New Insights on using Green Stormwater Infrastructure to Reduce Runoff

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Acknowledgements

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U.S. Geological Survey, Raleigh, NC USA

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What goes in, must come out.

USGS
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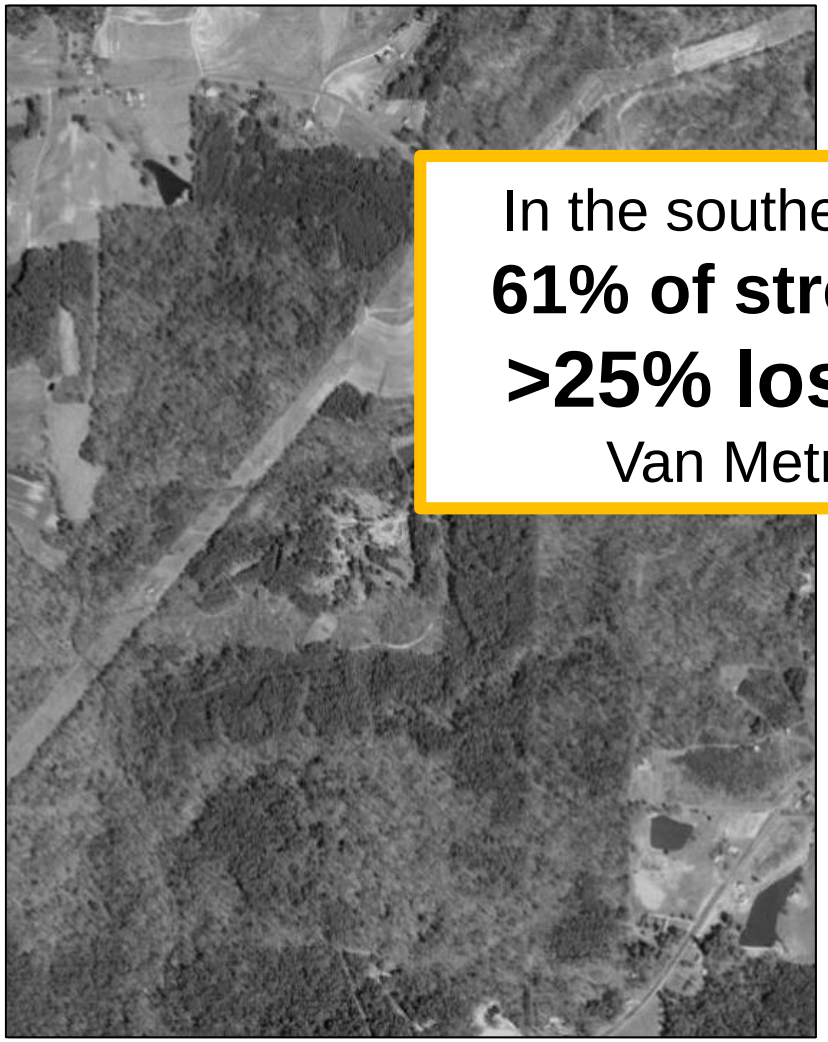
Rock Creek draining into the Potomac
July 28, 2017

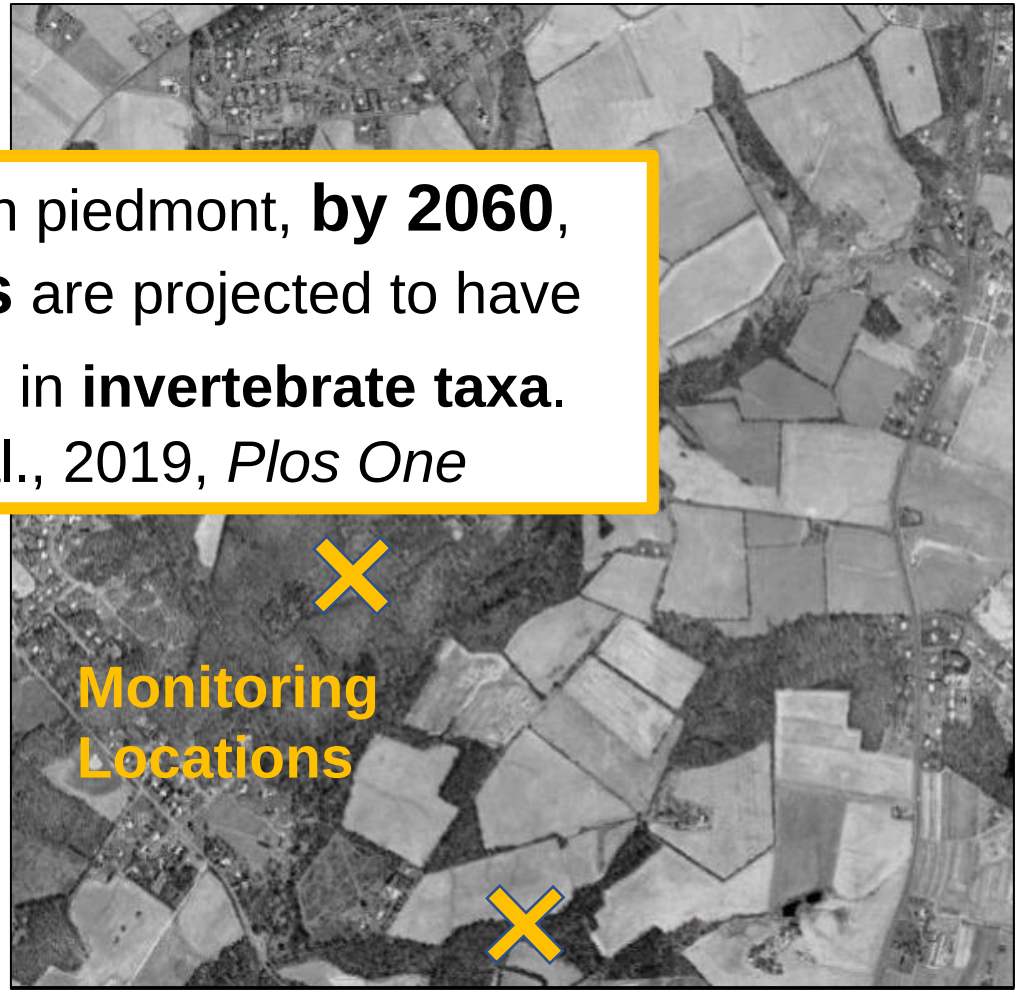
Suburban development is risky for streams



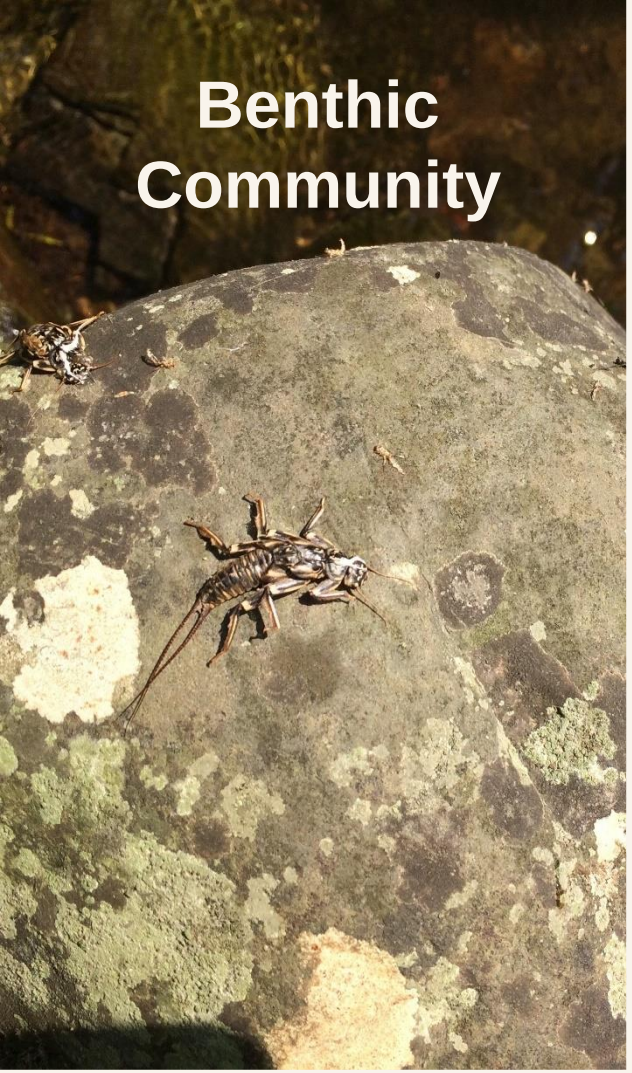
Forest to suburban in Durham, NC

In the southeastern 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

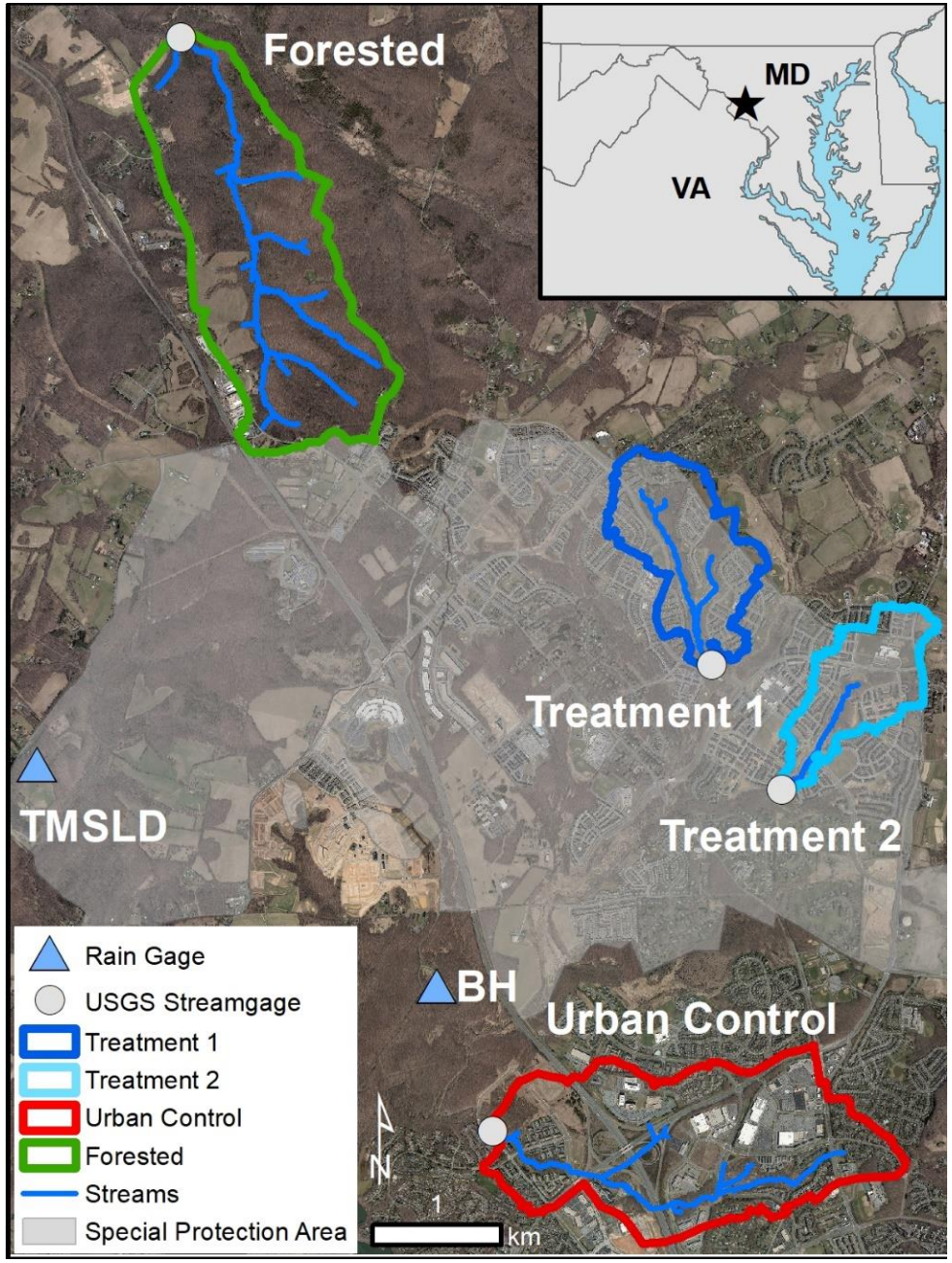


Tracking change as watersheds transition from agriculture to suburban development

Study area in Clarksburg, MD

Special Protection Area Law calls for strict water resource protection measures in new and expanded development projects.

- **Minimize impervious surfaces**
- Construct **temporary sediment and erosion control** structures during construction
- **Protect riparian buffers**
- Utilize **environmental site design** to the maximum extent possible to target replicating the hydrology of “woods in good condition”

