Emerging Methods for Mapping Wetlands in the Chesapeake Bay Watershed

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Mid-Atlantic Wetlands Workgroup 2023 Annual Meeting
November 16, 2023

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Restoration and Conservation

Wetlands are critical to the Vital Habitats and Land Conservation goals and outcomes listed under the Chesapeake Bay Watershed Agreement (2014)

- Vital Habitats:
    - Increase capacity of wetlands
    - Create or reestablish 85,000 acres (2025)
    - Enhance additional 150,000 acres (2025)
- Land Conservation: Conserve high priority wetlands ~250,000 acres & resources for stakeholders to mitigate wetland loss

Support

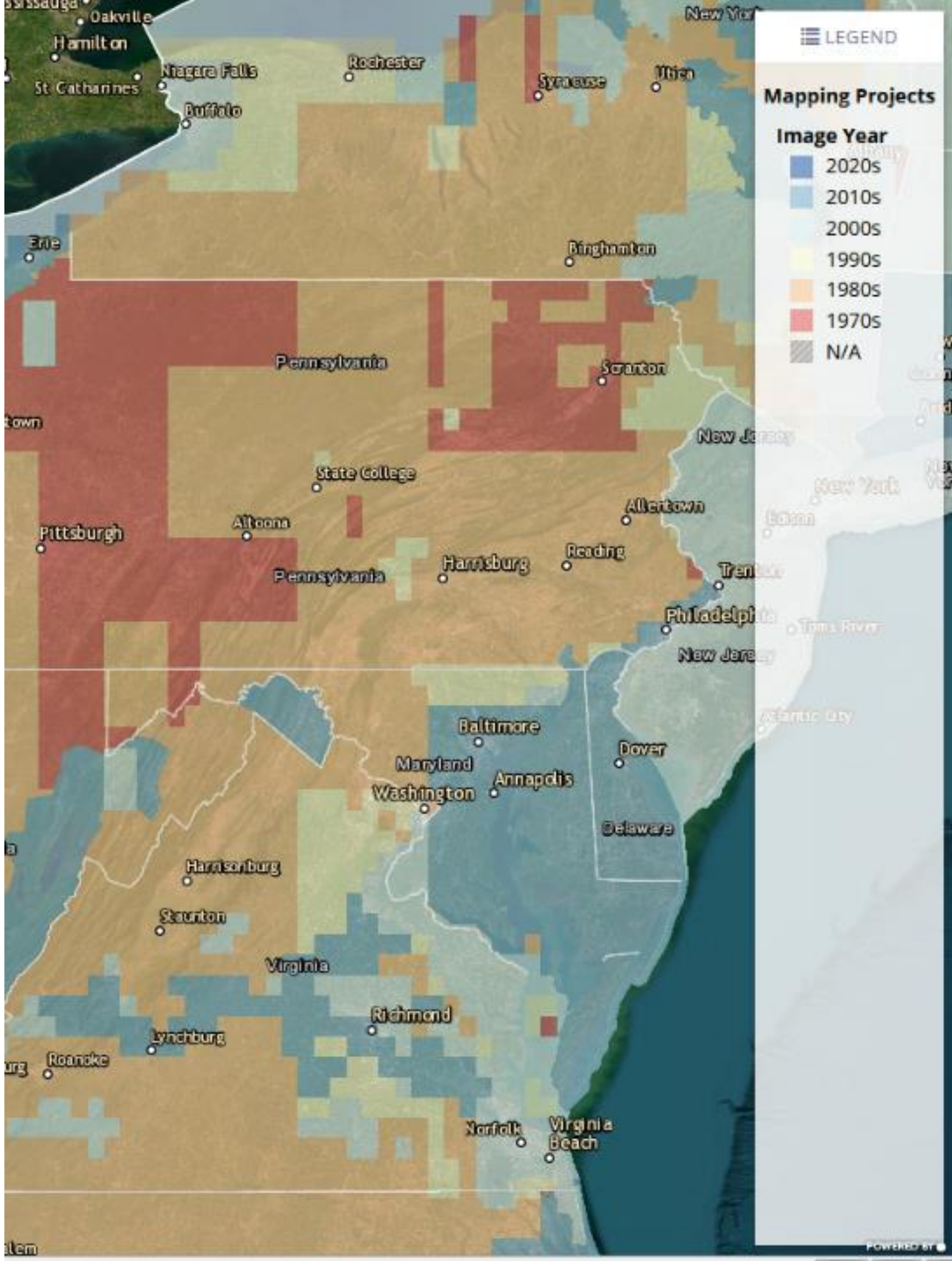
- Mapping of non-tidal and tidal wetlands across Chesapeake Bay at one-meter for multiple years
- Characterizing land use types in wetlands
- Monitor wetland change or loss (change over time)
- Characterizing hydromorphology of channels, floodplains, riparian areas associated with wetland complexes

Challenges using NWI

- NWI Project Mapper as of Nov. 2024
- Majority of image years ~70-90s
- Outdated but authoritative

Solution:

Develop wetland mapping methods that are complementary to NWI, and can potentially enhance NWI wetland mapping efforts



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Chesapeake Bay High Resolution Land Use/Land Cover (LULC)

Peter Claggett[1], Labeeb Ahmed[1], Ernie Buford[2], Jacob Czawlytko[3], Emily Mills[3], Patrick McCabe[3], Sarah McDonald[1], Sean MacFaden[2], Jarlath O'Neill-Dunne[2], Anna Royar[2], Kelly Schulze[2], Rachel Soobitsky[3], and Katie Walker[3]

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University of Vermont Spatial Analysis Lab

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[1]U.S. Geological Survey, [2]University of Vermont Spatial Analysis Lab, [3]Chesapeake Conservancy Center

Land Cover / Land Use

- 1-meter land cover (LC) and land use/land cover (LULC) along with LC and LULC change for Chesapeake Bay watershed and adjacent counties (~100,000 sq. miles)
- LC (13-classes) & LULC (54-classes)
- In 2024, releasing LC, LU, and change products for 2021/22

Data Type	Period 1 (2022)	Period 2 (2022)	Period 3 (2023)
Land Cover (LC)	2013/14	2017/18	2021/22
Land Use (LU)	2013/14	2017/18	2021/22
LC Change	2013/14 – 2017/18		2013/14 – 2021/22
LU Change	2013/14 – 2017/18		2013/14 – 2021/22

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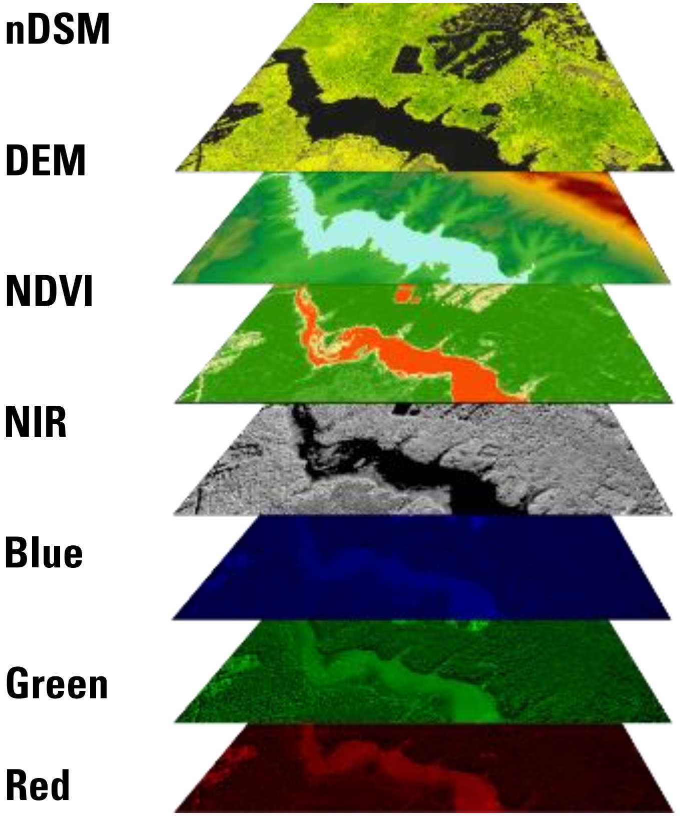
Development of 1m-Resolution Land Cover & Land Use Data

