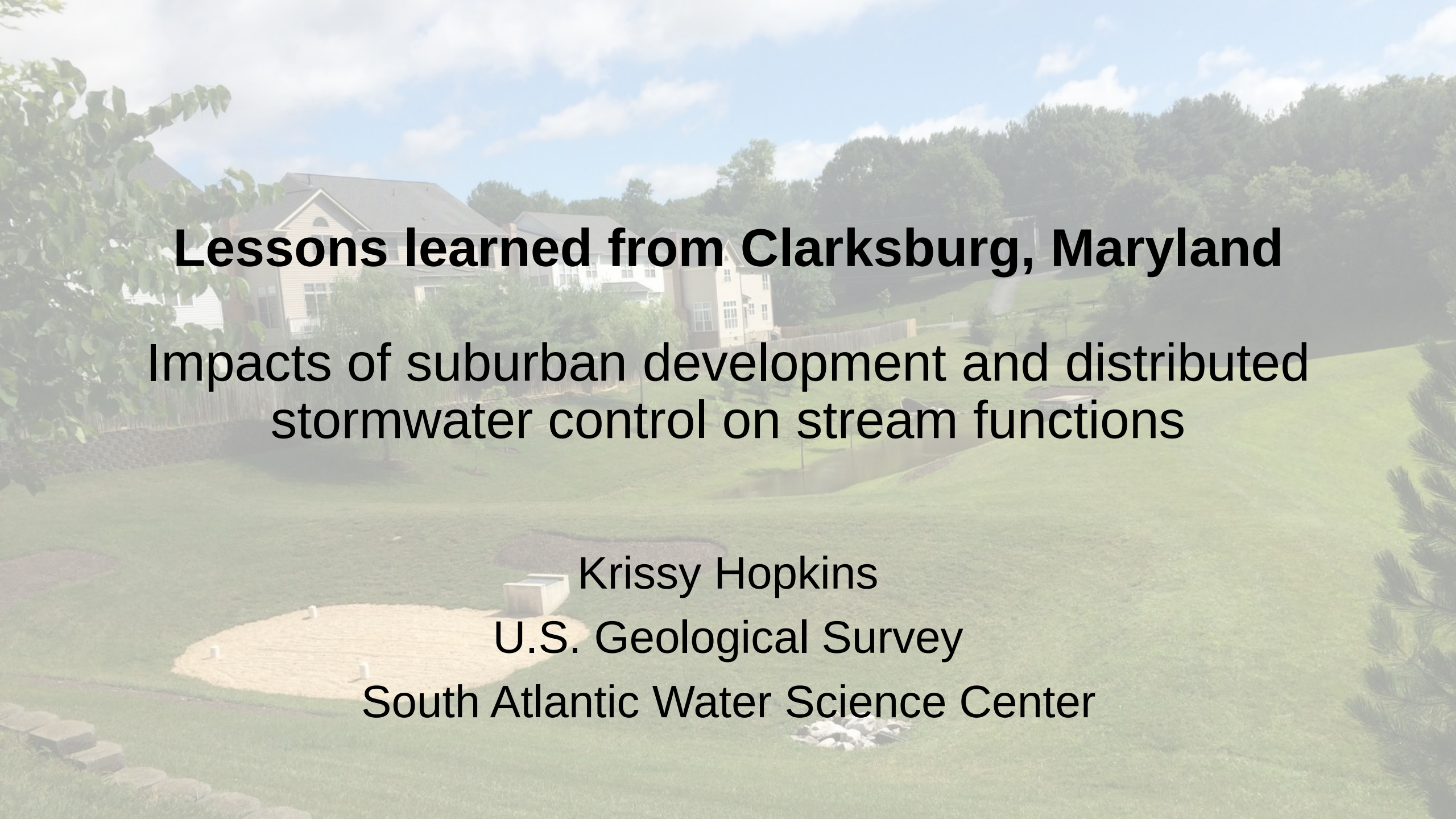


Lessons learned from Clarksburg, Maryland

Impacts of suburban development and distributed stormwater control on stream functions

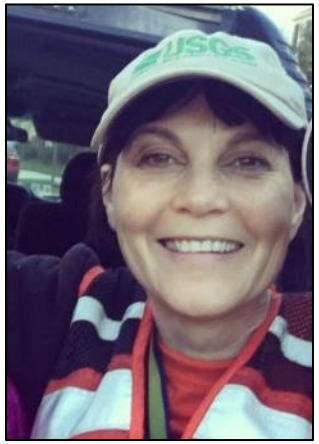
Krissy Hopkins

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

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Road Map

- Background
- Objectives
- Study area
- Lessons learned

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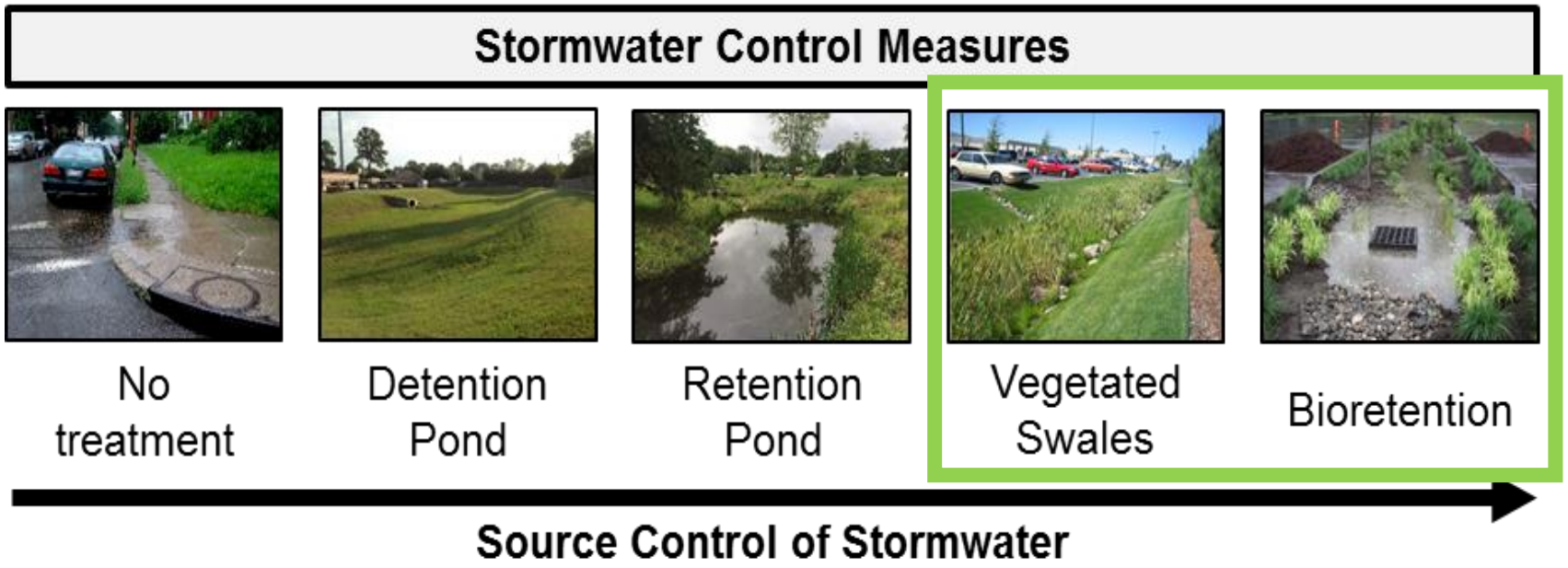
Suburban development is risky for streams

Forest to suburban in Durham, NC

In the piedmont, **by 2060**,
61% of streams are projected to have
>25% losses in **invertebrate taxa**.
Van Metre et al., 2019, *Plos One*

Agriculture to suburban in Clarksburg, MD

Focus on assessing the impacts of stormwater infrastructure at a watershed scale



Is this a good solution?

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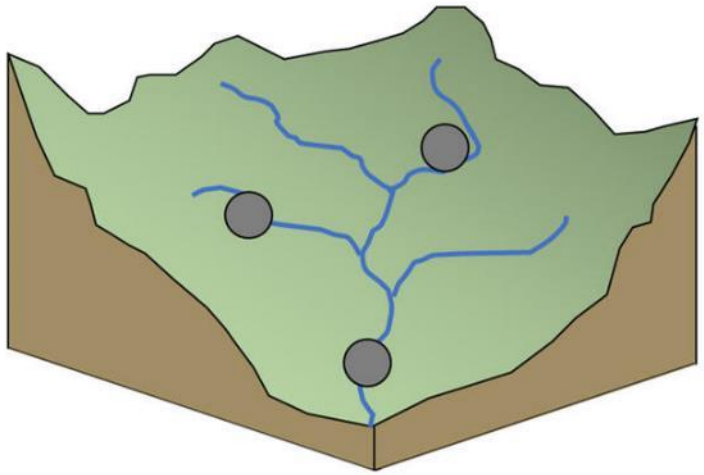
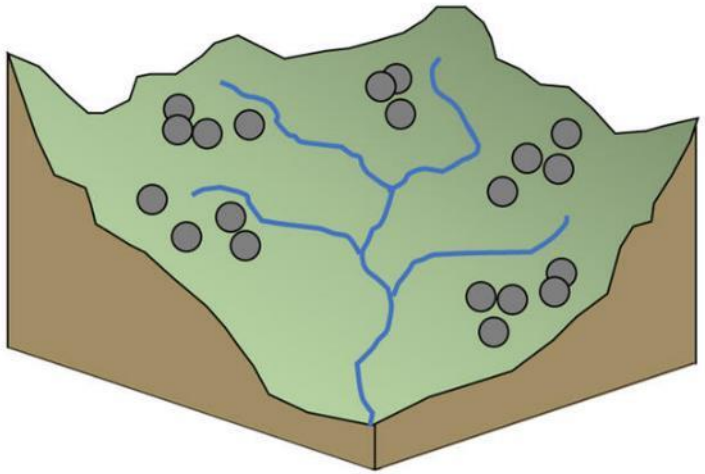
Objectives

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

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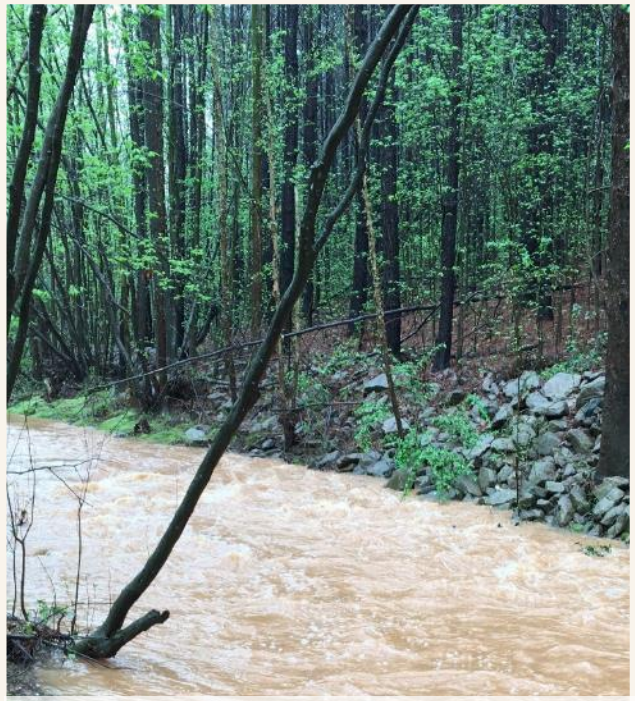
Objectives

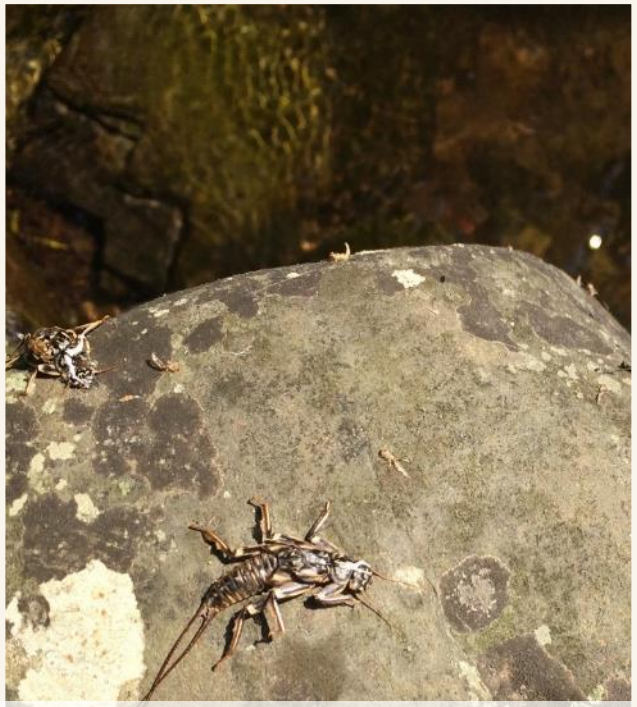
How does the use of distributed stormwater facilities on a watershed scale affect



Hydrology
Frequency
Volume/Peaks
Baseflow

Water Quality
Nutrients
Sediment
Conductance

Topography
Elevation change
Stream channels

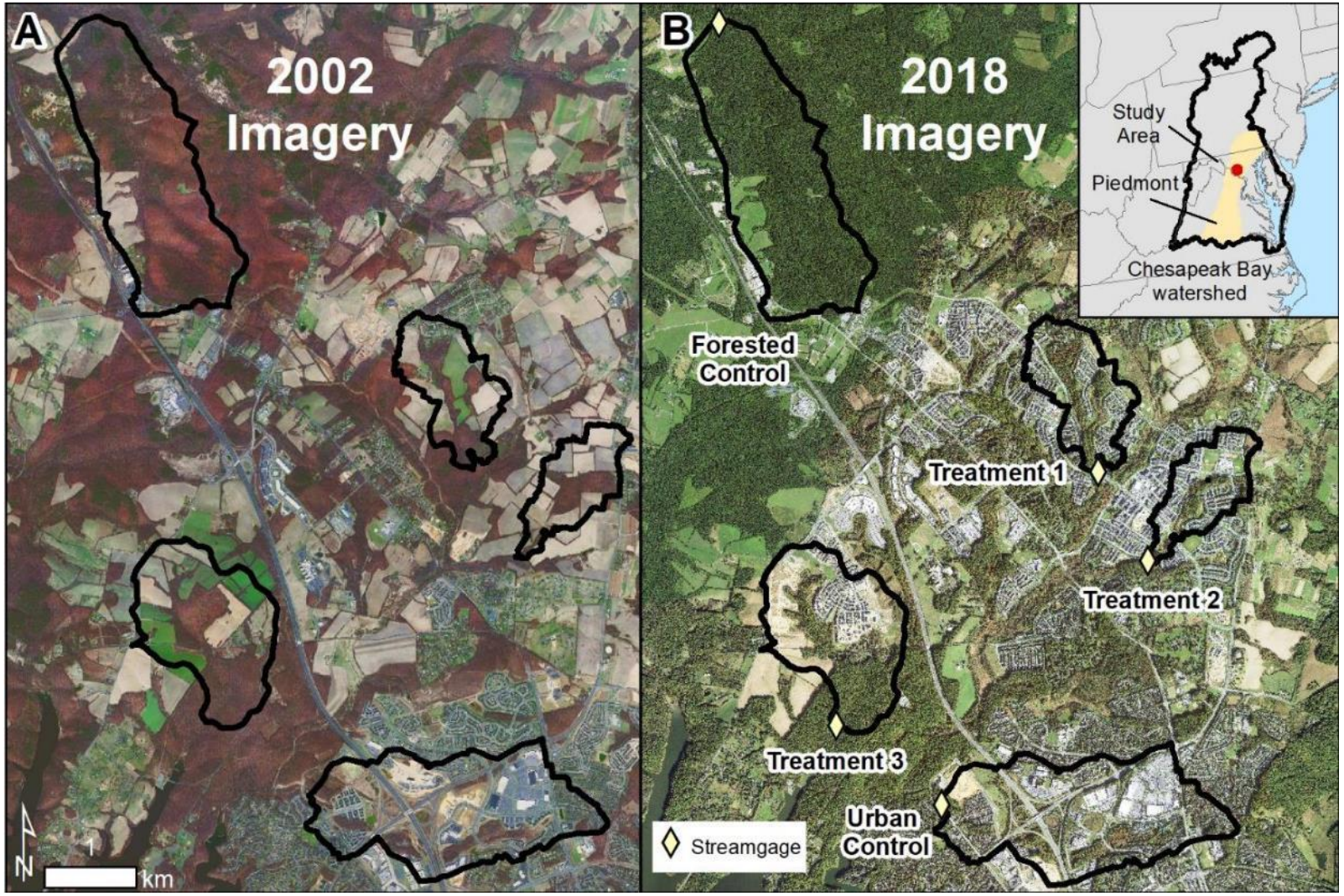


Benthic Community

Study Area

Clarksburg, Maryland

Control vs treatments sites



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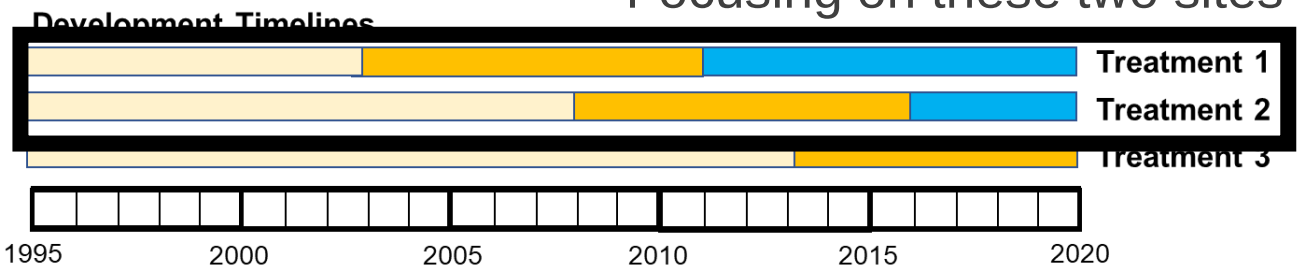
Tracking channel changes during and after development

Suburban high density of stormwater practices

Construction

Agriculture

Focusing on these two sites



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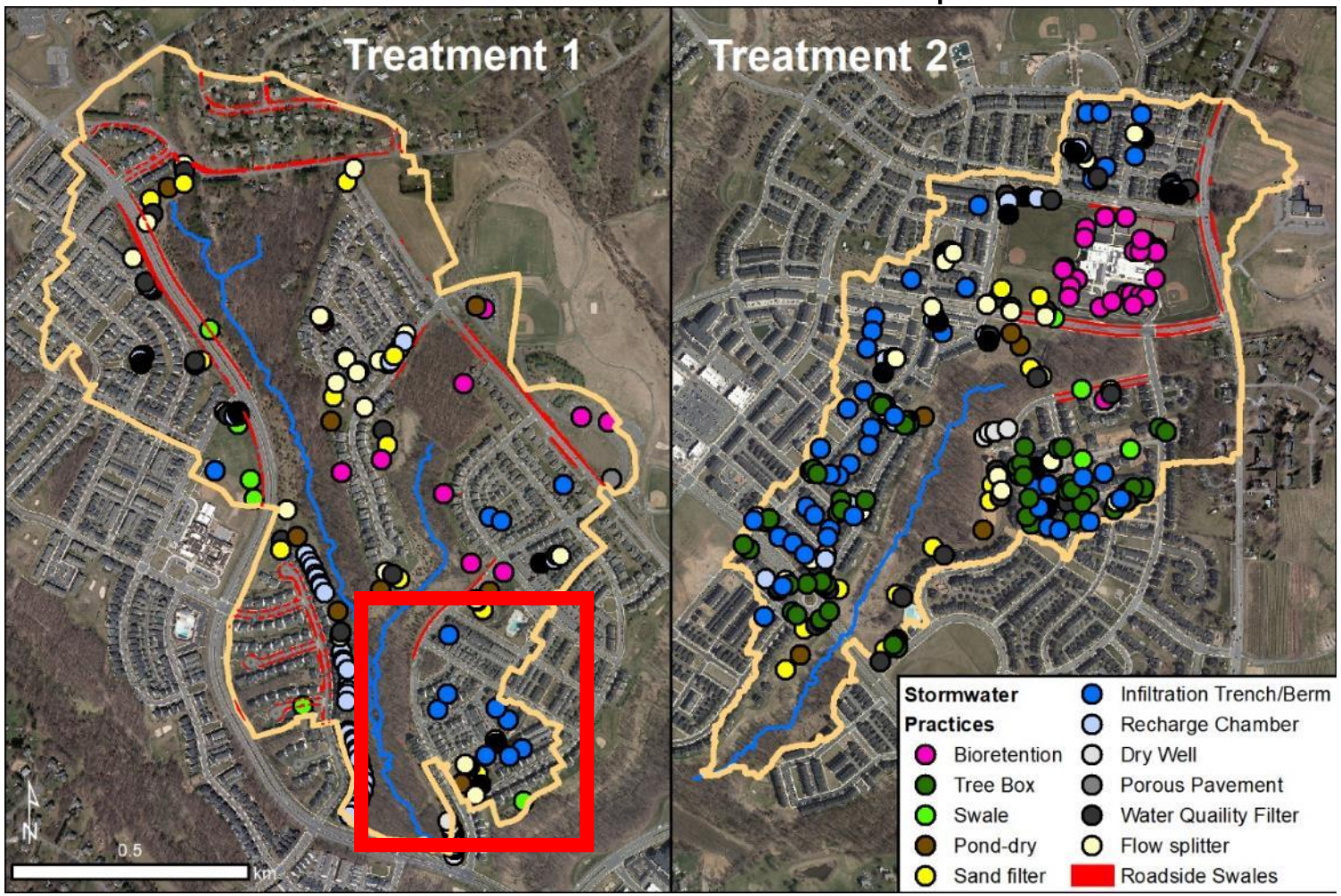
100% of impervious surfaces are treated

