Tracking Carbon and Nitrogen Pollution from Headwaters to Coasts

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How does land use impact the coastal carbon cycle?

- Urban development replaces natural drainage with infrastructure
  - Storm drain systems
  - Leaky sewers
  - Impervious surfaces
- Major impacts on carbon cycle over space and time

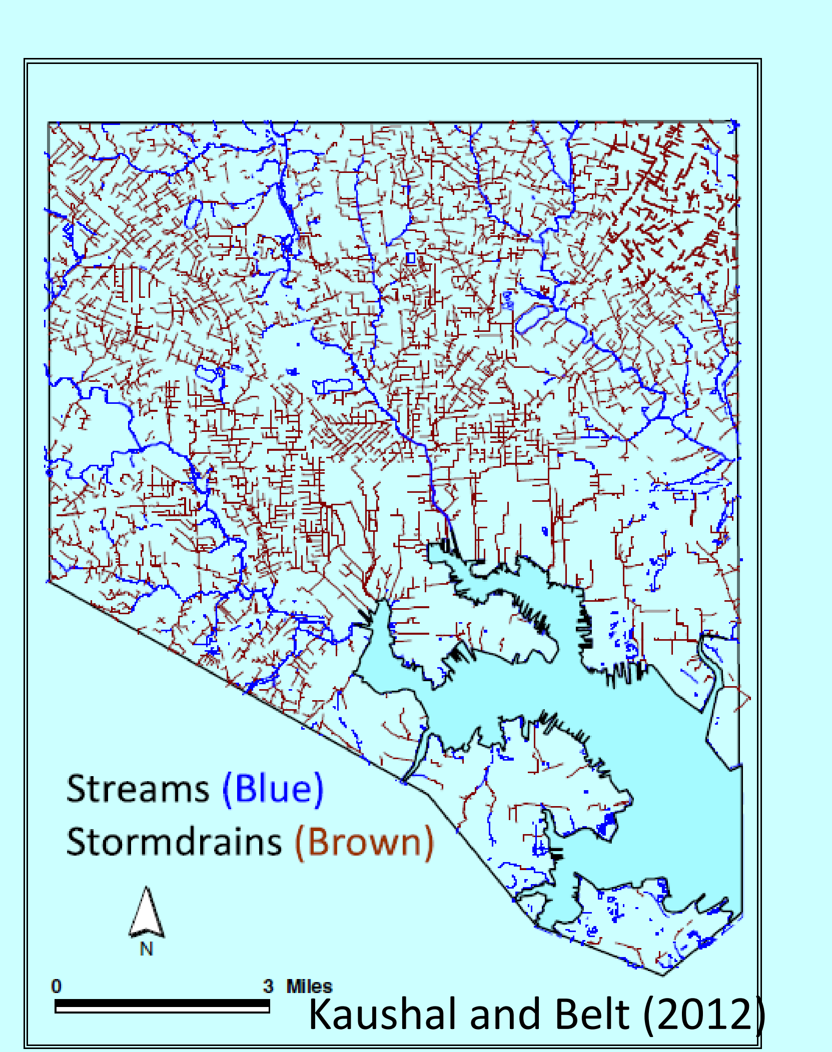


Figure xx. Stormdrain

Urban Watershed Continuum: Research Questions

- How does human-accelerated weathering impact the coastal carbon cycle?

- Is the urban river continuum a transporter or transformer of carbon?

- What are implications for the coastal carbon cycle?

1. Urban weathering impacts coastal carbon?

Evolving Weathering in Urbanized Watersheds Over Time

Cities create a distinct urban geology

Weathering of “urban karst”

Kaushal and Belt (2012)
Kaushal et al. (2014, 2015)

Increasing alkalinity in 66% of sites:

