Patterns of Headwater Stream Burial Due to Urbanization in the Gunpowder-Patapsco watershed

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Remote sensing of land/resource management

Land/Resource use policy and economics

Ecosystem Impacts

The Urban Stream Syndrome

Photo credits: (A) Ken Belt, (B) Paul Mayer, and (C) Dan Dillon.

Reissuance of Nationwide Permits

- “The NWPs will protect the aquatic environment and the public interest while effectively authorizing activities that have minimal individual and cumulative adverse effects on the aquatic environment.”

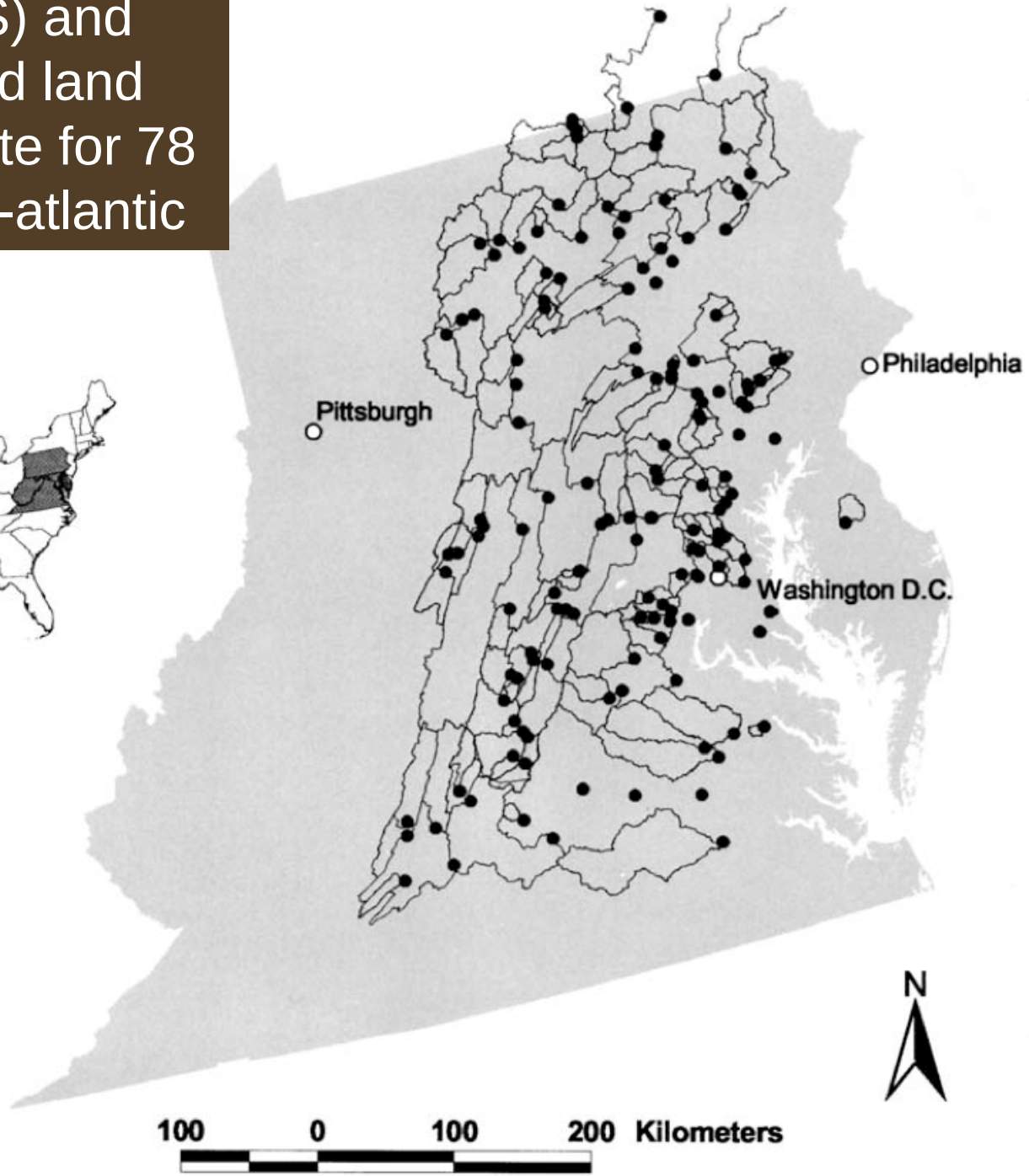
Problems . . .

- Headwater streams (flow < 5 ft^3/s) continue to be poorly protected
- Are intermittent streams protected at all?
- There appears to be no standardized way of measuring “cumulative adverse effects”

The impact of stream burial

- Increases roadway contaminant transport from impervious surfaces
- Decreases interactions between streams and “hot spots” of nutrient retention in nearby riparian soils
- Influence thermal regimes due to flow over pavement instead of stream channels
- Alters ecosystem metabolism and food web structure due to changes in primary production versus respiration in dark conditions

Bruce Jones (USGS) and colleagues compared land cover and stream nitrate for 78 watersheds in the mid-atlantic