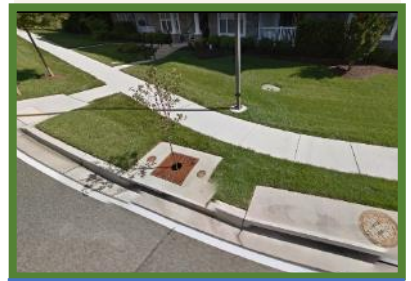
Dry wells
infiltration
detention
swales

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



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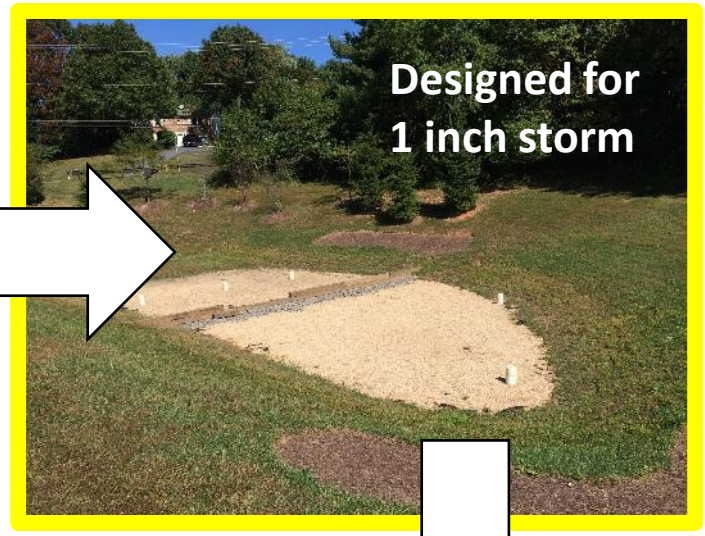
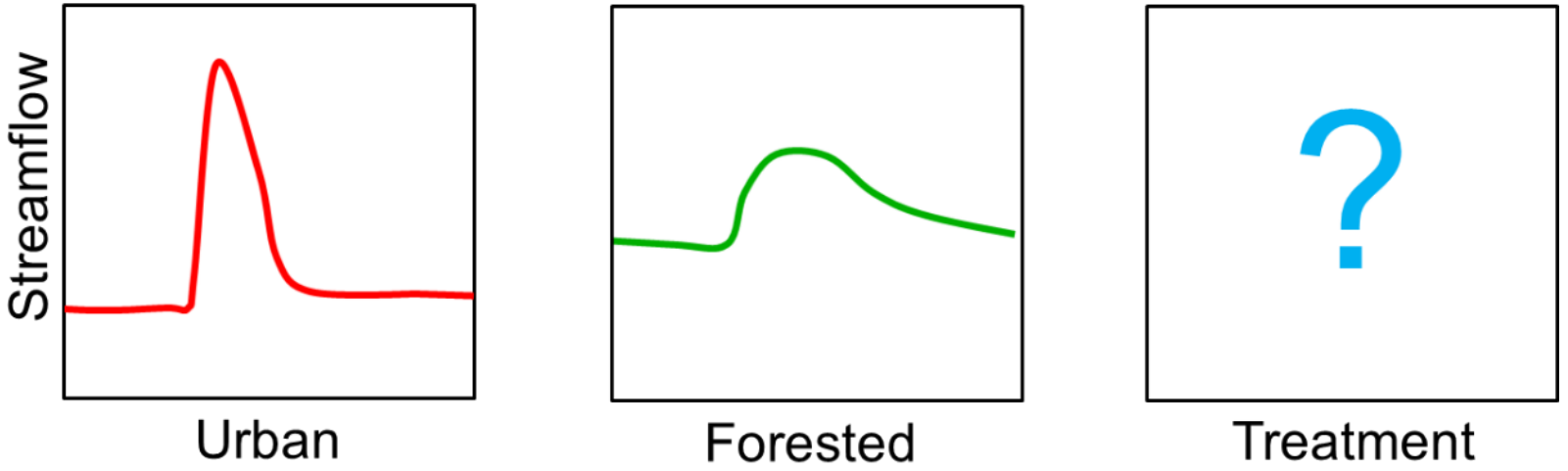
Stormwater practices arranged in treatment trains

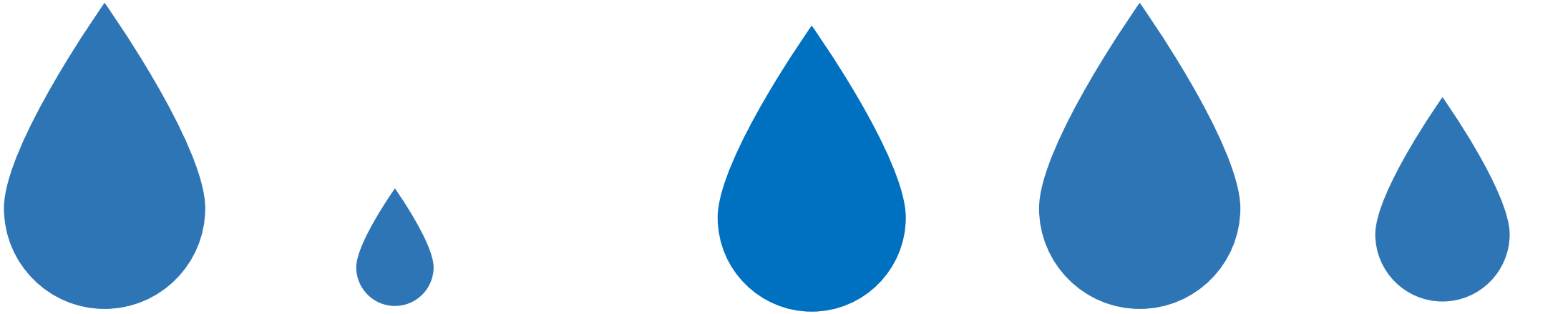


Hydrology

Hydrology
Frequency
Volume/Peaks
Baseflow



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

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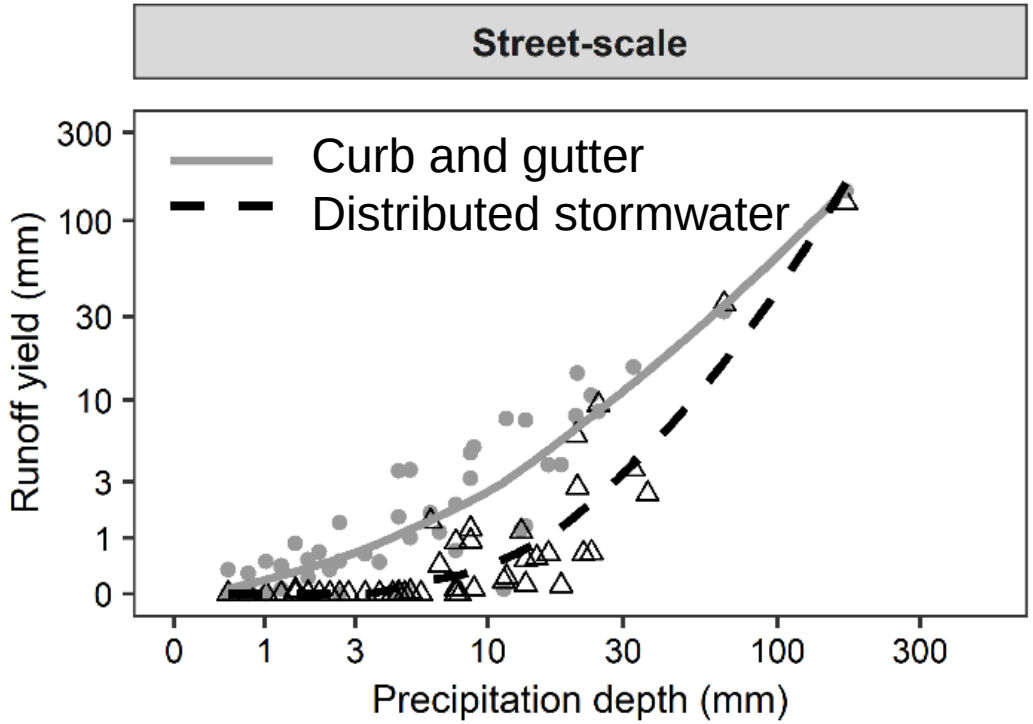
science for a changing world

Hopkins et al. 2020 *Hydro Processes*

What happens to runoff yield?

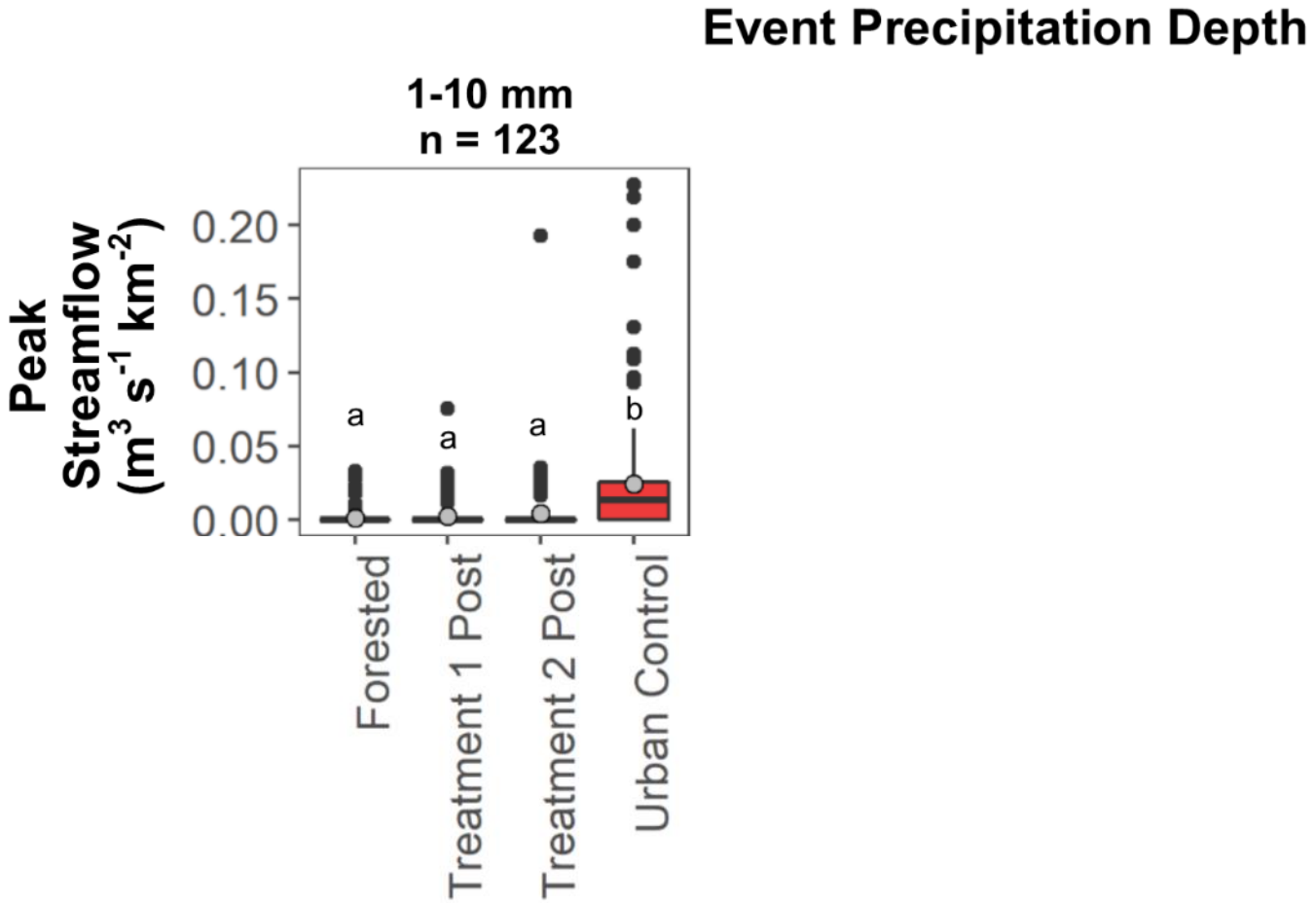
Less runoff with distributed stormwater management especially for events < 1 inch