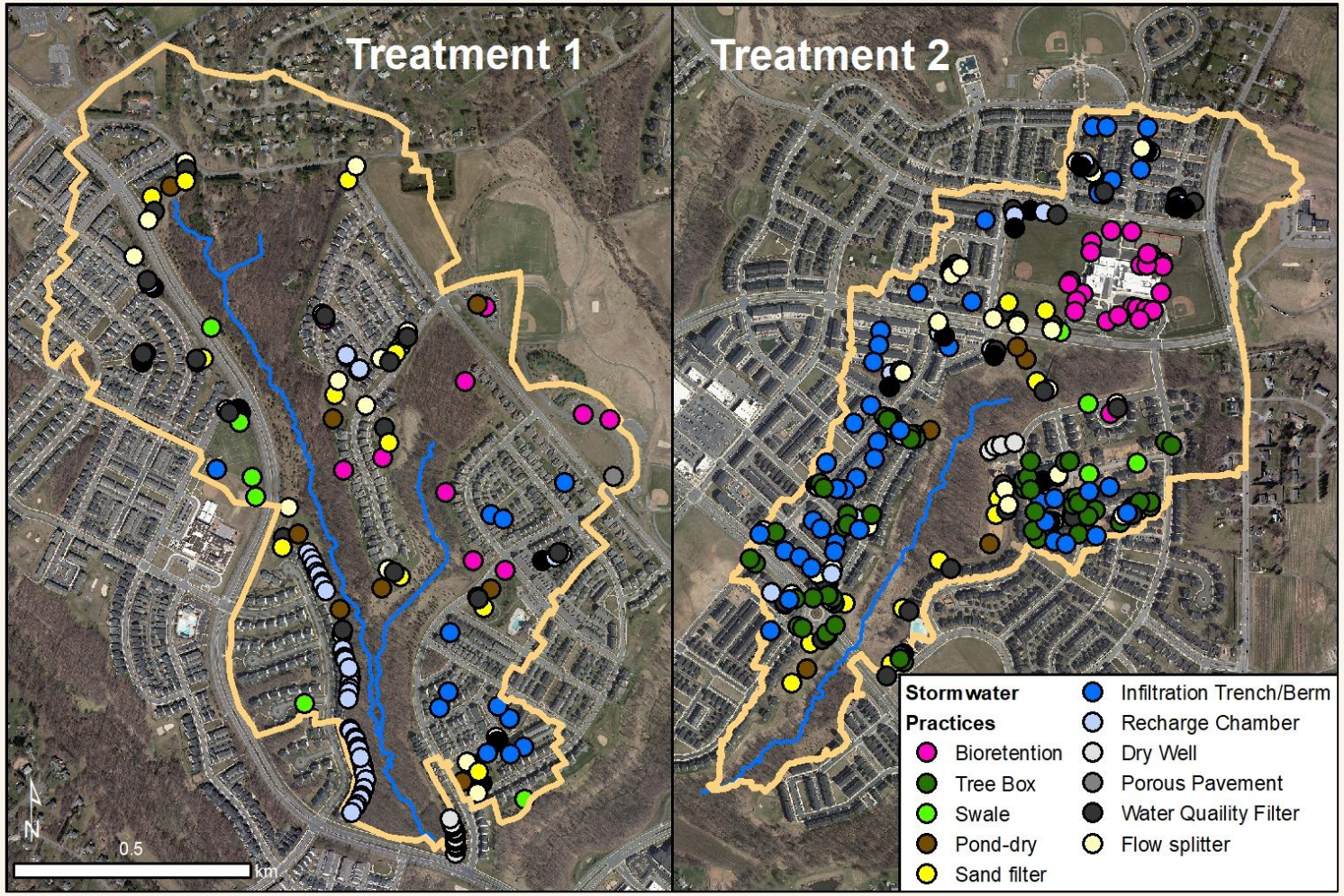


100% of impervious surfaces are treated

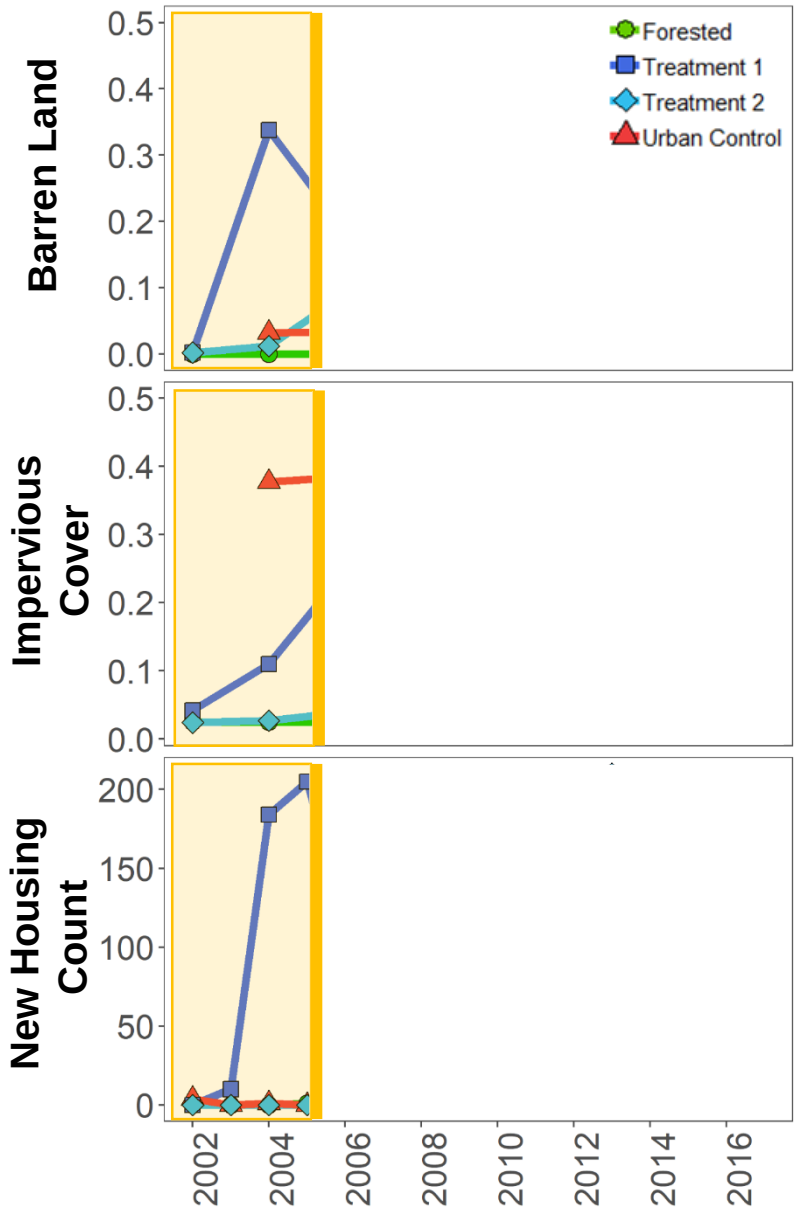
Dry wells infiltration detention

33% impervious
91% single family detached
0.4 practices/acre

44% impervious
50% detached, 50% townhouse
1.1 practices/acre



Tree boxes and infiltration detention


Barren Land
Impervious Cover
New Housing Count
Forested
Treatment 1
Treatment 2
Urban Control
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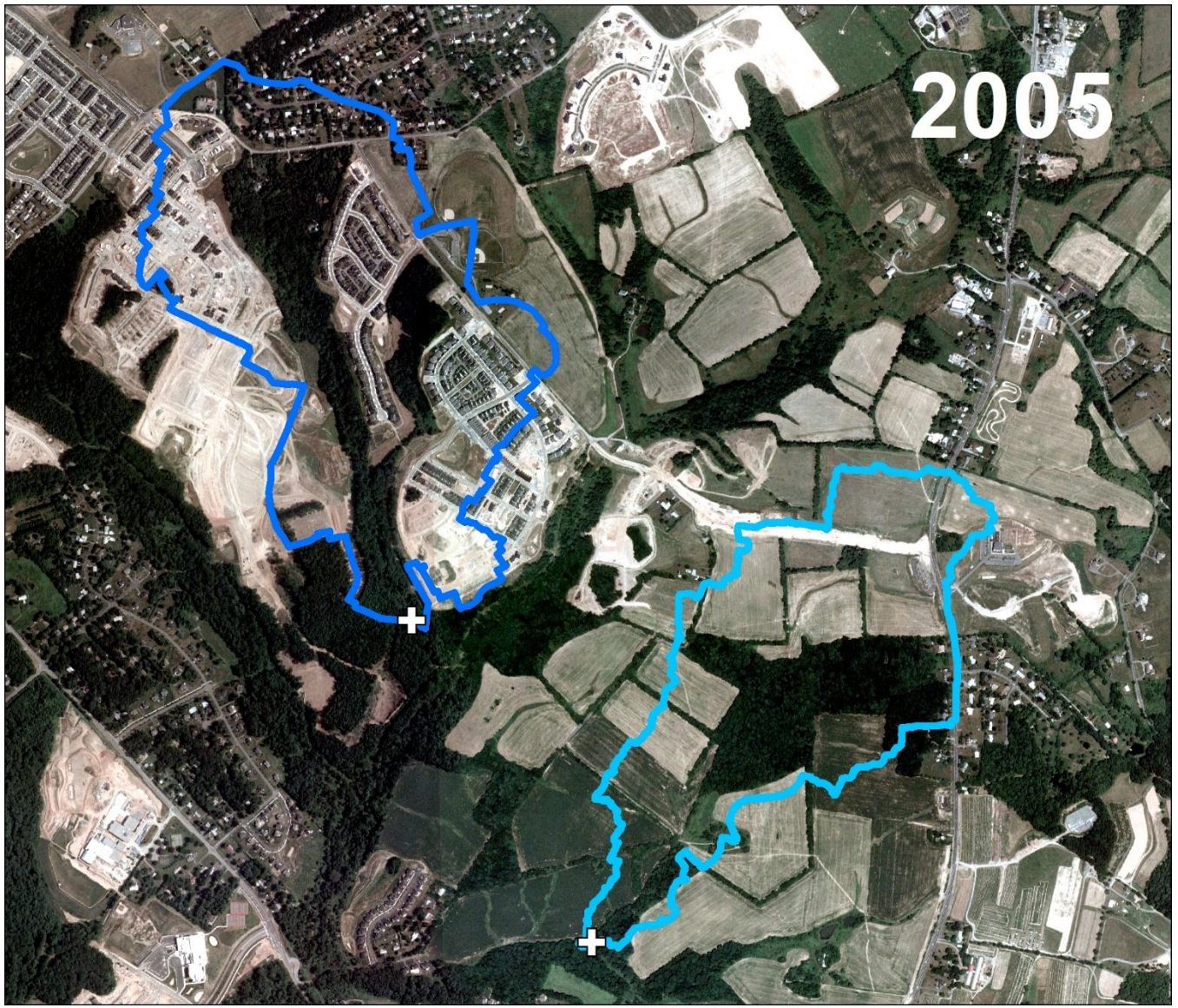
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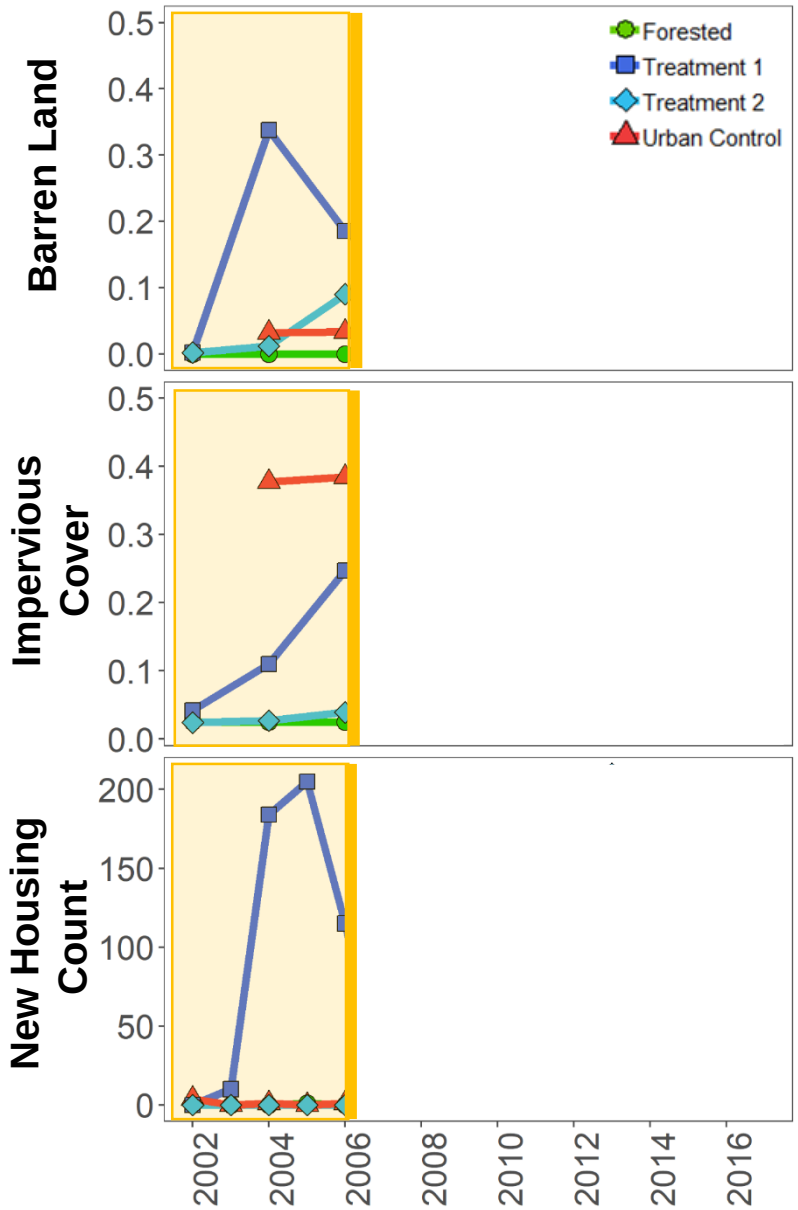
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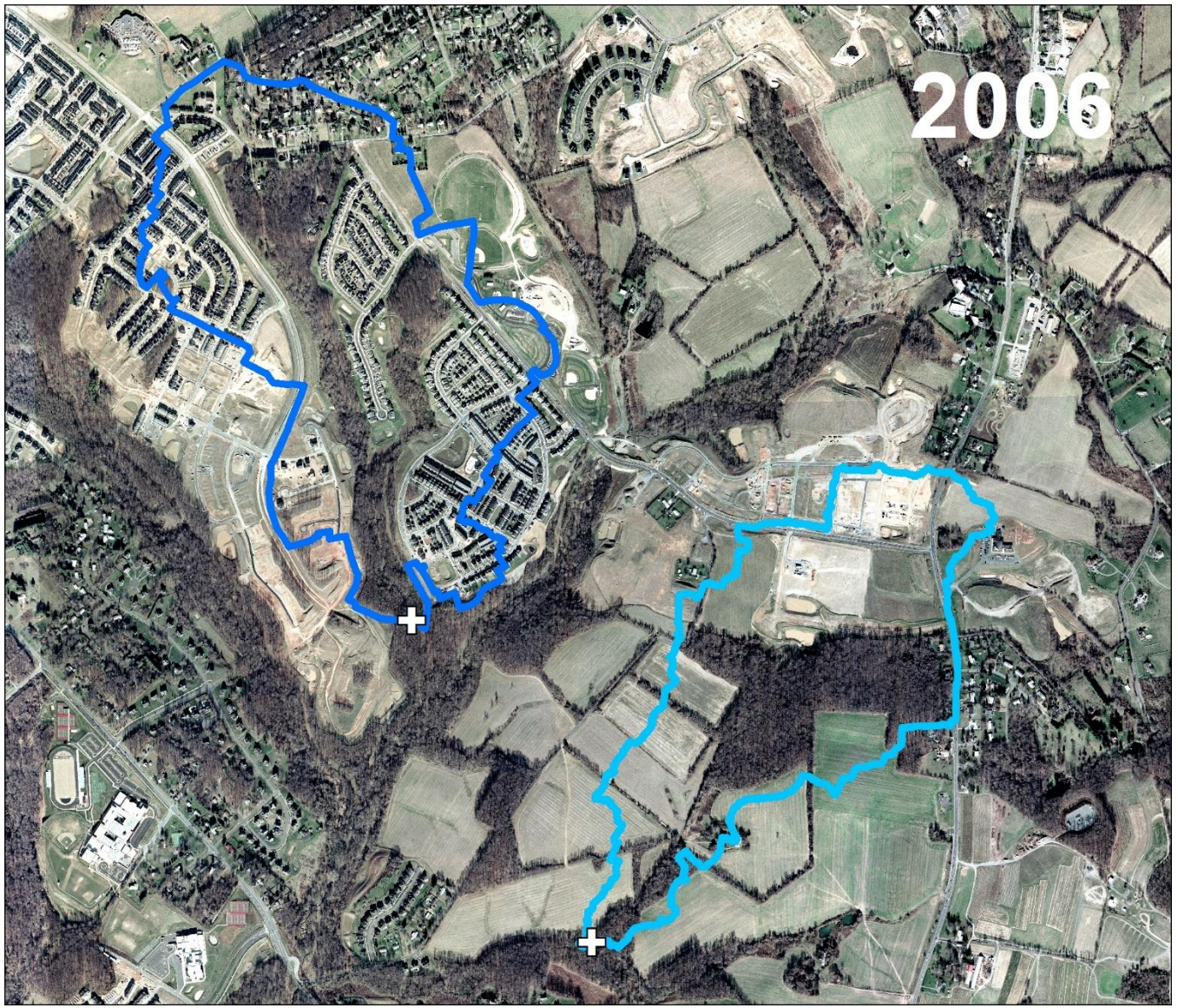
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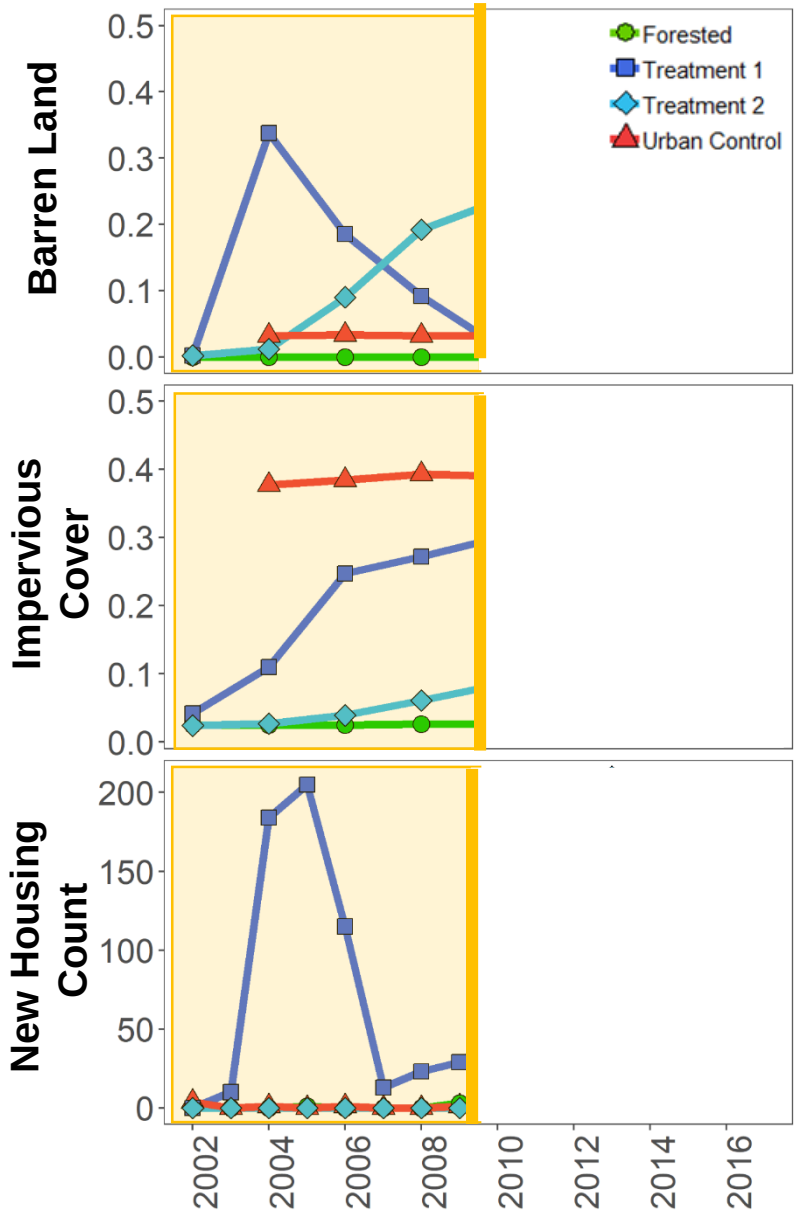
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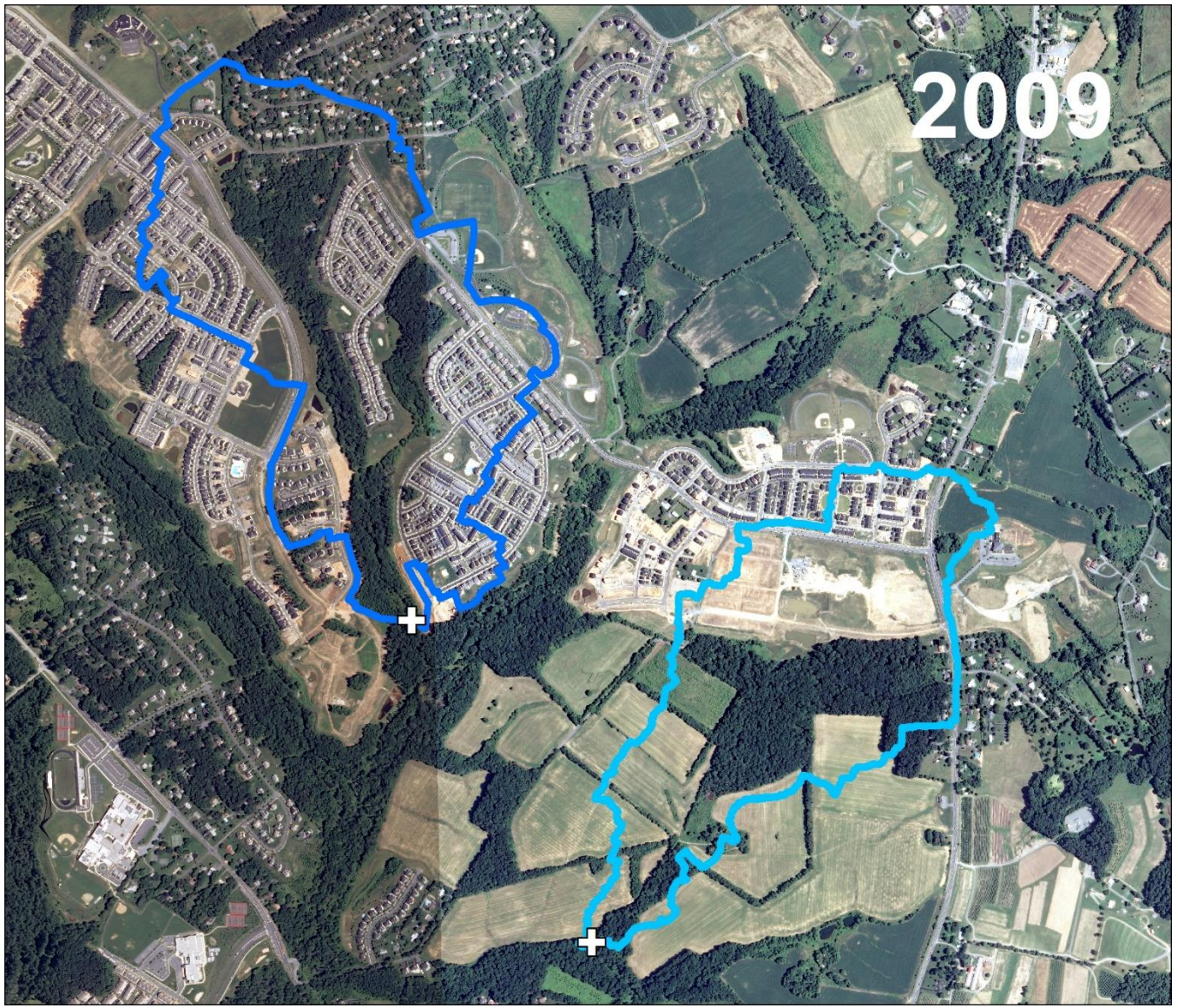
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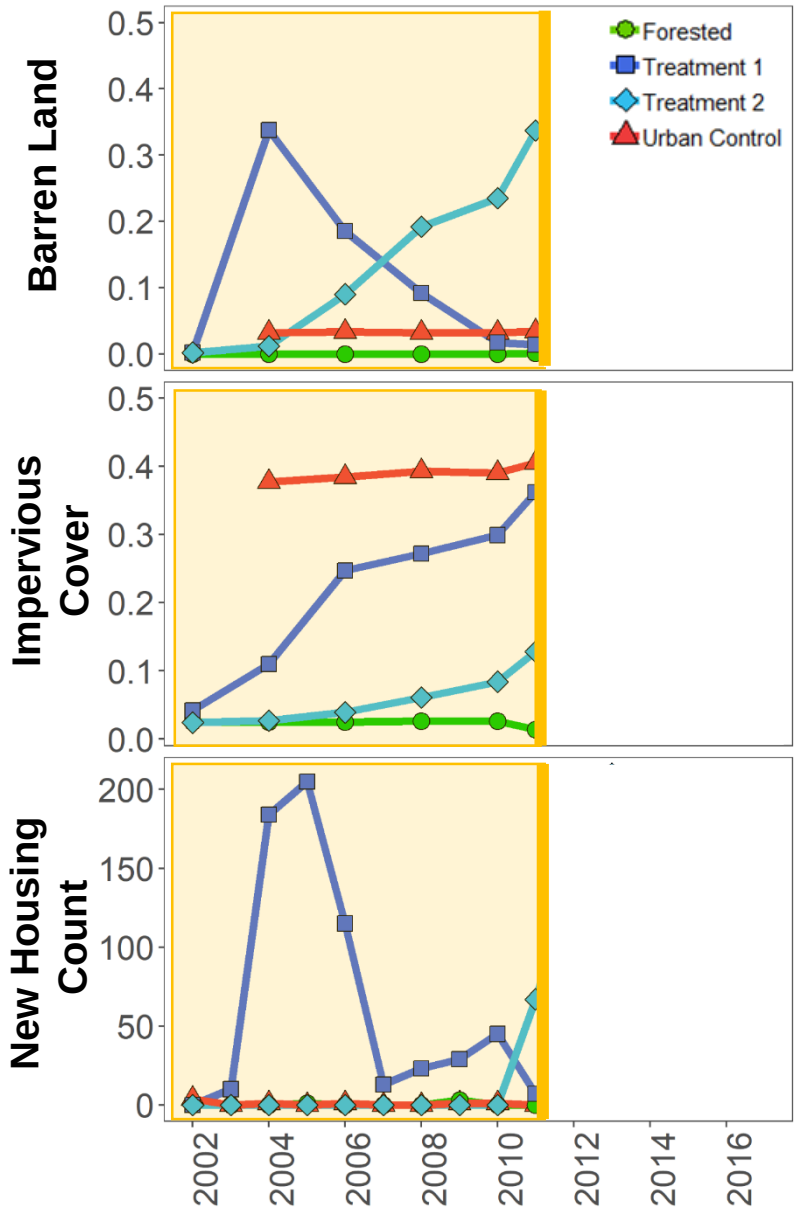
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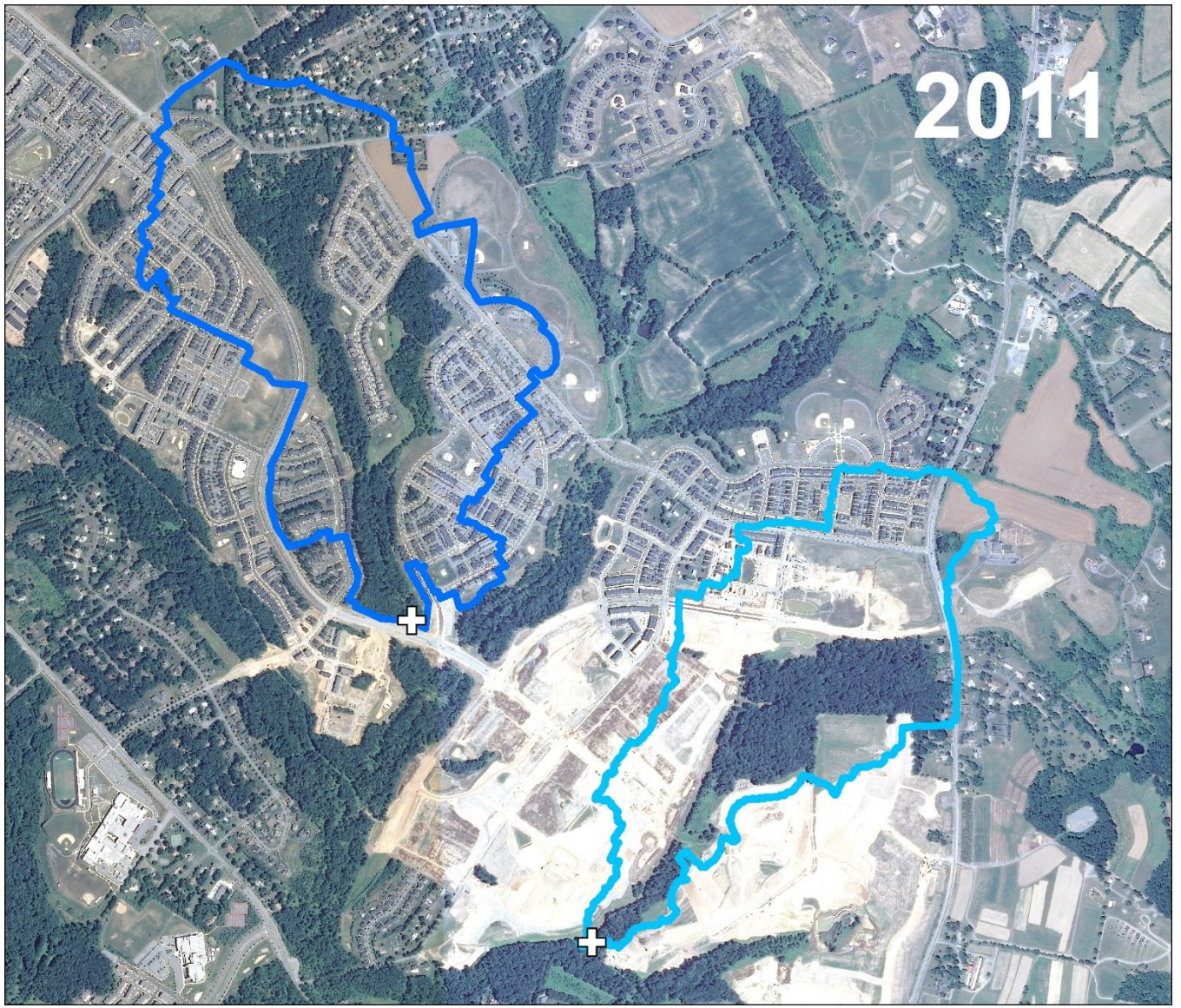
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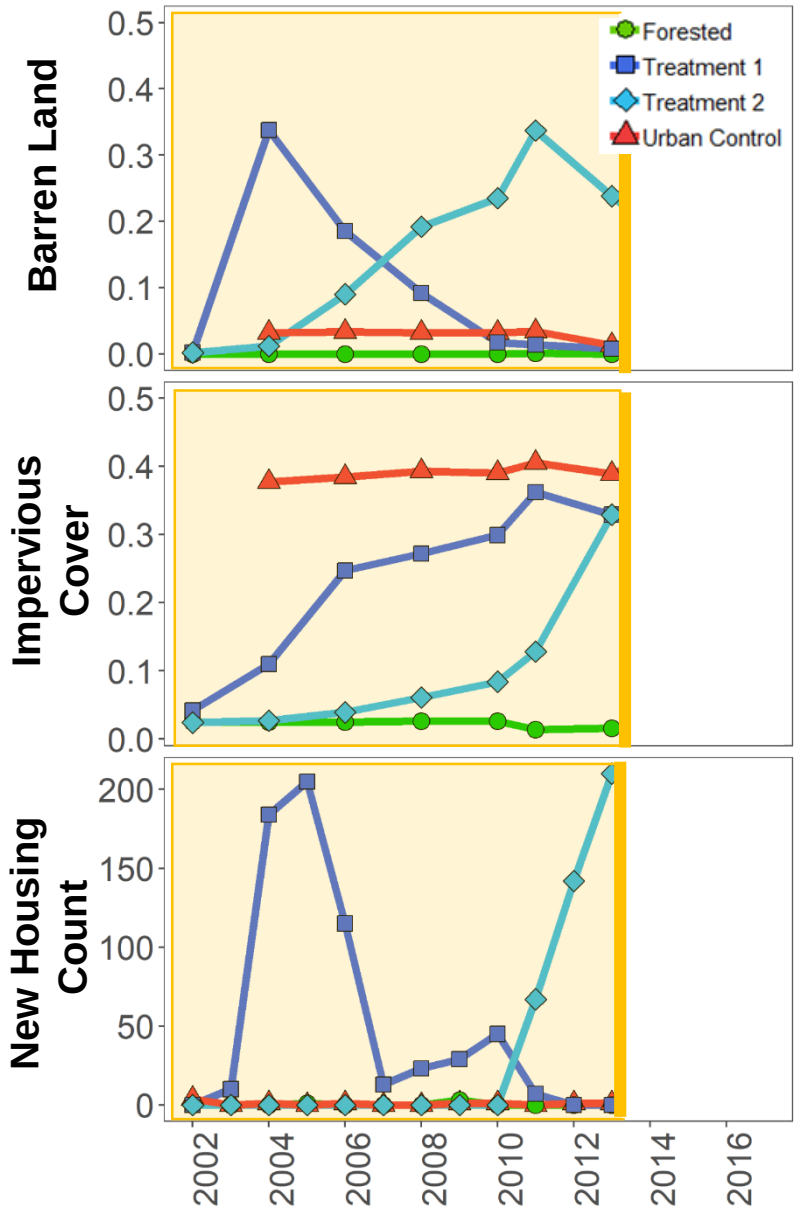
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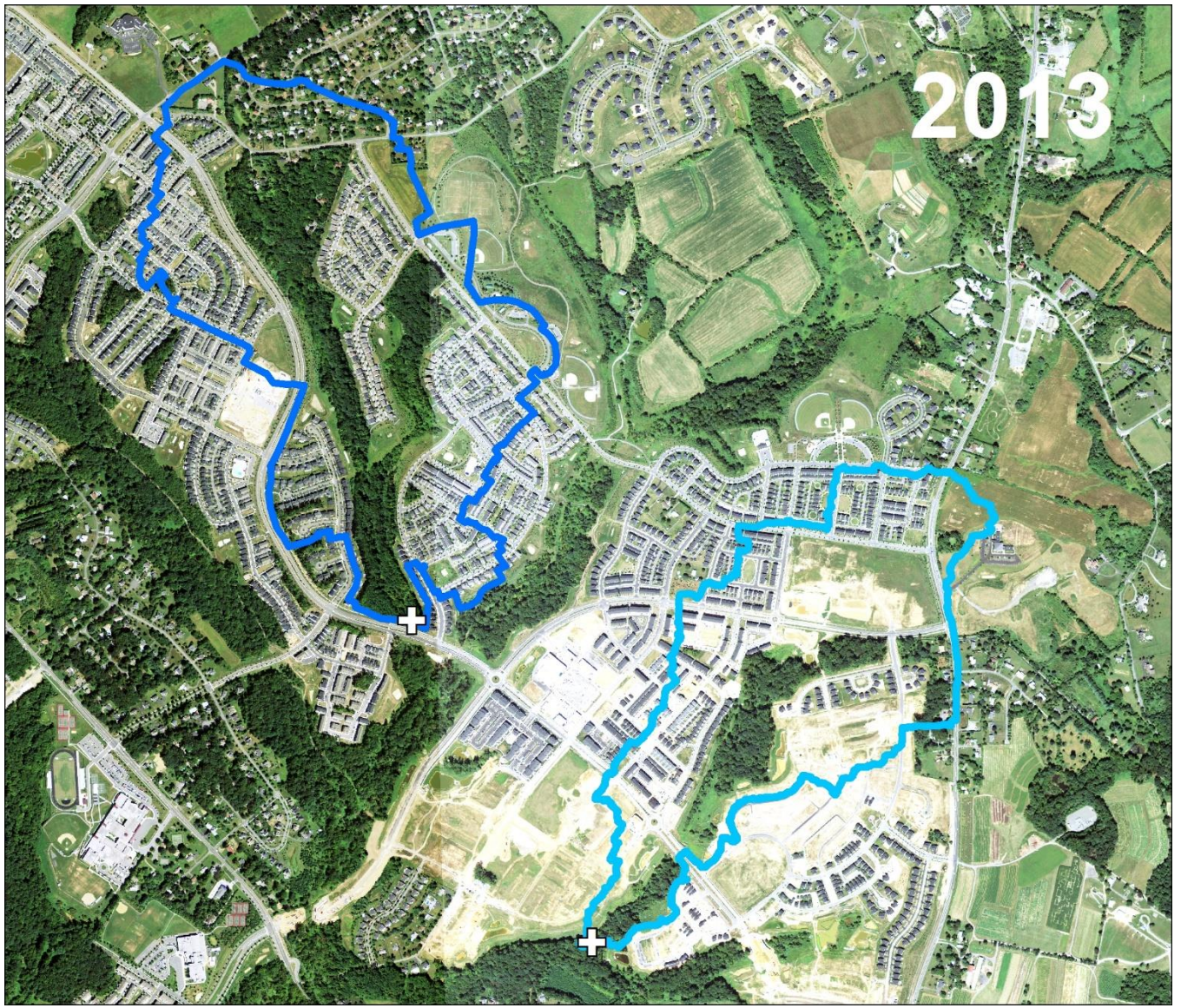
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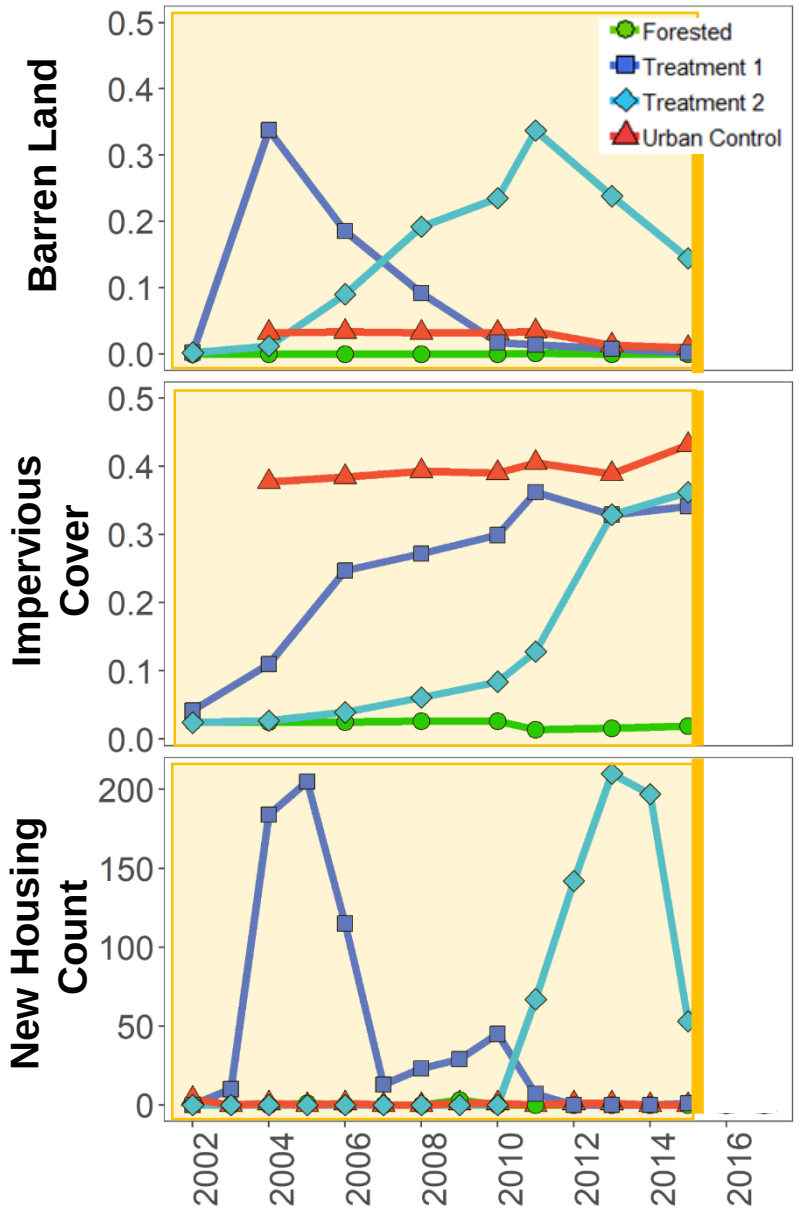
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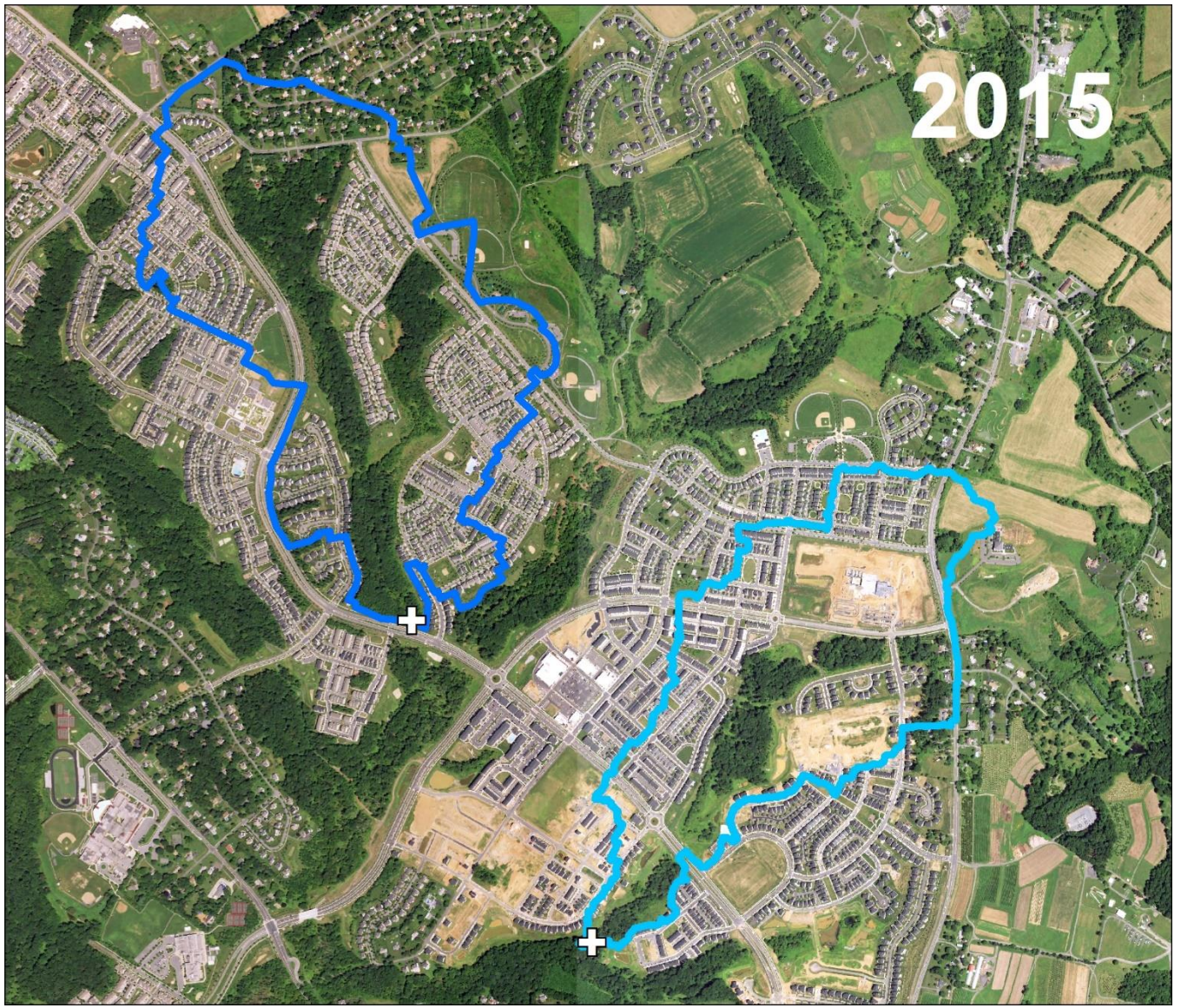
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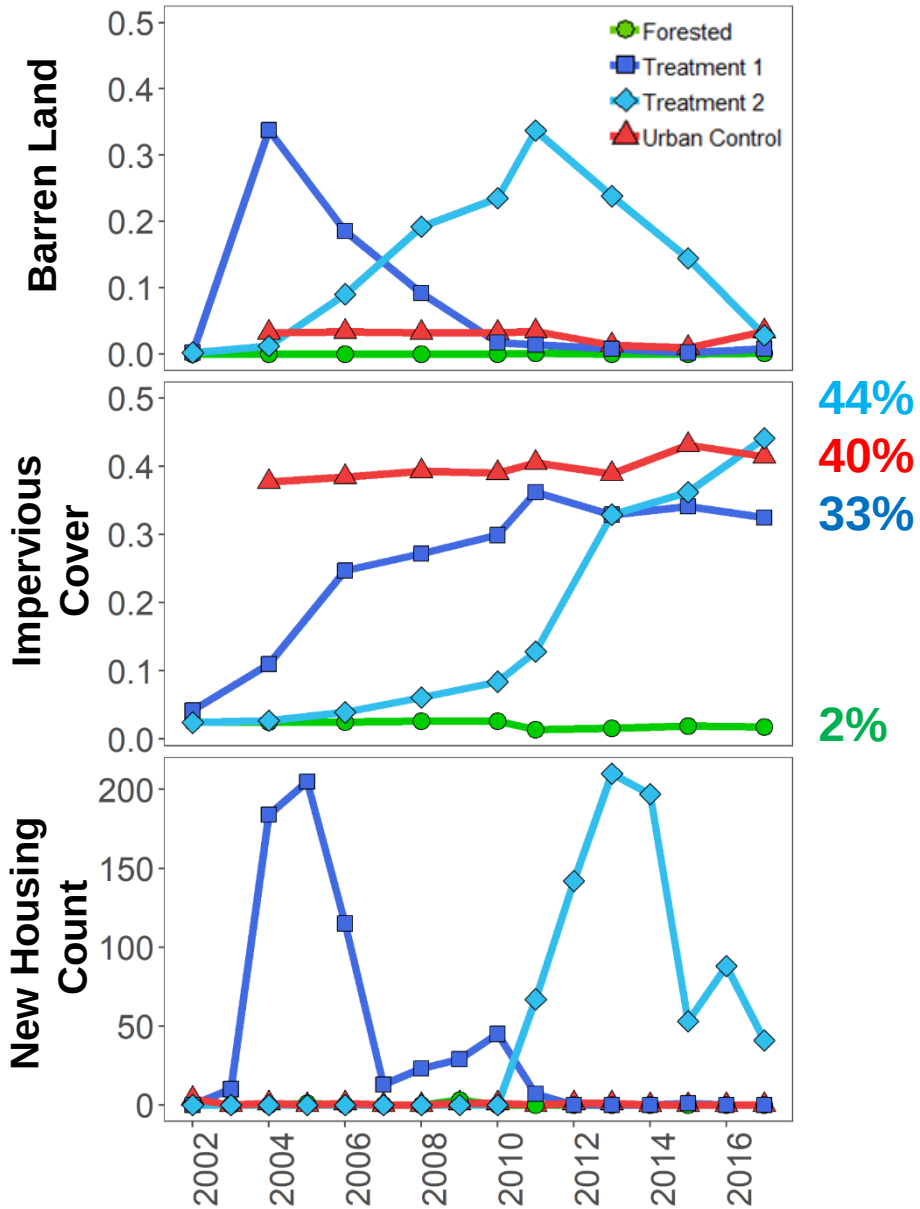
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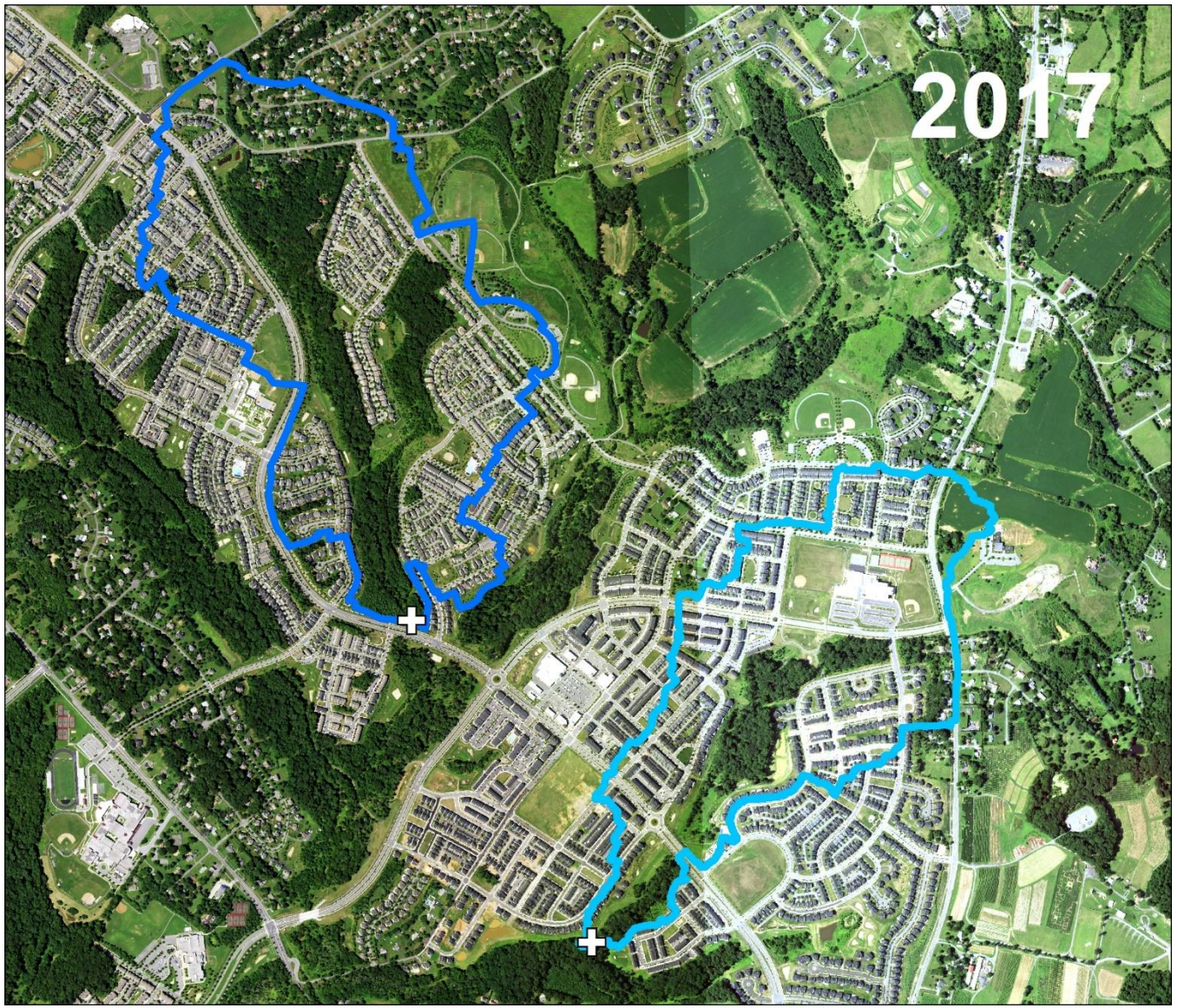
44%