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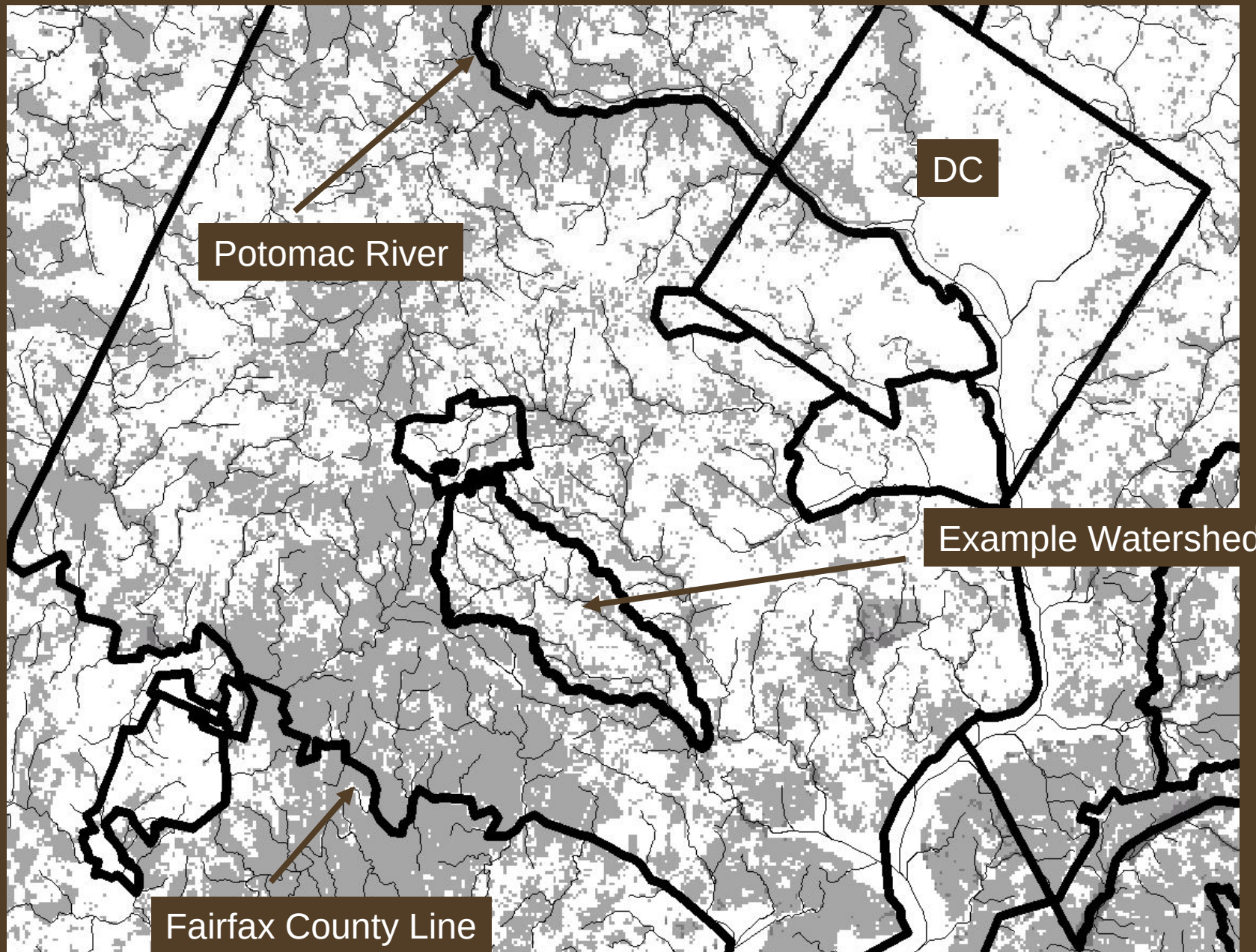
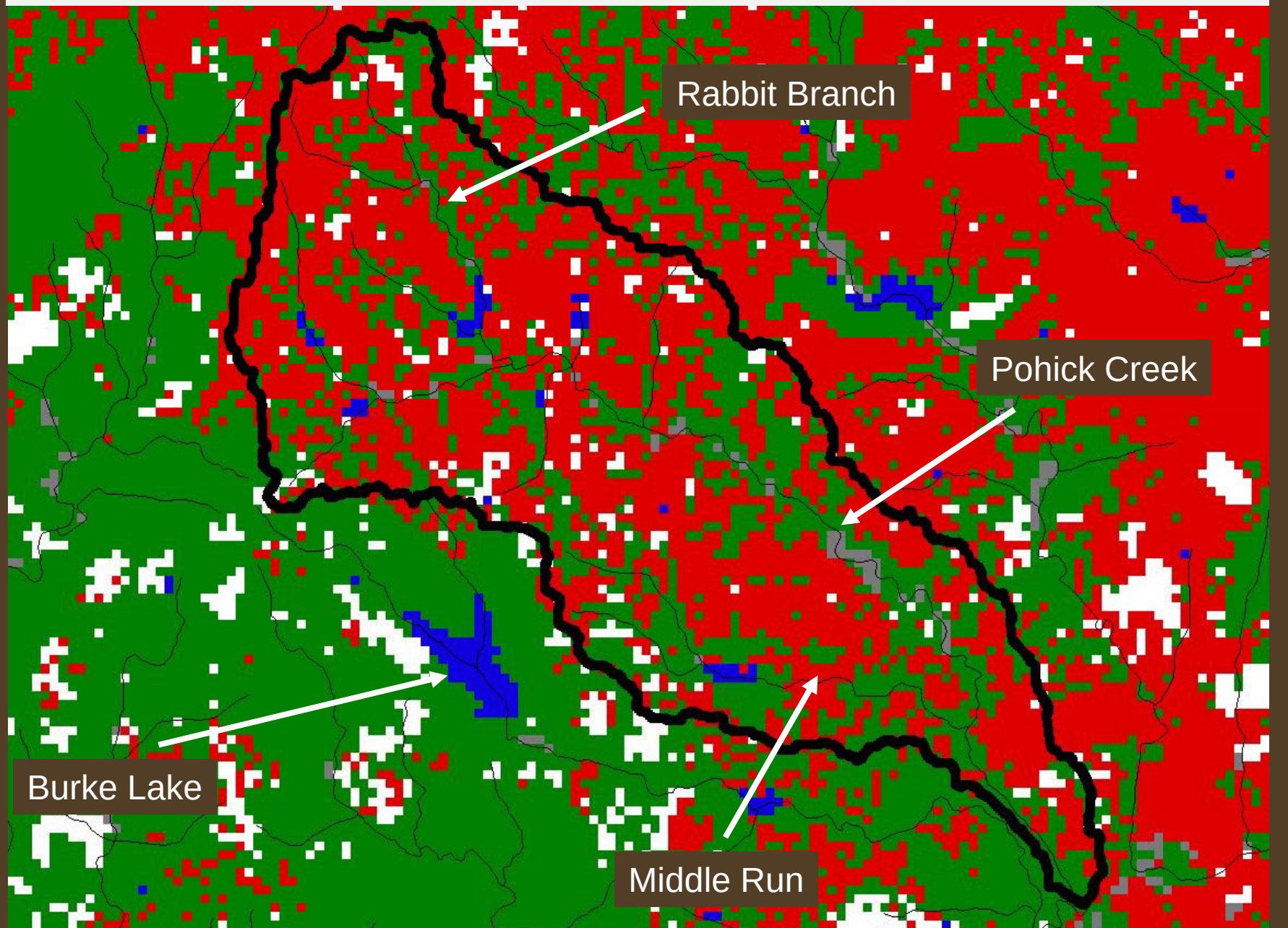
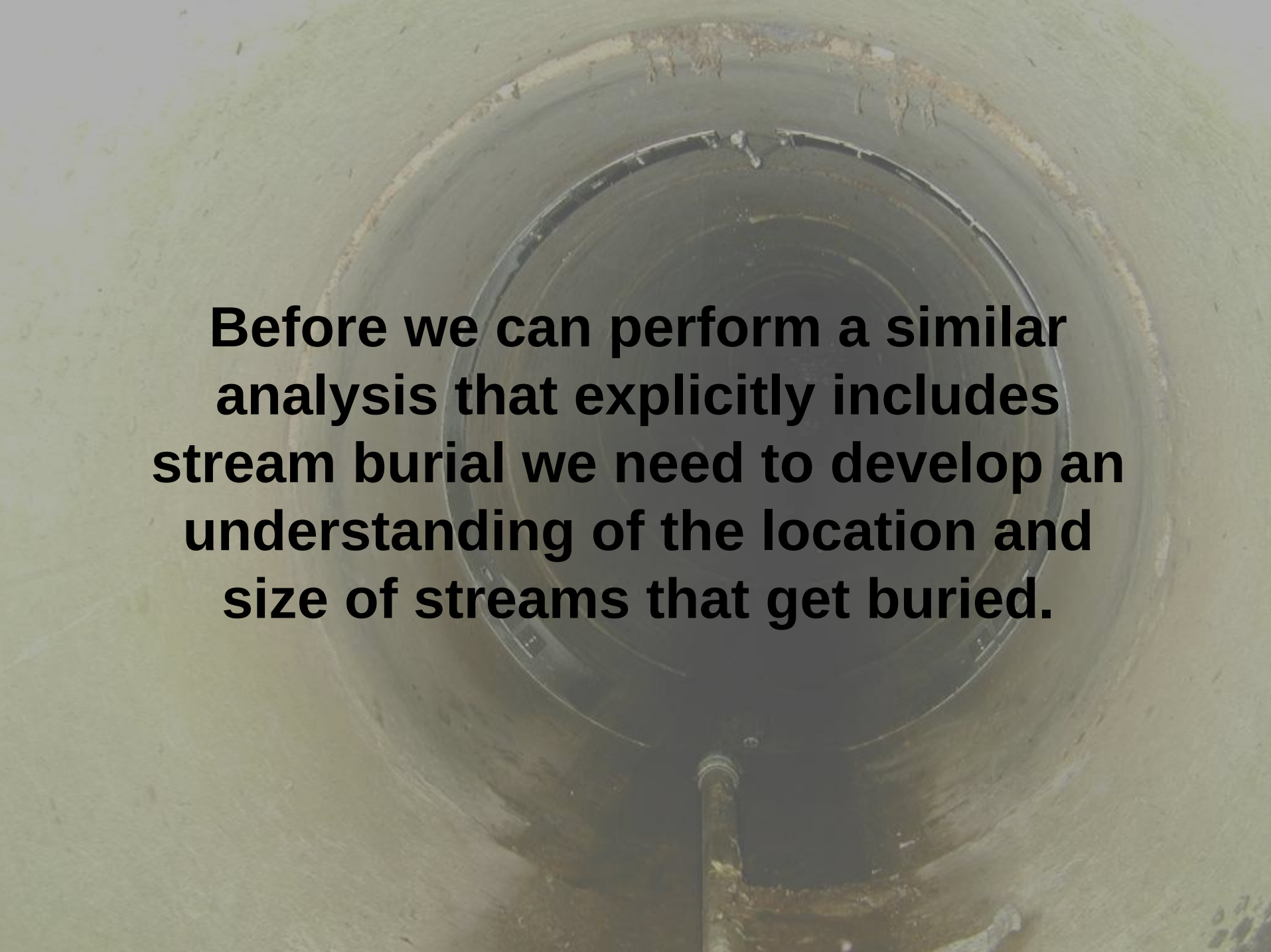


Red = Developed; Green = Forest/Woodland; Blue = Water;
Gray = Forested Wetland; White = Herbaceous (parks/ag)





Before we can perform a similar analysis that explicitly includes stream burial we need to develop an understanding of the location and size of streams that get buried.