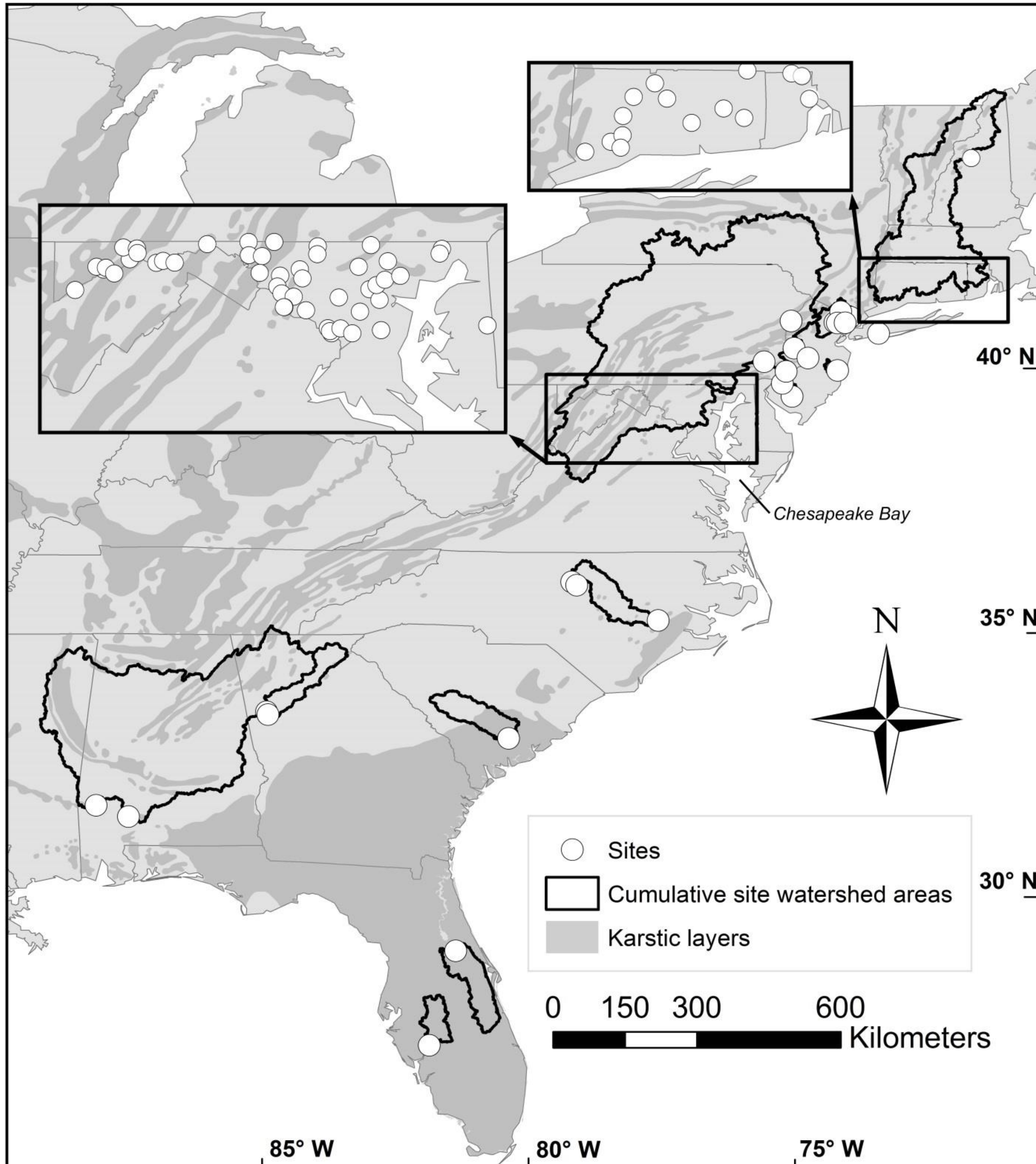
Watershed Size

Elevation

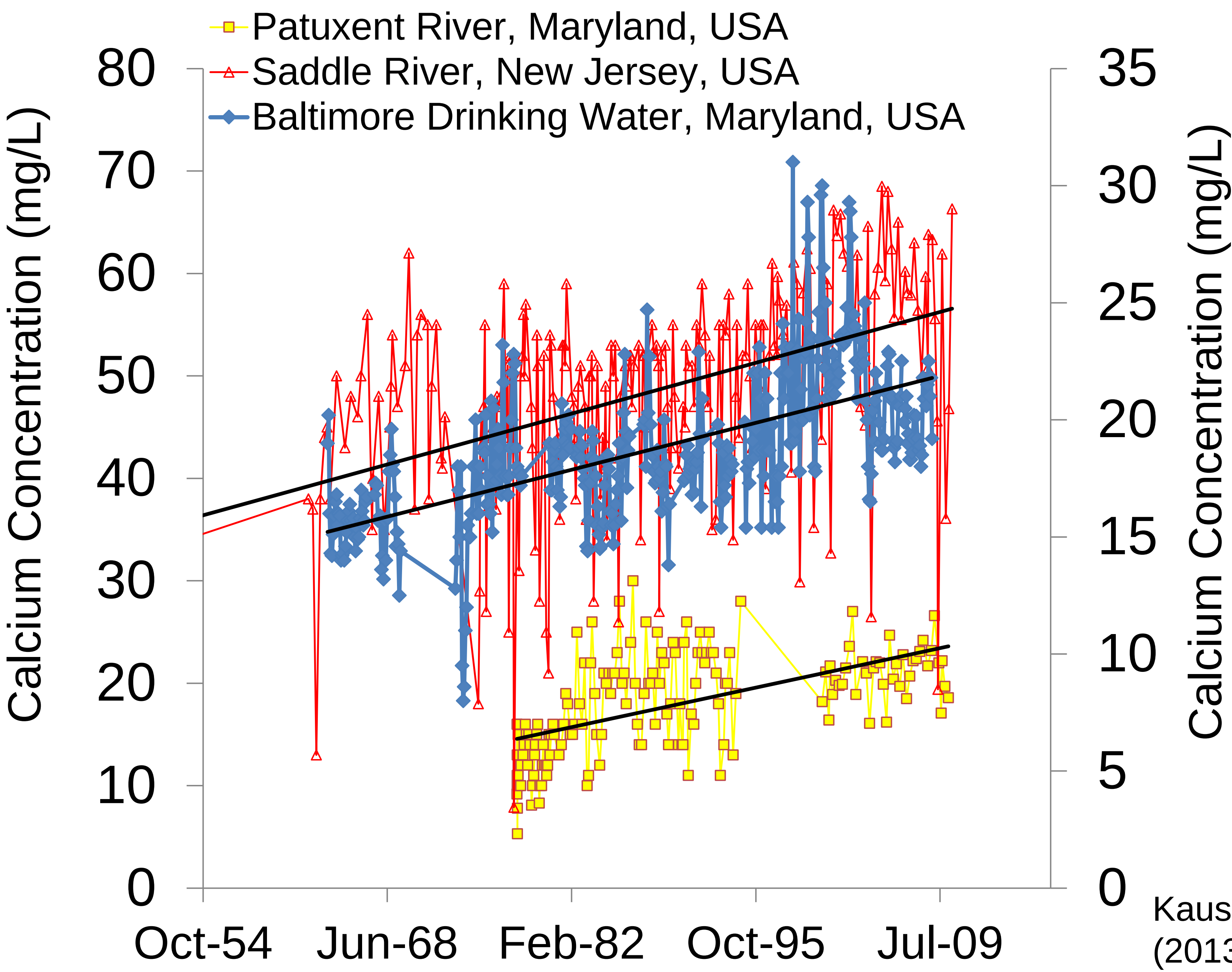
Lithology

Land Use

Kaushal et al. (2013), *ES&T*

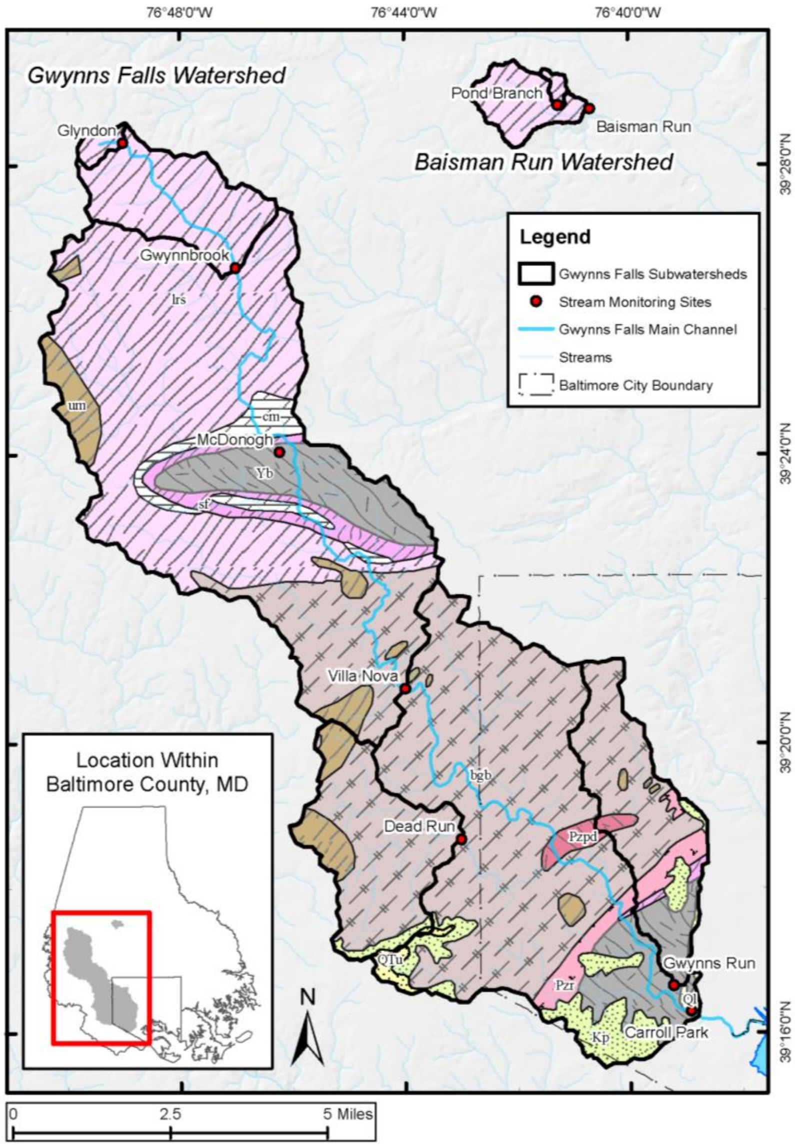


Human-Accelerated Weathering in Watersheds



Kaushal et al. (2013, 2014)