40%

33%

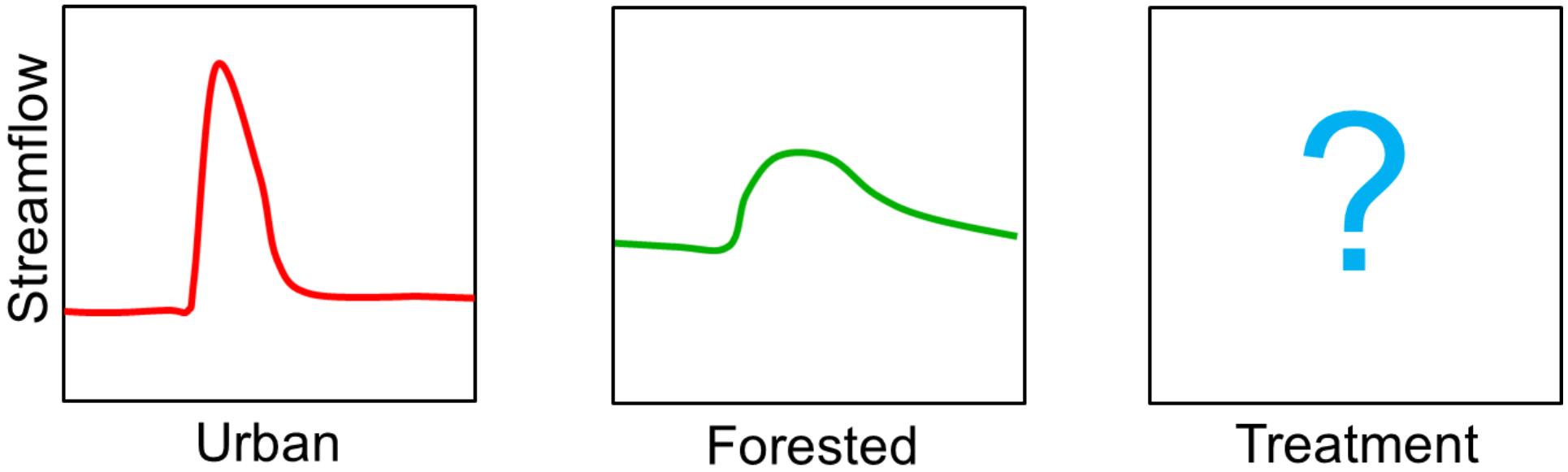
2%


2017

Tracking streamflow change as watersheds transition from agriculture to suburban development

Research Questions

1. **How much rain does it take to initiate a flow response?**
2. Do peak flows and runoff amounts increase?



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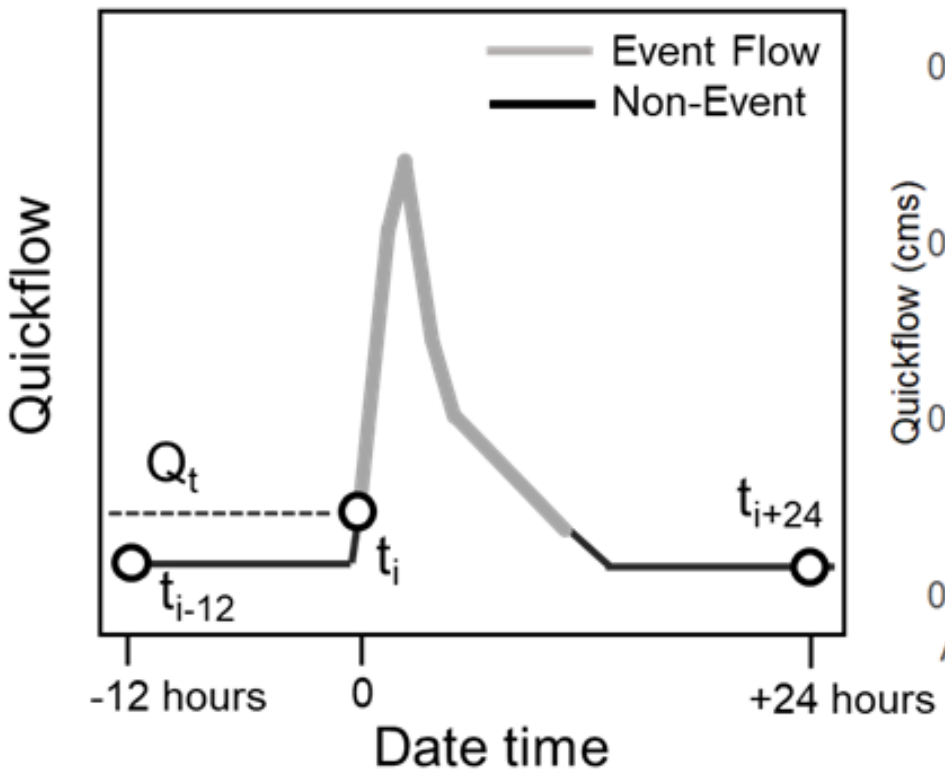
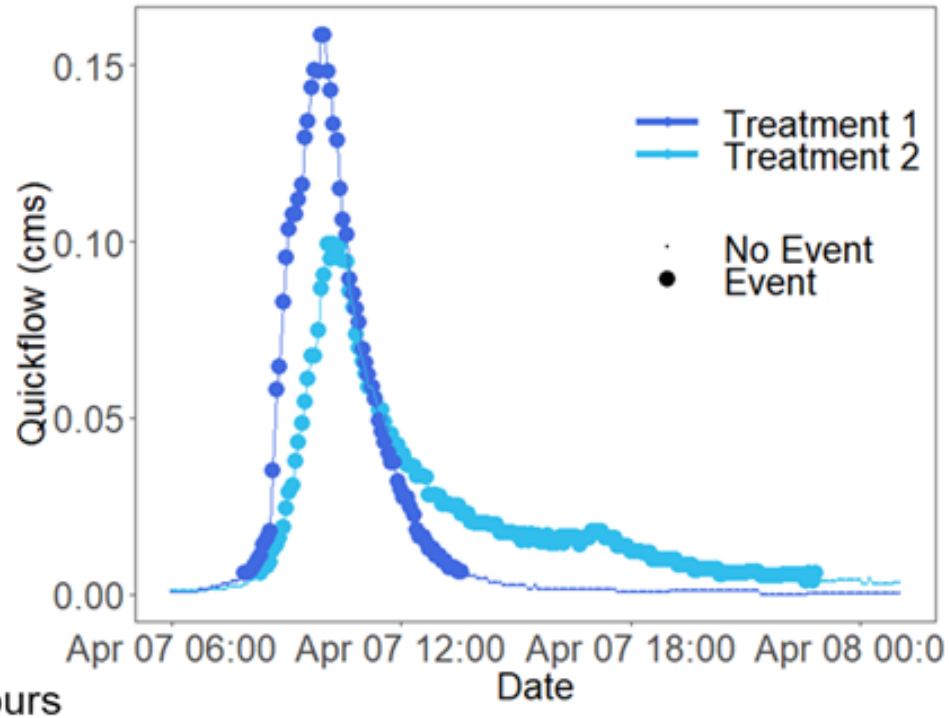
First we need to identify and match runoff events with precipitation events.

Streamflow from October 2004 through September 2018

>1 million streamflow records (5-min data) per watershed

Identified 1000+ events





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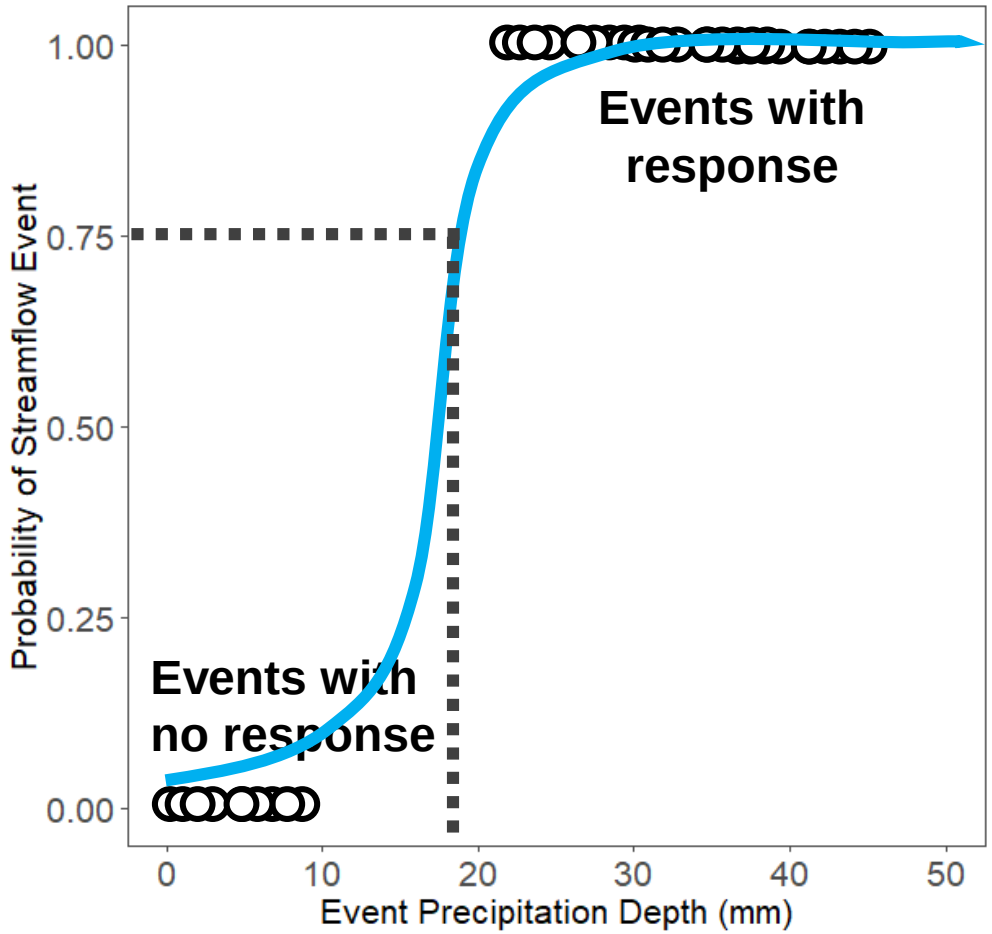
Hopkins et al. 2019 *Hydro Processes*

Use logistic regression to find the most probable precipitation depth that triggers a runoff event



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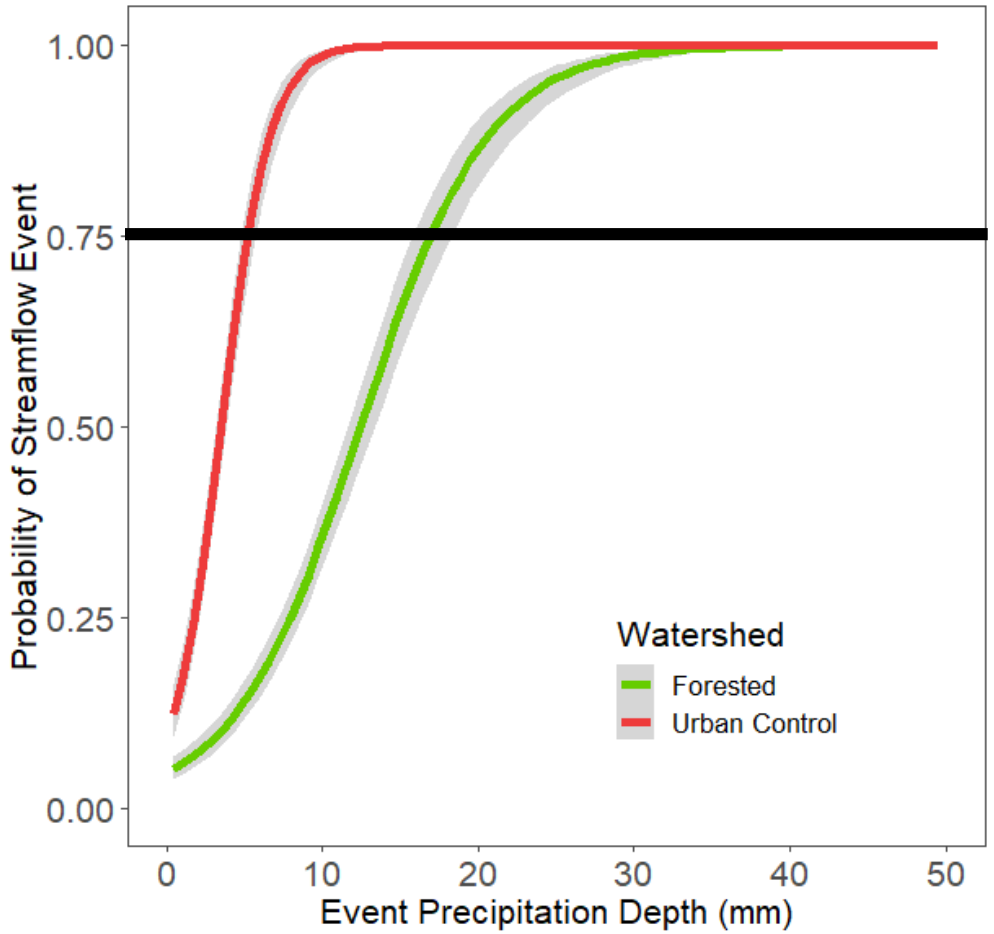
How much rain does it take to initiate a flow response?



Rainfall Threshold

0.67 in – Forested

0.20 in - Urban

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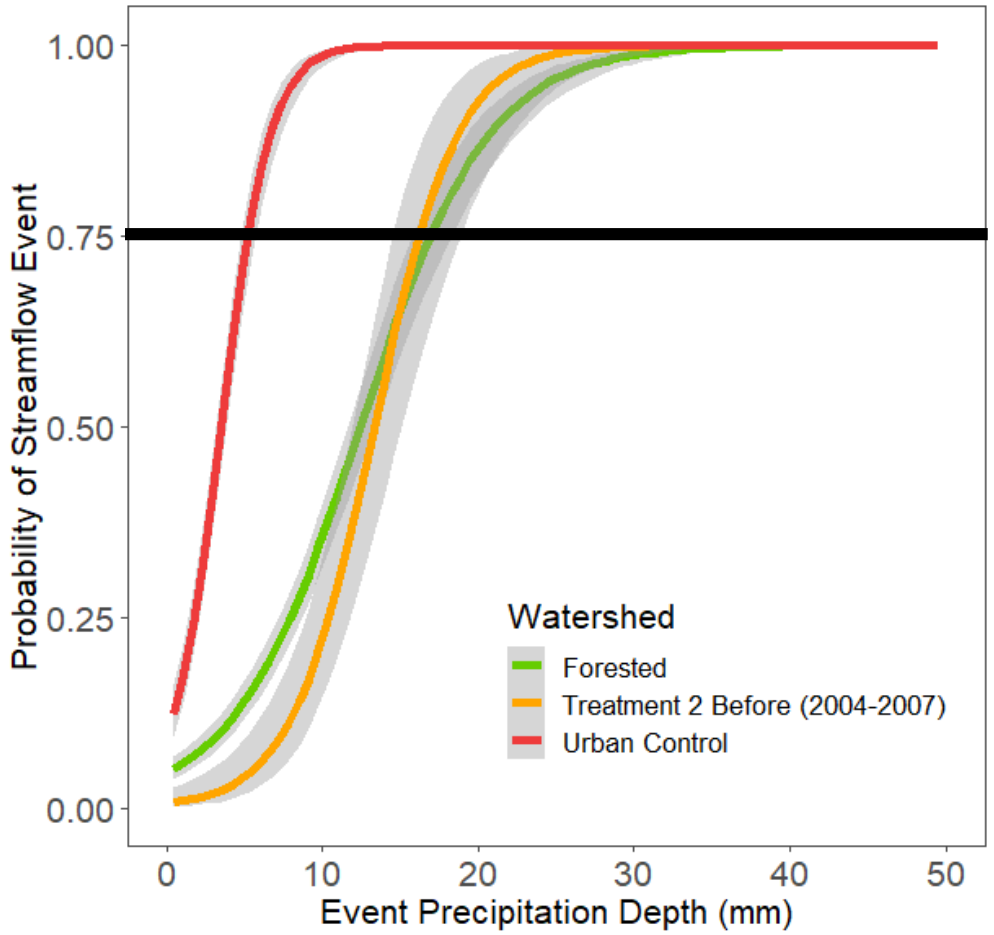
Hopkins et al. 2019 *Hydro Processes*

Treatment 2 pre-development was similar to the forested site.