Can remote sensing be used to detect buried streams?

(Figure out where a stream *should* be and then see if it is still there.)

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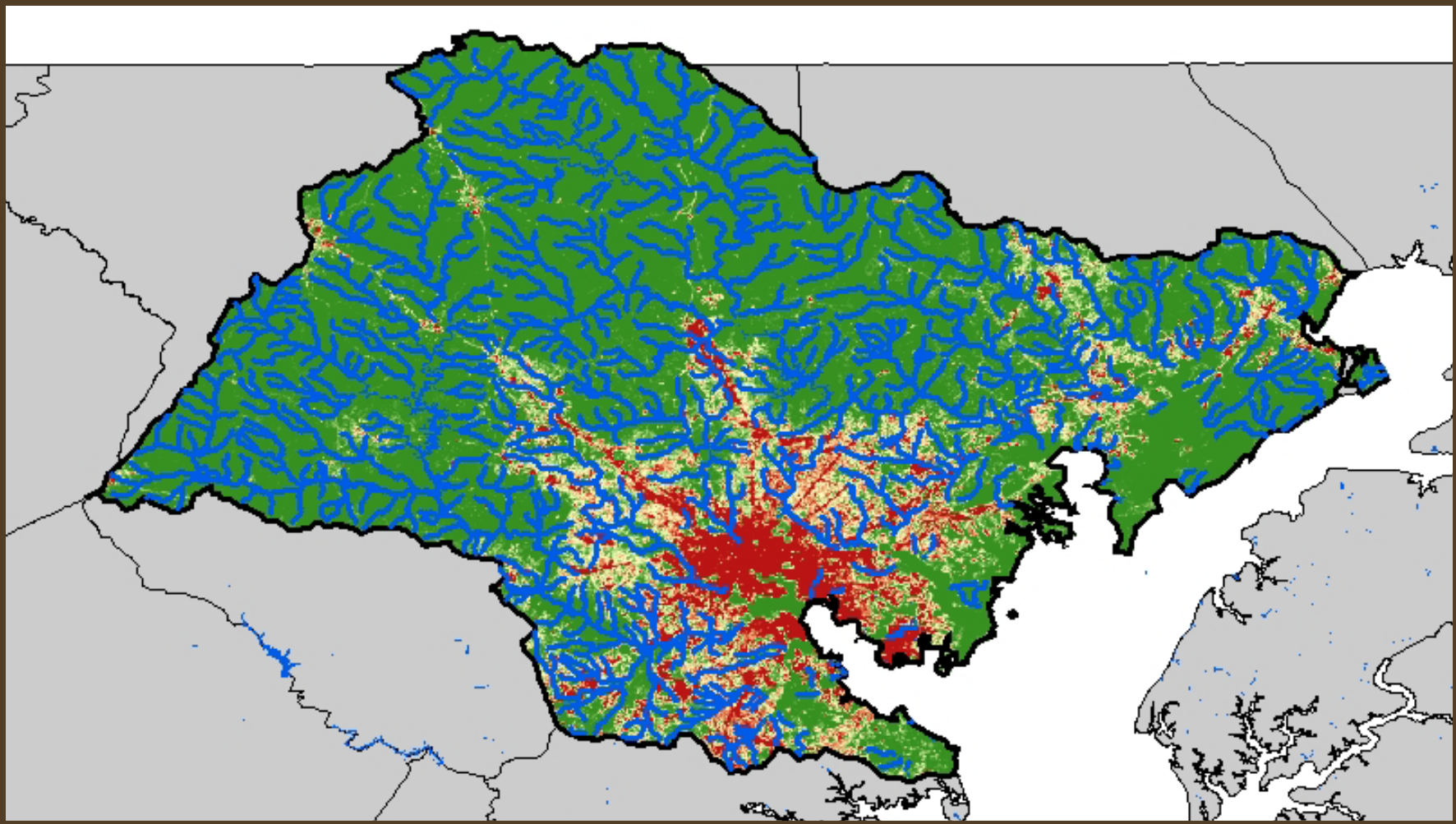
The National Hydrography Dataset (NHD) has problems for predicting the location of headwater streams



The National Hydrography Dataset (NHD) has problems for predicting the location of headwater streams

- Urban streams are typically not represented
- The catchment area at stream origin varies, particularly for tributaries of main stems

Use ArcHydro to model streams and catchment area from a digital elevation model (DEM)

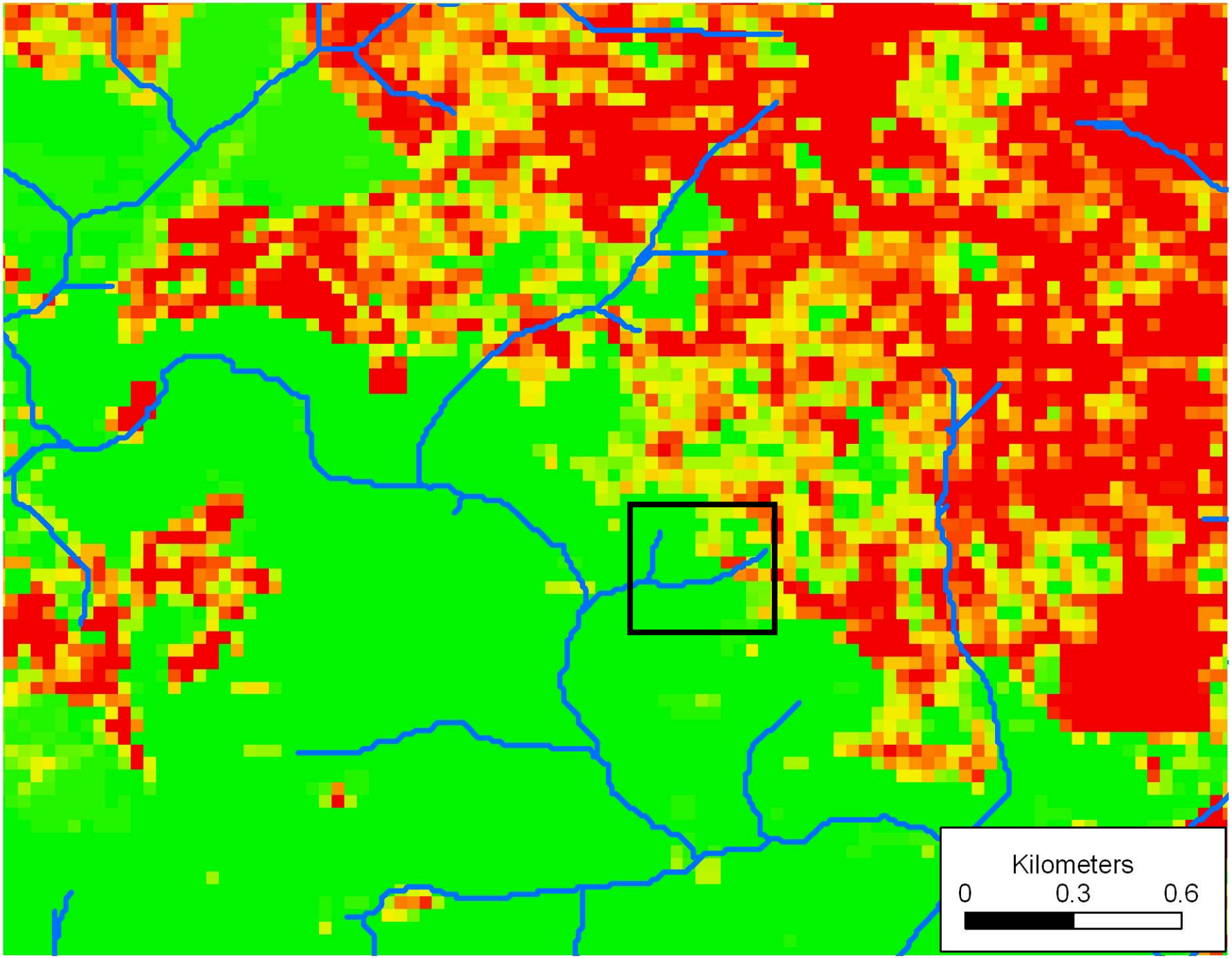
- Follows topography and is therefore better represents the path that water actually flows.
- Fills in gaps in urban areas where there hasn’t been a steam for >100yrs.