Baltimore Long Term Ecological Research Site Geology



Lithologic Descriptions

Coastal Plain Sediments

Quaternary — Pleistocene to Recent

Lowland Deposits (Ql)
Gravel, sand, silt and clay. Medium- to coarse-grained sand and gravel; cobbles and boulders near base; commonly contains reworked Eocene glauconite; varicolored silts and clays; brown to dark gray lignitic silty clay; contains estuarine to marine fauna in some areas (includes in part Pamlico, Talbot, Wicomico and Sunderland Formations of earlier reports); thickness 0 to 150 feet.

Pliocene (?)

Upland Deposits (Western Shore) (QTu)
Gravel and sand, commonly orange-brown, locally limonite-cemented; minor silt and red, white, or gray clay; (includes Brandywine, Bryn Mawr, and Sunderland Formations of earlier reports); lower gravel member and upper loam member in Southern Maryland; thickness 0 to 50 feet.

Cretaceous

Potomac Group (Kp)
Interbedded quartzose gravels; protoquartzitic to orthoquartzitic argillaceous sands; and white, dark gray and multicolored silts and clays; thickness 0 to 800 feet.

Glenarm Supergroup

Cambro - Ordivician (?)

Loch Raven Schist (lrs)
(Mapped as Lower Pelitic Schist in older publications and as the oligoclase facies of the Wissahickon Formation in even older publications.) Medium- to coarse-grained biotite-oligoclase-muscovite-quartz schist with garnet, staurolite, and kyanite; fine- to medium-grained semipelitic schist; and fine-grained granular to weakly schistose psammitic granulite; psammitic beds increase upward; apparent thickness 5,500 feet or more.

Cockeysville Marble (cm)
Metadolomite, calc-schist, and calcite marble are predominant; calc-gneiss and calc-silicate marble widespread but minor; thickness about 750 feet.

Setters Formation (sf)
Upper member: Feldspathic mica schist and mica gneiss; middle member: Impure quartzite interstratified with thin beds of mica schist; lower member: Medium-grained, feldspathic mica schist, locally granitized; total thickness 200 to 500 feet.

Granitic Series

Paleozoic

Port Deposit Gneiss (Pzpd)
Also mapped as Franklinville Gneiss. Moderately to strongly deformed intrusive complex composed of gneissic biotite quartz diorite, hornblende-biotite quartz diorite, and biotite granodiorite; all rocks foliated and some strongly sheared; age 550 +/- 50 m.y.* by radiogenic dating.

Gabbroic Series

Early Paleozoic - Late Precambrian (?)

Relay Felsite (Pzr)
Intensely foliated, fine-grained, light-colored; ranges from quartz diorite to albite granite; age 550 +/- 50 m.y.* by radiogenic dating.

Ultramafic Rocks (um)
Chiefly serpentinite with partly to completely altered dunite, peridotite, pyroxenite, and massive to schistose soapstone; talc-carbonate rock and altered gabbro are common in some bodies.

Baltimore Mafic Complex (bgb)
Hypersthene gabbro with subordinate amounts of olivine gabbro, norite, anorthositic gabbro, and pyroxenite; igneous minerals and textures well preserved in some rocks, other rocks exhibit varying degrees of alteration and recrystallization, and still others are completely recrystallized with a new metamorphic mineral assemblage.

Precambrian Basement

Proterozoic

Baltimore Gneiss (Yb)
Biotite-quartz-feldspar gneiss and biotite-hornblende gneiss; amphibolite widespread but subordinate; texturally varied; granitic gneiss, veined gneiss, augen gneiss, banded gneiss, and migmetite in places complexly intermingled; age 1,100 m.y.* by radiogenic dating. Layered paragneiss in Baltimore City southeast of Relay Felsite

Information from Maryland Geological Survey's ***Geologic Map of Maryland (1968)***

Information made available by he USDA, Service Center Agencies. More information: http://pubs.usgs.gov/of/2005/1325/#MD

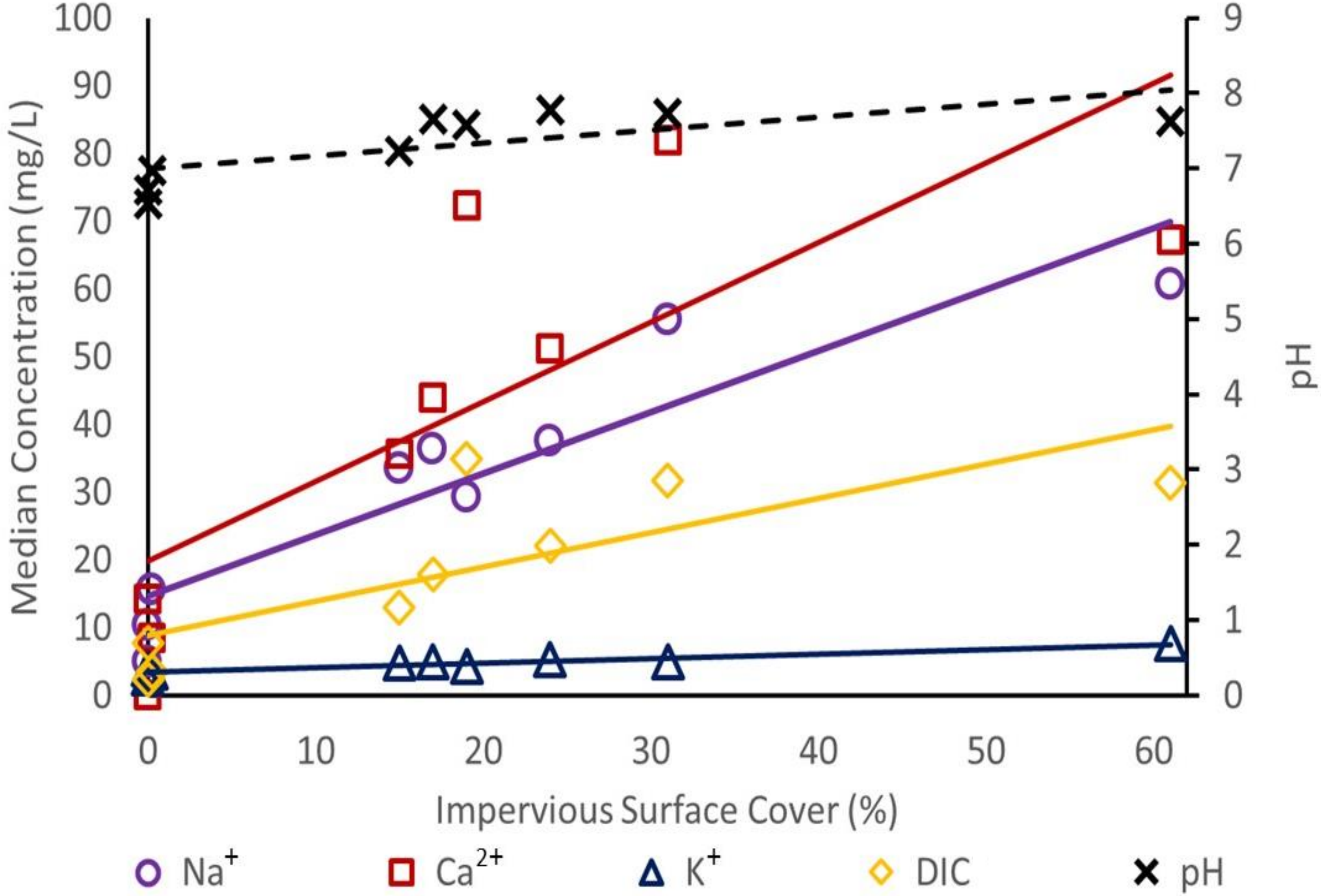
*Radiometric Date from Wetherill *et al.*, (1966)