Hopkins et al. 2022 *Freshwater Science*

After development in Treatment 1 and 2

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

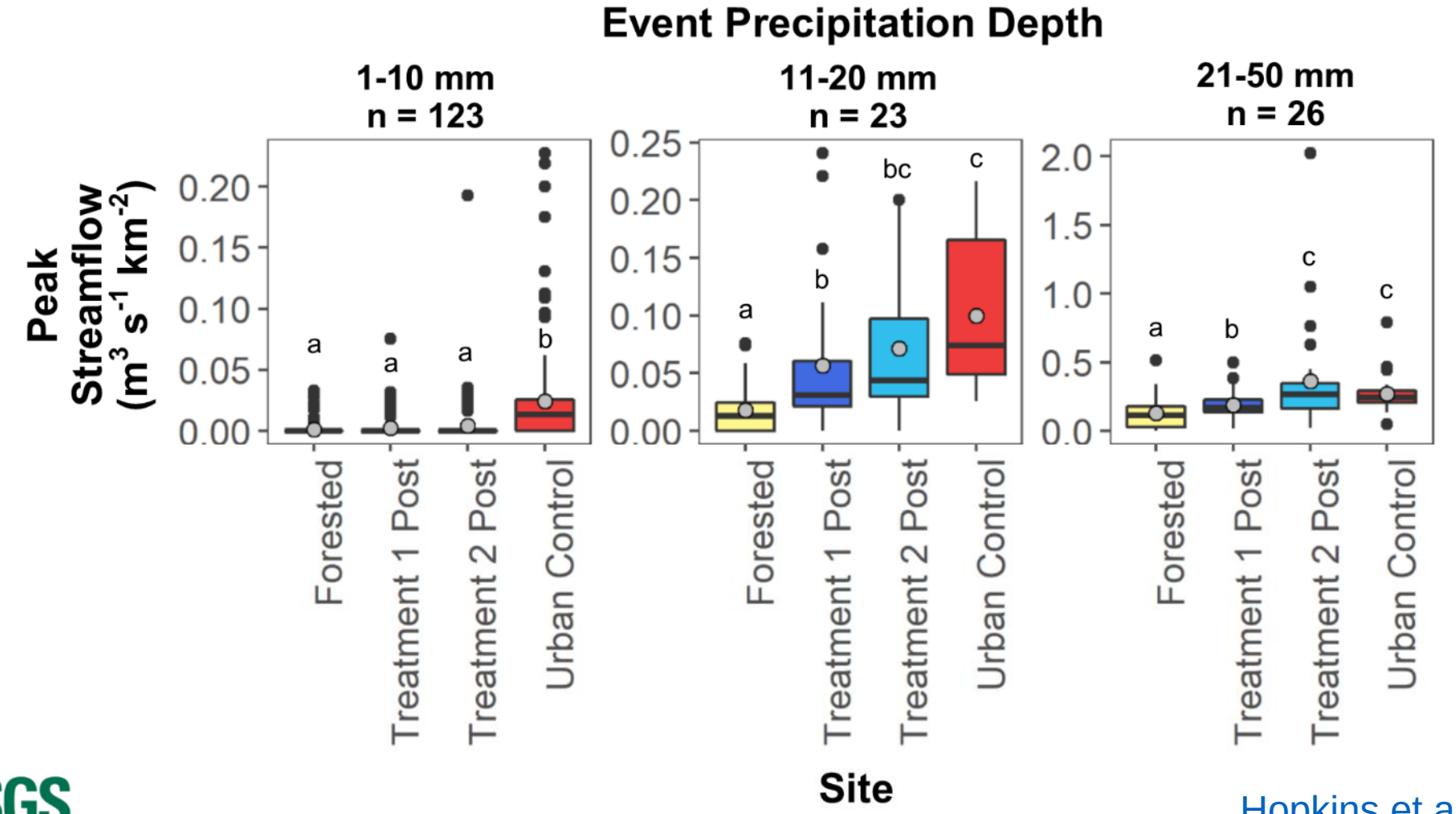


USGS science for a changing world

Hopkins et al. 2020 *Hydro Processes*

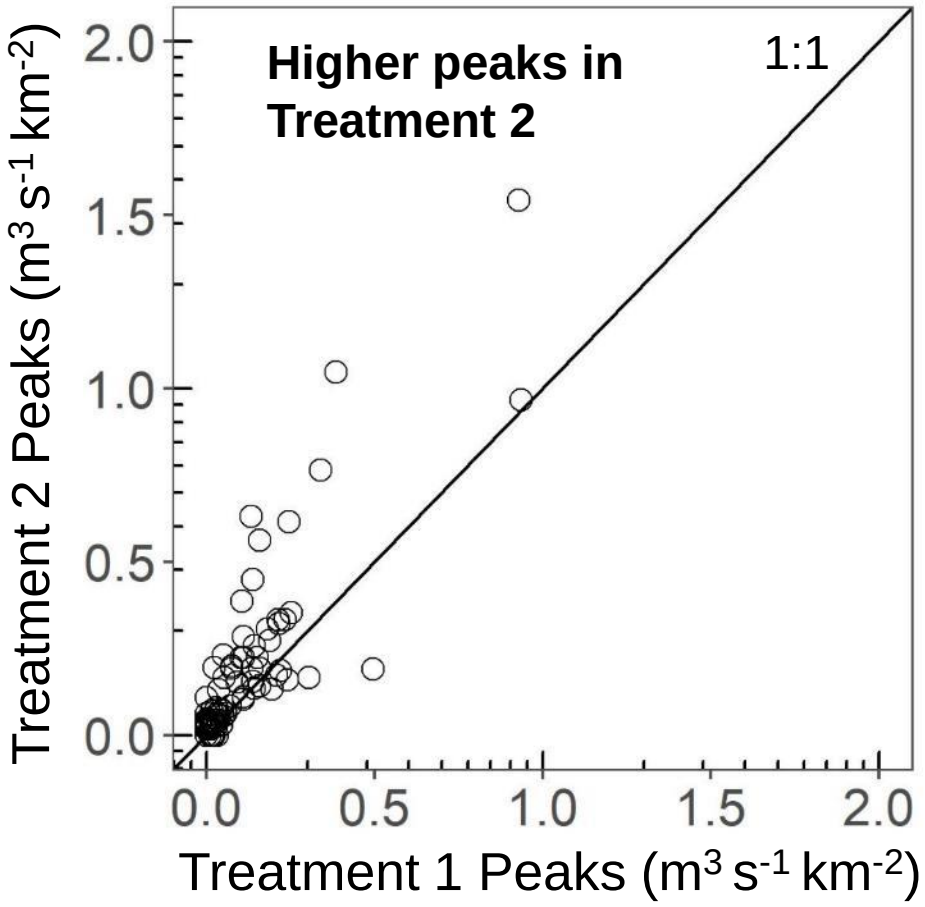
After development in Treatment 1 and 2

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

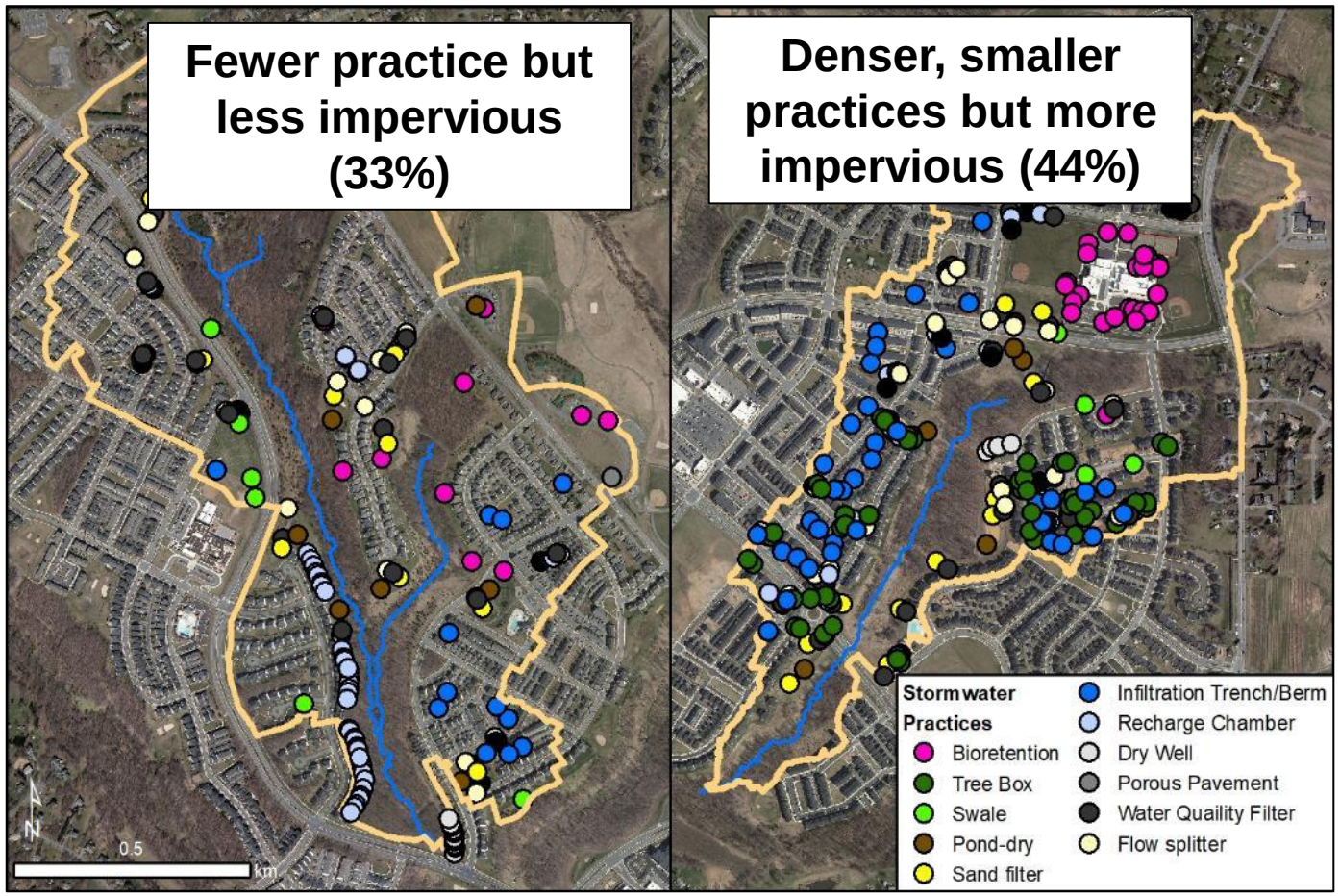


Hopkins et al. 2020 *Hydro Processes*

Streamflow: Stormflow peaks were typically larger in Treatment 2



Treatment 1 **Treatment 2**



Hopkins et al. 2020 *Hydro Processes*

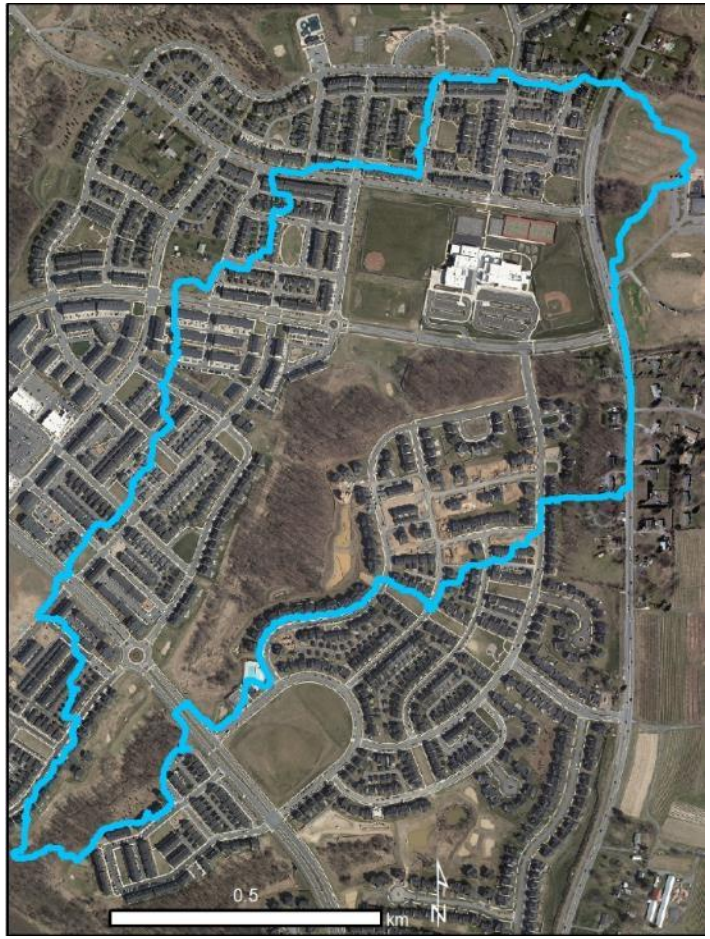
BEFORE

2004

2% impervious cover

VS

AFTER



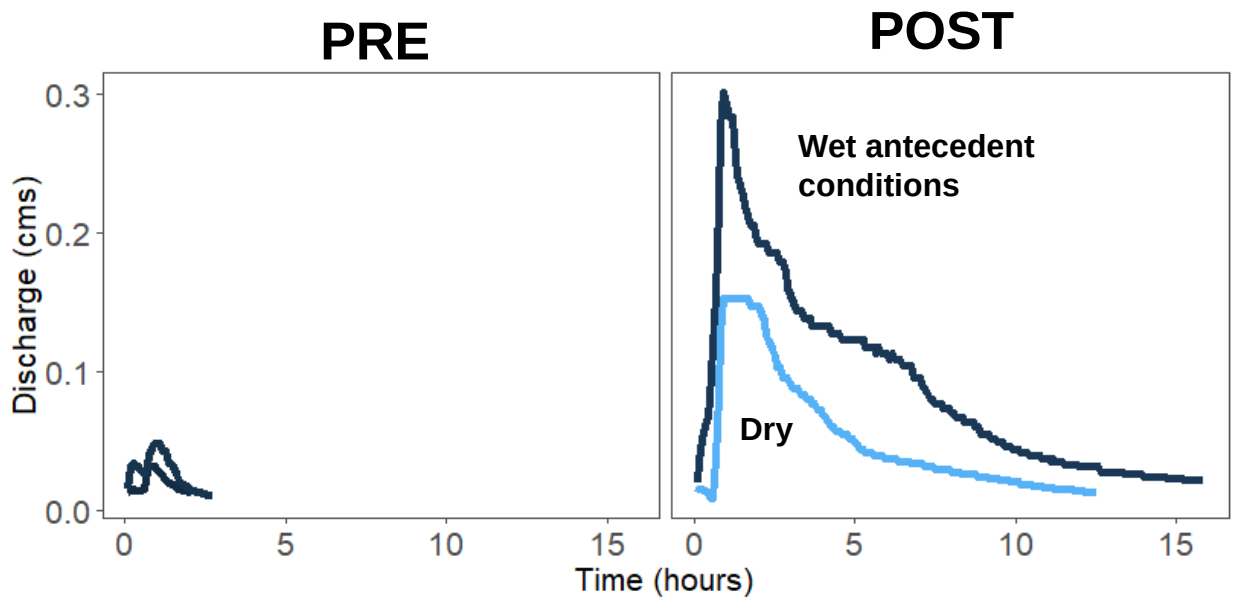
2017

44% impervious cover

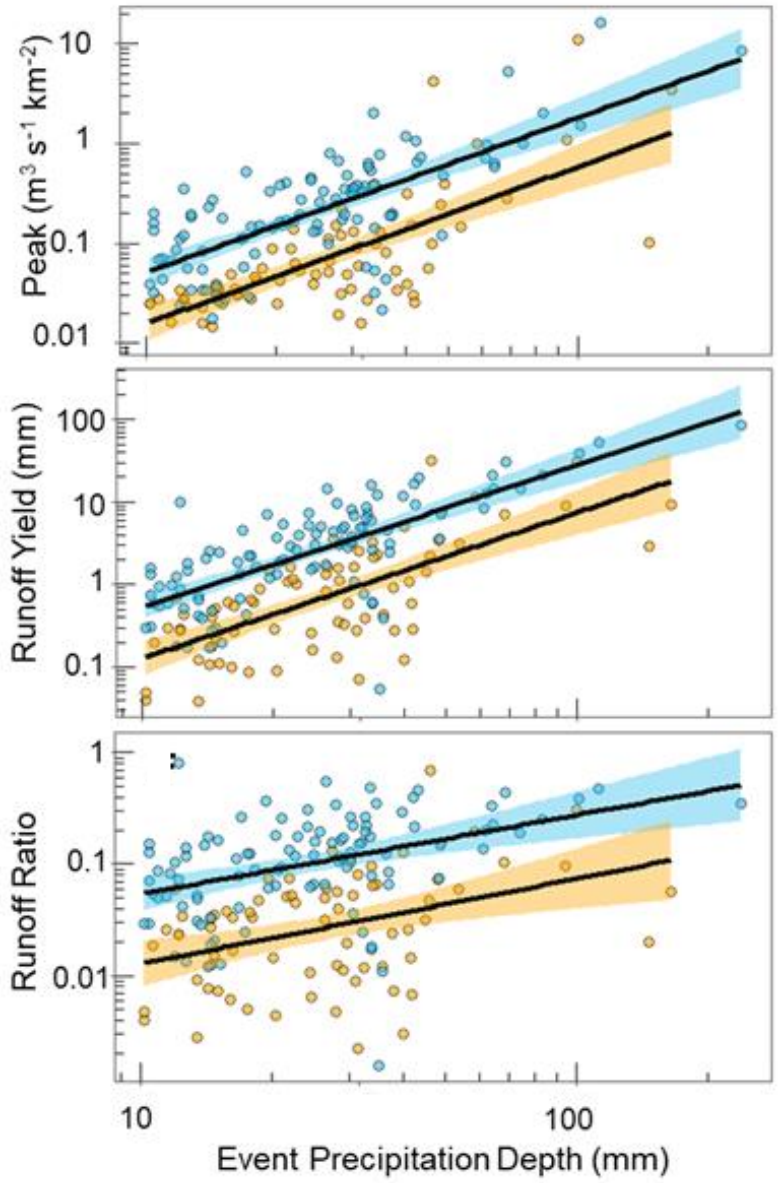
Streamflow changes in Treatment 2

Before Development vs After Development

Event Duration
Peak Streamflow
Runoff Yield
Runoff Ratio



1.2-1.6 inches rain



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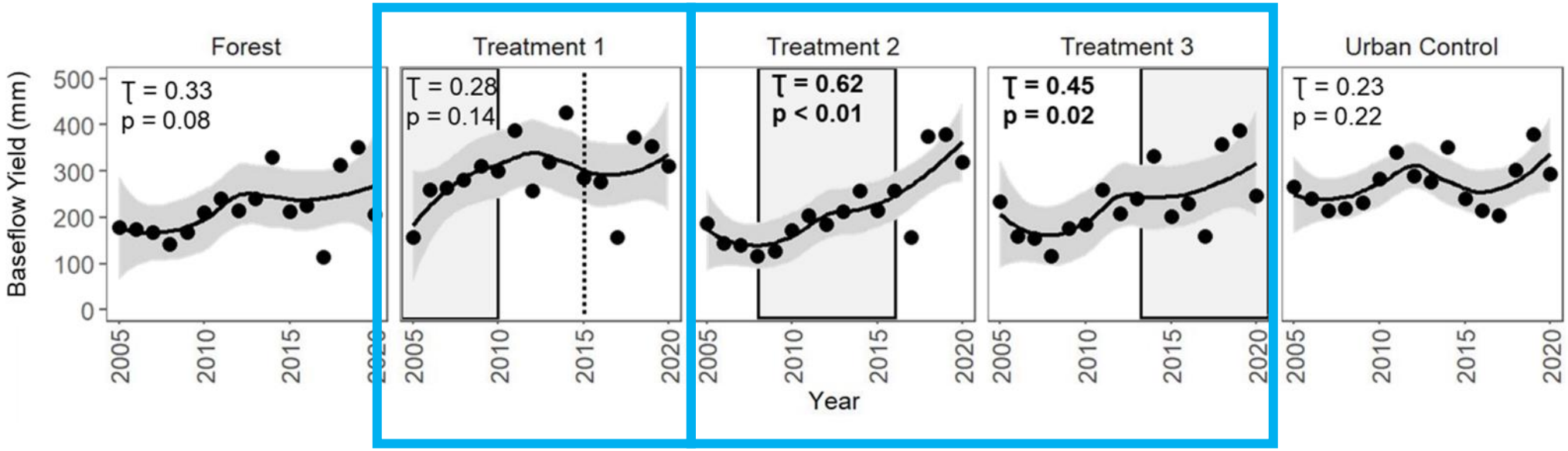
Hopkins et al. 2020 *Hydro Processes*

Baseflow increased during the construction phase of suburban development



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Can distributed stormwater control maintain hydrologic function?

Can reduce the frequency of events

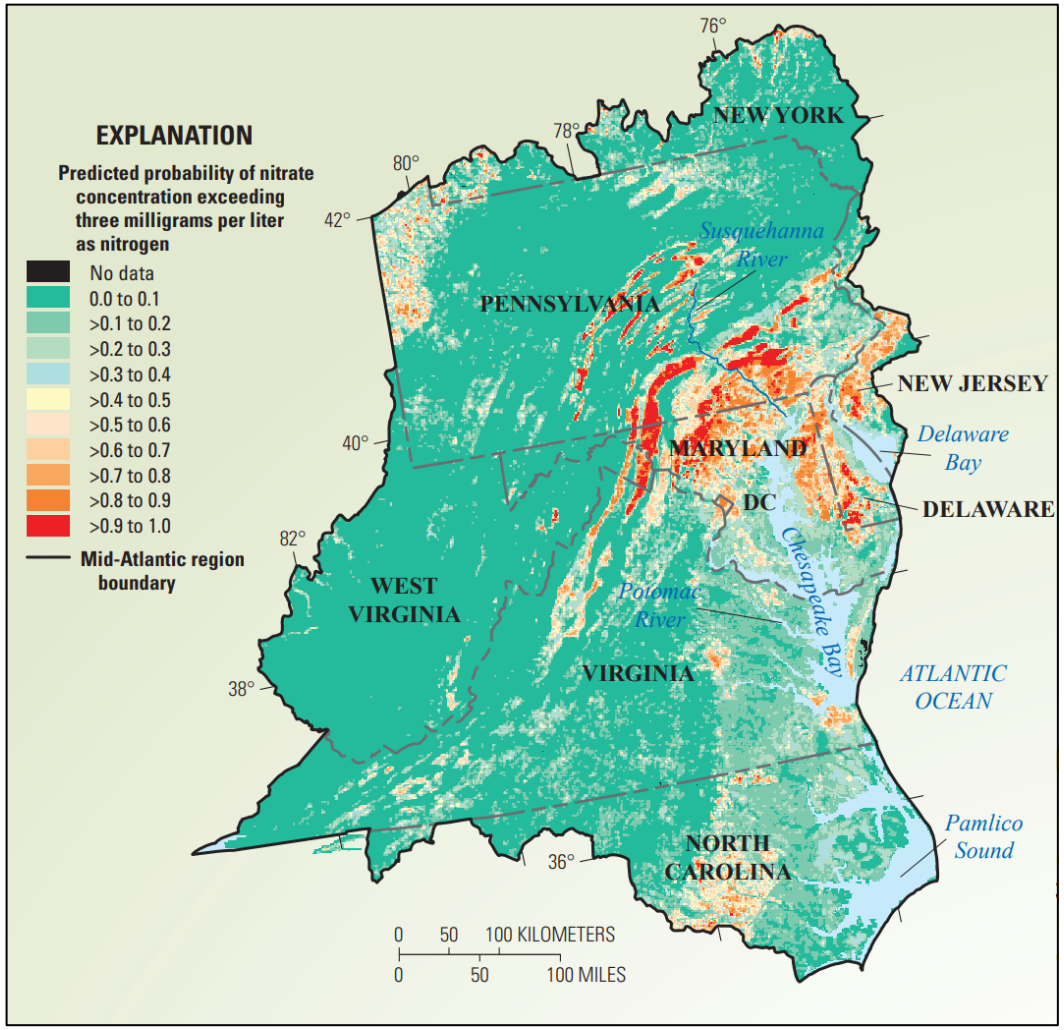
Can attenuate peak flows and runoff volumes, **but** storage capacity matters.

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

Baseflow may increase during construction and remain elevated.