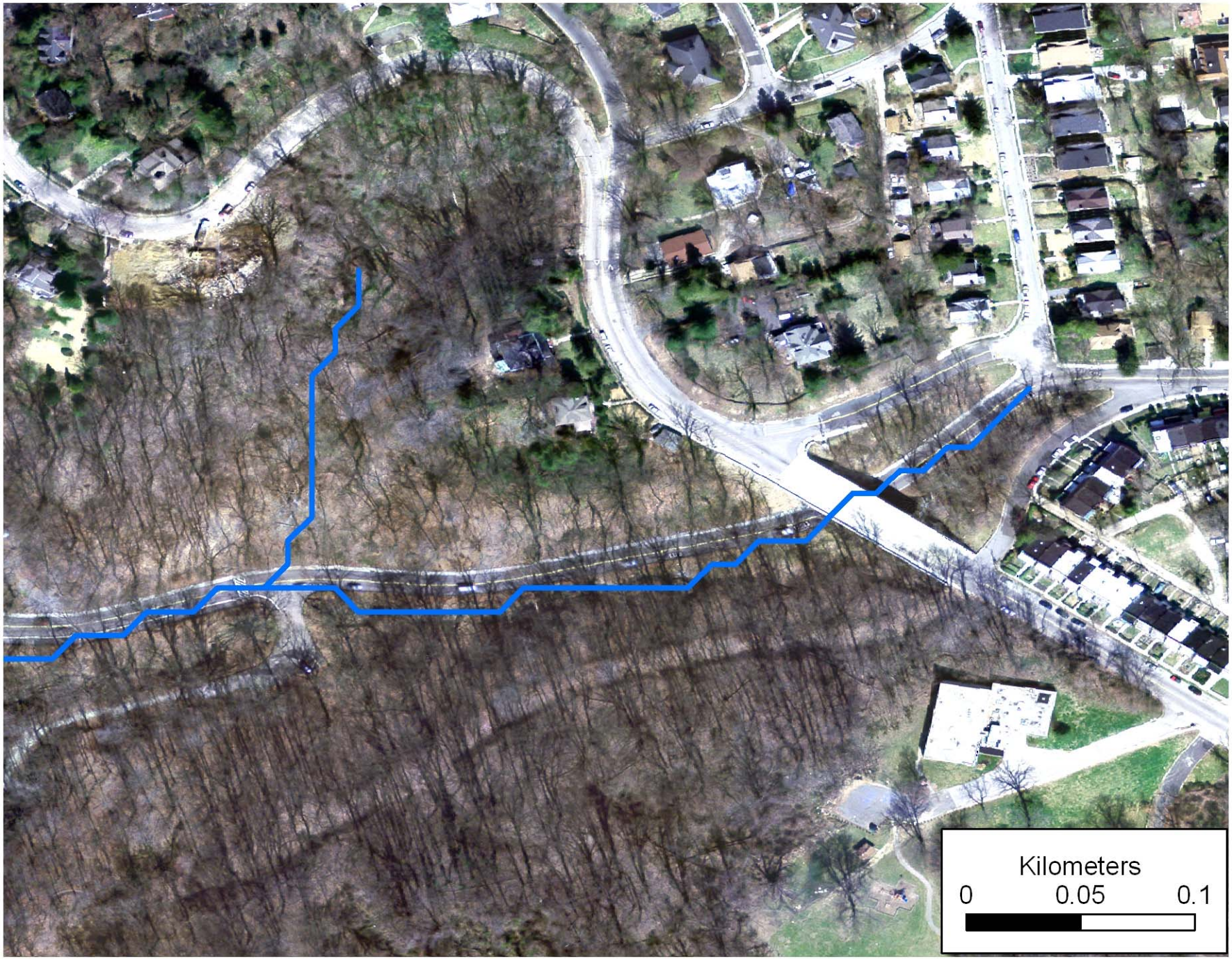
Impervious Surface Area (ISA)

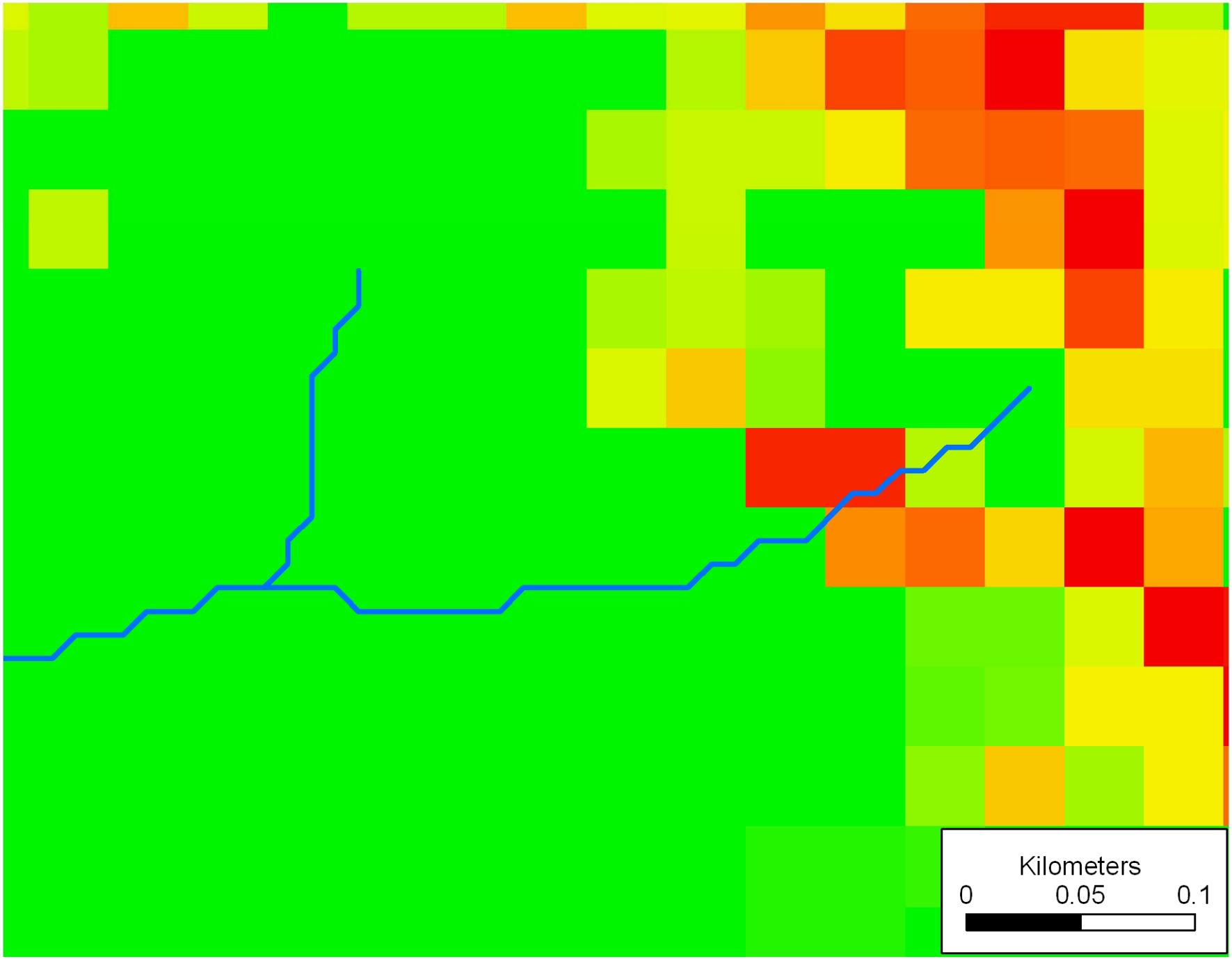
- All hard surfaces (e.g. roads, roofs)
- Acquired from the National Land Cover Dataset
- Long history of use in hydrology

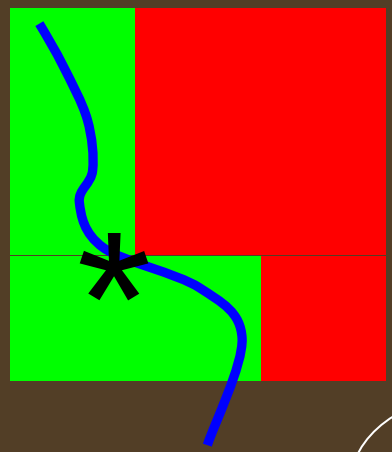
Can these two data sets (Streams from ArcHydro and ISA from the NLCD) be used to predict the extent of stream burial?

