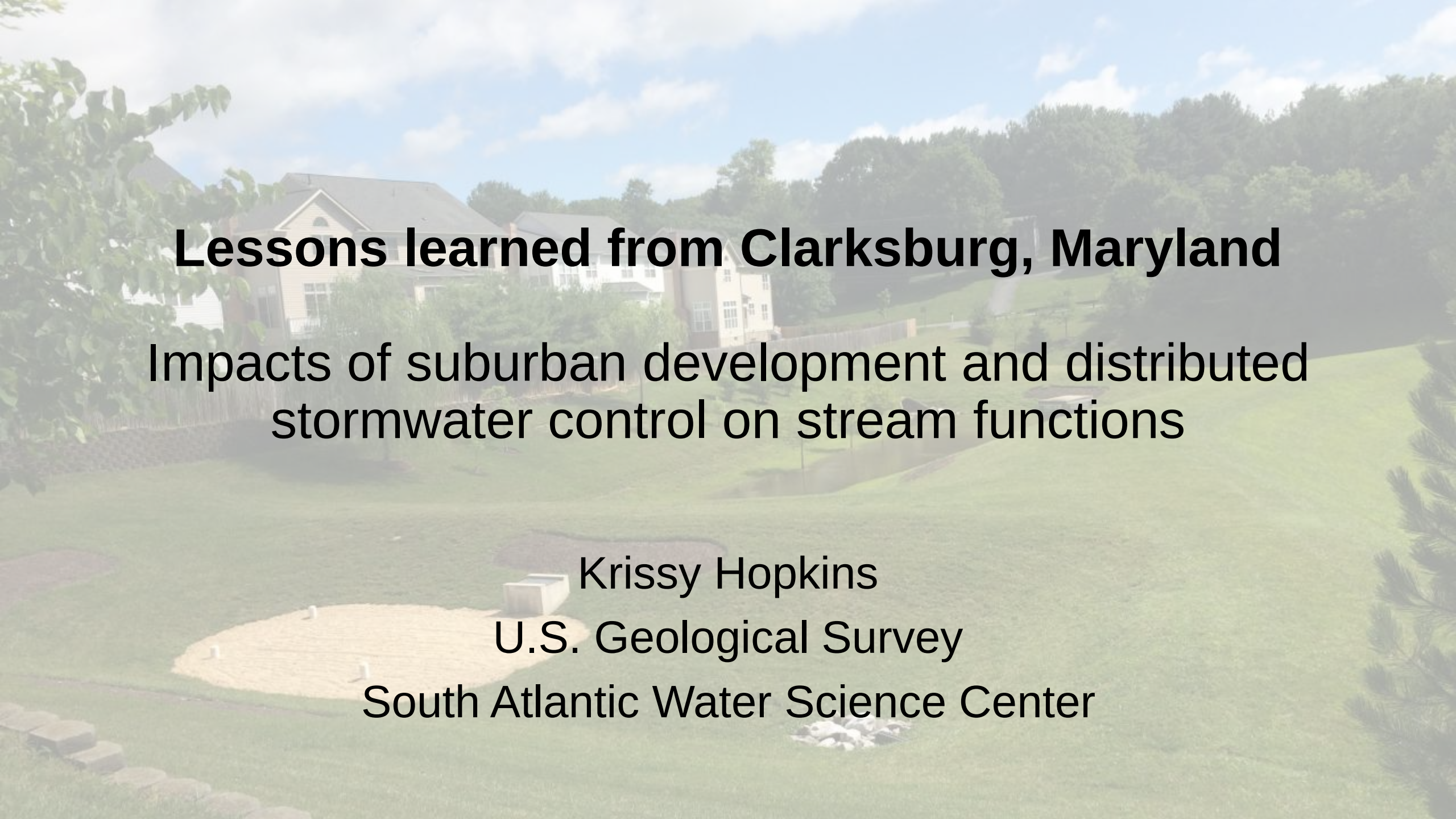


Lessons learned from Clarksburg, Maryland

Impacts of suburban development and distributed stormwater control on stream functions

Krissy Hopkins

U.S. Geological Survey

South Atlantic Water Science Center

USGS Urban BMP Team

Krissy Hopkins

Natalie Hall

Brianna Williams

Marina Metes

Charlie Stillwell

Rosemary Fanelli

Dan Jones

USGS
science for a changing world

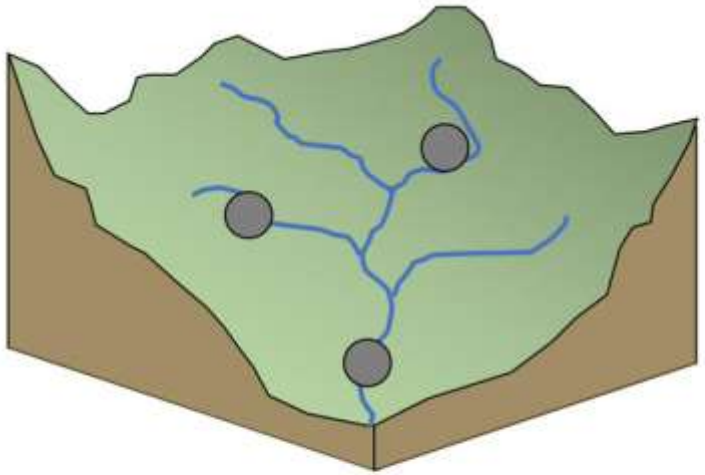
Road Map

- Objectives
- Study area
- Lessons learned

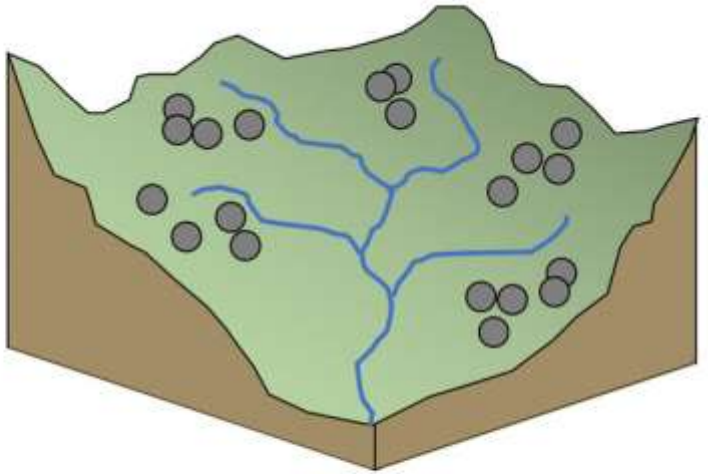
USGS
science for a changing world

Objectives

What happens to stream health when **agricultural land is converted to suburban development** with distributed stormwater infrastructure practices incorporated into the design of the neighborhood.



Centralized stormwater management
A few, large practices



Distributed stormwater management
Many, smaller practices

USGS
science for a changing world

Objectives

How does the use of distributed stormwater facilities on a watershed scale affect

Hydrology
Peak flows
Runoff volumes
Baseflow

Water Quality
Nutrients
Specific conductance

Topography
Elevation change
drainage

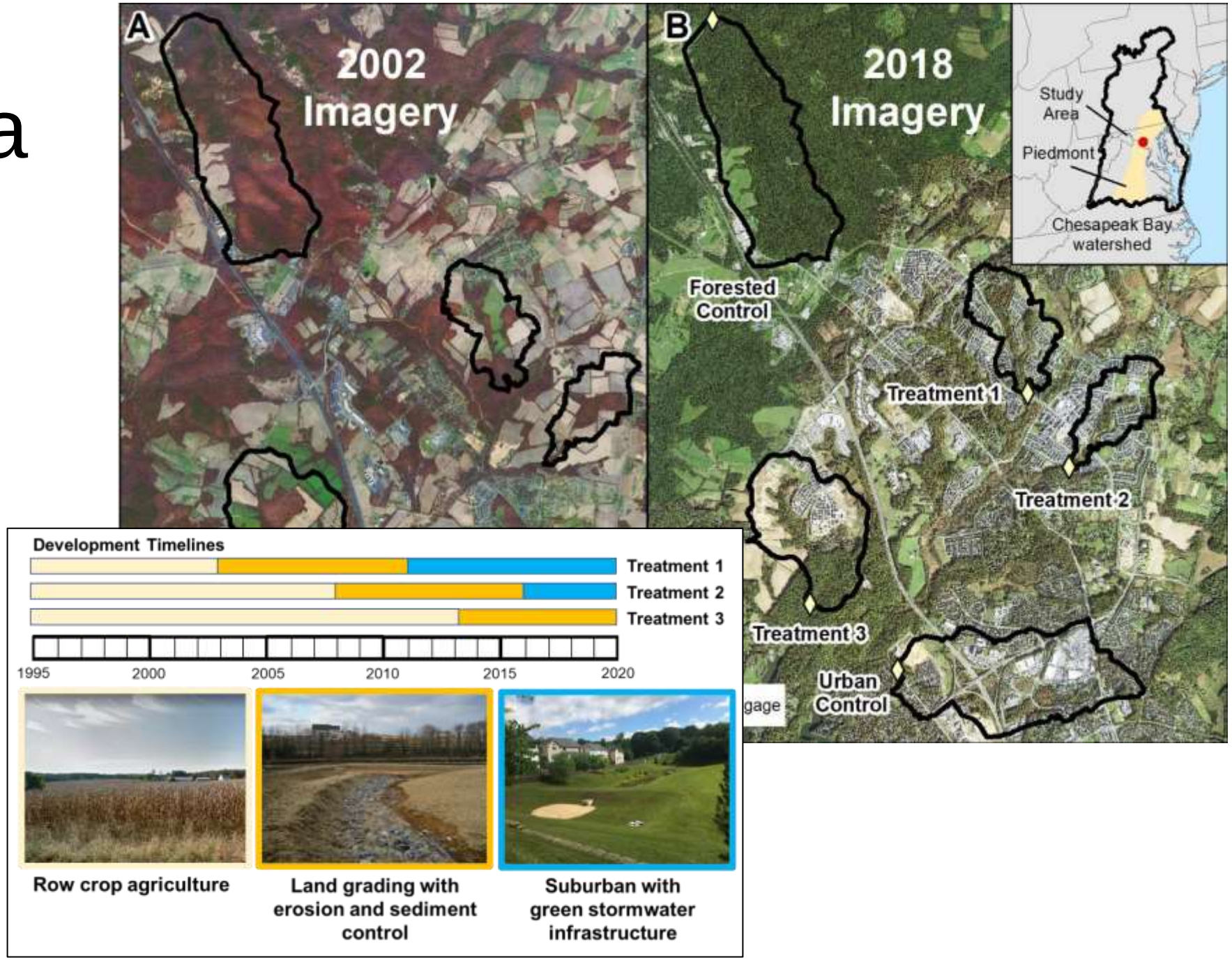
Benthic Community

Study Area

Clarksburg, Maryland

Control vs treatments sites

Tracking changes during and after development



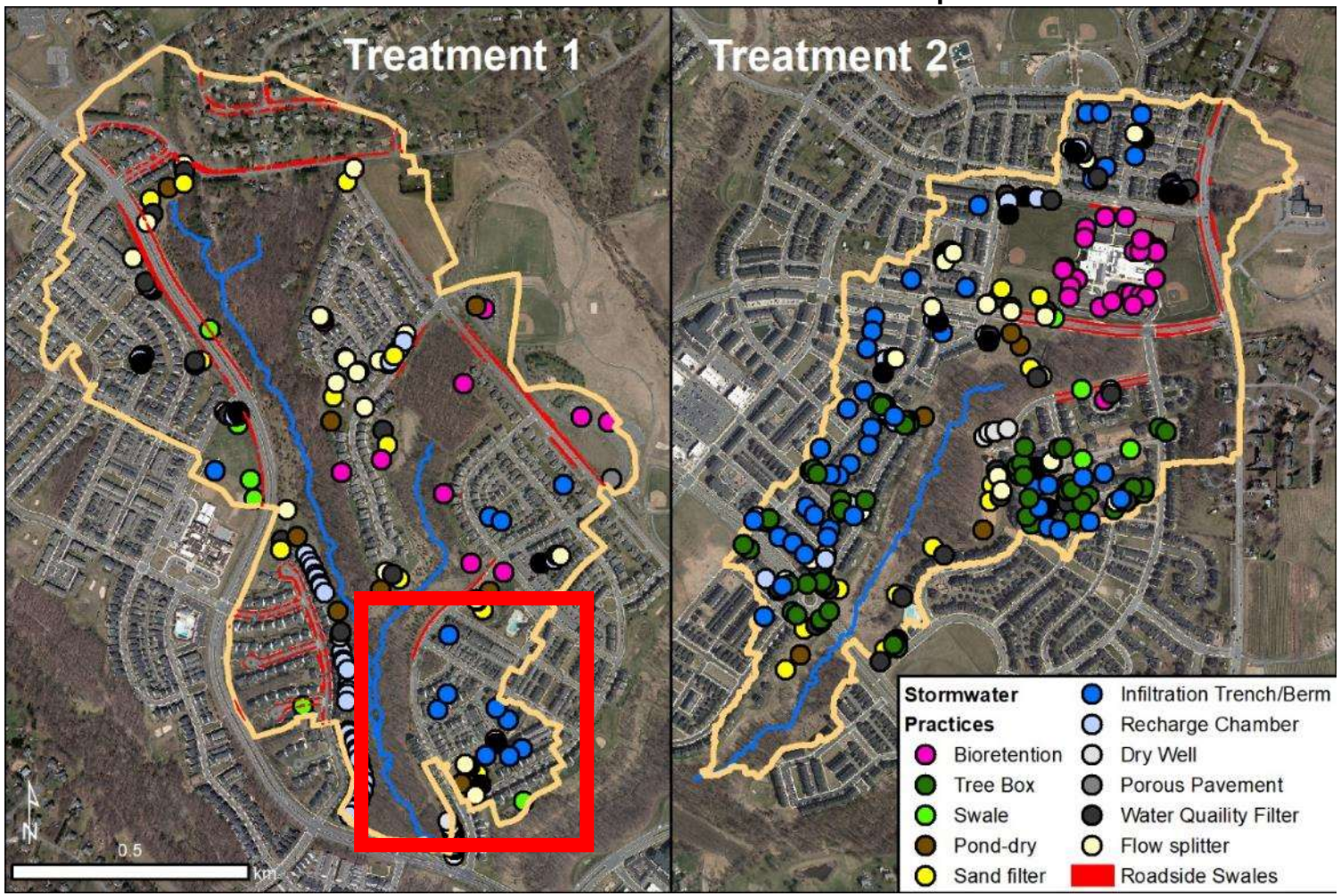
USGS
science for a changing world

100% of impervious surfaces are treated

Dry wells
infiltration
detention
swales

33% impervious
91% single family detached
105 practices/km^2

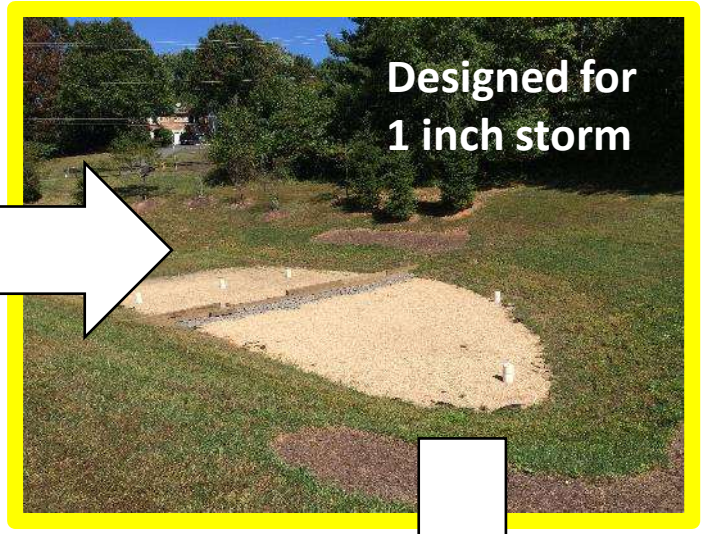
44% impervious
50% detached, 50% townhouse
274 practices/km^2



Tree boxes and
infiltration
detention

USGS
science for a changing world

Stormwater practices arranged in treatment trains

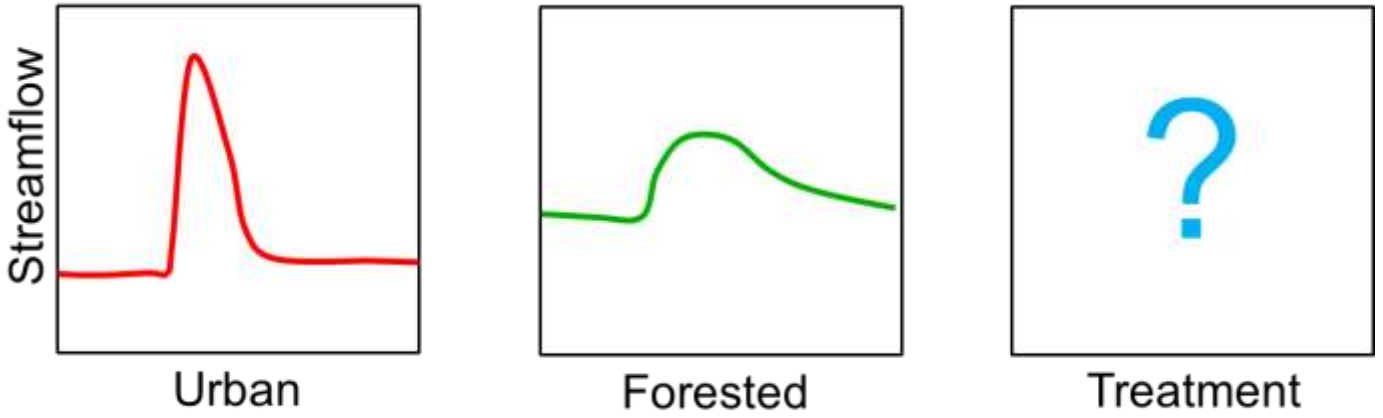


How does the use of distributed stormwater facilities on a watershed scale affect

