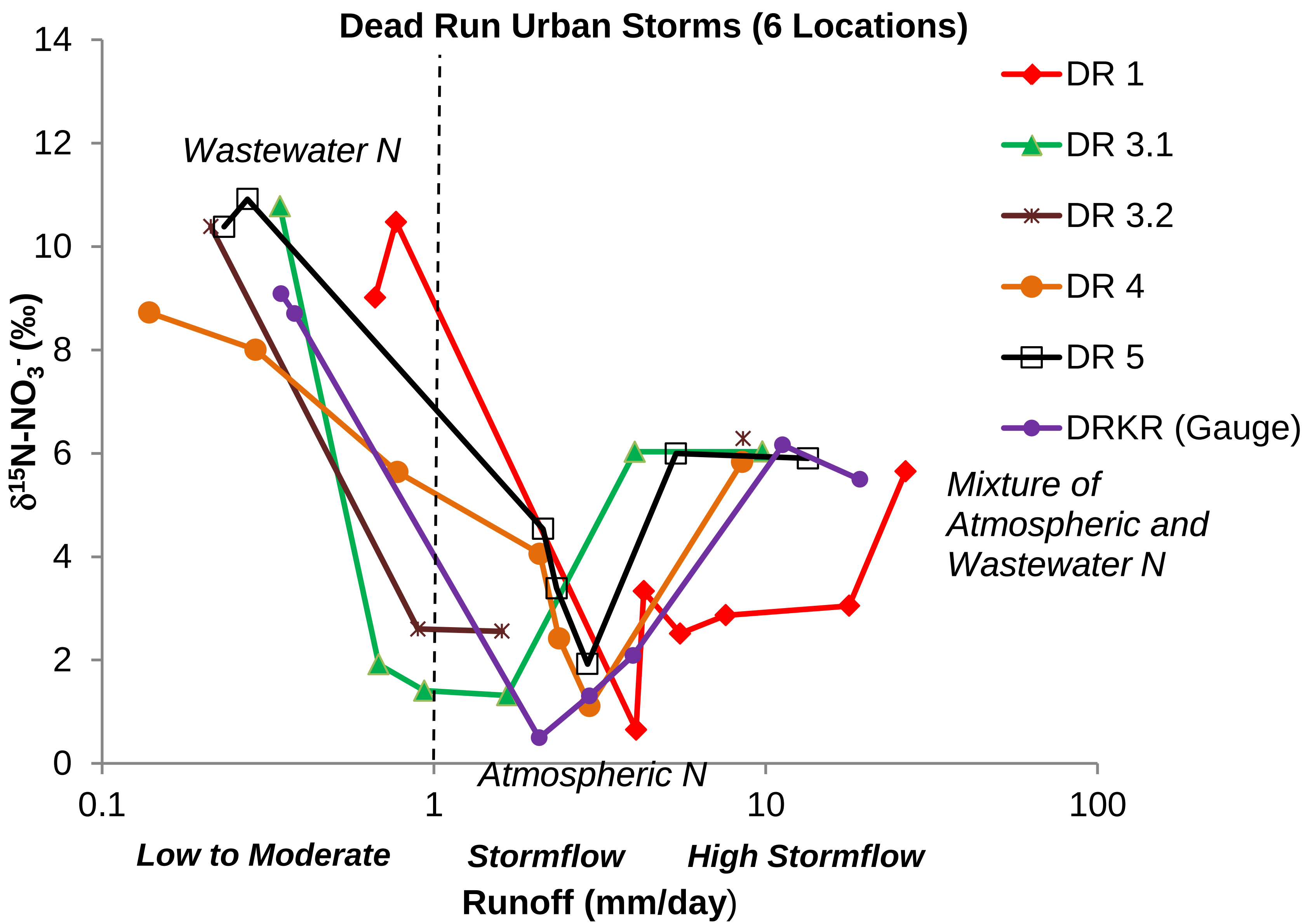


Kaushal et al. (2011)

Hydrologic Variability Alters N Sources



Kaushal et al. (2011)



Kaushal et al. (2011)