Updated unit names and ages from Crowley, W.P. (1976)

Projection: NAD StatePlane Maryland 1983

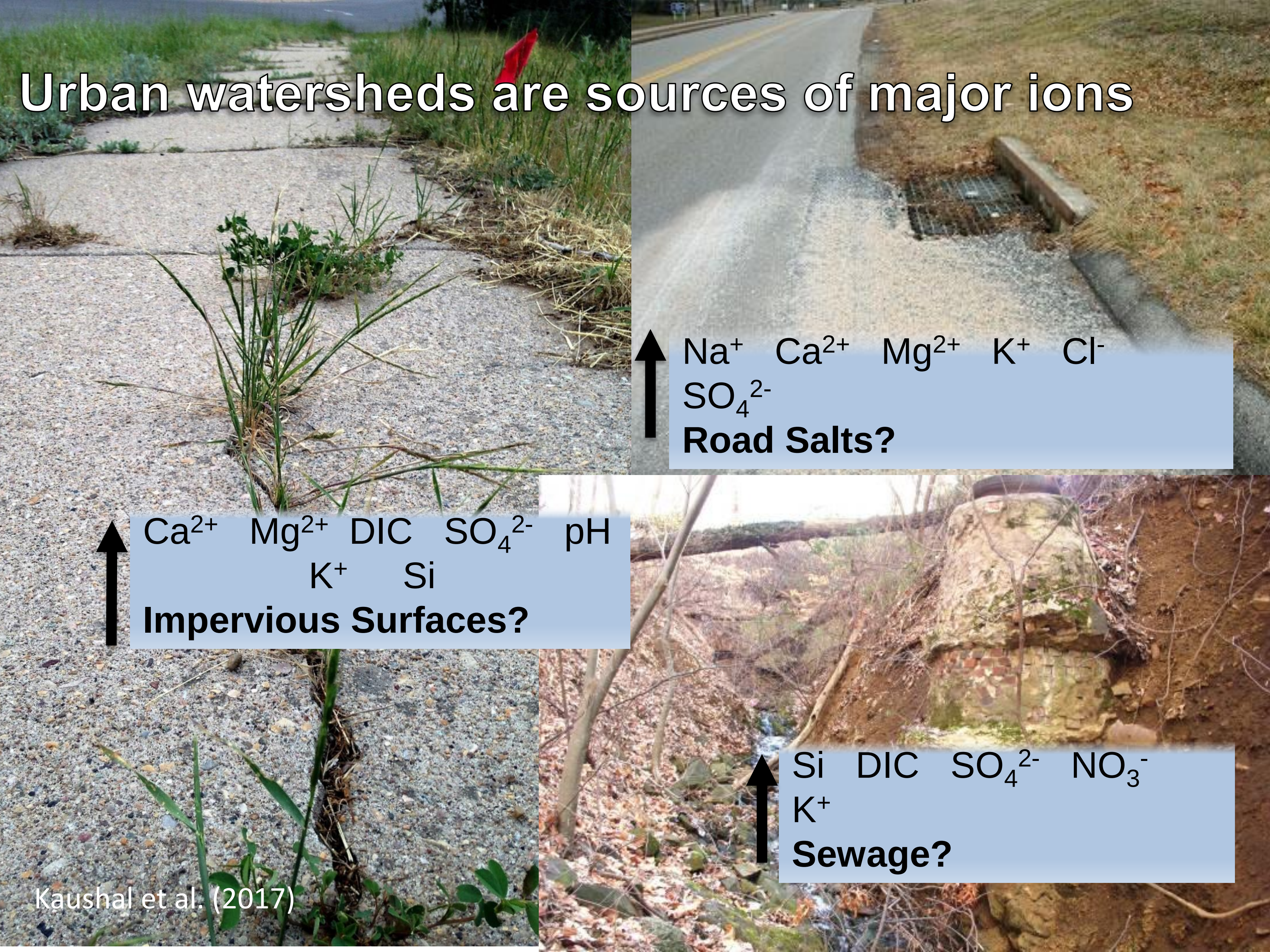
Lithologic Patterns adapted from the Federal Geographic Data Committee Digital Cartographic Standard for Geologic Map Symbolization (2006)

Map Created by Noah Bowman - Kaushal et al. (2017)