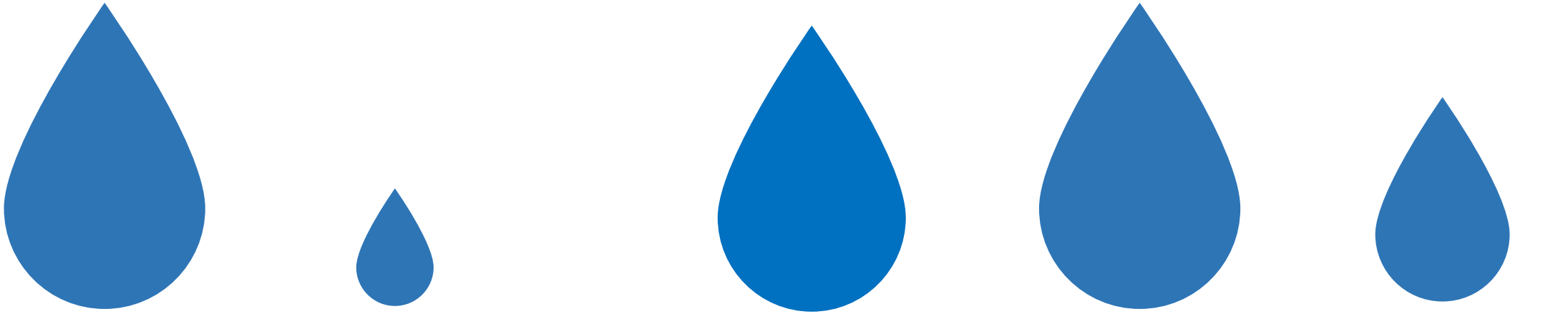
Hydrology

Hydrology
Peak flows
Runoff volumes
Baseflow

Distributed stormwater management can **reduce runoff yields and peak flows compared** with **centralized** stormwater management



How much rain falls before a flow response?



Forested
0.7 in

Urban
Centralized
0.2 in

Treatment 1
After
0.6 in

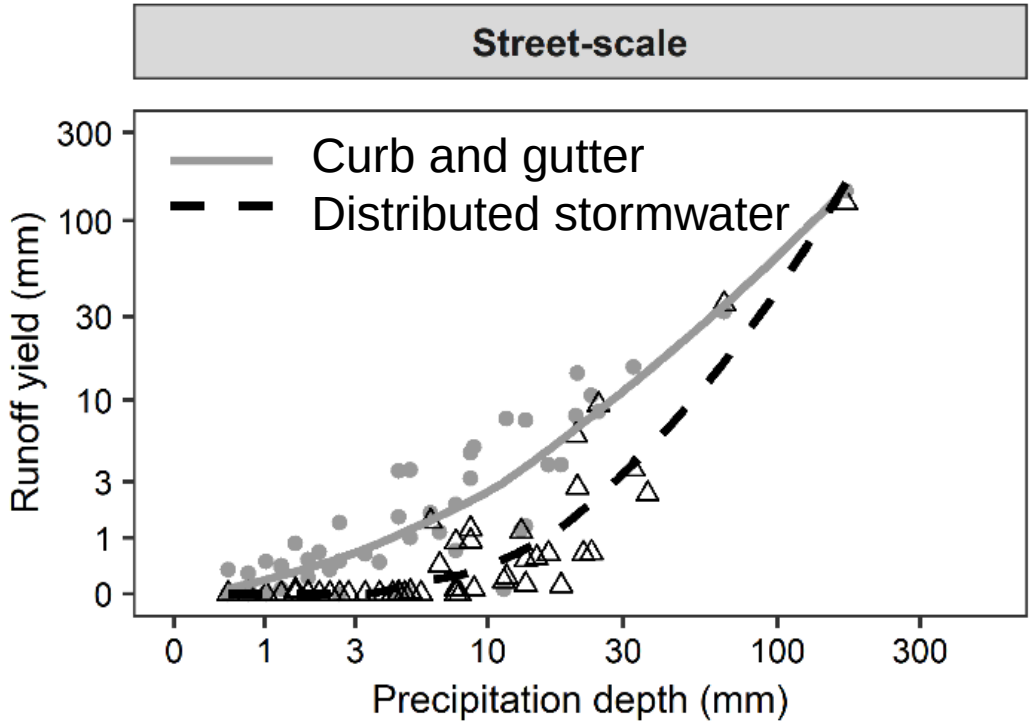
Treatment 2
Before
0.7 in

Treatment 2
After
0.5 in

USGS
science for a changing world

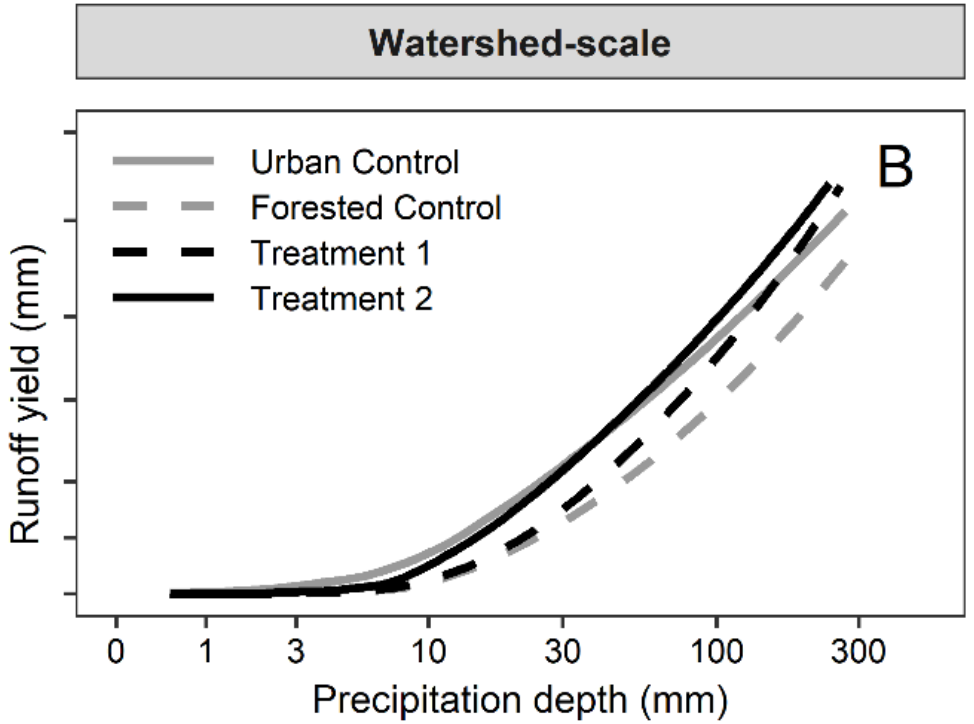
Hopkins et al. 2020 *Hydro Processes*

What happens to runoff yield at the street scale?
More runoff from the curb and gutter neighborhood



Hopkins et al. 2022 *Freshwater Science*

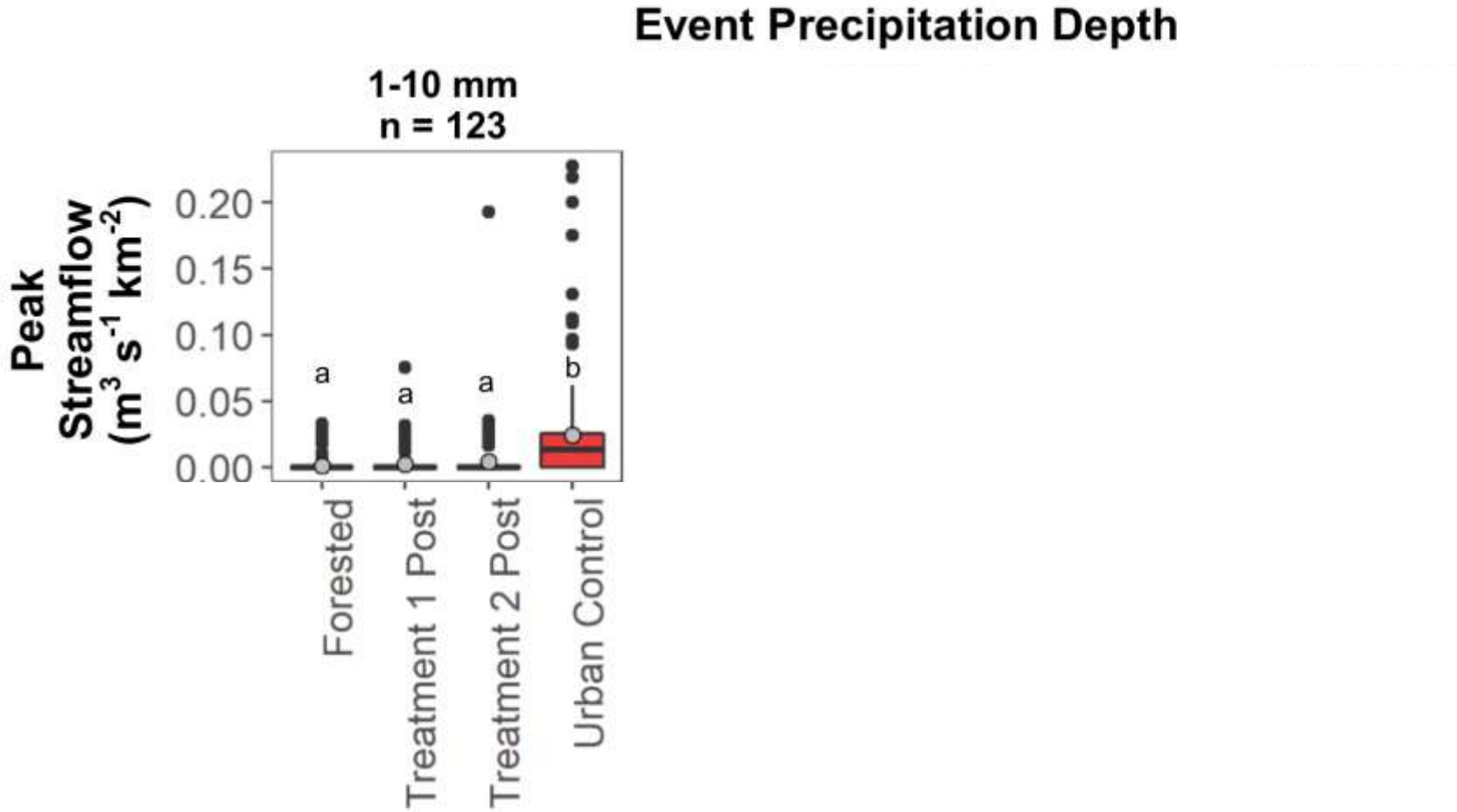
What happens to runoff yield at the watershed scale?
More runoff from centralized urban control and Treatment 2



Hopkins et al. 2022 *Freshwater Science*

After Development in Treatment 1 and 2

Peak flows were attenuated for small precipitation events (< 10mm)

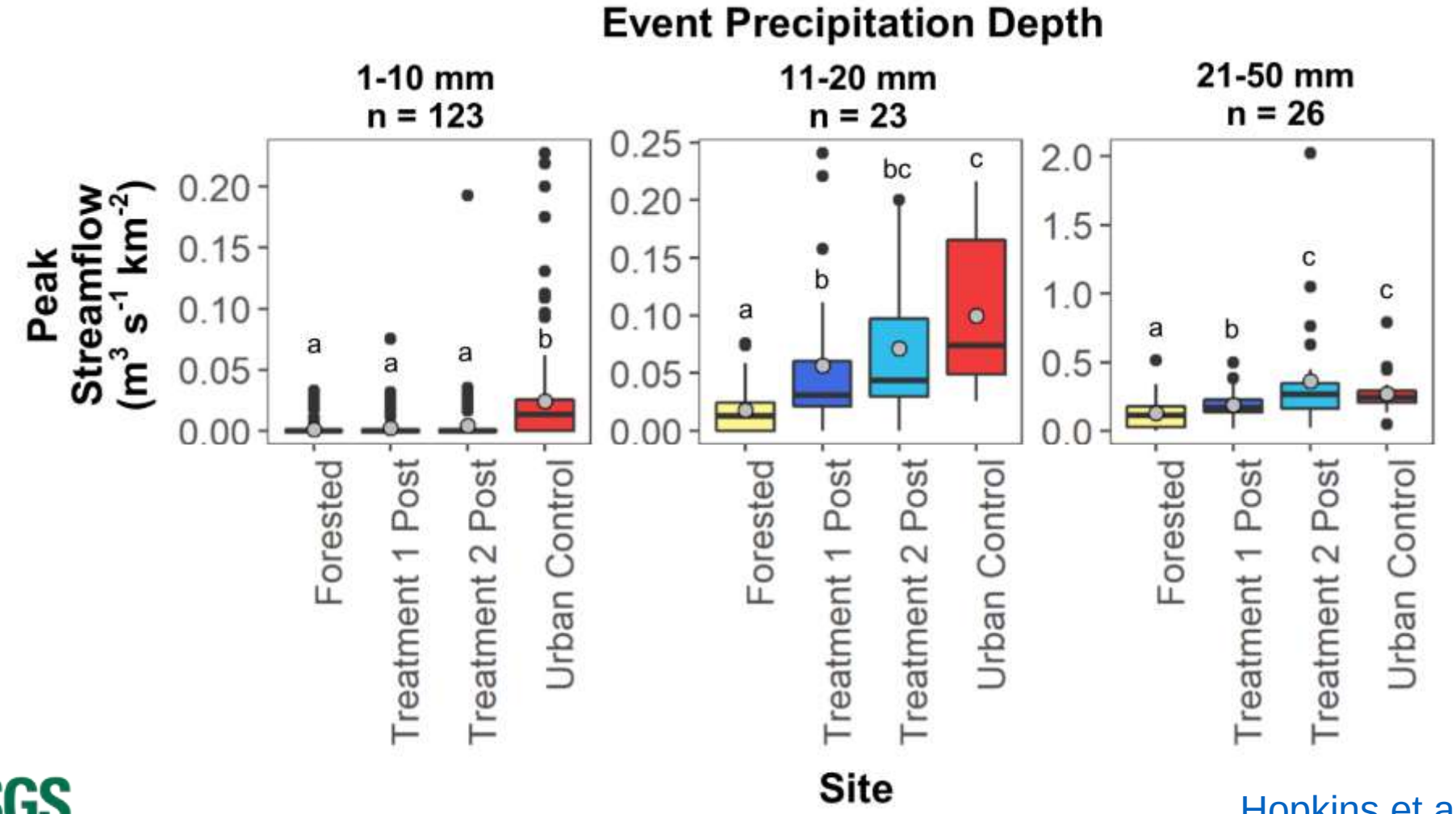


USGS science for a changing world

Hopkins et al. 2020 *Hydro Processes*

After Development in Treatment 1 and 2

Peak flows were 2-3 higher in treatments than forested site (11-20 mm)