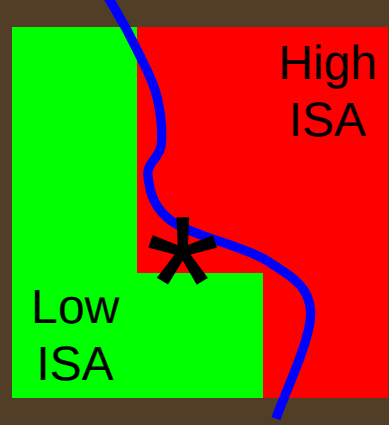

Kilometers
0
0.3
0.6


Kilometers
0
0.3
0.6


Kilometers
0
0.05
0.1


Kilometers
0
0.05
0.1





ISA Center
P < 0.001

≤16

>16

ISA Sum
P < 0.001

ISA Min
P = 0.023

≤37

>37

≤29

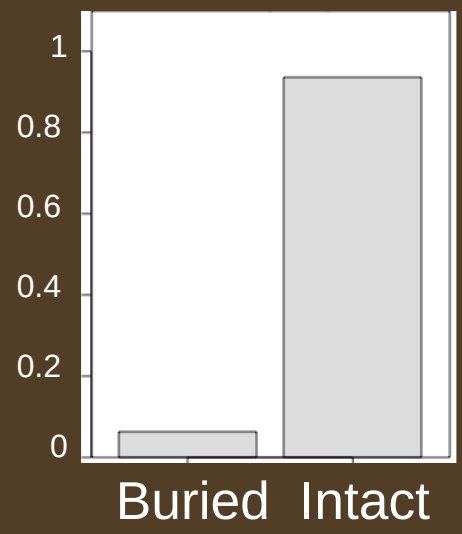
>29

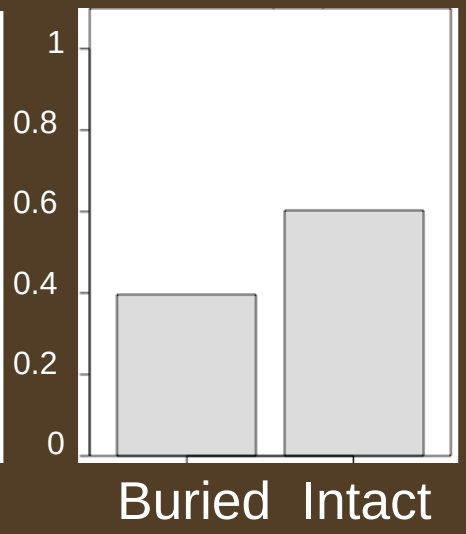
8% Burial Probability
(n = 120)

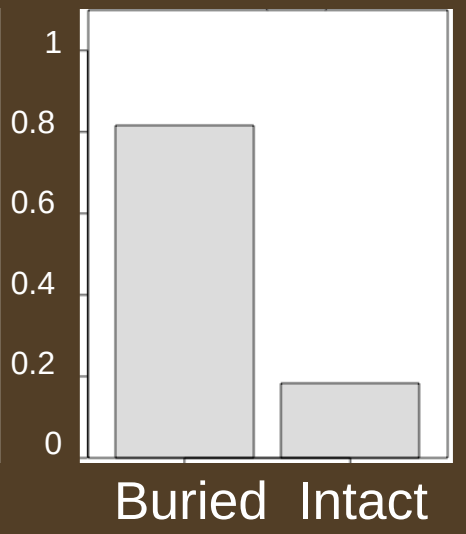
40% Burial Probability
(n = 93)

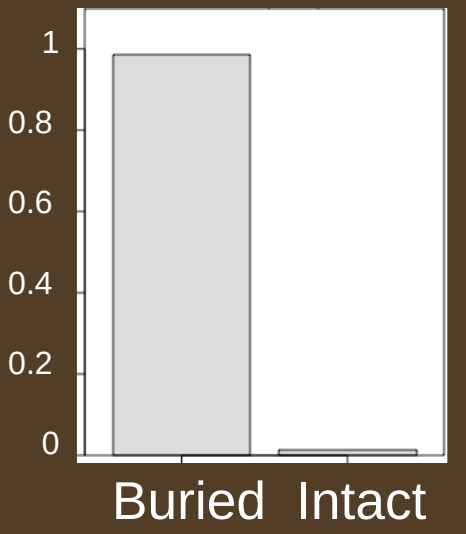
80% Burial Probability
(n = 148)

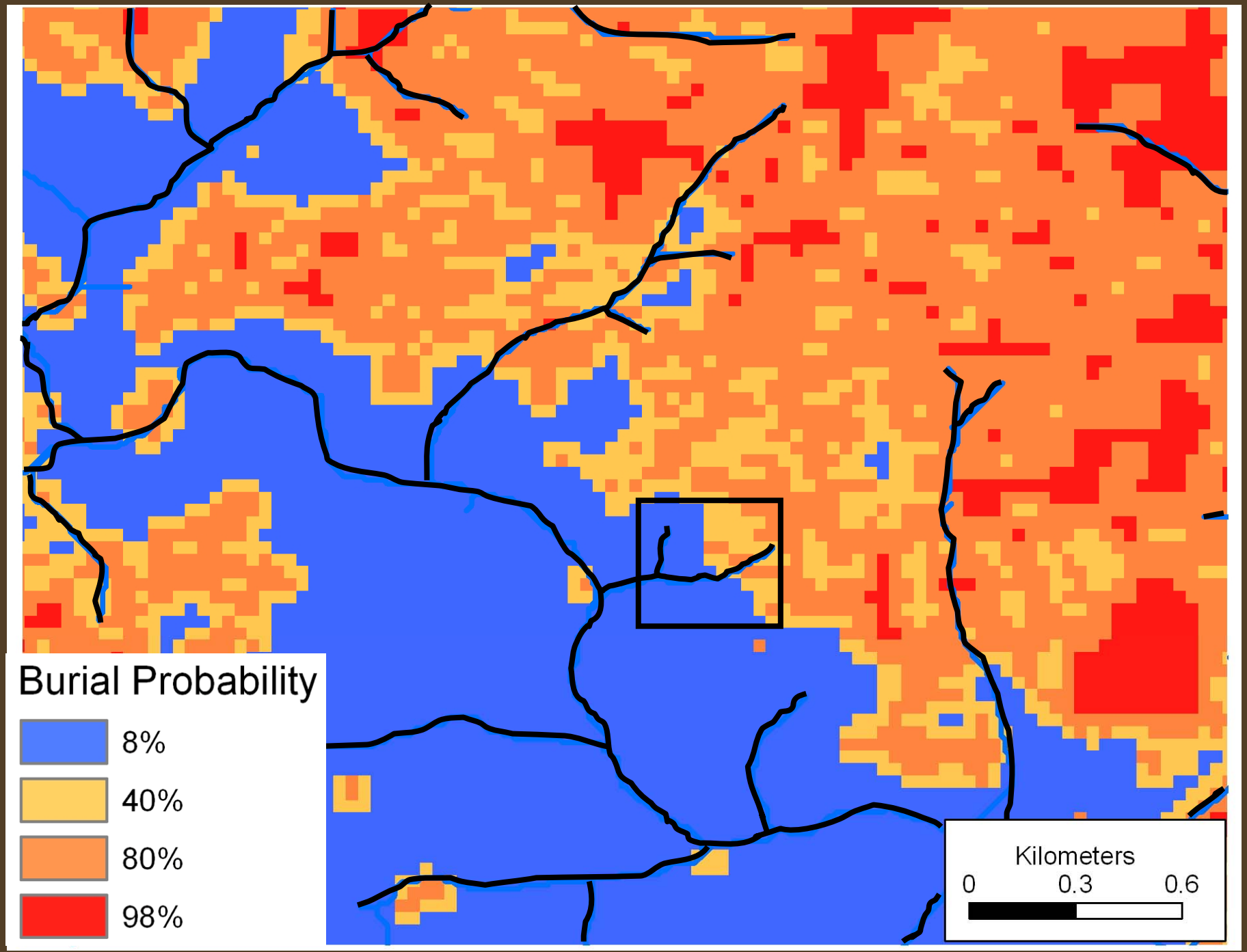
98% Burial Probability
(n = 68)