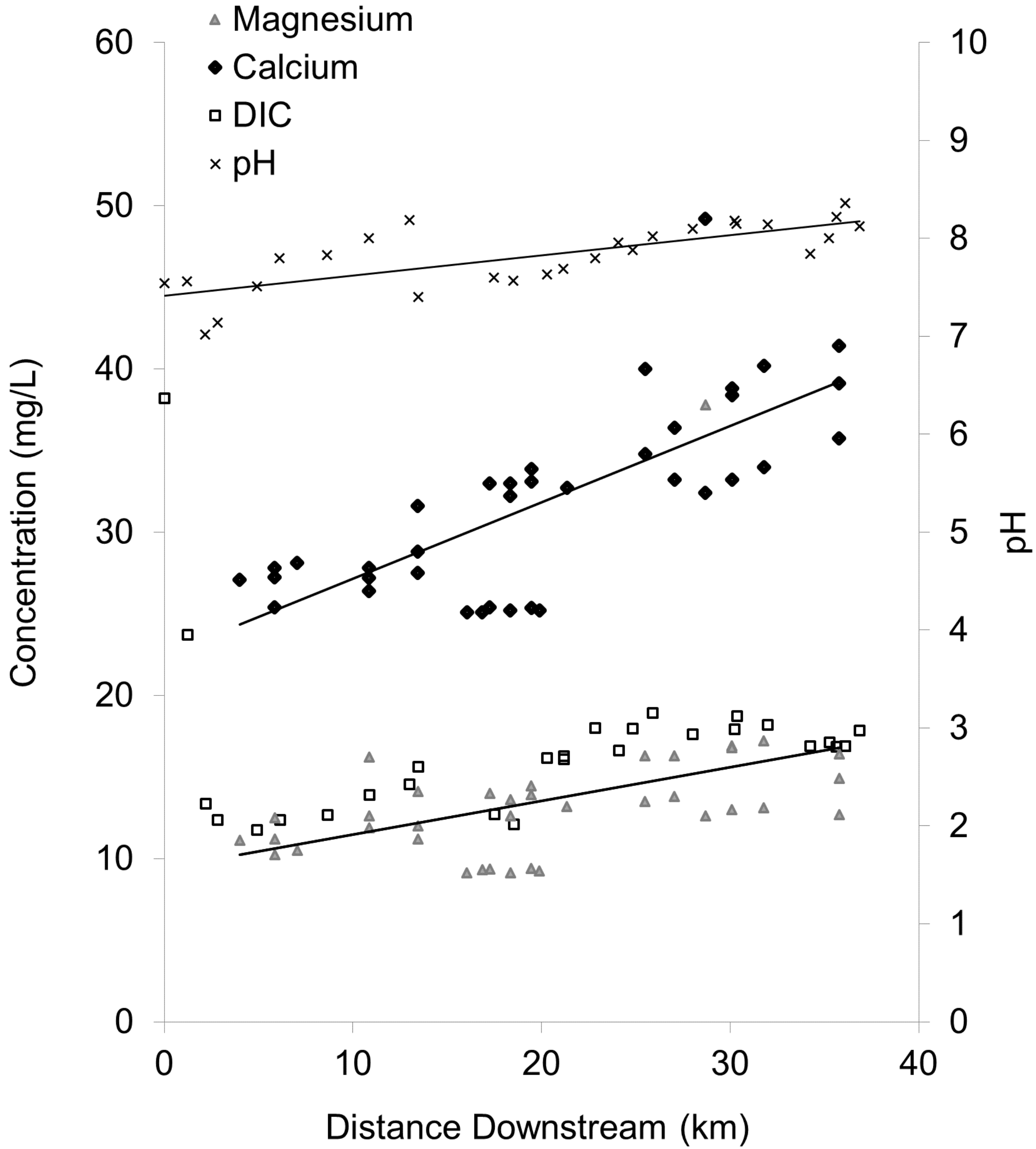


Kaushal et al. (2017)

Urban watersheds are sources of major ions



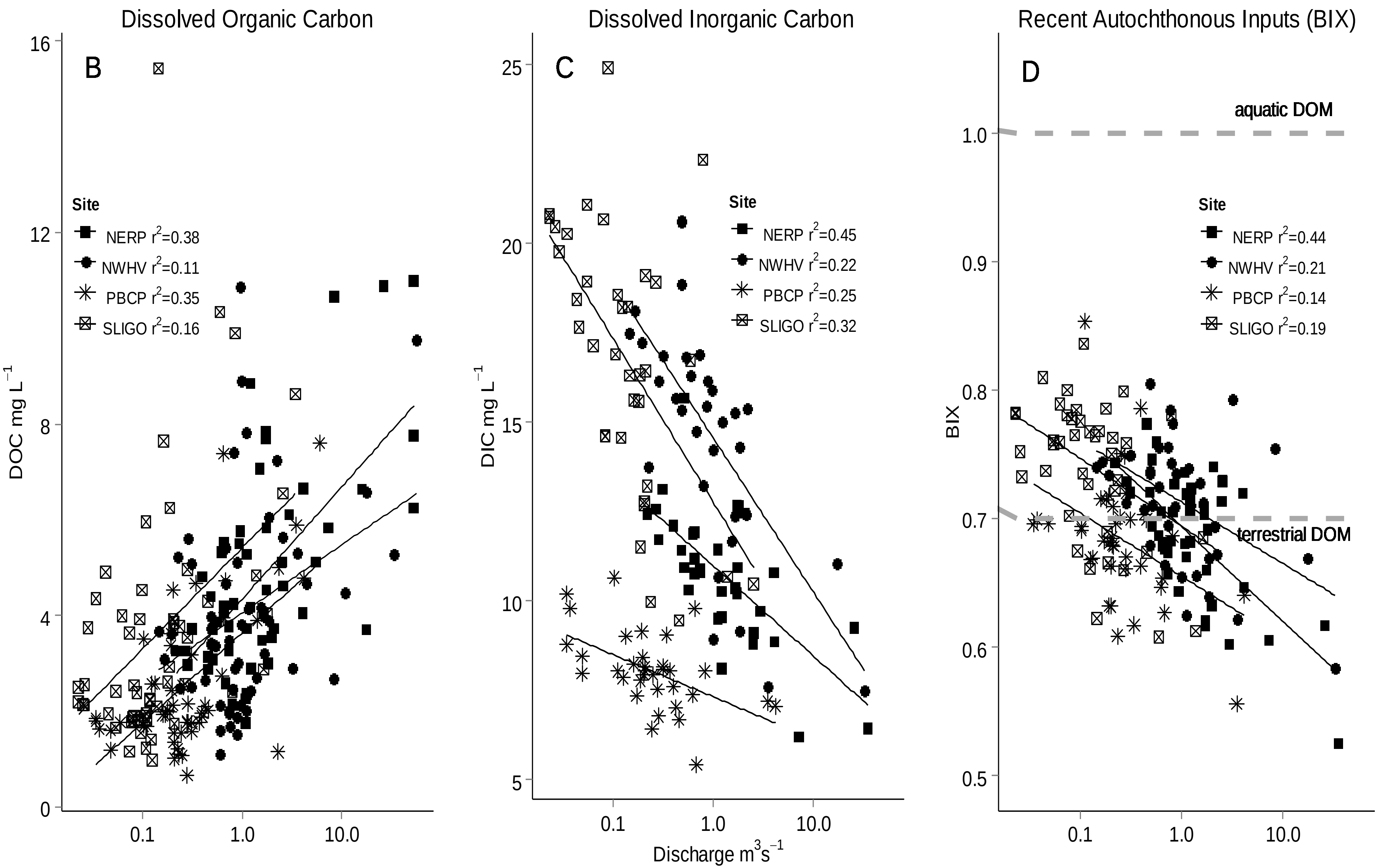
Coastal Alkalinization?