Water Quality – Baseflow Nitrate

Water Quality
Nutrients
Sediment
Conductance

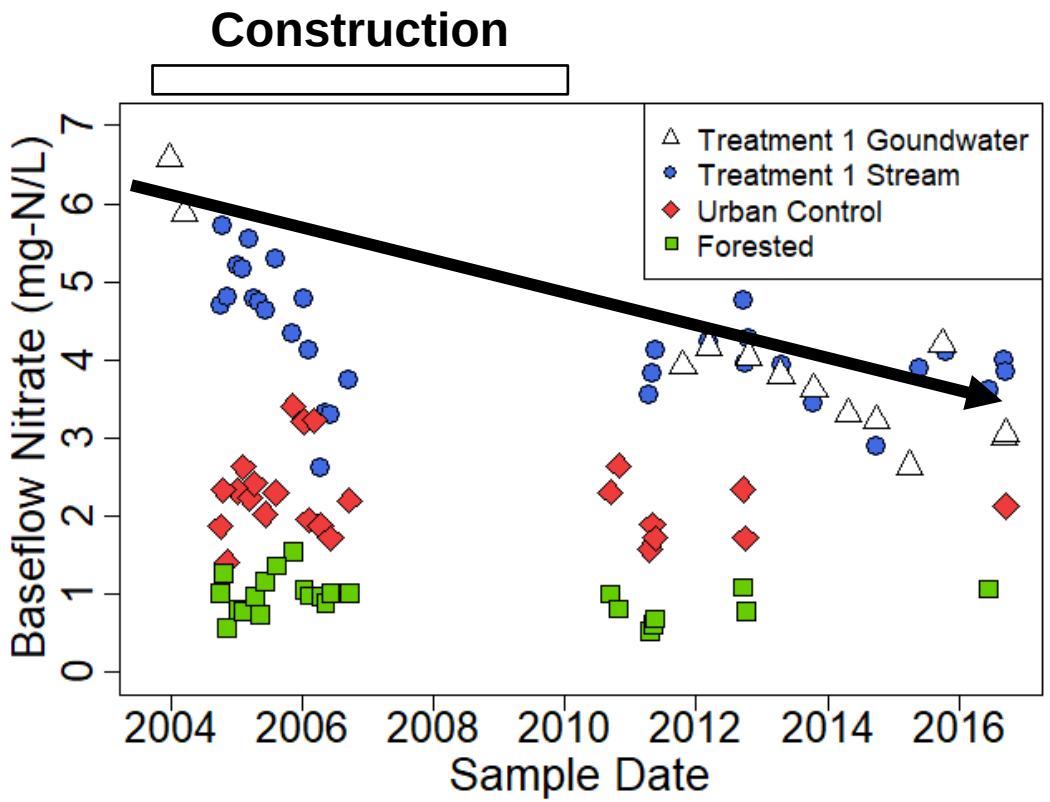


Probably of groundwater nitrate exceeding 3 mg/L

[Clune & Capel 2021 USGS Circular]

Baseflow nitrate concentrations

Nitrate concentration declined but remain elevated



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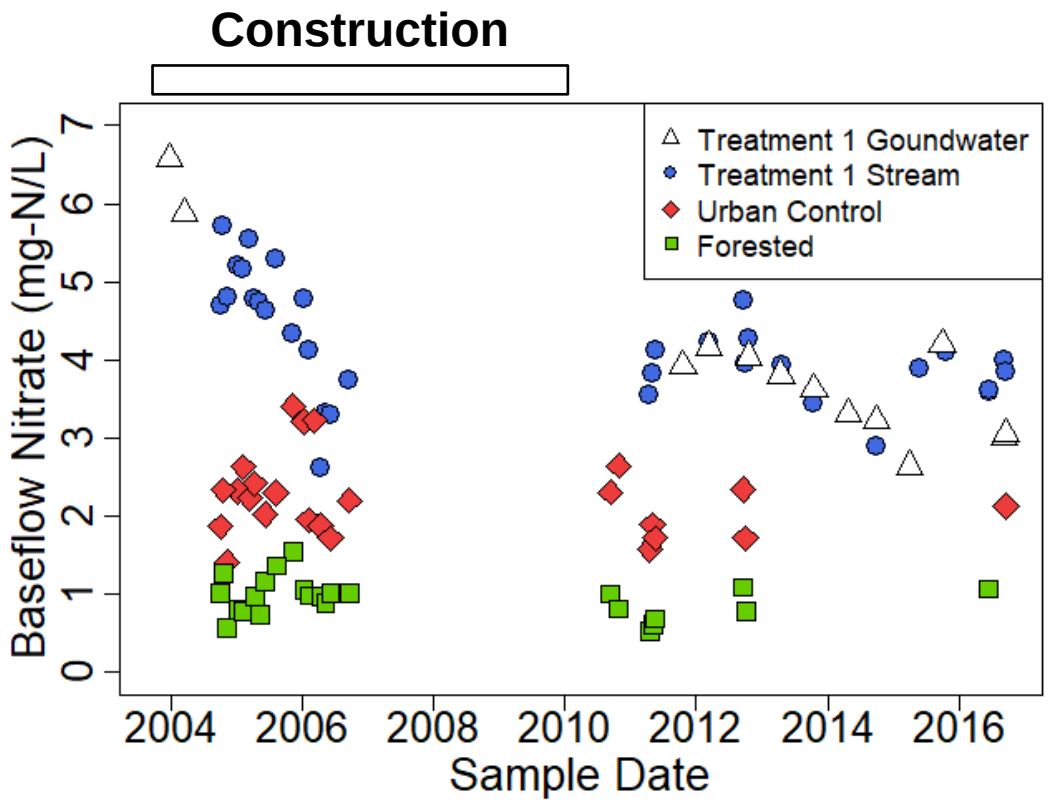
Baseflow nitrate concentrations

- 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



Legacy Nitrogen
Timing of agricultural land conversion

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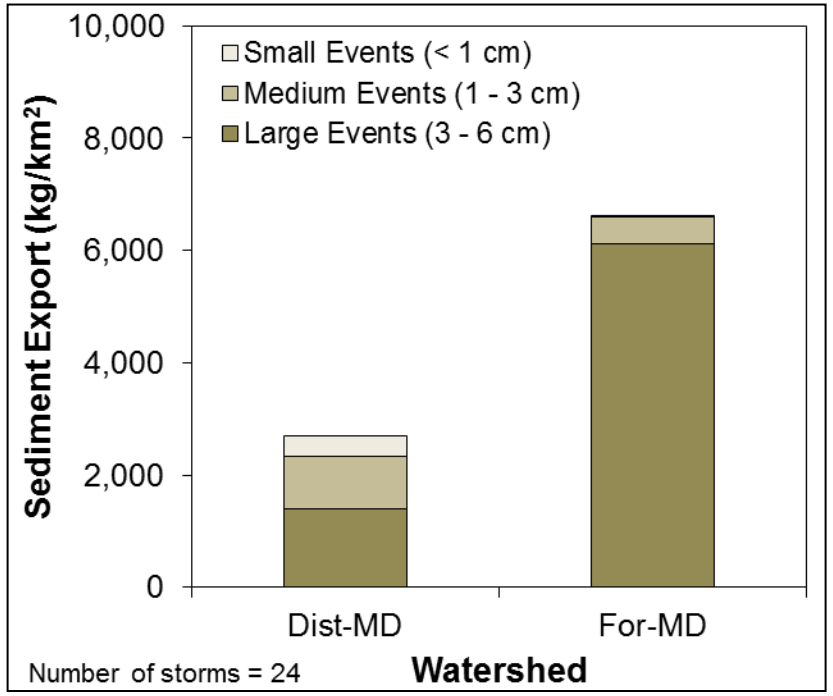
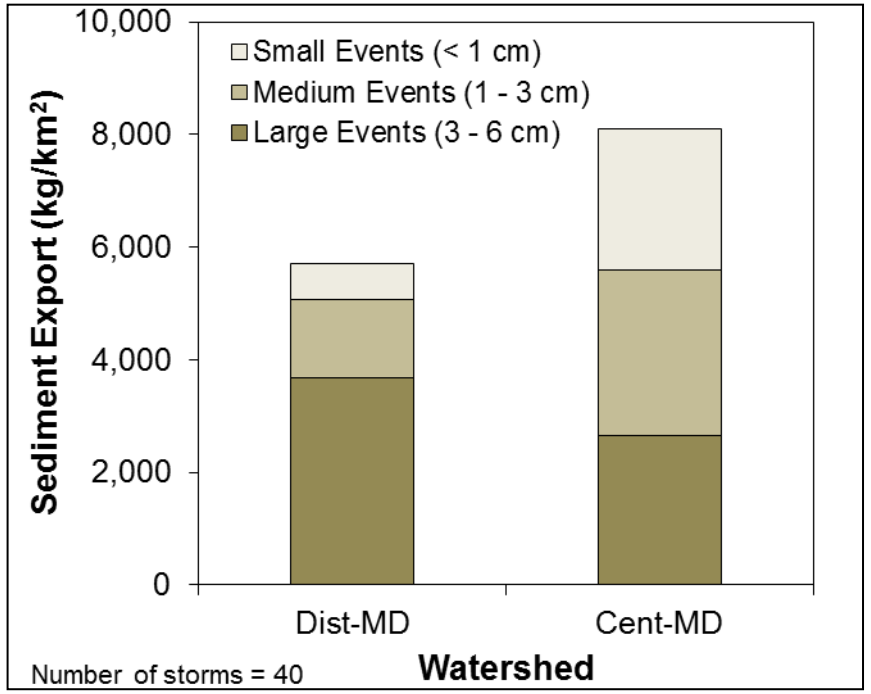
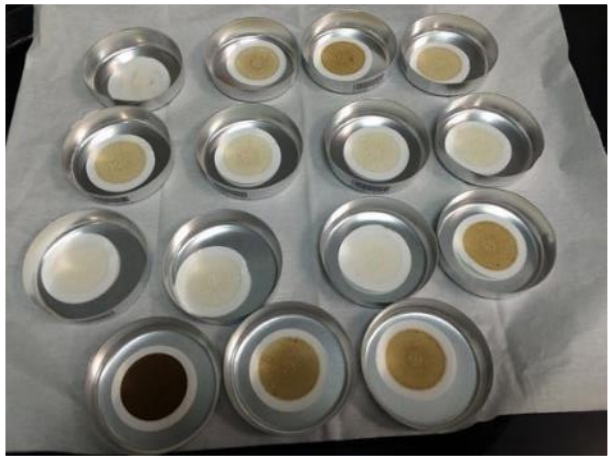
Treatment 1 had LESS overall sediment export than the forested and urban controls

Distributed vs Forested



Distributed vs Centralized





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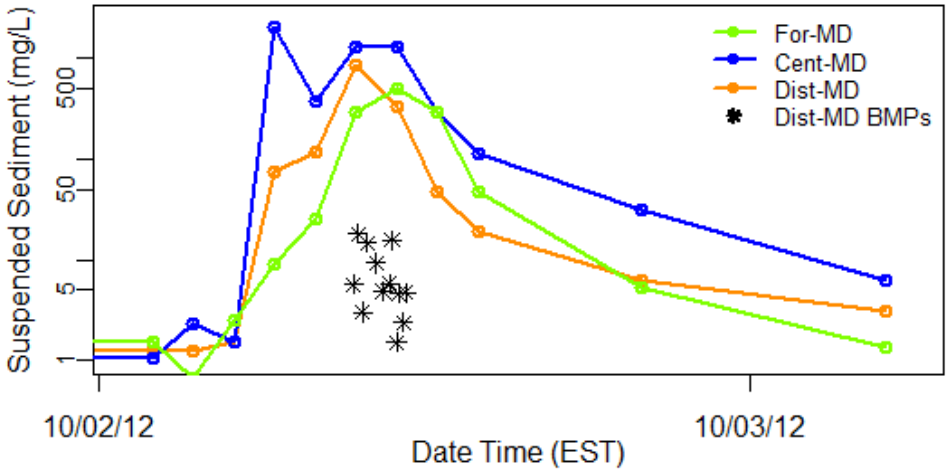
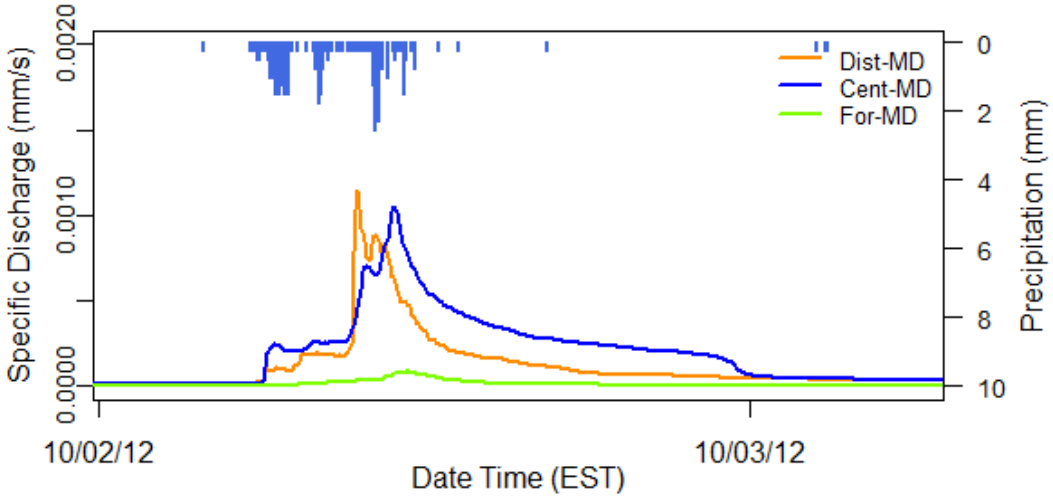
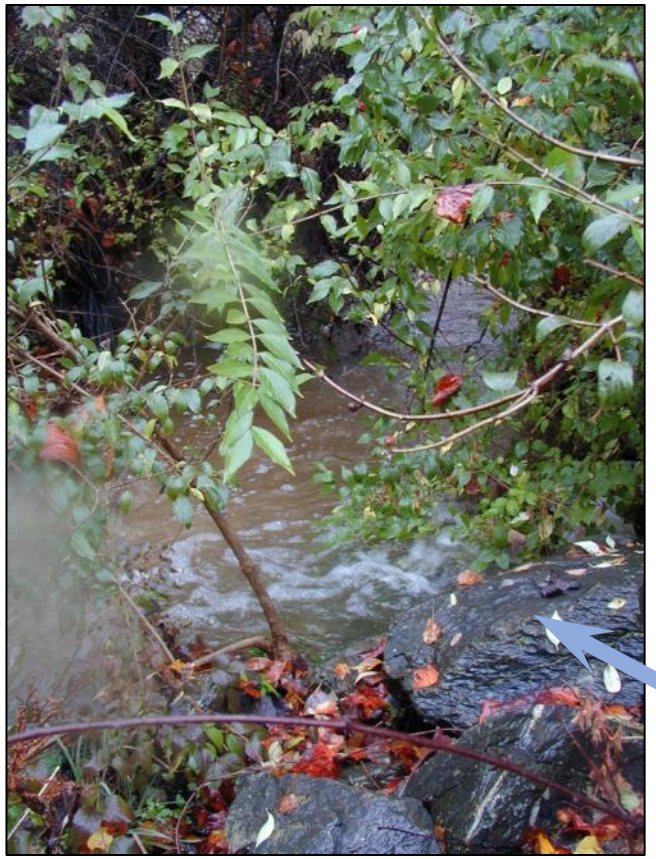
Hopkins et al. 2017 *Environmental Management*

Sediment concentration coming out of stormwater practices was lower than in stream.



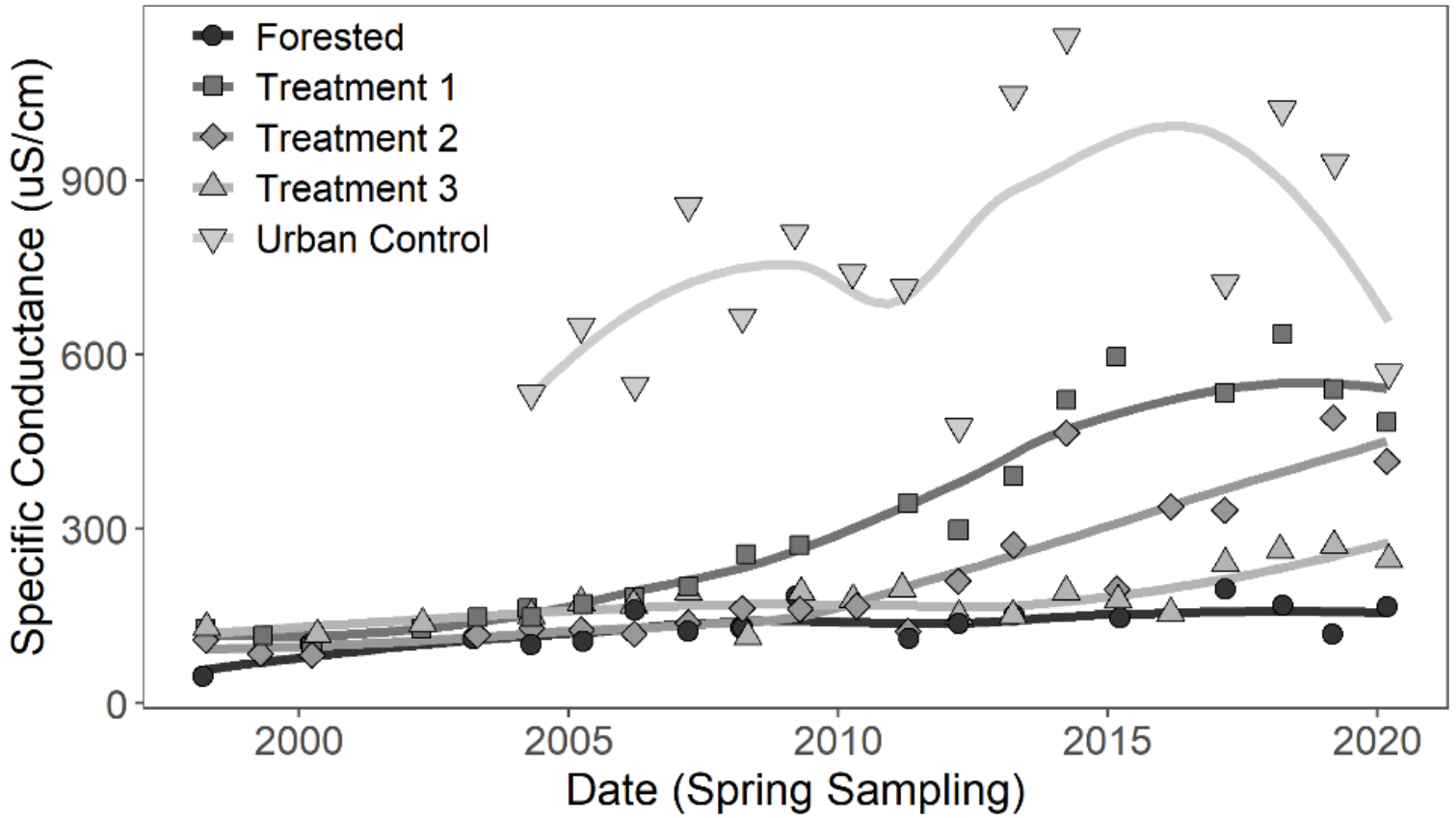




Water drainage from stormwater practice

Hopkins et al. 2017 *Environmental Management*

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

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Hopkins et al. 2022 *Freshwater Science*

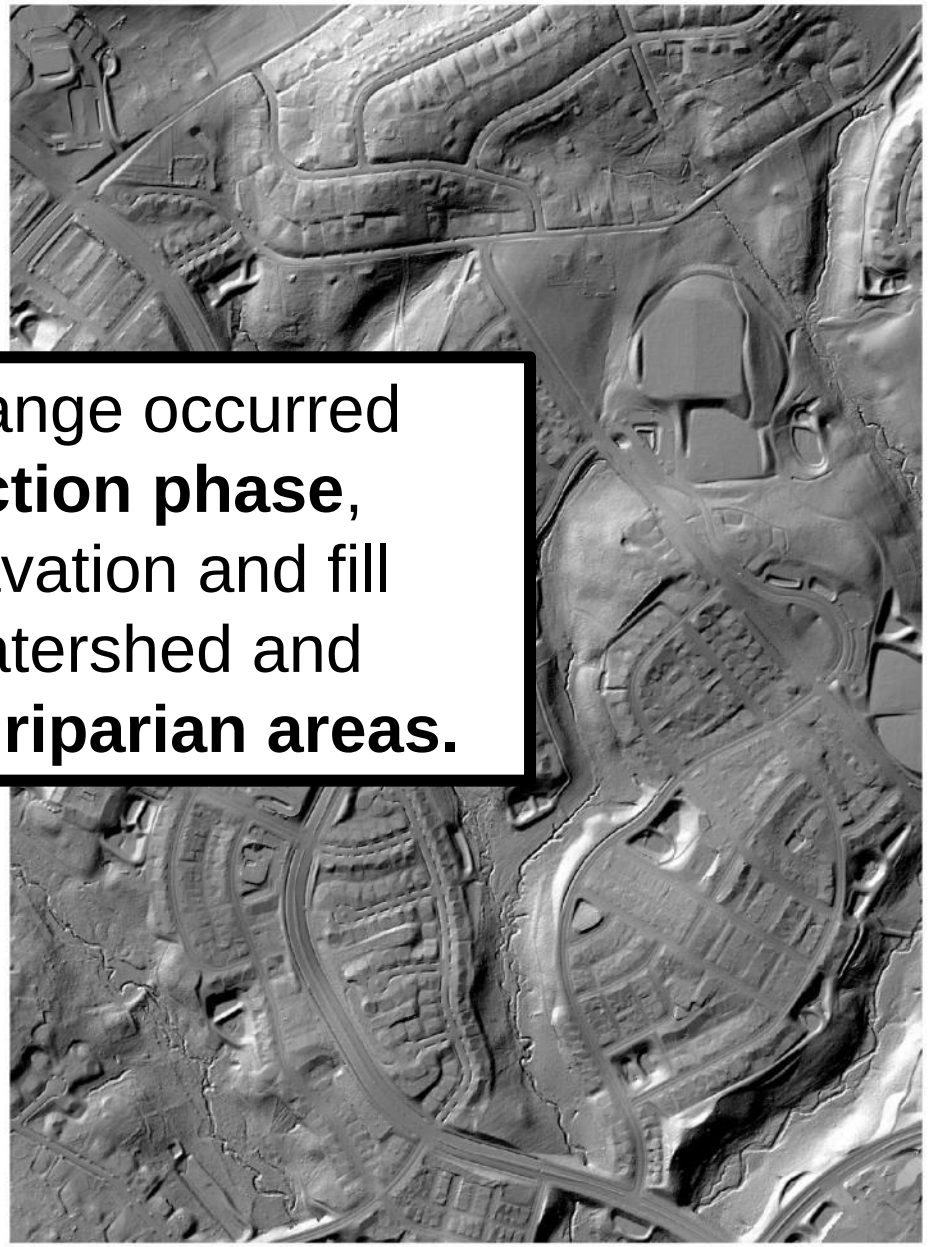
Can distributed stormwater control maintain water quality?