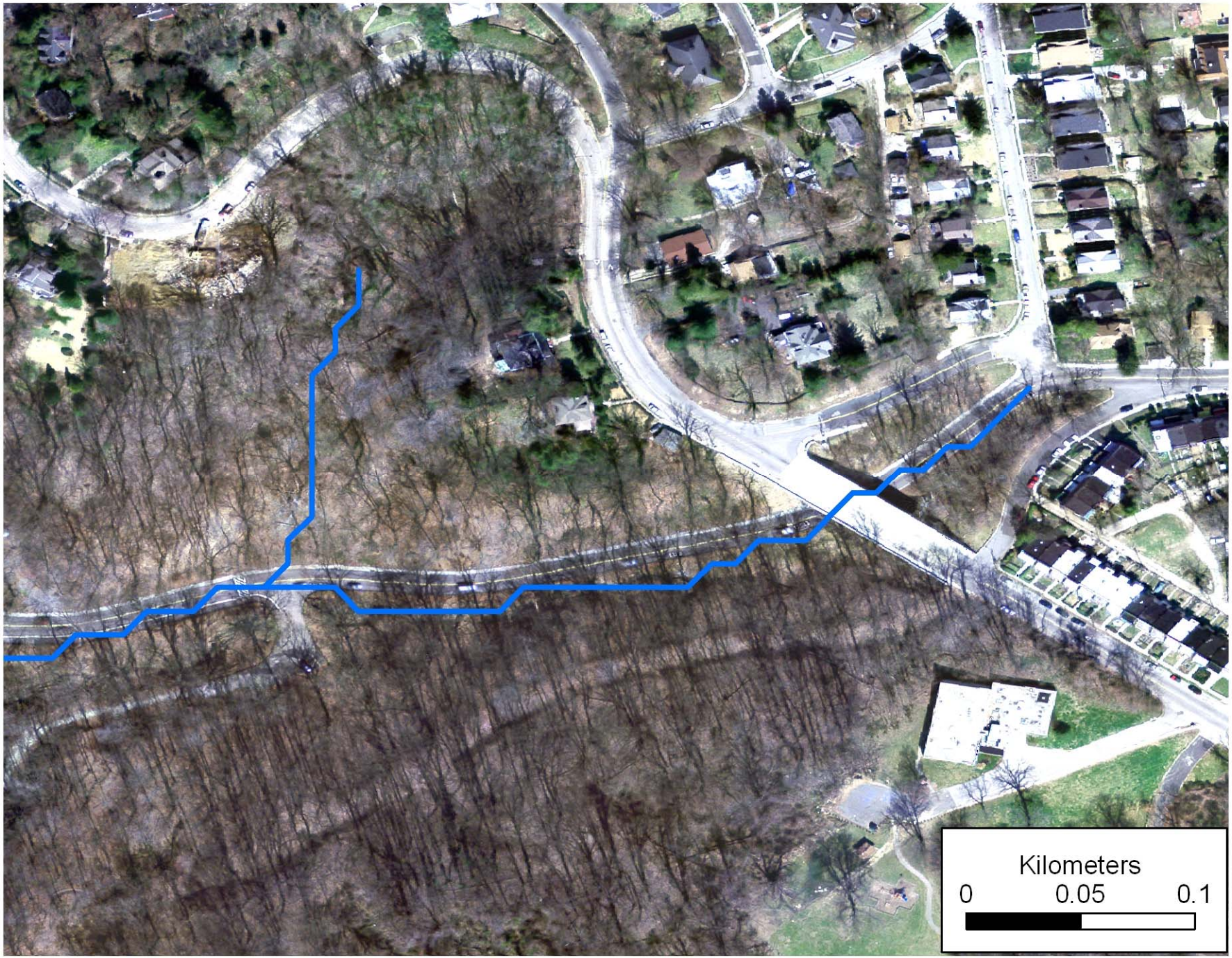


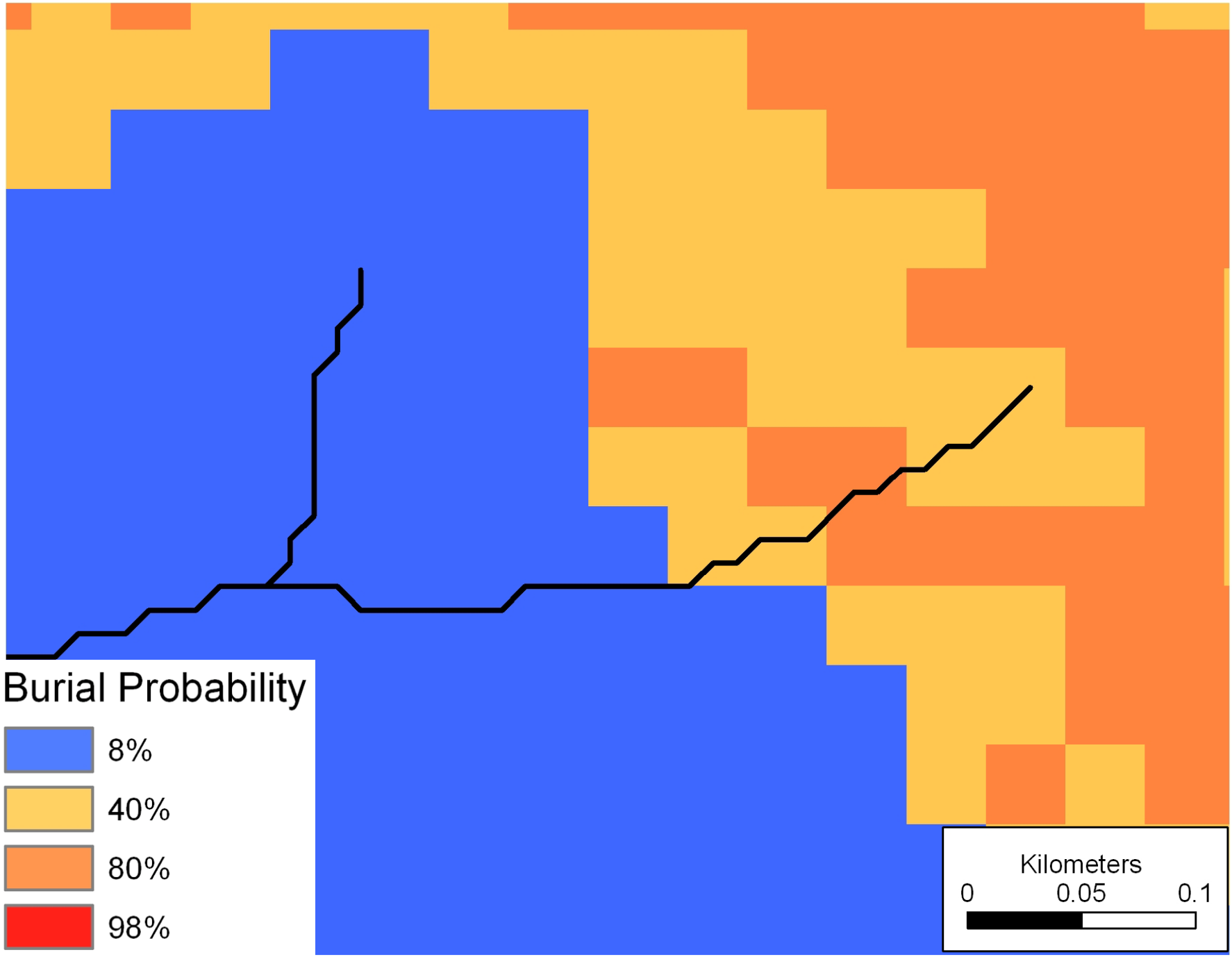







Burial Probability
8%
40%
80%
98%
Kilometers
0
0.3
0.6


Kilometers
0
0.05