NAIP Ortho-imagery
+
LiDAR



High-resolution land cover data

- Impervious surfaces
- Tree canopy
- Low vegetation
- Water

Land Uses

- Impervious-Roads
- Forests
- Turf Grass
- Natural Succession

Local land use and parcel data

- Low-density residential
- Recreation
- Agriculture
- Roads

Table 3 - 54 LULC Classes Grouped by 18 LULC Generalized Classes

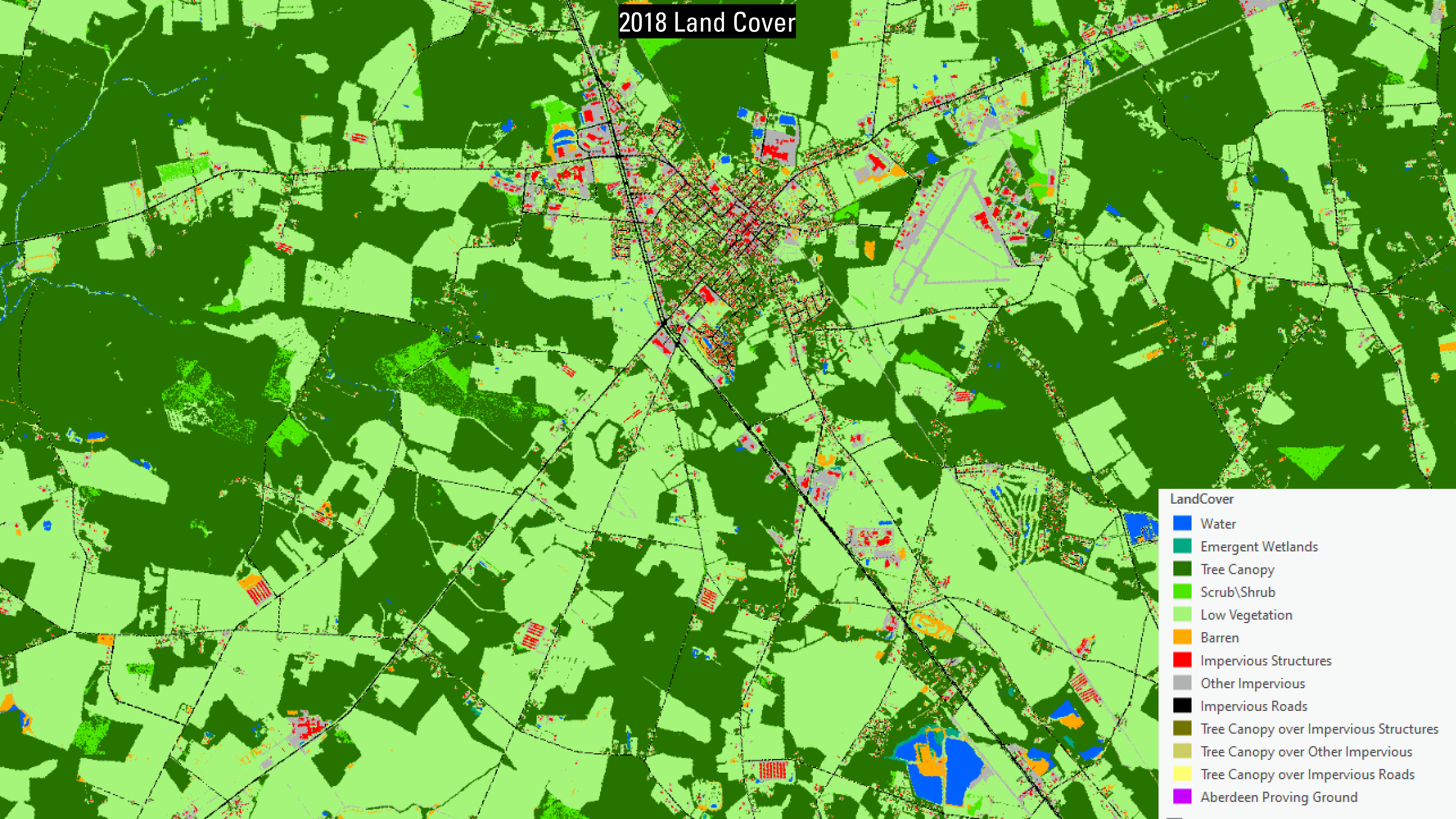
Cropland	Extractive	Forest	Harvested Forest
Cropland Barren Cropland Herbaceous Orchard/Vineyard Barren Orchard/Vineyard Herbaceous Orchard/Vineyard Scrub/Shrub	Extractive Barren Extractive Impervious	Forest Riverine Wetlands Forest Terrene Wetlands Forest Tidal Wetlands Forest	Harvested Forest Barren Harvested Forest Herbaceous
Impervious Roads	**Impervious Structures**	**Impervious, Other**	**Natural Succession**
Roads	Structures	Other Impervious Solar Field Impervious	Bare Shore Natural Succession Barren Natural Succession Herbaceous Natural Succession Scrub/Shrub
Pasture/Hay	**Pervious Developed, Other**	**Tree Canopy over Impervious**	**Tree Canopy over Turf Grass**
Pasture/Hay Barren Pasture/Hay Herbaceous Pasture/Hay Scrub/Shrub	Solar Field Barren Solar Field Herbaceous Solar Field Scrub/Shrub Suspended Succession Barren Suspended Succession Herbaceous Suspended Succession Scrub/Shrub Transitional Barren	Tree Canopy Over Other Impervious Tree Canopy Over Roads Tree Canopy Over Structures	Tree Canopy Over Turf Grass
Tree Canopy, Other	**Turf Grass**	**Water**	**Wetlands, Riverine Non-forested**
Other Tree Canopy Riverine Wetlands Tree Canopy Terrene Wetlands Tree Canopy Tidal Wetlands Tree Canopy	Turf Grass	Estuarine/Marine Lakes and Reservoirs Lotic Water (fresh) Riverine Ponds Terrene Ponds	Riverine Wetlands Barren Riverine Wetlands Herbaceous Riverine Wetlands Scrub/Shrub
	Wetlands, Terrene Non-forested	**Wetlands, Tidal Non-forested**	
	Terrene Wetlands Barren Terrene Wetlands Herbaceous Terrene Wetlands Scrub/Shrub	Tidal Wetlands Barren Tidal Wetlands Herbaceous Tidal Wetlands Scrub/Shrub	

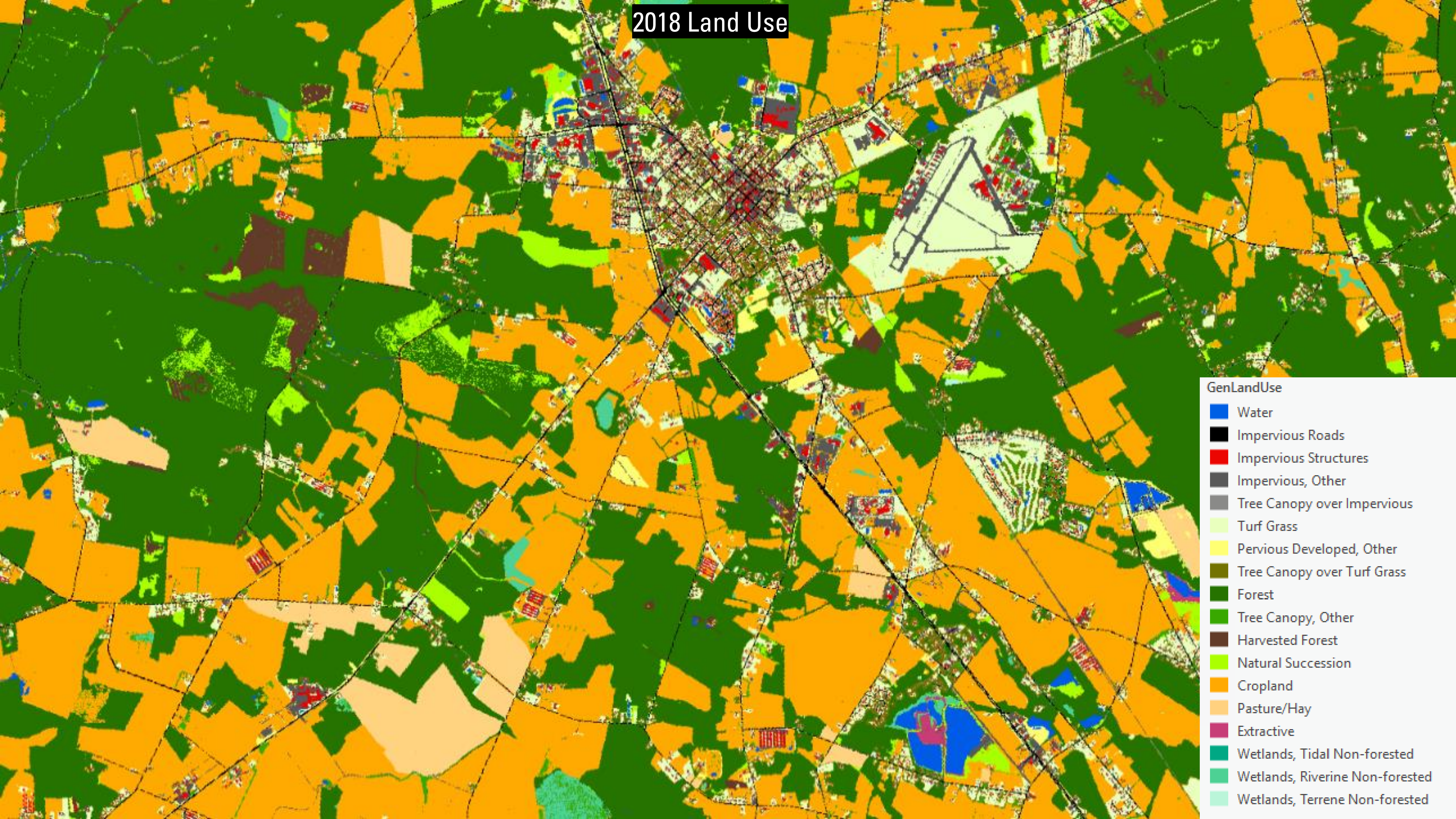
Table 3 - 54 LULC Classes Grouped by 18 Generalized Classes