It can reduce nitrate concentrations, **but** overall export remained about the same.

It can reduce sediment loads, **but** in-channel sources remain due to altered hydrology.

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

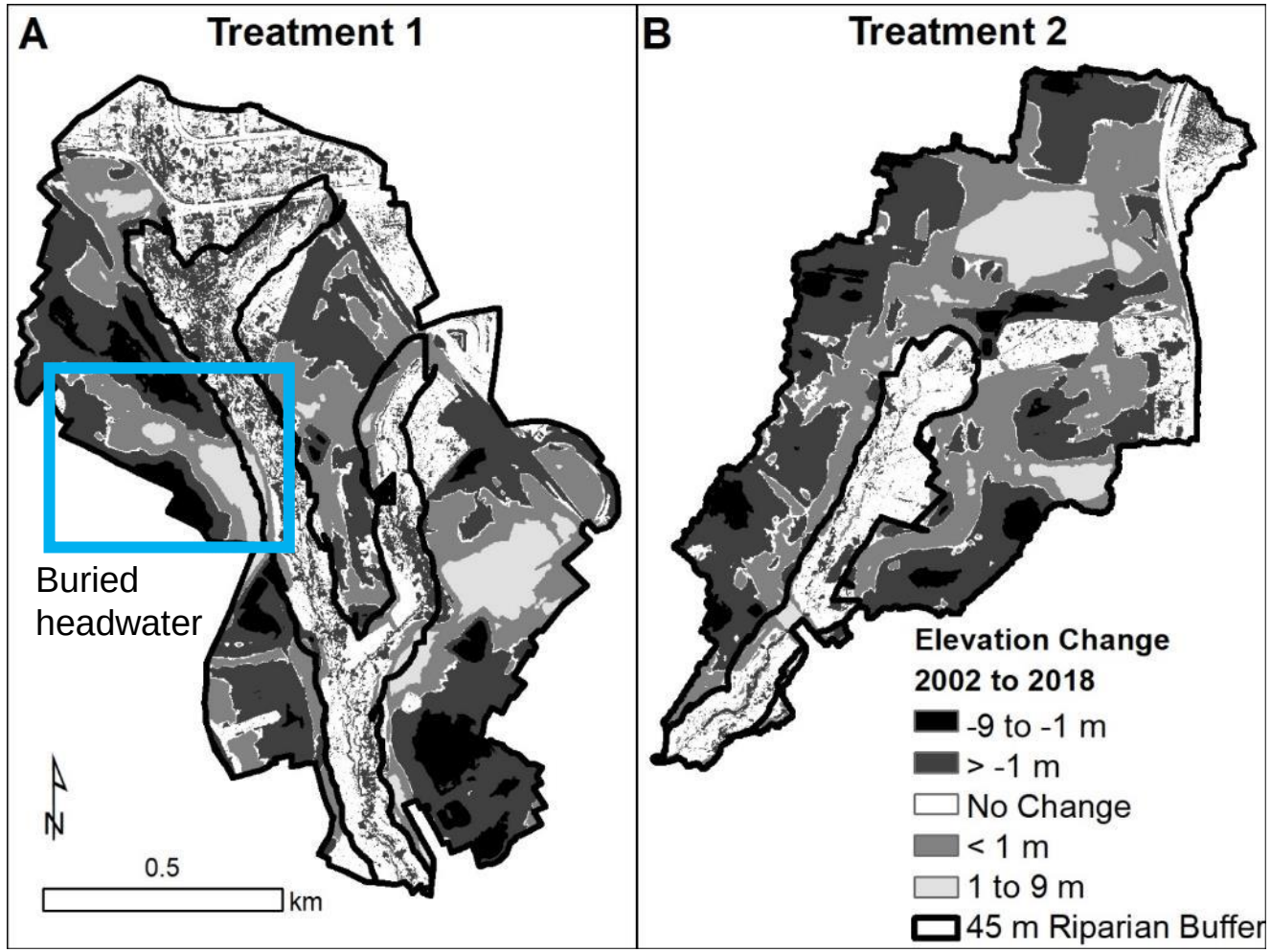
Topography

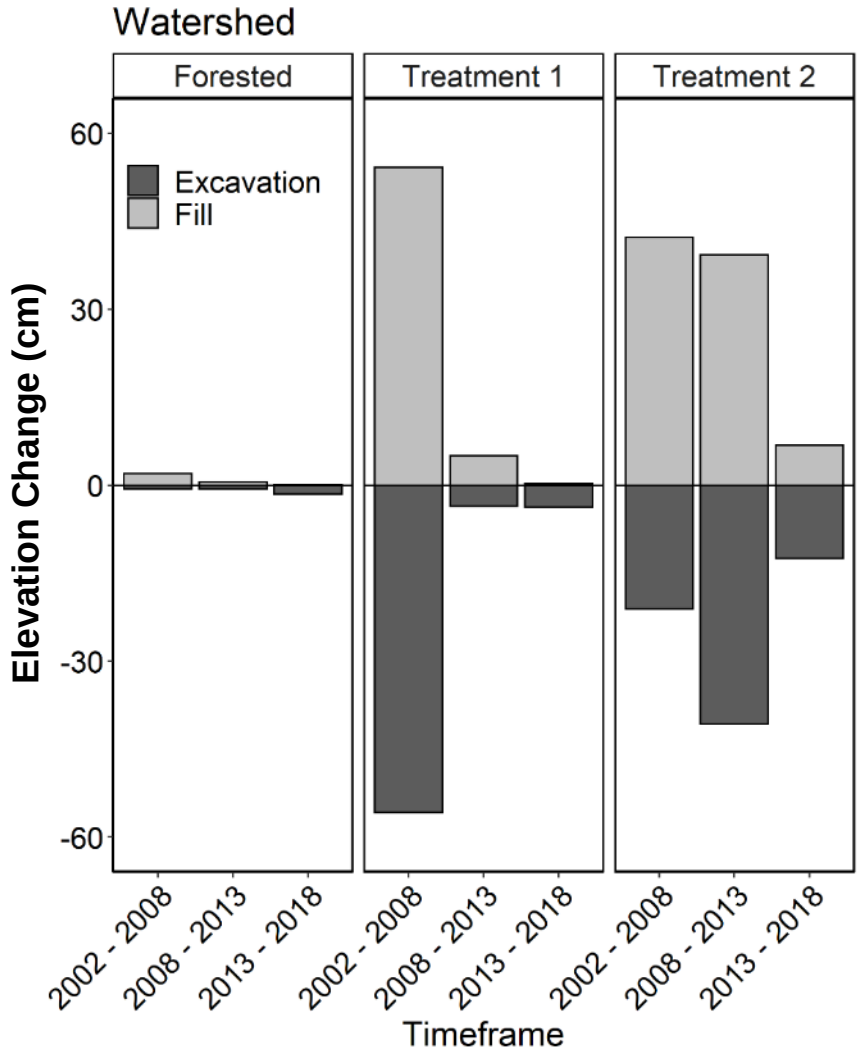


Most topographic change occurred during the **construction phase**, with substantial excavation and fill across the entire watershed and **deposition within the riparian areas.**

Topography
Elevation change
Stream channels

Large scale fill and excavation. Flatten ridgetops and fill valleys





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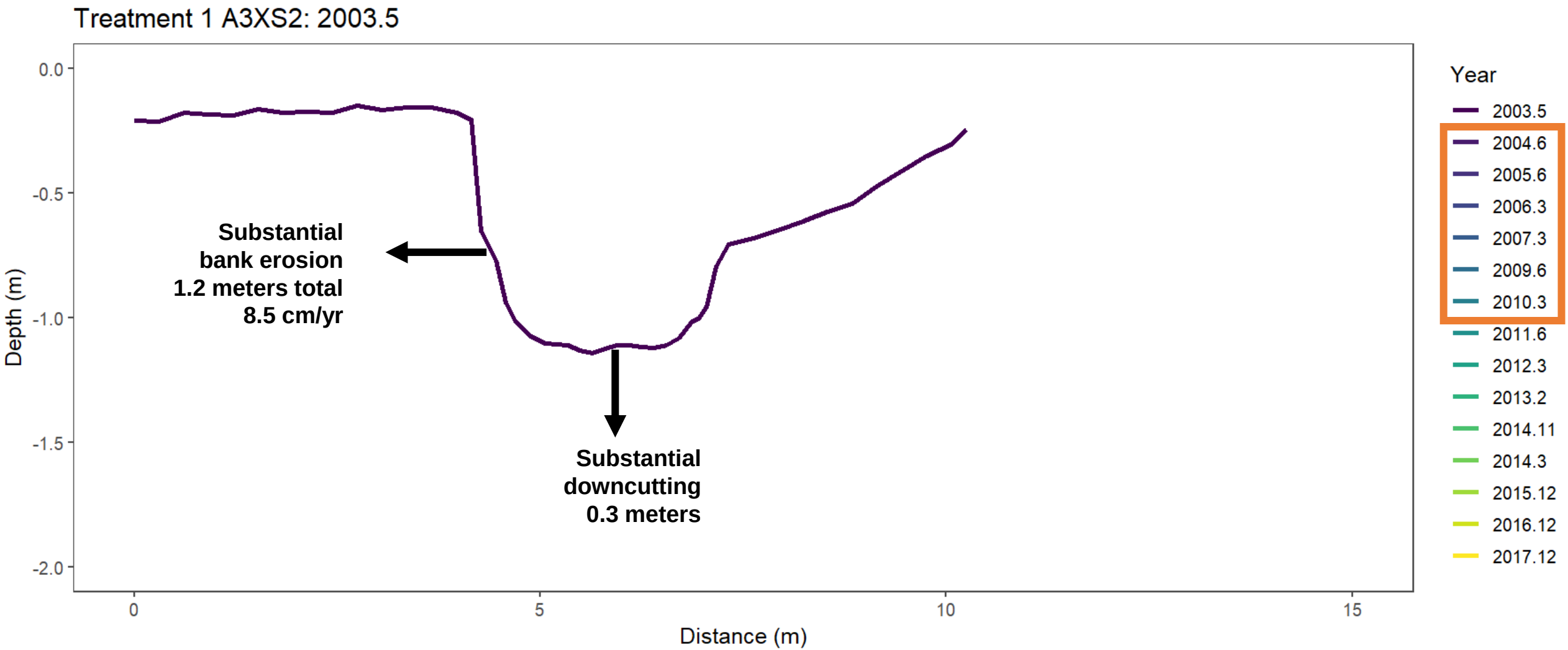
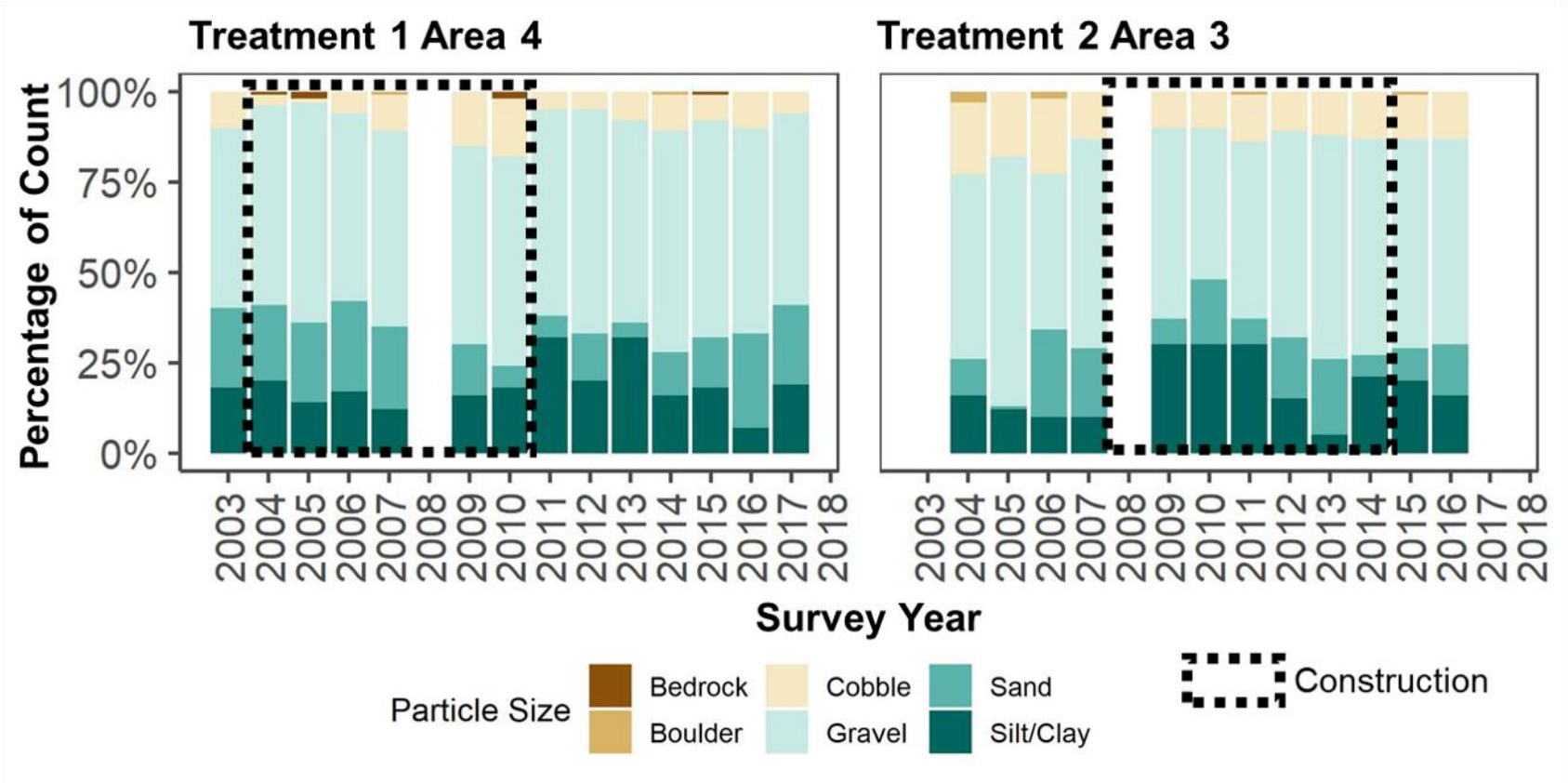
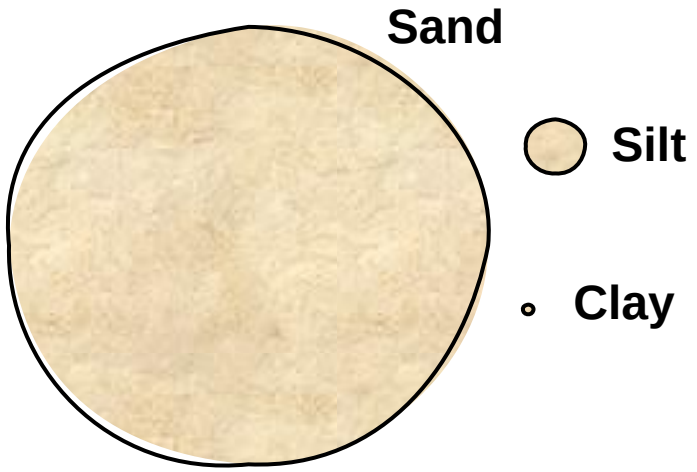
Channels were incised prior to development
Streambanks continue to erode



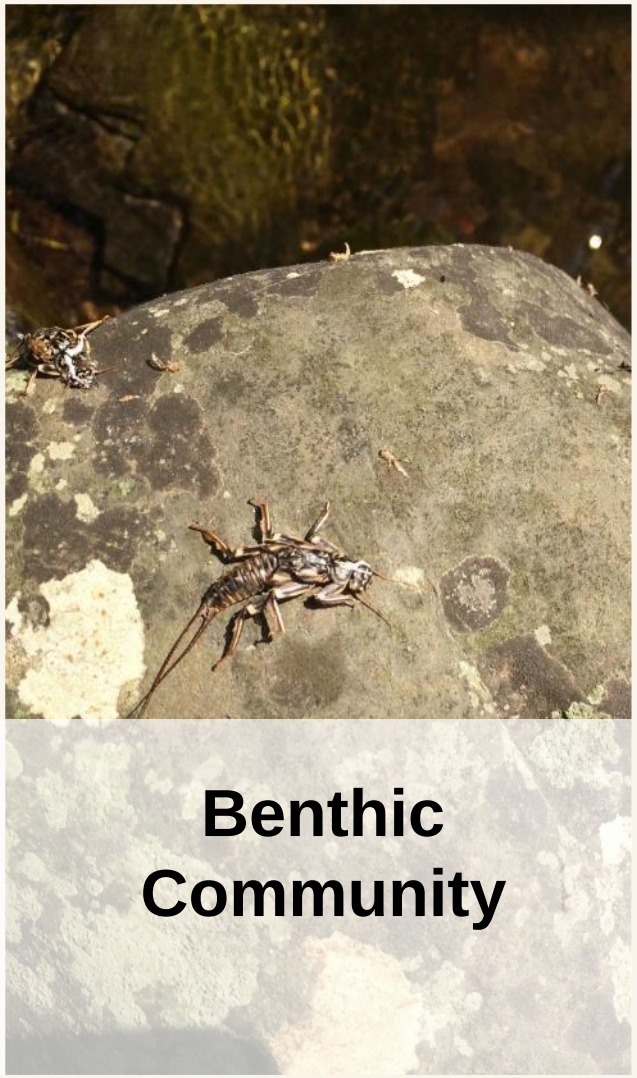
Increase in silt/clay in Treatment 2 during construction and after construction in Treatment 1