Rainfall Threshold

0.67 in – Forested

0.67 in – Treatment 2 Before

0.20 in - Urban

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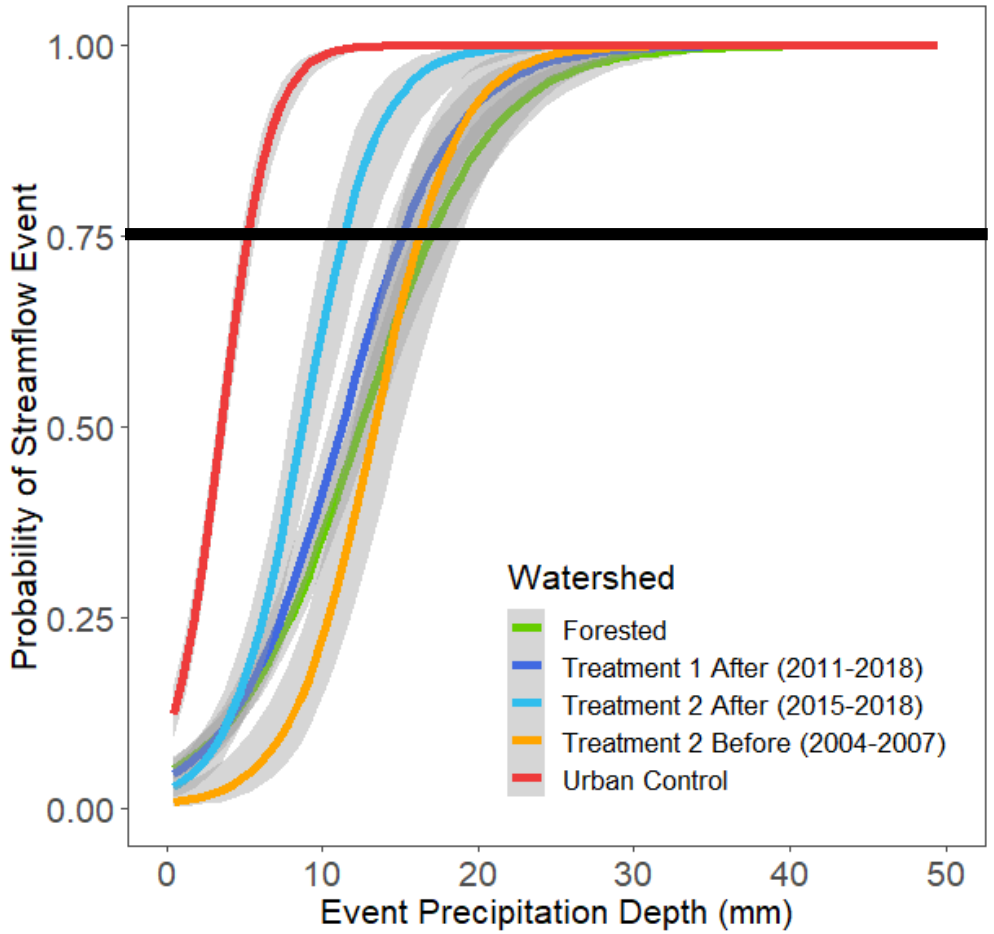
Hopkins et al. 2019 *Hydro Processes*

Treatment 2 after development was not similar to the forested site



Rainfall Threshold

0.67 in – Forested

0.67 in – Treatment 2 Before

0.47 in – Treatment 2 After

0.20 in - Urban

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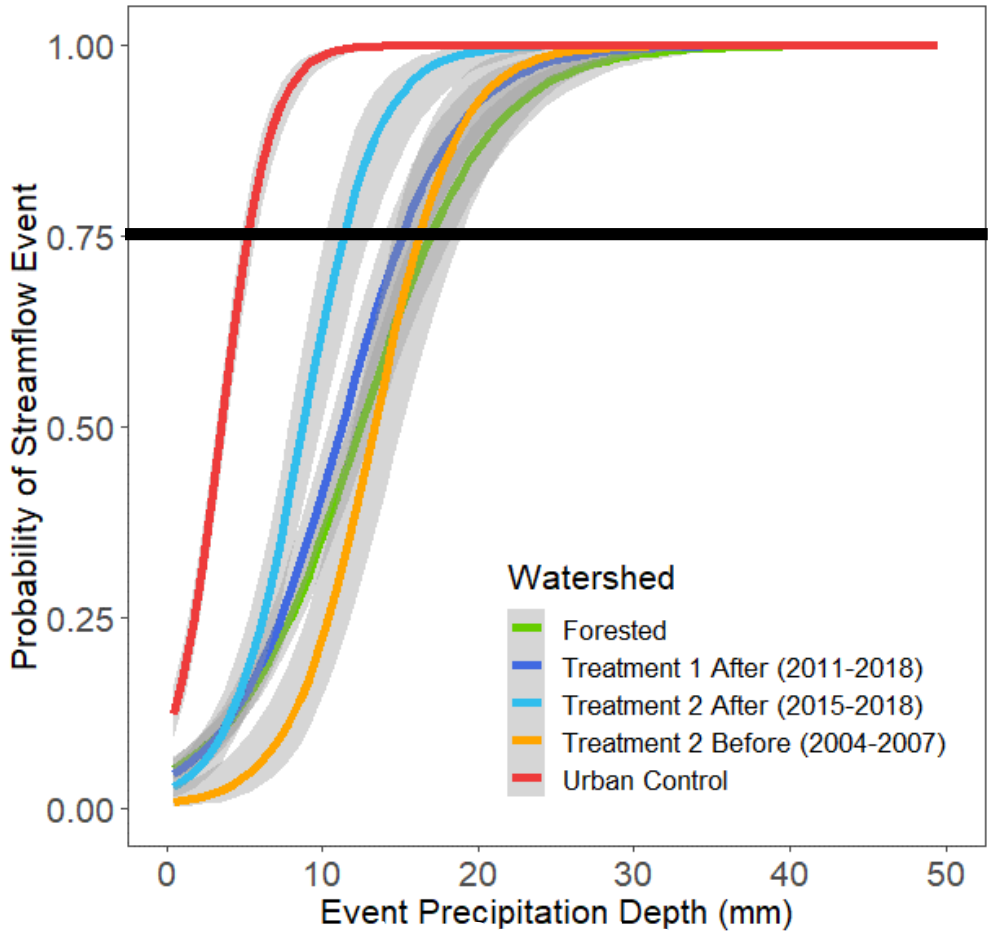
Hopkins et al. 2019 *Hydro Processes*

Treatment 1 after development was similar to the forested site



Rainfall Threshold

0.67 in – Forested

0.67 in – Treatment 2 Before

0.47 in – Treatment 2 After

0.63 in – Treatment 1 After

0.20 in - Urban

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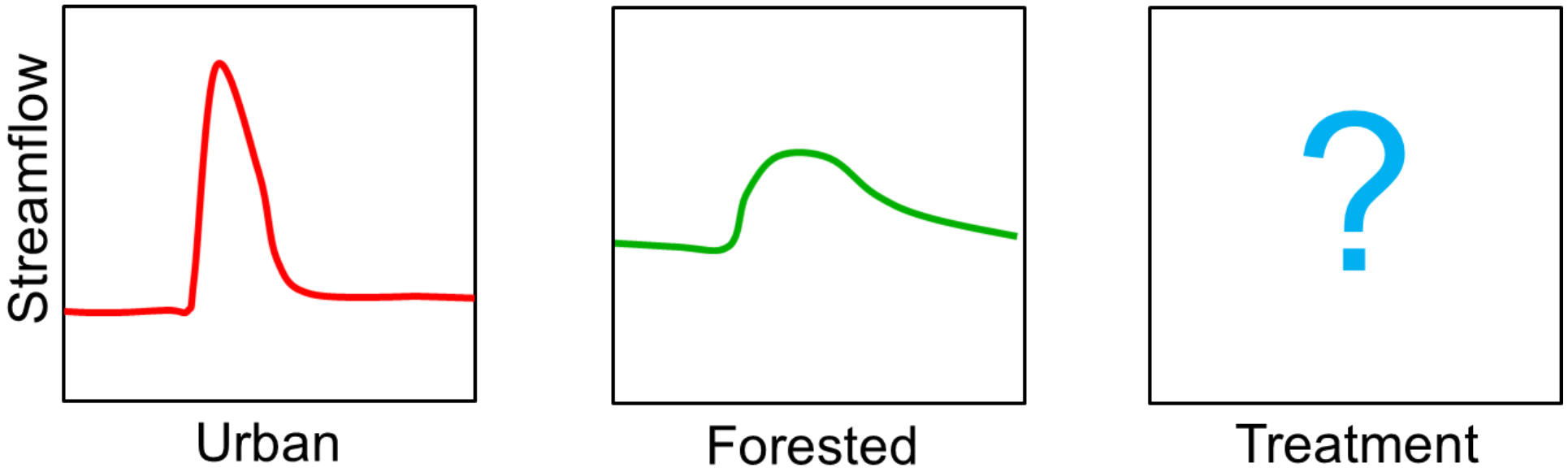
Hopkins et al. 2019 *Hydro Processes*

Research Questions

1. How much rain does it take to initiate a flow response?
2. **Do peak flows and runoff amounts increase?**



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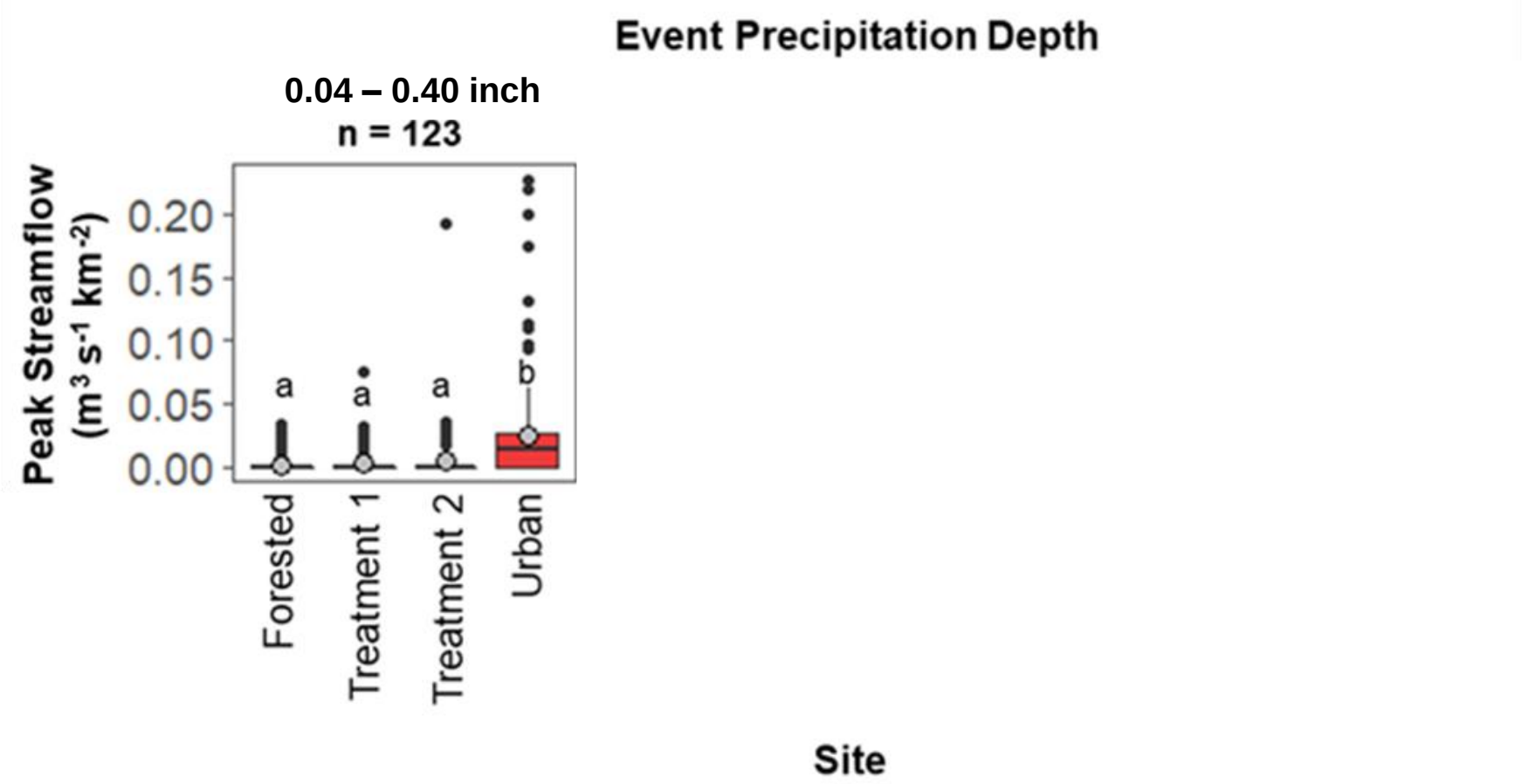
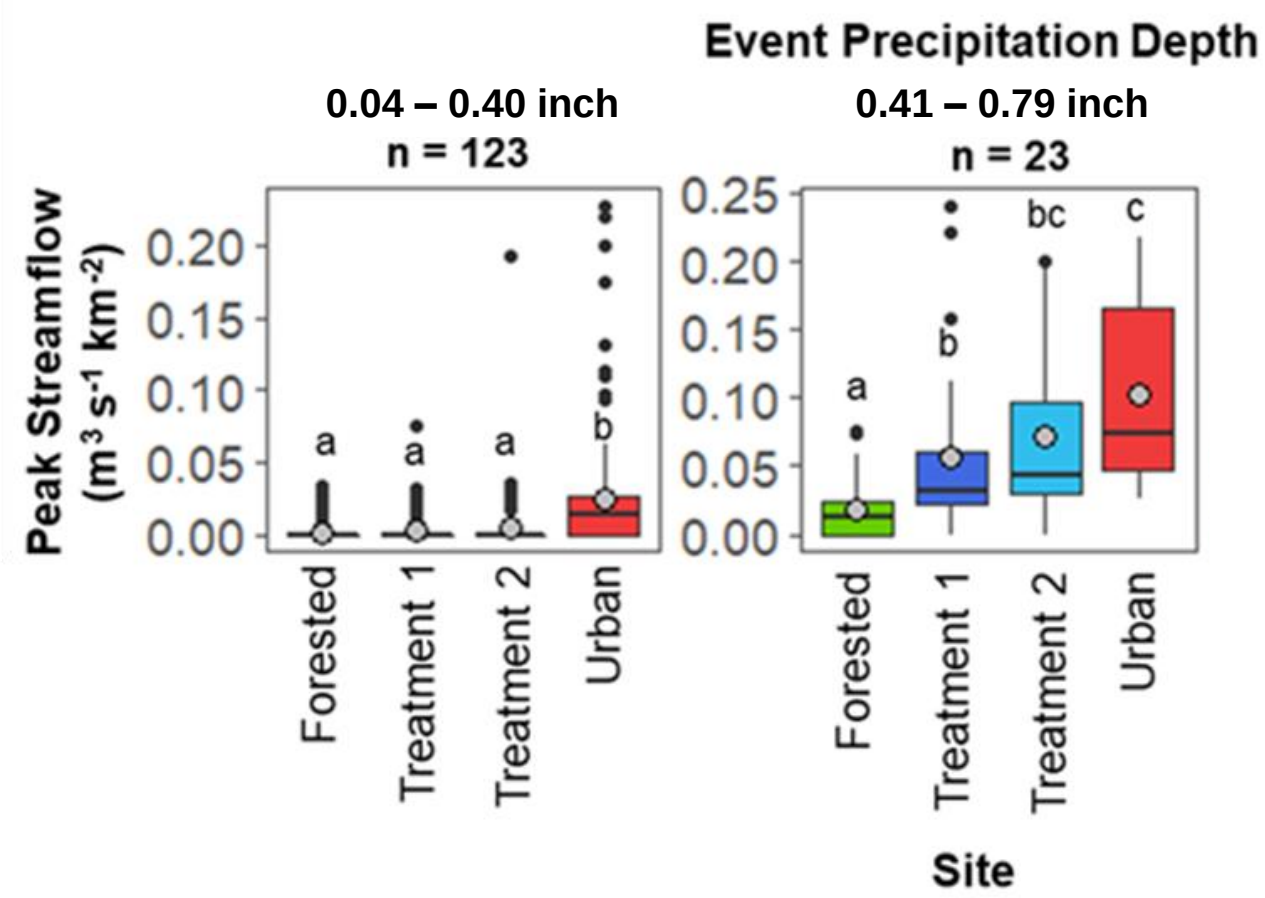
Peak flows were attenuated for small precipitation events (< 0.40 inch)



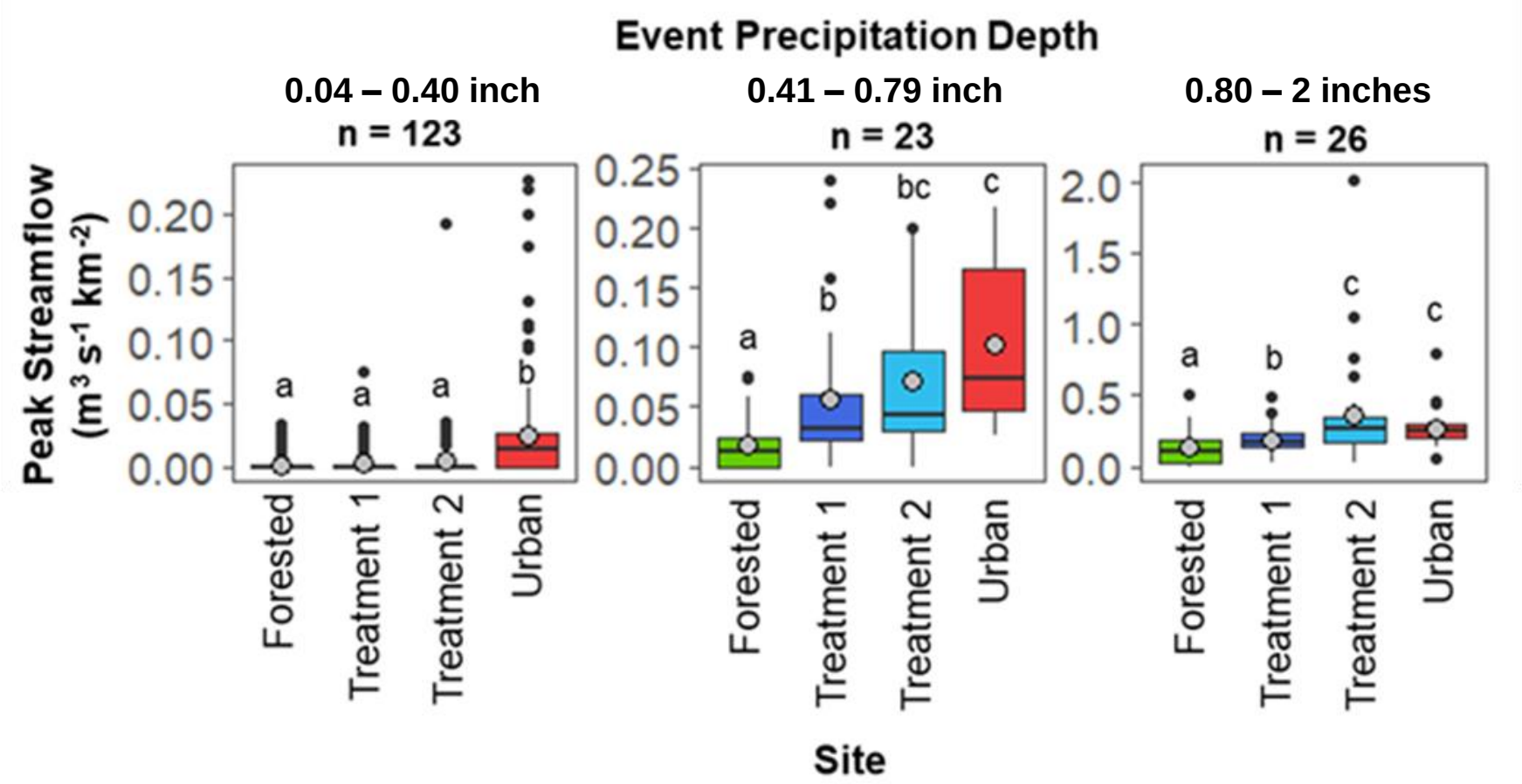
Hopkins et al. 2019 *Hydro Processes*

Peak flows altered, but somewhat attenuated for medium events



Hopkins et al. 2019 *Hydro Processes*

Peak flows attenuated more in Treatment 1 than 2 for large events



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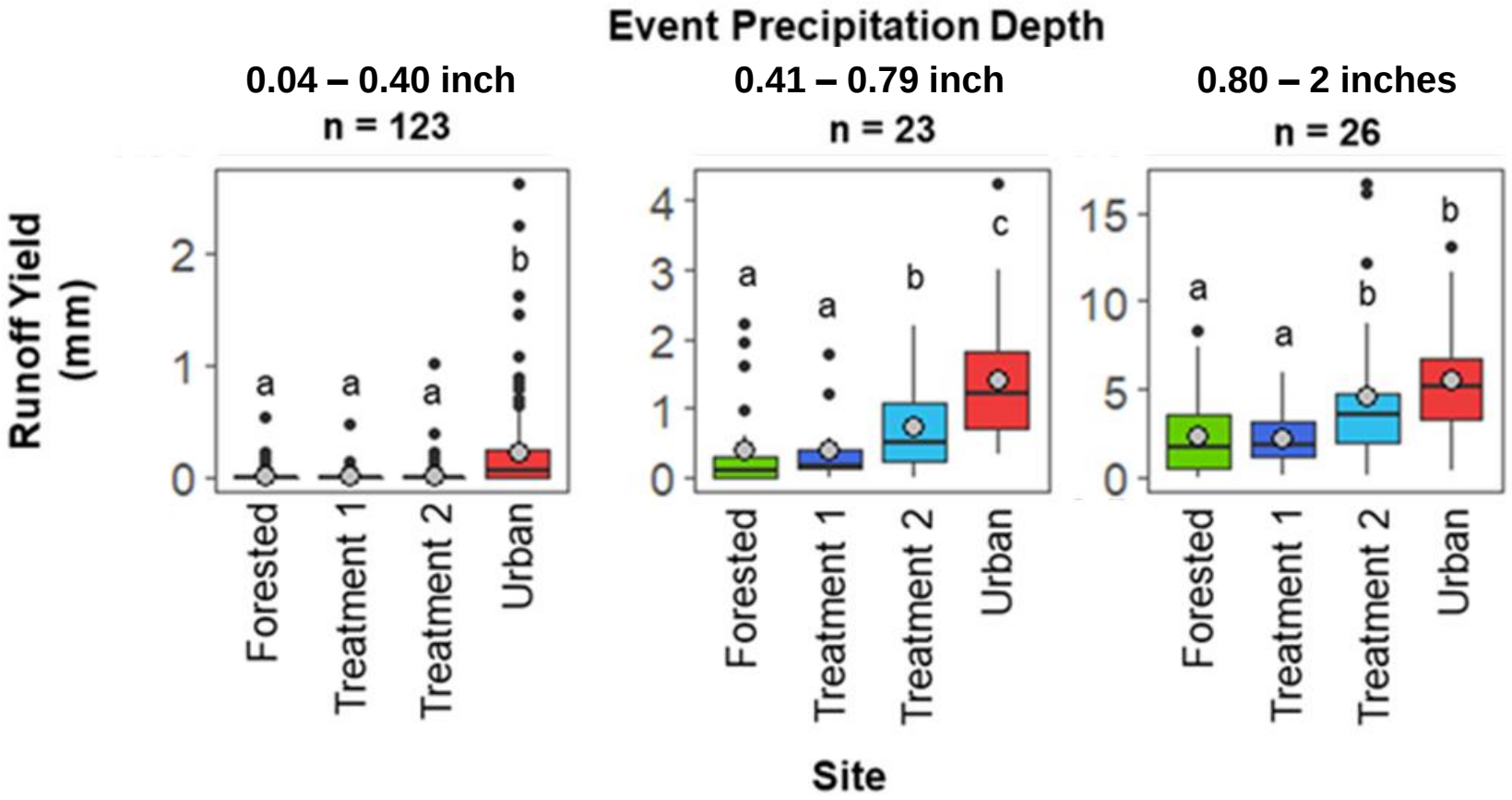
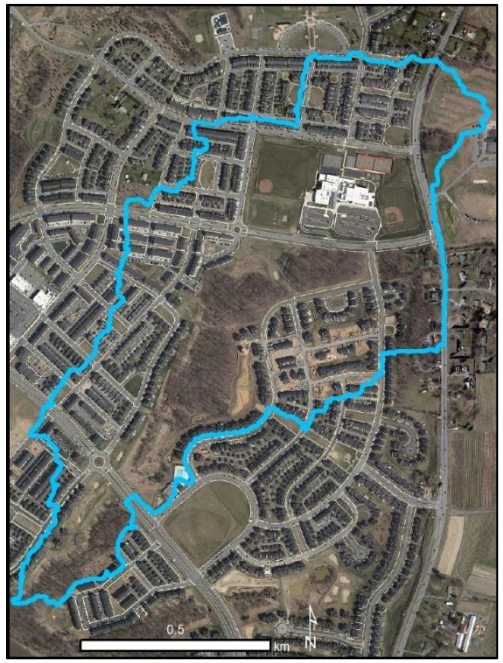
Hopkins et al. 2019 *Hydro Processes*