Sources of Nitrogen Export in Urban Streams

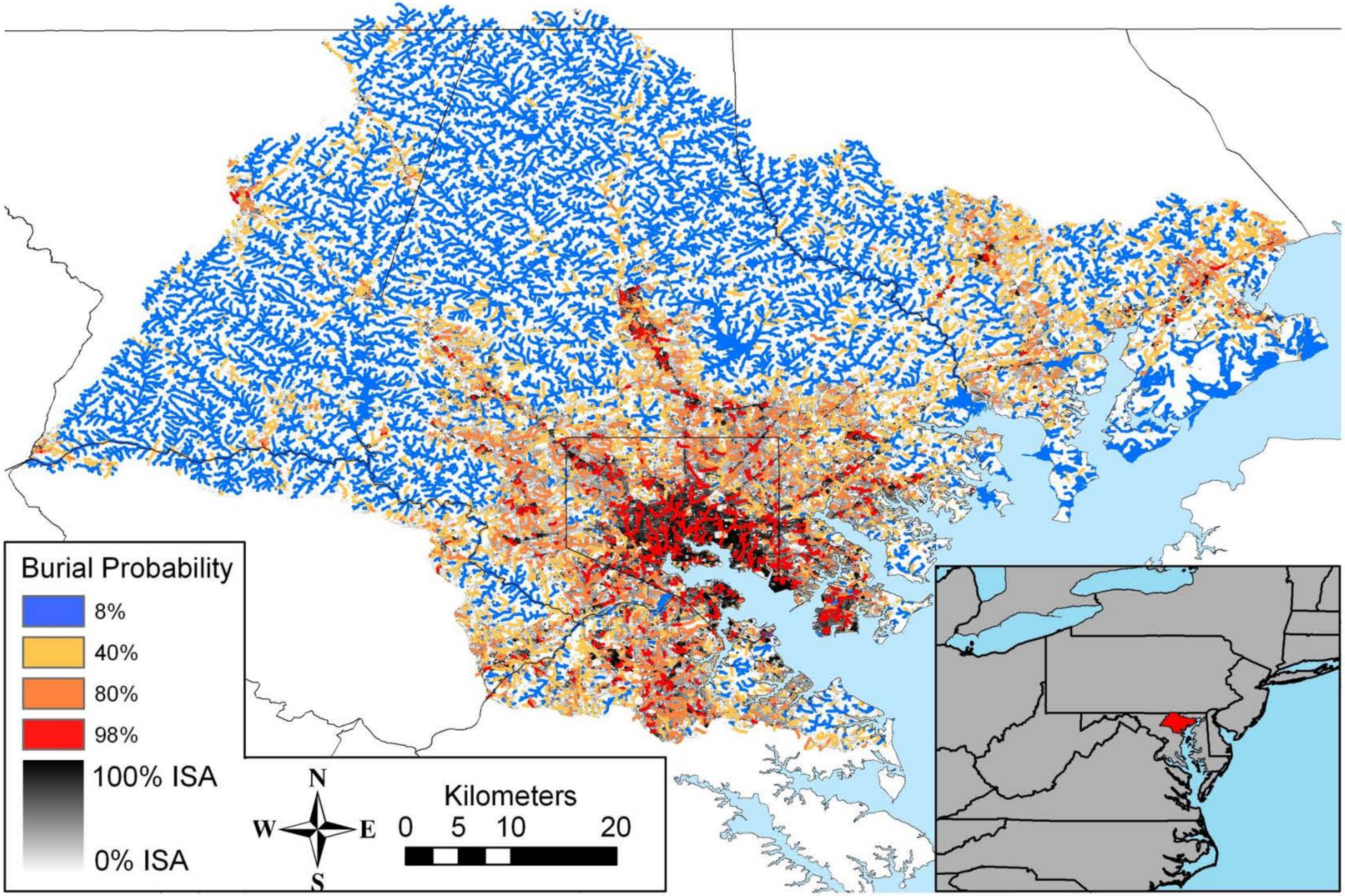
Site	% Wastewater N	% Atmospheric N
DR1	7 - 50	8 – 92
DR 3.1	13 – 53	6 - 87
DR 3.2	24 – 90	10 - 76
DR 4	11 – 76	24 - 89
DR 5	18 – 95	5 - 82
DRKR	13 – 79	21 - 94

Kaushal et al. (2011)