Hopkins et al. 2020 *Hydro Processes*

BEFORE

2004
2% impervious cover

VS

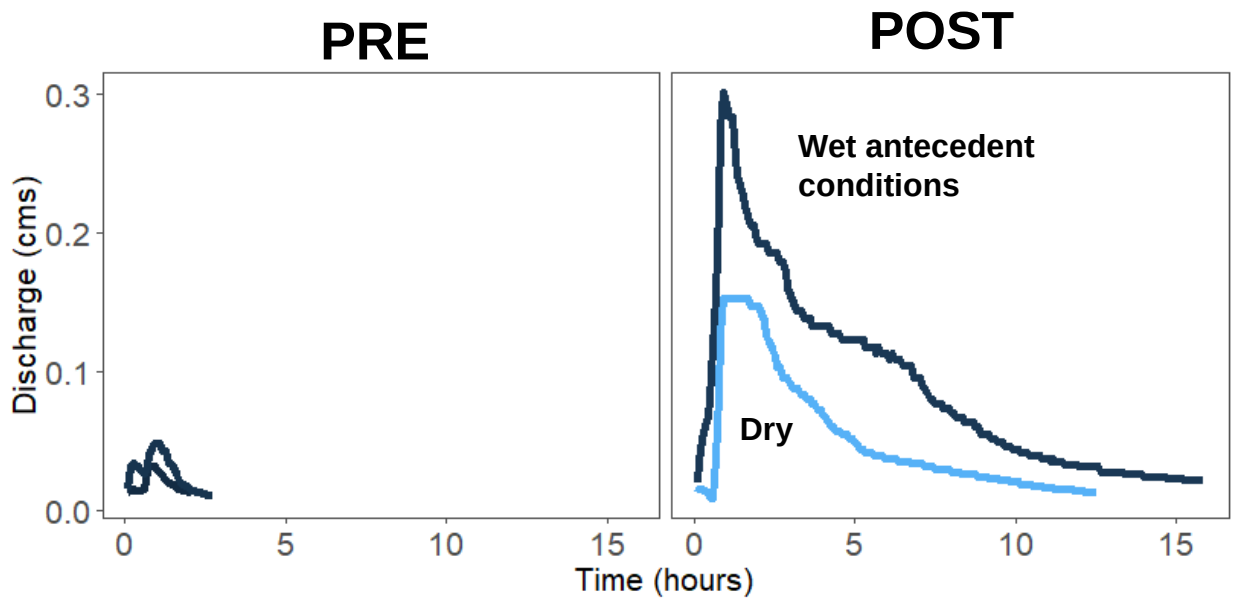
AFTER

2017
44% impervious cover

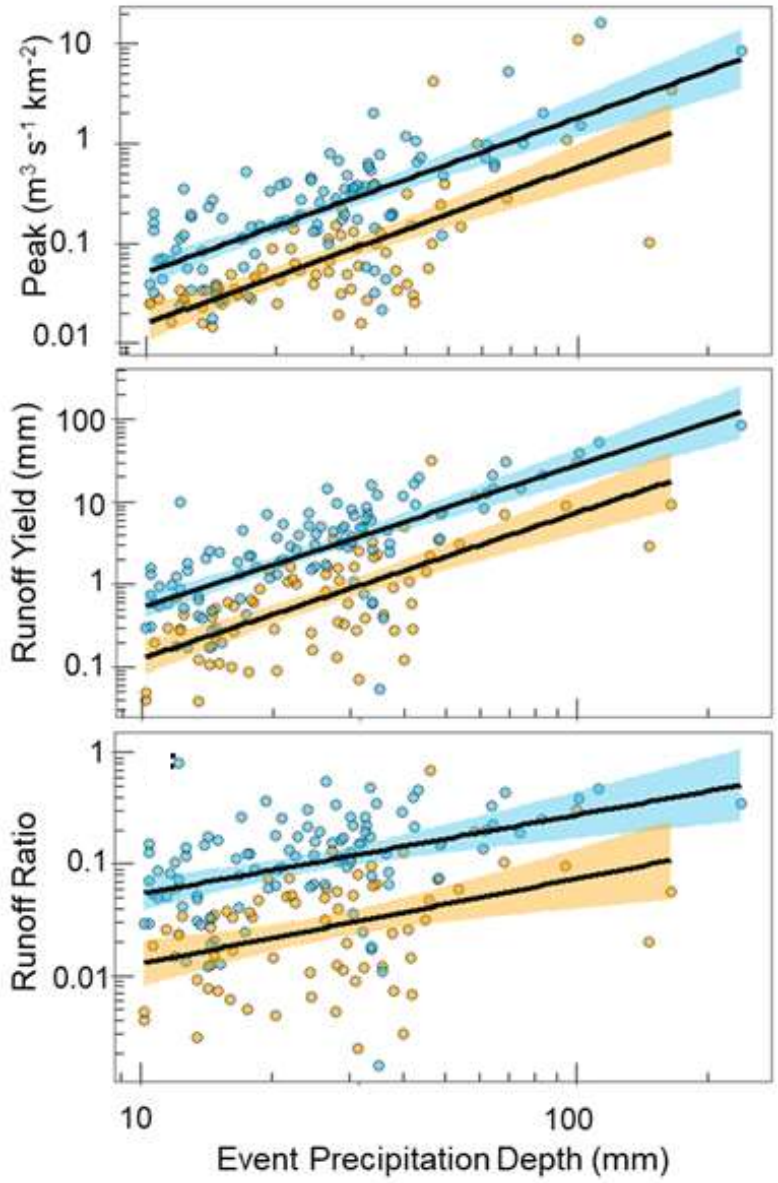
Streamflow changes in Treatment 2

Before Development vs After Development

Event Duration
Peak Streamflow
Runoff Yield
Runoff Ratio



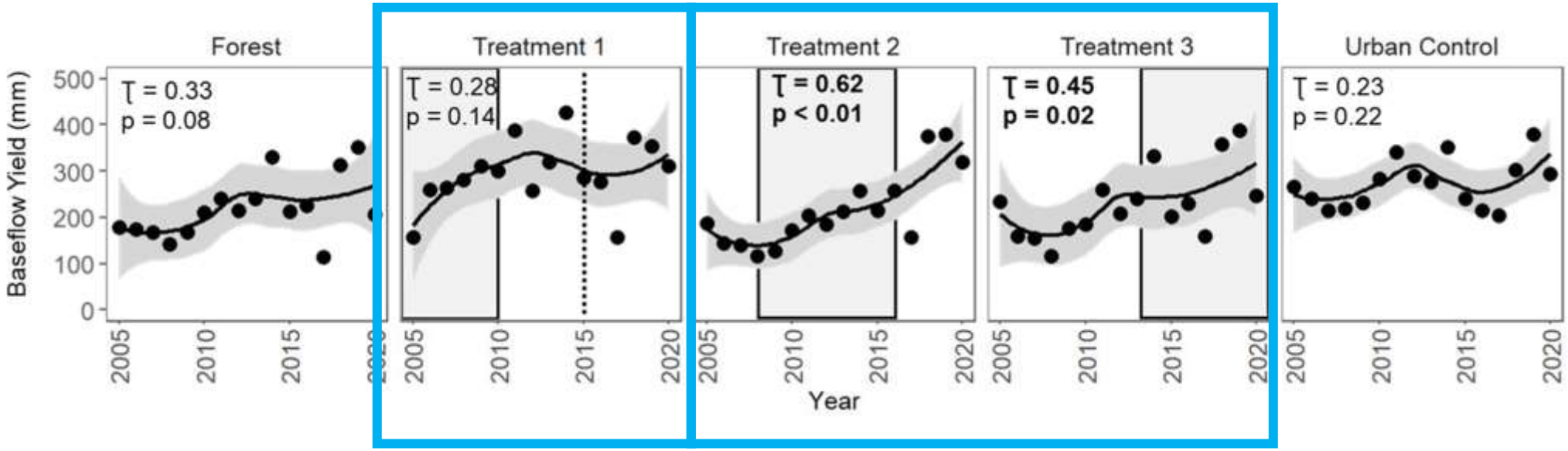
1.2-1.6 inches rain



USGS science for a changing world

Hopkins et al. 2020 *Hydro Processes*

Baseflow increased during the construction phase of suburban development



USGS science for a changing world

Hopkins et al. 2022 *Freshwater Science*

Can distributed stormwater control maintain hydrologic function?

Can attenuate peak flows and runoff volumes, **but** storage capacity matters.

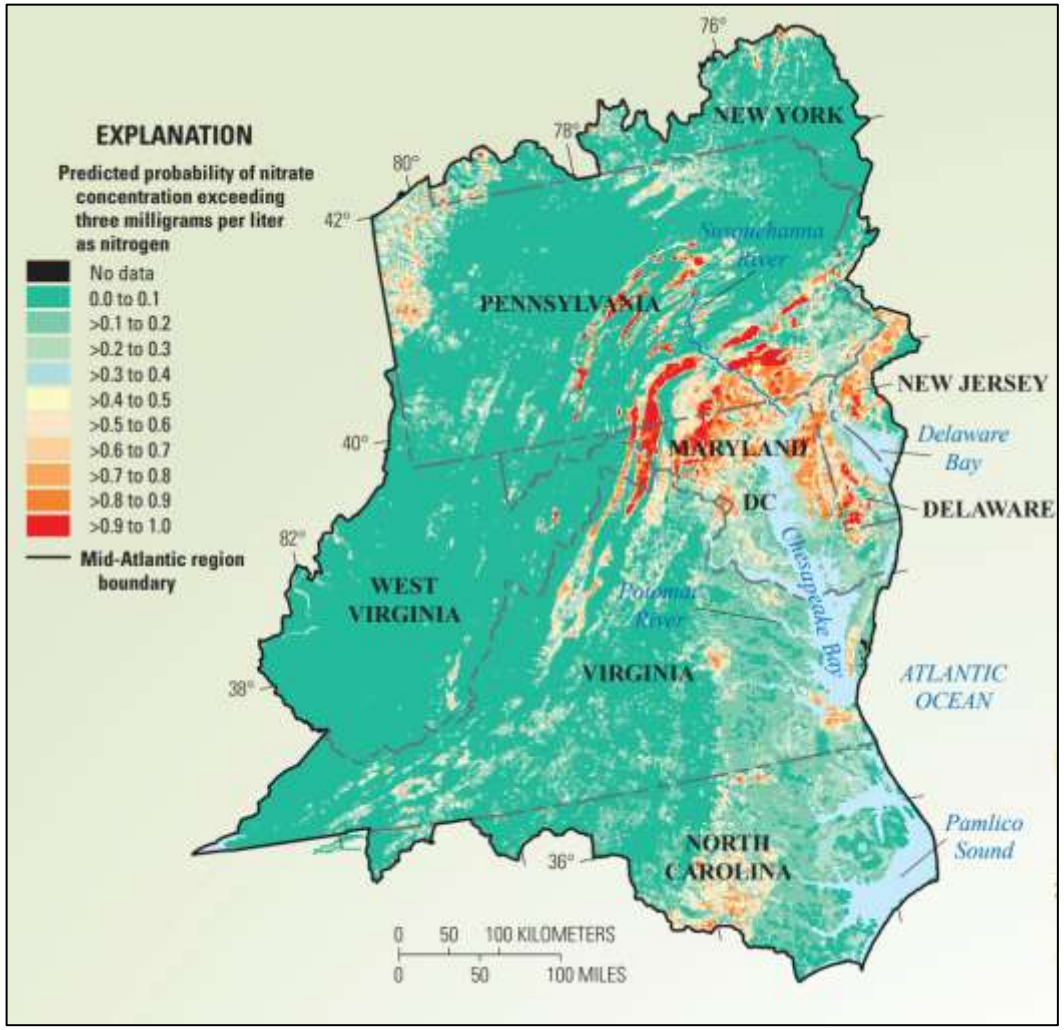
Large rain events not adequately controlled in any of the urban sites.

Baseflow may increase during construction and remain elevated.

How does the use of distributed stormwater facilities on a watershed scale affect

Water Quality – Baseflow Nitrate

Water Quality
Nutrients
Specific conductance

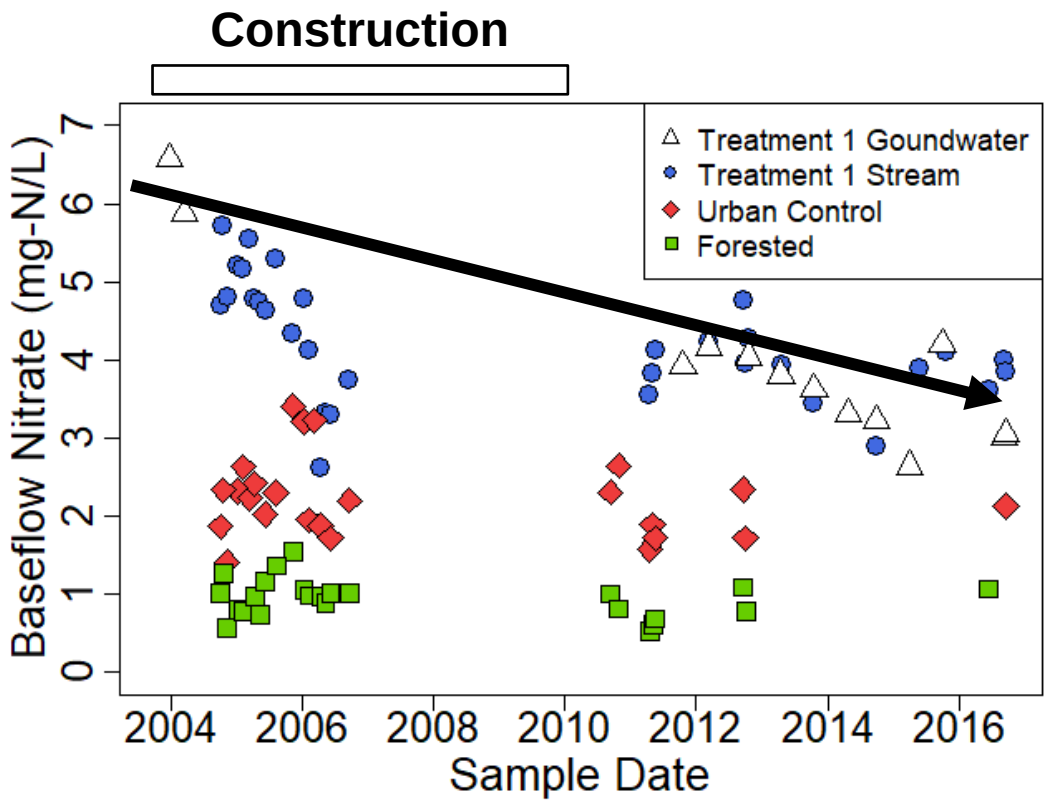


Probably of groundwater nitrate exceeding 3 mg/L

Clune & Capel 2021 USGS Circular

Baseflow nitrate concentrations

- Nitrate concentration declined but remain elevated

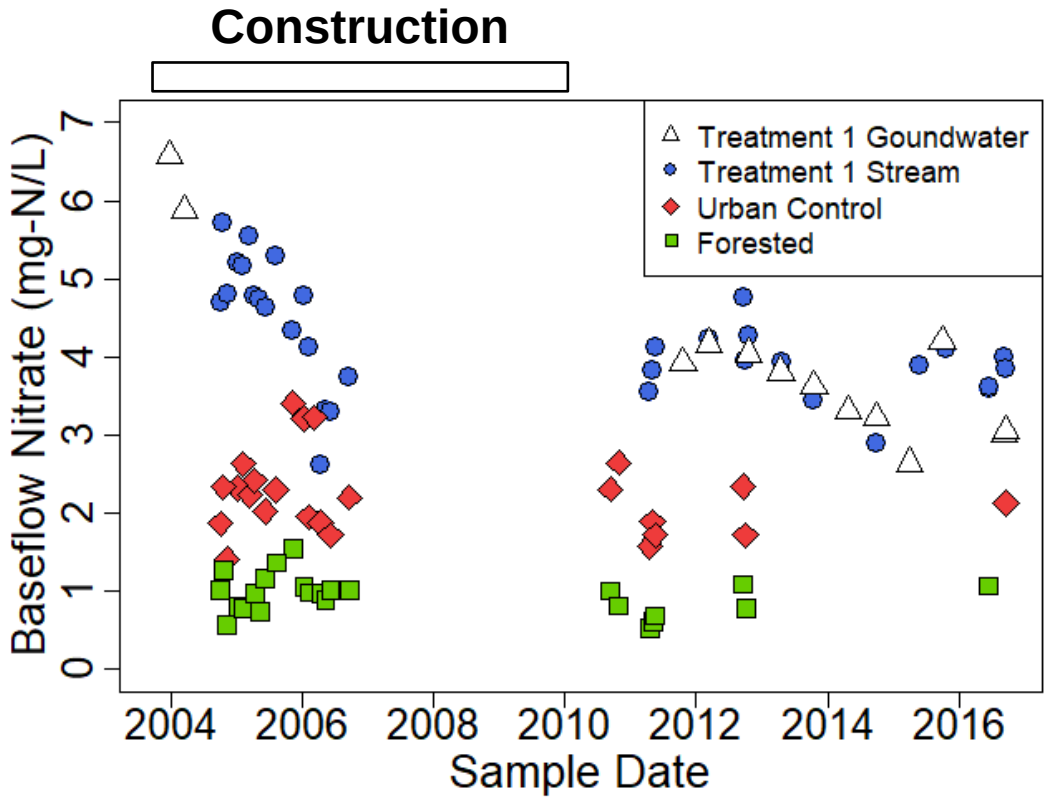


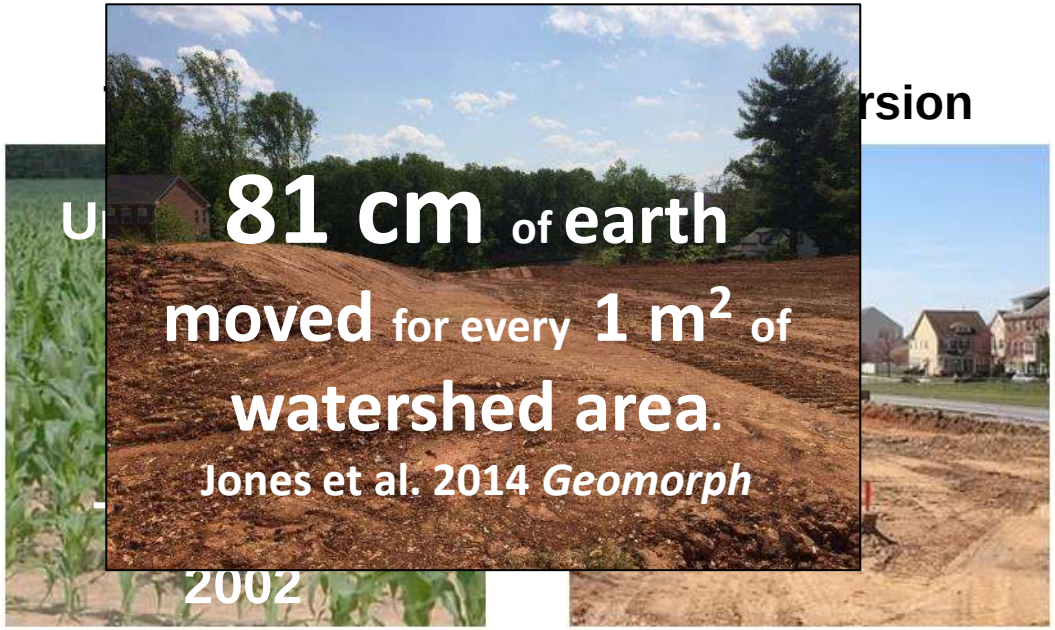
USGS science for a changing world

Hopkins et al. 2022 *Freshwater Science*

Baseflow nitrate concentrations

- Overall export remained about the same due to increased baseflow
- Declines in concentration may be related to removal of agriculture soils and reduction in fertilizer inputs