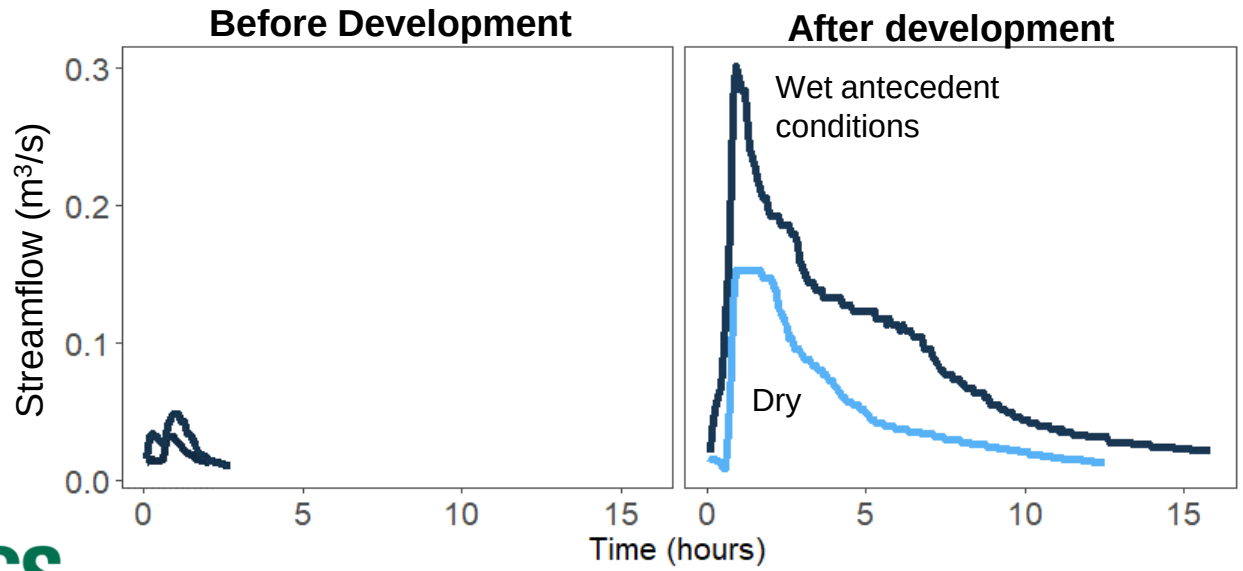
Runoff amount was lower in Treatment 1 than 2



Hopkins et al. 2019 *Hydro Processes*

Flow changes in Treatment 2 before and after development

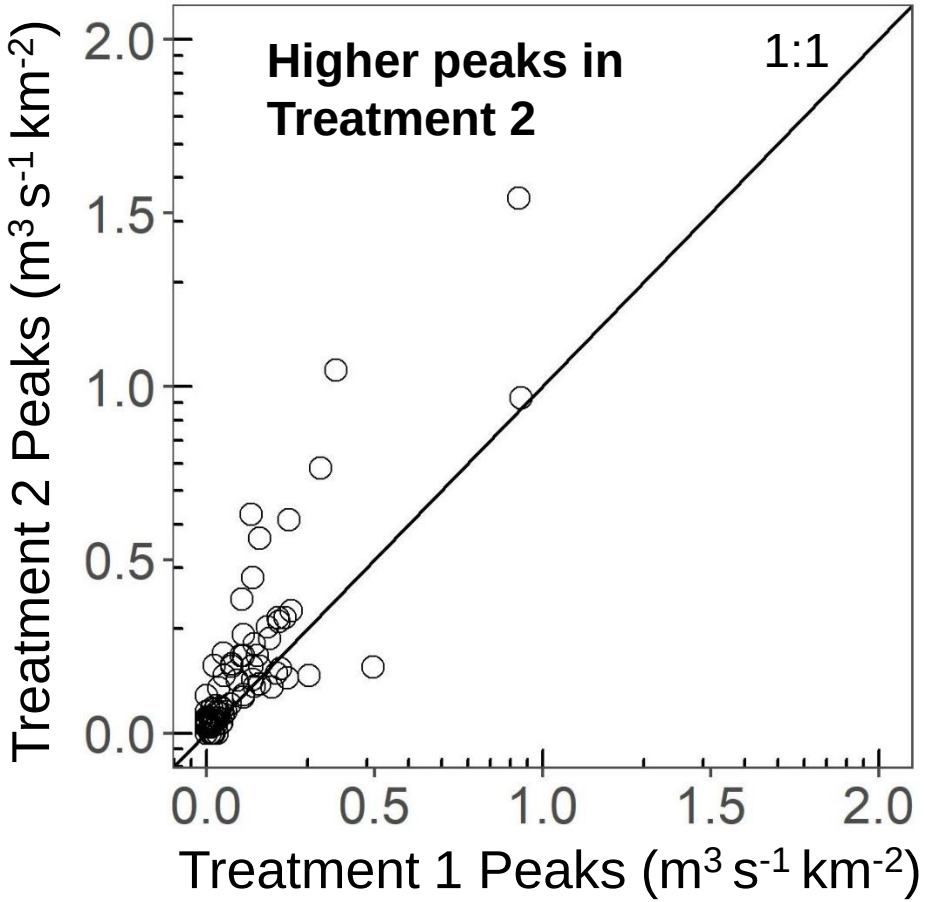




1-1.5 inches of rain

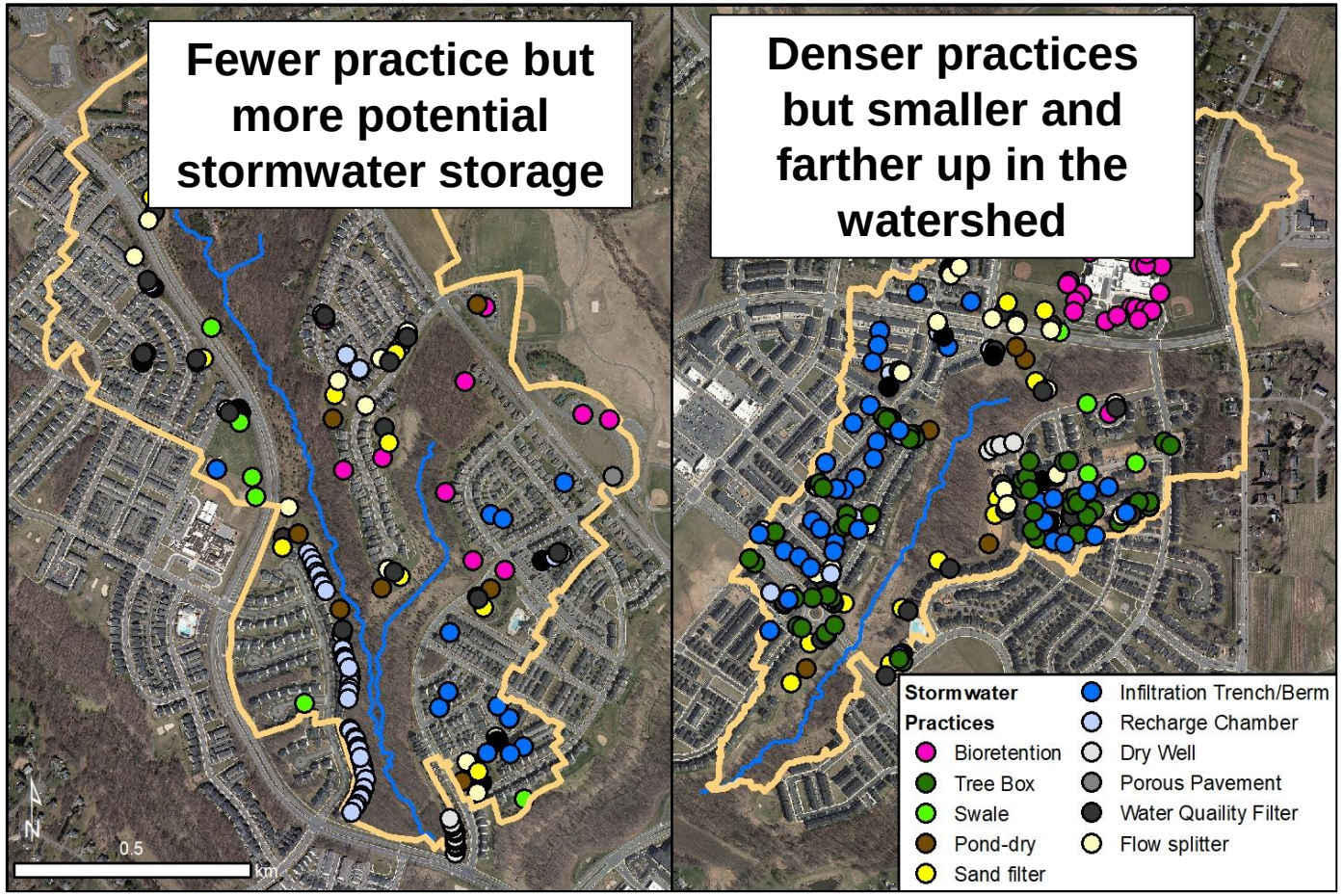
Hopkins et al. 2019 *Hydro Processes*

Treatment 1 typically had higher peaks than Treatment 2

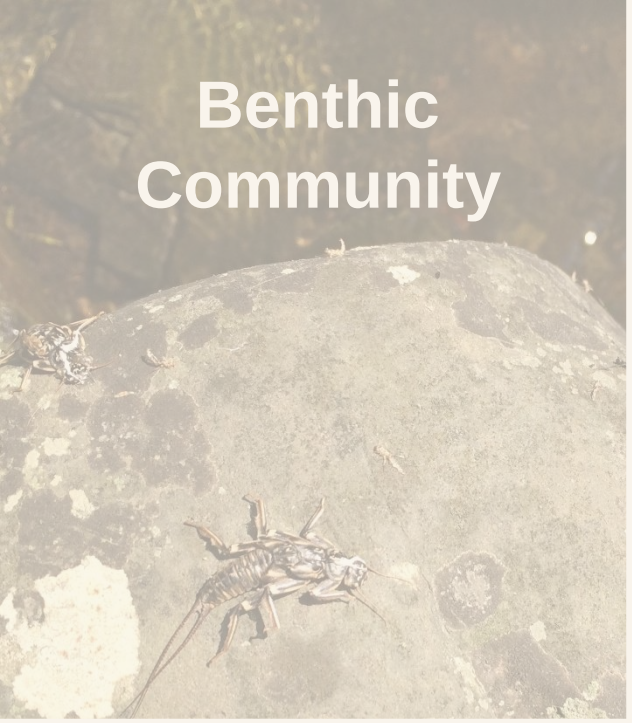


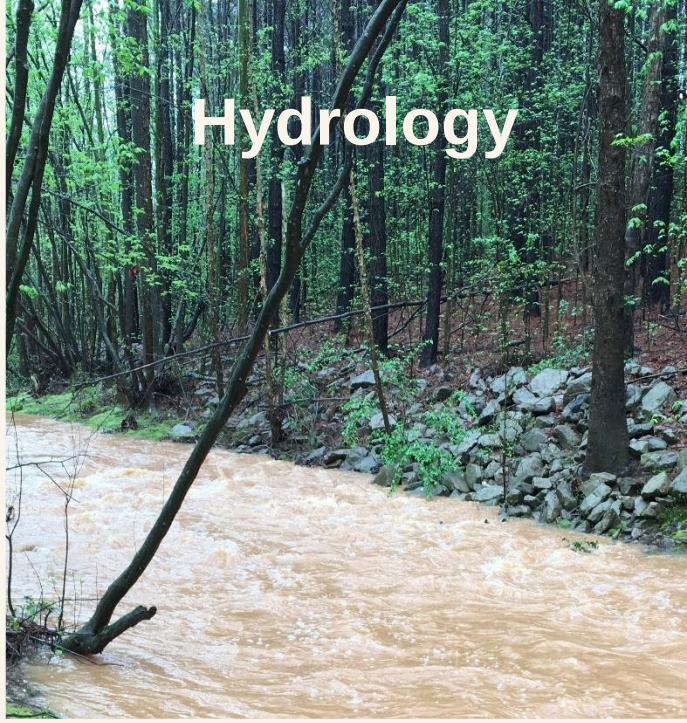
Treatment 1

Treatment 2



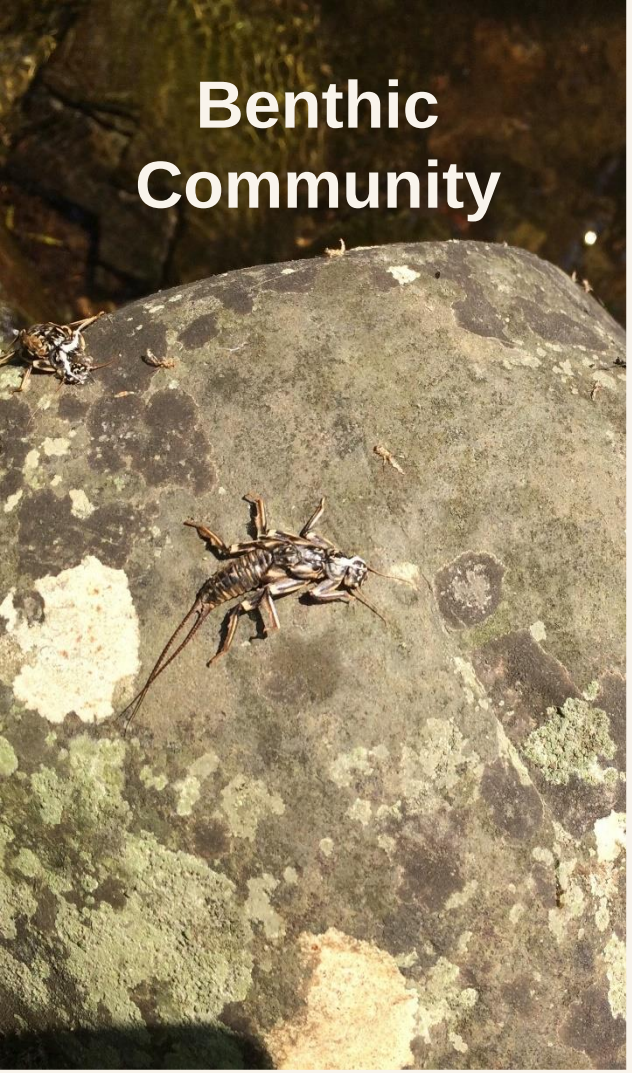
Hopkins et al. 2019 *Hydro Processes*





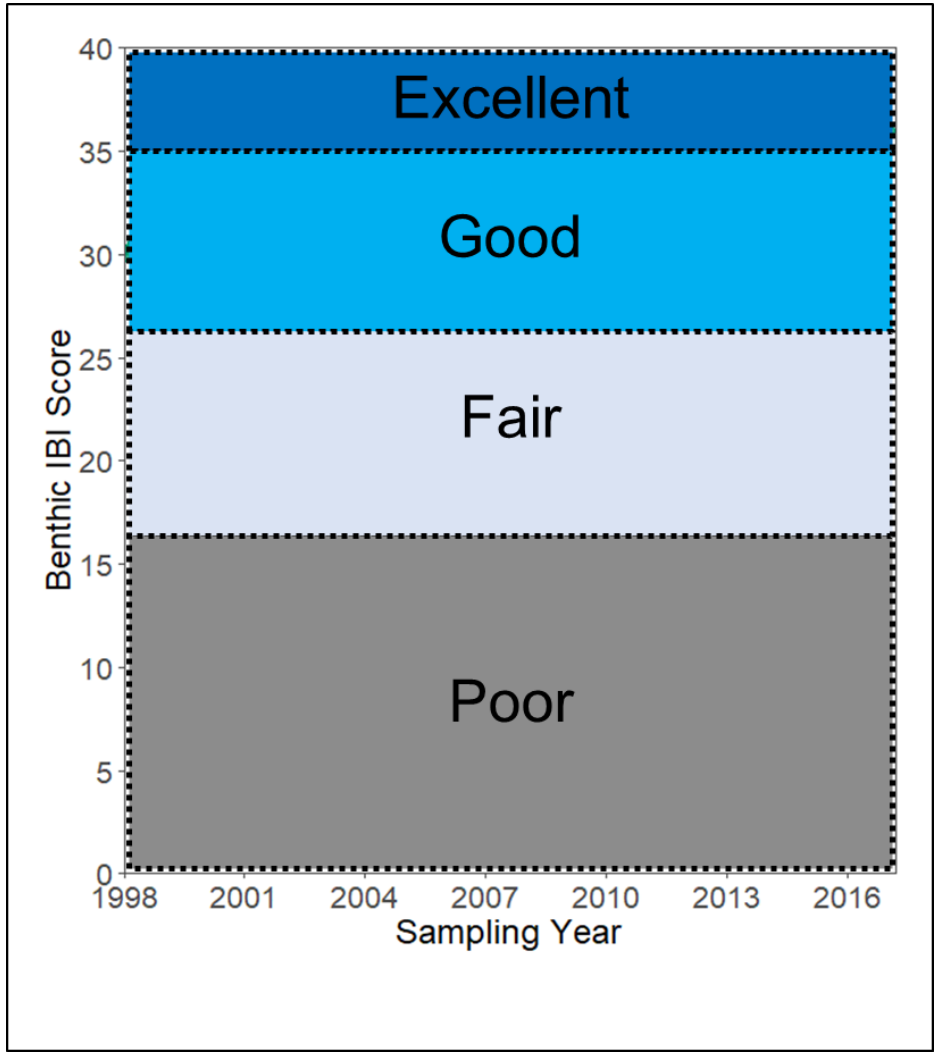
Watershed-scale green stormwater infrastructure in

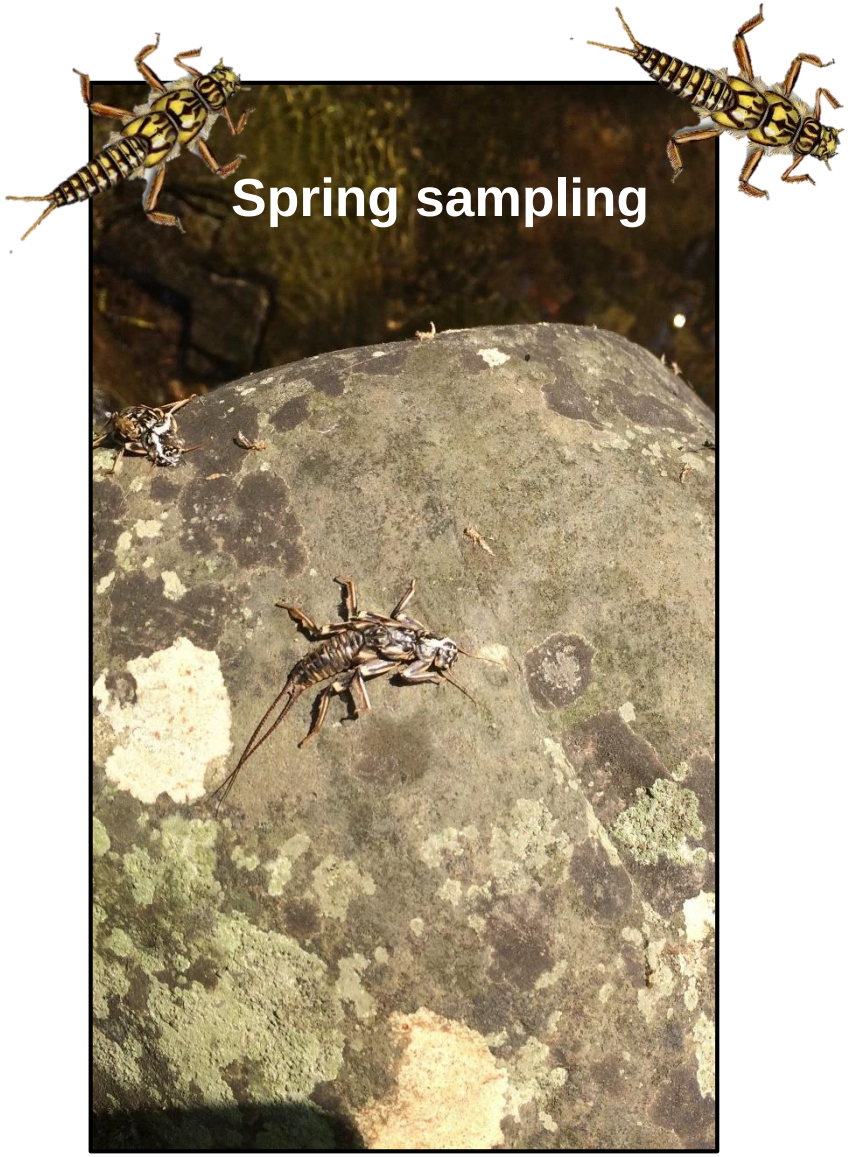
1. **Did not** maintain pre-development conditions for all events.
2. **Did** mitigate some of the impacts of increased impervious cover particularly for events with precipitation < 0.8 inches.
3. Treatment 1 had **less severe** changes than Treatment 2, likely resulting from less impervious cover in Treatment 1 (33% impervious) compared to Treatment 2 (44%).



What happens to stream health?

Do benthic macroinvertebrate health scores change after development?





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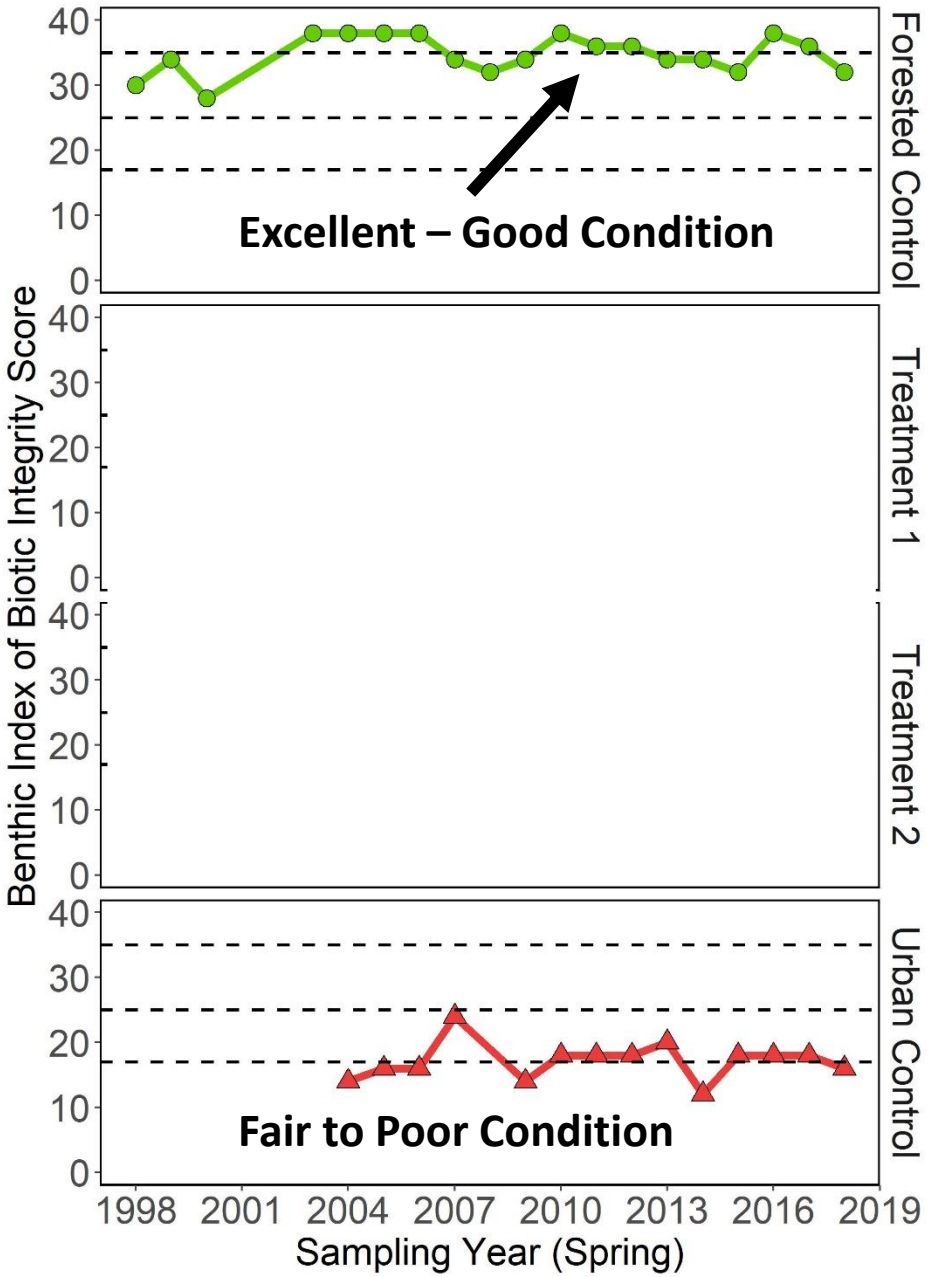
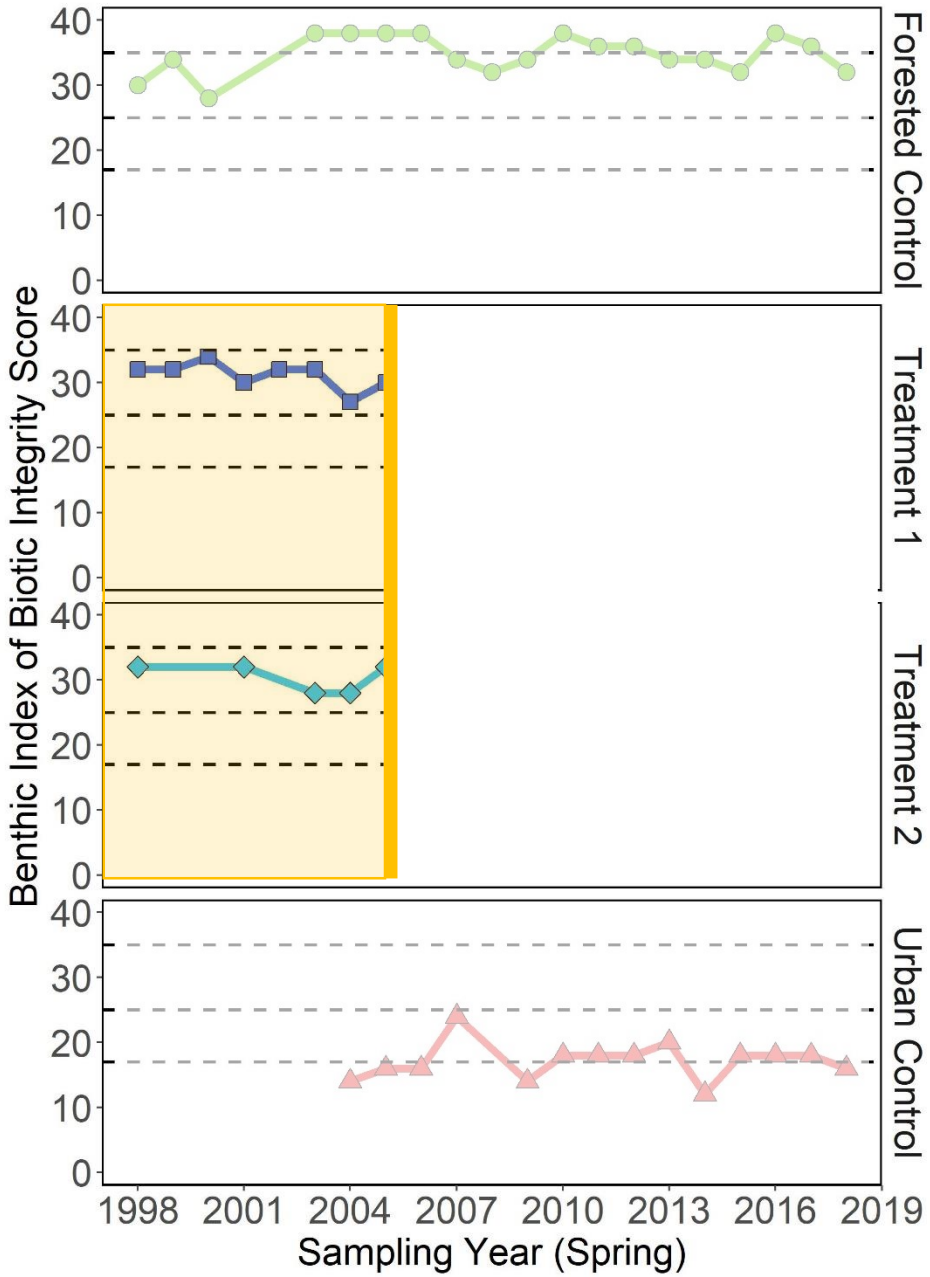
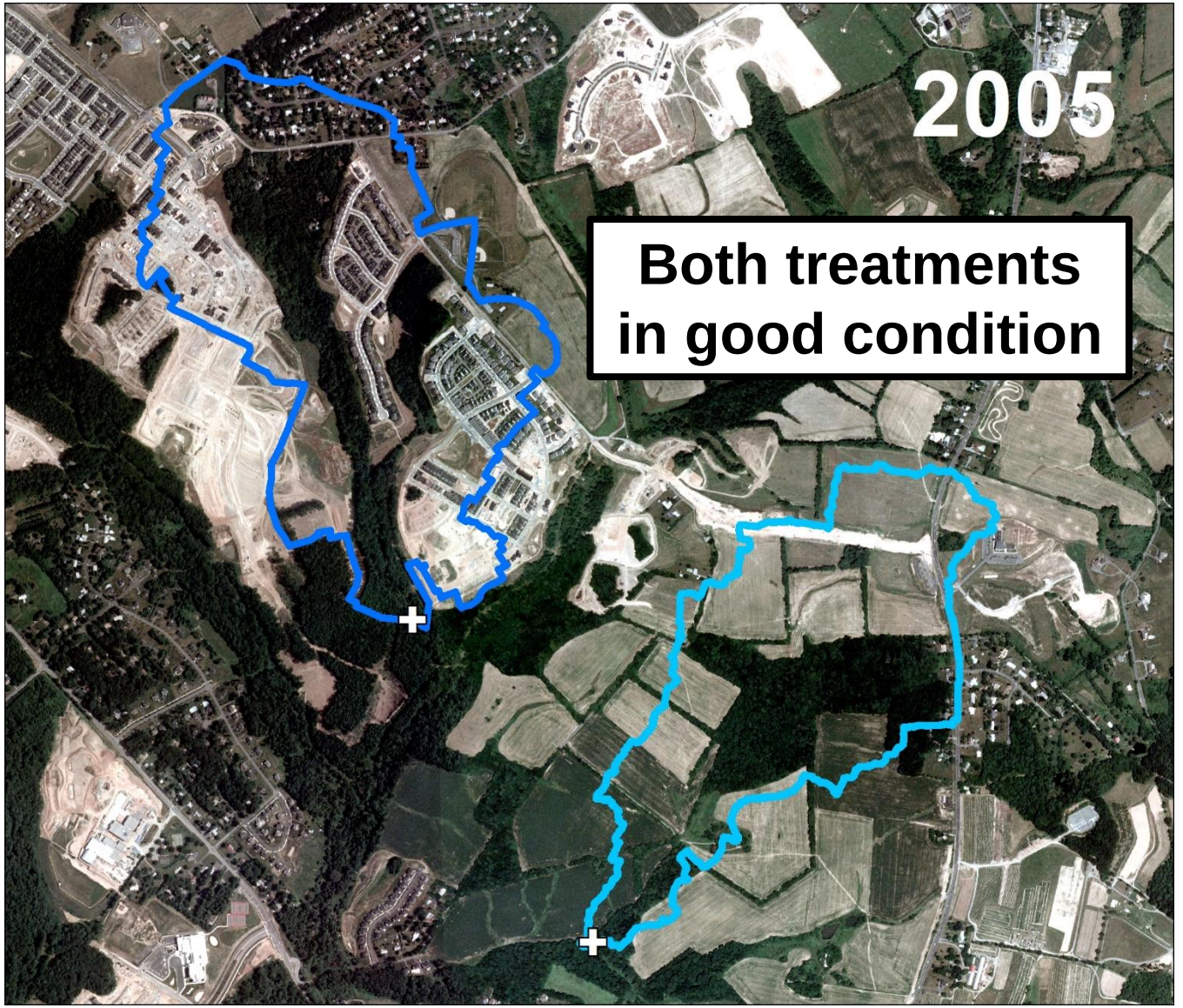