Wetland Mapping Methodology

- Land Use Wetlands
  - National Wetland Inventory
  - Local wetlands (state/county) e.g. UVM Probablistic Wetlands in PA (Rainey et. al.,)
  - Only wetland footprints are used
- Delineation:
  - Riverine wetlands: ~1.5 year active flood extent, hydric and Frequently Flooded Soils
  - Tidal: NOAA’s 1-ft Sea Level Rise layer


2018 National Agriculture Imagery Program (NAIP)


2018 Land Cover
LandCover
Water
Emergent Wetlands
Tree Canopy
Scrub\Shrub
Low Vegetation
Barren
Impervious Structures
Other Impervious
Impervious Roads
Tree Canopy over Impervious Structures
Tree Canopy over Other Impervious
Tree Canopy over Impervious Roads
Aberdeen Proving Ground


2018 Land Use
GenLandUse
Water
Impervious Roads
Impervious Structures
Impervious, Other
Tree Canopy over Impervious
Turf Grass
Pervious Developed, Other
Tree Canopy over Turf Grass
Forest
Tree Canopy, Other
Harvested Forest
Natural Succession
Cropland
Pasture/Hay
Extractive
Wetlands, Tidal Non-forested
Wetlands, Riverine Non-forested
Wetlands, Terrene Non-forested


2012 Google Earth Imagery


2013 Land Use
Riparian Zone
FACET Streams (1:100k)
GenLandUse
Water
Impervious Roads
Impervious Structures
Impervious, Other
Tree Canopy over Impervious
Turf Grass
Pervious Developed, Other
Tree Canopy over Turf Grass
Forest
Tree Canopy, Other
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2018 National Agriculture Imagery Program (NAIP)


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Wetlands, Tidal Non-forested
Wetlands, Riverine Non-forested
Wetlands, Terrene Non-forested

Land Use for Wetland Monitoring

- Snapshot of land use over multiple time periods with each release all the dataset in series are updated
- Mapping wetland change is challenging
    - E.g., tidal stage, rainfall/drought and herbaceous adjacent to water (fuzziness)
    - Change from wetland to development (possible)
    - Change from wetland <-> water (possible)
- In 2024, mapping harvesting in wetlands (e.g., eastern shore, MD)
- Categorizing surface water ponds using land use context e.g., agriculture, stormwater etc.,

Mapping Non-Tidal Vegetated Wetlands in Areas with Outdated Wetland Maps

Team: Mike Evans[1], David Saavedra[1], Charlotte Weinstein[1] and Katie Walker[1]

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[1]Chesapeake Conservancy Center

Project Overview

- Develop AI methods to automate and map non-tidal wetlands at 1-meter resolution
- Use free and publicly available remote-sensing data such as NAIP, Sentinel-2, DEMs provided by USGS 3DEP/NOAA and SSURGO
- Building previously published methods by Mainali et. al.,
- Goal: *develop methods to generate data that's NWI-compliant and can potentially update NWI*
- Supervision provided by Megan Lang, US F&WS

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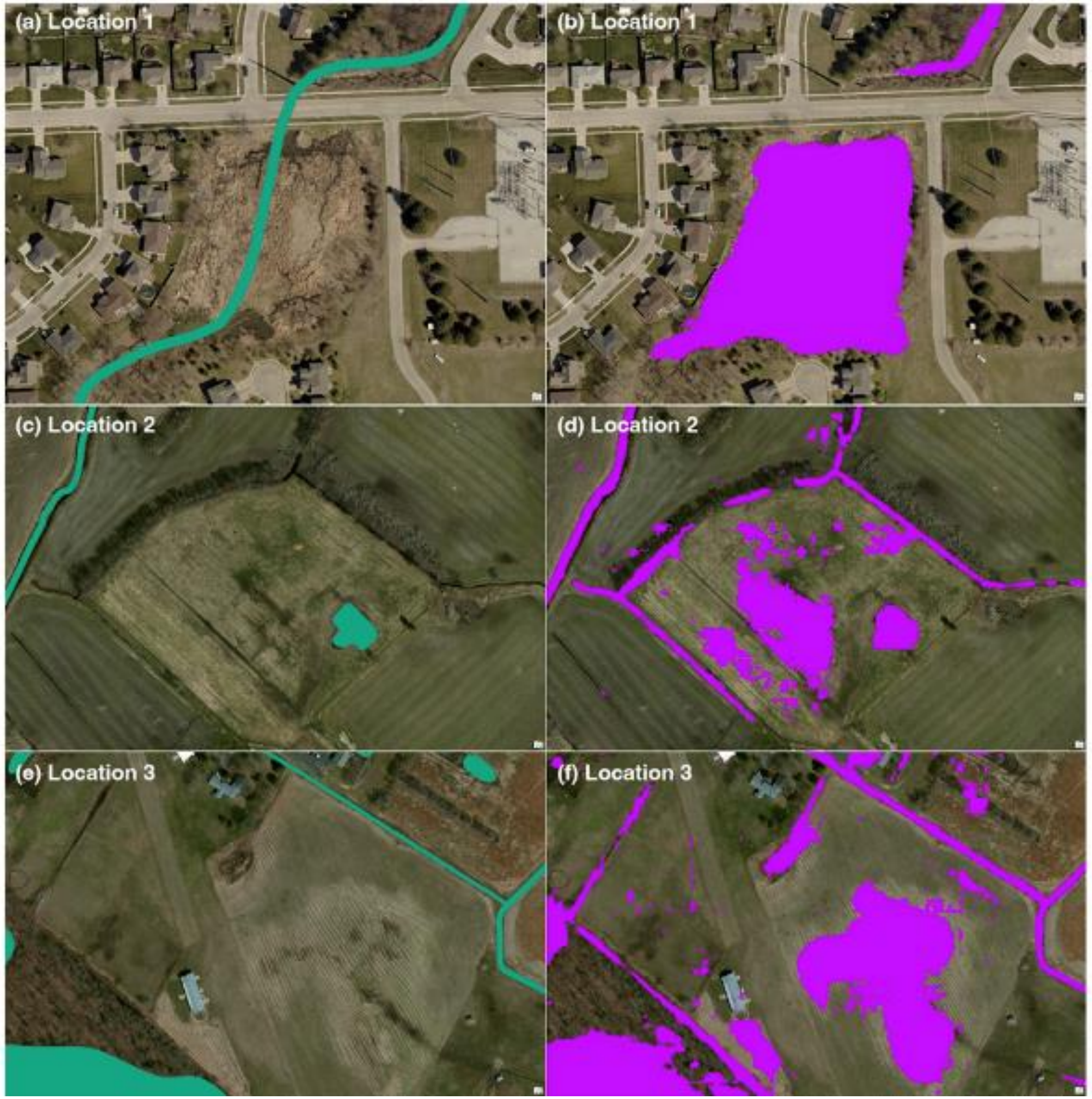
Science of The Total Environment