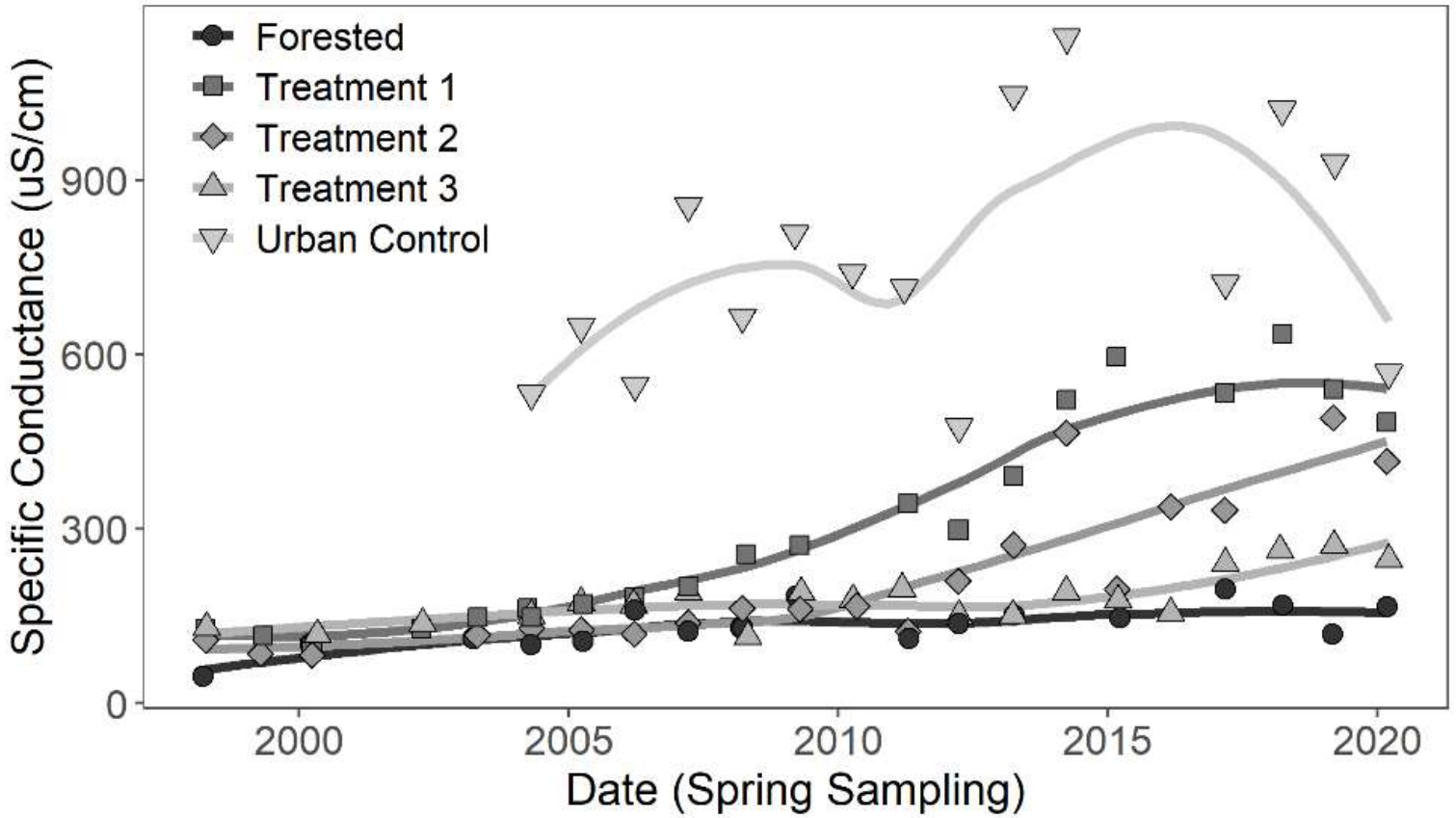




USGS science for a changing world

Hopkins et al. 2022 *Freshwater Science*

Rising specific conductance trends in all three treatment watersheds likely driven by imperious cover



32 µS/cm per year increase

20 µS/cm per year increase

6 µS/cm per year increase

USGS science for a changing world

Hopkins et al. 2022 *Freshwater Science*

Can distributed stormwater control maintain water quality?

It can reduce nitrate concentrations, **but** concentrations remain high due to ag past.

It can increase ion loads, **because** of more impervious cover and winter salting.

How does the use of distributed stormwater facilities on a watershed scale affect

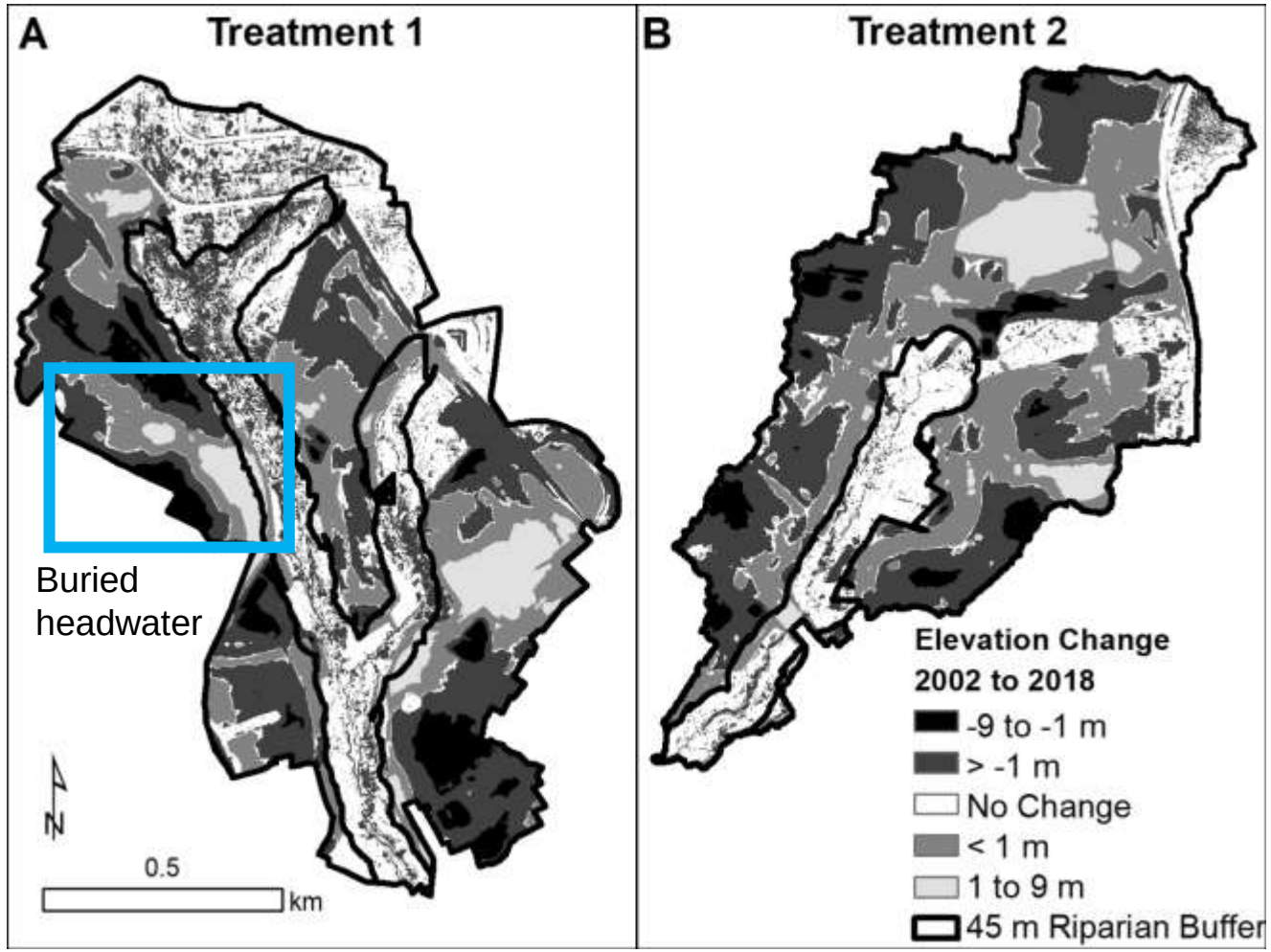
Topography and drainage patterns

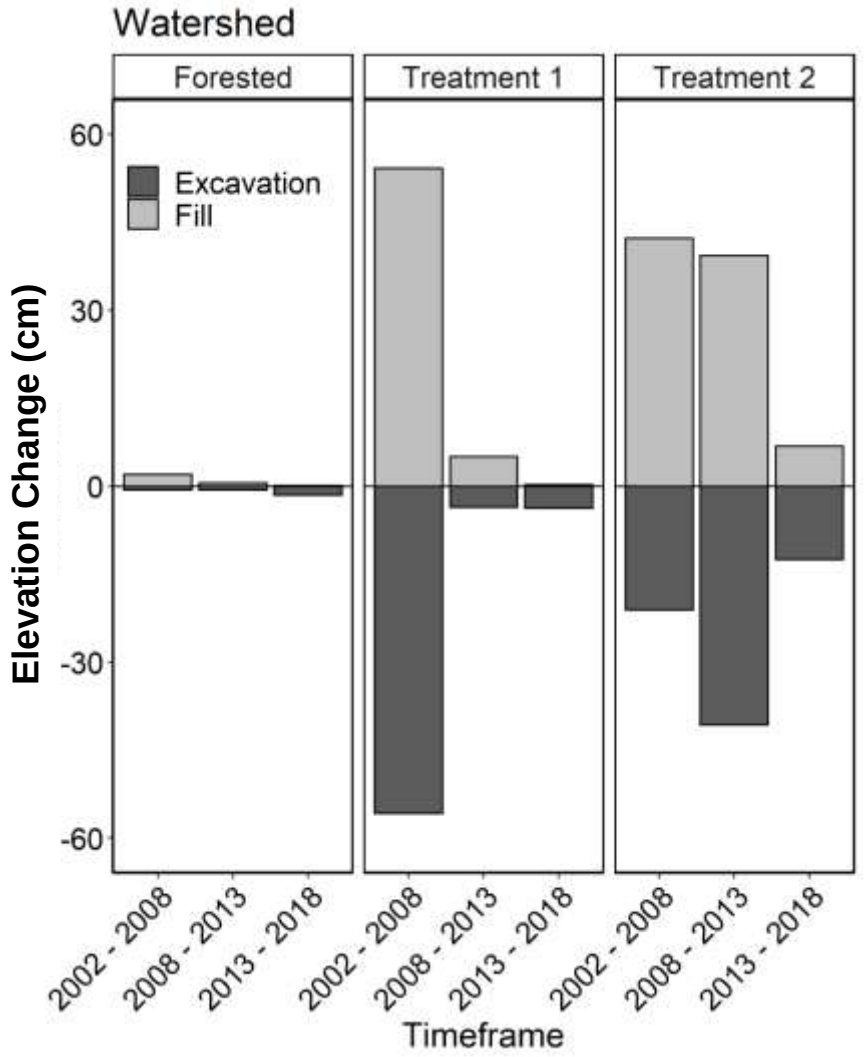
Topography and drainage patterns

Most topographic change occurred during the **construction phase**, with substantial excavation and fill across the entire watershed and **deposition within the riparian areas.**