Forested site remains in excellent to good condition

Urban control site remains in fair to poor condition

Data: Montgomery County Department of Environmental Protection





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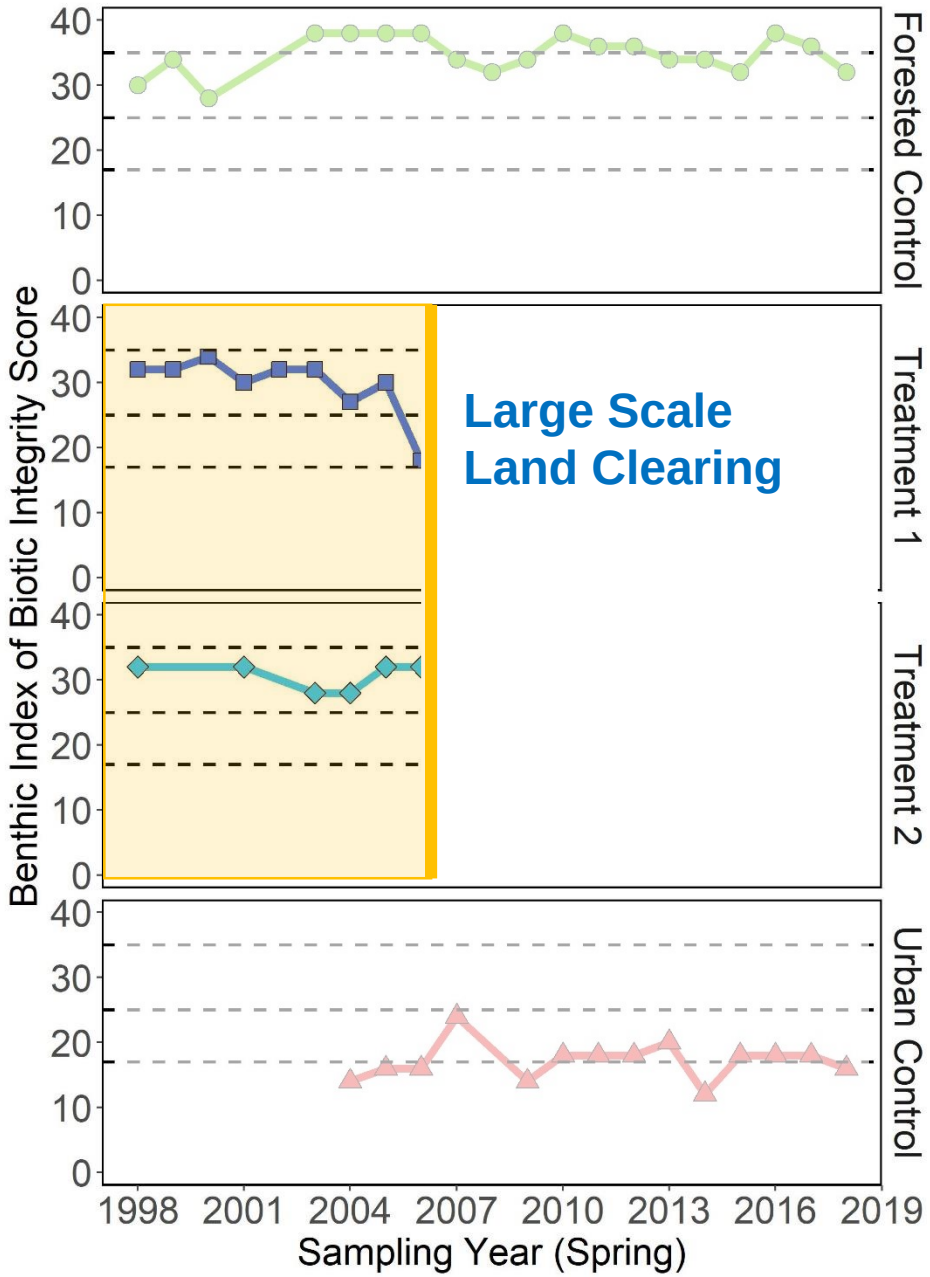
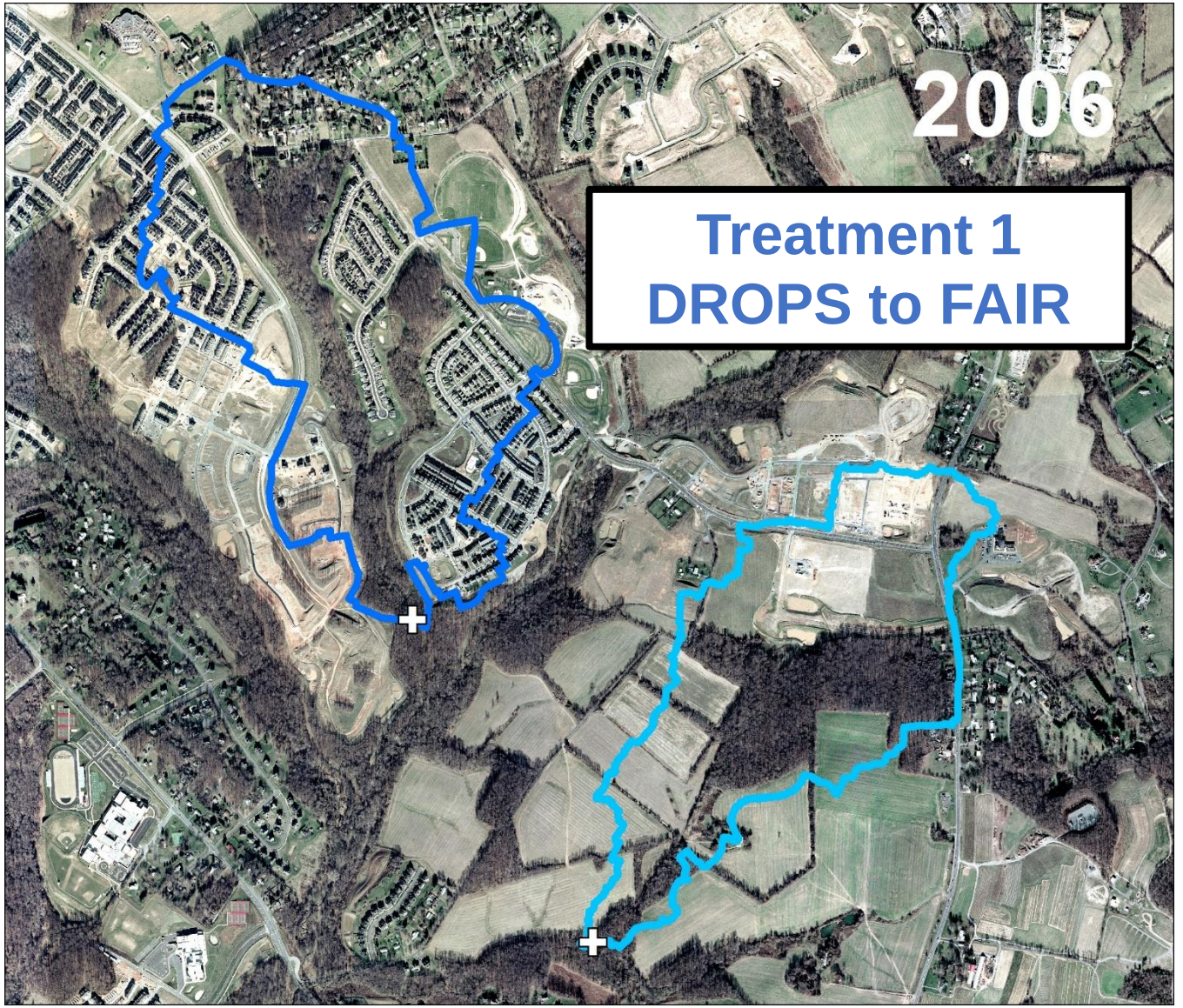
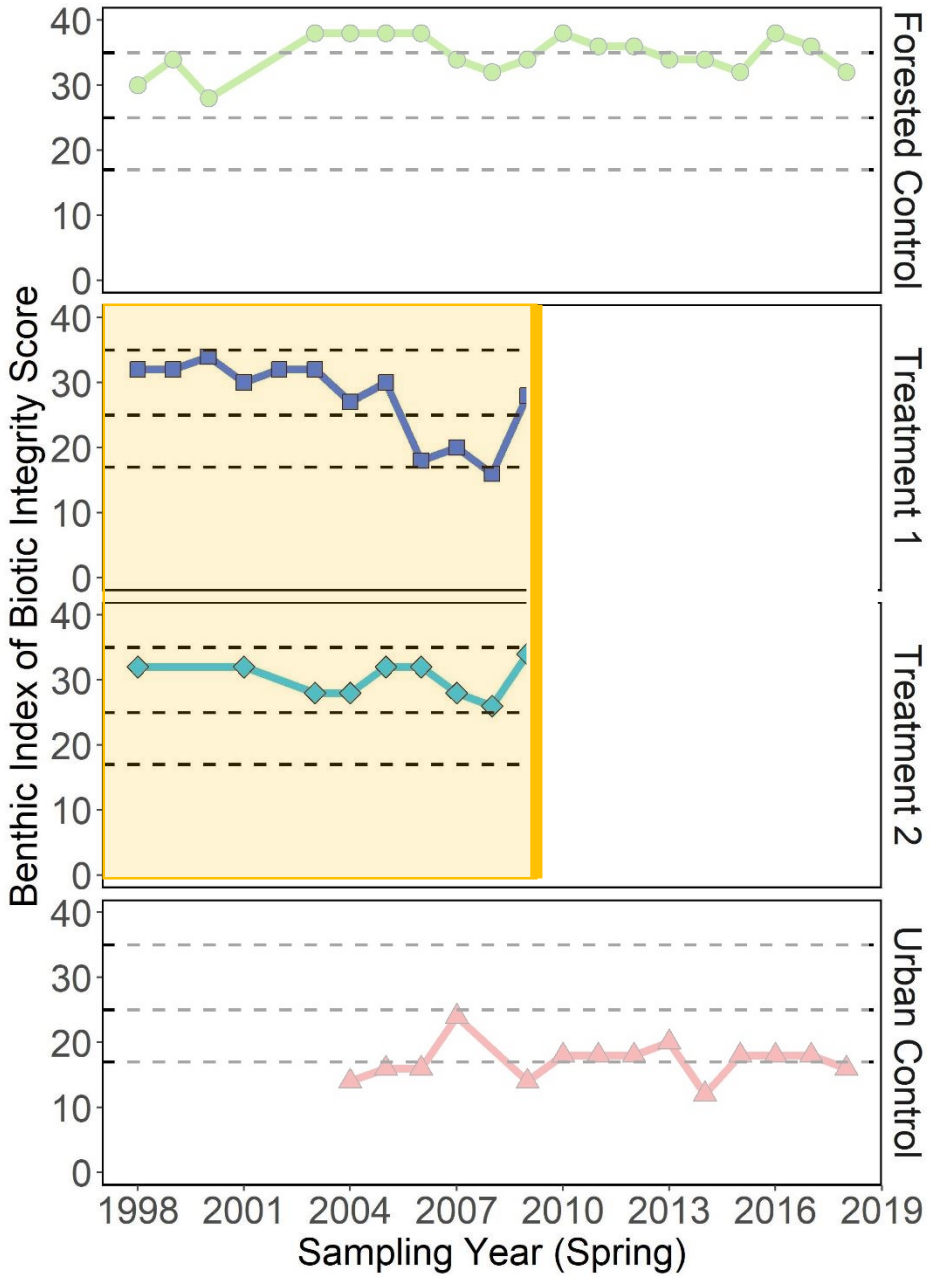
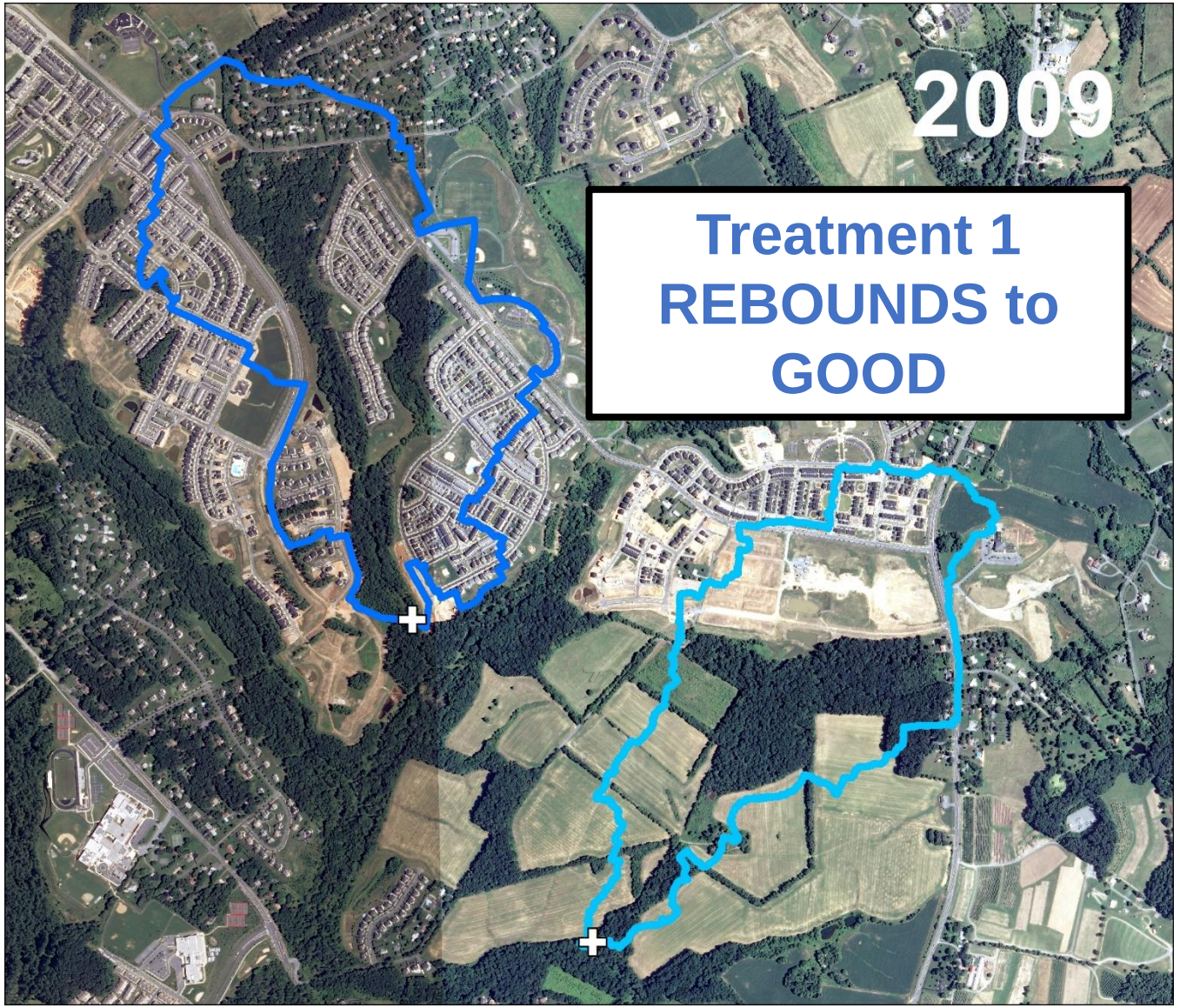




Data: Montgomery County Department of Environmental Protection





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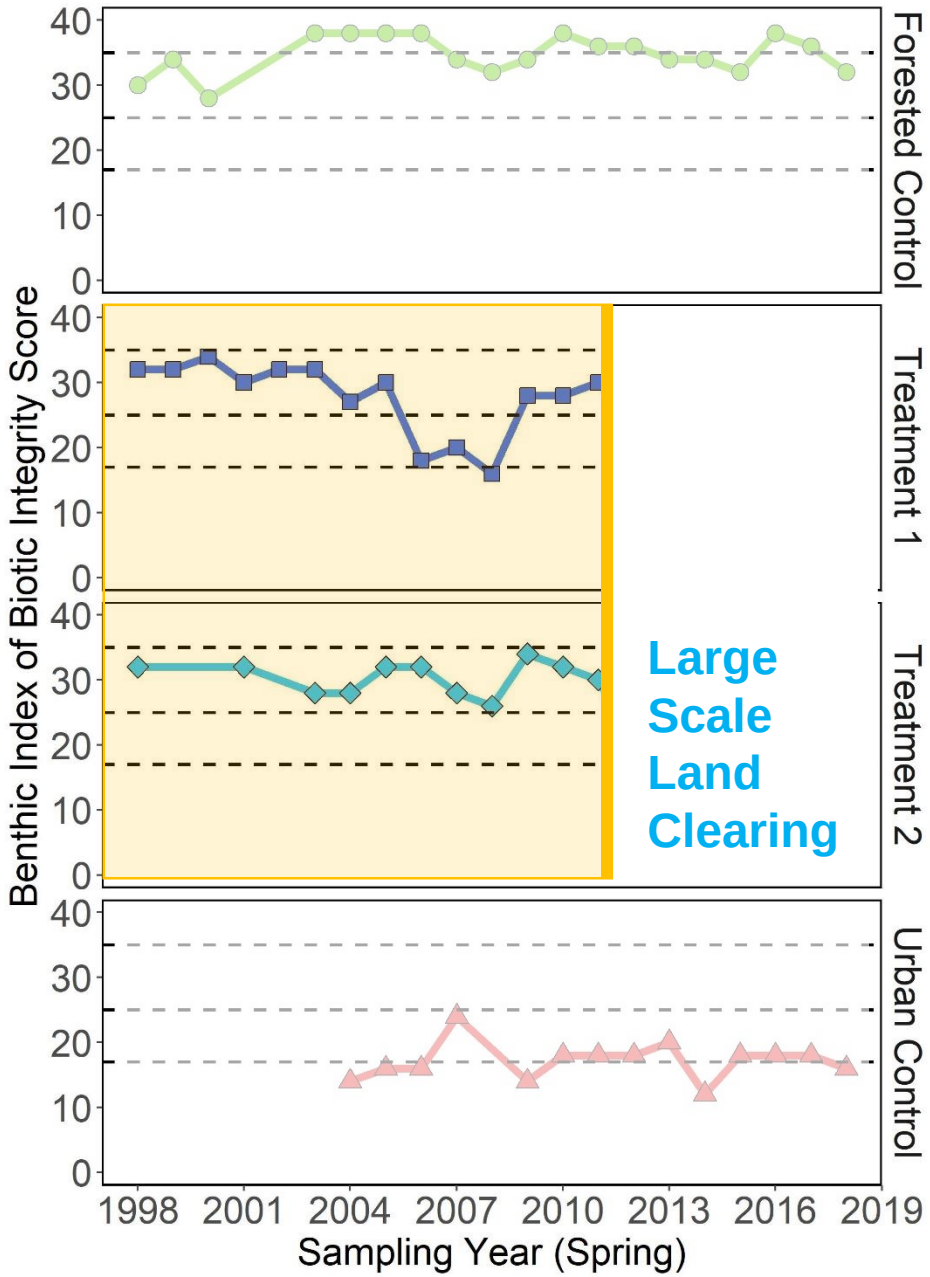