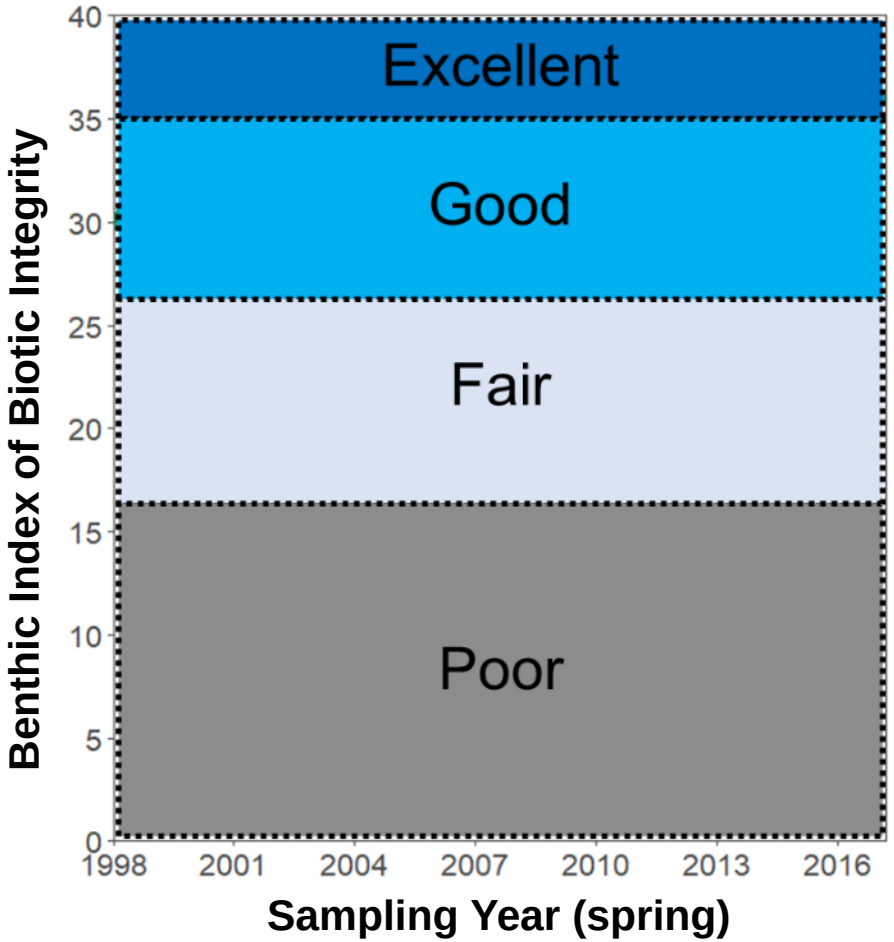


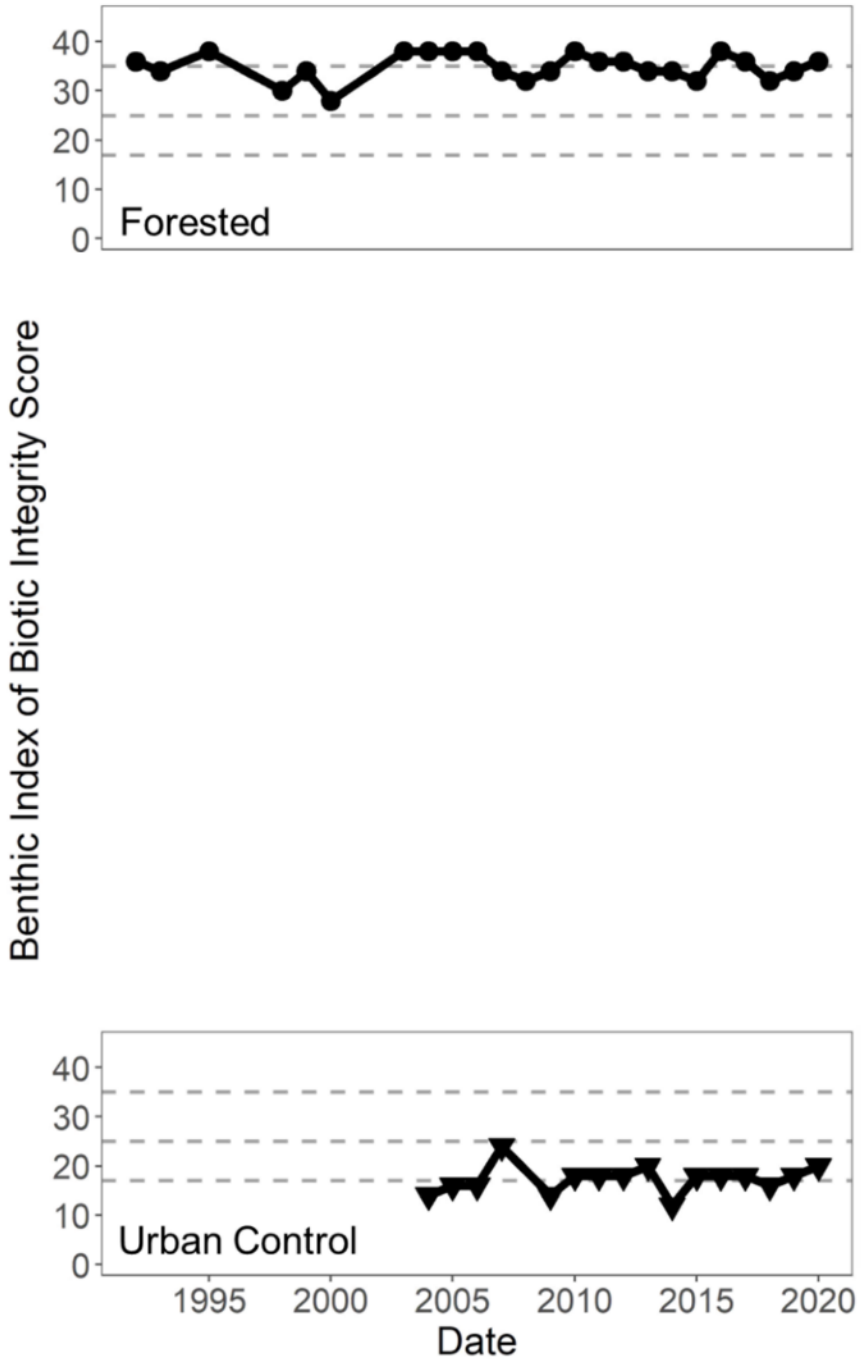


Data: Montgomery County DEP

Benthic community



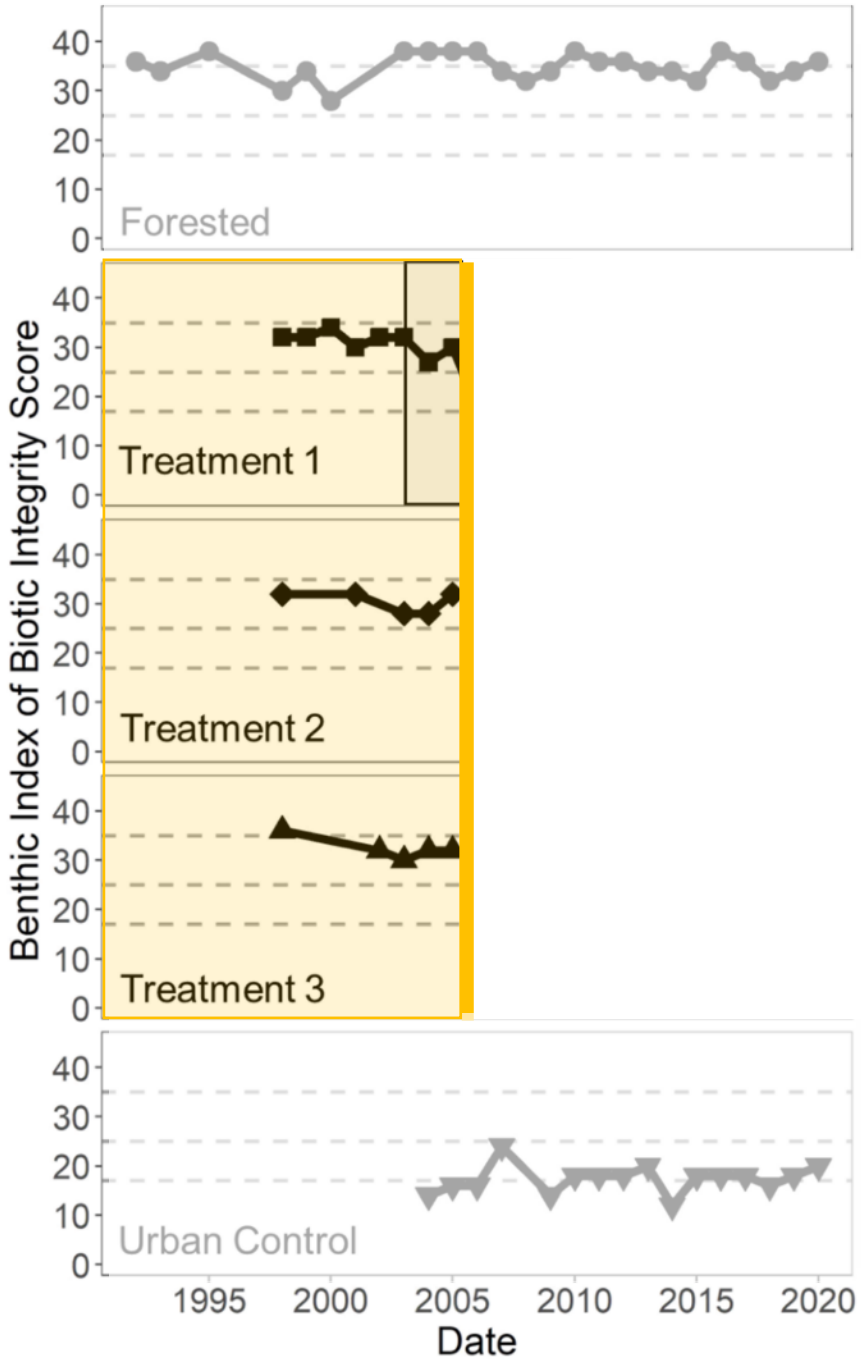


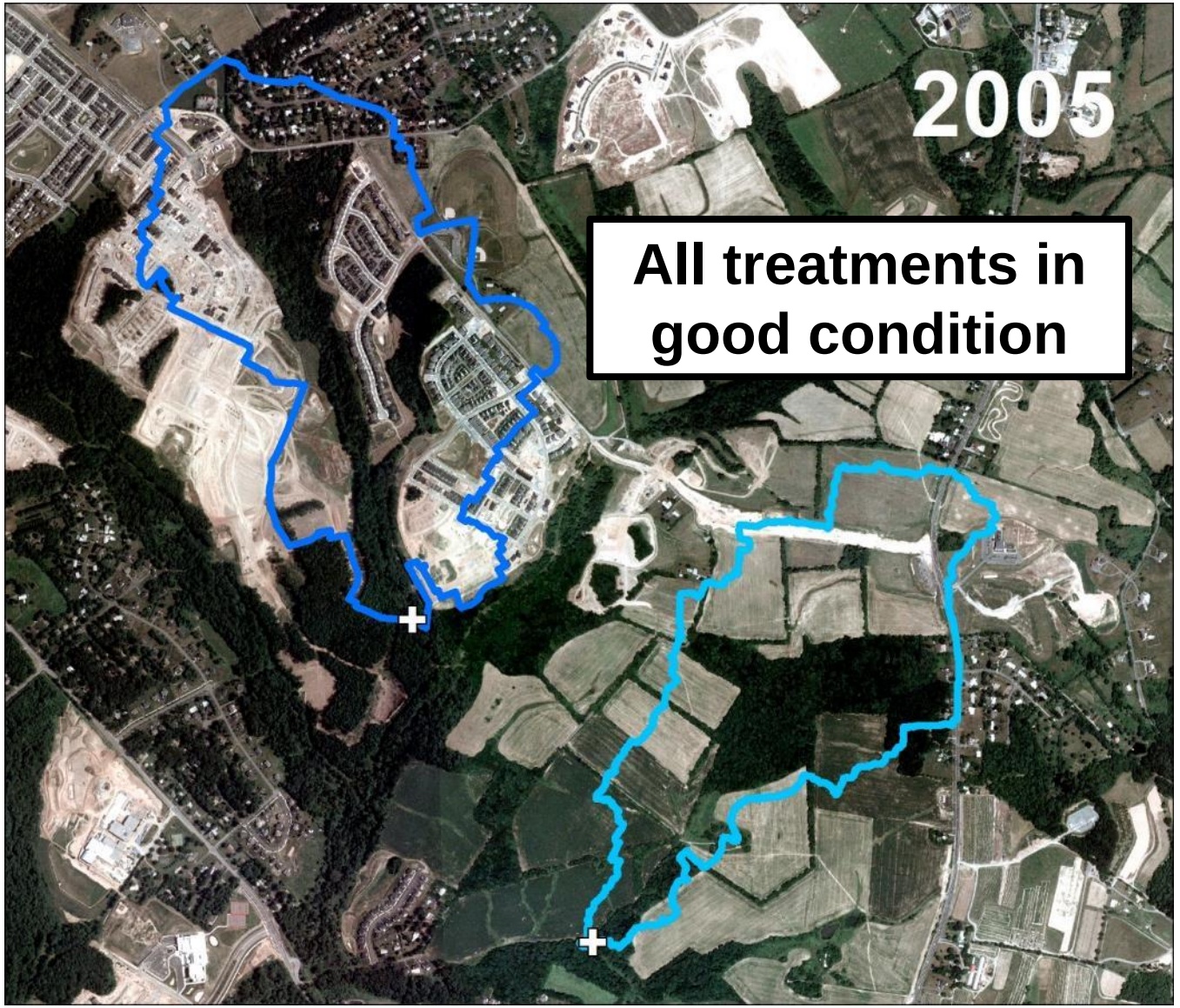


Forested site remains in excellent to good condition

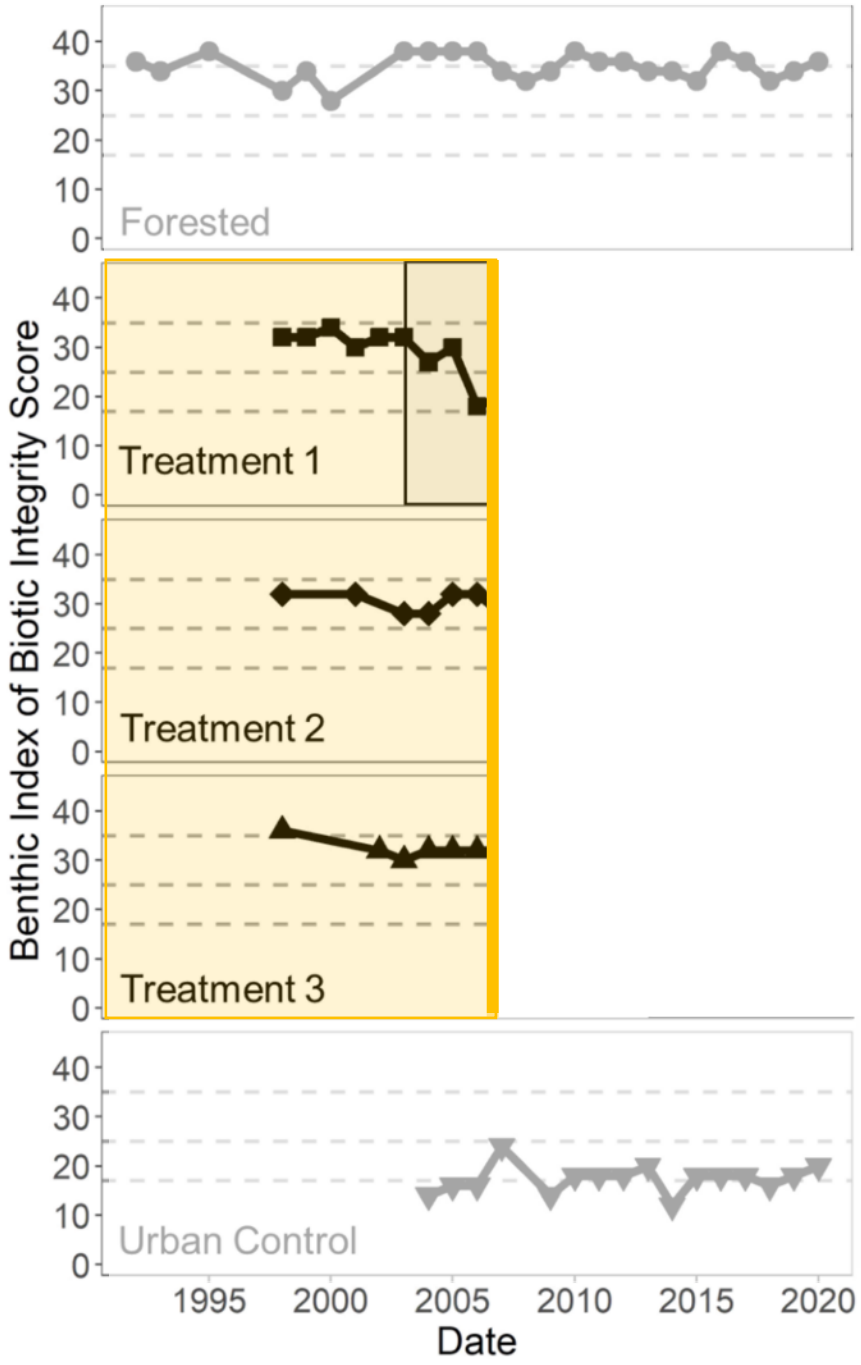
Urban control site remains in fair to poor condition

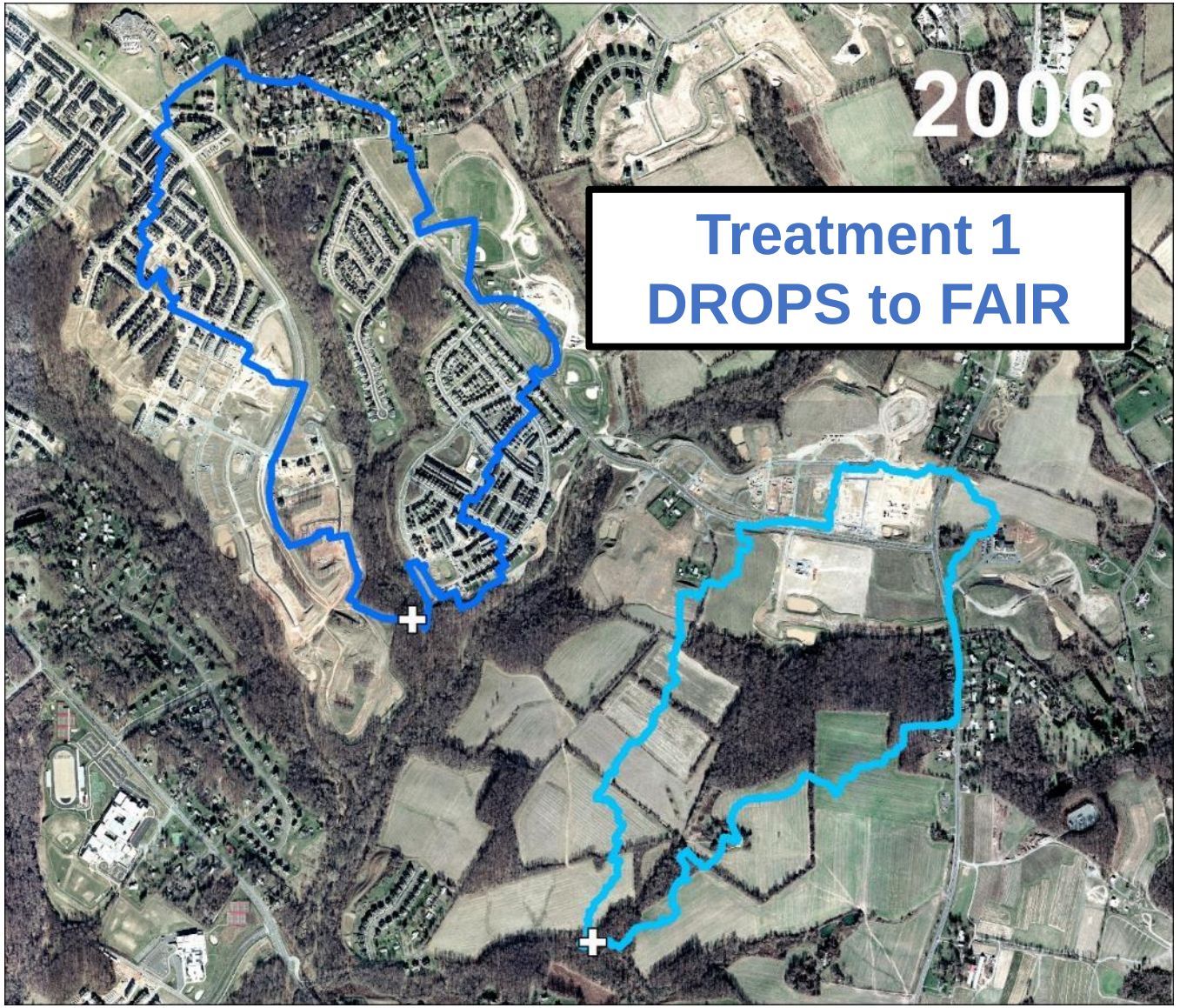
Hopkins et al. 2022 *Freshwater Science*