Treatment 2 during construction in 2012

Large scale fill and excavation. Flatten ridgetops and fill valleys

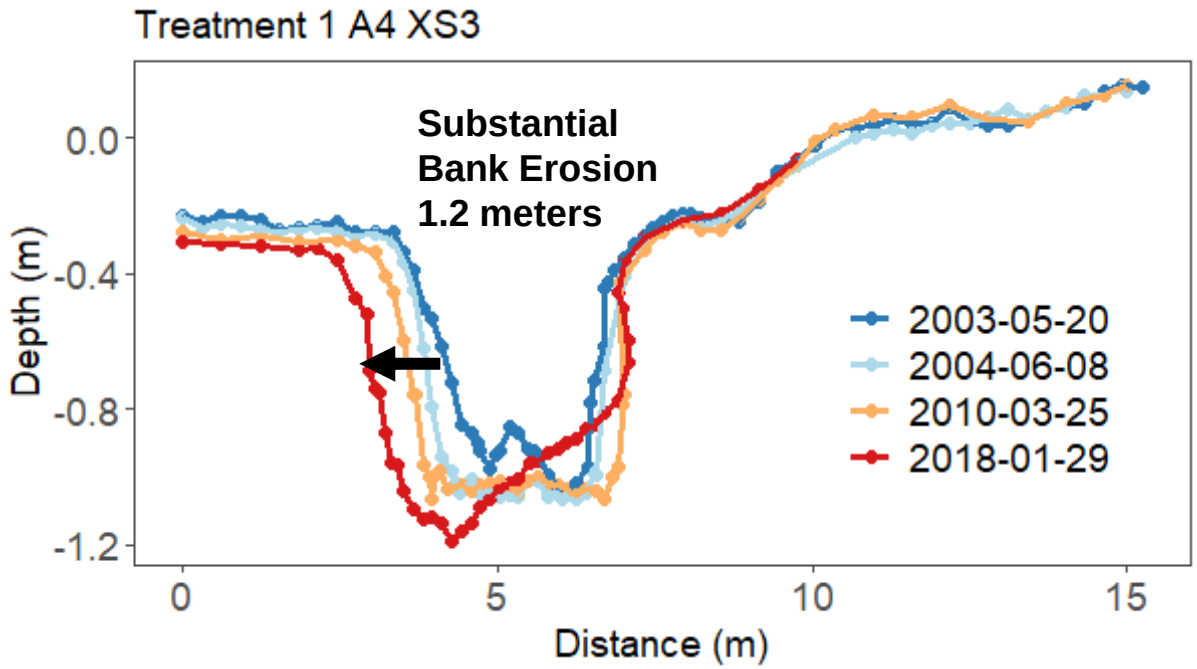


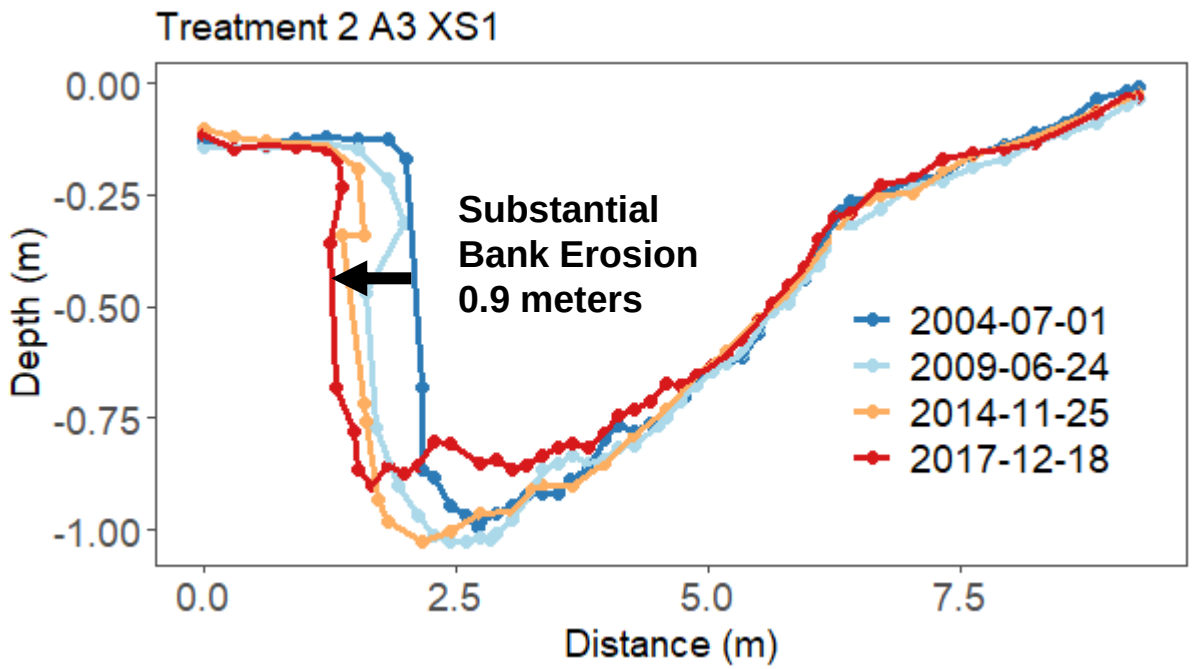


USGS science for a changing world

Hopkins et al. 2022 *Freshwater Science*

Channels were incised prior to development
Streambanks continue to erode

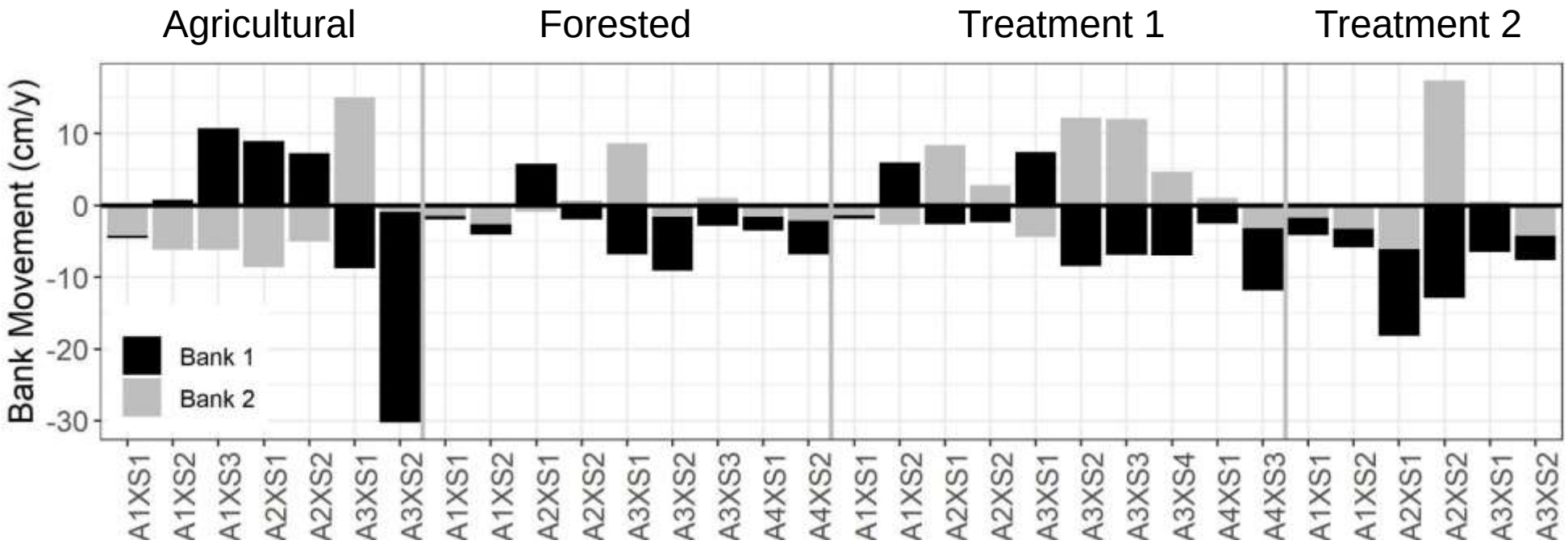




USGS science for a changing world

Williams et al. 2021 Data Release

Substantial bank erosion at many cross sections regardless of site



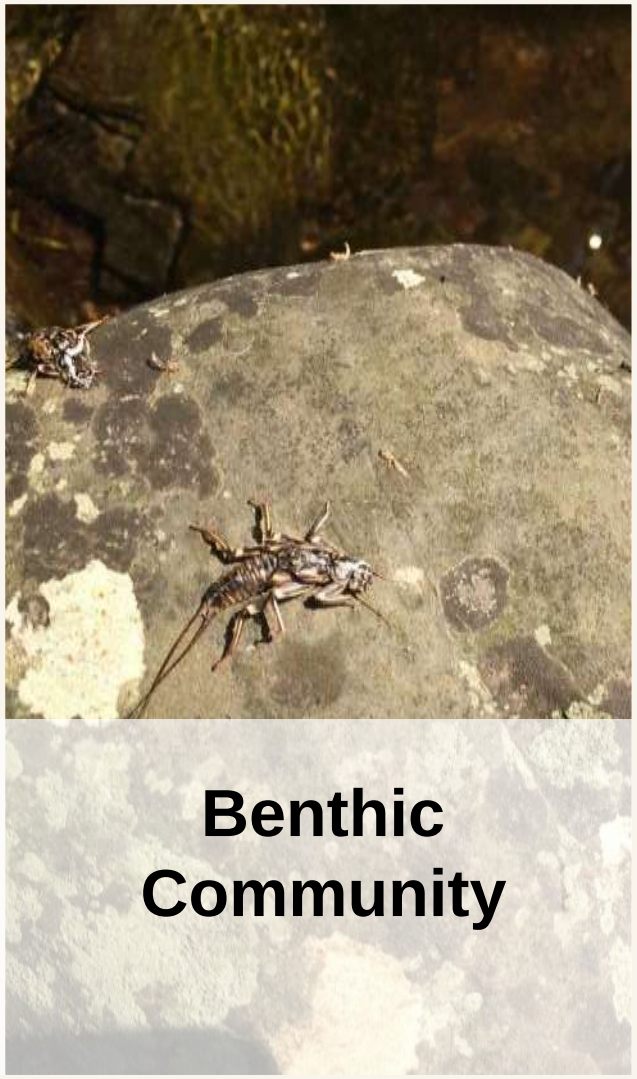
Point bar deposition

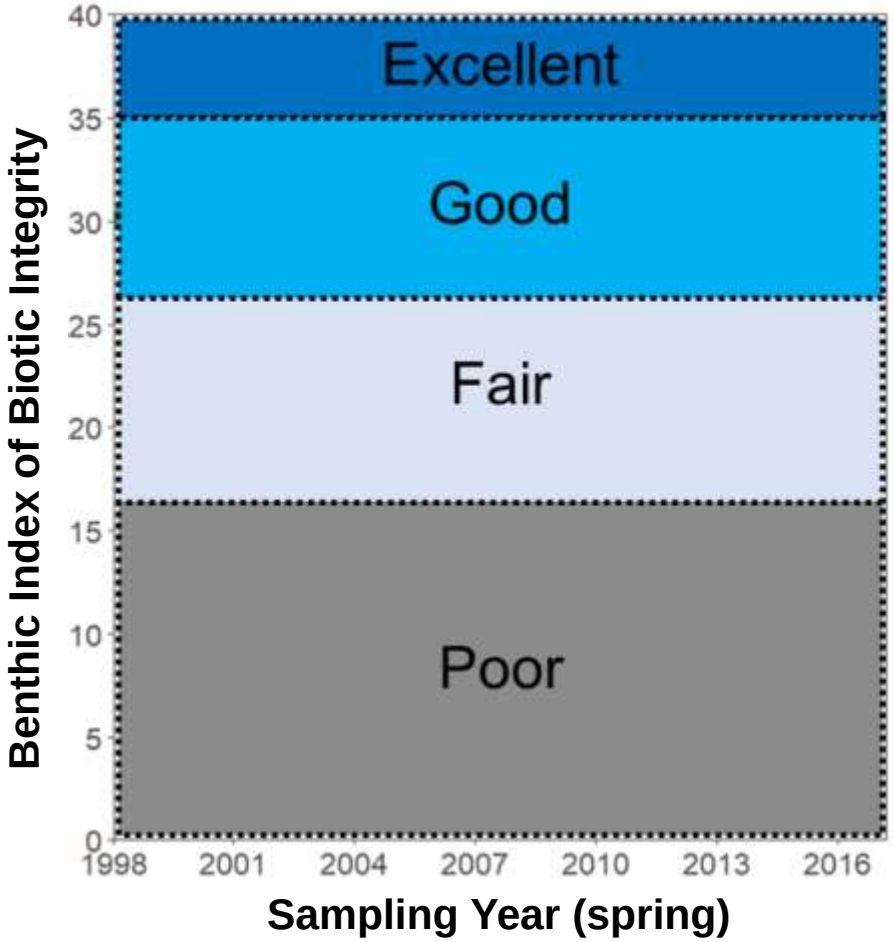
Bank erosion

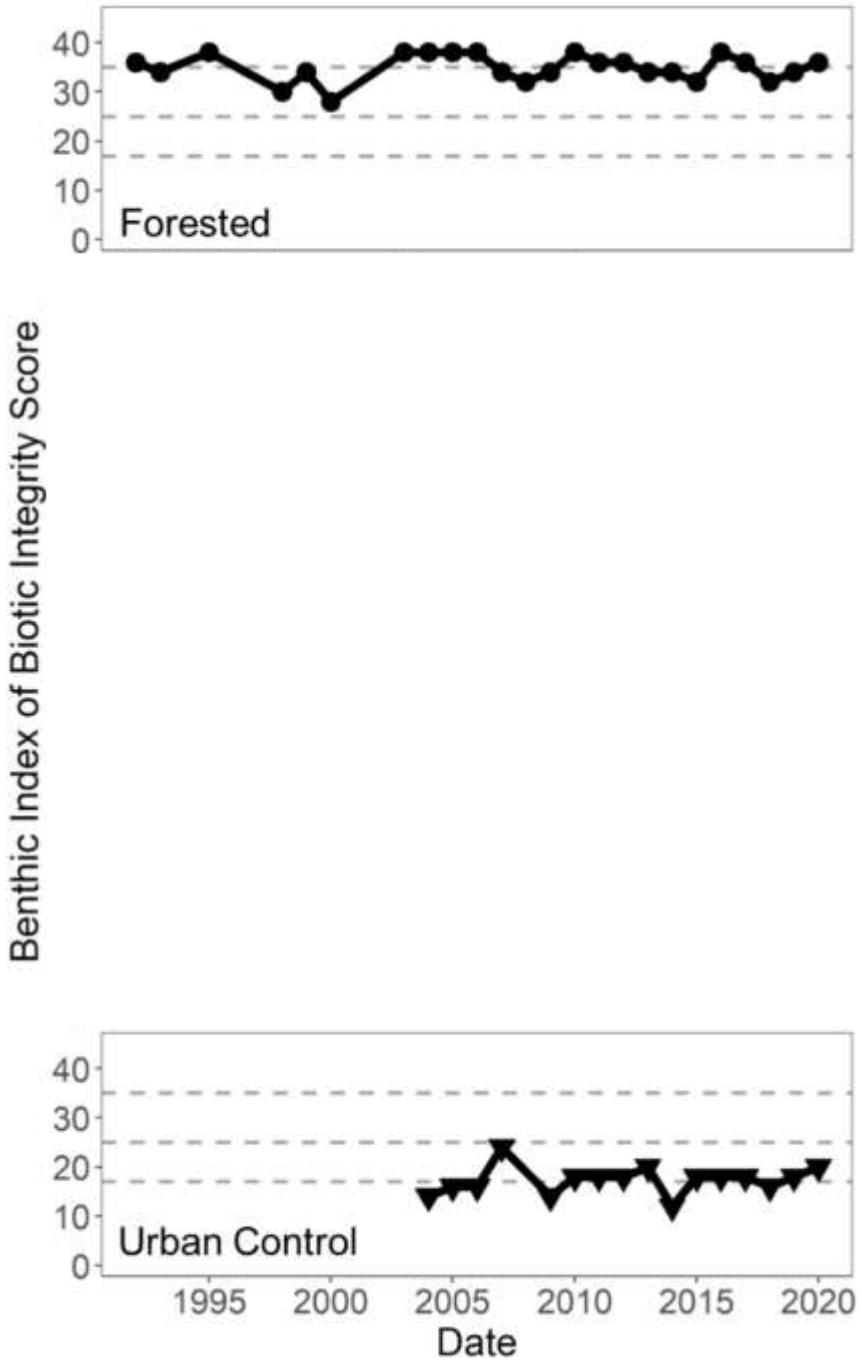
USGS science for a changing world

How does the use of distributed stormwater facilities on a watershed scale affect