Part 2: Key Points

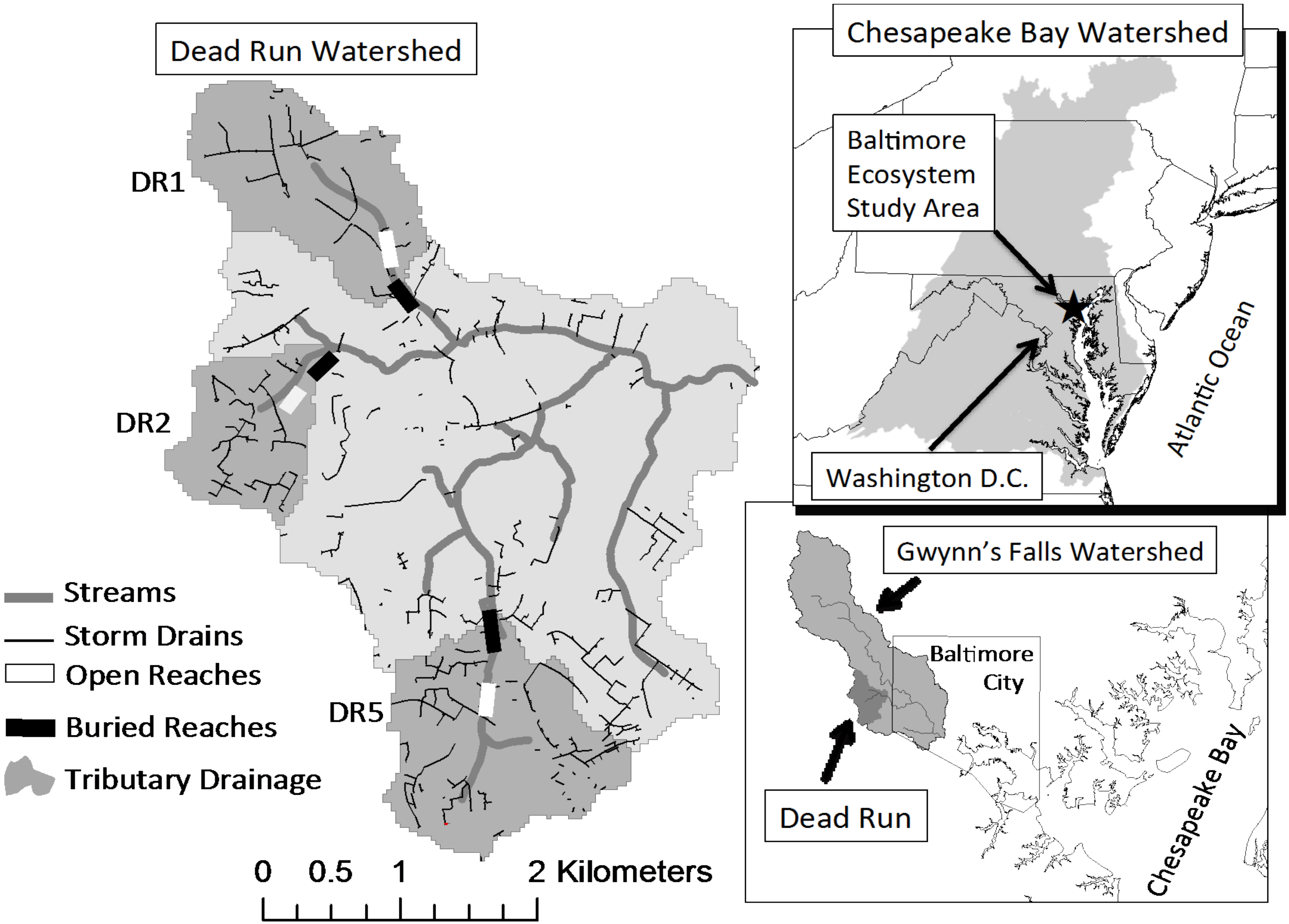
- Hydrologic connectivity with sanitary infrastructure is important during baseflow and high stormflow
- Atmospheric N sources can be important during light and moderate storms due to impervious surfaces
- Nonpoint N sources shift with storms and runoff