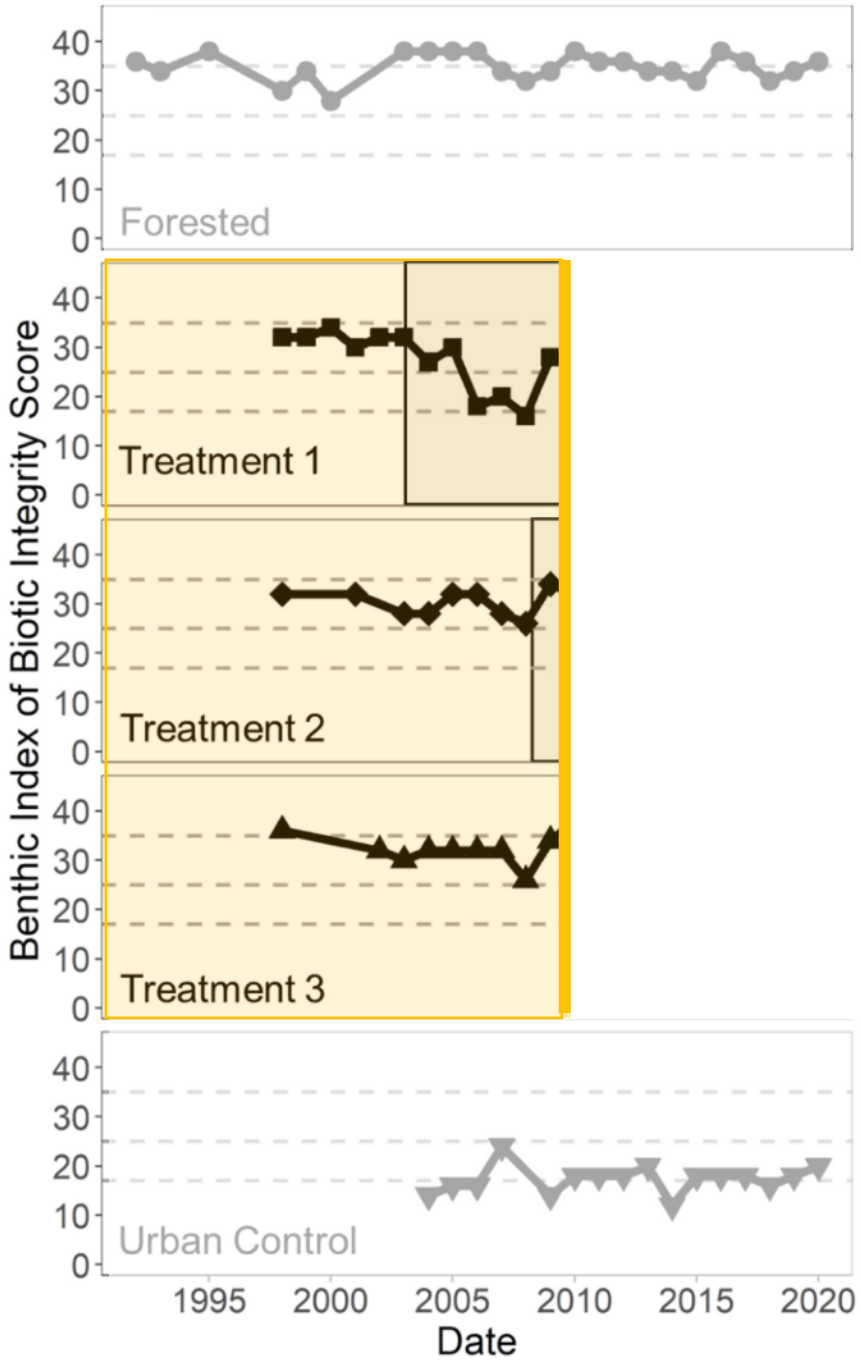


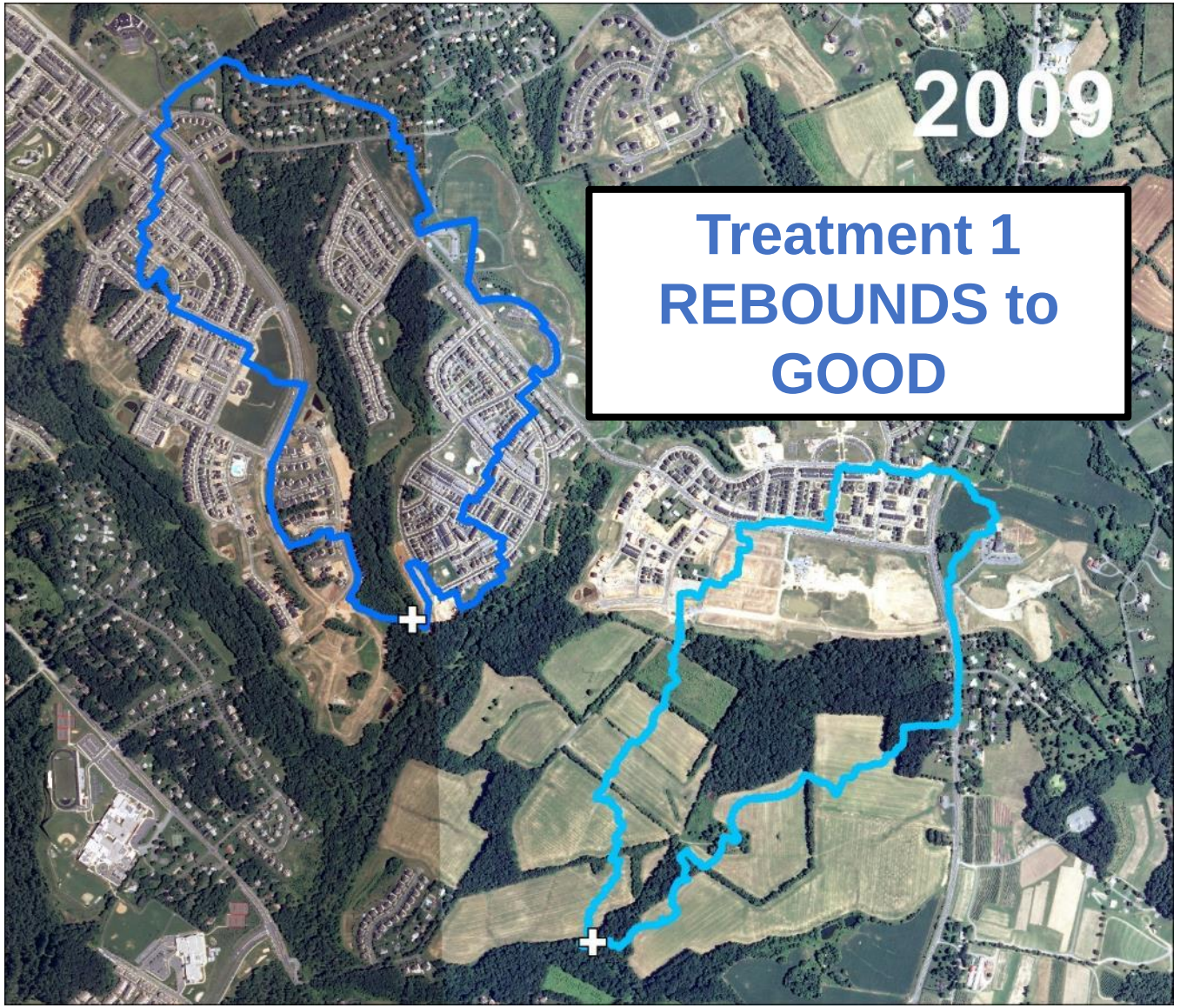
Hopkins et al. 2022 *Freshwater Science*



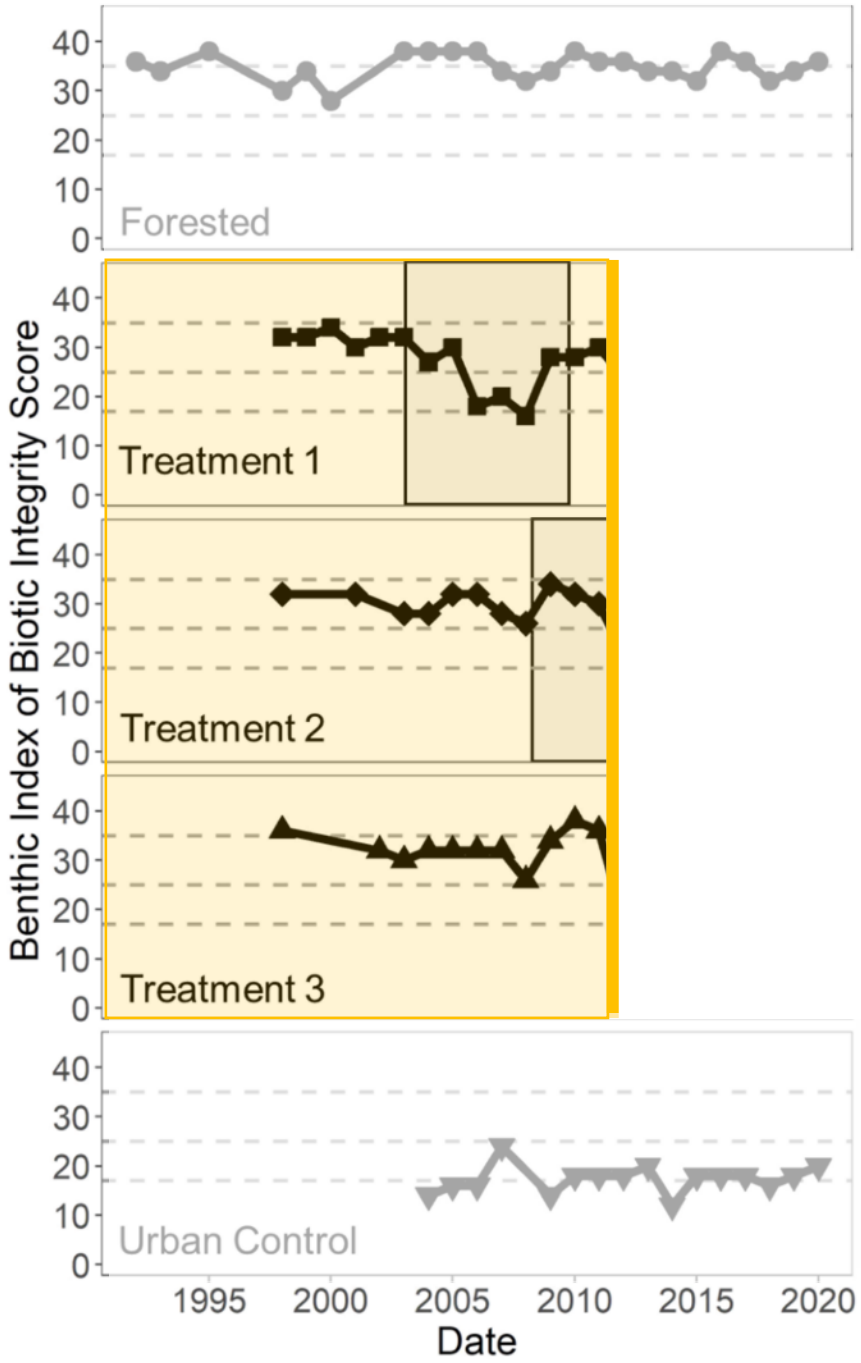


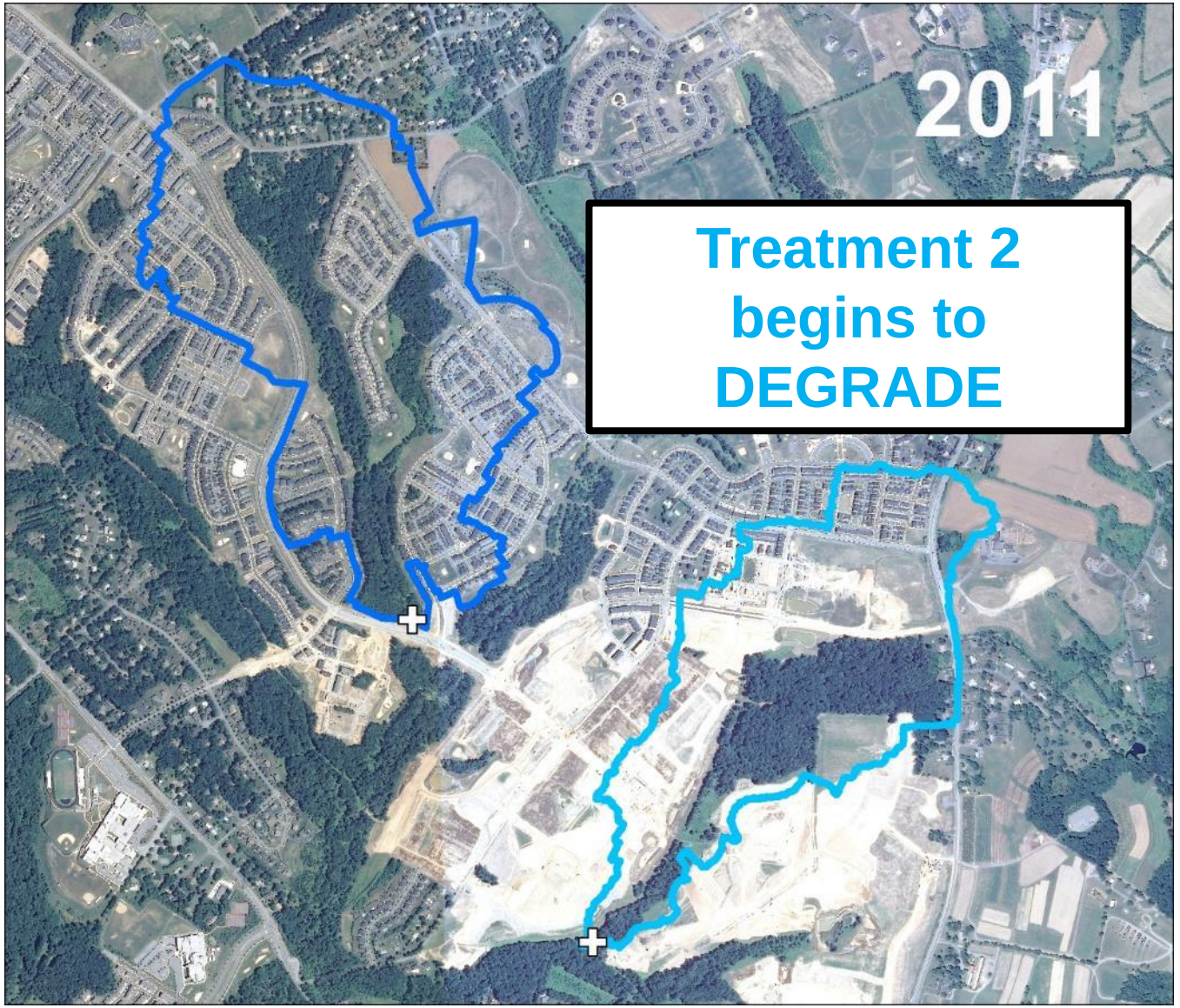
Hopkins et al. 2022 *Freshwater Science*





Hopkins et al. 2022 *Freshwater Science*





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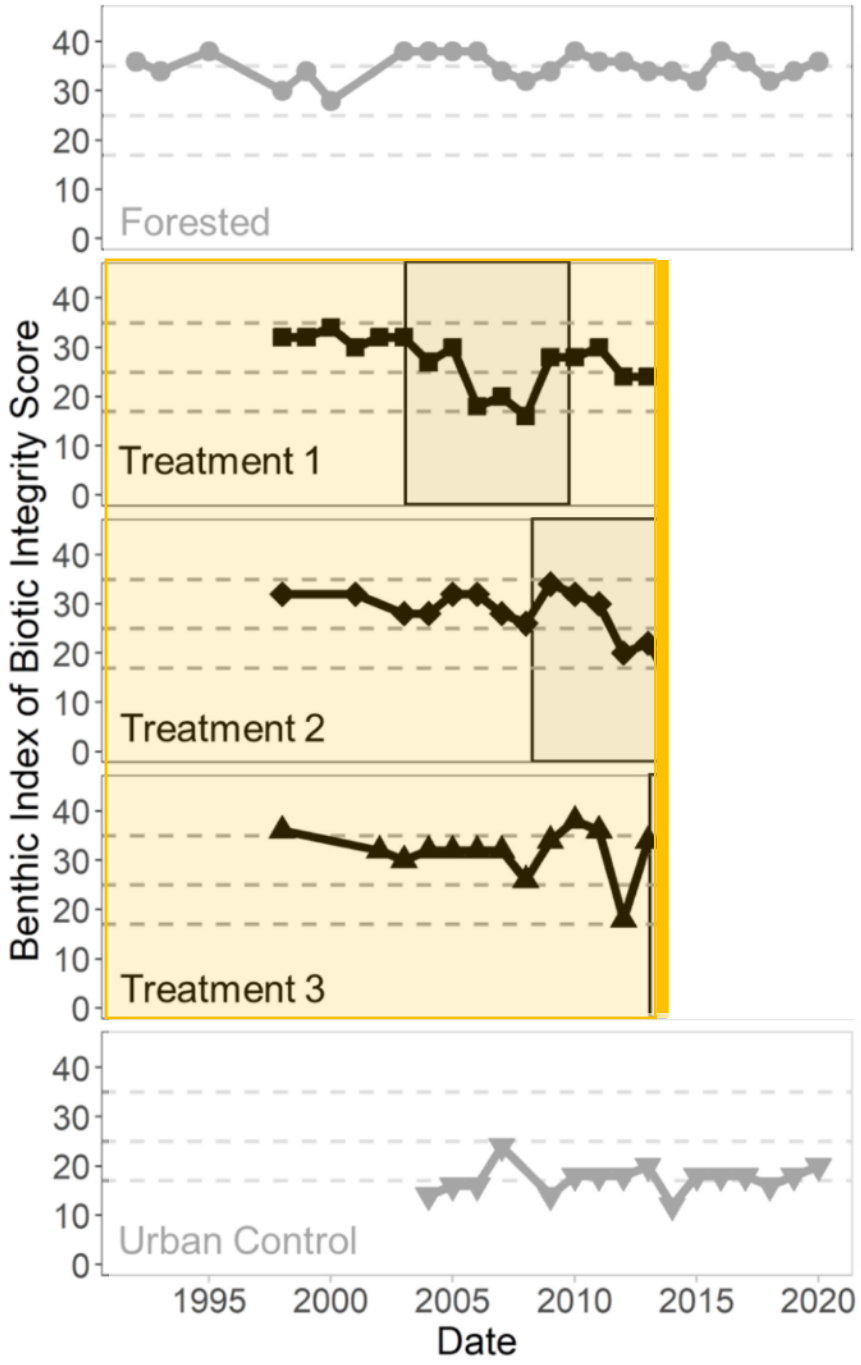