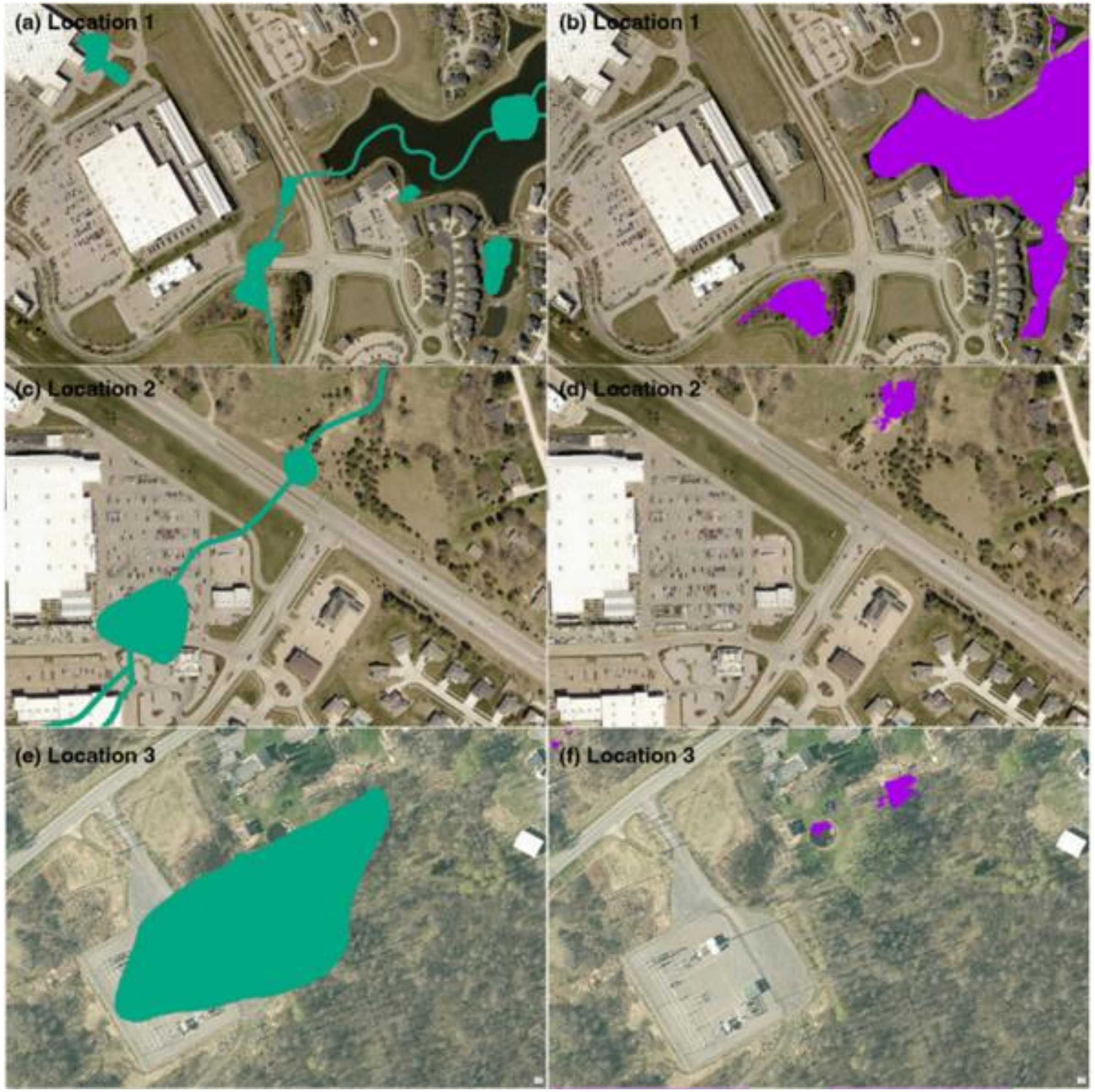
Volume 861, 25 February 2023, 160622

Convolutional neural network for high-resolution wetland mapping with open data: Variable selection and the challenges of a generalizable model

Kumar Mainali [a b 1], Michael Evans [a c 1], David Saavedra [a], Emily Mills [a d], Becca Madsen [a], Susan Minnemeyer [a]

Old NWI data   AI model output





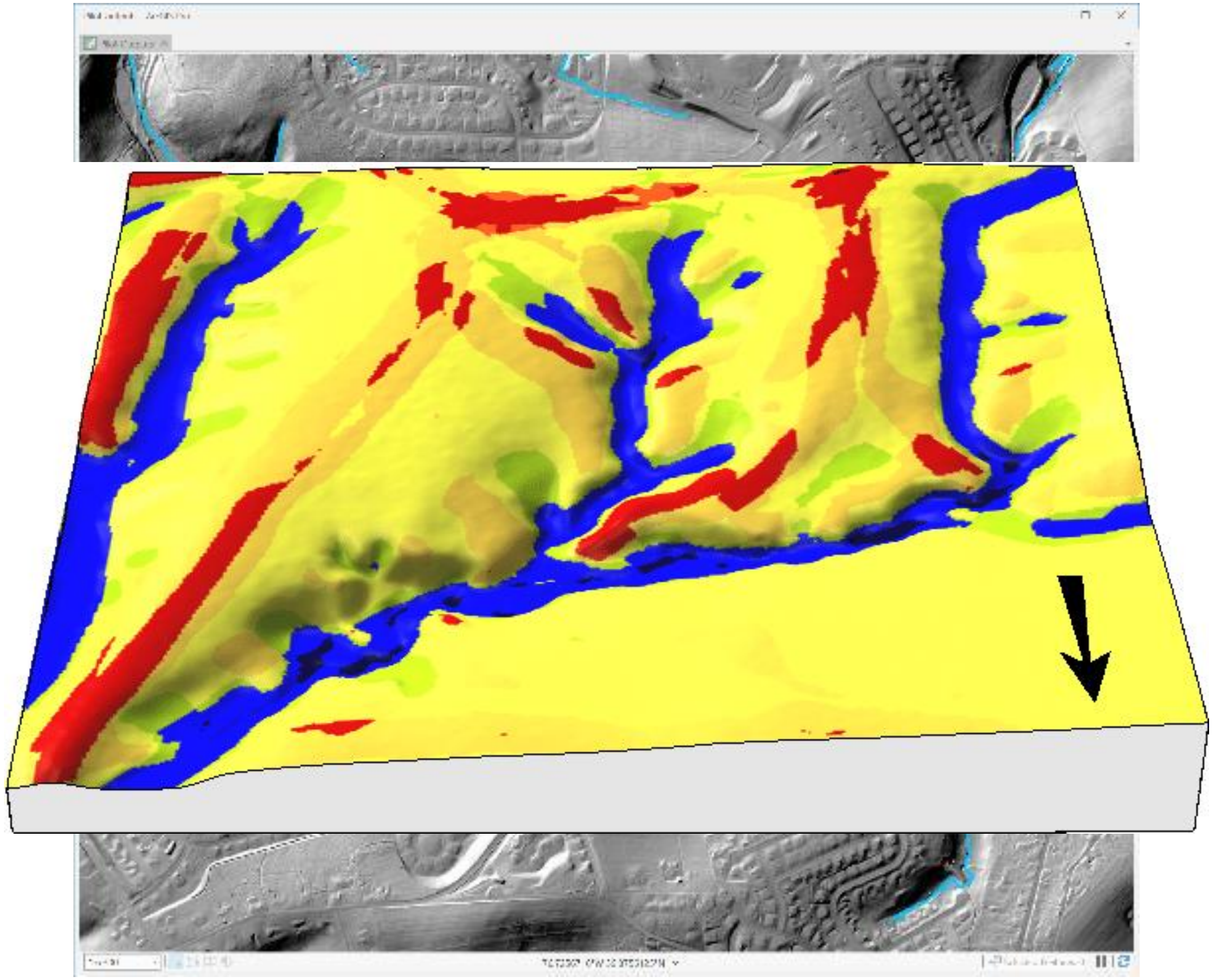
Hyper-Resolution Hydrography

Team: Matt Baker[1], Xuezhi Cang[1], and David Saavedra[2]