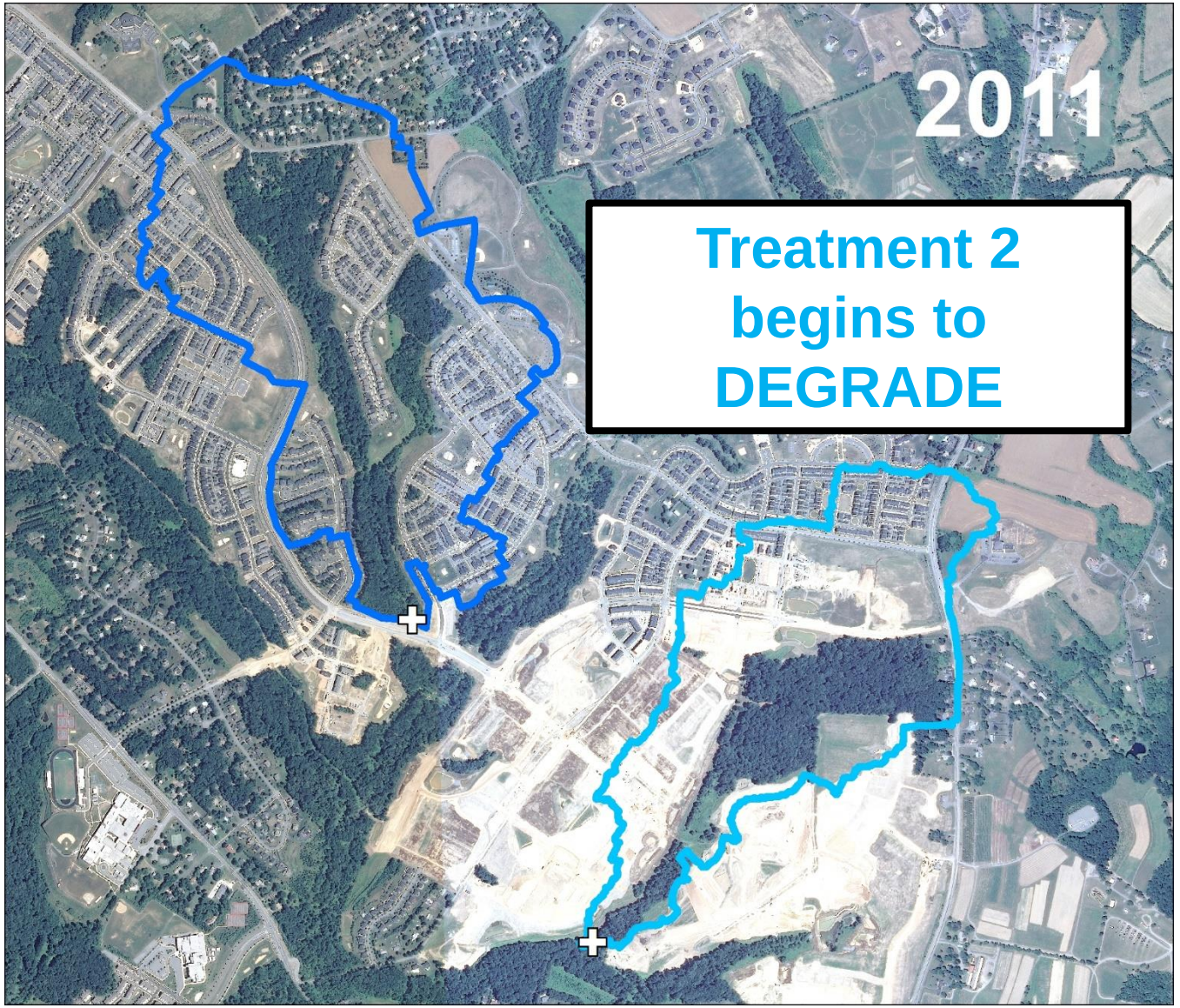

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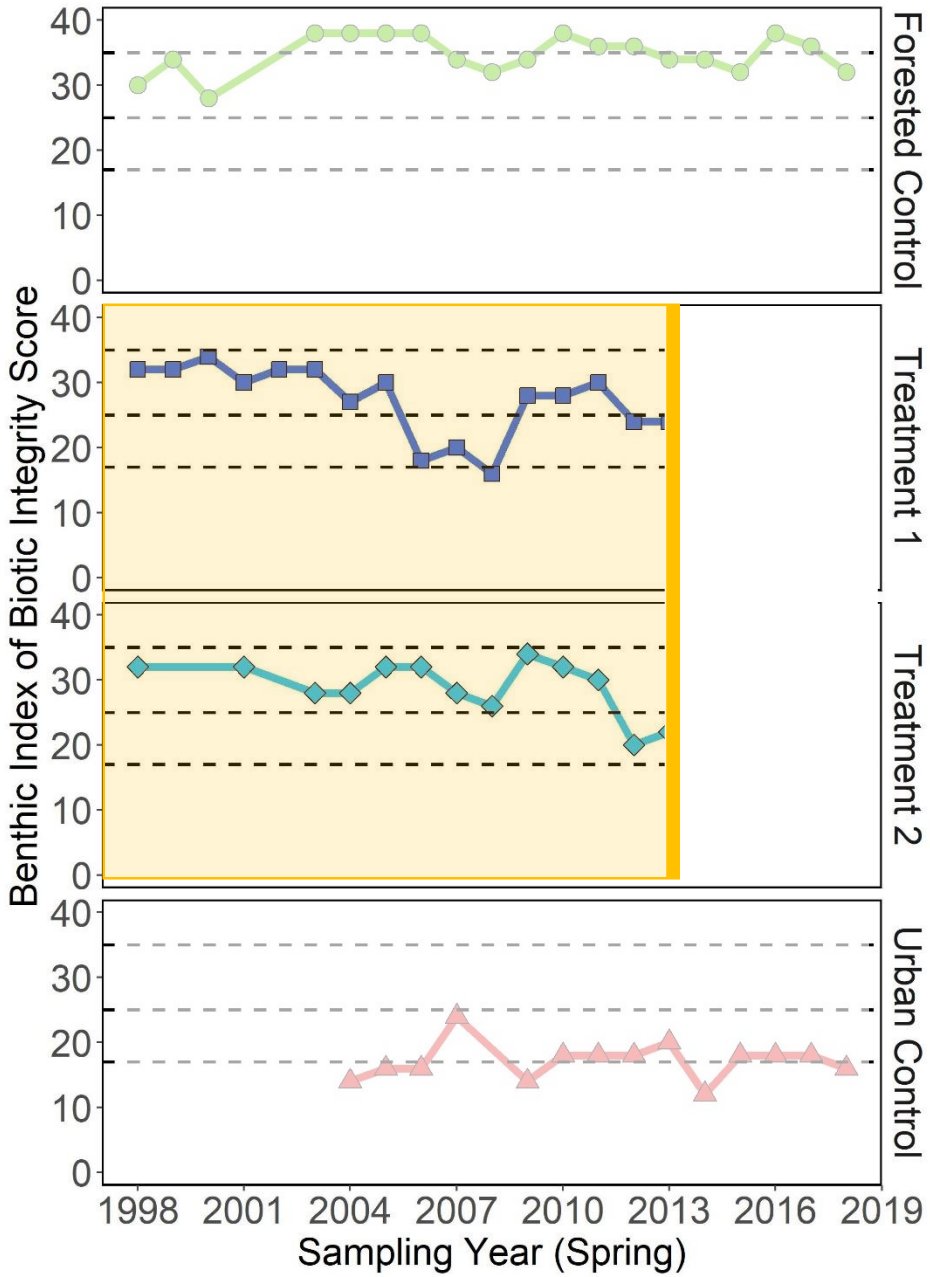

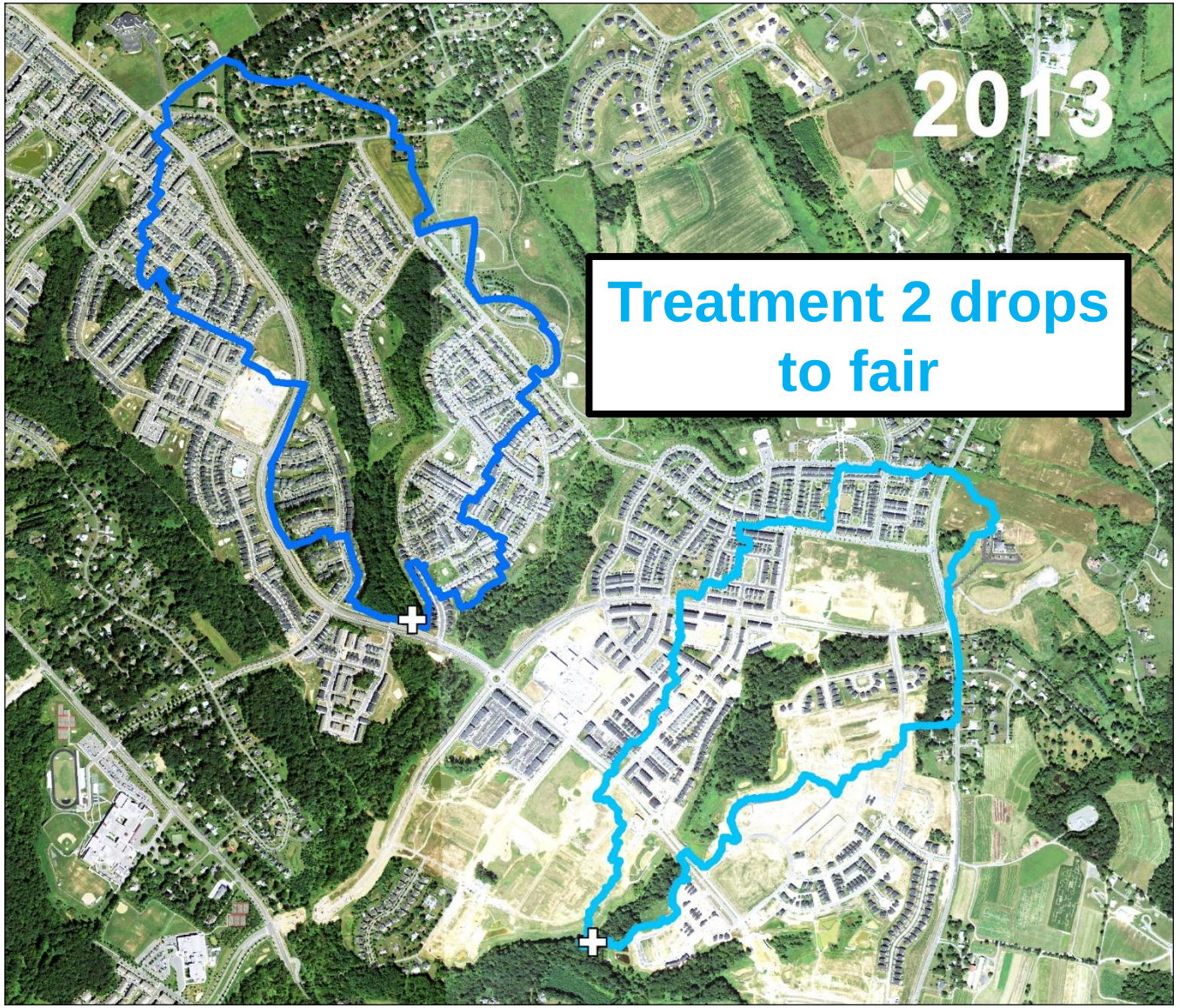

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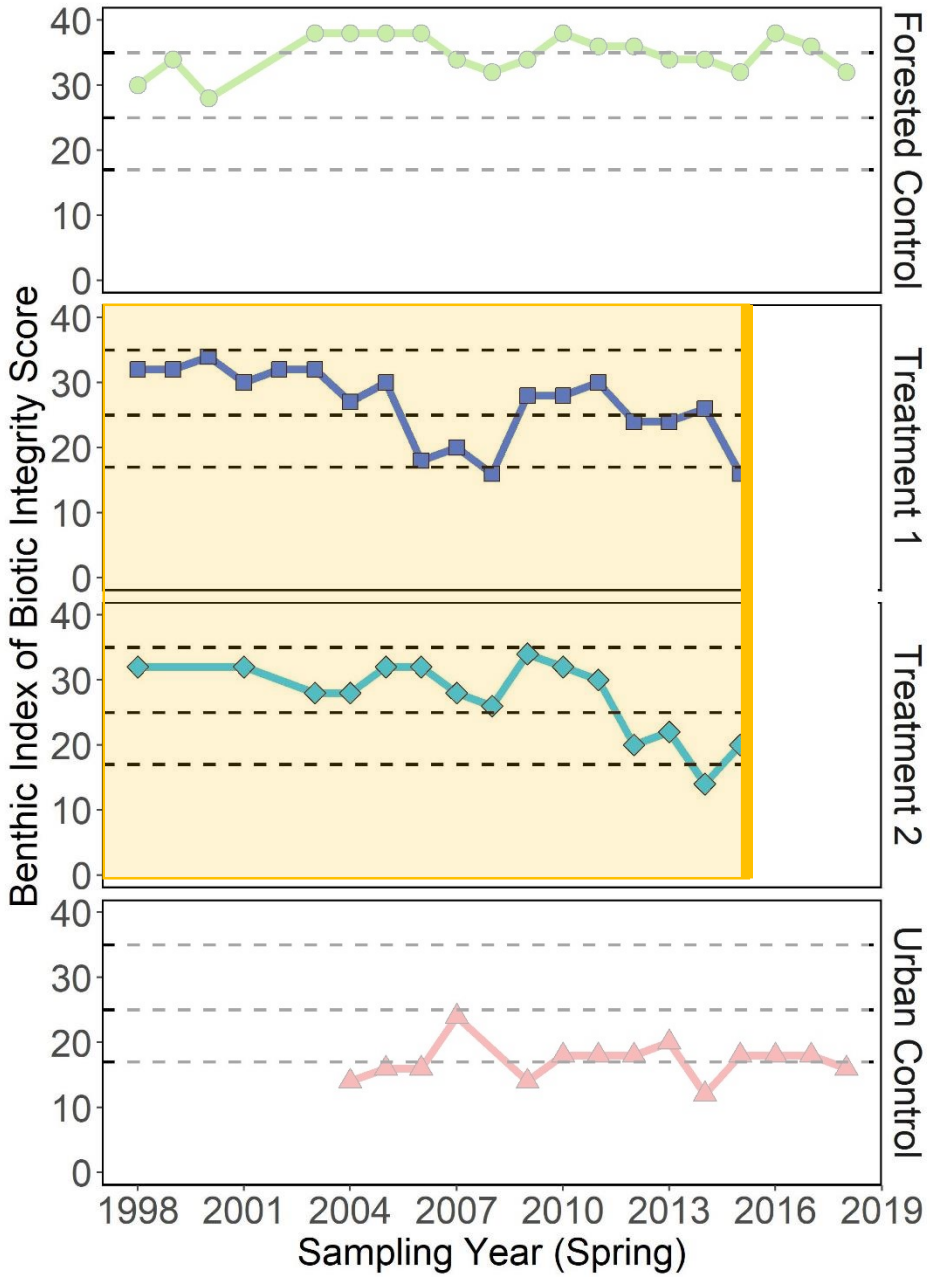

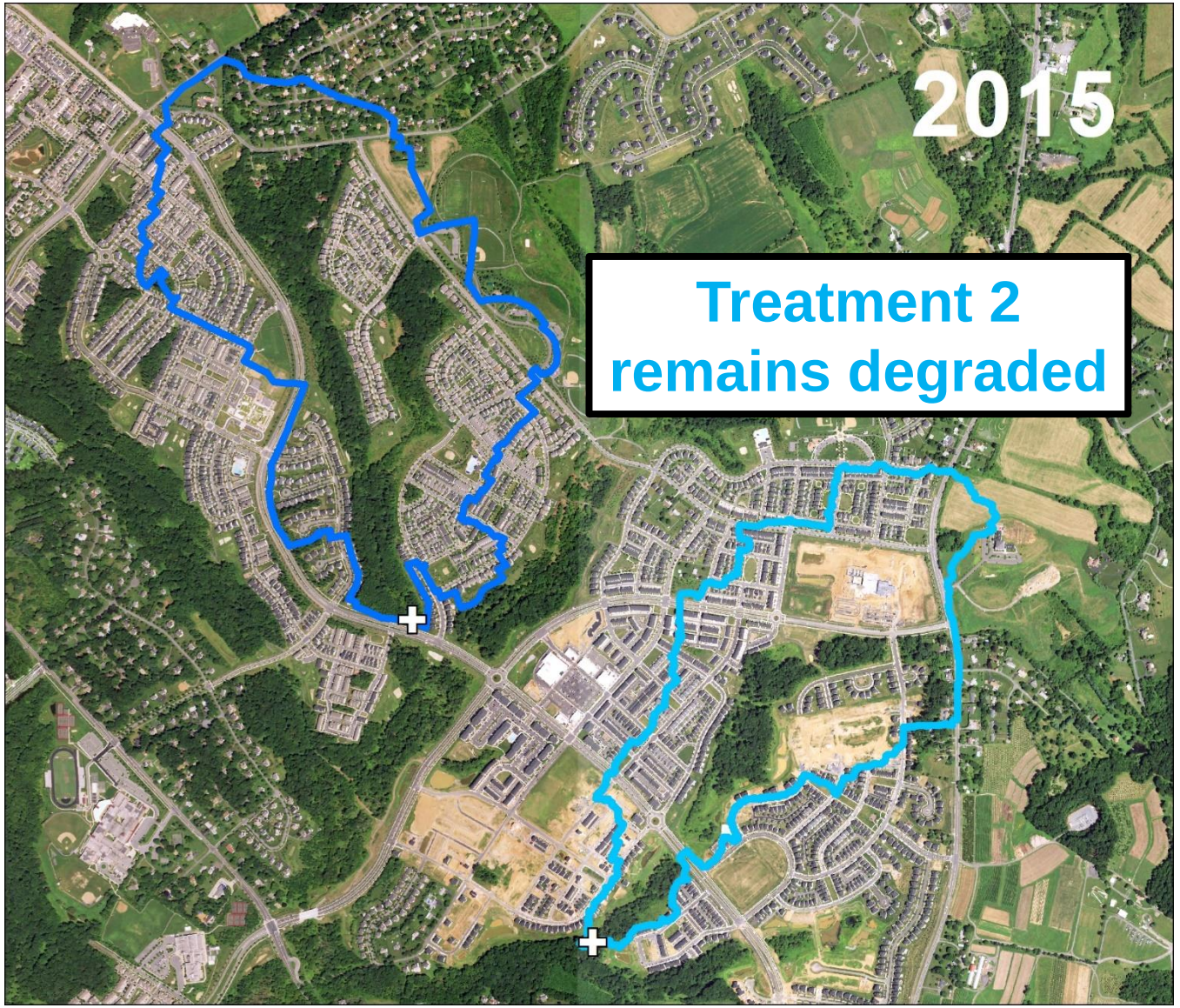

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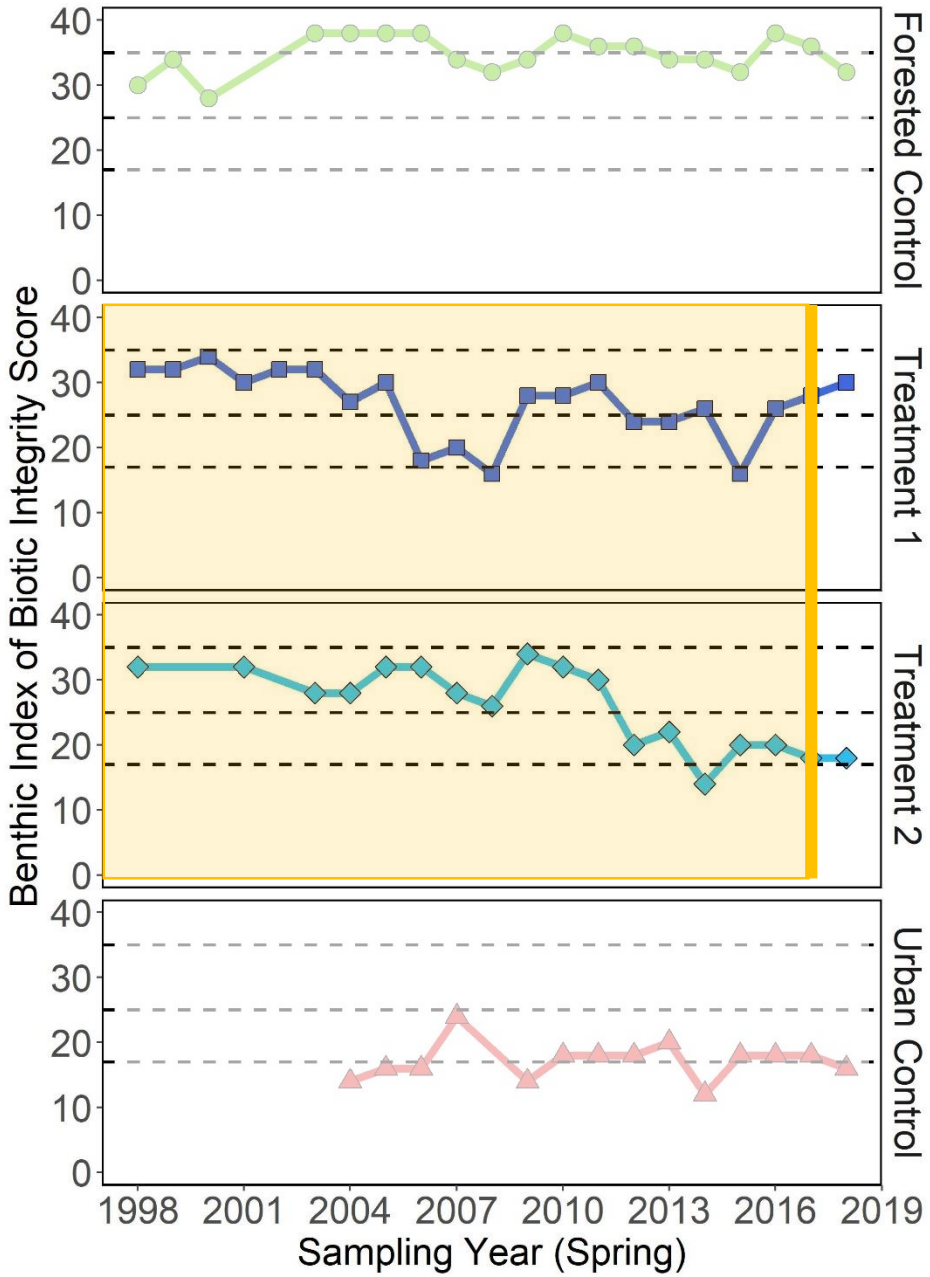

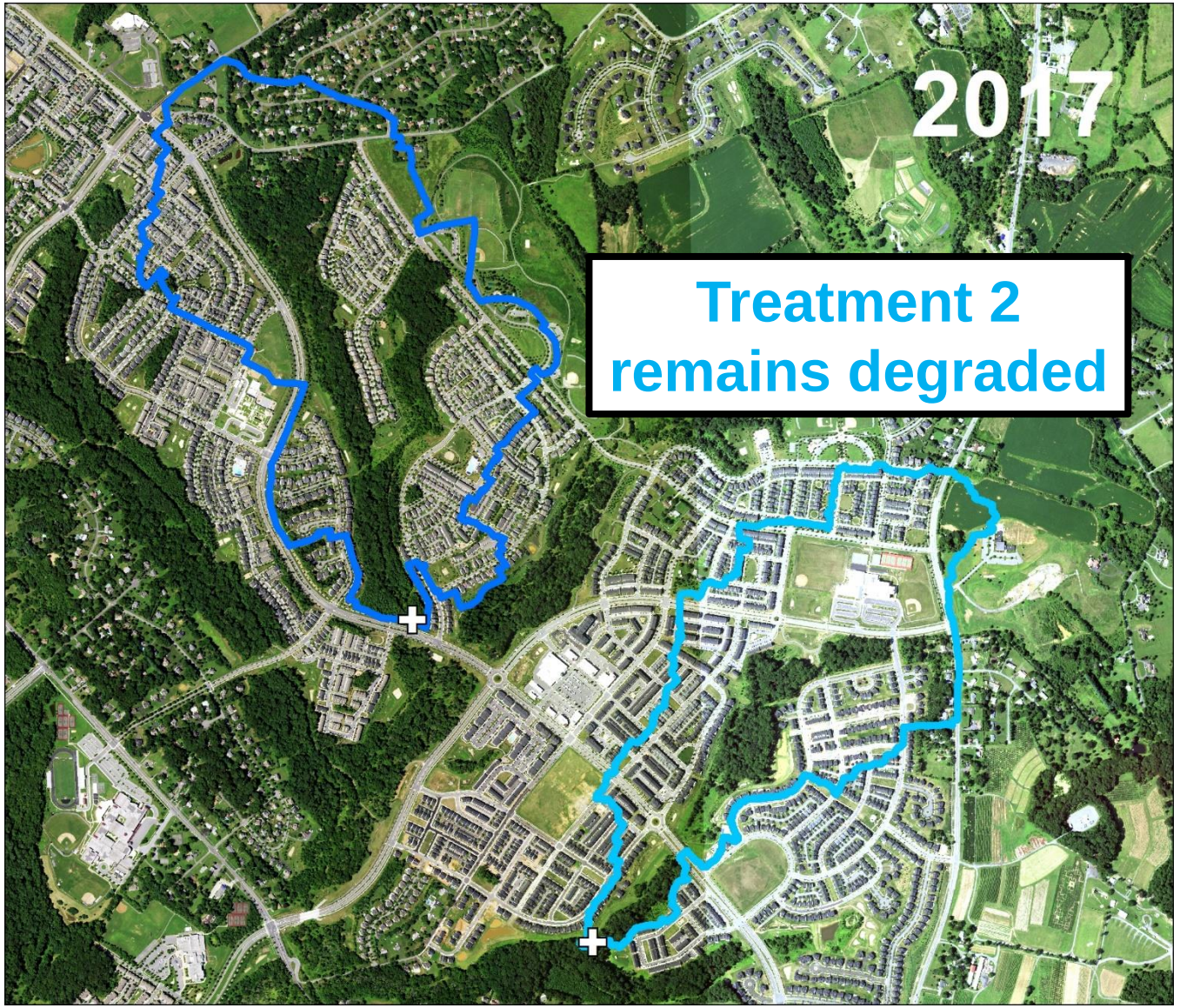

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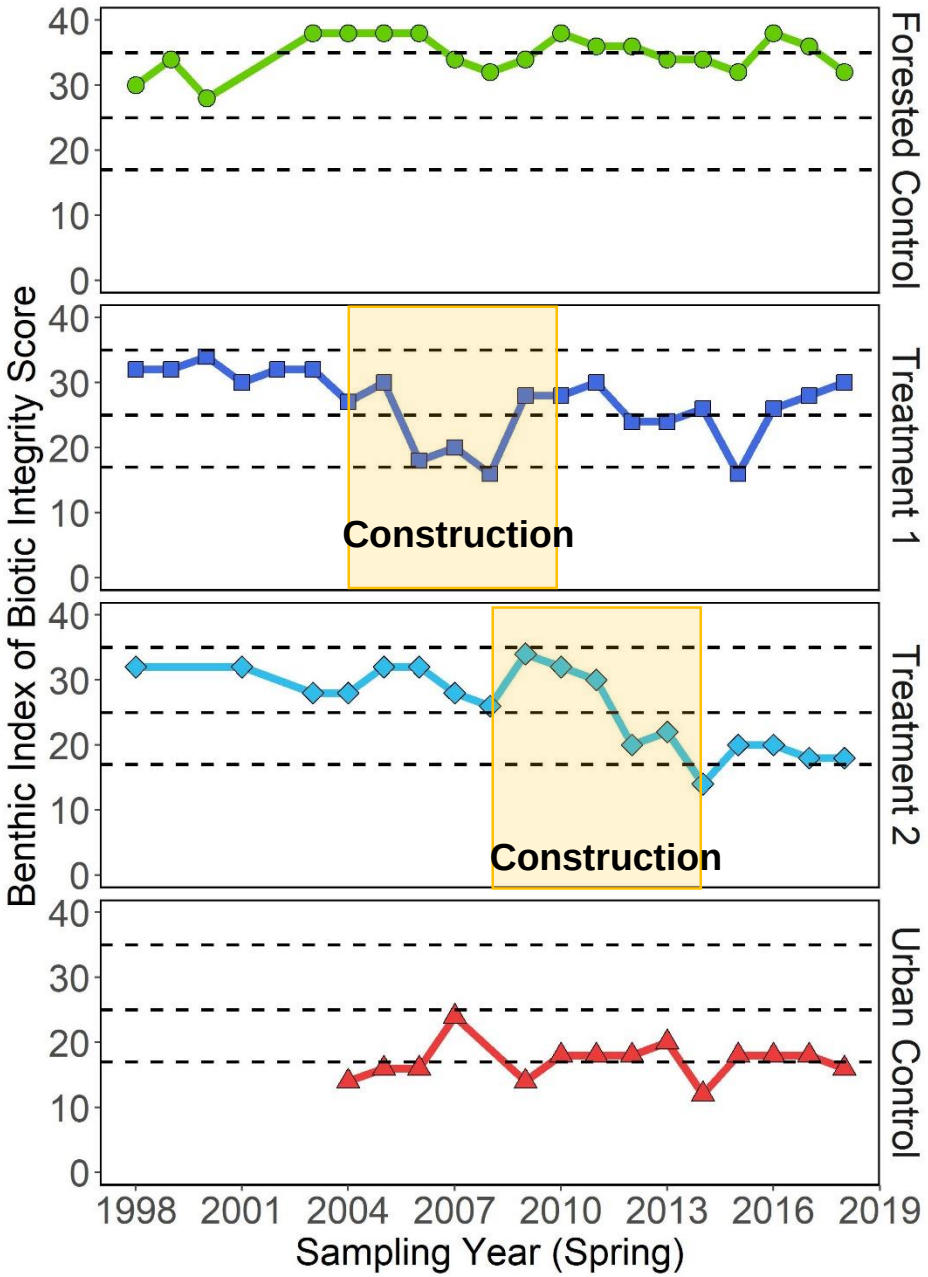