3. N Transformations in Urban Streams?

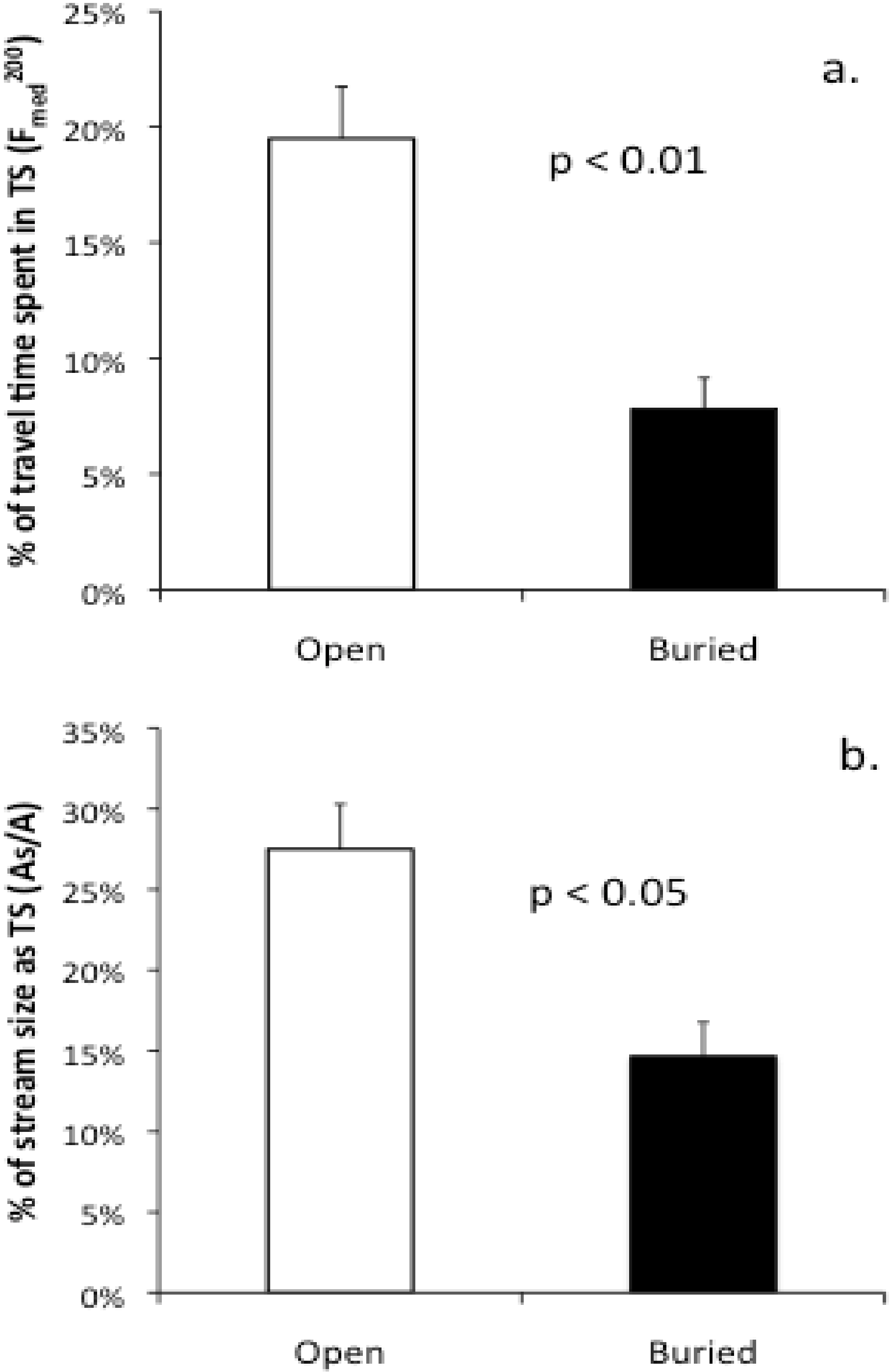


Elmore and Kaushal (2008), *FEE*

Disappearing Streams?