[1]University of Maryland Baltimore County (UMBC) and [2]Chesapeake Conservancy Center

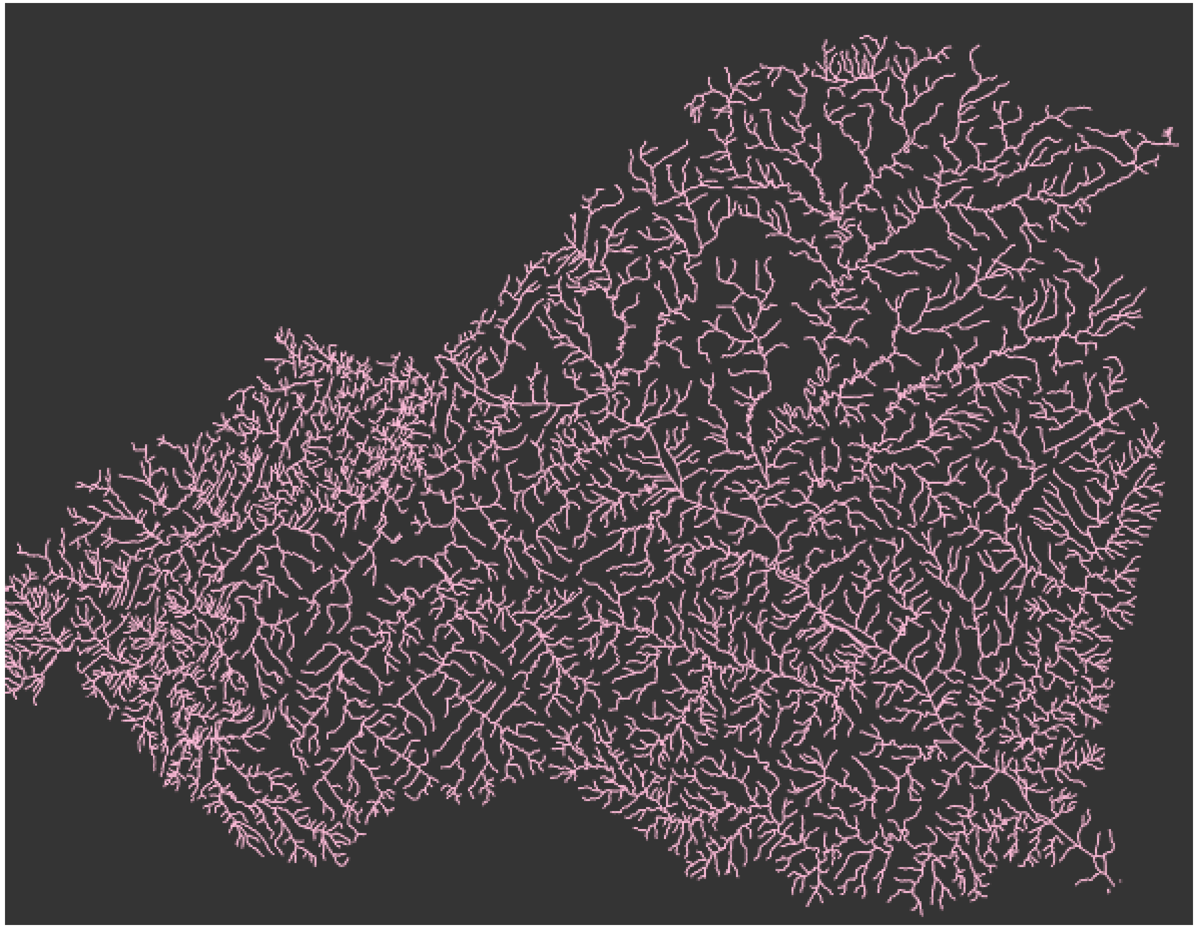
Project Overview

- Using high-resolution elevation imagery (1-meters) classifying the landscape into various landforms using Geomorphons algorithm
- Valley-scale geomorphons
- Channel-scale geomorphons
- Extract valley network
- Extract channels using valley network
- QAQC channel skeleton
- Connect stream network
- Attributed with bank-height ratio, channel width, floodplain width, entrenchment ratio
- Resolution: 1-meters / 1:2,000

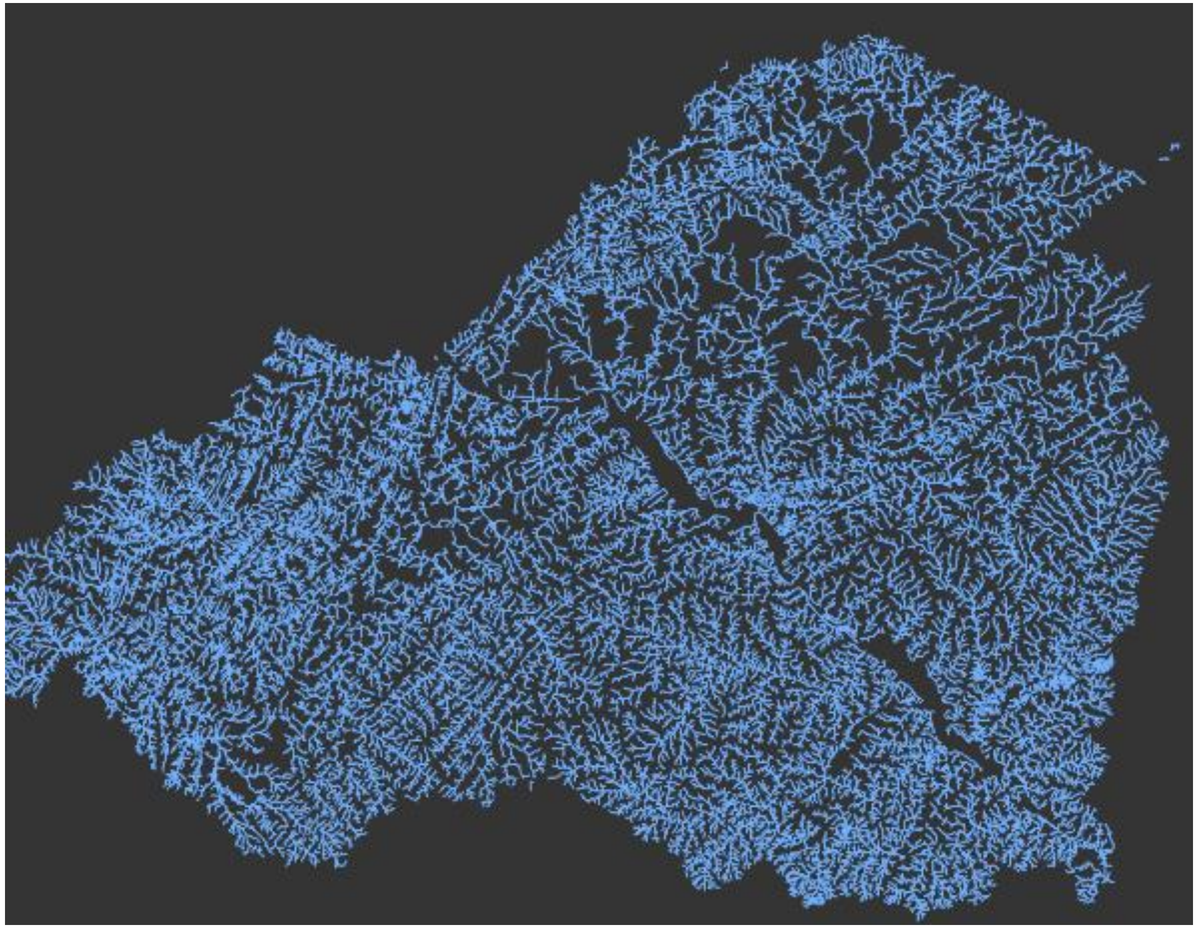


New Hyper-res Streams (1:2000 scale)