0.1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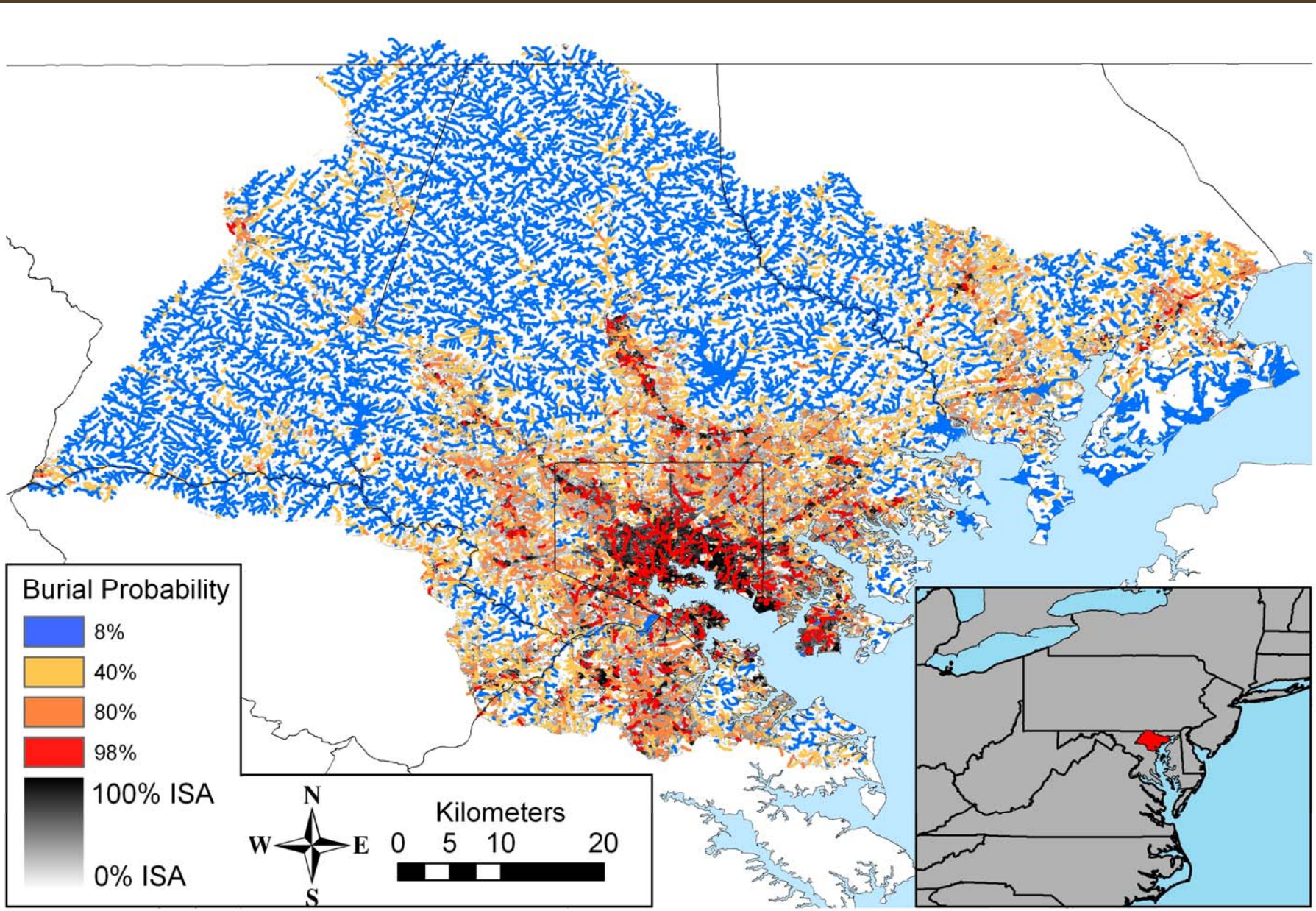
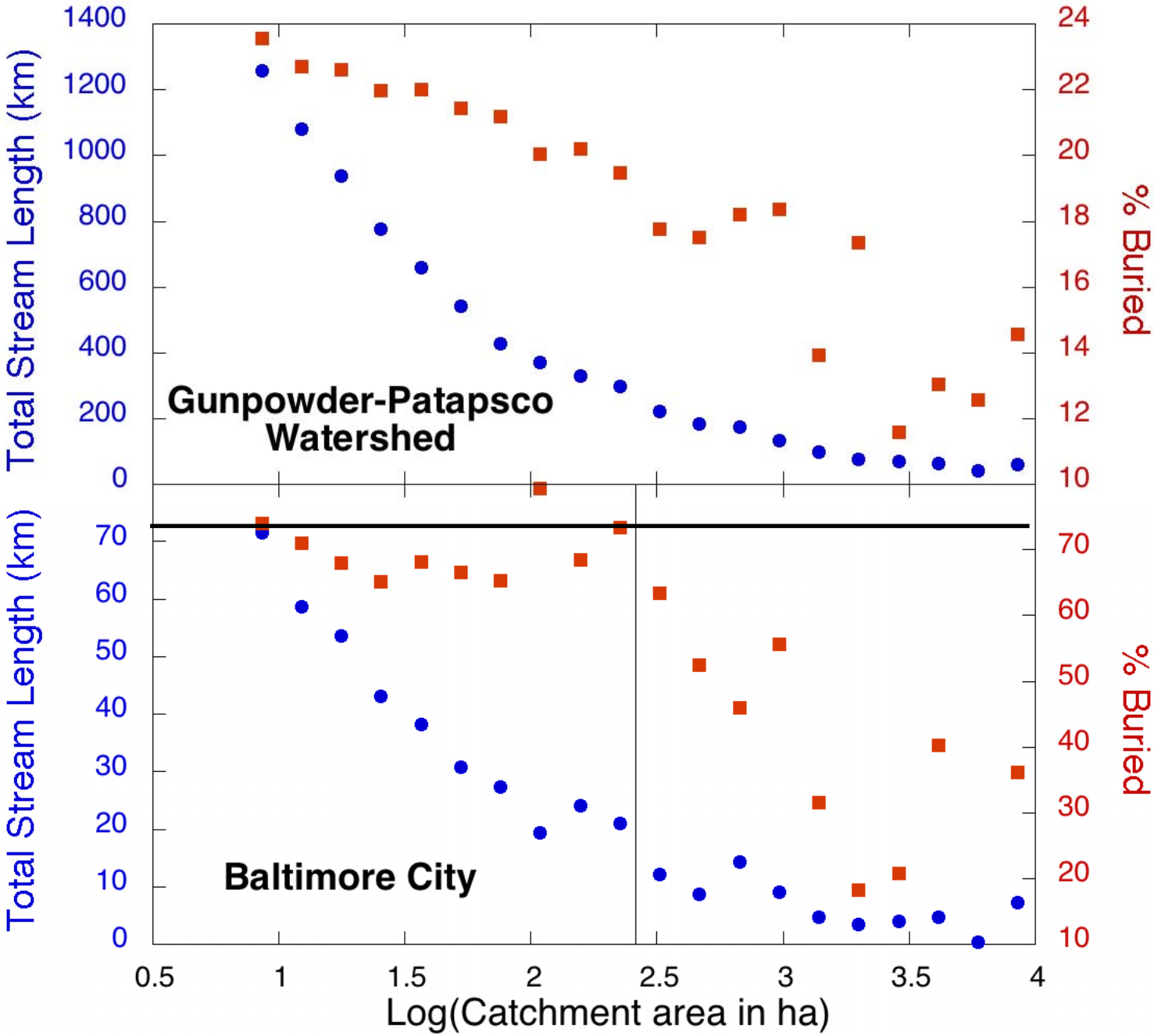
Kilometers
0
0.05
0.1