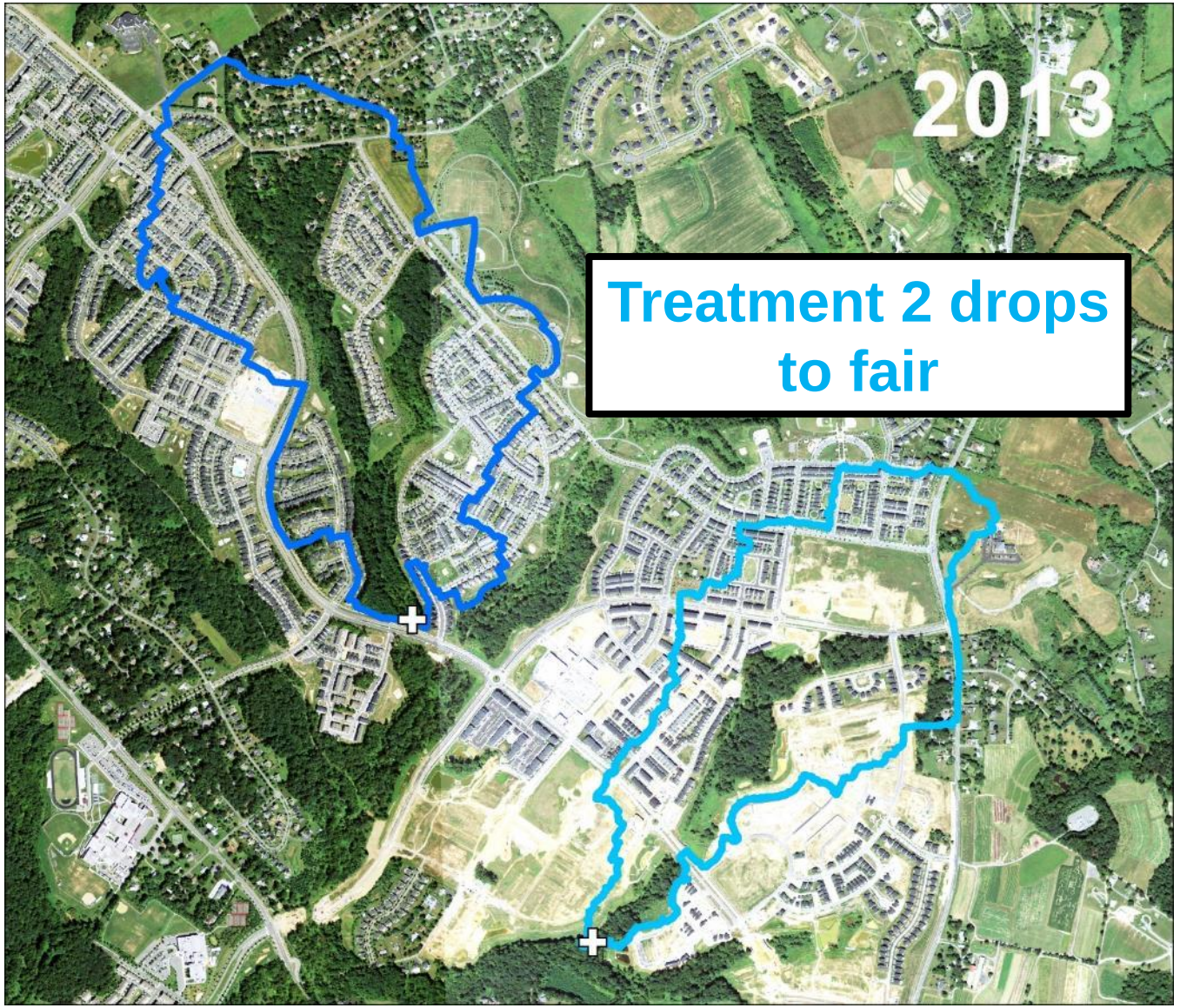

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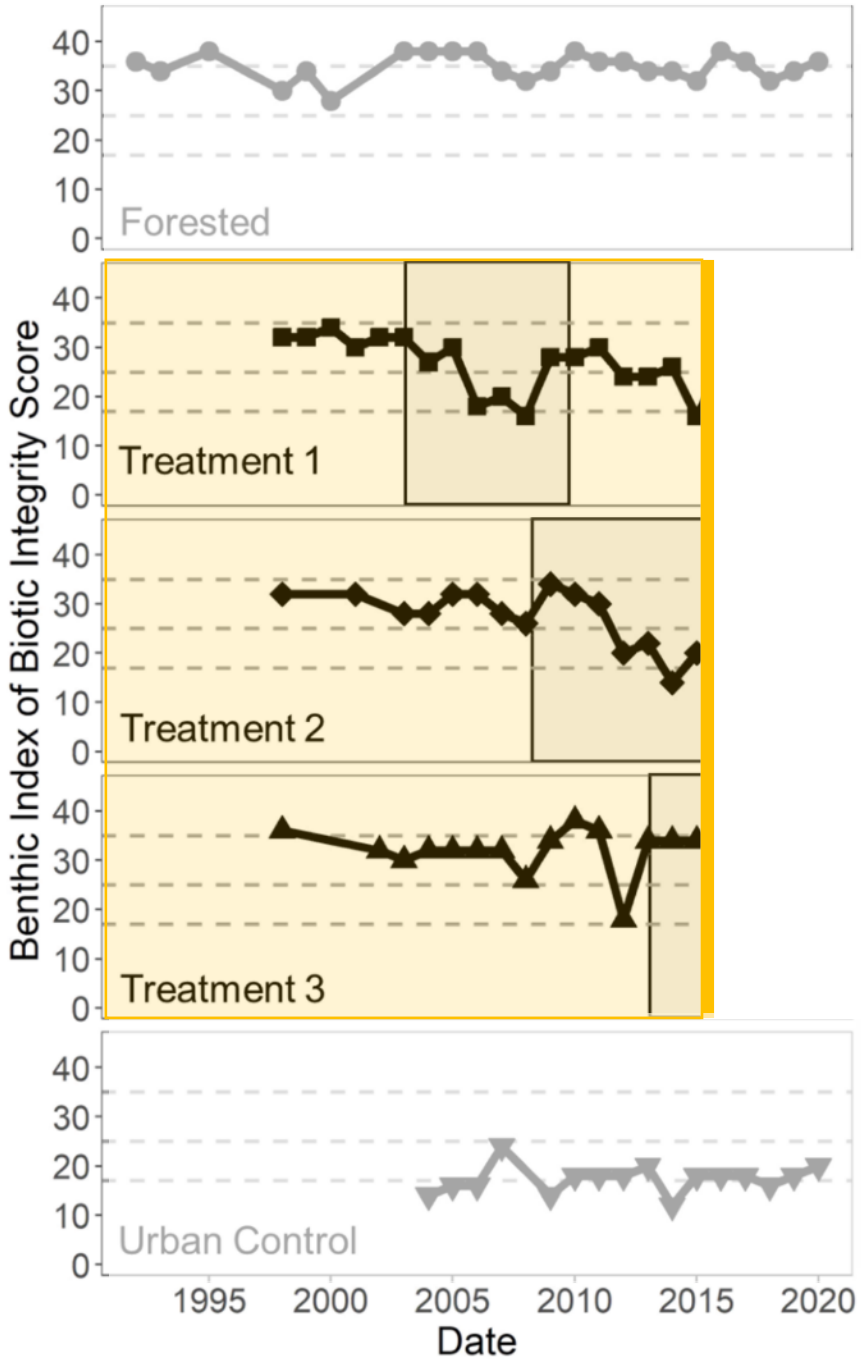

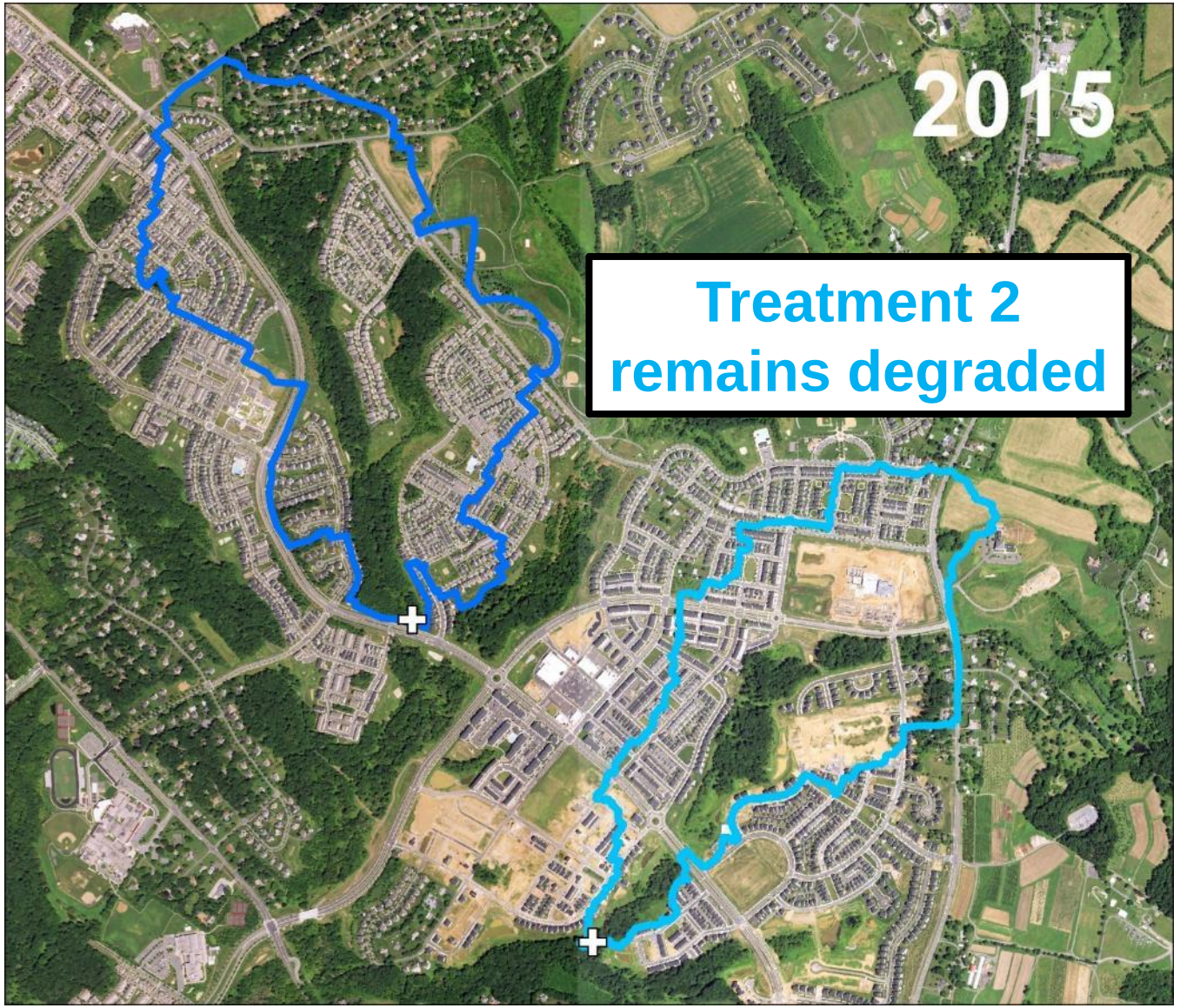

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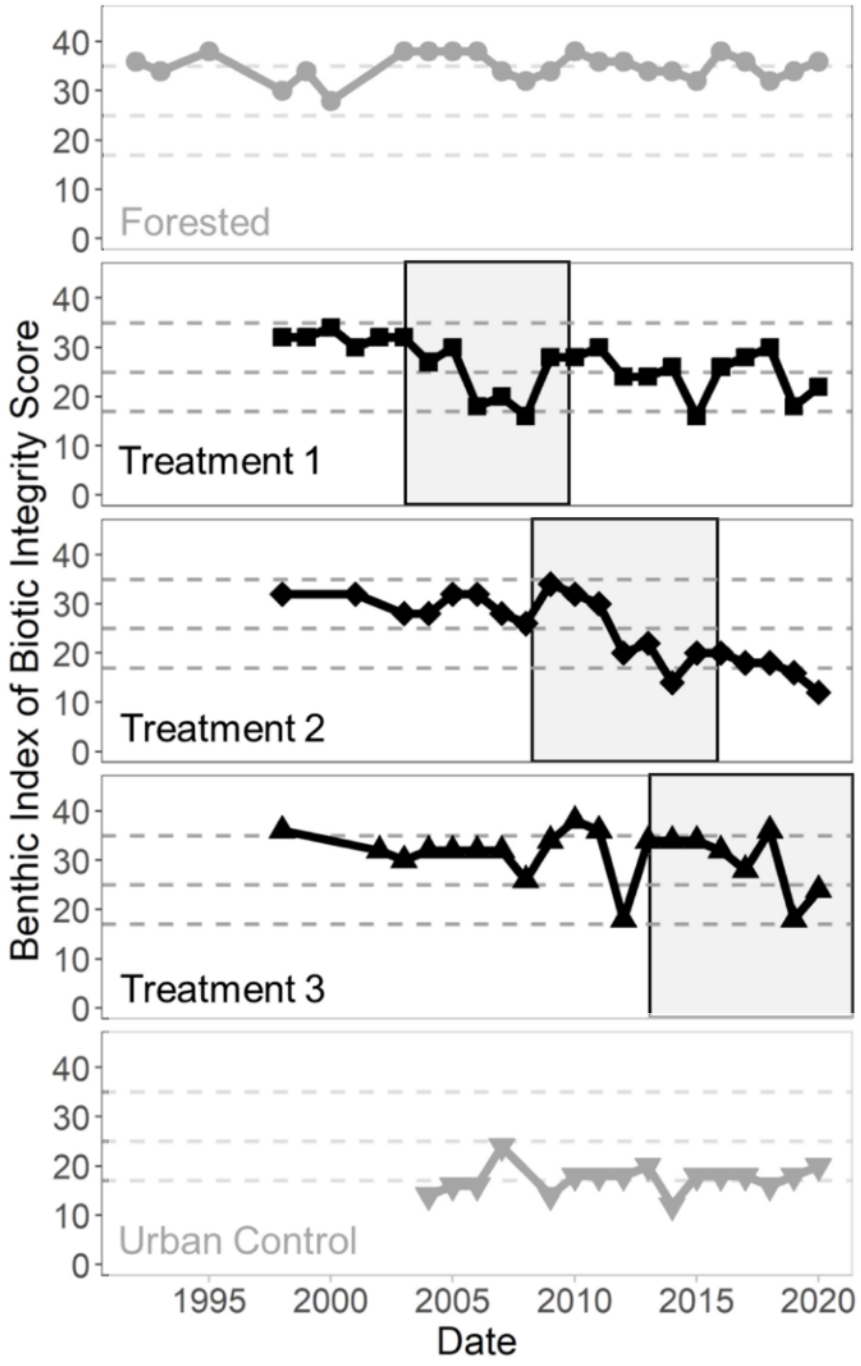

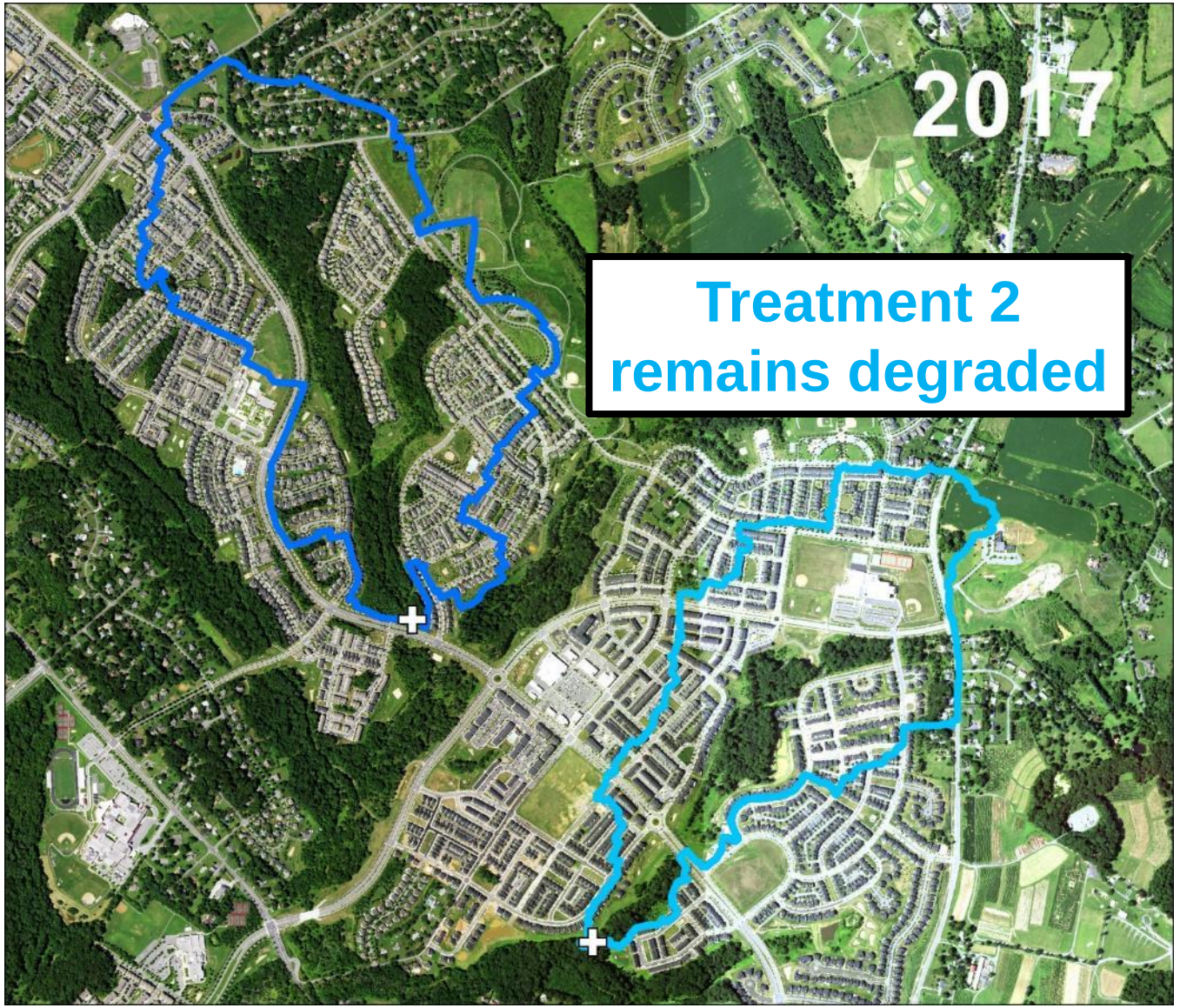

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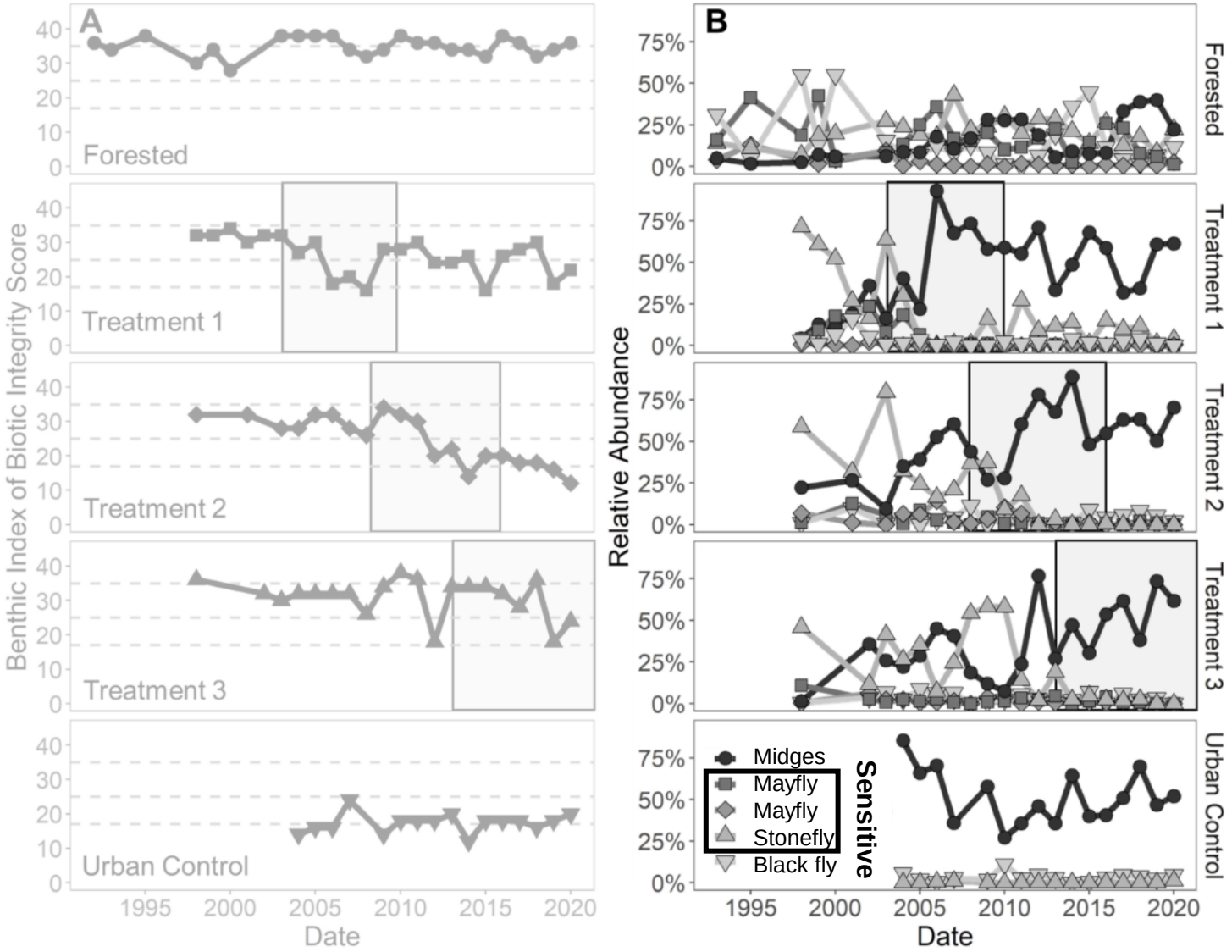
Dominated by a single tolerant family



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

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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

Increase in **fine sediment** in the channel

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.

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