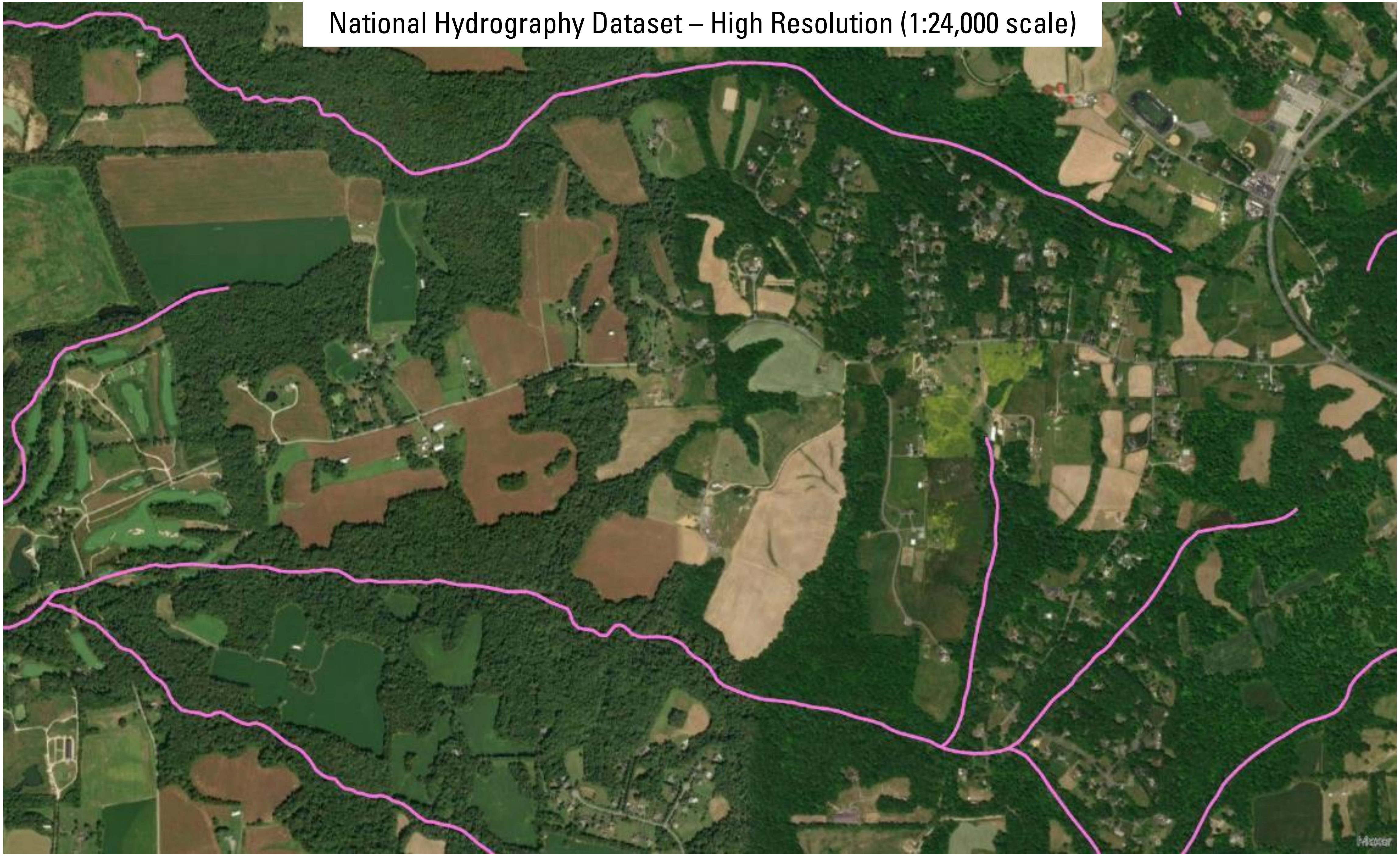
National Hydrography Dataset, 1:24,000
6,923.6 km



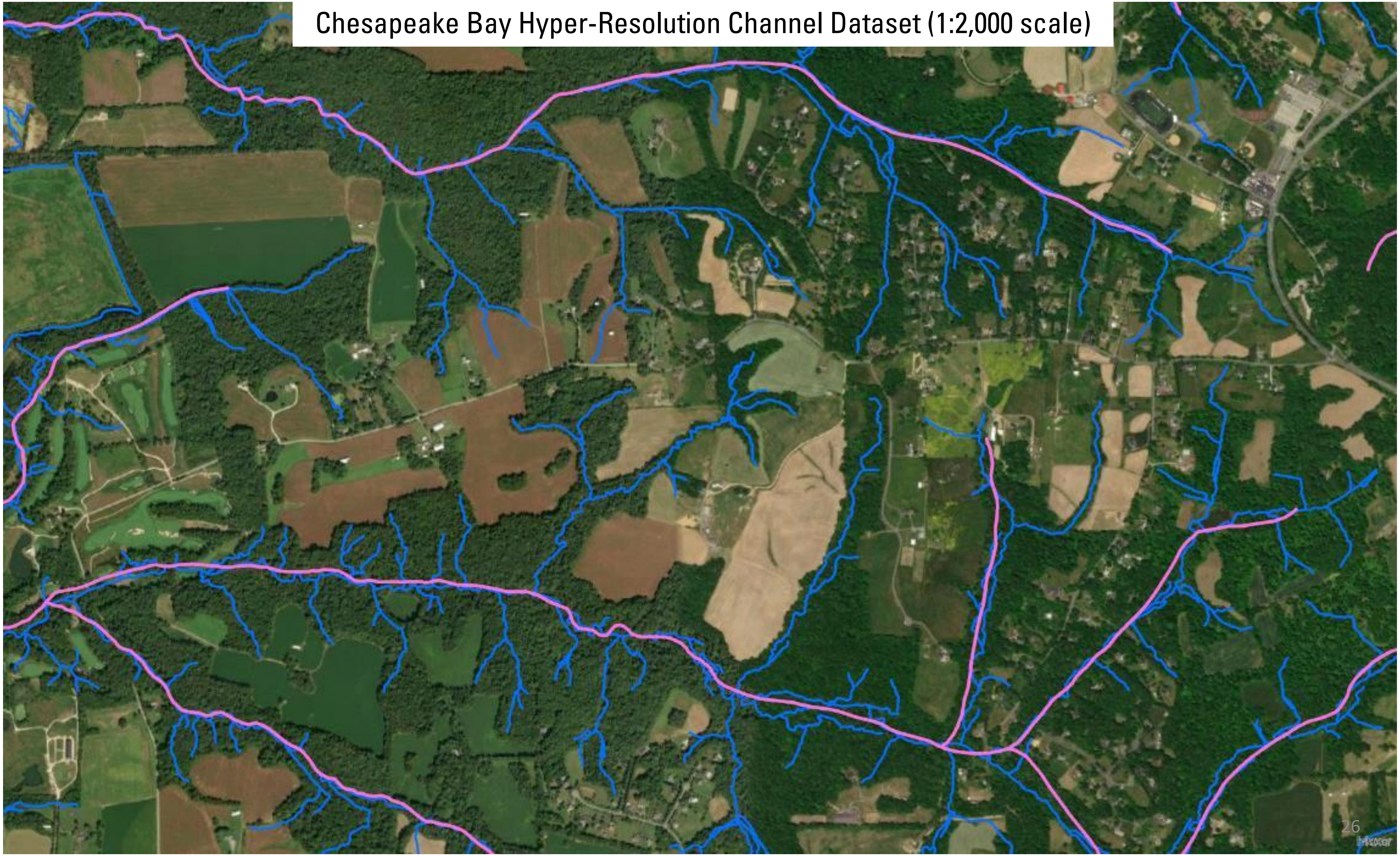
CBP Hyper-Resolution Streams, 1:2000
16,784.6 km



National Hydrography Dataset – High Resolution (1:24,000 scale)