Kaushal et al. (2017)

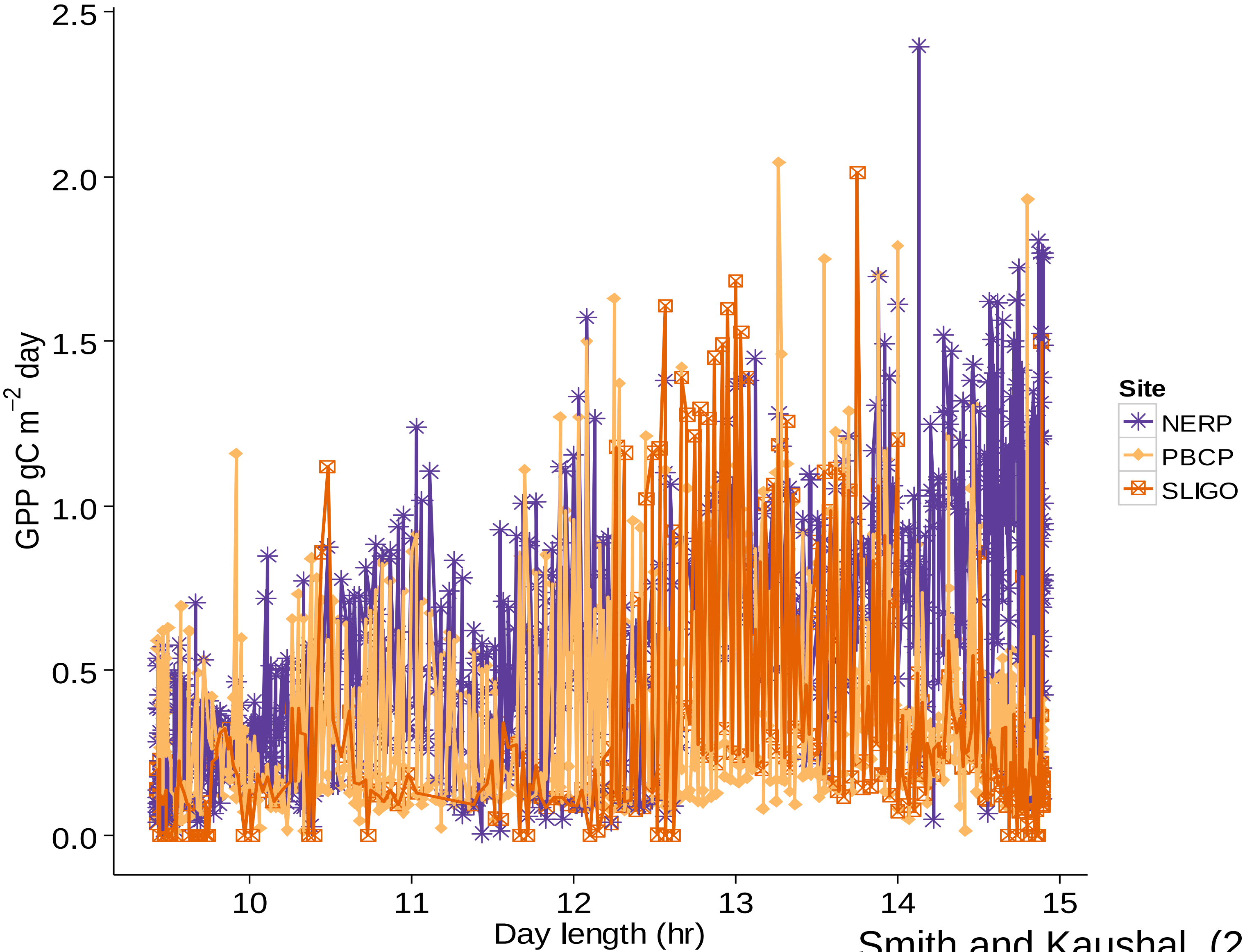
2. The Urban Watershed Continuum: Transporter or Transformer?

Discharge Controls Carbon Transport



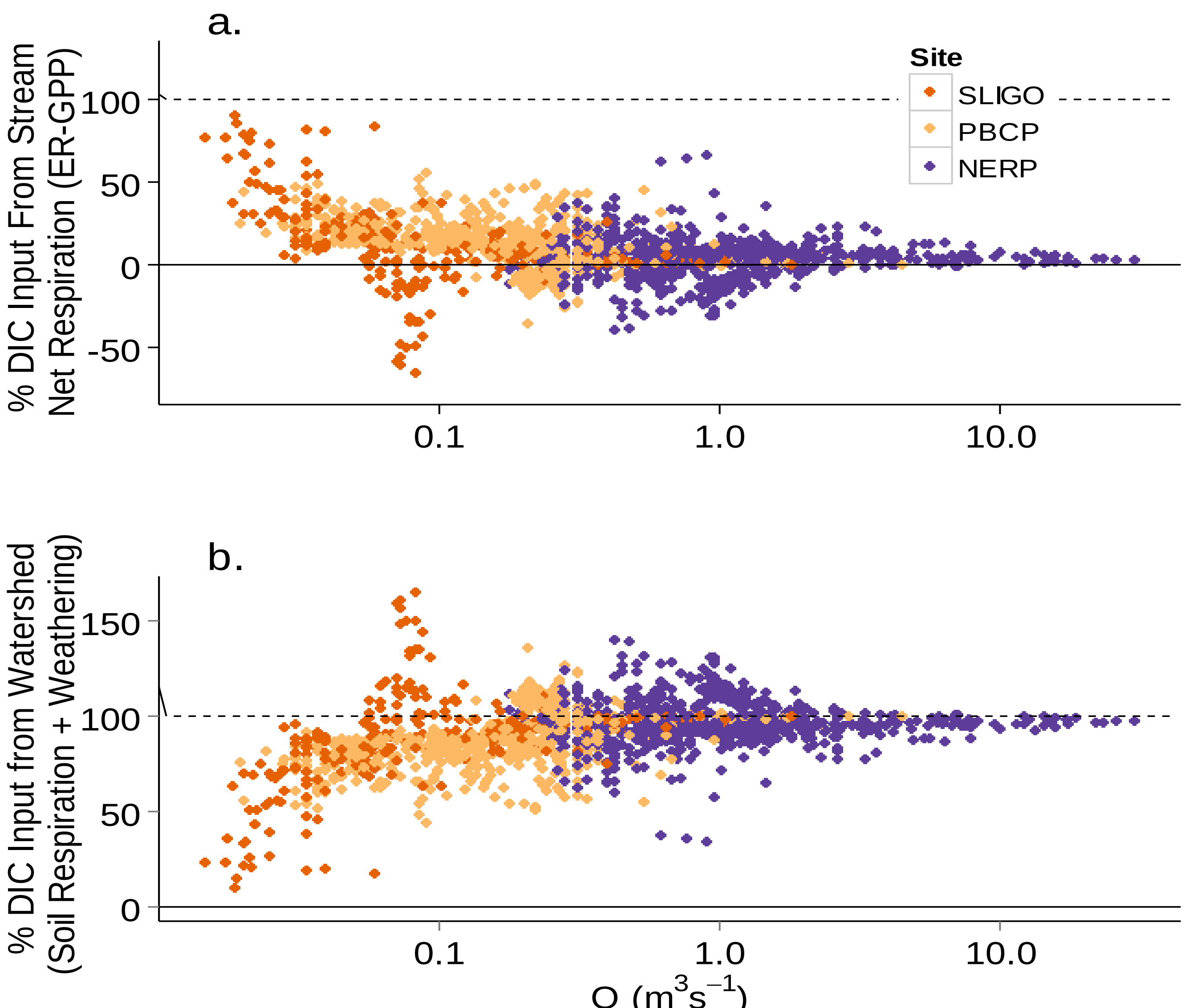
Smith and Kaushal (2015)

Light Controls Carbon Metabolism



Smith and Kaushal (2015)

Streams as Tranporters *vs.* Transformers?