Benthic community



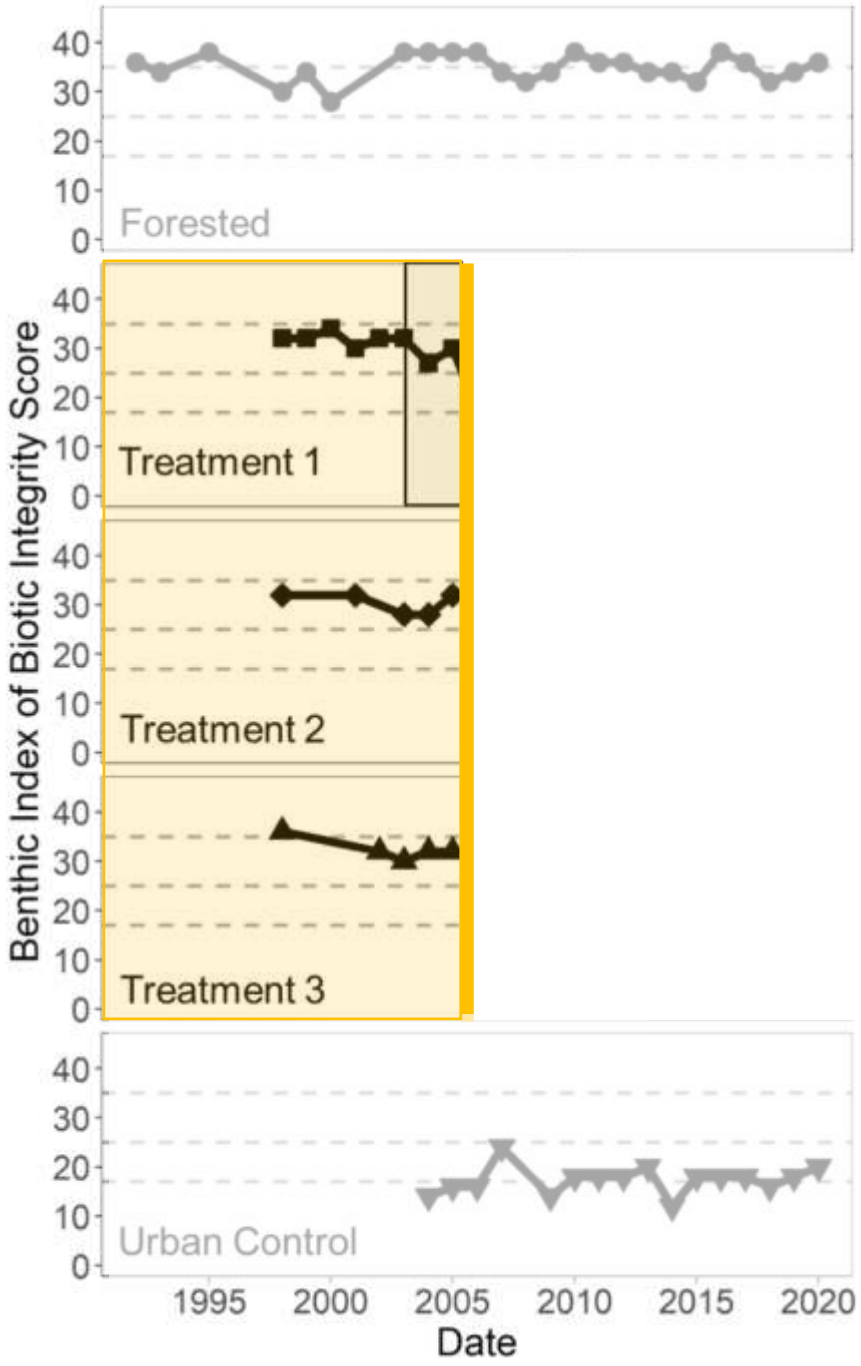


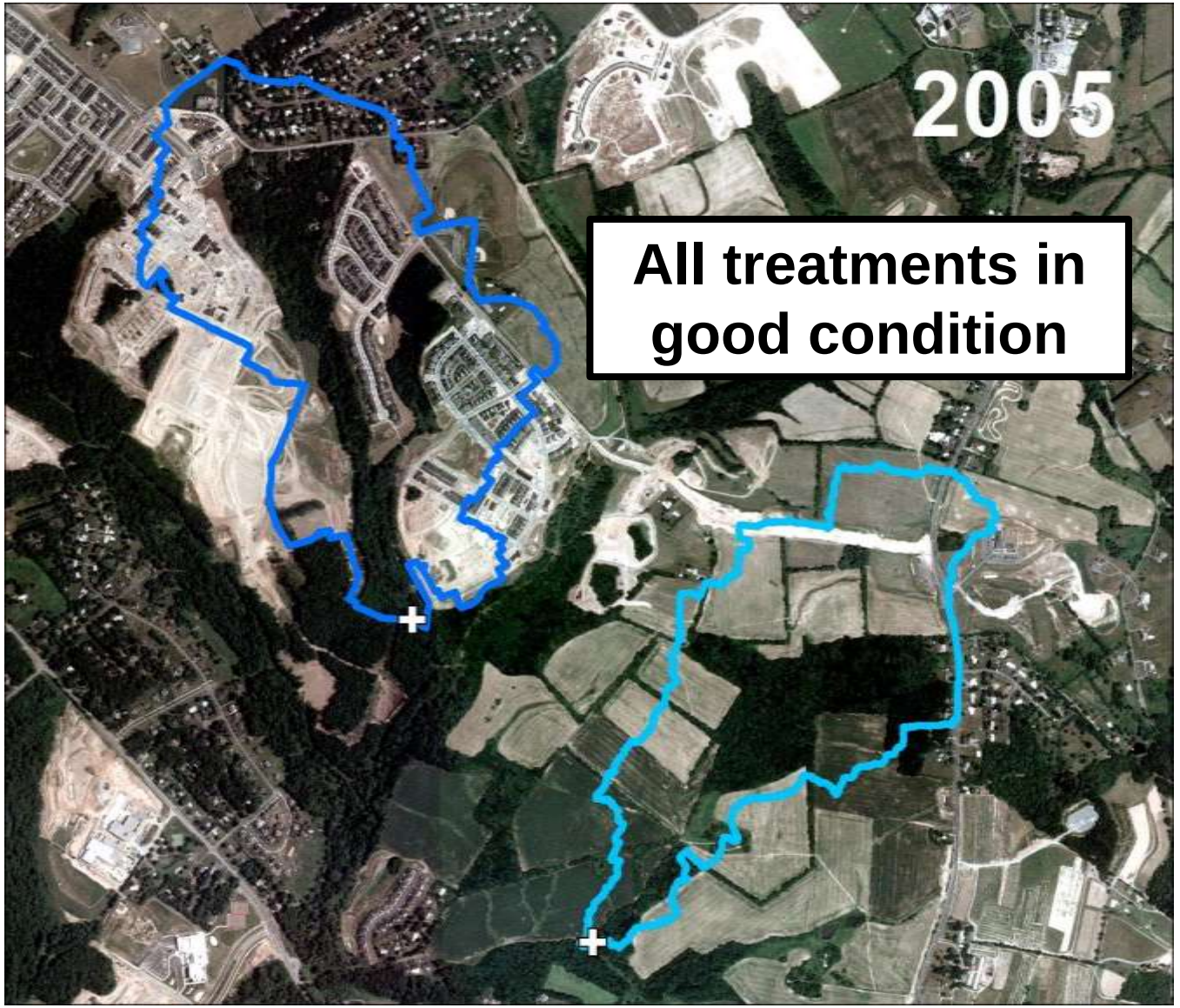


Forested site remains in excellent to good condition

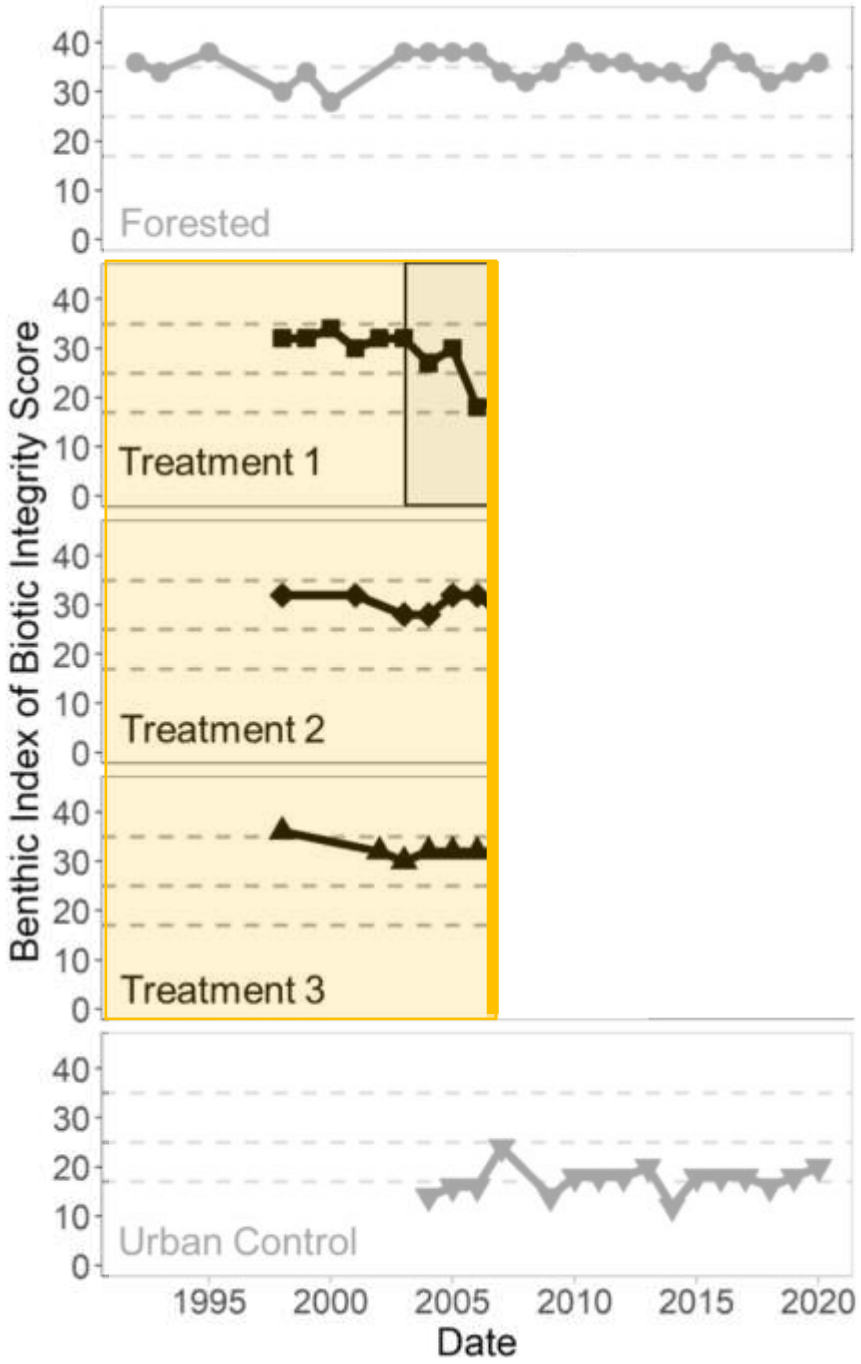
Urban control site remains in fair to poor condition

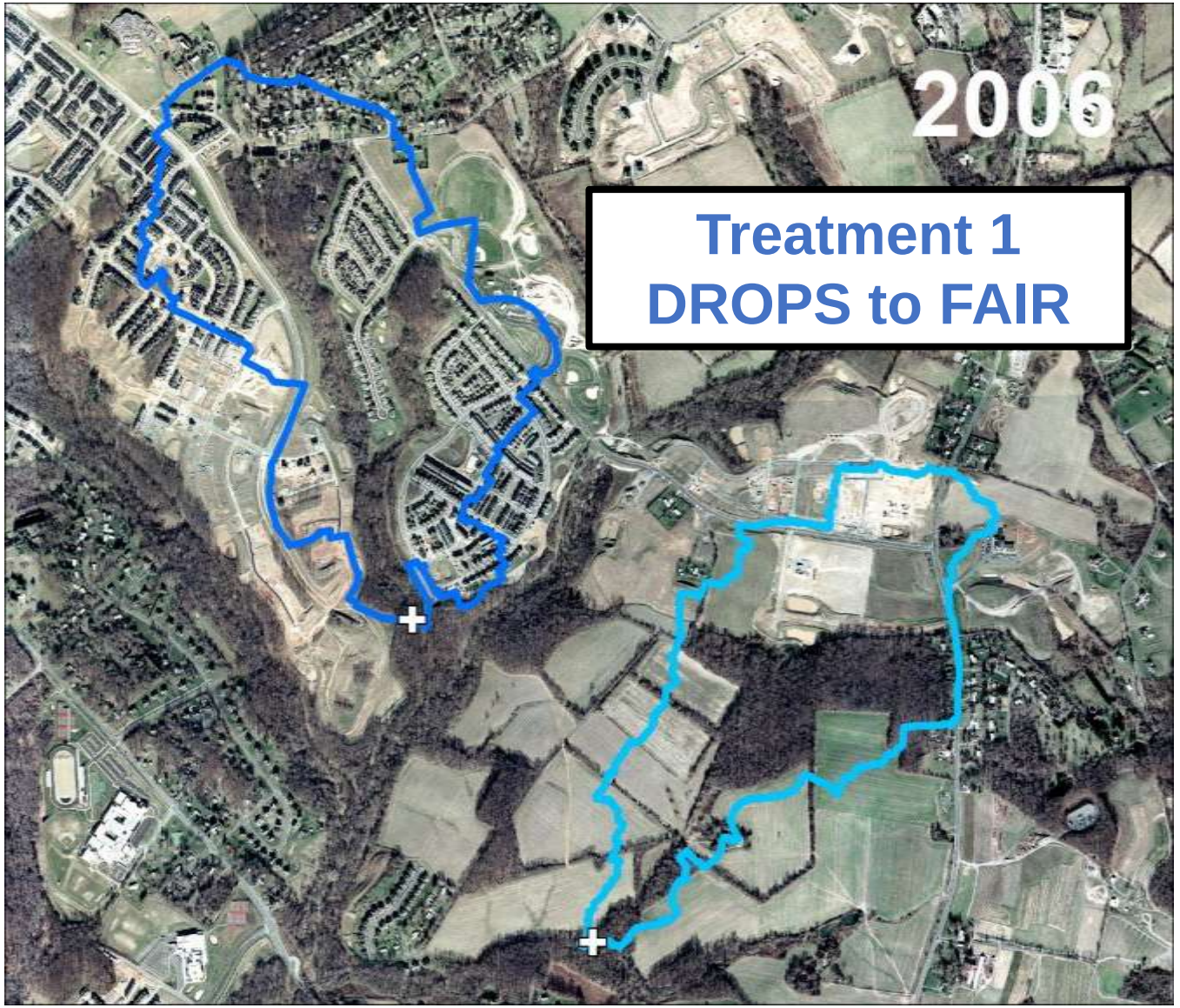
Hopkins et al. 2022 *Freshwater Science*



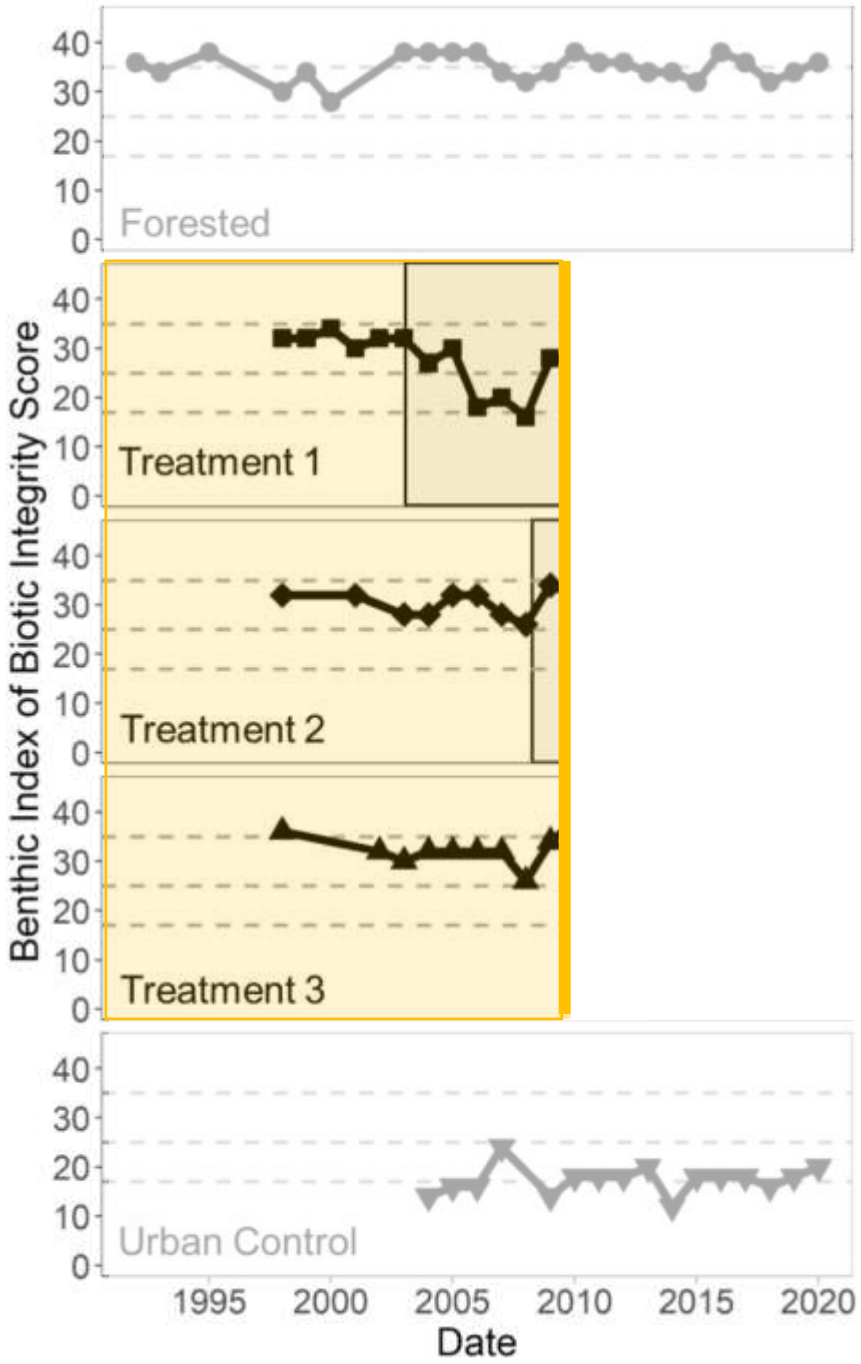


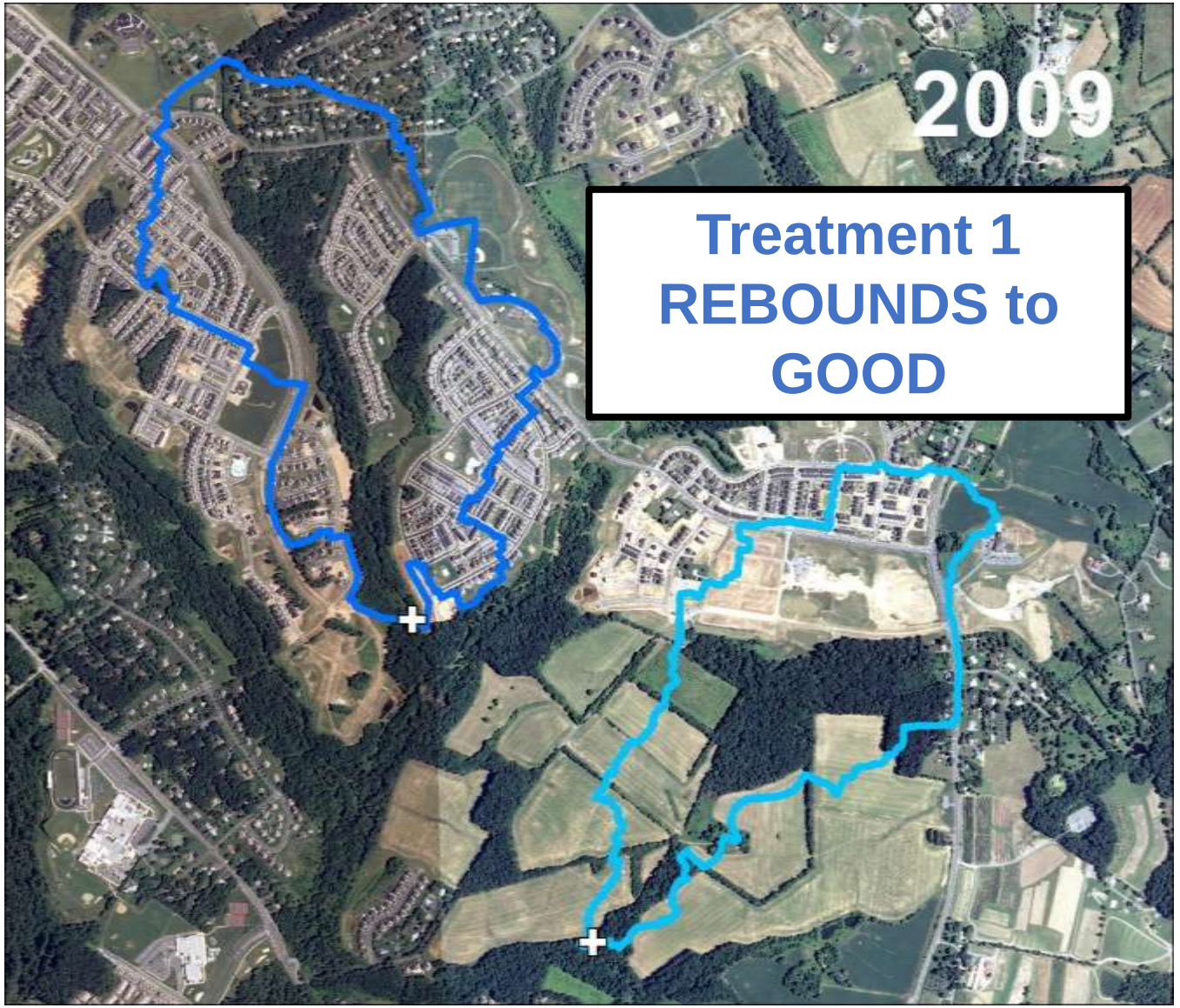
Hopkins et al. 2022 *Freshwater Science*