Benthic IBI Scores

Rebound in Treatment 1

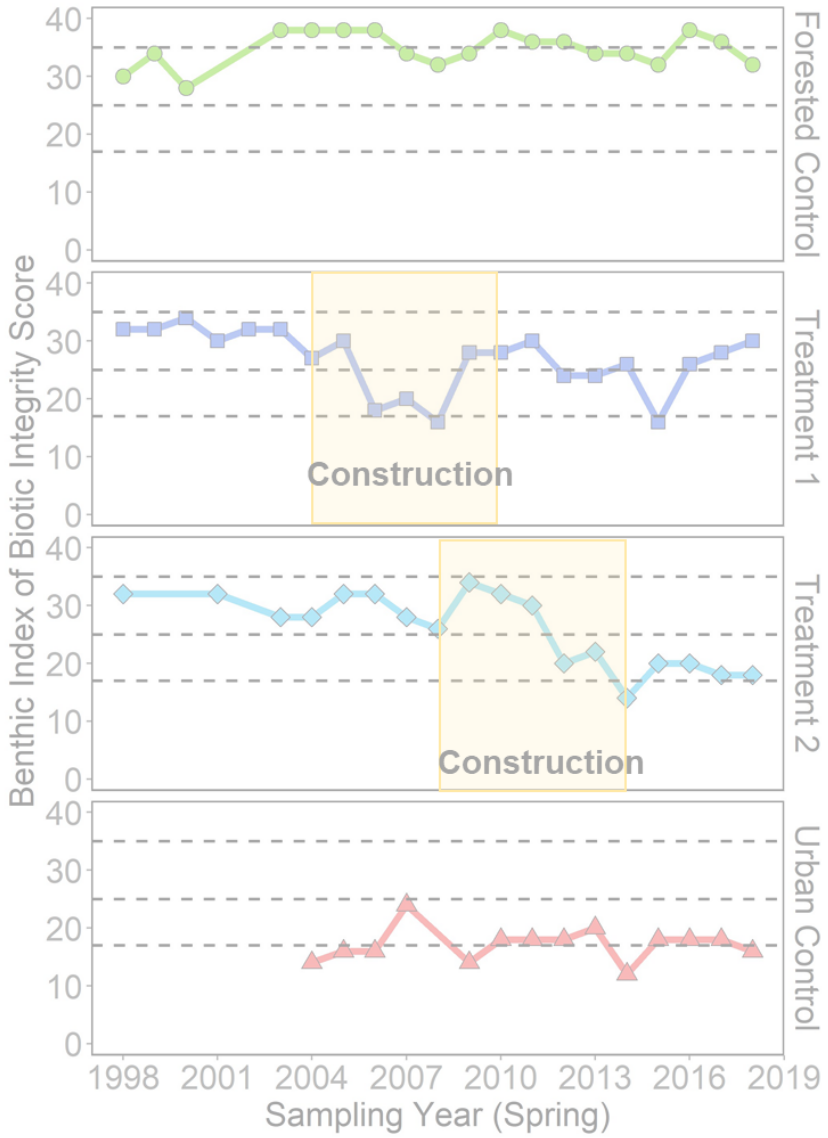
33% Impervious

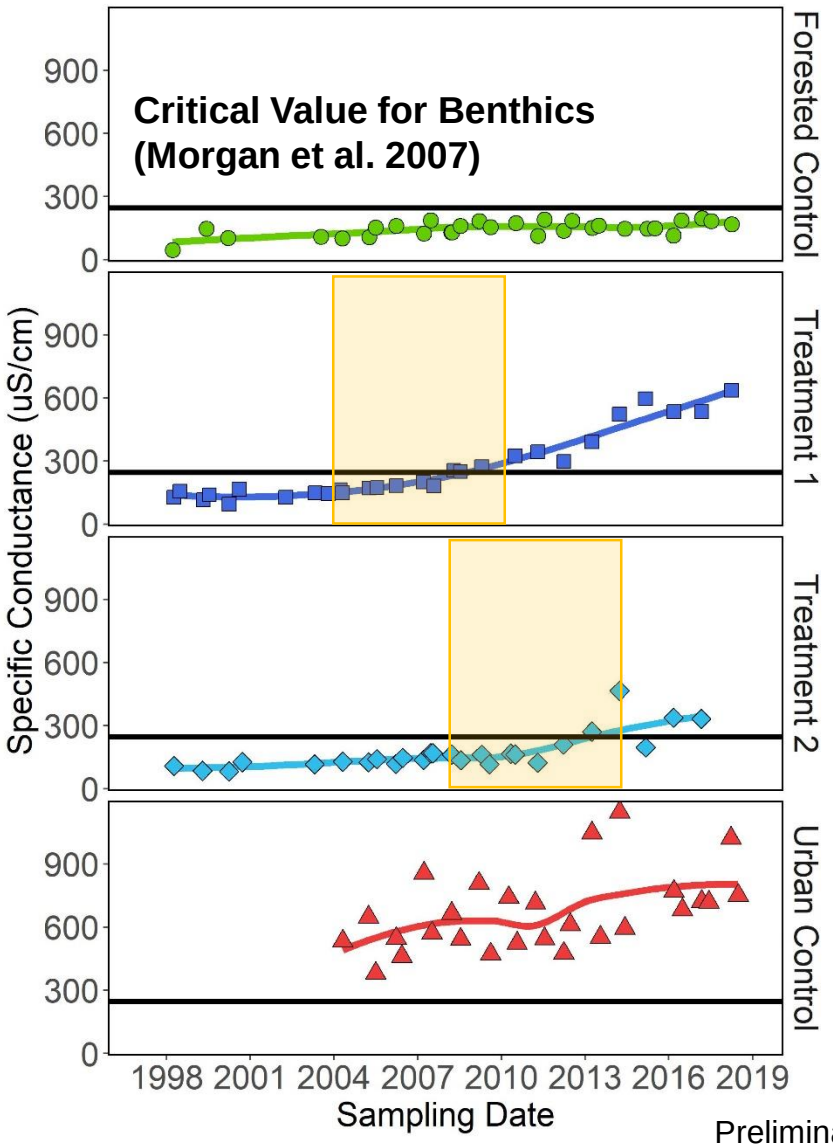
Decline in Treatment 2

44% impervious

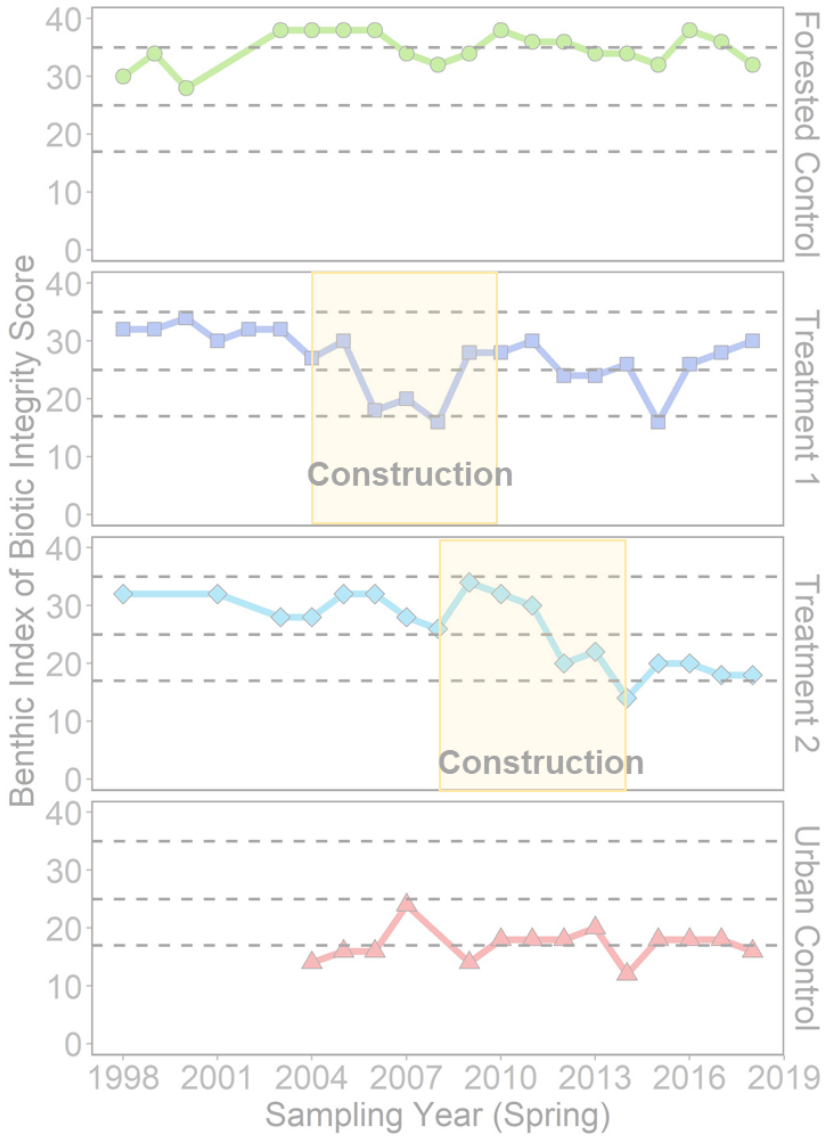
Can water quality help explain changes in benthic health?

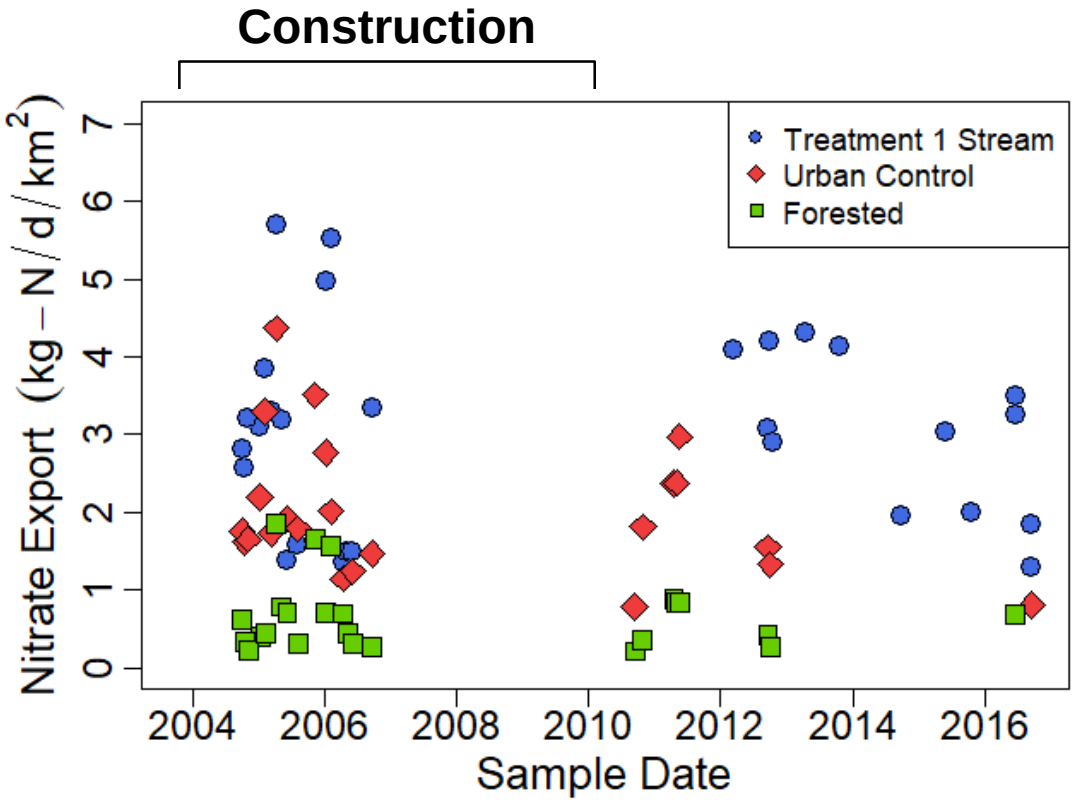
Water Quality: Specific conductance is increasing at all sites





Water Quality: Baseflow nitrate concentrations have declined but export remained about the same

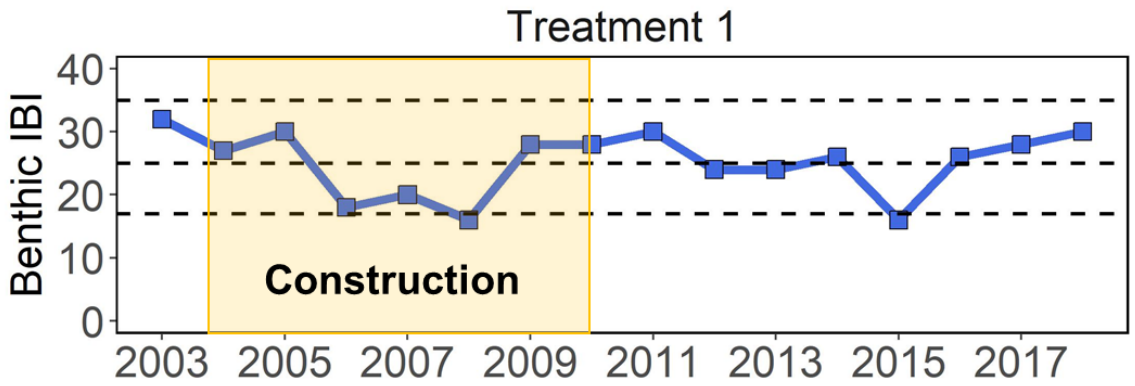


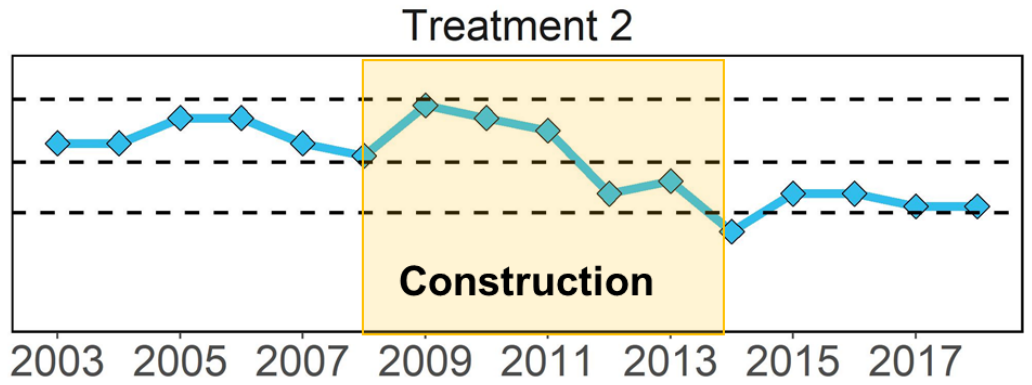


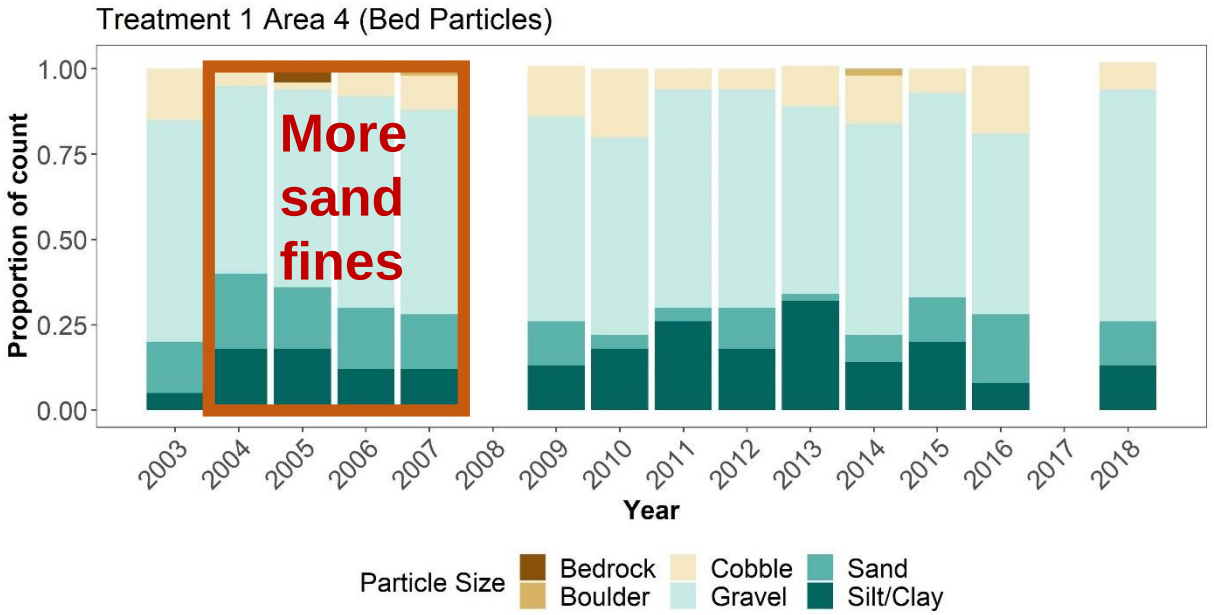
Hopkins et al. 2017 *J. Env Manage*

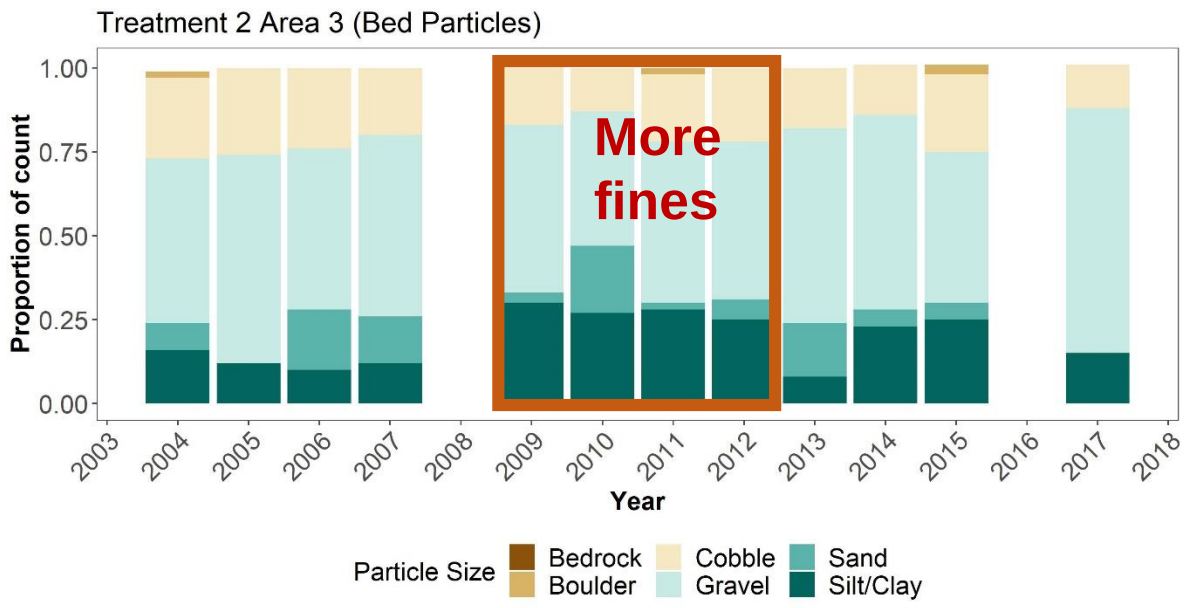
Can particle sizes (habitat) help explain changes in stream health?

Geomorphology: Increase in sand and silt/clay during construction









Preliminary Information-Subject to Revision.
Not for Citation or Distribution.

USGS
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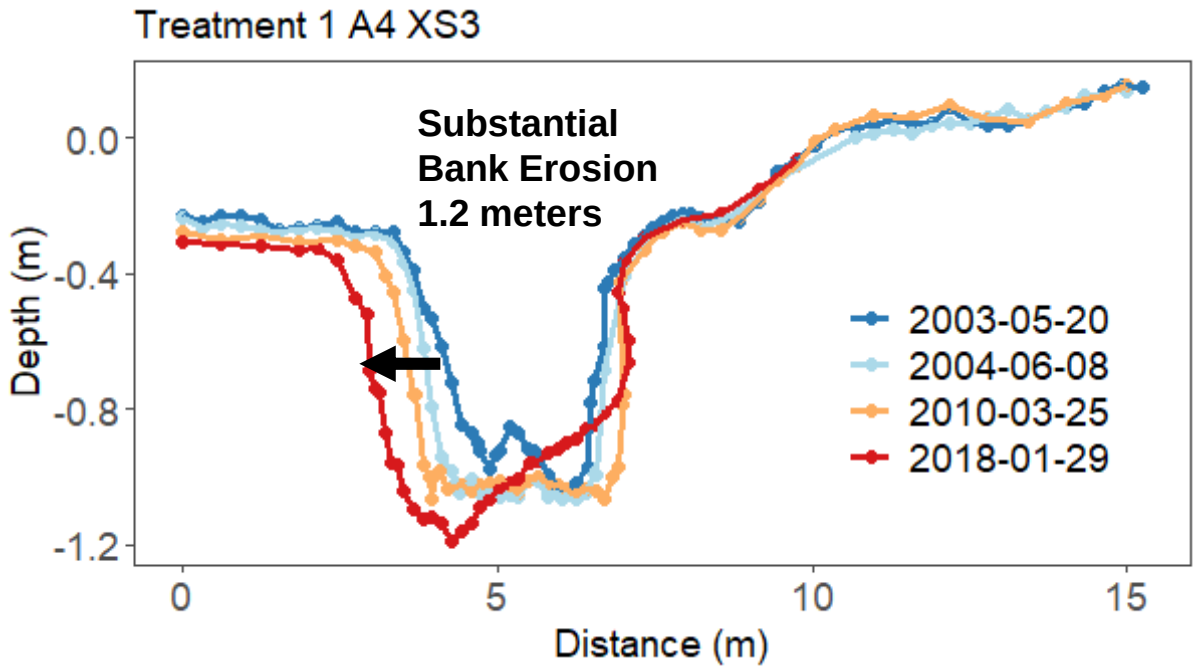
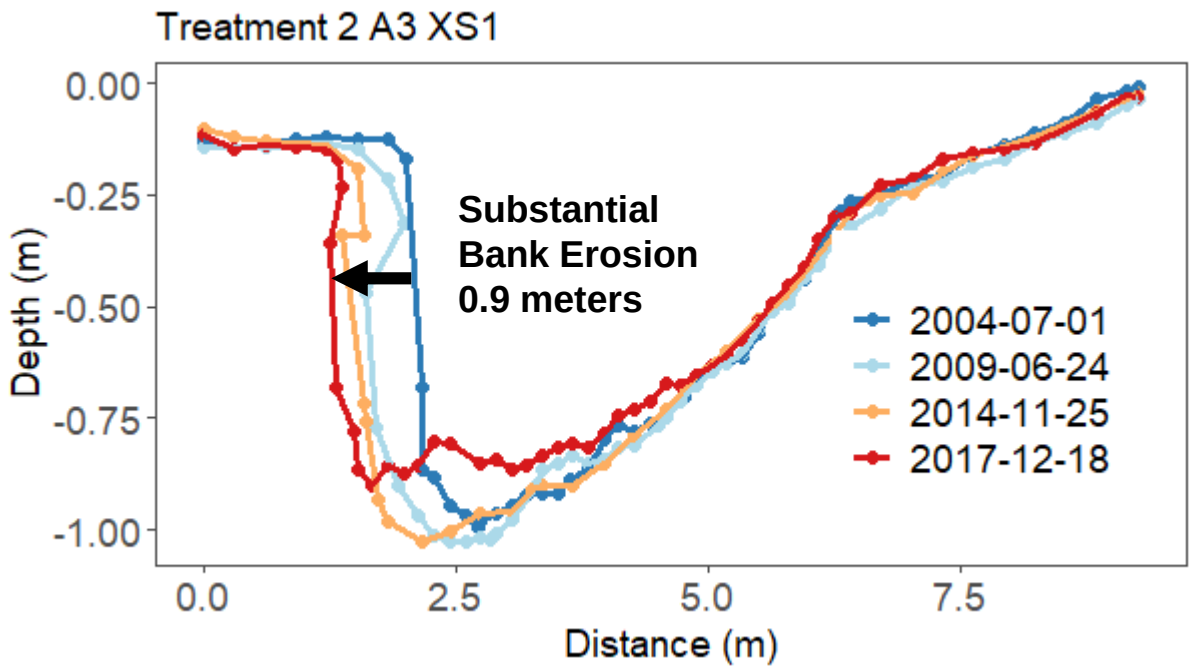
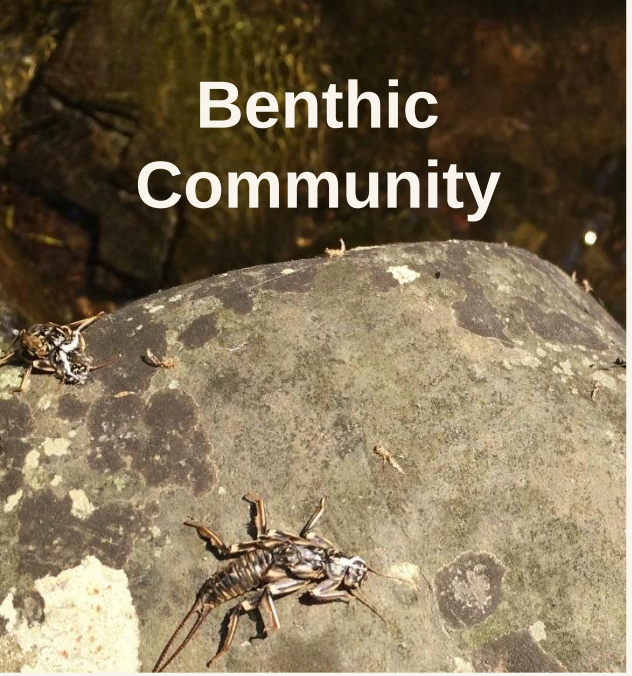
Geomorphology: Channels were incised prior to development banks continue to erode, source of sand and fines





USGS
science for a changing world



Green stormwater infrastructure can minimize impacts BUT,

- Degradation can occur during construction
- The amount of impervious cover may be an important factor for predicting benthic rebound
- More practices and more distributed stormwater control isn't always better
- Need to consider multiple stressors

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