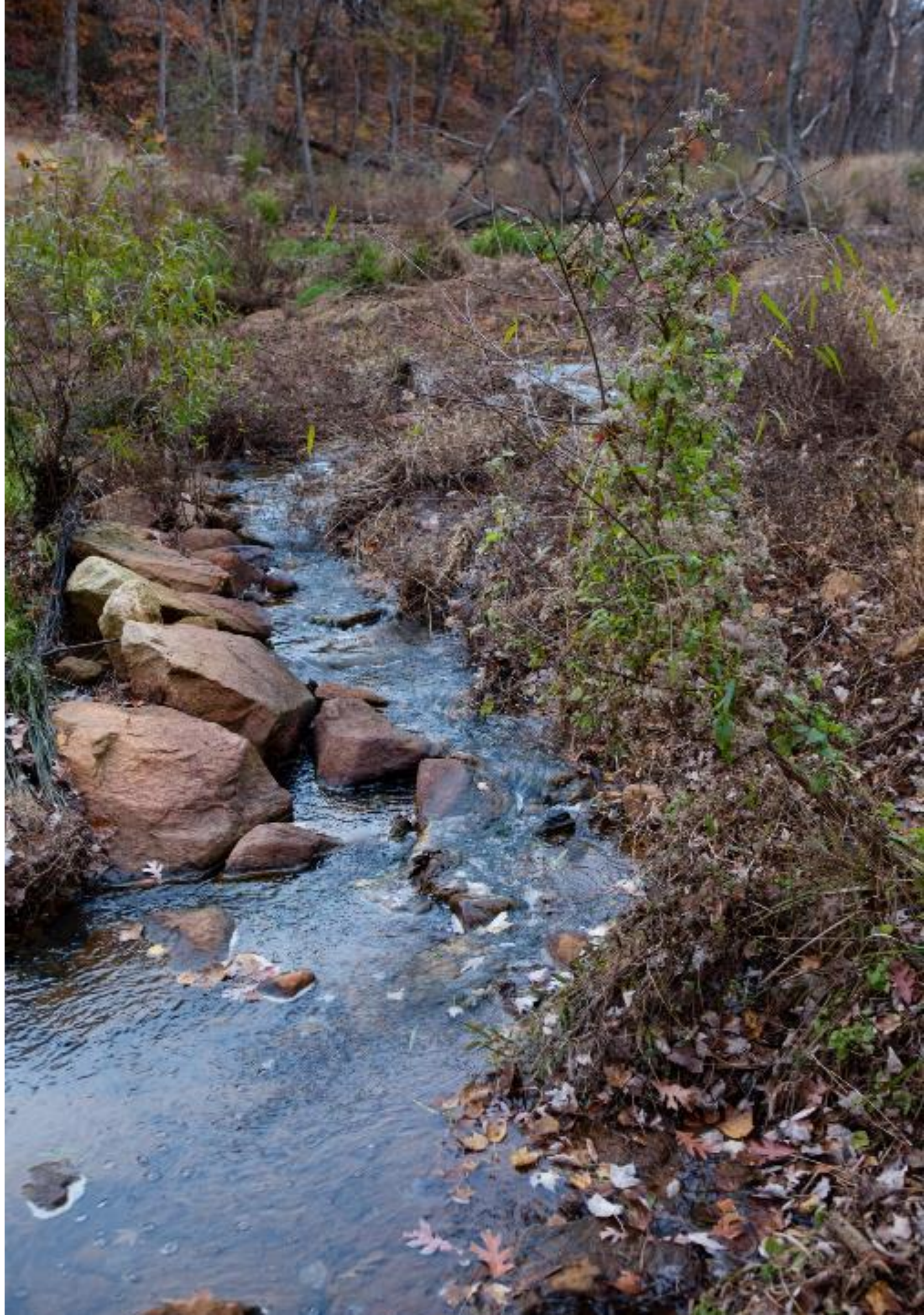


Chesapeake Bay Hyper-Resolution Channel Dataset (1:2,000 scale)



Wetland Mapping Relevance

- Significant increase in stream density and hydrographic connectivity – potentially increase wetland footprint
- Flow regimes in mapped channels? Attribution of stream periodicity is being explored by Matt Baker
- Potential mapping of headwater wetlands and landforms associated with wetland-complexes



Remote Sensing Approach for Channel & Floodplain Characterization

Labeeb Ahmed[1], Marina Metes[2], Kristina Hopkins[3], Greg Noe[4], Sam Lamont[5], Tristan Mohs[2], Jacqueline Welles[3] and Peter Claggett[1]

What is FACET?

- Floodplain and Channel Evaluation Tool (FACET)
- An automated desktop GIS tool to measure fine-scale geomorphometry (Open source & Python)
- Requirements:
  - Elevation: 1 or 3-meter DEMs (Digital Elevation Models)
  - Stream network: NHD Plus HR (1:24K) or NHD HR (1:100K)
- Timeline:
  - Code published (2019)
  - Data published (2020)
  - Paper published (2023)

Example FACET output for Wissahickon Creek at Fort Washington, PA

Study Area

Chesapeake Bay watershed (CBW) and Delaware River basin (DRB)

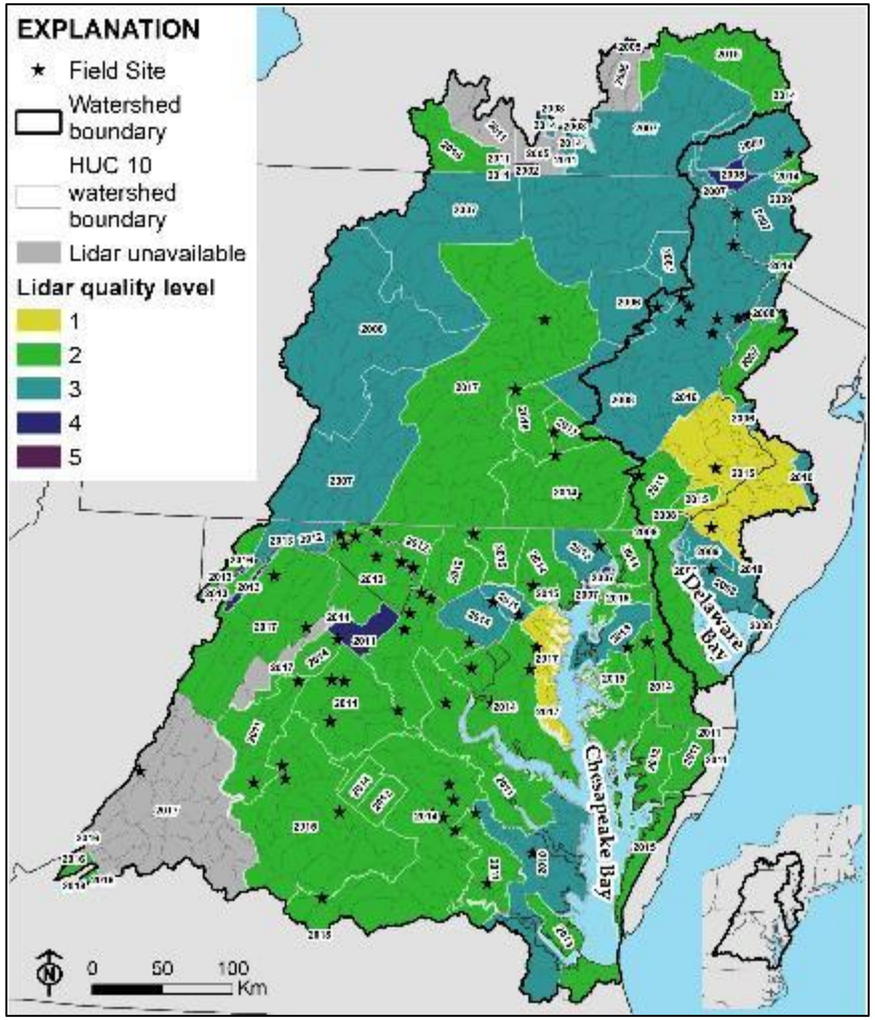
FACET has been run on 1 and 3-meter DEMs covering 100% in the DRB & 85% in CBW

Calibrated and Validated using Bank and floodplain geomorphic measurements against field data at 67 reaches

Code: https://code.usgs.gov/water/facet

Data: https://doi.org/10.5066/P9RQJPT1

Paper: https://doi.org/10.1111/1752-1688.13163



Data Products

Location: Patuxent River @ Route-50, Maryland
(HUC 0206000604)