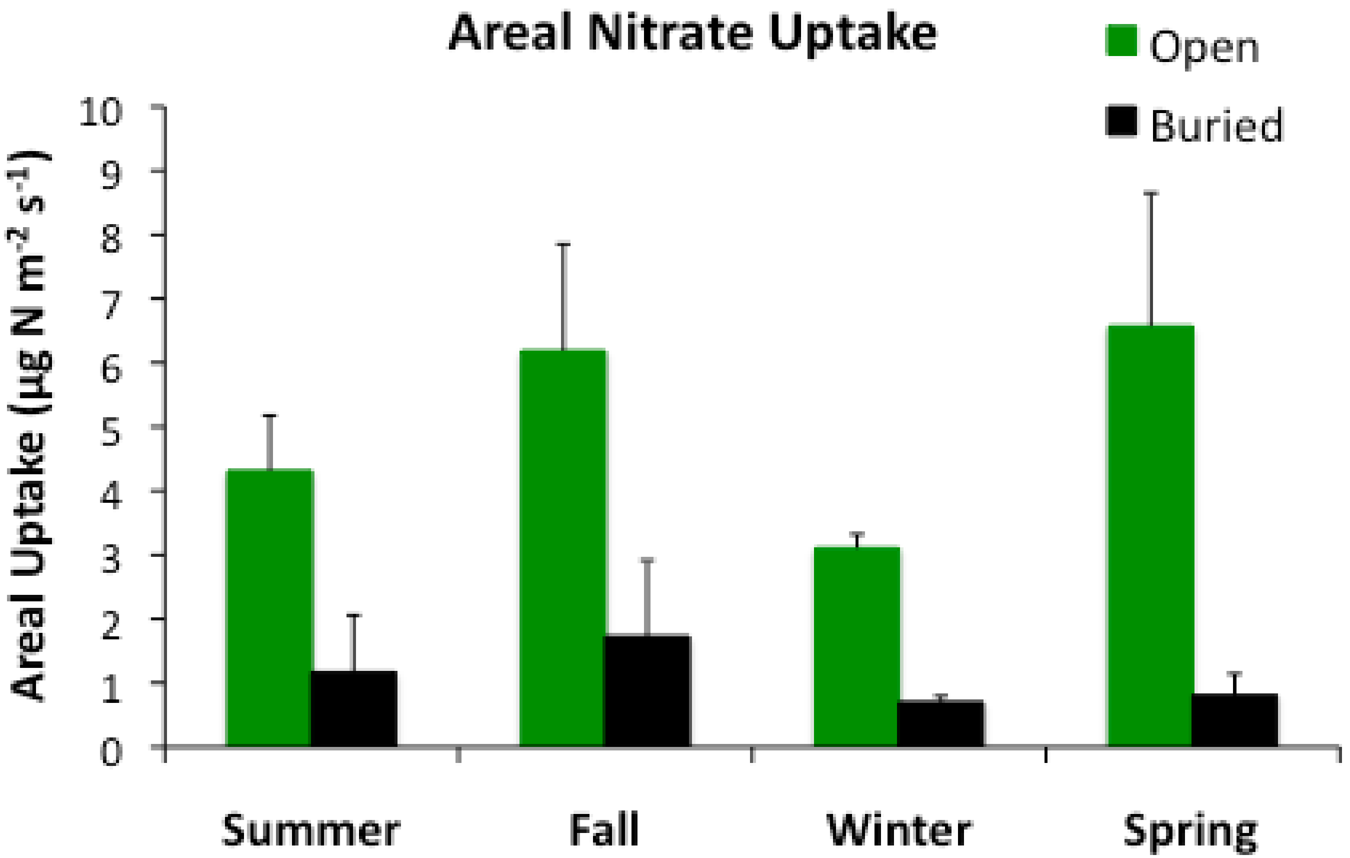
Pennino *et al.* (2014), *Biogeochemistry*



Stream burial reduces hydrologic connectivity and residence time in transient storage

Pennino *et al.* 2014, *Biogeochemistry*

Headwater Burial Decreases Nitrogen Uptake



Pennino *et al.* 2014, *Biogeochemistry*

Part 3: Key Points

- Headwater stream burial decreases hydrologic connectivity between streams and floodplains
- Headwater stream burial decreases N uptake
- Daylighting or de-channelization may have impacts at watershed scale

Pennino *et al. 2014* (*Biogeochemistry*)

CONCLUSION

- Hydrologic connectivity can alter fluxes, sources, and transformations of N in watersheds.