Burial Probability
8%
40%
80%
98%
100% ISA
0% ISA
N
W
E
S
Kilometers
0 5 10 20

Results

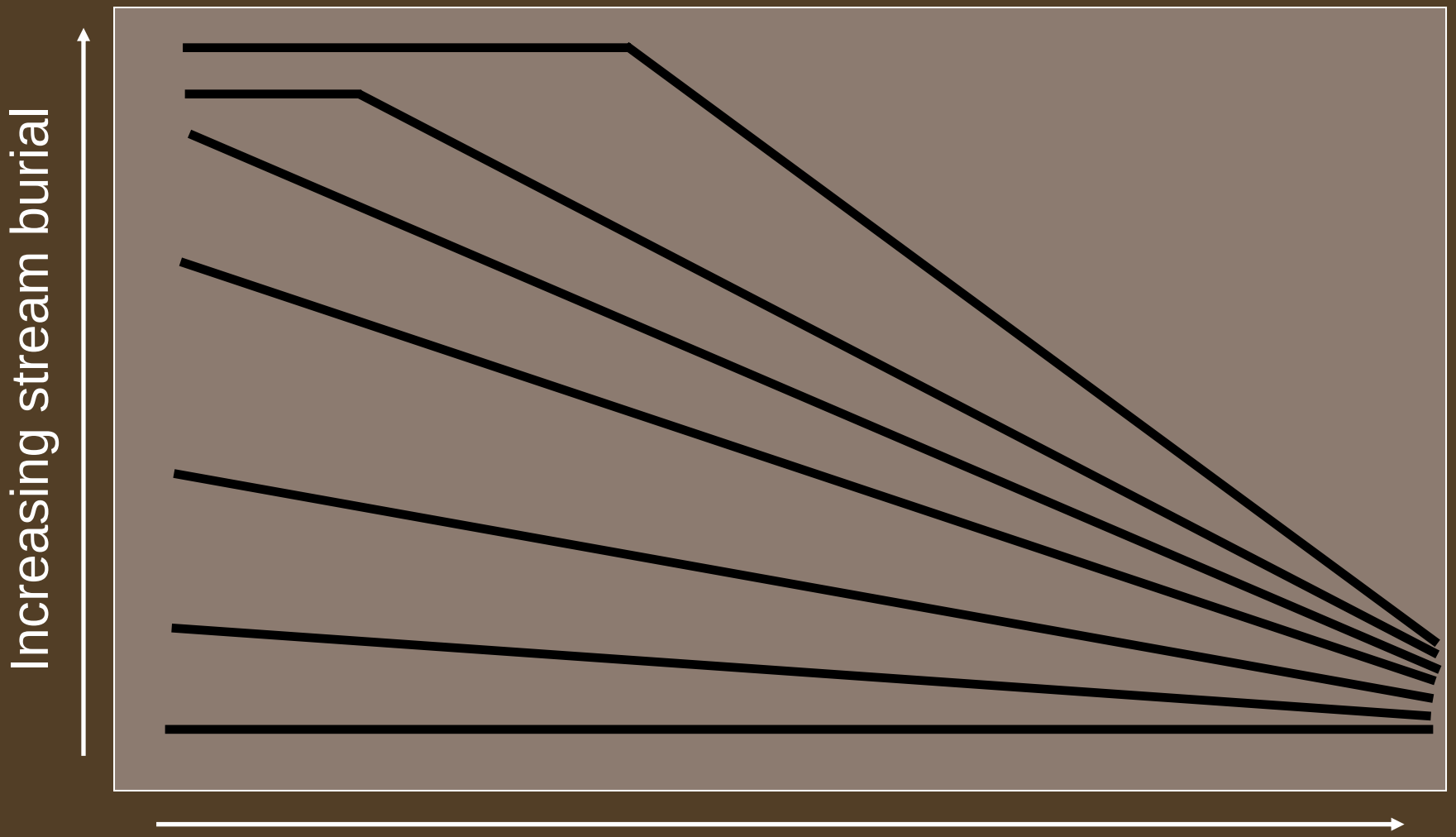
- 20% of all streams are buried
- 66% of Baltimore City streams are buried
- 18% of streams outside the city are buried


Total Stream Length (km)
1400
1200
1000
800
600
400
200
0
% Buried
24
22
20
18
16
14
12
10
Gunpowder-Patapsco
Watershed
Total Stream Length (km)
70
60
50
40
30
20
10
0
% Buried
70
60
50
40
30
20
10
Baltimore City
0.5
1
1.5
2
2.5
3
3.5
4
Log(Catchment area in ha)

Why is the threshold at 260 ha?

- Clean Water Act?
- FEMA regulations of the 100-yr floodplain?
- Or is it just where developers over the years have determined it best to start leaving the stream above ground?

Does the spatial extent of stream burial speak to the pattern of development through time?



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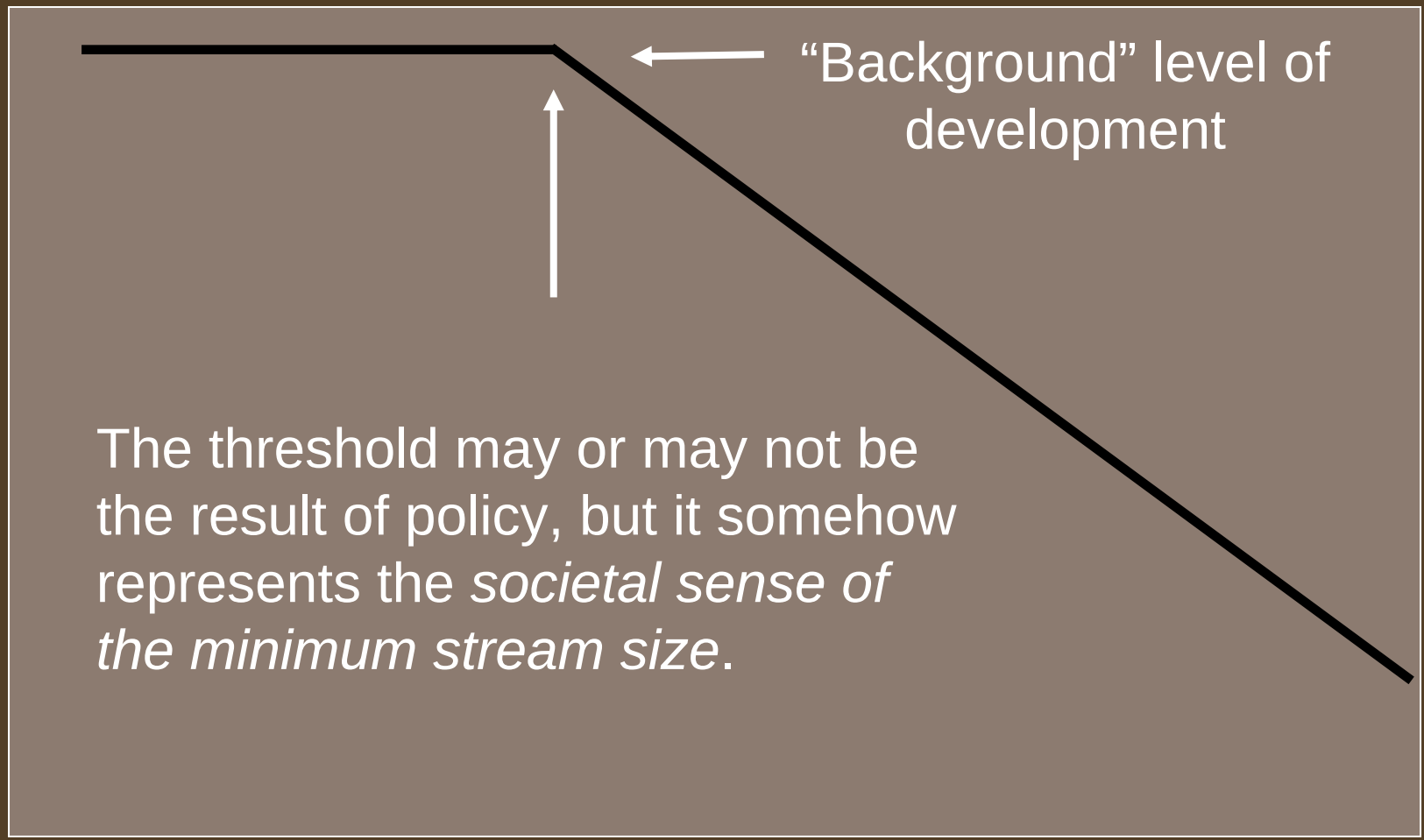

Future Work
(some ideas)

- Use the same techniques to map the extent of other forms of stream impairment.

- Use length-based estimates of in-stream processing to calculate the ecosystem impacts of stream burial.

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Thank You!

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