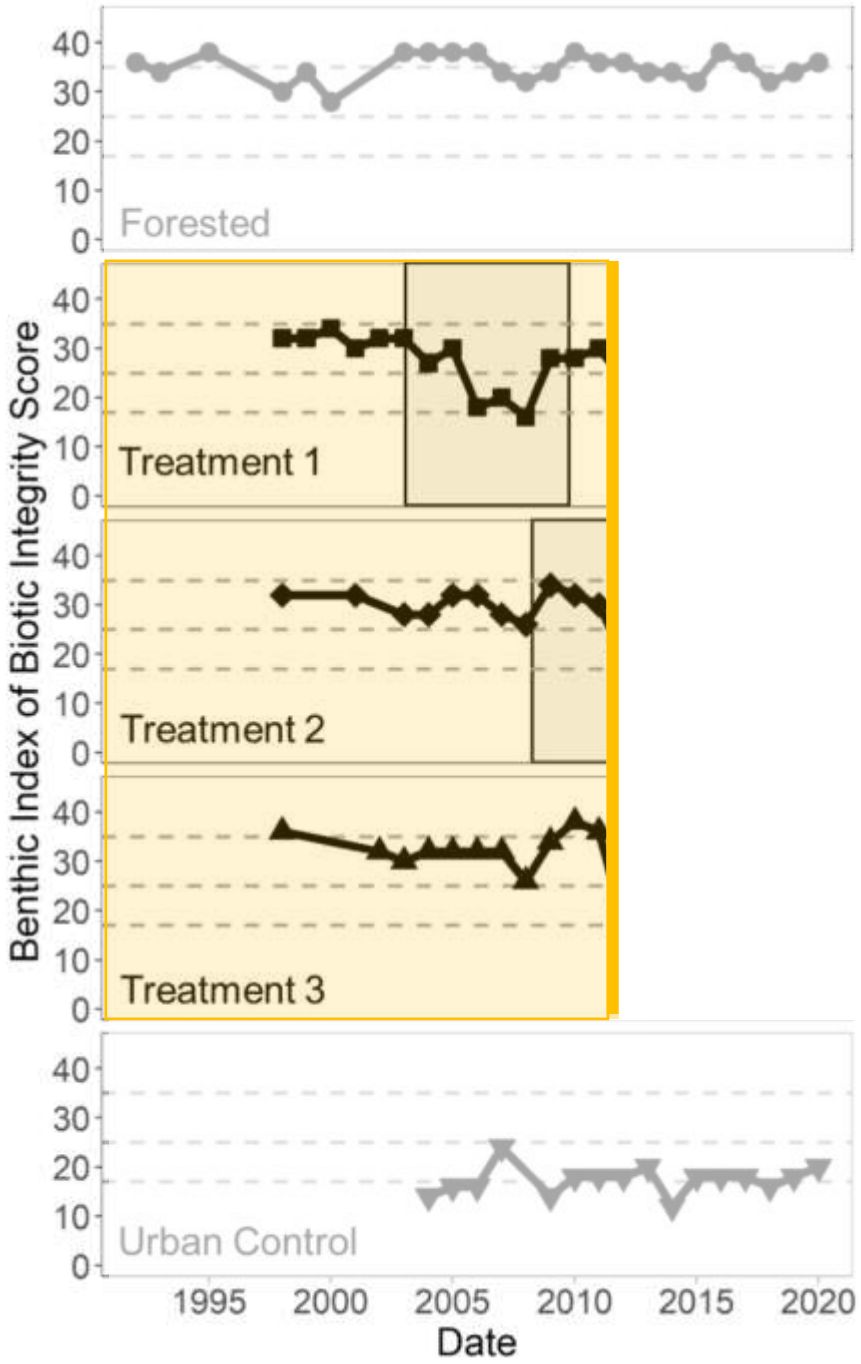


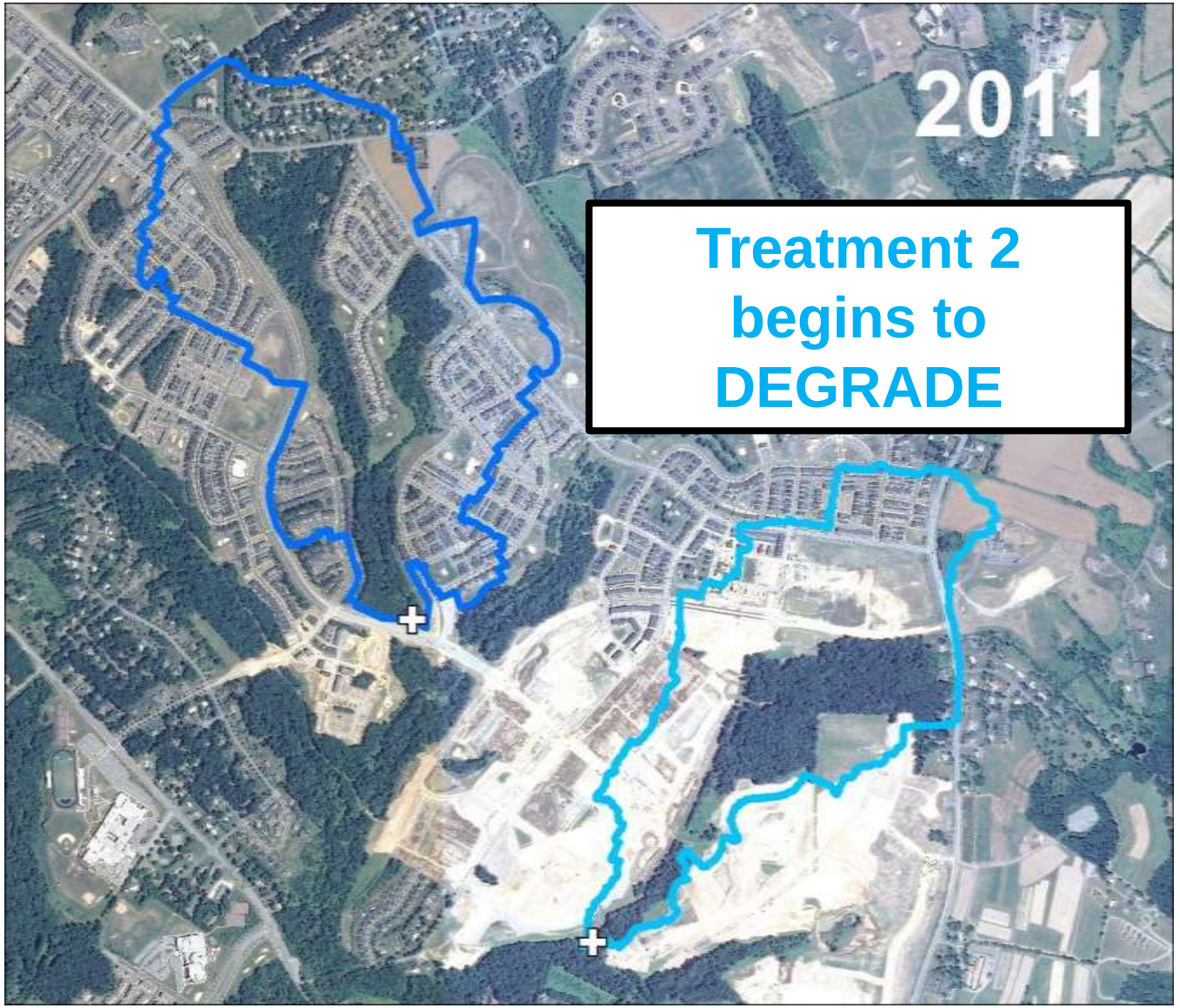
Hopkins et al. 2022 *Freshwater Science*



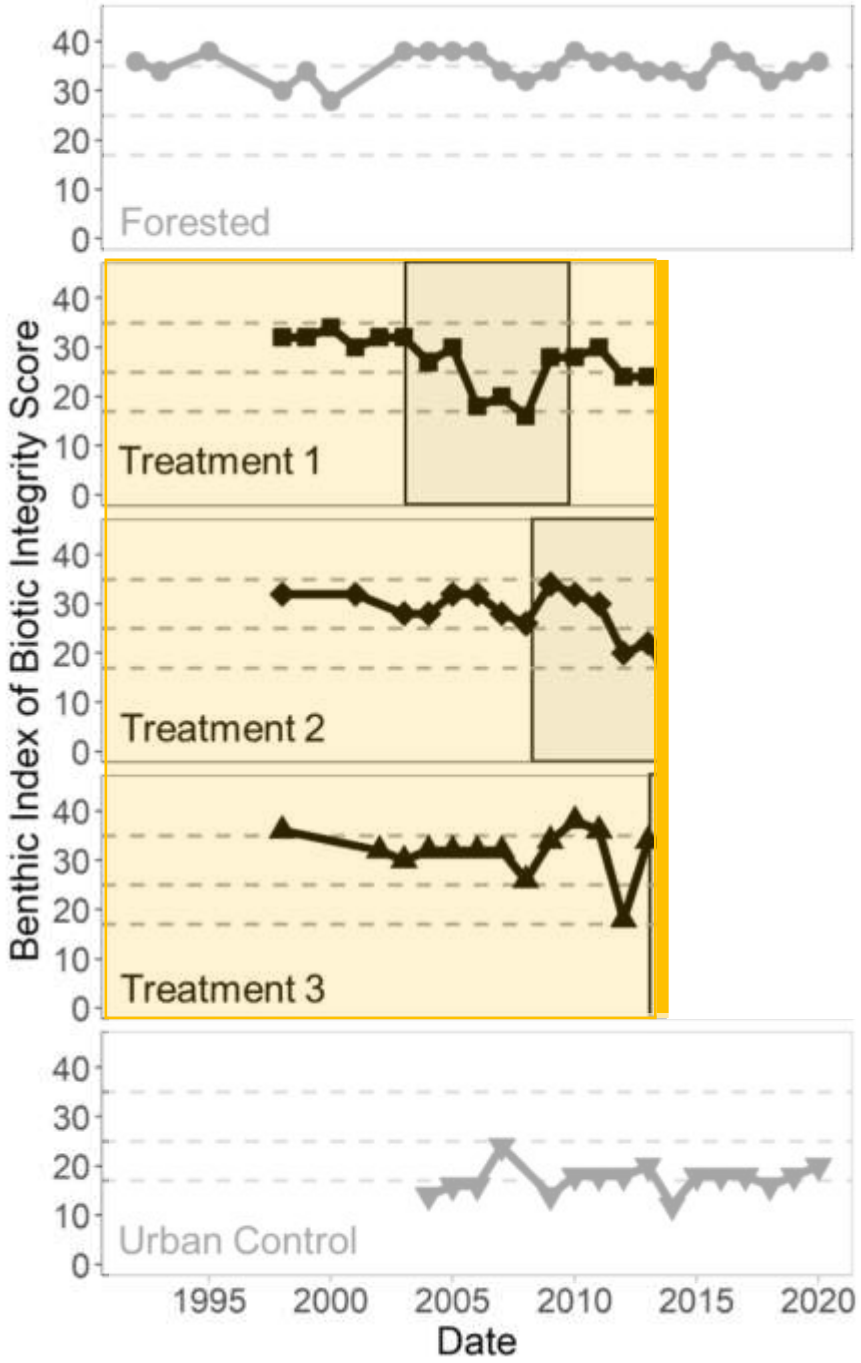


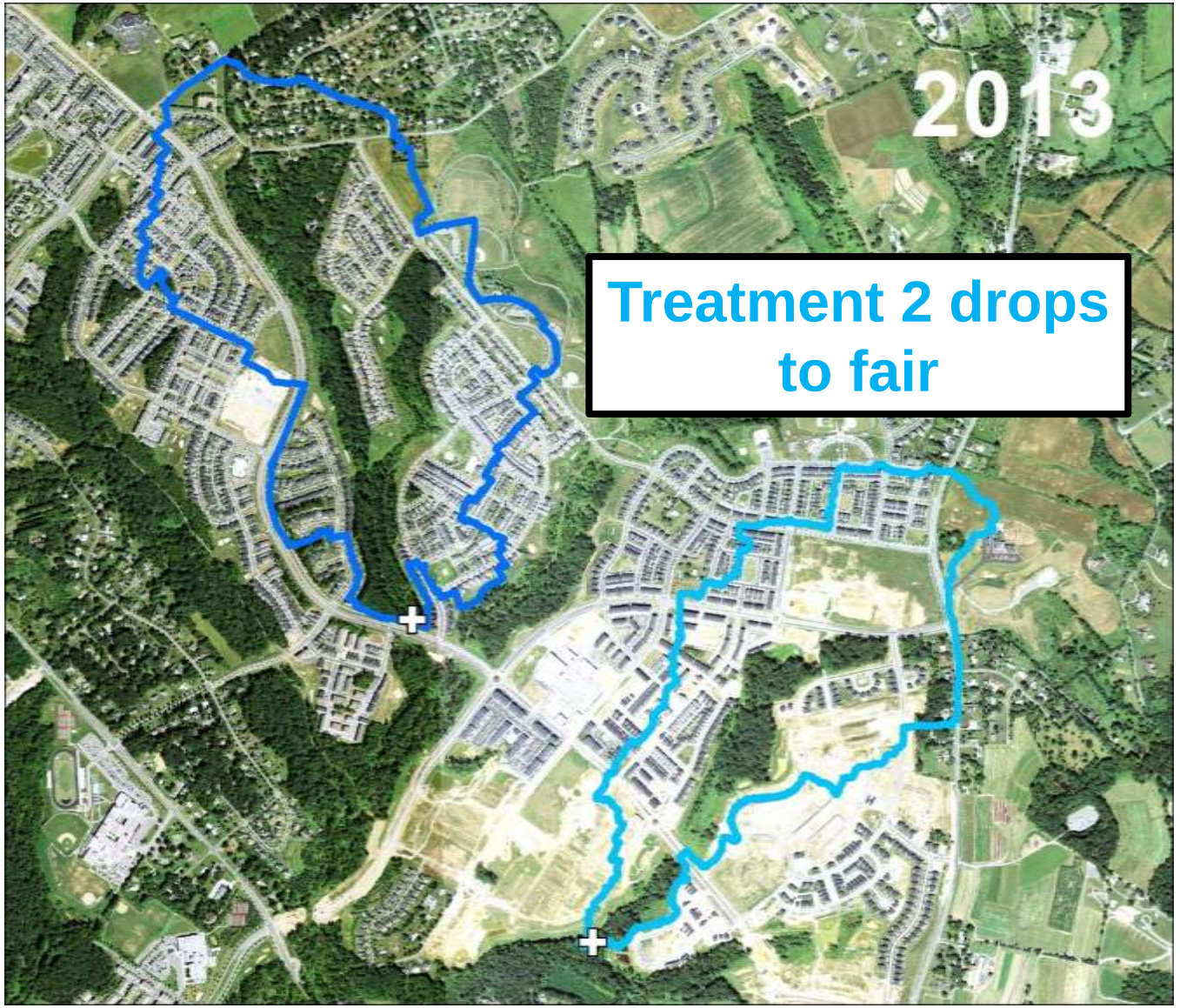
Hopkins et al. 2022 *Freshwater Science*