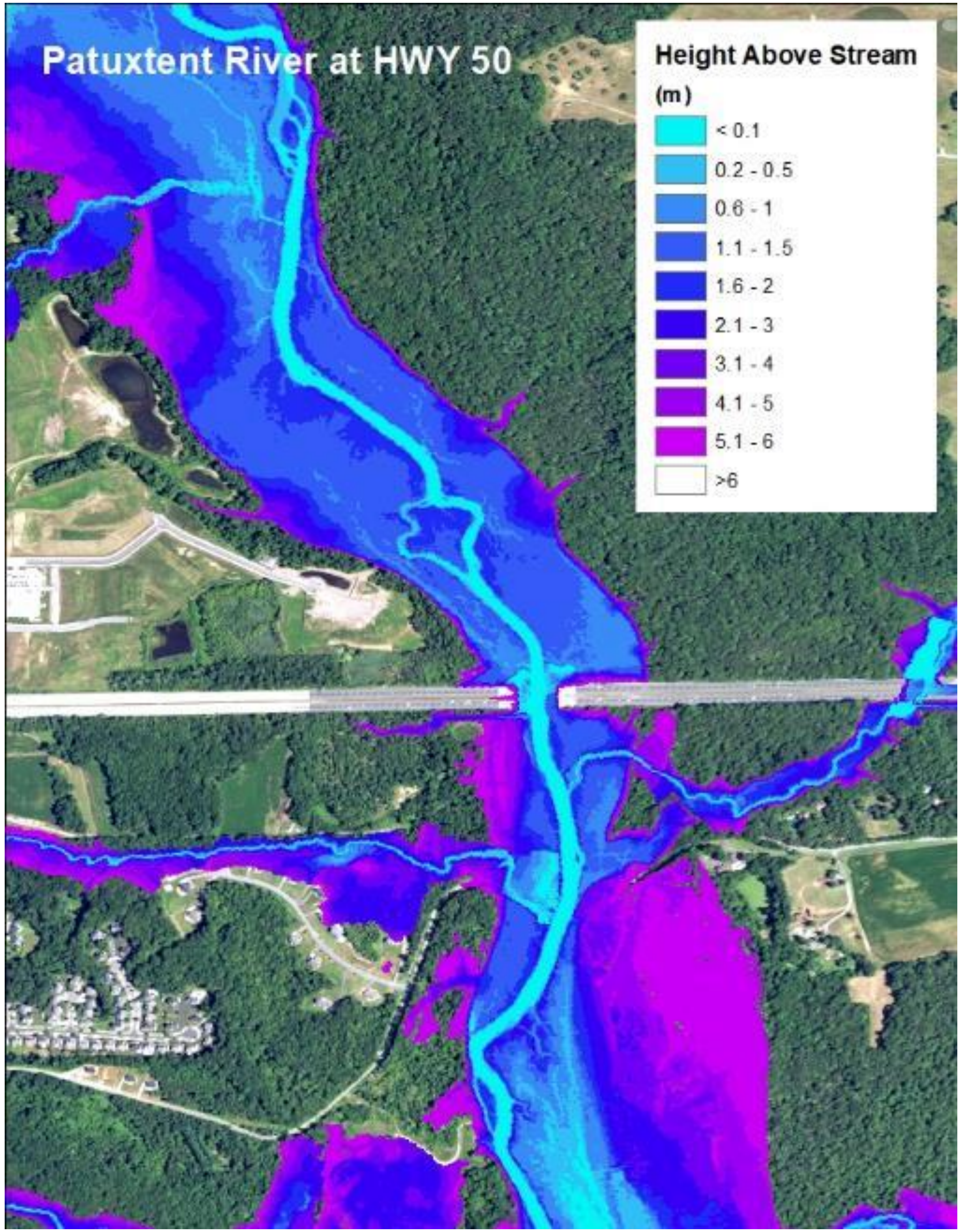
1. Elevation derived hydrography (EDH), or stream network
2. 1-D Cross-section and Bank Points
3. Raster-based Curvature with Bank Pixels
4. Flood inundation raster using HAND grid.

Channel Cross-section Metrics

- Bank height (m)
- Bank angle, avg (deg)
- Bank angle, max (deg)
- Channel width (m)
- Channel length (m)
- Bank-full area (m^2)
- Floodplain width (m)
- Floodplain elevation, range (m)
- Floodplain elevation, sd (m)

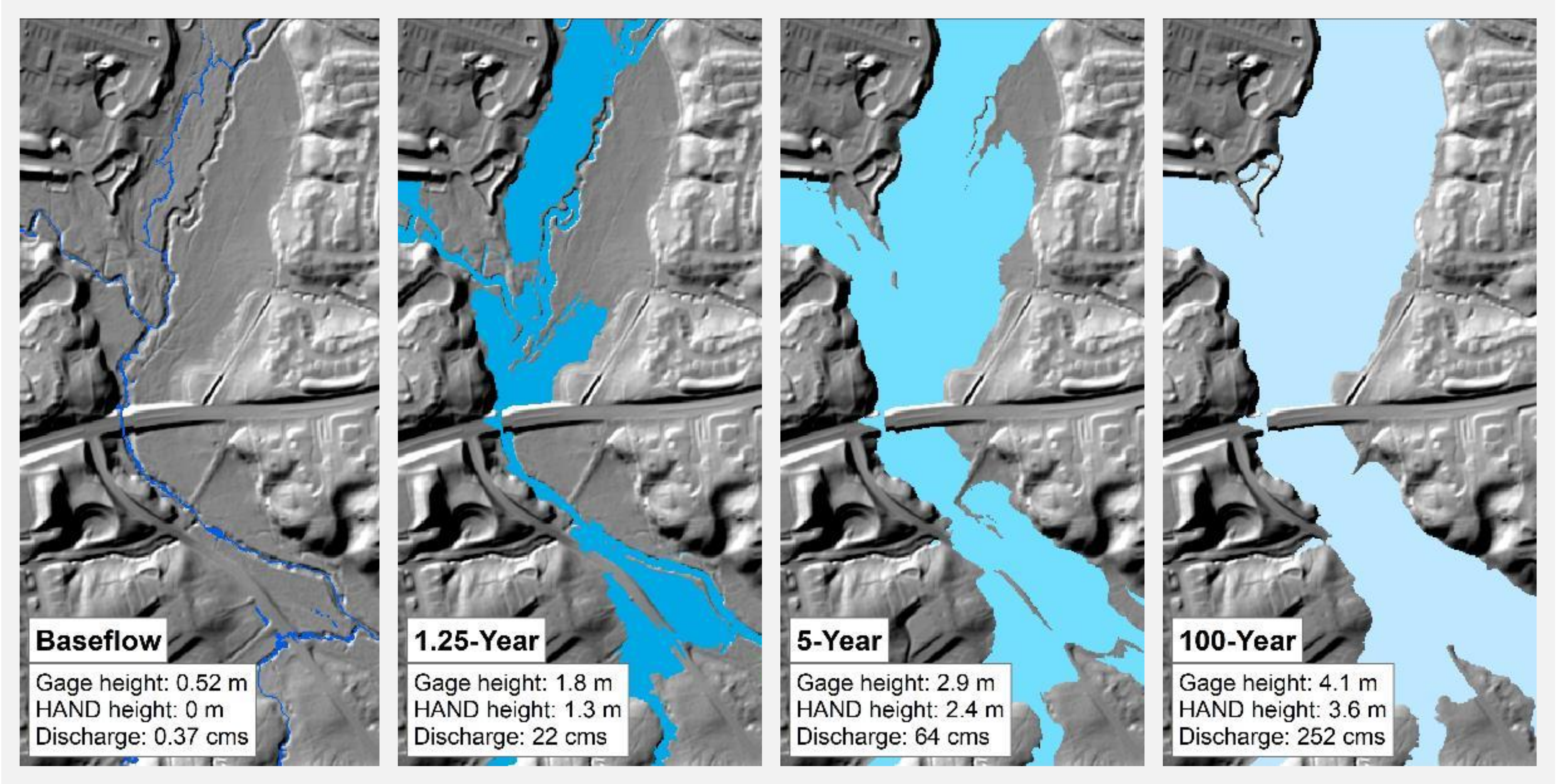
Stream Reach Metrics

- Length (m)
- Profile slope (deg)
- Order (Strahler)
- Magnitude (Shreve)
- Upstream and downstream IDs
- Drainage area (m^2)



Data Release: Hopkins et al. 2020, https://doi.org/10.5066/P9RQJPT1

Calibrated floodplain extent to various flood recurrence intervals using FACET
Pilot Site: Northwest Branch Anacostia at Colesville, MD



Wetland Mapping Relevance

- Focus of FACET work has been on fine-scale flood inundation mapping
  - Currently, FACET can map ~1.5-year active flood extent
  - Successful prototype approach can map multiple annual exceedance probabilities
- Exploring application for targeting of stream restoration and/or monitoring

Questions?

Contact:
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