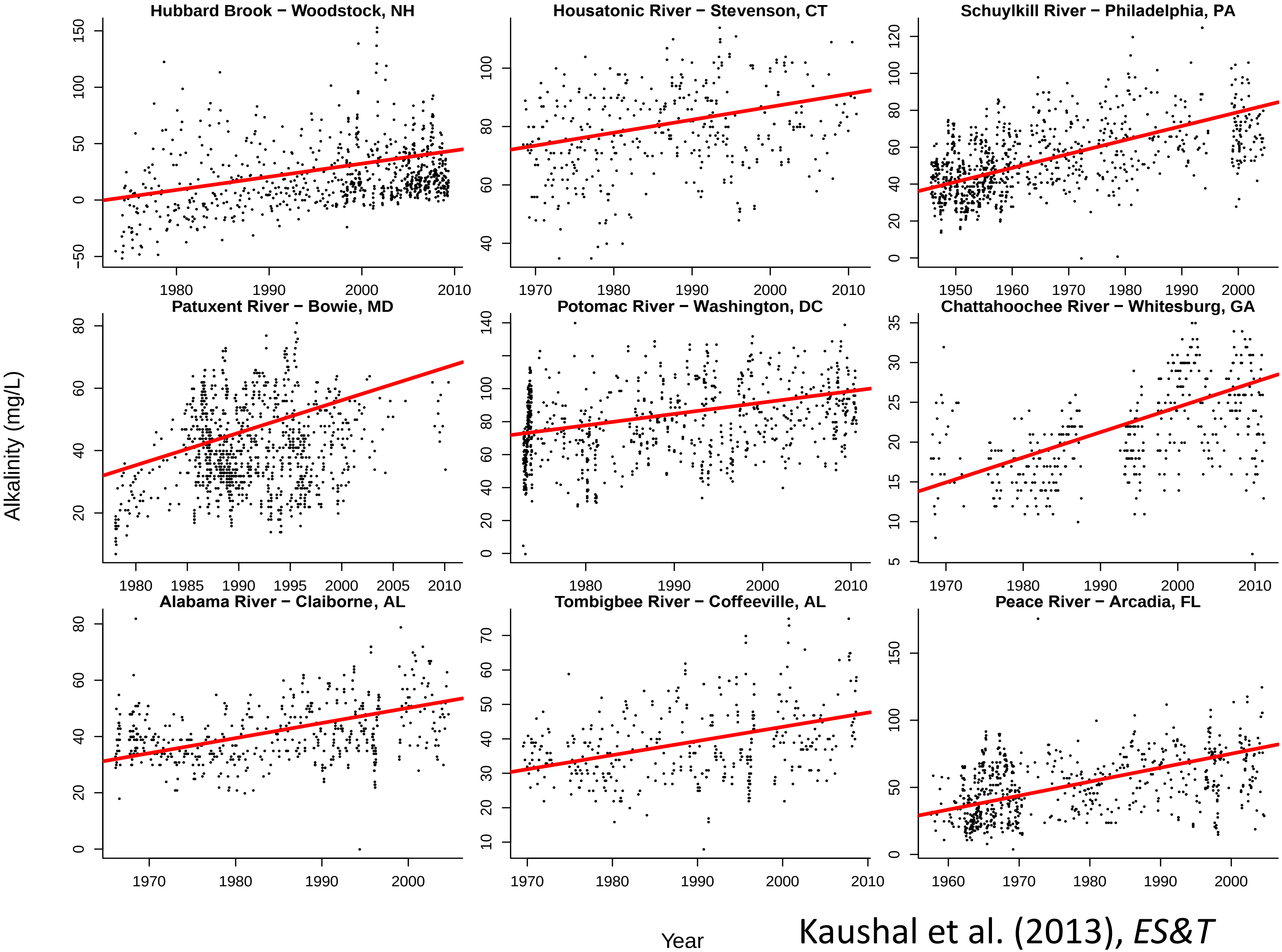


Smith and Kaushal (2015)