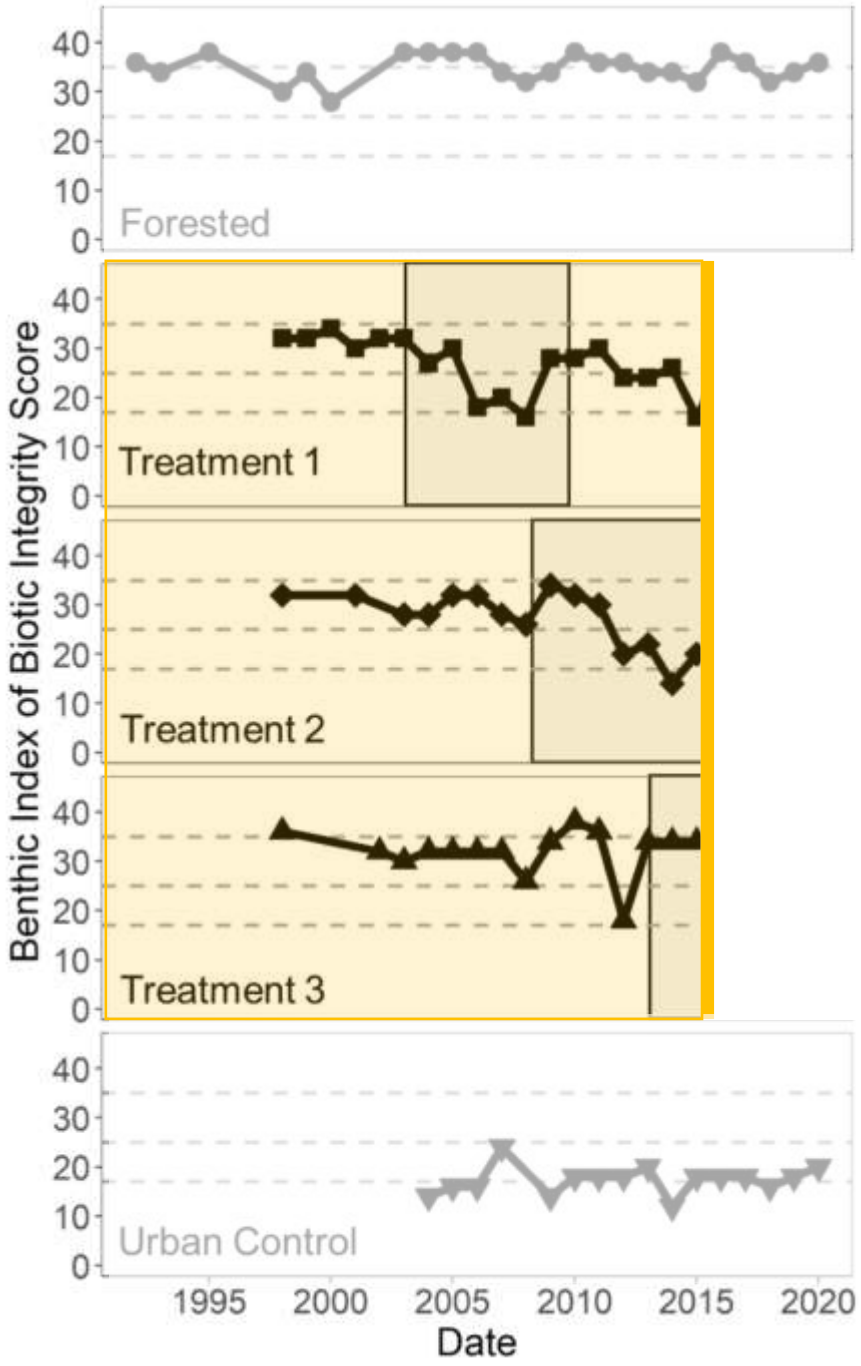


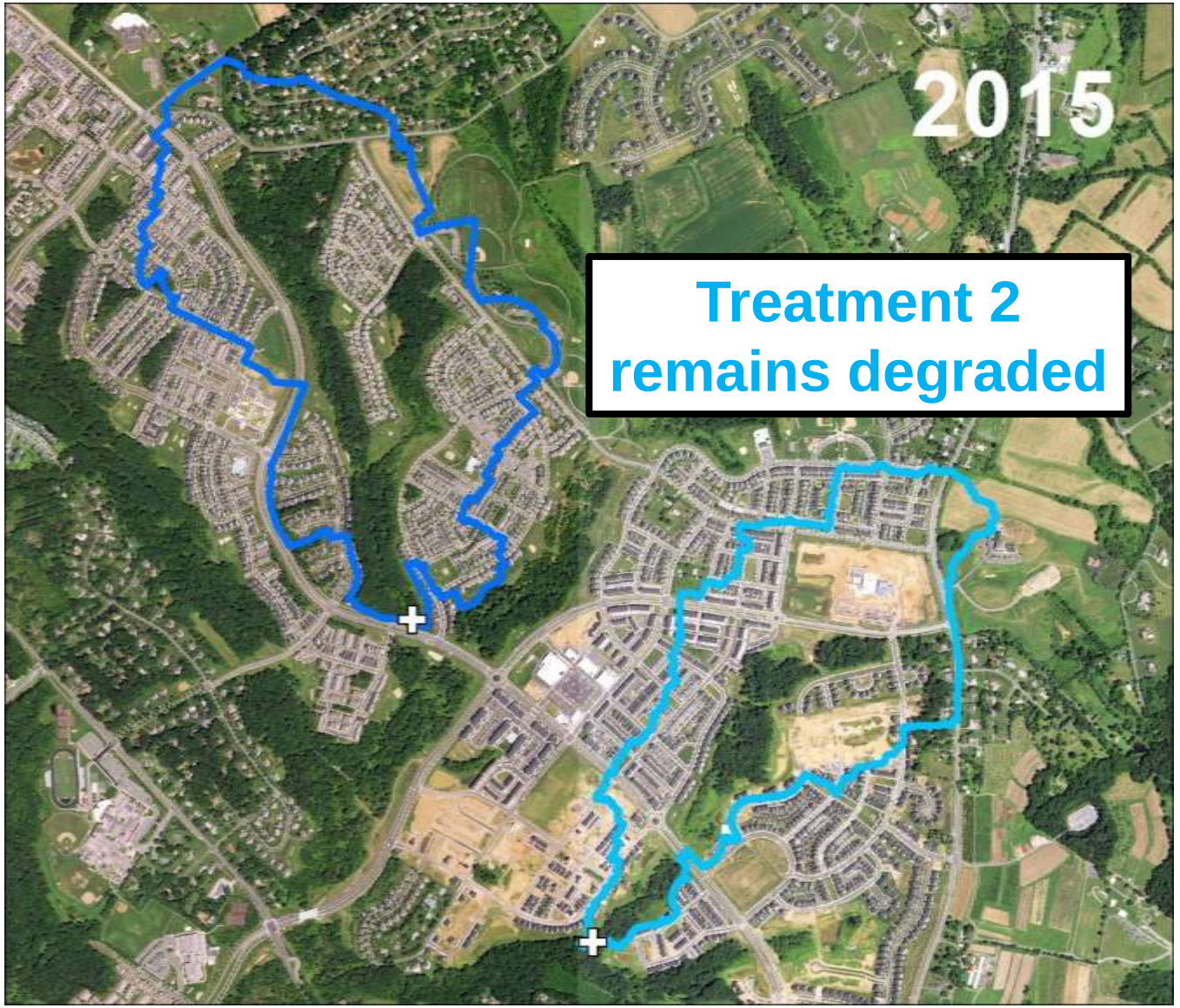
Hopkins et al. 2022 *Freshwater Science*



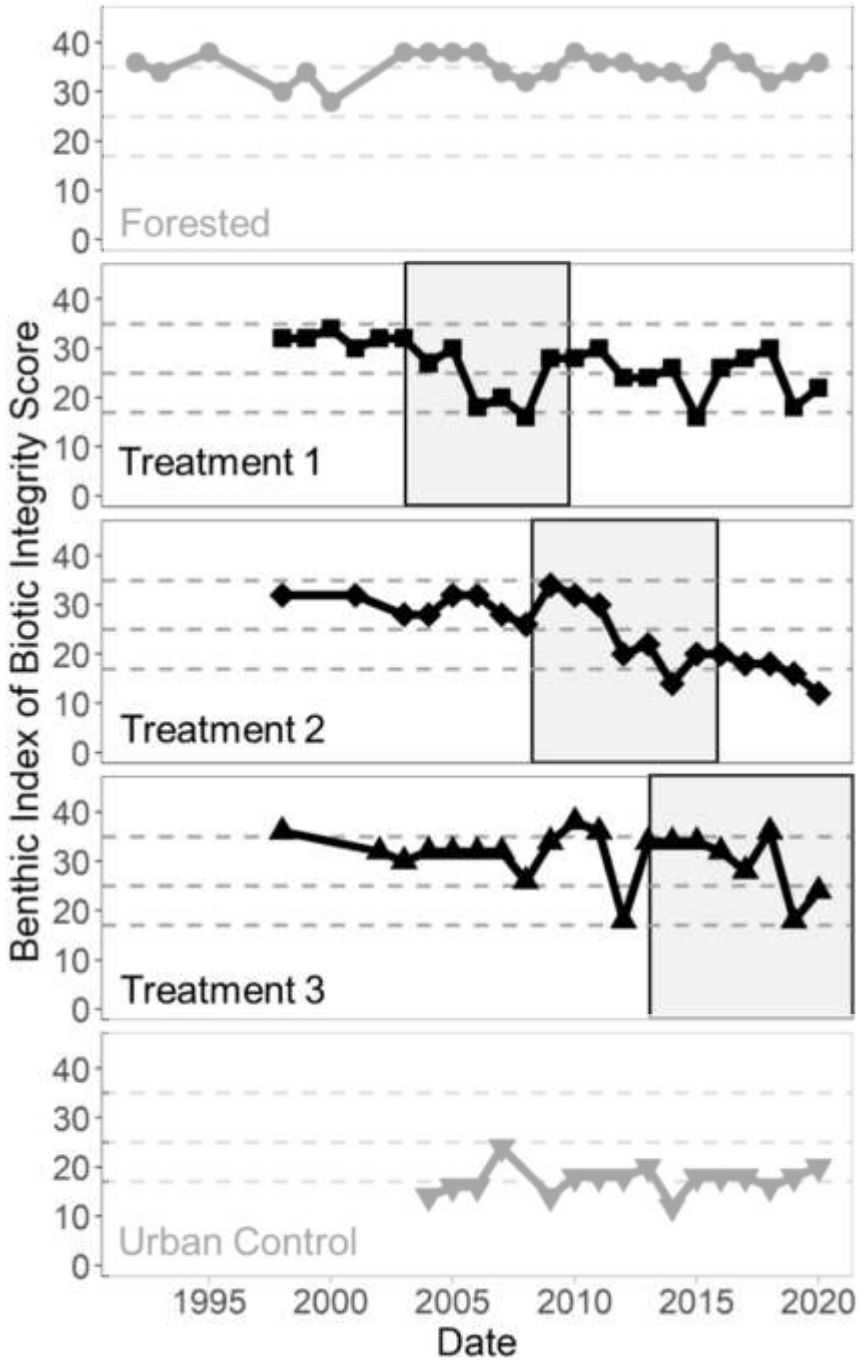


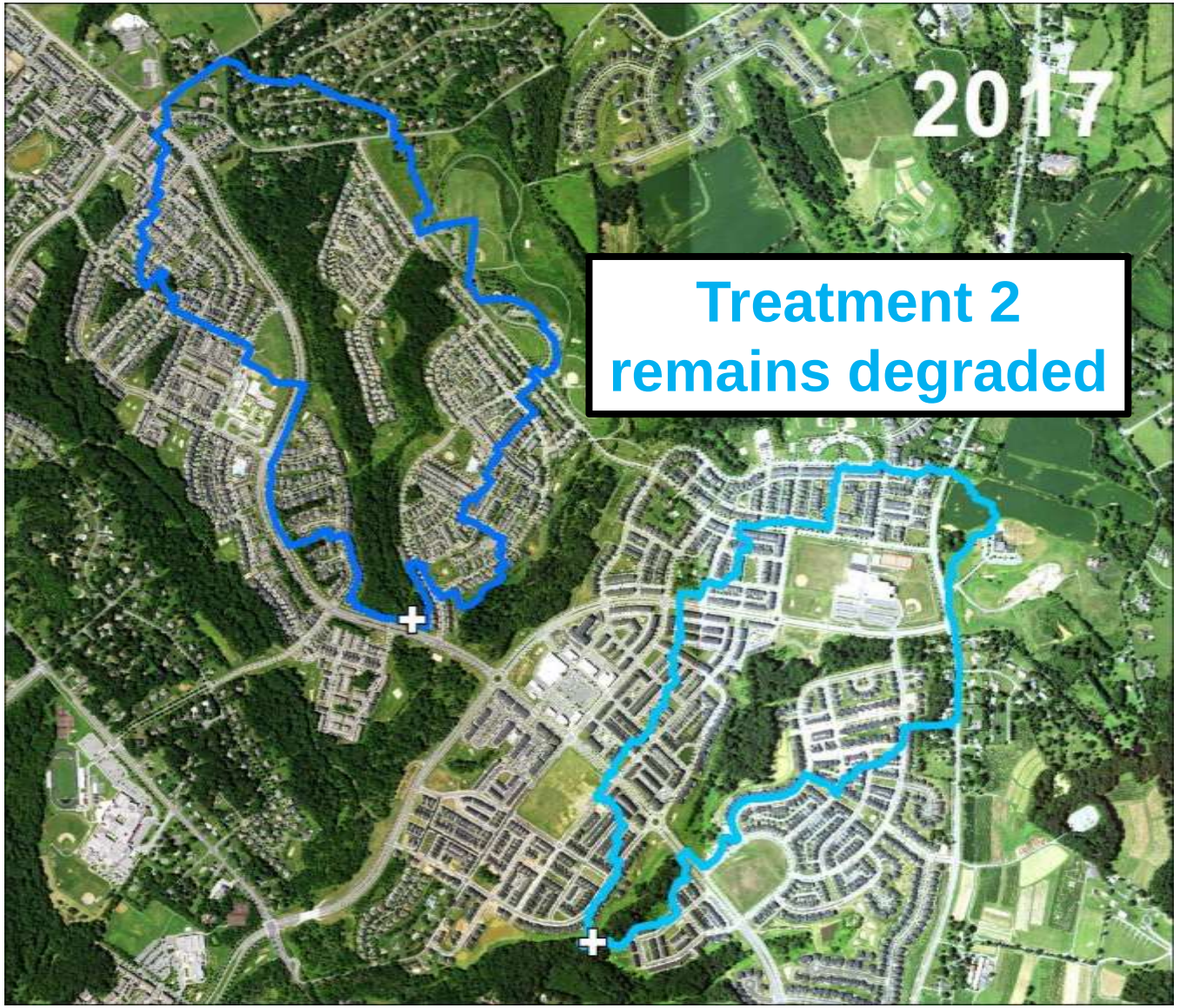
Hopkins et al. 2022 *Freshwater Science*





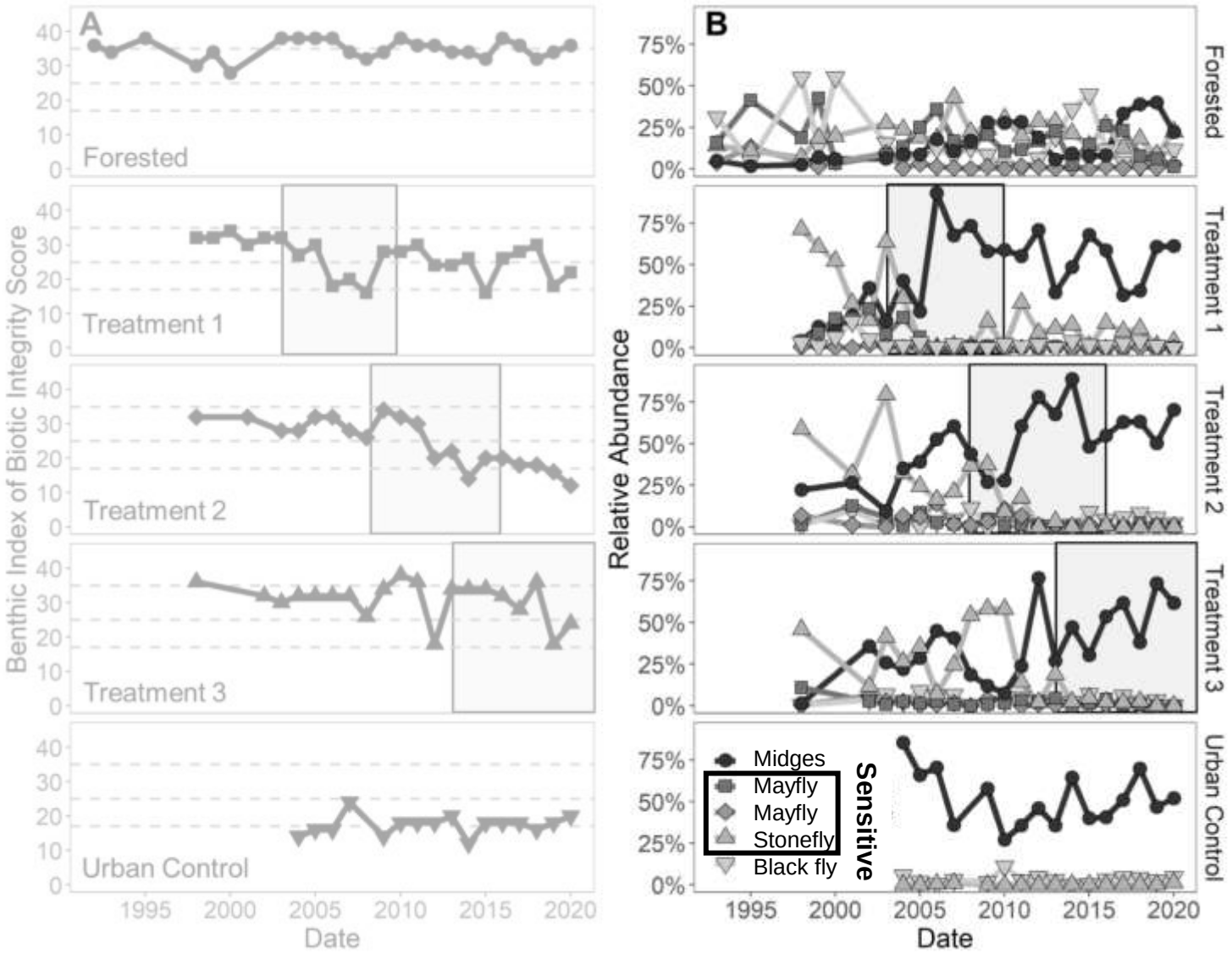
Hopkins et al. 2022 *Freshwater Science*





Hopkins et al. 2022 *Freshwater Science*

Dominated by a single tolerant family



Benthic assemblages may be **somewhat protected** by stormwater facilities**, but sensitive families may not fully recover**

Hopkins et al. 2022 *Freshwater Science*

Lessons learned

Distributed stormwater management,

Can attenuate peak flows and runoff volumes, **but** storage capacity matters.

Can improve water quality for some, **but** not all constituents (e.g., salt).

Can reduce impacts to biota, **but** sensitive families may not recover.

Lessons learned

Construction phase is important,

Baseflow **increased** during construction

Substantial **excavation and fill** across the entire watershed during construction

Deposition in riparian areas during construction

Lessons learned

Summary

- Long-term datasets are valuable
- Need to assess multiple stressors to understand suite of impacts on biota
- Distributed stormwater control can accomplish some goals, but not all

Find the science summary HERE.

Krissy Hopkins, khopkins@usgs.gov