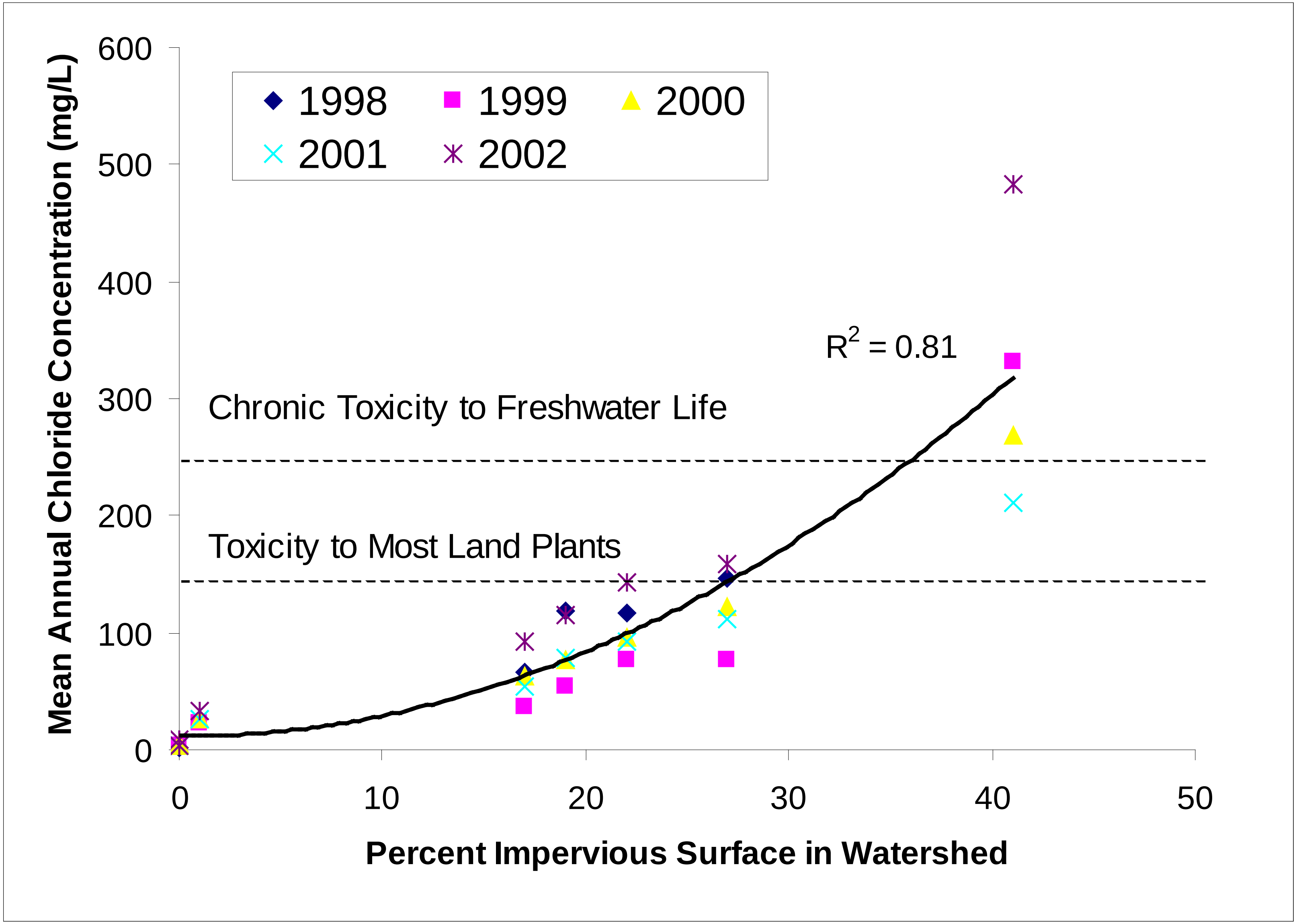
- Hydrologic connectivity needs to consider both surface and subsurface flowpaths.

- Salinization, warming, and alkalinization represent additional water quality concerns potentially influenced by impervious surfaces

Increased salinization of fresh water in the Northeastern US

Courtesy of Ken Belt

Link between Urbanization and Salinization of Fresh Water



Kaushal et al. (2005) *PNAS*