3. Implications for the Coastal Carbon Cycle?

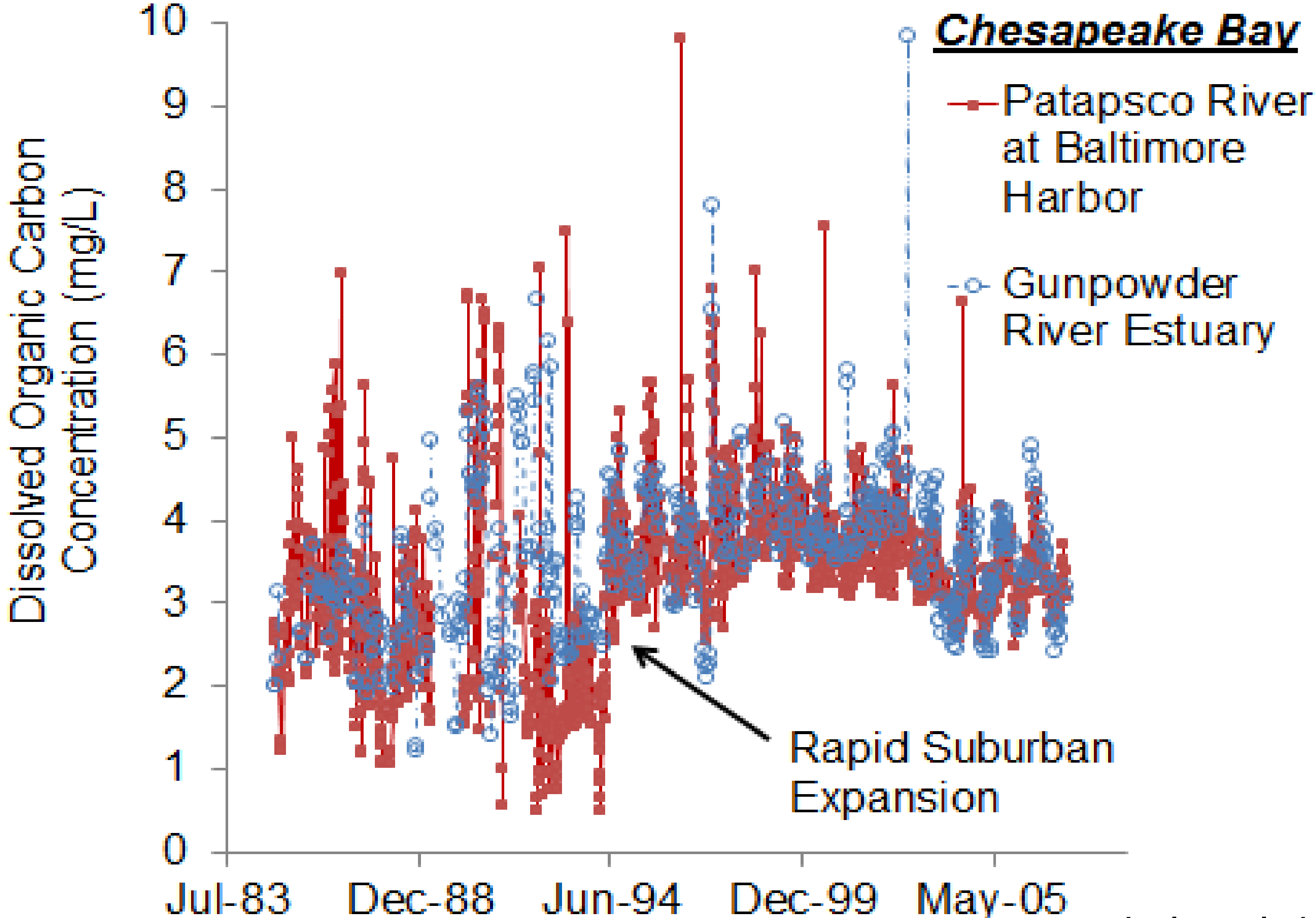
Courtesy of ICPRB

Increased Inorganic Carbon in Rivers



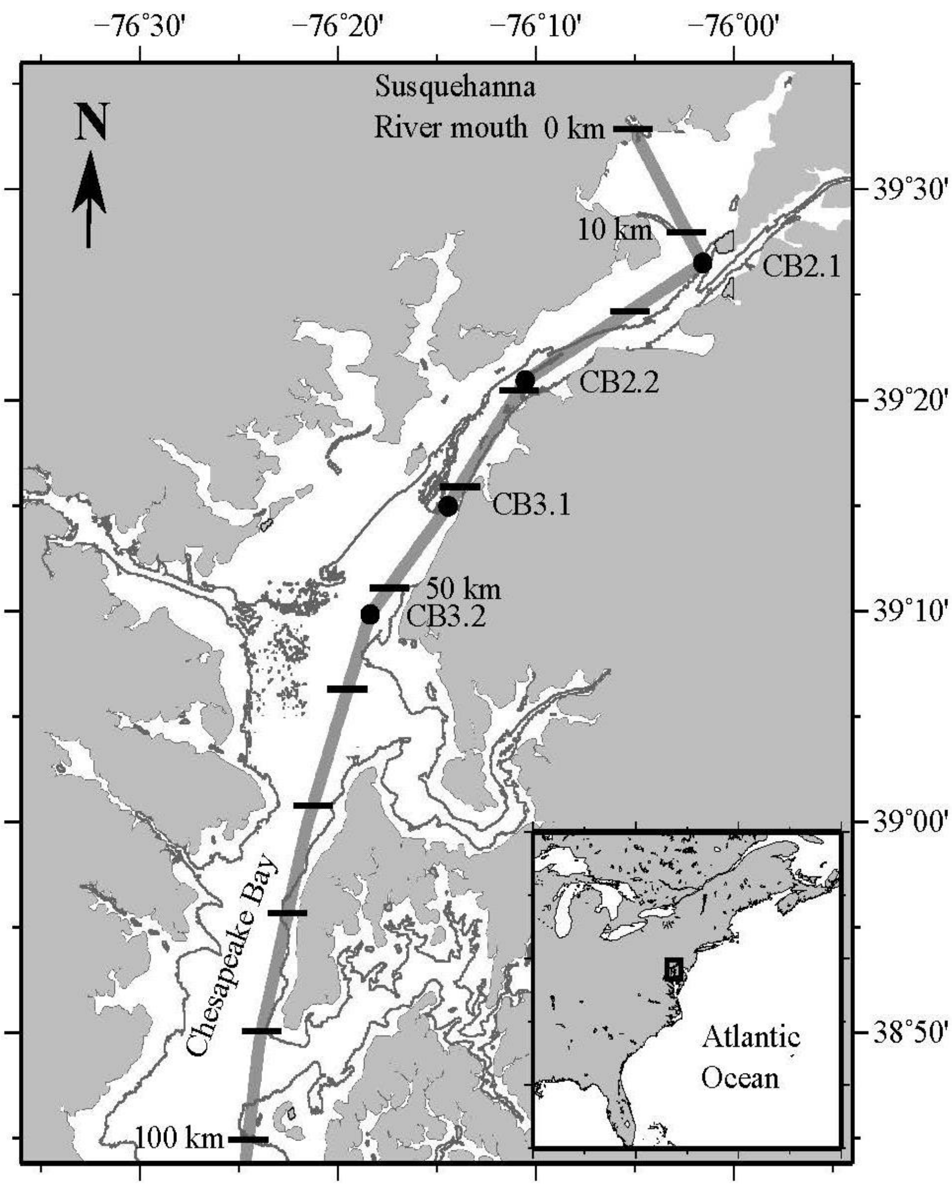
Kaushal et al. (2013), *ES&T*

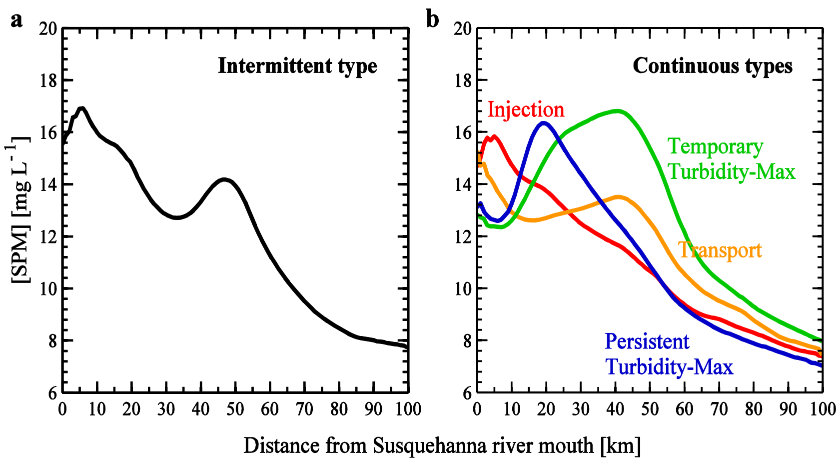
Land Use Change Increases Carbon to Coastal Zones



Kaushal et al. (2014)

Links with Remote Sensing?





Evolution of sediment plumes in the Chesapeake Bay (2015)

Guangming Zheng, Paul M. DiGiacomo, Sujay S. Kaushal, Marilyn A. Yuen-Murphy, Shuiwang Duan

CONCLUSIONS

- Transport and transformation along an urban watershed continuum (space and time)
- Long-term changes in coastal carbon cycle – human-accelerated weathering and metabolism
- Links between remote sensing and coastal biogeochemistry…exploring w/ NOAA

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